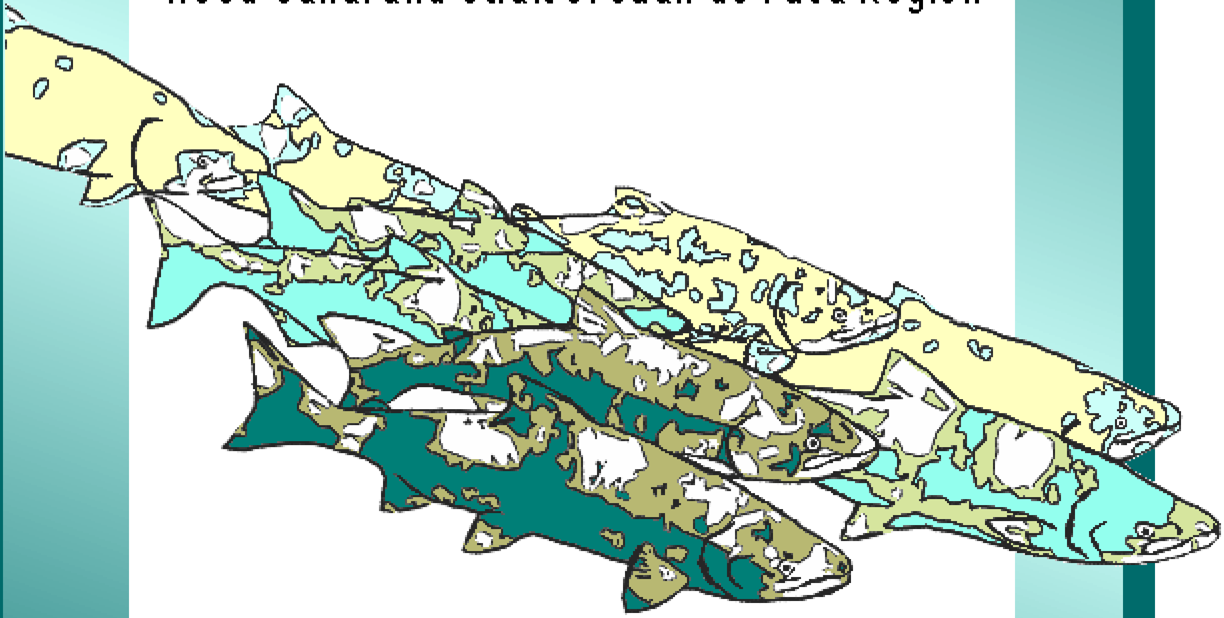
# Summer Chum Salmon Conservation Initiative

## An Implementation Plan to Recover Summer Chum Salmon in the Hood Canal and Strait of Juan de Fuca Region



Washington Department of Fish and Wildlife
Point No Point Treaty Tribes

April 2000

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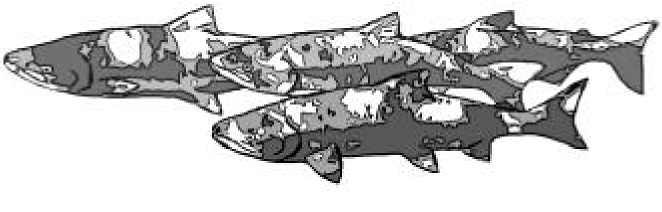

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**April 2000**

# Contributors

This summer chum salmon conservation initiative is the result of the collective efforts of a team of fisheries biologists representing tribal organizations, and state and federal agencies. The following individuals were instrumental in developing the technical analyses and written material that make up this recovery plan.

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# Cover

“Calico Salmon” by Jim Ames. Based on a photograph of Big Quilcene River chum salmon taken by Thom H. Johnson.

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## Foreword

### Background and Goal

Hood Canal and Strait of Juan de Fuca summer chum experienced a severe drop in abundance in the 1980s, and returns decreased to all time lows in 1989 and 1990 with less than a thousand spawners each year. In response to this alarming decline, the state and tribal co-managers began to implement harvest management actions in 1992 to afford greater protection to summer chum in terminal area fisheries and, together with the U.S. Fish and Wildlife Service (USFWS) and citizen groups, initiated three summer chum hatchery supplementation programs. Those actions were expanded in subsequent years and led to the development of the Summer Chum Salmon Conservation Initiative - An Implementation Plan to Recover Summer Chum in the Hood Canal and Strait of Juan de Fuca Region.

**Hood Canal and Strait of Juan de Fuca Salmon Co-managers**

***The Point-No-Point Treaty Tribes including: the Skokomish Tribe, the Port Gamble S'Klallam Tribe, The Jamestown S'Klallam Tribe, and the Lower Elwha Klallam Tribe; and the Washington State***

In March of 1999, the National Marine Fisheries Service (NMFS) determined that the summer chum originating from Hood Canal and the Strait of Juan de Fuca represented an Evolutionarily Significant Unit (ESU), and formally listed these fish under the Endangered Species Act (ESA) as a threatened species.

**The Summer Chum Salmon Conservation Initiative Goal is:**

***To protect, restore and enhance the productivity, production and diversity of Hood Canal summer chum salmon and their ecosystems to provide surplus production sufficient to allow future directed and incidental harvests of summer chum salmon.***

## Plan Development

The conservation initiative (or plan) has been developed and agreed upon by the Washington Department of Fish and Wildlife (WDFW) and the Point No Point Treaty (PNPT) Tribes under their authority to co-manage salmon pursuant to the rules and orders of U.S. v. Washington. The plan is consistent with and fulfills the intent of section 13 of the Puget Sound Salmon Management Plan, which calls for the development of comprehensive regional resource management plans for Puget Sound stocks of salmon. In addition, the goal, direction, and provisions of the summer chum recovery initiative are consistent with the guidance within the WDFW Wild Salmonid Policy. The USFWS and NMFS have also participated in the development of the plan at the request of the WDFW and the PNPT Tribes.

## Plan Organization

Organization of the conservation initiative is in five major parts: the Foreword, which sets the stage; Part One - Life History and Stock Assessment, which describes summer chum life history, discusses the available data, and provides stock evaluation tools; Part Two - Region-wide Factors for Decline, which contains a region-wide analysis and summary of those factors believed responsible for the recent decline of summer chum; Part Three - Evaluation and Mitigation of Factors for Decline, which provides more detailed, location-specific analysis of factors affecting summer chum and presents strategies for their protection and recovery; and Part Four - Summary of Plan Elements, which contains a summary description of the management components, and also describes specific actions, evaluation and monitoring, roles of the participating parties, and time frames.

## Future Actions

It is the intent of WDFW and the PNPT Tribes to implement the initiative as a comprehensive regional management plan, as provided for in the Puget Sound Salmon Management Plan. The implementation of the elements of the plan, that are specifically within the jurisdiction of the state and tribal co-managers, would then be under a Federal court order. This will provide certainty that the sections of the plan dealing with the elements of artificial production, ecological interactions, and harvest management will be carried out consistent with the plan. To facilitate an adaptive management approach, annual reports and five year plan reviews will be conducted to measure overall progress toward recovery and to evaluate and/or revise the strategies and actions provided in the plan.

The habitat element assesses habitat factors for decline and recommends strategies and actions to sustain and rebuild summer chum salmon in this region. The authorities to implement these measures, however, are dispersed through a variety of federal, state and local jurisdictions. The parties to the plan will continue to work with the appropriate jurisdictions to develop the implementation plans and actions for habitat protection and restoration. Habitat implementation plans and actions developed by a variety of agencies and processes are expected to be consistent and integral to the plan and are vital to its success. Furthermore, the plan provides critical guidance to the lead entities and the Salmon Recovery Funding Board, helping to ensure that funded recovery projects in Hood Canal and the eastern Strait of Juan de Fuca will have a high likelihood of supporting summer chum recovery.

# Part One
# Life History and Stock Assessment

## Summer Chum Salmon Life History

Summer chum salmon are the earliest returning chum salmon stocks in the Hood Canal and Strait of Juan de Fuca (HC-SJF) region. These stocks have been shown to be genetically distinct from fall and winter timed chum salmon. A total of 11 streams in Hood Canal have been identified as recently having indigenous summer chum populations: Big Quilcene River, Little Quilcene River, Dosewallips River, Duckabush River, Hamma Hamma River, Lilliwaup River, Union River, Tahuya River, Dewatto River, Anderson Creek, and Big Beef Creek. Summer chum are occasionally observed in other Hood Canal drainages, including the Skokomish River which once supported a large summer chum population. Summer chum salmon populations in the eastern Strait of Juan de Fuca occur in Snow and Salmon creeks in Discovery Bay, in Jimmycomelately Creek in Sequim Bay, and have been reported in Chimacum Creek. Recent stock assessment data indicate that summer chum also return to the Dungeness River, but the magnitude of returns is unknown.

Summer chum spawning occurs from late August through late October, generally within the lowest one to two miles of the streams. Depending upon temperature regimes in spawning streams, eggs and alevins develop in the redds for approximately 18-20 weeks before emerging as fry between February and the last week of May. Summer chum fry emerge from the stream gravels and immediately commence migration downstream to estuarine areas, with total brood year migration from freshwater ending within roughly 30 days for smaller streams and rivers.

In Puget Sound, chum fry have been observed through annual estuarine area fry surveys to reside for their first few weeks in the top 2-3 centimeters of surface waters and extremely close to the shoreline. Chum fry maintain a nearshore distribution until they reach a size of about 45-50 mm, at which time they move to deeper off-shore areas. Upon reaching threshold size in the estuary summer chum are thought to immediately commence migration seaward.

After two to four years of rearing in the northeast Pacific Ocean, maturing Puget Sound-origin chum salmon follow a southerly migration path parallel to the coastlines of southeast Alaska and British Columbia. Summer chum mature primarily at 3 and 4 years of age with low numbers returning at age 5. They enter the Strait of Juan de Fuca from the first week of July through September and the Hood Canal terminal marine area from early August through the end of September. Summer chum adults may mill in front of their stream of origin for up to ten to twelve days before entering freshwater to spawn.

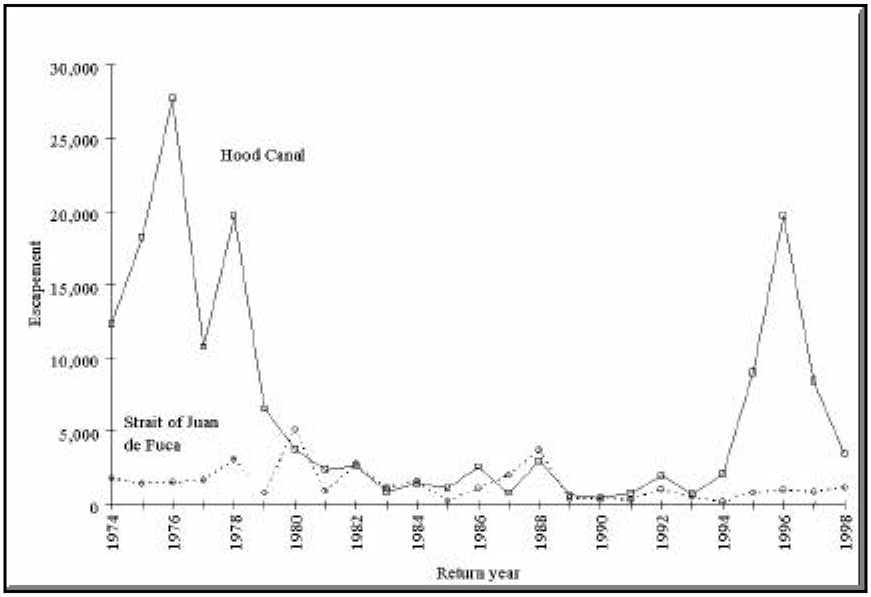
## Use of Stock Assessment Data

The quality and quantity of the available stock assessment data for summer chum salmon varies for individual parameters. New data will be incorporated into the recovery plan as it becomes available. The following are summaries of the utility of the various types of summer chum stock assessment data.

**Escapement and Runsize** - Both escapement and runsize (run re-construction) databases have been reviewed and substantially improved to provide the best available information for use in recovery planning. The summer chum salmon recovery plan focuses on escapement and runsize information for the 1974 through 1998 return years.

**Age Data and Productivity Estimates** - Because of the multi-brood life history pattern, resulting in returns of 3 to 5 year old summer chum salmon each year, any direct measures of their productivity necessarily depends on the availability of reliable age data. The age data that have been previously collected are not of sufficient quality to meet this need. A point that must be emphasized is that because of the lack of useable age data, no estimates of summer chum productivity (brood return or survival rates) are used in the recovery plan. The collection of appropriate age data for deriving survival rates is a high priority and is imperative to measure progress toward recovery.

**Period of Decline** - The summer chum salmon populations of Hood Canal and Strait of Juan de Fuca streams are affected by different environmental and harvest impacts, and display varying survival patterns and stock status trends. The summer chum stocks from both regions have dropped in abundance, but at different times and with different trends of abundance. While the rate and pattern of decline varies by individual population, all Hood Canal summer chum populations (except Union River) experienced a decline after 1978, and Strait of Juan de Fuca populations dropped in abundance ten years later (see, for example, figure above). Some improvements in total run size and escapements for these summer chum stocks have been noted in recent years, however, the time frame is short, and some individual populations are still experiencing very small escapements.



**Hood Canal and Strait of Juan de Fuca summer chum spawning escapements, 1974-98.**

## Stock Evaluations

The evaluation tools that will be used to identify summer chum stocks performing poorly and to measure the success of recovery measures are a major component of the recovery plan. Three independent assessment methods are presented below, each serving a separate purpose.

**Stock Definition and Status (SASSI)** - The first stock evaluation approach reviews and updates the summer chum stock definitions and status ratings using the SASSI criteria for identifying stocks based on their degree of reproductive isolation, and rating the status of stocks into the general categories of healthy, depressed, critical, extinct, and unknown. For the recovery plan, the most recent information on historical and current summer chum salmon distribution and on the genetic profiles of the populations has been reviewed. This analysis has produced an updated list of 16 summer chum stocks, which form the basic population units used throughout the recovery plan. Status ratings for each stock are also presented, primarily for use in various other processes and evaluations that are based on the SASSI approach. The recovery plan does not directly use these SASSI status ratings, but instead relies on the more detailed status evaluations below; which specifically focus on annual escapement numbers and extinction risk for summer chum salmon.

Known, recently extinct stocks have also been included where there is strong evidence to show that a stock formerly existed but is now extirpated from its former stream. Of the 16 stocks identified (see table below), seven are recent extinctions. The determination that these are distinct stocks is based solely on past distribution and presumed past reproductive isolation.

**Summary of Hood Canal and the Strait of Juan de Fuca native summer chum salmon stocks, including existing and recently extinct stocks and stock origin.**

| Stock | Status | Stock | Status |
|---|---|---|---|
| Union | Healthy | Dungeness | Unknown |
| Hamma Hamma | Depressed | Big Beef | Extinct |
| Duckabush | Depressed | Anderson | Extinct |
| Dosewallips | Depressed | Dewatto | Extinct |
| Big/Little Quilcene | Depressed | Tahuya | Extinct |
| Snow/Salmon | Critical | Skokomish | Extinct |
| Lilliwaup | Critical | Finch | Extinct |
| Jimmycomelately | Critical | Chimacum | Extinct |

It is likely that summer chum were historically distributed among additional streams within the region. For several streams, relatively recent evidence indicates that summer chum were historically present. However, this evidence is fragmentary and judged insufficient to identify stocks. A distinction is made here between stock and historic distribution, where a stock is defined under SASSI as being (or formerly has been) self-sustaining and reproductively isolated from other stocks based on available evidence. The assessment of the historic use of these streams by summer chum salmon could change as more information becomes available.

**Annual Abundance Evaluation** - The second evaluation approach compares spawner escapements and runsizes to stock-specific critical abundance thresholds (see table below). This annual process reviews escapements, and identifies (flags) any stock that falls below its threshold. At the end of each season, all flagged stocks will undergo an in-depth review of stock performance, and possible causes of the low escapement or runsize will be identified. If necessary, remedial measures will be incorporated into recovery activities the following year.

**Critical Thresholds for Hood Canal and Strait of Juan de Fuca Management Units.**

| Management Units | Contributing Stocks | Critical Escapement Thresholds | Critical Runsize Thresholds |
|---|---|---|---|
| **Sequim Bay** | Jimmycomelately | 200 | 220 |
| **Discovery Bay** | Snow/Salmon | 850 | 930 |
| **Mainstem Hood Canal (Hood Canal Bridge to Ayres Point)** | Lilliwaup<br>Hamma Hamma<br>Duckabush<br>Dosewallips<br>Total | 2,660 | 3,980 |
| **Quilcene/Dabob Bays** | Big/Little Quilcene | 1,110 | 1,260 |
| **SE Hood Canal** | Union | 300 | 340 |
| **Total** | | **4,750** | **5,400** |

**Stock Extinction Risk -** The third procedure is used to estimate extinction risk based on the numbers of effective spawners representing each summer chum stock. This evaluation assesses extinction risk using an approach described in the paper Prioritizing Pacific Salmon Stocks for Conservation, by Allendorf et al. (1997). The approach focuses on the minimum numbers of spawners required to have a viable population, and estimates the risk of extinction for populations below the viability threshold. This assessment identifies two stocks that are currently rated as having a high risk of extinction; Lilliwaup and Jimmycomelately. A moderate risk of extinction rating is assigned to the Hamma Hamma and Union stocks, and Dungeness is rated of special concern because of the lack of stock assessment information. The remaining summer chum stocks currently have a low risk of extinction.

# Part Two
# Region-wide Factors For Decline

Like all Pacific salmon, summer chum salmon are influenced by a variety of factors, with both positive and negative consequences for their overall survival. Part Two examines ***region-wide*** factors affecting production, both natural and human caused, to identify those that have been observed to change in concert with the recent summer chum salmon decline.

Those factors implicated in the recent abrupt decline of summer chum salmon do not necessarily include those effects that over time, gradually and cumulatively have impacted salmon survivals. For example, many negative anthropogenic habitat-related impacts affecting salmon populations have occurred prior to the period of recent decline addressed here. Additionally, nearly two decades have passed since the beginning of the recent decline of summer chum, and a broader range of negative conditions now exist. All known negative factors must be addressed to effect the recovery, stability, and sustainability of Hood Canal and the Strait of Juan de Fuca summer chum salmon stocks.

## Negative Impacts On Abundance

Those factors that can influence summer chum salmon abundance have been examined in an attempt to identify specific sources of mortality that have contributed to the declines of Hood Canal and the Strait of Juan de Fuca summer chum salmon. Potential factors affecting production have been examined individually in the following four categories: 1) climate, 2) ecological interactions, 3) habitat, and 4) harvest.

Among the factors for decline, only the effects of harvest can be readily quantified. Because of this, the ranking of the various factors for decline is necessarily a subjective process. The following four categories are used to rate the various factors for decline: 1) major impact, 2) moderate impact, 3) low or not likely impact, or 4) undetermined impact. The ratings of factors for decline are presented in the table below. Three primary factors have combined to cause the decline of summer chum salmon in both Hood Canal and Strait of Juan de Fuca streams; habitat loss, fishery exploitation, and climate related changes in stream flow patterns.

**Ratings of region-wide factors for decline of summer chum salmon in Hood Canal and Strait of Juan de Fuca streams.**

**Impact ratings:** UUU **Major** UU **Moderate** U **Low or not likely** **? Undetermined**

| **Factor** | **Hood Canal** | **Strait of Juan de Fuca** |
|---|---|---|
| Climate | | |
| Ocean conditions | ? | ? |
| Estuarine conditions | ? | ? |
| Freshwater conditions | UU | UUU |
| Ecological Interactions | | |
| Wild fall chum | U | U |
| Hatchery fall chum | U? | U |
| Other salmonids (including hatchery) | UU | U |
| Marine fish | U | U |
| Birds | U | U |
| Marine mammals | U | U |
| Habitat | | |
| Cumulative impacts | UUU | UUU |
| Harvest | | |
| Canadian pre-terminal catch | U | UU |
| U.S. pre-terminal catch | U | U |
| Terminal catch | UUU | U |

## Factors Affecting Recovery

The general assessment of factors for decline of summer chum salmon has focused specifically on changes in fish production and potential survival factors that occurred twenty years ago in Hood Canal and ten years ago in the Strait of Juan de Fuca. Because of the time that has passed since the declines in the two regions, recovery may not involve just the factors that contributed to the decline. Some of the factors discussed above may not have had major, or even moderate impacts on the declines of summer chum salmon, but now may be factors that will slow recovery. Two examples of these impediments to recovery are the recent increase of the harbor seal population (potential summer chum predators) and recent climate changes causing unfavorable spawning and incubation stream flows.

There have also been a number of factors that are positive for summer chum salmon recovery. One is the successful reduction of Hood Canal terminal area exploitation rates. The average terminal area incidental harvest has been just over 1% during the 1993-1997 seasons. Successful supplementation projects on two stocks are increasing the numbers of returning summer chum adults to two streams (Quilcene River and Salmon Creek). There have also been meaningful changes in the management and culture of hatchery salmonids in the region, designed to reduce negative interactions with summer chum juveniles. The combined effects of these changes in summer chum salmon management have contributed to the increased escapements in recent years. However, additional measures, particularly with respect to habitat protection and restoration, are required for successful recovery of summer chum.

# Part Three

# Evaluation and Mitigation of Factors for Decline

Part Three of the plan evaluates factors for decline for summer chum salmon at the watershed and management unit levels, and provides specific strategies for recovery. It is arranged in five sections; Artificial Production, Ecological Interactions, Habitat, Harvest Management, and Program Integration and Adaptive Management. Each of these sections provides specific recommendations for actions to aid the recovery of summer chum stocks.

## Artificial Production

**Goals and Objectives** - The following statement presents the goals for artificial production, which are directed at ***only*** those existing populations identified as ***at risk of extinction*** in the plan, and also are directed at ***selected***, extirpated populations within the region.

> ***"Restore naturally-producing, self-sustaining populations to their historic localities and levels of production, and minimize the risk of further declines, while conserving the genetic and ecological characteristics of the supplemented and reintroduced populations, and avoiding genetic and ecological impacts to other populations."***

The co-manager's objectives in developing supplementation and reintroduction projects are: 1) to rebuild summer chum populations at risk of extinction, 2) to restore summer chum to streams where a viable spawning population no longer exists, 3) to maintain or increase summer chum populations of selected streams to a level that will allow their use as broodstock donors for streams where the summer chum population has been lost, and 4) to avoid and reduce the risk of deleterious genetic and ecological effects.

**Benefits and Risks** - Implied within the list of objectives is the intent to consider potential benefits and risks associated with artificial production. Potential benefits to natural populations include: 1) reduction of short-term extinction risk, 2) preservation of populations while factors for decline are being addressed, 3) speeding recovery, 4) establishing a reserve population for use if the natural population suffers a catastrophic loss, 5) re-seeding vacant habitats capable of supporting salmon, and 6) providing scientific information regarding the use of supplementation in conserving natural populations. Potential hazards known to be associated with artificial production include: 1) partial or total hatchery failure resulting in a loss of summer chum that had been placed in the hatchery, 2) ecological effects on natural populations from predation, competition or disease transfer, 3) loss of genetic variability between or within natural populations, 4) effects from selection or reducing the population size of donor stocks, and 5) effects on other salmonid populations and species.

**Operational Criteria and Adaptive Management** - Operational criteria are described that provide guidelines on how to supplement and reintroduce summer chum while minimizing risk. Specific project operational recommendations are made regarding how broodstocking, incubation, rearing, and release or planting of summer chum should occur. Adaptive management guidelines are also provided that describe when to modify a project.

**Monitoring and Evaluation** - Monitoring and evaluating the effects of supplementation and reintroduction on the natural summer chum populations, and monitoring the performance of the programs in effecting the recovery of summer chum, are essential to the successful use of artificial production. The basic approach to monitoring and evaluation will be to collect information that will help determine: 1) the degree of success of each project, 2) if a project is unsuccessful, why it failed, 3) what measures can be implemented to adjust a program that is not meeting objectives set forth for the project, and 4) when to stop a supplementation project. Descriptions are provided of the specific elements of monitoring and evaluation actions consistent with this approach.

**Project Selection** - To better accommodate realization of potential benefits and to avoid potential hazards, a selection process has been applied to the existing and recently extinct stocks (identified in Part One) to identify candidates for supplementation and reintroduction. Stocks with existing supplementation and reintroduction projects are included in this selection process to show how they would fare in comparison to the other streams.

The first part of the selection process is a general assessment that considers the need, urgency, and practicality of supplementation/reintroduction for each stock. The second part of the selection process subjects each candidate stock to an assessment focusing on potential risks from hatchery failure, ecological hazards, and genetic hazards. The results of the selection process are discussed and recommendations are provided on whether or not to proceed with a supplementation or reintroduction project (see following table).

**Recommended summer chum salmon supplementation and reintroduction projects.**

| | | |
|---|---|---|
| **Existing Projects** | *Recommended to Continue* | |
| | Supplementation | Big Quilcene, Lilliwaup, Salmon |
| | Reintroduction | Big Beef, Chimacum |
| | *Recommended with Qualification* | |
| | Supplementation | Hamma Hamma (requires effective broodstocking) |
| **New Projects** | Supplementation | Jimmycomelately |
| | Reintroduction | None |
| **Potential Future Projects** | Supplementation | Union (for developing as donor stock) |
| | Reintroduction | Tahuya, Dewatto |
| **Projects Not Recommended at This Time** | Supplementation | Dungeness, Dosewallips, Duckabush |
| | Reintroduction | Skokomish, Anderson, Finch |

**Funding Priorities and Descriptions of Existing Projects -** Priorities for funding recommended actions related to supplementation and reintroduction are described, including specific projects, monitoring and research activities. Detailed descriptions of ongoing supplementation and reintroduction projects are provided as an appendix report.

## Ecological Interactions

There are complex sets of interactions that occur between organisms that share an ecosystem, and summer chum salmon can be affected in both positive and negative ways. Such ecological interactions can include factors like competition for food and space, direct predation, sources of nutrient input to the ecosystem, etc. This section only addresses those negative competition and predation impacts that were identified in Part Two as; 1) potentially contributing to the summer chum decline (hatchery salmonids), and 2) possibly impacting recovery (marine mammal predation).

**Hatchery Salmonids -** The potential effects on summer chum salmon caused by hatchery production of anadromous salmonids are addressed by the following steps:

1. Average annual salmon and steelhead production from the Hood Canal and eastern strait of Juan de Fuca is summarized by program; including release numbers, size and life stage at release, and release timing. This information serves as a basis for assessment of potential impacts and determination of appropriate mitigation measures.

2. An assessment of each program (for each hatchery species) is made that identifies program risks of deleterious effects to wild summer chum. The assessment is made based on specific criteria that define conditions for high, moderate and lowrisk of impacts from hatchery operations, predation, competition, behavioral modification, and fish disease transfer.

3. Measures for risk aversion, monitoring, and evaluation are identified to reduce the risks of hatchery operational and ecological hazards to summer chum. The specific measures are described within the same categories used above in assessing hatchery impacts (i.e., hatchery operations, predation,

competition, etc.). Also, specific applications of the measures are recommended for each hatchery program to mitigate the risk factors identified in the above described program assessment.

The intent of the above described process is to reduce all moderate and high risks of hatchery programs to low risks. The co-managers are already implementing the risk aversion and monitoring and evaluation measures recommended in this section of the plan.

**Marine Mammals -** The impacts of predation by two pinniped species, harbor seal and California sea lion, on summer chum salmon requires further study. NMFS (1997b) has reported that where existing information on the seriously depleted status of many salmonid stocks is sufficient, it may warrant actions to remove pinnipeds in areas where pinnipeds prey upon depressed salmonid populations. Therefore, if predation on critical summer chum stocks is identified as substantial, mitigative measures may be applied to control the predation, including institution of federally authorized pinniped removal programs.

## Habitat

Habitat is a critical element in the recovery of summer chum in Hood Canal and Strait of Juan de Fuca, because without high-quality habitat there is little likelihood that species recovery will be possible. This section of the plan initiates the discussion of habitat issues by describing the association between summer chum life stages and their habitats, in the streams and estuaries of Hood Canal and Strait of Juan de Fuca. Important natural processes that maintain these habitats are also discussed. To develop watershed-specific protection and restoration recommendations, available habitat data have been gathered, and aerial photos of streamside forests and subestuaries[1] have been examined. Habitat factors (stream flow, temperature, water quality, sediment, channel complexity, streamside forest condition, fish passage, and subestuary condition) have been rated by their degree of degradation in individual watersheds. Habitat factor ratings have shaped the development of watershed-specific protection and restoration measures (presented in an appendix report), and have allowed the summarization and comparison of conditions across watersheds.

Several key habitat factors are degraded in nearly all watersheds:

1. Riparian habitats along streams used by summer chum are degraded. These stands are dominated by small trees and deciduous species, and are frequently too narrow to provide fully functional habitat for summer chum.
2. In-stream habitat is also degraded. In most watersheds, stream-side development, water withdrawal, and channel manipulations (removal of large wood, dredging, bank armoring) have severely damaged salmon habitat.
3. Floodplains have been diked for residences and businesses and converted for agriculture. This has reduced the storage area of floodwaters. Habitat is degraded in the diked portions of the channel that is not allowed to meander naturally across the floodplain.
4. Most subestuaries have been developed for human use, which has resulted in loss or degradation of summer chum rearing habitat. Road and dike construction, ditching, dredging, filling, and other

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[1] The river deltas at the mouths of tributaries to Hood Canal-SJF, which typically include a complex of tidal channel, mudflat, marsh, and eelgrass meadow habitats.

modifications have all taken their toll. In spite of their importance to salmon, these habitats have received only limited conservation attention to date.

While the evaluation of nearshore estuarine habitat impacts to summer chum have not been done in detail, available information suggests that shoreline development (bulkhead and dock construction) threatens summer chum habitat at the scale of the entire Hood Canal and Strait of Juan de Fuca region. This suggests that estuarine habitat recovery planning and implementation must be coordinated regionally.

Protection and restoration strategies for each habitat factor limiting to salmon recovery are described in the plan. In most cases protection strategies are needed throughout entire watersheds (not just the portion of the channel used by summer chum). Restoration options appropriate to a particular habitat factor are also outlined. The plan recommendations stress the need for protection and re-establishment of natural watershed, estuarine, and nearshore processes that are critical to the maintenance of summer chum habitat. The plan provides guidance to focus local recovery activities on the key limiting factors in individual watersheds, to help prioritize restoration funding to make the most efficient use of limited resources.

Both protection and restoration measures will have to be fully integrated into a coordinated recovery strategy involving landowners, community groups, the tribes, and government agencies. Habitat monitoring is discussed in this section of the plan, which stresses the need for a long-term focus and periodic evaluation so that learning can occur from successes and failures during recovery plan implementation. Finally, this section of the plan identifies key federal, state, and tribal government entities, and links their mandates and responsibilities with actions needed to fully recover summer chum habitat. Current institutional impediments, enforcement problems, and oversight limitations that will need to be overcome are also identified, and potential pathways to achievement of full recovery are provided.

## Harvest Management

The short-term goal of the harvest strategies outlined in the plan is to protect the summer chum populations within Hood Canal and Eastern Strait of Juan de Fuca from further decline by minimizing the effect of harvest as a major factor for decline. The long-term goal of these strategies is to assist in the restoration and maintenance of self-sustaining summer chum populations while maintaining harvest opportunities on co-mingled salmon of other species.

Recommended harvest management measures are designed to limit fishing mortality to a rate that permits a high proportion of the summer chum run to return to spawning grounds, and thus accommodate the maintenance and rebuilding of self-sustaining populations. Furthermore, the measures will apportion harvest impacts between or within management units[2] based on population status and individual population characteristics, and to result in a broad distribution of spawners throughout all stocks in the HC-SJF region. These harvest management actions, when coordinated with habitat protection/restoration and supplementation actions, should lead to the maintenance and restoration of genetic and biological diversity within the region.

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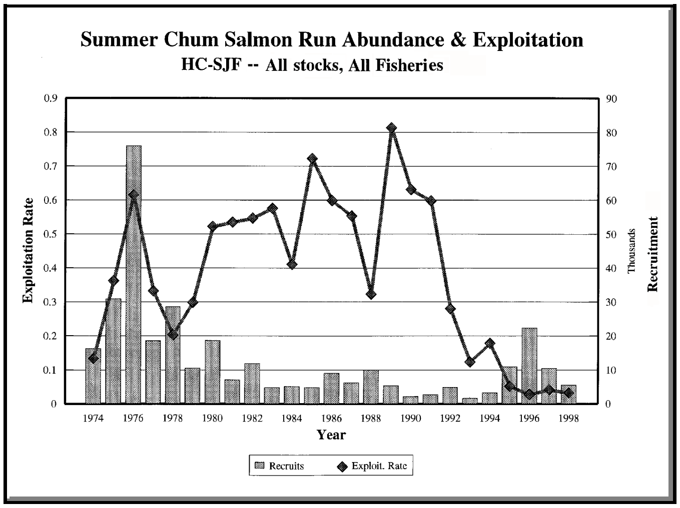
[2] A management unit is defined as "A stock or group of stocks which are aggregated for the purposes of achieving a desired spawning objective". Conceptually, the management unit approach is designed to recognize the practical and biological limitations to how we can manage fisheries for salmon populations.

**Harvest Management Strategies -**

*Base Conservation Regime* **-** The harvest management strategies described in the plan are expected to result in significant reductions of total exploitation rates on HC-SJF region summer chum, compared to those observed in the period from 1975 to 1992. The plan accomplishes that by establishing an annual fishing regime (called the Base Conservation Regime) for Washington pre-terminal, and Washington terminal area fisheries, and recommends harvest rates for Canadian fisheries. These fishing plans are designed to minimize incidental impacts to summer chum salmon, while providing opportunity for fisheries conducted for the harvest of other species. The fishery specific management measures comprising this regime are outlined in tabular form in the plan. Actions include closure of summer chum-directed fisheries, delayed or truncated fishery openings for other salmonid species designed to protect approximately 90% or more of the run of each HC-SJF summer chum management unit, chum non-retention in fisheries directed at other species, and area closures around freshwater spawning tributaries. The expected reduction in incidental interceptions, relative to the high rates observed during previous years is approximately78% for Canadian fisheries, 65% for U.S. pre-terminal, and 92% for Washington terminal area fisheries. The Base Conservation Regime will conserve, and not appreciably reduce the likelihood of survival and recovery of HC-SJF summer chum in the wild. Many of the harvest restrictions incorporated in the Base Conservation Regime have been initiated in recent years. The result has been a major reduction in exploitation rates and harvest of summer chum salmon (see figure).



**Hood Canal and Strait of Juan de Fuca summer chum abundance and incidental fishery exploitation rates.**

*Exploitation Rate Expectations* - The management actions described in the Base Conservation Regime are expected to result in, on the average, a 10.9% total (range = 3.3-15.3%) incidental exploitation rate on the Hood Canal management units and 8.8% (range=2.8-11.8%) incidental exploitation rate on Strait of Juan de Fuca management units (see table).

**Expected Base Conservation Regime incidental exploitation rates and ranges by fishery.**

| Fishery | Lower Guideline | Expected Average Exploitation Rate | Upper Guideline |
|---|---|---|---|
| Canadian | 2.3% | 6.3% | 8.3% |
| U.S. pre-terminal | 0.5% | 2.5% | 3.5% |
| Hood C. terminal | 0.5% | 2.1% | 3.5% |
| Hood Canal Total[1] | 3.3% | 10.9% | 15.3% |
| SJF Total[2] | 2.8% | 8.8% | 11.8% |

[1] Total of Canadian, U.S. pre-terminal, and Hood Canal terminal exploitation rates.

[2] Total of Canadian and U.S. pre-terminal exploitation rates. There is no terminal area harvest of Strait of Juan de Fuca stocks.

*Harvest Regime Modification* - If incidental exploitation rates are higher than expected, or the critical thresholds for abundance or escapement (described in Part One) are not met, the co-managers will investigate whether or not to implement additional harvest management measures (as provided for in the plan), which may be necessary to assist in restoring the management unit or stock to non-critical status. When exploitation rates are less than expected, or population-based recovery goals are exceeded, then the possibility of liberalizing the harvest regime may be considered. However, the co-managers still must develop and achieve the population-based recovery goals and determine how to structure a recovery harvest regime before directed harvest would be considered.

*Fishery Performance Standards* - By achieving fishery performance standards, the harvest element will contribute to the stability and recovery of the HC-SJF summer chum. The following fishery performance standards will be used to assess whether the harvest management strategy is being successfully implemented.

Compliance - Regulations are adopted and implemented consistent with the plan's management actions, and enforcement patrols indicate a high level of compliance with regulations adopted consistent with the plan.

Exploitation Rates - Exploitation rates are within the identified range in any year. At the time of 5-year plan review the expected rates are within the established range and are not clustered toward either extreme of the range.

Preseason Forecasts - Annual run size forecasts are a component of our performance standards for harvest regime assessment and modification, and efforts should be made to ensure they are as precise and accurate as possible.

**Compliance and Enforcement** - "Compliance" is adherence, by each of the parties, to the guidelines, mandates and performance standards of the plan, including adoption of any necessary regulations to implement their responsibilities under the plan. Compliance certainty shall be assured through the application of U.S. v Washington rules and procedures. "Enforcement" shall mean the efforts of each party to implement the guidelines, measures and standards of the plan, including the enforcement of rules and regulations adopted to implement the guidelines, measures and standards.

**Harvest Management Monitoring and Assessment** - Specific, integrated monitoring programs shall be established to improve stock assessment methodologies as well as effectiveness of harvest management actions and objectives. These programs should include, at least: 1) consistent escapement monitoring methods, 2) identification and quantification of harvest contributions, 3) assessment of survival rates to recruitment by age, and 4) assessment of stock productivity and productive capacity. Escapement and harvest monitoring form the core elements of the monitoring program. These core elements are stable and will continue at or above current levels. Information gained from the other suggested monitoring activities would improve management, but additional funding and resources will be required for implementation. The co-managers have designed the management actions in this plan to provide sufficient protection for summer chum populations at the current levels of monitoring. The co-managers commit to maintaining the core elements of the monitoring programs, and recognize that the additional monitoring activities are important over the long term and funding support will be sought for them.

## Program Integration and Adaptive Management

The summer chum salmon conservation initiative is intended to be an integrated plan, with each element contributing in concert with the other elements, leading to a successful outcome in restoring these summer chum populations. Each of the preceding sections of Part Three addresses a specific element of the plan and defines how the performance (compliance and effectiveness) of the specific strategies and actions relevant to that element will be evaluated. However, the success of the overall plan can only be measured by how well the populations of summer chum respond. The following section describes the measures that will be used to evaluate the performance of the plan relative to specific population criteria.

**Critical Threshold Response -** If any management unit or stock falls below its critical abundance or escapement threshold, the co-managers will: 1) promptly identify any emergency actions that can be taken immediately to respond to the critical condition, and 2) within six months, prepare an assessment of the factors resulting in this failure to determine if actions and modifications to the plan are necessary to promptly restore the management unit or stock to non-critical status. The emergency response will include any actions that can be implemented to avoid further declines in abundance while the causes for the failure are being evaluated and corrective actions developed.

**Annual Plan Report -** Annually, management actions and their results are assessed for compliance with the specific plan provisions, including the determination if any critical population thresholds have been triggered. In the preceding sections on Artificial Production, Ecological Interactions, and Harvest Management, there are descriptions of annual actions that must be taken to assess compliance with and effectiveness of the plan provisions. By June of each year the co-managers will compile the annual assessments required in Part Three of the plan into an annual plan progress report.

**Five Year Plan Review -** A five year plan review will assess whether progress towards recovery is being achieved and whether the results of monitoring and evaluation studies indicate a need to revise assumptions and/or strategies and actions. As stocks within management units are rebuilt, the plan review will determine if the conservation and recovery criteria are being met, and will incorporate the results of monitoring and evaluation studies.

**Population-Based Performance Standards -** Specific population-based performance standard criteria are provided for the following categories. The measurement of several of the following standards (e.g. productivity) is dependent on the collection of representative age data.

*Abundance* - As used in the plan, abundance refers to the annual total number of adult recruits or the adult run size prior to any fishing related mortality. Escapement refers to the portion of the abundance that has "escaped" through the various fisheries and arrived on the spawning grounds. Progress toward recovery of abundance and escapement will be measured by the performance of natural-origin recruits (NOR) of each management unit and the stock(s) within them. The abundance standards are: 1) annual post season estimated abundance must be equal to, or greater than that of the parent brood abundance; 2) it should be stable or increasing and 5-year average abundance must be higher than the critical threshold; and 3) annual estimated abundances shall not fall below the critical threshold in more than two of five years.

*Productivity* - As used in the plan, productivity refers to the ratio of maturing recruits per parent brood spawner. The standards are: 1) five year mean estimated productivity shall be greater than 1.2 recruits per spawner, and 2) the number of recruits per spawner when management units are at or near critical thresholds must be stable or increasing.

*Escapement* - Annual NOR escapements shall be: 1) stable or increasing, and 2) 5-year average escapements must be higher than the critical thresholds (see table, page xiv). Information concerning the productivity and productive capacity of the stock(s) shall be used to further refine the thresholds themselves.

*Management Actions* - At a minimum, the plan strategies and actions shall result in stable recruit abundances at current levels, while ensuring that escapement rates are high. The plan's strategies shall be considered successful if progress toward recovery is demonstrated by positive trends in NOR abundance. Strategies and actions directed at management units or stocks whose abundance is below their currently estimated thresholds, will be considered successful if they stop and reverse the decline in productivity and/or abundance.

# Part Four
# Summary of Plan Elements

Part Four provides tabular summaries to show what and where specific objectives, strategies, and actions are to be applied, and by whom, to meet the plan's goal of protecting and restoring the summer chum runs. Additionally, this part of the plan discusses how the plan goal and ESA objectives are being addressed, the development of population-based recovery goals, and implementation of the plan.

## Summary of Plan Objectives, Strategies, and Actions

Plan objectives, strategies, and actions are summarized in tabular descriptions of Artificial Production, Ecological Interactions, Harvest Management, Habitat, Monitoring and Evaluation, and Program Integration and Adaptive Management. For each objective, one or more actions/strategies are described: including the participants with jurisdiction/authority, additional partners, status of available resources/funding, and time frame. These summaries are intended to provide quick reference to the elements of this initiative.

## Accomplishing Goals of the Recovery Plan and Meeting ESA Objectives

**Achieving the Recovery Plan Goal -** Recovery activities for summer chum salmon were begun by the co-managers in 1992. The recovery goal was, and still is, to return summer chum salmon to full health and to allow future harvests (see definition in Foreword section). The recovery objectives and actions identified for artificial production, ecological interactions, and harvest management will be immediately implemented by the co-managers (most are already underway). The implementation of strategies for habitat recovery is necessarily an activity that is longer term and will involve participants other than just the co-managers.

In summary, the following results from implementation of the initiative are expected. No further extinctions will occur. Re-introductions of summer chum to currently unpopulated streams will occur through time.

The past negative consequences potentially resulting from hatchery fish interactions will be largely eliminated as a precautionary measure. The impacts of incidental fishery harvests on summer chum stocks will be minimized. Habitat, both freshwater and estuarine, will be gradually returned to a more productive state. Annual monitoring, evaluation, and adaptive management will assure that recovery objectives are achieved. Ultimately, the combined effects of these actions will recover summer chum salmon.

**Meeting ESA Objectives** - In 1996, NMFS published a document titled "Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast". The purpose of this guidance is to identify the elements that would constitute a successful salmon recovery plan. NMFS described three major criteria to be met by a conservation plan: 1) the plan must have substance; that is, it includes measures that will effect recovery; 2) there must be certainty that the measures will be undertaken by the parties with the authority and means to implement recovery actions; and 3) the plan must include monitoring and assessment that will lead to effective adaptive management and help determine what recovery is and when it occurs. This recovery plan provides the basis for addressing all three criteria.

## Population-Based Recovery Goals

Specific quantitative, population-based recovery goals are needed to determine when recovery has been achieved. These goals should define recovery in terms of population abundance, productivity, and diversity. The co-managers are developing a comprehensive set of population-based recovery goals that are scheduled for completion in spring 2000, and will be made available in a supplement to the this recovery plan.

## Plan Implementation

The plan is a comprehensive document that addresses all the components for protection and recovery of summer chum and provides a scientific basis for recommending actions/strategies. The fisheries co-managers, WDFW and PNPT Tribes, are committed to carrying out those provisions of the plan for which they have the authority (measures addressing harvest management, artificial production and ecological interactions). However, particularly with respect to summer chum habitat, the plan is only the first step to a larger planning and implementation effort that must continue if recovery of the summer chum is to succeed. Counties and other agencies, who have not participated in the development of the plan but have provided review comments during its development, are encouraged to address the recommended strategies and actions that fall under their jurisdiction or authority. This will lead to additional planning, that will result in definition and execution of specific protection and recovery actions. The support of landowners, private non-profit organizations, volunteer groups, and local citizens is also important if these efforts are to succeed. The co-managers will offer technical support in how to interpret and apply the recommendations of the plan.

It is expected that many measures identified in the plan will subsequently be developed further based on recommendations contained in the plan. These should be incorporated into the ESA permitting process, which has been in development during the same time frame as the plan. There may be a need to adapt or modify measures within the plan in response to the permitting requirements (i.e., under ESA sections 4 (d), 7 or 10).

# Foreword

## Introduction

In recent years, it has become apparent that many wild salmon populations in the northwest have experienced serious declines in abundance due to a variety of factors negatively influencing the salmon and their environment imposed by our modern society.  In some cases these wild salmon populations have declined to the point where they face immediate risks of permanent harm or even extinction.

In response to these declines in wild salmon populations, the tribes in western Washington and the Washington Department of Fish and Wildlife (WDFW), in 1991, began a broad and ambitious effort to halt the decline and restore these populations, referred to as the Wild Stock Restoration Initiative (WSRI).  The first step in the WSRI was to inventory the status of all wild salmonid populations. This task, the Salmon and Steelhead Stock Inventory (SASSI), was completed in 1993 and identified a number of populations that were believed to be in critical condition.  A critical rating meant that the biologists reviewing the status of the populations felt that the stock of fish was "experiencing production levels that were so low that permanent damage to the stock is likely or has already occurred".  The inventory identified most of the summer chum originating in Hood Canal and the Strait of Juan de Fuca as being in critical condition.

Hood Canal and Strait of Juan de Fuca summer chum experienced a severe drop in abundance in the 1980s, along with other chum salmon throughout the Puget Sound region.  The summer chum remained at very low levels even though other chum stocks rebounded by the mid to late 1980s.  The region's summer chum returns hit all time lows in 1989 and 1990 with less than a thousand spawners in total.  In response to this alarming decline and consistent with the WSRI and the critical status identified in SASSI, the state and tribal co-managers implemented actions in 1992 to afford greater protection of summer chum in terminal area fisheries and, together with the U.S. Fish and Wildlife Service (USFWS) and citizen groups initiated hatchery supplementation programs

**Hood Canal and Strait of Juan de Fuca Salmon Co-managers**

***The Point-No-Point Treaty Tribes including: the Skokomish Tribe, the Port Gamble S'Klallam Tribe, The Jamestown S'Klallam Tribe, and the Lower Elwha Klallam Tribe; and the Washington State Department of Fish and Wildlife.***

on two summer chum stocks utilizing native brood stocks. Those actions have been expanded in subsequent years and have resulted in this Summer Chum Salmon Conservation Initiative (also referred to in the document as the "recovery plan", or simply "the plan").

In addition to the concerns of the tribal and state co-managers, the National Marine Fisheries Service (NMFS) initiated coast-wide status reviews for all west coast salmon species under the Endangered Species Act (ESA) in 1994. The NMFS review of chum salmon found that the summer chum originating from Hood Canal and the Strait of Juan de Fuca represented an Evolutionarily Significant Unit (ESU). They further found in their review that this ESU was at some risk of extinction and in March of 1999 the summer chum salmon were listed under the ESA as a threatened species.

## Goal of the Initiative

**The goal of the Summer Chum Salmon Conservation Initiative is:**

***To protect, restore and enhance the productivity, production and diversity of Hood Canal summer chum salmon and their ecosystems to provide surplus production sufficient to allow future directed and incidental harvests of summer chum salmon.***

This Hood Canal and Strait of Juan de Fuca Summer Chum Salmon Conservation Initiative is intended to formalize and expand on the recovery efforts already initiated for Hood Canal and Strait of Juan de Fuca summer chum salmon, such that there will be a comprehensive and cohesive strategy or plan for the recovery and restoration of these populations.

**Parties to the Recovery Plan**

***The co-managers (the Point-No-Point Treaty Tribes and WDFW) along with USFWS, and NMFS are "parties" to the recovery plan.***

The recovery plan applies to all summer-timed chum salmon returning to streams in Hood Canal and the eastern Strait of Juan de Fuca, including populations that may have been extirpated. This is consistent with the scope of the ESU defined by NMFS for ESA purposes. The agencies involved with the development of this plan and committed to ensuring it is implemented, include the Skokomish Tribe, the Port Gamble S'Klallam Tribe, the Jamestown S'Klallam Tribe, and the Lower Elwha Klallam Tribe; the WDFW; USFWS; and the NMFS.

The recovery plan has both short-term and long-term objectives. Some actions and measures will be implemented immediately (or have already been implemented) to stabilize these populations and increase their abundance, while others will be implemented over a longer time frame to effect the broader recovery and restoration of the populations and the fisheries that depend on them. It is the intent of the agencies that developed the plan that it be an adaptive plan that will encourage collection of new information on these populations and will be modified and adapted as we learn what works and what doesn't in meeting the overall plan goal. Thus, there are many actions and measures still to be developed based on the results of further assessments. The success of the recovery plan will determined by how well the specific objectives are achieved in each of the functional elements of the plan and how well the overall goal is achieved.

# Relevant Standing Orders and Agreements

The Puget Sound Salmon Management Plan (PSSMP) and the Hood Canal Salmon Management Plan (HCSMP) are federal court orders that currently control both the harvest management rules and production schedules for salmon in Hood Canal. The parties recognize that it may be necessary to modify these plans in order to implement the recommendations that will result from this summer chum plan. However, the provisions of the PSSMP and HCSMP will remain in effect until modified through court order by mutual agreement.

Previous agreements between the state and the tribes that may have a bearing on this plan include the Hood Canal Production and Evaluation Program (HCPEP) and the Hood Canal Wild Coho Salmon Evaluation and Rehabilitation Program (HCWCP). The HCPEP was implemented in 1989, outlining a six year study plan to evaluate new salmon production alternatives. The results of the HCPEP may be used to guide activities included within this plan.

The HCWCP carries the objective of rebuilding the Hood Canal wild coho salmon stocks. Management measures outlined in the HCWCP that are designed to facilitate rehabilitation of Hood Canal wild coho stocks must also address management of summer chum that commingle with coho. Sections included within the HCWCP regarding development of a comprehensive approach for protection and rehabilitation of Hood Canal salmon habitat should also benefit summer chum production. To the extent practicable, efforts directed towards the rehabilitation of Hood Canal wild coho will be designed to benefit summer chum as well.

When agreed to by the co-managers, modification of the above plans will be accomplished as necessary as part of the implementation phase of the summer chum recovery plan.

# Ongoing Activities, Initiatives, and Processes

The following is a chronological list of major efforts directed at or contributing to the recovery of Hood Canal and Strait of Juan de Fuca summer chum salmon.

## 1992 - Wild Stock Restoration Initiative (WSRI)

In 1992, the Washington Department of Fish and Wildlife and the Western Washington Treaty Indian Tribes (WWTIT) began a process to develop the Washington State Salmon and Steelhead Wild Stock Restoration Initiative. The Initiative's goal is "to maintain and restore healthy wild salmon and steelhead stocks and their habitats in order to support the region's fisheries, economies, and other societal values" (WDF et al. 1993).

An initial task under this initiative was to develop a Salmon and Steelhead Stock Inventory (SASSI). The State fisheries agencies and the WWTIT reviewed the salmonid stocks and reported on their status (WDF et al.. 1993, WDFW and WWTIT 1994). Completion of this inventory was the first step in a statewide effort to maintain and restore wild salmon and steelhead stocks and fisheries. The inventory represents the starting point to address the objective of restoring stocks identified as "depressed" and "critical". All but one of the identified Hood Canal summer chum stocks were classified critical or depressed in the inventory.

## 1992 - Artificial Production

Summer chum supplementation projects were begun in 1992 on the Big Quilcene River, Lilliwaup Creek and Salmon Creek. The recent project on the Big Quilcene River is a joint effort by the WDFW, Point No Point Treaty (PNPT) Tribes and USFWS, that was initiated because the summer chum population in the Big Quilcene River was depressed to the point that immediate intervention was necessary and because the habitat in the lower river was extremely degraded. The agencies and PNPT Tribes began this program to rebuild and protect the summer chum run until the habitat was recovered and able to support natural production. The project included modification of Tribal fisheries to minimize summer chum interceptions and help collect brood stock. Eggs were taken to the Quilcene National Fish Hatchery on the river where they were hatched, reared and released. The project continues to the present day; its initial success in rebuilding the run indicated by the high returns in recent years.

A supplementation project was also begun in 1992 on Lilliwaup Creek with the objective of rebuilding the summer chum run of that stream. The project is operated by Long Live the Kings, a non-profit salmon conservation group, under the supervision of WDFW. Eggs are collected and, after hatching and early rearing, the summer chum fry are released back into the stream. The desire to minimize impacts on natural spawning in the creek and difficulties encountered in collecting brood stock have resulted, so far, in this being an intermittent, low production project.

A citizen volunteer conservation group, Wild Olympic Salmon, began a cooperative effort with WDFW to supplement summer chum salmon in Salmon Creek in 1992. This project is similar in operation to the other two, except that final rearing before release of the fry occurs in a saltwater net pen near the mouth of Salmon Creek. The initial success of the project is indicated by escapement levels approaching 900 fish in recent years.

The Hood Canal Salmon Enhancement Group began a cooperative project with WDFW in 1997 to rebuild summer chum salmon in the Hamma Hamma River. Operations are similar to the other supplementation projects. However, there were problems collecting brood stock in the first years of the project.

In 1996, two projects were begun to reintroduce summer chum into streams where they had been extirpated, Big Beef Creek and Chimacum Creek. The donor population for the Big Beef project was the Quilcene River brood stock, where a surplus of eggs was available. Similarly, surplus eggs were made available for the Chimacum project from the Salmon Creek project. The project operations include the hatching, early rearing and release of juvenile summer chum. WDFW participates with the University of Washington (at its research station) and another citizen volunteer organization, the Hood Canal Salmon Enhancement Group, in operating the Big Beef project. Wild Olympic Salmon is the cooperator with WDFW on the Chimacum project.

These summer chum salmon recovery efforts are described in more detail in Part Three - 3.2 Artificial Production.

## 1992 - Harvest Management

Summer chum are subject to fisheries harvest in mixed stock areas, terminal marine areas and freshwater areas. Beginning in 1992, the co-managers substantially reduced the harvests of summer chum salmon in terminal marine and freshwater fishing areas.

The terminal marine areas for Hood Canal summer chum are Sequim Bay, Discovery Bay, and Dungeness Bay, along with all marine areas in Hood Canal south of the Hood Canal Bridge. No commercial harvest has been allowed for any salmonid species in either Sequim or Discovery bays since 1976. Within Hood Canal proper, there has been a directed fishery at summer chum within the terminal marine areas only in 1976, when an unusually high return of summer chum was observed. All other catches of summer chum have been the result of fisheries directed at chinook and coho salmon. Since 1992, tribal, commercial, and sport fisheries have been substantially modified to minimize summer chum interceptions.

Treaty fisheries, within freshwater areas and during the times summer chum may be present, have in recent years only been conducted within the Big Quilcene and Skokomish rivers. Since 1990 there have been no treaty net fisheries in the Quilcene River.

Mixed stock fisheries interceptions (as by-catch of fisheries directed at other species or runs) can occur in Canadian fishing areas and in Washington pre-terminal areas, including the Strait of Juan de Fuca, San Juan Islands, Admiralty Inlet and central Puget Sound. The impact on summer chum salmon has been estimated for these fisheries, and harvest management actions are being taken to protect summer chum. Overall, the Hood Canal summer chum bycatch of these fisheries can be significant. The co-managers intend to continue to obtain genetic samples to refine the relative estimates of impacts on Hood Canal summer chum.

For a more detailed discussion of the management of fisheries affecting summer chum salmon, see Part Three - 3.5 Harvest Management.

## 1993 - Wild Salmonid Policy (WSP)

In 1993, the Washington State Legislature passed EHB 1309 that directed WDFW to develop a wild salmonid policy that "*shall ensure the department actions and programs are consistent with the goals of rebuilding wild stock populations to levels that permit commercial and recreational fishing opportunities.*" Prior to the legislative initiative, the state and the tribes were working towards maintaining and achieving healthy native populations. The WDFW Commission adopted a wild salmonid policy in December 1997. Presently, WDFW is bound by the provisions of the policy. The goal, direction, and provisions of the summer chum recovery initiative are consistent with the guidance within the WDFW Wild Salmonid Policy.

## 1994 - Endangered Species Act (ESA)

In 1994 the Northwest Region of the National Marine Fisheries Service (NMFS) received three petitions for the listing of distinct populations of chum salmon from Puget Sound and the Strait of Juan de Fuca (including Hood Canal summer chum). In response to these petitions, NMFS reviewed the status of chum salmon. As a result, a Hood Canal summer chum ESU was defined and Hood Canal and Strait of Juan de Fuca summer chum were formally listed as a threatened species under ESA in March of 1999. The Hood Canal Summer Chum Initiative is meant to complement ESA activities and to provide the basis for additional planning to recover these summer chum stocks.

Several recent planning processes and documents have been developed to guide management of at-risk salmonid populations. These efforts have a bearing on the present initiative in that they reflect the current thinking and direction of planning for salmonid protection and recovery. The Hood Canal summer chum initiative has been prepared in full cognizance of the following documents.

> Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast (NMFS 1996a).
>
> Status review of chum salmon from Washington, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-32. (Johnson et al. 1997).

## 1994 - Hood Canal Coordinating Council (HCCC)

The HCCC is a council of governments formed under Washington State RCW 29.34 consisting of Jefferson, Kitsap and Mason counties, Port Gamble S'Klallam and Skokomish tribes, and with the support of federal and state agencies. Its mission is to coordinate actions that protect and restore the environment and natural resources of the Hood Canal basin. It also provides educational services to local communities. The Council began to consider responses to summer chum needs following the initiation of the NMFS chum status review in 1994.

## 1997 - Governor’s Salmon Recovery Office (SRO)

The Governor’s Salmon Recovery Office was legislatively created (ESHB 2496) to provide overall coordination for the state’s salmon recovery and ESA response. The SRO works with the Joint Cabinet and its member natural resource agencies to develop the Statewide Salmon Recovery Strategy, along with an implementation plan with performance measures to monitor progress. The SRO also works with regional and sub-regional salmon recovery entities and lead entities to develop salmon recovery plans and ESA responses.

### 1997 - Conservation Commission

The Washington State Legislature tasked the Conservation Commission, under ESHB 2496, to oversee the development of a state-wide habitat related limiting factors analysis for salmon recovery (in consultation with technical advisory groups).

### 1997 - Salmon Recovery Lead Entities

Also under ESHB 2496, the legislature authorized the formation of “Lead Entities” from local groups or governments. Lead Entities are empowered to solicit and prioritize salmon habitat restoration projects, and to seek funding from Salmon Recovery Funding Board. Where available, the Lead Entities are mandated to use the Limiting Factors Analysis, produced by the Conservation Commission, as a basis for project prioritization.

### 1999 - Salmon Recovery Funding Board

The Salmon Recovery Funding Board provides support to Lead Entities for salmon recovery by funding habitat protection and restoration projects that produce sustainable and measurable benefits for wild salmon and their habitat. Established under SB 5595, the Salmon Recovery Funding Board disperses state and federal monies through a scientific review process to ensure a coordinated and consistent accounting of funding appropriated for salmon recovery.

### 2000 - Forest and Fish Report

The Forest and Fish Report and associated WACs (under ESHB 2091) represent the development and implementation of emergency rules and programs for non-federal forest practice activities, and are designed to achieve the following goals: 1) to provide compliance with the Endangered Species Act for aquatic and riparian-dependent species on non-federal forest lands; 2) to restore and maintain riparian habitat on non-federal forest lands to support a harvestable supply of fish; 3) to meet the requirements of the Clean Water Act for water quality on non-federal forest lands; and 4) to keep the timber industry economically viable in the State of Washington. The emergency rules remain in effect until June 30, 2001, or until permanent rules are adopted by the Forest Practices Board.

## Plan Development and Organization

Staff of the PNPT Tribes, WDFW, NWIFC, USFWS and NMFS have participated in development of this conservation initiative (or plan) for Hood Canal and Strait of Juan de Fuca summer chum. This has been a technical process that has included analysis and summarization of existing data and the formulation of a management process for protection, recovery and restoration of the summer chum.

## Plan Development

This conservation initiative (or plan) has been developed and agreed upon by the WDFW and the PNPT Tribes under their authority to co-manage these salmon populations pursuant to the rules and orders of U.S. v. Washington (1974). This plan is consistent with and fulfills the intent of section 13 of the Puget Sound Salmon Management Plan (1985), which calls for the development of comprehensive regional resource management plans for Puget Sound stocks of salmon. The USFWS and NMFS have also participated in the development of this plan at the request of the WDFW and the PNPT Tribes. The USFWS participated largely because of their involvement with artificial production in the region and their general background in providing technical support for tribal/state fisheries management programs. The NMFS participated to assist the co-managers develop a plan which will also satisfy NMFS's concerns and criteria for recovery under the ESA, and to fulfill their trust obligations to the tribes to provide technical support.

**United States v. Washington**

***More commonly referred to as the "Boldt Decision", U.S. v. Wash. is the 1974 Federal Court Decision (and subsequent orders) that affirmed the fishing rights of western Washington Treaty Indian Tribes.***

A rough draft of the plan was prepared in January 1997. This initial draft was incomplete; a number of harvest management issues had not yet been resolved, supplementation planning required refinement, and the habitat protection and recovery component had not yet been developed. Still, the draft was submitted to NMFS to inform them of the status of the planning effort. Comments were subsequently received from NMFS that encouraged the parties to proceed with the full development of the plan.

The planning effort was renewed in the summer of 1997 with the objectives of providing direction for the management and recovery of summer chum. NMFS advised the co-managers that to be successful the initiative must: 1) include substantive management provisions with measurable performance standards, 2) incorporate participation of all parties possessing the management authority necessary to carry out the provisions, 3) provide for effective monitoring and evaluation to determine whether performance standards are being met, and 4) be adaptive to changing circumstances and knowledge gained over time. Agency and tribal staff have worked to meet these criteria in preparing the conservation initiative. Personnel from NMFS have participated in planning meetings and work sessions to facilitate communication with that agency, a need made more apparent by the official listing of Hood Canal and Strait of Juan de Fuca summer chum as a threatened species in March 1999.

## Plan Organization

Organization of the conservation initiative is in five major parts: Foreword, which sets the stage; Part One - Life History and Stock Assessment, which describes summer chum life history, and discusses the available data and provides stock evaluation tools; Part Two - Region-wide Factors for Decline, which provides a region-wide analysis and summary of those factors believed responsible for the recent decline of summer chum; Part Three - Evaluation and Mitigation of Factors for Decline, which provides more detailed, location-specific analysis of factors affecting summer chum and presents strategies for their protection and recovery; and Part Four - Summary of Plan Elements, which provides a comprehensive description of the management components, and also describes specific actions, evaluation and monitoring, roles of the participating parties, and time frames.

Four workgroups of technical staff were formed to perform technical analyses and prepare individual sections of the initiative. A general organizational workgroup was responsible for developing Parts One, Two, and Four, and for editing and assembling the final document. The three other workgroups performed technical analyses and addressed management strategies pertaining to 1) habitat protection and recovery, 2) harvest management, and 3) supplementation, reintroduction, and ecological interactions. The products of these latter three workgroups are presented in Part Three and are summarized in Part Four of the initiative.

This document is organized to meet the needs of the co-managers in terms of clearly laying out the problems that exist, actions that will be taken, and the goals and objectives to be achieved. It is also designed to address the issues raised in the NMFS status review for chum salmon and to address their needs for a recovery plan under the ESA. Part One of the plan clearly lays out the status of the region's summer chum populations as we understand them with our current knowledge and also identifies what we don't know and need to know for the plan to be effective. There are substantial discussions of the factors for decline (Parts Two and Three), which are pivotal components of the recovery plan for setting priorities and tying action strategies back to specific problems they are designed to correct. Part Three contains four sections that deal with the broad categories of recovery under Artificial Production, Ecological Interactions, Habitat, and Harvest Management, and these sections contain both evaluations of factors for decline and the substance and details of the specific recovery assessments, strategies and actions. Also Part Three includes the section, Plan Integration and Adaptive Management, that describes management responses to populations at critical threshold, outlines procedures for reviewing and modifying the plan, and presents performance standards. Finally, Part Four discusses what recovery and restoration means in the context of the plan, summarizes objectives, strategies, and actions in each recovery category, and discusses plan implementation.

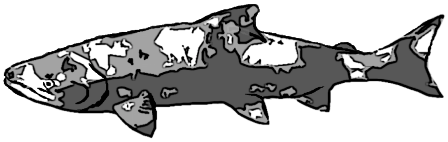
# Future Actions

It is the intent of WDFW and the PNPT Tribes to implement this initiative as a comprehensive regional management plan, as provided for in the Puget Sound Salmon Management Plan. Some elements of the plan require agreement from tribes other than PNPT Tribes. Upon gaining their concurrence, the plan will be adopted as an agreed plan in the U.S. v. Wash. proceeding. The implementation of the elements of the plan, that are specifically within the jurisdiction of the state and tribal co-managers, would then be under a Federal court order. This will provide certainty that the sections of the plan dealing with the fishery management elements of harvest and artificial production will be carried out consistent with the plan.

The implementation of the habitat element of this plan will involve a continuing and evolving process. The habitat element assesses habitat factors for decline and recommends strategies and actions to sustain and rebuild summer chum salmon in this region. However, the authorities to implement these measures is dispersed through a variety of federal, state and local jurisdictions. The parties to this plan will continue to work with the appropriate jurisdictions on developing the implementation plans for habitat protection and restoration. This will include working with the lead entities, Hood Canal Coordinating Council and local governments, the Governor's Salmon Recovery Office, the Salmon Recovery Funding Board, U.S. Forest Service, etc. Implementation plans developed by these agencies and processes are expected to be consistent and integral to this plan and are vital to its success.

The Summer Chum Salmon Conservation Initiative provides specific actions to be taken to lead to the recovery of the region's summer chum salmon. It is anticipated that management of all elements of the plan will periodically be evaluated and reshaped if necessary to achieve plan objectives. To facilitate this adaptive management approach, annual reports will be prepared to gage progress and assess the effectiveness of actions taken. In addition, five year plan reviews will be conducted to measure overall progress toward recovery and evaluate and/or revise the strategies and actions provided in this plan.

# Part One
# Life History and Stock Assessment



## 1.1 Introduction

This chapter provides a summary of summer chum salmon life history, an overview of summer chum current status, a review and recalculation of escapement and run size data, and formal evaluations of current status and risk for summer chum stocks. Because having the best possible summer chum salmon data is critical for all elements of this recovery plan, the existing escapement, run size, and age data for summer chum salmon are reviewed below, and newly up-dated escapement and run size data bases are provided. The status review provides new assessments of summer chum stocks and their current status at the time of publication. This stock information will be used in the initiative to identify the population units that will form the basis of recovery planning. Two separate approaches are included for assessing risk, and these evaluations will be used throughout the process to help prioritize recovery actions.

## 1.2 Background

The following is a brief overview of the current status of summer chum salmon. More detailed discussions of summer chum status are provided in the following sections of this chapter.

Summer chum of the Hood Canal and Strait of Juan de Fuca region are defined as those fish that have an average peak of spawning before November 1. These fish have declined in the recent past to critically low total adult return and escapement levels. Although the area and timing of spawning ground surveys has varied, particularly in the early survey years, it is evident that spawner returns to production streams have fallen from combined escapements of up to tens of thousands to less than a thousand, with a low of 770 spawners in 1990. Over the last few years, however, there has been an increasing trend in overall escapement.

The 1992 Washington State Salmon and Steelhead Stock Inventory (WDF et al. 1993) describes the majority of the populations of summer chum in the Hood Canal/SJF region as being of critical status; that is, "experiencing production levels that are so low that permanent damage to the stock is likely or has already occurred". Chronically low escapements are the reason for the critical status ranking. Two populations are not described as critical; the Union River population, which is rated healthy, and the Jimmycomelately Creek population which is described as depressed. The Dungeness River is not included in the 1993 inventory as currently supporting a summer chum population, however, a subsequent analysis of spawning ground counts indicates that summer chum may be present in the river.

The generally critical status of the Hood Canal summer chum is heightened by the recent loss of populations in a number of production streams historically utilized for spawning. Of at least fifteen streams that have historically produced annual returns of summer chum, seven are now considered to no longer support summer chum salmon.

The National Marine Fisheries Service listed summer chum in the Hood Canal and Strait of Juan de Fuca Evolutionarily Significant Unit (ESU) as a threatened species in March of 1999.

# 1.3 Summer Chum Salmon Life History

While much of the following life history summary is based on specific information about summer chum salmon, some of the descriptive material is derived from observations made on fall chum salmon.

## 1.3.1 Description and Distribution

### 1.3.1.1 Description

Adult chum salmon and sockeye salmon are distinguished from other Pacific salmon by a lack of distinct black spots on the back and caudal fin. The 19 or 20 short, stout gill rakers on the first arch of the chum salmon distinguish it from sockeye, which have 28 to 40 long, slender gillrakers (Wydoski and Whitney 1979). Juvenile chum salmon are distinguished by parr marks of relatively regular height that are smaller than the vertical diameter of the eye, and that are faint or absent below the lateral line (McConnell and Snyder, undated). When in spawning condition, adult chum salmon have greenish to dusky mottling on the sides, with males exhibiting distinctive reddish-purple vertical barring. Adult chum in Puget Sound range in size from 17 to 38 inches, with an average weight of 9 to 11 pounds.

**Summer Chum Salmon**

***The earliest returning chum salmon (Onchorynchus keta) stocks in the Hood Canal and Strait of Juan de Fuca region. Summer chum salmon return from the ocean from mid-August through October, and spawn predominately in September and October. These stocks have been shown to be genetically distinct from fall and winter timed chum salmon.***

One distinguishing characteristic of this group of summer chum populations is an early nearshore marine area, adult run timing (early August into October). This early timing creates a temporal separation from the more abundant indigenous fall chum stocks which spawn in the same area, allowing for reproductive isolation between summer and fall chum stocks in the region (WDF et al. 1993). The distance between summer chum spawning tributaries of Hood Canal and the eastern

Strait of Juan de Fuca, and the rest of the Puget Sound streams, creates a geographical separation among the stocks.

Hood Canal and Strait of Juan de Fuca summer chum populations are one of three genetically distinct lineages of chum salmon in the Pacific Northwest region (Johnson et al. 1997). WDFW has concluded that the Hood Canal and Strait of Juan de Fuca summer chum comprise a distinct major ancestral lineage, defined as stocks whose shared genetic characteristics suggest a distant common ancestry, and substantial reproductive isolation from other chum lineages (Phelps et al.1995, WDFW 1995). NMFS (Johnson et al. 1997) has designated Hood Canal and Strait of Juan de Fuca summer chum as an evolutionarily significant unit, based upon distinctive life history and genetic traits. Genetic differences between summer chum and all other chum stocks in the U.S. and British Columbia are a result of long-standing reproductive isolation of the Hood Canal and Strait of Juan de Fuca summer chum populations (Tynan 1992). This isolation has been afforded by a significantly different migration and escapement timing, and geographic separation from other chum stocks in the Pacific Northwest (Tynan 1992, Johnson et al. 1997).

### 1.3.1.2 Distribution

A total of 11 streams in Hood Canal have been identified as recently having indigenous summer chum populations : Big Quilcene River, Little Quilcene River, Dosewallips River, Duckabush River, Hamma Hamma River, Lilliwaup River, Union River, Tahuya River, Dewatto River, Anderson Creek, and Big Beef Creek (Tynan 1992). Summer chum are occasionally observed in other Hood Canal drainages, including the Skokomish River which was once a major summer chum stream. SASSI (WDF et al. 1993) lists two, distinct summer chum populations in Hood Canal - the Union River population and a group including all other Hood Canal summer production streams, but this assessment has been modified for this recovery plan (see 1.7.2 Stock Definition and Status below).

Summer chum salmon populations in the eastern Strait of Juan de Fuca occur in Snow and Salmon creeks in Discovery Bay and Jimmycomelately Creek in Sequim Bay and have been reported in Chimacum Creek, located near Port Hadlock in Admiralty Inlet (WDF et al. 1993, Sele 1995). Recent stock assessment data indicate that summer chum also return to the Dungeness River, but the magnitude of returns is unknown (Sele 1995).

Summer chum in the region use Hood Canal and the Strait of Juan de Fuca estuarine and marine areas for rearing and seaward migration as juveniles. The fish spend two to four years in northeast Pacific Ocean feeding areas prior to migrating southward during the summer months as maturing adults along the coasts of Alaska and British Columbia in returning to their natal streams. Adults may delay migration in extreme terminal marine areas for up to several weeks before entering the streams to spawn. Spawning occurs in the lower reaches of each summer chum stream.

## 1.3.2 Life History Strategy

Summer chum have evolved to exploit freshwater and estuarine habitats during periods, and for durations, when interaction with other Pacific salmon species and races is minimized. The uniqueness of summer chum is best characterized by their late summer entry into freshwater spawning areas, and their late winter/early spring arrival in the estuaries as seaward-migrating juveniles.

Summer chum spawning occurs from late August through late October, generally within the lowest one to two miles of the tributaries. Depending upon temperature regimes in spawning streams, eggs reach the eyed stage after approximately 4-6 weeks of incubation in the redds, and hatching occurs approximately 8 weeks after spawning (L. Telles, Quilcene National Fish Hatchery, Quilcene, WA, pers. comm., 1996). Alevins develop in the redds for additional 10-12 weeks before emerging as fry between February and the last week of May. Estimated peak emergence timings for Hood Canal and Strait of Juan de Fuca summer chum populations are March 22 and April 4 respectively. By contrast, indigenous fall chum stocks spawn in Hood Canal streams predominately in November and December, and the resulting fry emerge from the spawning gravels approximately one month later than summer chum salmon, between late April and mid-May (Koski 1975, Tynan 1997). Chum fry recovered in Hood Canal marine areas during the summer chum emergence period range in size from 35-44 mm.

## 1.3.3 Freshwater Juvenile Life History

### 1.3.3.1 Incubation

Developing chum salmon incubate as eggs or sac fry in the gravel for five or six months after fertilization, a time period determined mainly by ambient temperature regimes characteristic of Pacific Northwest streams (Bakkala 1970, Koski 1975, Schreiner 1977, Salo 1991). Stream flow, dissolved oxygen levels, gravel composition, spawning time, spawning density and genetic characteristics also affect the rate of egg/alevin development, and hence gravel residence time (Bakkala 1970, Koski 1975, Schroder 1981, Salo 1991). The earliest eggs deposited enter the tender stage starting the first week in September, with the majority of incubating eggs reaching the eyed stage by November 3. Bakkala (1970) reports total gravel residence times for chum ranging from 78 to 183 days across the range of chum salmon distribution, dependent on stream temperature. Koski (1975) has documented an average gravel residence time from spawning to 50% (peak) population emergence for Big Beef Creek summer chum of 166 days, with 95 % emergence after 177 days. Telles (1996) reports 100 % emergence (swim-up) of 1994 brood Big Quilcene River summer chum 111 days after fertilization at QNFH.

### 1.3.3.2 Emergence and Downstream Migration

Summer chum fry emergence timing in Hood Canal can range from the first week in February (“warm” years and/or earlier spawn date years) through the second week in April (colder and/or later spawn date years). The 10 %, 50 % and 90 % average emergence dates across years reported for Big Beef Creek summer chum are March 13, March 18, and March 27, respectively (Tynan 1997). The 10 % to 90 % emergence range observed across years is February 7 through April 14. Strait of Juan de Fuca summer chum generally emerge later than Hood Canal summers due to colder stream incubation temperatures. Estimated, average 10%, 50%, and 90% emergence dates for Strait of Juan de Fuca summer chum are March 6, April 4, and April 26, respectively. The 10% to 90% emergence range estimated across years for Strait chum is February 15 through May 26 (Tynan 1997).

Fry emerge with darkness, and immediately commence migration downstream to estuarine areas (Bakkala 1970, Koski 1975, Schreiner 1977, Koski 1981, Salo 1991), with total brood year migration from freshwater ending within 30 days for smaller streams and rivers (Salo 1991). Emerging chum fry have been shown to become very active with darkness (Hoar 1951), preferring the swiftest areas of downstream flow and exhibiting strong negative rheotaxis, often swimming more rapidly than the current (Hoar 1951, Neave 1955).

## 1.3.4 Estuarine and Marine Life History

### 1.3.4.1 Estuarine Behavior

Upon arrival in the estuary, chum salmon fry inhabit nearshore areas (Schreiner 1977, Bax 1982, Bax 1983, Whitmus 1985). Chum fry have a preferred depth of between 1.5-5.0 meters at this time (Allen 1974) and are thought to be concentrated in the top few meters of the water column both day and night (Bax 1983b). In Puget Sound, chum fry have been observed through annual estuarine area fry surveys to reside for their first few weeks in the top 2-3 centimeters of surface waters and extremely close to the shoreline (Ron Egan, WDFW, Olympia, WA, pers. comm.). Iwata (1982) reports that, in Japan, chum are located in stratified surface waters (20-100 cm depth) upon arrival in the estuary, showing a very strong preference for lower salinity water (10 to 14 ppt) found above the freshwater/saltwater interface, perhaps as a seawater acclimation mechanism. This nearshore and surface behavior could also be linked to survival, as small size exposes youngest fry to heavy predation. Onshore location may protect the fry from larger fish (Gerke and Kaczynski 1972, Schreiner 1977) and schooling behavior may be an adaptation to predator avoidance (Feller 1974).

Chum fry arriving in the Hood Canal estuary are initially widely dispersed (Bax 1982), but form loose aggregations oriented to the shoreline within a few days (Schreiner 1977, Bax 1983, Whitmus, 1985). These aggregations occur in daylight hours only, and tend to break up after dark (Feller 1974), regrouping nearshore at dawn the following morning (Schreiner 1977, Bax 1983). Bax et al. (1978) report that chum fry at this initial stage of out-migration use areas predominately close to shore. “Early run” chum fry in Hood Canal (defined as chum juveniles migrating during February and March) usually occupy sublittoral seagrass beds with residence time of about one week (Wissmar and Simenstad 1980). Schreiner (1977) reports that Hood Canal chum maintain a nearshore distribution until they reach a size of 45-50 mm, at which time they move to deeper off-shore areas.

### 1.3.4.2 Food

Chum fry captured in nearshore environments during out-migration in upper Hood Canal are found to prey predominantly on epibenthic organisms, mainly harpacticoid copepods and gammarid amphipods (Bax et al. 1978, Simenstad et al. 1980). Diet changes to predominantly pelagic organisms in early May for fry migrating in off-shore areas. Dabob Bay chum fry are reported to feed continuously (day and night) in using nearshore areas as a source of food (Feller 1974). Feller (1974) and Gerke and Kaczynski (1972) have documented initial preference (and predominance in the diet) of epibenthic prey by chum fry in Dabob Bay, followed by a gradual switch to pelagic prey as time progressed. Several researchers have documented a reliance on drift insects by migrating chum fry in British Columbia (Mason 1974) and in Dabob Bay, Hood Canal (Gerke and Kaczynski 1972). Hatchery-released chum fry in southern Hood Canal are found initially to prey almost exclusively on terrestrial insects, likely made available as drift from the Skokomish River (Whitmus 1985). Faster-migrating fry that have moved further north of the Skokomish delta are found to feed entirely on neritic and epibenthic organisms. Simenstad et al. (1980) show a gradual decrease in the epibenthic fraction of stomach contents as the chum increase in size. Migration off-shore could result from opportunistic movement of fry to take advantage of larger, more prevalent prey organisms in the neritic environment (Bax 1983).

#### 1.3.4.3 Juvenile Seaward Migration

Upon reaching a threshold size (~ 50 mm), summer chum entering the estuary are thought to immediately commence migration seaward, migrating at a rate of 7 - 14 km/day (Tynan 1997). Rapid seaward movement may reflect either “active” migration in response to low food availability or predator avoidance, or “passive” migration, brought on by strong, prevailing south/southwest weather systems that accelerate surface flows and move migrating fry northward (Bax et al. 1978, Simenstad et al. 1980, Bax 1982, Bax 1983). Assuming a migration speed of 7 km/day, the southernmost out-migrating fry population in Hood Canal would exit the Canal 14 days after entering seawater, with 90 % of the annual population exiting by April 28 each year, on average. Applying the same migration speed, summer chum fry originating in Strait of Juan de Fuca streams would exit the Discovery Bay region 13 days after entering seawater, or by June 8 each year (90 % completion).

#### 1.3.4.4 Ocean Migration

After two to four years of rearing in the northeast Pacific Ocean, maturing Puget Sound-origin chum salmon follow a southerly migration path parallel to the coastlines of southeast Alaska and British Columbia (Neave et al. 1976, Salo 1991, Myers 1993). The precise timing of this migration from Gulf of Alaska waters for Hood Canal summer chum is unknown. Genetic stock identification data collected from Canadian Strait of Juan de Fuca commercial net fisheries (LeClair 1995, 1996), Canadian fishery recoveries in 1995 of coded wire tagged Big Quilcene summers (PSMFC data, August 14, 1996) and a single recovery in Big Beef Creek of a summer chum tagged in a southeast Alaska ocean fishery study (Koski 1975), suggest that the southerly ocean migration down the Pacific Northwest coast and into the Strait of Juan de Fuca likely commences in mid-July, and continues through at least early September. Migrational timing of Strait of Juan de Fuca summer chum into Washington marine waters appears earlier than arrival timing observed for Hood Canal summer chum. The stocks in this region enter the terminal area (the Strait) from the first week of July through September (WDFW and WWTIT 1994). GSI data collected from Canadian net fisheries at the entrance to the Strait suggests that Hood Canal and Strait of Juan de Fuca summer chum are present through August and into early September (LeClair 1995, 1996).

### 1.3.4.5 Adult Nearshore Migration

Summer chum mature primarily at 3 and 4 years of age with low numbers returning at age 5 (there are rare observations of age 2- and 6-year fish). They enter the Hood Canal terminal area from early August through the end of September (WDFW and WWTIT 1994). Entry pattern data for Quilcene Bay provided by Lampsakis (1994) suggest that summer chum enter extreme terminal marine areas adjacent to natal streams from the third week in August, through the first week in October, with a central 80% run timing of August 30 through September 28, and a peak on September 16.

Comparison of extreme terminal area entry timing in Quilcene Bay with spawning ground timing estimates developed from Big Quilcene River data, suggests that summer chum may mill in front of their stream of origin for up to ten to twelve days before entering freshwater (with shorter milling times later in the run). Thus, it is assumed that summer chum observed on spawning grounds entered the river five days earlier, based on a ten day average survey life (Appendix Report 1.2). This behavior is likely related to the amount of time required for the chum to complete maturation and to acclimate to freshwater, but is also affected by available stream flows.

## 1.3.5 Adult Freshwater Migration and Spawning

### 1.3.5.1 River Entry

Spawning ground entry timing in Hood Canal ranges from late August through mid-October. Lampsakis (1994) reports a central 80 % spawning ground timing in the Big Quilcene River of September 11 through October 14, with a peak on or about September 28, based on 22 years of spawning ground survey data. Strait of Juan de Fuca summer chum begin spawning during the first week of September, reaching completion in mid-October (WDFW and WWTIT 1994). Time density analysis of Snow, Salmon and Jimmycomelately creeks' spawner survey data for the lower portions of the drainages indicates a central 80 % spawning ground timing of September 16 through October 20, with an average peak on October 2 (Lampsakis 1994). For more detailed discussion of timing see Appendix Report 1.2.

### 1.3.5.2 Spawning

Hood Canal summer chum typically spawn soon after entering freshwater in the lowest reaches of natal streams (Koski 1975, Schroder 1977, Johnson et al. 1997). This characteristic may reflect an adaptation to low flows present during their late summer/early fall spawning ground migration timing, which confine spawning to areas with sufficient water volume. Spawning in lower river reaches during low flows, however, confines incubating eggs to center channel areas, exposing the eggs to increased risk of egg pocket scouring during freshets. Koski (1975) notes that Big Beef Creek summer chum spawning takes place predominantly in the lower 0.8 km of stream. Cederholm (1972) reports that 100 % of the summer chum run to Big Beef Creek in 1966 and 1967 spawned in the lower 0.6 km of the creek. WDFW documentation of summer chum spawning in the Big Quilcene River indicates that 90% of spawning occurs in the lower mile of the 2.2 miles of river accessible to salmonids. Summer chum spawn in the lower mile of Salmon Creek and in the lower one-half mile of Snow and Jimmycomelately creeks (WDFW and WWTIT 1994). As with Hood Canal summer chum, low summer-time flows likely have acted to confine summer chum spawning in this region to the lowest reaches of each production stream.

# 1.4 Summer Chum Salmon Data

## 1.4.1 Introduction

The overall quality of the data available to evaluate the possible factors responsible for the decline of summer chum salmon in Hood Canal and the Strait of Juan de Fuca will impose limitations on the ability to understand the exact nature of the problem. Ideally, survival data for individual broods and individual spawning populations would be used to measure the impacts of potential factors limiting production. In the case of these summer chum stocks, however, some of the data needed to calculate survival rates is either missing or is only sporadically available.

## 1.4.2 Escapement Data

An important source of information for the management of summer chum salmon (or any other salmon species) is the numbers of mature fish escaping all sources of prior mortality to successfully spawn in their natal streams. The numbers of spawning fish provide: 1) a measure of the status of populations, 2) a way to determine the impacts of fisheries and other mortality agents, and 3) a primary element used in predicting future run sizes. The quality of summer chum salmon escapement estimates has varied over the years, primarily because of changes in the amount of effort expended to count spawners.

**Escapement**

***The number of adult fish returning to a stream that escape mortality from harvest and natural attrition, and comprise a spawning population.***

### 1.4.2.1 Historical Estimates

Spawning ground counts of Hood Canal and the Strait of Juan de Fuca summer chum salmon were conducted at least since 1943, when 0.8 stream miles were surveyed during the time of year when summer chum spawn. Since then, survey effort increased in several stages, driven by the increasing need for better management information. Only a handful of counts were made up to 1952, when a system of standardized index areas was implemented by WDF to monitor the escapement of all species of salmon in Puget Sound streams. Summer chum salmon spawner survey effort in Hood Canal and Strait of Juan de Fuca streams averaged a modest seven miles per year between 1952 and 1963. An increased emphasis was placed on monitoring both pink and chum salmon in the mid-1960s, with the result that summer chum surveys in the region doubled for the 1964-1973 period, to an average of 14 miles surveyed per year. During these early years of counts in index streams (1952-1973), escapements were evaluated by comparing the relative annual changes in peak live and dead spawner abundance (WDF et al. 1974). This approach to monitoring escapements did not require an intensive survey schedule; usually the peak abundance was counted with between one and three surveys of each stream. One negative result of this survey methodology was that not all summer chum spawning streams were surveyed every year.

The 1974 Boldt Decision imposed the need for more accurate escapement numbers. There was an immediate increase in count frequency, and survey effort was expanded to include all summer chum salmon streams. Between 1974 and 1980, survey effort in Hood Canal and Strait of Juan de Fuca streams averaged 65 miles per year. Technical staff of USFWS and treaty tribes began to make counts, which also added to the total miles surveyed. In 1978, the methodology for estimating south Puget Sound, Hood Canal, and Strait of Juan de Fuca chum salmon escapements was changed to a spawner curve approach, which required that serial surveys be conducted on each stream at seven to ten day intervals throughout the spawning season (Ames 1984). Survey effort scaled up in 1981 to support this new escapement approach, and between 1981 and 1997 survey effort averaged 107 miles per year for Hood Canal and Strait of Juan de Fuca summer chum salmon.

Concurrent with the 1978 change in the Puget Sound chum salmon escapement methodology, it was decided to recalculate chum escapements back to the 1968 return year using the spawner curve method. This decision was made based on a substantial increase in total Puget Sound chum salmon spawner survey effort in 1968. That year, over 3,800 fall chum salmon were tagged in the waters of Admiralty Inlet between October 7 and November 25 (Fiscus 1968). Because of tag recovery efforts in south Puget Sound and Hood Canal streams, the total Puget Sound chum salmon survey effort jumped from a pre-1968 average of about 90 miles per year to 437 miles in 1968 (Egan 1978). After 1968, survey effort stayed at a higher level, averaging 219 miles per year between 1969 and 1973, and then increased to over 1,000 miles per year after the 1974 Boldt Decision.

The decision to extend the total Puget Sound chum escapement data base back to 1968 is based on the improved survey data for fall chum stocks for the years following the tagging study. However, as discussed earlier, the increase in Hood Canal and the Strait of Juan de Fuca summer chum salmon index mileage did not occur until 1974. For the six year period of 1968 to 1973, summer chum escapement estimates are often based on limited data and resultant estimates are subject to question. This topic is discussed in more detail in Appendix Report 1.1.

### 1.4.2.2 Current Estimates

Since the summer chum salmon escapement estimates are an integral element of the recovery process, all spawner counts have been reexamined by the co-managers as a part of the development of this plan and updated estimates of escapements have been generated. The primary objectives for reevaluating the escapement numbers are; 1) to be sure that all available count data were included in the analysis, and 2) to ensure that the escapement estimates were made in a consistent manner for all years and all streams.

Spawning escapement estimates are annually derived by WDFW for all of the currently recognized, non-extirpated summer chum populations in Hood Canal and the Strait of Juan de Fuca (Table 1.1). WDFW has attempted to derive quantitative point estimates of escapement for most Washington chum populations since approximately 1968. However, both the field data collection and data analysis methods have an "adaptive learning" characteristic to them that has resulted in the expectation that the newer escapement estimates are generally considered to be of higher precision and accuracy than many of the older ones, due to 1) improvements in the understanding of the location, number and timing of field surveys required, and 2) increased knowledge of the fish entry pattern characteristics allowing more appropriate and consistent data analysis to account for the inevitable gaps and defects in the field survey observations due to environmental and/or personnel problems. Because of this, all summer chum escapement estimates for Hood Canal and Strait summer chum from 1968 to 1996 have been recalculated, to produce a historical summary of escapements with generally higher precision and accuracy.

> ***"...all summer chum escapement estimates for Hood Canal and Strait summer chum from 1968 to 1996 have been recalculated, to produce a historical summary of escapements with generally higher precision and accuracy."***

Escapement estimates for most Puget Sound chum populations are based upon the collection and analysis of multiple live and dead fish counts made in each stream throughout the spawning season.

**Table 1.1** Spawning survey index reaches for summer chum in Hood Canal and the eastern Strait of Juan de Fuca[1]

| WRIA | Stream name | WRIA river miles | Comments |
|---|---|---|---|
| 15.0389 | Big Beef Cr. | 0.0-1.7 | Fixed rack passage - operated late summer to late fall. |
| 15.0412 | Anderson Cr. | 0.0-1.0 | |
| 15.0420 | Dewatto R. | 0.3-1.8 | |
| 15.0446 | Tahuya R. | 0.0-2.6 | |
| 15.0495 | Big Mission Cr. | 0.0-1.6 | Early fall run (peaks late Oct., early Nov.). |
| 15.0503 | Union R. | 0.3-2.1 | |
| 16.0001 | Skokomish R (mainstem and SF) | 9.0-13.3 | Summer chum data collected incidentally during chinook surveys. |
| 16.0230 | Lilliwaup R. | 0.0-0.7 | |
| 16.0251 | Hamma Hamma R. | 0.3-1.8 | |
| 16.0253 | John Cr. | 0.0-1.6 | |
| 16.0351 | Duckabush R. | 0.0-2.3 | |
| 16.0442 | Dosewallips R. | 0.02.3 | |
| 17.0012 | Big Quilcene R. | 0.0-2.8 | |
| 17.0076 | Little Quilcene R. | 0.0-1.8 | |
| 17.0219 | Snow Cr. | 0.0-1.5 | |
| 17.0245 | Salmon Cr. | 0.0-0.8 | Includes rack counts. |
| 17.0285 | Jimmycomelately Cr. | 0.0-1.5 | |
| 18.0018 | Dungeness R. | 0.0-18.9 | Pink and chinook surveys. |
| 18 0048 | Greywolf R. | 0.0-5.1 | |

[1] Surveys conducted late August to late October. On all streams except the Strait of Juan de Fuca tributaries directed chum survey effort is continued into the fall chum run period.

An estimate of the total abundance of chums in each stream from this data is made by use of an "area-under-the-curve" (AUC) methodology (Ames 1984). The AUC escapement methodology is based upon the principle that each species of salmon has an average stream residence life that can be used to convert a series of instantaneous estimates of live fish, collected through the spawning season, into an estimate of total spawning escapement for the surveyed stream. Other methods, such as rack and redd counts are also used where available and/or appropriate. Table 1.2 presents updated total escapement estimates, and Appendix Report 1.1 and Haymes (2000) contain detailed discussions of the procedures used in reassessing summer chum escapements.

**Table 1.2.** Total escapements for Hood Canal and the Strait of Juan de Fuca summer chum salmon stocks (1974-1998).

| Return year | Hood Canal escapement | St. Juan de Fuca escapement | HC/SJF combined |
|---|---:|---:|---:|
| 1974 | 12,281 | 1,768 | 14,049 |
| 1975 | 18,248 | 1,430 | 19,678 |
| 1976 | 27,715 | 1,494 | 29,209 |
| 1977 | 10,711 | 1,644 | 12,355 |
| 1978 | 19,710 | 3,080 | 22,789 |
| 1979 | 6,554 | 761 | 7,315 |
| 1980 | 3,777 | 5,109 | 8,886 |
| 1981 | 2,374 | 884 | 3,258 |
| 1982 | 2,623 | 2,751 | 5,374 |
| 1983 | 863 | 1,139 | 2,002 |
| 1984 | 1,414 | 1,579 | 2,993 |
| 1985 | 1,109 | 232 | 1,341 |
| 1986 | 2,552 | 1,087 | 3,639 |
| 1987 | 757 | 1,991 | 2,748 |
| 1988 | 2,967 | 3,690 | 6,657 |
| 1989 | 598 | 388 | 986 |
| 1990 | 429 | 341 | 770 |
| 1991 | 745 | 309 | 1,054 |
| 1992 | 2,368 | 1,070 | 3,438 |
| 1993 | 751 | 573 | 1,324 |
| 1994 | 2,423 | 178 | 2,601 |
| 1995 | 9,462 | 839 | 10,301 |
| 1996 | 20,514 | 1,084 | 21,598 |
| 1997 | 8,971 | 962 | 9,933 |
| 1998 | 4,020 | 1,270 | 5,290 |

### 1.4.2.3 Escapement Timing

Table 1.3 presents estimates of the average time periods when 10%, 50%, and 90% of the escapement for each summer chum salmon stock are achieved. These average values are derived from selected spawning ground survey data for the 1974 to 1998 period. Two different methodologies have been used to estimate spawner timing (both are presented in Table 1.3), and show similar results. There can be significant annual variations from the average timing of spawning for individual populations, where spawning timing can be substantially earlier or later than average.

Such annual differences in spawning timing may be influenced by environmental factors (e.g., water temperature, flow regime), and/or harvest impacts. A more detailed description of the data used, derivation methods, and results of the analysis is presented in Appendix Report 1.2.

**Table 1.3.** Summary of summer chum salmon average escapement timing estimates (10%, 50%, and 90% completion) derived with two different methodologies. See Appendix Report 1.2 for a detailed discussion of the methodologies used.

| | | **PNPTC timing estimate** | | | | **WDFW timing estimate** | | | |
|---|---|---|---|---|---|---|---|---|---|
| Management Unit | Stock | No. Yrs (N) | 10% date | 50% date | 90% date | No. Yrs (N) | 10% date | 50% date | 90% date |
| Sequim Bay | Jimmycomelately | 14 | 9/17 | 9/26 | 10/9 | 15 | 9/14 | 9/24 | 10/10 |
| Discovery Bay | Snow/Salmon | 20 | 9/19 | 9/29 | 10/13 | 20 | 9/18 | 9/29 | 10/16 |
| Mainstem Hood Canal | Dosewallips | 16 | 9/13 | 9/25 | 10/9 | 13 | 9/12 | 9/23 | 10/9 |
| | Duckabush | 24 | 9/19 | 9/28 | 10/11 | 16 | 9/17 | 9/29 | 10/11 |
| | Hamma Hamma | 23 | 9/17 | 9/27 | 10/8 | 21 | 9/14 | 9/27 | 10/10 |
| | Lilliwaup | 18 | 9/15 | 9/28 | 10/10 | 13 | 9/17 | 9/28 | 10/10 |
| Quilcene Bay | Big/Little Quilcene | 16 | 9/12 | 9/22 | 10/1 | 17 | 9/10 | 9/22 | 10/5 |
| SE Hood Canal | Union | 18 | 9/6 | 9/16 | 9/29 | 16 | 9/3 | 9/15 | 9/30 |

## 1.4.3 Harvest Data

The changing nature of the harvest of summer chum salmon during the last three decades created consistency problems with catch data. Prior to the 1974 Boldt Decision, Hood Canal, Sequim Bay, and the southern half of Discovery Bay were designated as salmon preserves, in which no commercial fishing was allowed (WDF et al. 1974). The Puget Sound salmon preserve system was established between 1921 and 1934. The harvest of summer chum outside of these salmon preserves was affected by the passage of Initiative 77 in 1934, which closed portions of the eastern Strait of Juan de Fuca and all of inner Puget Sound to fishing with purse seines prior to October 5th, and traps, set nets, and fish wheels throughout the year. The purse seine prohibition was amended in 1949 by the State Legislature to allow fishing on odd-numbered years for pink salmon from August 1 through September 1 in the eastern Strait and northern portion of Admiralty Inlet. Gill net fisheries during this period operated throughout Puget Sound waters, outside of the salmon preserves (WDF et al. 1974).

The purse seine regulations prior to 1974 provided some protection to summer chum salmon on non-pink years; with October 5th openings most summer chum presumably passed into terminal area salmon preserves. On the odd-numbered pink salmon years, all Puget Sound summer chum stocks likely were subjected to harvest by purse seines during the months of August and September. Gillnet fisheries did not have variable seasons and areas, and likely had a more uniform harvest impact on summer chum salmon stocks.

The 1974 Boldt Decision resulted in a number of changes in the conduct of net fisheries, including the elimination of most salmon preserves, the movement of fisheries to more terminal areas, and the splitting of harvest management areas into smaller, more discrete management units.  This allowed a finer resolution of the contribution of various stocks to each area's harvest.  For example, since a higher proportion of the harvest of Hood Canal  summer chum salmon occurring in U. S. waters now takes place within the Canal, those catches can be allocated to Hood Canal stocks without the fear of a serious mis-allocation of south Puget Sound-origin  fish to Hood Canal stocks.  When major summer chum harvests occurred in northern Admiralty Inlet, there was significant uncertainty about the origin of the fish harvested.  Due to more consistent fishing patterns and increased efforts to collect harvest data since 1974, summer chum salmon harvest estimates are now more representative of local stocks.

There were also some harvests of summer chum salmon in freshwater areas.  There were recreational fisheries in selected streams throughout this period, and in some cases, freshwater Treaty Indian fisheries also occurred.  In both cases, no reliable records were kept, however, the harvests in freshwater areas were of limited magnitude.

## 1.4.4  Run Size

### 1.4.4.1  Run Re-construction

**Run Re-construction**

***A post season accounting of all salmon harvest and escapement for each individual stock or management unit.***

To determine the total numbers of salmon returning to specific production areas, fish that are harvested in mixed stock and terminal fisheries must be allocated to the streams from which they originated.  This allocation is done through a post-season process called "run re-construction", which splits the harvests in each catch area into the numbers of fish that likely are contributed by the individual stocks or management units thought to be transiting the area.  A management unit is a stock or group of stocks which are aggregated for the purpose of achieving a desired spawning escapement objective.  All estimated harvests for each stock or management unit are added to the escapement for that grouping to derive the estimated total return for each year.

The former Puget Sound salmon run re-construction models attempt to allocate salmon harvests by run or stock, and require many assumptions on migration routes and timing.  When two salmon runs overlap in timing in a mixed stock harvest area, an allocation date splitting the two runs is selected even though it is known that some fish would be mis-allocated.  When there are great differences in abundance levels between two runs, the harvest and run size of the smaller run could potentially be substantially overestimated.  In the case of Hood Canal, as the summer chum salmon returns have declined, the hatchery fall chum salmon program have increased, creating the potential for significant mis-allocation of fall fish to the summer chum run size estimates.  Mis-allocation of this type would potentially be the most serious at the end of the summer chum salmon harvest allocation period (July 1 to October 11), when the earliest portion of the fall chum return may be beginning to contribute to catches.  The result of this type of mis-allocation is that the proportional impacting activities are greatest when summer chum salmon populations are lowest. Attempts have been made to use the traditional run reconstruction estimates to calculate recruit per spawner rates for individual streams (Johnson et al. 1997), which can compound the error because the mis-allocated fish are included with some extremely small numbers of wild fish.

### 1.4.4.2 New Summer Chum Run Re-construction

As discussed above, the mis-allocation of early returning fish from the abundant fall chum runs in Hood Canal had potentially inflated the estimates of summer chum salmon run sizes. For this restoration planning effort, a different version of run-reconstruction was developed to try to remove most of the fall chum salmon catch from summer chum run sizes. Within Hood Canal, this was accomplished by using earlier cut-off dates for catches to be allocated to summer chum stocks: Areas 9A and 12 - September 27, Area 12A - October 5, and Areas 12B, 12C, 12D - September 30.

While this approach presumably reduces the mis-allocation of fall chum salmon, it also possibly omits the catches of later returning summer chum from the run-reconstruction. Because of this, the potential for small under- or over-estimation biases for summer chum salmon run sizes may still exist. Another feature of the current run-reconstruction is the inclusion of Washington recreational and Canadian Area 20 commercial catches, which provides a more complete view of total harvest impacts. Table 1.4 presents the run size estimates resulting from the new run-reconstruction, and a more detailed discussion and tables are provided in Appendix Report 1.3.

**Table 1.4.** Total runsizes for Hood Canal and the Strait of Juan de Fuca summer chum salmon stocks (1974-1998).

| Return year | Hood Canal runsize | St. Juan De Fuca runsize | HC/SJF combined |
|---|---:|---:|---:|
| 1974 | 14,222 | 1,985 | 16,207 |
| 1975 | 29,112 | 1,728 | 30,840 |
| 1976 | 74,218 | 1,673 | 75,891 |
| 1977 | 16,679 | 1,810 | 18,488 |
| 1978 | 25,336 | 3,240 | 28,576 |
| 1979 | 9,513 | 900 | 10,413 |
| 1980 | 13,018 | 5,574 | 18,592 |
| 1981 | 5,857 | 1,140 | 6,997 |
| 1982 | 8,302 | 3,543 | 11,845 |
| 1983 | 3,500 | 1,218 | 4,718 |
| 1984 | 3,365 | 1,708 | 5,073 |
| 1985 | 4,411 | 412 | 4,822 |
| 1986 | 7,832 | 1,217 | 9,049 |
| 1987 | 3,965 | 2,181 | 6,147 |
| 1988 | 5,696 | 4,128 | 9,825 |
| 1989 | 4,472 | 795 | 5,267 |
| 1990 | 1,556 | 529 | 2,085 |
| 1991 | 2,195 | 425 | 2,620 |
| 1992 | 3,375 | 1,394 | 4,769 |
| 1993 | 866 | 644 | 1,509 |
| 1994 | 2,951 | 214 | 3,165 |
| 1995 | 9,977 | 882 | 10,858 |
| 1996 | 21,097 | 1,106 | 22,202 |
| 1997 | 9,372 | 985 | 10,357 |
| 1998 | 4,162 | 1,303 | 5,466 |

## 1.4.5 Age Data

Summer chum salmon in the region mature and return to their spawning streams primarily as 3- and 4-year old fish, plus relatively minor numbers of 5-year fish. To calculate survival rates for chum salmon, the number of recruits (returning fish) that are produced by each year's spawning population must be determined. To accomplish this, it is necessary to measure the age composition for each year's return; to ascertain how many fish returned from the three parent years that make up each return (e.g. the 1998 returns will be made up of 3-, 4-, and 5-year old fish from spawning in 1993, 1994, and 1995). The numbers of fish in each age category are assigned to their parent spawning escapement, and the total brood return for each spawning year is determined.

Aging of returning chum salmon is typically accomplished by analyzing scales or otoliths collected from fish caught in fisheries operating specifically on the stocks to be aged. Hood Canal and the Strait of Juan de Fuca summer chum stocks have not historically been subjected to directed fisheries, which has limited access to harvested fish for sampling purposes. The majority of summer chum salmon scale samples collected in the past 20 years have come from fish caught during fisheries conducted for other salmon species, primarily coho salmon. Since these fisheries are dependent on the abundance, location, and timing of different species of salmon, opportunities to sample summer chum salmon are often sporadic and not representative of all populations. A complicating factor is that prior to the Boldt Decision of 1974, Hood Canal was a commercial fishing preserve and marine area net fisheries did not occur in this region for any salmon. The only summer chum salmon age data available prior to 1976 are from sampling at the UW Big Beef Creek weir, and those data are useful only for that specific population (now extirpated). The low numbers of returning fish, coupled in recent years with protective harvest regulations, has minimized the numbers of summer chum salmon caught in local fisheries, which has virtually eliminated the opportunity to sample scales in mixed stock fisheries at acceptable levels for age determinations. Age data are now being collected for fish returning to the National Fish Hatchery on the Big Quilcene River (see Appendix Table 1.2) and to the Salmon Creek weir, and some sporadic age data have been collected from spawners in various streams during stock identification sampling.

The available age data for the combined Hood Canal summer chum returns are summarized in Appendix Table 1.3. Only ten of 29 data base years (1968-1996) had sample sizes of greater than 100 fish (77-82, 85-87, and 92), and only six years had sample sizes in excess of 200 fish. No long term age data base exists for Strait of Juan de Fuca stocks because there have been no fishery sampling opportunities owing to the lack of directed fisheries on these fish. In recent years, age samples have been collected from a supplemented summer chum population in Discovery Bay (Salmon Creek). The incomplete nature of the available age data prohibits the development of meaningful total brood return information for Hood Canal or the Strait of Juan de Fuca summer chum salmon; either as individual or combined populations. The lack of useful brood data further translates into a lack of estimates of survival, e.g. recruit per spawner rates.

The available summer chum age data can provide a general estimate of the average age at return for Hood Canal summer chum salmon. From 1977 to 1982 the Hood Canal sample sizes ranged from 102 to 1,201 fish per year (Appendix Table 1.3). These ages are representative only of the combined Hood Canal summer chum return, and constitute too short a period to construct meaningful estimates of brood returns. Average age composition for this six year period was 43.3% age-3, 54.6% age-4, and 2.1% age-5 fish. Based on these age compositions, the average age at return for Hood Canal summer chum salmon would be 3.59 years. Four other years, 1985-1987 and 1992, had more than 100 fish sampled, which provide limited measures of return year age compositions. The average return age of 3.6 years for Hood Canal summer chum salmon is used for risk assessments in this recovery plan.

## 1.4.6 Use of Stock Assessment Data

The quality and quantity of the available stock assessment data for summer chum salmon varies for individual parameters. New data will be incorporated into this recovery plan as it becomes available. The following are summaries of the utility of the various types of summer chum stock assessment data.

### 1.4.6.1 Escapement and Runsize

Both escapement and runsize (run re-construction) databases have been reviewed and substantially improved to provide the best available information for use in recovery planning. The summer chum salmon recovery plan focuses on escapement and runsize information for the 1974 through 1998 return years. While these estimates can be improved through the collection of additional data, the summer chum escapement and runsize numbers over this range of years are thought to be of sufficient reliability to meet most of the needs of the recovery plan. The disqualification of the 1968 through 1973 years is based on the limited utility of both escapement and harvest data for those years as discussed above. These early years should not be totally discounted, however, because various spawner counts may provide a sense of the prior magnitude of summer chum salmon escapements in some streams (see Appendix Report 1.1).

### 1.4.6.2 Age Data and Productivity Estimates

Because of the multi-brood life history pattern of summer chum salmon, any direct measures of their productivity necessarily depends on the availability of reliable age data. The age data that have been previously collected are not of sufficient quality to meet this need. A point that must be emphasized is that because of the lack of useable age data, no estimates of summer chum productivity (brood return or survival rates) are used in this recovery plan. The collection of appropriate age data for deriving survival rates is a high priority of this plan and is imperative to measure progress toward recovery. The limited extant age data are considered only in a general manner in the recovery plan.

> ***"... because of the lack of useable age data, no estimates of summer chum productivity (brood return or survival rates) are used in this recovery plan."***

### 1.4.6.3 Population Structure and Genetics

Genetic stock identification data have been collected for all current summer chum salmon stocks except for Dungeness. As with all stock assessment data, the information from GSI analyses can be improved through the collection of additional genetic data. A significant short-coming is the lack of specific stock contribution information for various marine area fisheries, by time and location. There is also a lack of data relating to various biological traits, like age (discussed above), sex ratios, body size, etc.

# 1.5 Period of Decline

## 1.5.1 Introduction

The summer chum salmon populations of the Hood Canal and Strait of Juan de Fuca streams are affected by different environmental and harvest impacts, and display varying survival patterns and stock status trends. The summer chum stocks from both regions have dropped in abundance, but at different times and with different trends of abundance. While the rate and pattern of decline varies by individual population, all Hood Canal summer chum populations (except Union River) experienced a decline after 1978, and Strait of Juan de Fuca populations dropped in abundance ten years later.

## 1.5.2 Hood Canal

The escapement and overall abundance of summer chum salmon in Hood Canal have declined abruptly, beginning with the 1979 return year. In that year, the Hood Canal summer chum run dropped to a total return of 9,513 and an escapement of 6,554 spawners. Both of these numbers are substantially lower than the previous low values; 14,222 runsize in 1974 and 10,711 fish escaping in 1977 (see Tables 1.2 and 1.4). The 1979 return is made up predominately of 1976 brood age-3 fish (34.7%) and 1975 brood age-4 fish (61.1%)(see Appendix Table 1.3). This age composition falls within the expected range for summer chum salmon, and indicates that the low return in 1979 is not the result of a failure of just one of the two brood years. Parent year escapements are strong for the 1975 and 1976 broods (18,248 and 27,715 spawners respectively), and it seems probable that reduced survivals for both the 1975 and 1976 broods have contributed to the decline in the 1979 return.

The magnitude of the decline of Hood Canal summer chum can be demonstrated by examining average escapements and runsizes before and after the decline. Table 1.5 presents the five year average escapements and runsizes from 1974 through 1998. The average escapement of summer chum salmon for the 1979-1983 return years (3,238 spawners) represents a greater than five-fold drop from the average escapement of the previous five years (17,733 spawners). The decline continues through the 1980s and early 1990s, with five year average escapements dropping to a low of 978 spawners for the 1989-1993 period. The lowest single escapement was observed during this period, with only 429 spawners estimated in 1990 ( Table 1.2). Runsizes for Hood Canal stocks display a similar, but somewhat less abrupt rate of decline (Table 1.5). The fact that runsize drops coincident to escapement is evidence that a reduction in the production (total survival) rate has been a significant contributor to the decline.

One of the 12 summer chum salmon streams in Hood Canal, the Union River, does not follow the declining trend. Union River summer chum escapements are low prior to 1980, but then increase substantially and have apparently stabilized at escapement levels that are approximately 3 to 4 times pre-1979 levels (see Appendix Table 1.1).

**Table 1.5.** Five year average runsizes and escapements for Hood Canal summer chum stocks, 1974 to 1998.

| Return Years | Hood Canal runsize | Hood Canal escapement |
|---|---:|---:|
| 1974-78 | 31,913 | 17,733 |
| 1979-83 | 8,038 | 3,238 |
| 1984-88 | 5,054 | 1,760 |
| 1989-93 | 2,493 | 978 |
| 1994-98 | 9,512 | 9,078 |

## 1.5.3 Strait of Juan de Fuca

The drop in summer chum salmon escapements and runsizes for the stocks in the eastern Strait of Juan de Fuca, occurred in 1989, a decade after the decline in Hood Canal. Escapements dropped three-fold, from a 1984 to 1988 average of 1,716 spawners (Table 1.6), to only 388 spawners in 1989. Escapements stabilized at this low level, averaging 536 spawners for the 1989 through 1993 period. The streams of this region also experienced low escapements in 1979 (761 spawners), but in contrast to Hood Canal, Strait of Juan de Fuca summer chum escapements immediately rebounded in 1980 (5,109 spawners), and continued to be strong until the drop in 1989 (Table 1.2). As with Hood Canal stocks, the runsizes of Strait of Juan de Fuca summer chum stocks declined for the same return years as escapements (Table 1.6), indicating that an overall drop in total production was a major contributor to the observed decline.

**Table 1.6.** Five year average runsizes and escapements for Strait of Juan de Fuca summer chum stocks, 1974 to 1998.

| Return years | Strait of Juan de Fuca runsizes | Strait of Juan de Fuca escapements |
|---|---:|---:|
| 1974-78 | 2,087 | 1,883 |
| 1979-83 | 2,475 | 2,129 |
| 1984-88 | 1,929 | 1,716 |
| 1989-93 | 757 | 536 |
| 1994-98 | 898 | 867 |

## 1.6 Recent Abundance Trends

The abundance of the Hood Canal summer chum salmon has shown improvement for the 1995 through 1998 return years, and Strait of Juan de Fuca summer chum have experienced more modest increases during the same years (Table 1.2). In recognition of the critical status of Hood Canal summer chum, actions to protect returning spawners in terminal area fisheries were initiated in 1992, and continued through the present year. Supplementation programs on the Big Quilcene River, Lilliwaup River and Salmon Creek were begun in 1992, with the goal of rebuilding depressed summer chum stocks in those drainages. Projects were also begun in 1996 to reintroduce summer chum into Chimacum and Big Beef creeks where they had been extirpated. These actions are addressed in more detail in section 3.2 Artificial Production.

Affected at least in part by the above actions and programs, average total run size of Hood Canal summer chum in the most recent five years (1994-1998) is substantially higher than observed over the previous 14 years (Table 1.4), and the total escapements of Hood Canal summer chum during the most recent four years (1995 - 1998) are substantially higher than annual totals observed for the previous 14 years (Table 1.2). Hood Canal summer chum escapements have averaged 9,078 spawners over the last five years (2,423 - 20,514 range), which represents a substantial increase over the average escapement for the preceeding five years (Table 1.5). Escapements to Strait of Juan de Fuca streams have averaged 867 spawners for 1994 through 1998, a 62% increase over the 536 fish post-decline average (1989-1993) (Table 1.6). While the improvements in total run size and escapements for these summer chum stocks are encouraging, the time frame is short, and some individual populations are still experiencing very small escapements.

The estimated natural spawning summer chum escapement in 1995 was 10,301 (9,462 in Hood Canal tributaries and 839 in the Strait of Juan de Fuca tributaries). The 1995 escapement to the Big Quilcene was the highest observed in the 24 year database record to date (4,520 fish). Improved escapements over recent years were also noted on most of the streams entering the west side of Hood Canal, with 476 in the Hamma Hamma River, 825 in the Duckabush River, and 2,787 in the Dosewallips River. There were poor returns to the Lilliwaup River and Little Quilcene River (79 and 54 fish respectively). No fish were observed in the streams entering the east side of Hood Canal (Big Beef Creek, Dewatto River, Anderson Creek, and Tahuya River). The Union River had a good escapement of 721 fish. In the Strait of Juan De Fuca, Salmon Creek and Jimmycomelately Creek experienced fairly good escapements (591 and 223 fish respectively), but the Snow Creek escapement was again extremely poor (25 fish), continuing a trend.

The estimated natural spawning summer chum escapement in 1996 was 21,598 fish (20,514 in Hood Canal tributaries and 1,084 in the Strait of Juan de Fuca tributaries). The overall upward trend in escapement from recent years was primarily carried by the major streams entering the west side of Hood Canal. A new record chum escapement was observed in the Big Quilcene River (9,250 fish). However, this return originated from a mix of natural and hatchery produced fish, and it is assumed a significant portion of the spawners were progeny of the artificial production program. The Dosewallips River also had a record escapement of 6,976 chum, all of wild origin. The Hamma Hamma and Duckabush River had good returns also (774 and 2,650 fish respectively). On a down note, in this region Lilliwaup Creek had another poor escapement of 100 fish and the eastern Hood

Canal streams again showed no evidence of any significant returns. The Union River escapement was fair (494 fish). In the Strait of Juan De Fuca, Salmon Creek experienced a fairly good escapement of 785 fish (progeny of natural spawning and an on-going enhancement program), but Snow Creek and Jimmycomelately escapements were poor(160 and 30 fish respectively).

The estimated natural spawning summer chum escapement in 1997 was 9,933 fish (8,971 in Hood Canal tributaries and 962 in the Strait of Juan de Fuca tributaries), a declining trend from the previous two relatively strong years. Again, the majority of escapement occurred in the major streams entering the west side of Hood Canal. The Big Quilcene River again experienced a good spawning run (7,339 fish). As in 1996, this return originated from a mix of natural and enhancement program produced fish, and it is assumed a significant portion of the spawners were progeny of the artificial enhancement program. The Hamma Hamma, Dosewallips and Duckabush rivers had radical declines in spawner abundance from the previous two years (104, 47, and 475 fish respectively). Lilliwaup Creek and the Little Quilcene continued to be weak, with 26 and 29 natural spawners estimated respectively. The eastern Hood Canal streams again showed no evidence of any significant returns. Six fish were observed in the Dewatto, however. The Union River escapement was again fair (410 fish). In the Strait of Juan De Fuca, Salmon Creek experienced a fairly good escapement of 834 fish (progeny of natural spawning and an on-going enhancement program), but Snow Creek and Jimmycomelately escapements were again poor (67 and 61 fish respectively).

The estimated natural spawning summer chum escapement in 1998 was 5,290 fish (4,020 in Hood Canal tributaries and 1,270 in the Strait of Juan de Fuca tributaries), continuing a declining trend from the strong years in 1995 and 96. Again, the majority of escapement occurred in the major streams entering the west side of Hood Canal. The Big Quilcene River again experienced a good natural spawning run (2,244 fish). As in 1996 and 97, this return originated from a mix of natural and enhancement program produced fish, and it is assumed a significant portion of the spawners were progeny of the artificial enhancement program. The Hamma Hamma, Dosewallips and, Duckabush rivers had poor to fair spawner abundance (143, 336 and 226 fish respectively). Lilliwaup Creek continued to be weak, with 24 fish. The Little Quilcene River re-bounded a little, with a 265 fish escapement. The eastern Hood Canal streams again showed no evidence of any significant returns. However, twelve fish were observed in the Dewatto. The Union River's escapement was again fair, but down from last year (223 fish). In the Strait of Juan de Fuca, Salmon Creek experienced a good escapement of 1,144 fish (progeny of natural spawning and an on-going enhancement program), but the Snow Creek and Jimmycomelately 1998 escapements were again poor (28 and 98 fish respectively).

The 1989-93 period represents the years of lowest escapements, an average of only 1,514 total summer chum escaping to the region (Tables 1.5 and 1.6). By comparing the mean escapement of that five year period to the most recent five year mean escapement, a substantial improvement in escapements is apparent; increases of 928% in Hood Canal, 162% in the Strait of Juan de Fuca, and up 657% for the region as a whole. The results in Hood Canal have been enhanced by the strong returns to the supplementation program at Big Quilcene. However, if the Quilcene fish are removed from recent average escapements, the remaining Hood Canal streams averaged 793 spawners for 1989-93 and 3,416 spawners for 1994-98, a 431% increase. The improved escapements to wild production streams combined with the success of supplementation on selected streams has substantially lowered the extinction risk for this region. For descriptions of the recent performances of individual stocks, see the following stock evaluations.

# 1.7 Stock Evaluations

## 1.7.1 Introduction

The evaluation tools that will be used to identify summer chum stocks performing poorly and to measure the success of recovery measures are a major component of this recovery plan. Three approaches used to evaluate summer chum stocks are described in the following sections: 1.7.2 - Stock Definition and Status (SASSI), 1.7.3 - Annual Abundance Evaluation, and 1.7.4 - Stock Extinction Risk. These are independent assessment, each serving a separate purpose.

The first stock evaluation approach reviews and updates the summer chum stock definitions and status ratings originally reported in the 1992 Washington State Salmon and Steelhead Stock Inventory (WDF et al. 1993). This inventory, also known as SASSI, presents criteria for identifying stocks based on their degree of reproductive isolation, and rates the status of each stock into the general categories of healthy, depressed, critical, extinct, and unknown. For this recovery plan, the most recent information on historical and current summer chum salmon distribution and on the genetic profiles of the populations has been reviewed. This analysis has resulted in an updated list of 16 summer chum stocks, which form the basic population units used throughout this recovery plan. Status ratings for each stock are also presented, primarily for use in various other processes and evaluations that are based on the SASSI approach. This recovery plan does not directly use these SASSI status ratings, but instead relies on the more detailed status evaluations below; which specifically focus on annual escapement numbers and extinction risk for summer chum salmon.

> ***“This analysis has resulted in an updated list of 16 summer chum stocks, which form the basic population units used throughout this recovery plan.”***

The second evaluation approach compares spawner escapements to stock-specific critical abundance thresholds. This annual process reviews escapements, and identifies (flags) any stock that falls below its threshold. At the end of each season, all flagged stocks will undergo an in-depth review of stock performance, and possible causes of the low escapement will be identified. If necessary, remedial measures will be incorporated into recovery activities the following year.

The third procedure is used to estimate extinction risk based on the numbers of effective spawners representing each summer chum stock. This evaluation assesses extinction risk using an approach described in the paper Prioritizing Pacific Salmon Stocks for Conservation, by Allendorf et al. (1997). The approach focuses on the minimum numbers of spawners required to have a viable population, and estimates the risk of extinction for populations below the viability threshold. Other sources of risk are acknowledged (e.g. habitat loss and climate change), but no attempt has been made to incorporate these additional risks. While it is clear that salmonids are affected by an extensive range of risk factors, we do not have the data or the knowledge to conduct complete risk assessments for any of our summer chum populations. That does not mean, however, that we should not attempt to estimate risk, and minimum population size criteria (as recommended by Allendorf et al.) can serve to guide the conservation of summer chum stocks while the science of risk assessment develops.

## 1.7.2 Stock Definition and Status (SASSI)

The status of summer chum stocks in the Hood Canal region has been reevaluated as part of the development of this comprehensive recovery plan for the summer chum. The evaluation generally follows protocols established by the WDFW and Treaty Tribes in preparing the 1992 Salmon and Steelhead Stock Inventory (SASSI) (WDF et al. 1993). Newly available information has been reviewed in making the evaluation. Results of the evaluation include:

- A revised description of the summer chum stocks. Revisions are based on review of existing and new stock assessment data (including genetic stock identification data, and adult escapement and catch data). The description includes existing stocks, documents recent extinctions, and identifies possible former summer chum distributions based on limited available evidence.

- A revised description of the status of the stocks following the descriptive protocol of SASSI (e.g., healthy, depressed, critical or unknown status).

The SASSI process inventories naturally reproducing stocks of salmon and steelhead regardless of origin (including native, non-native, and mixed parentage). It is a two stage approach which first identifies individual stocks, and then determines their current status. The factors contributing to the current status of summer chum stocks are discussed in detail in Parts Two and Three.

**SASSI Stock Definition**

***The fish spawning in a particular lake or stream(s) at a particular season, which fish to a substantial degree do not interbreed with any group spawning in a different place, or in the same place at a different season.***

The primary criterion used to distinguish stocks is that there is evidence of substantial reproductive isolation, either temporally or spatially, that over time leads to local adaptation of individual stocks. While run timing and spawning distributions are the most common stock determinants, documented genetic differentiation is also evidence of reproductive isolation, and is also used to identify stocks.

In this stock assessment, the current status of each of the identified stocks has been rated primarily based on trends in survival rates or population size, but the process does not focus directly on possible future risks to the stocks or causative factors. Stocks with escapement, run-size, and survival levels within normal ranges given available habitat, and not displaying a pattern of chronically low abundance, are rated as healthy stocks. Those stocks that currently display low production or survival values are assigned to one of two separate rating categories: depressed stocks or critical stocks, depending on the current condition of the stock. Stocks are also rated as unknown stocks when data limitations do not allow assessments of current status.

**SASSI Status Definitions**

**Healthy Stock**: ***A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.***
**Depressed Stock**: ***A stock of fish whose production is below expected levels based on available habitat and natural variations in survival rates, but above the level where permanent damage to the stock is likely.***
**Critical Stock**: ***A stock of fish experiencing production levels that are so low that permanent damage to the stock is likely or has already occurred.***
**Unknown Stock**: ***There is insufficient information to rate stock status.***
**Extinct Stock:** ***A stock of fish that is no longer present in its original range, or as a distinct stock elsewhere. Individuals of the same species may be observed in very low numbers, consistent with straying from other stocks.***

The rating category for stocks in the extinct category is for stocks whose recent extinctions are documented in current stock assessment data bases. Past extinctions are not included because SASSI is a current resource inventory and the historic information on lost stocks is incomplete and often anecdotal. A more detailed discussion of the SASSI definitions is provided in the Appendix Report 1.4.

The following are individual stock discussions that review the stock definitions and status ratings for existing stocks, recently extinct stocks, and possible historic distributions of summer chum salmon in Hood Canal and the Strait of Juan de Fuca streams.

### 1.7.2.1 Existing Stocks

The 1993 salmon and steelhead inventory identified two summer chum salmon stocks in the streams of the eastern Strait of Juan de Fuca; a stock in Discovery Bay, and another stock in Sequim Bay. In Hood Canal, Union River was designated as a separate stock, and the summer chum salmon spawning in all other streams were designated as a single stock because of a lack of genetic data for individual spawning groups. At the time it was recognized that there may be more summer chum stocks in the region: "Preliminary results from ongoing genetic studies indicate that there may be more than two summer stocks in Hood Canal" (WDFW and WWTIT 1994). The following stock status ratings were assigned in the 1993 inventory to the four stocks: Hood Canal, critical; Union River, healthy; Discovery Bay, critical; and Sequim Bay, depressed.

Existing stocks are those stocks for which there is good information that they continue to exist and are likely to be sustainable. Spawner count data for each stream that currently supports summer chum salmon spawning have been reexamined for evidence of temporal or spacial overlap of spawning populations. There is strong temporal separation between summer and fall chum stocks in the region, with the exception of Big and Little Mission creeks which are an early fall stock (see discussion below). Because of the geographic separation of the majority of summer chum spawning streams, substantial spacial overlap of spawners is judged to be unlikely, except in Snow and Salmon creeks (Discovery Bay) and in Big and Little Quilcene creeks. Genetic differentiation has been examined for ten spawning populations using the results of a new Genetic Stock Identification (GSI) study. Most spawning populations have been found to display significant genetic differentiation (Table 1.7, see also Appendix Figures 1.1 and 1.2).

**Genetic Stock Identification (GSI)**

***A method that can be used to characterize populations of organisms based on the genetic profiles of individuals. The GSI process consists of a series of steps: 1) collect selected tissues from a representative sample of individuals from the population(s) under investigation; 2) develop genetic profiles for the individuals in each population by conducting starch-gel electrophoresis and histo-chemical staining using tissue extracts; 3) characterize each population by aggregating the individual genetic profiles and computing allele frequency distributions; and 4) conduct statistical tests using the allele counts characterizing each population to identify significantly different populations.***

Based on the standard of substantial reproductive isolation (indicated by distributional and genetic differences), nine existing summer chum stocks have been identified, three in Strait of Juan de Fuca streams and six in Hood Canal streams (Table 1.8). Details regarding the categories and status of the individual summer chum stocks are discussed below.

## Union River

**Stock Definition** - The Union River enters Lynch Cove at the far end of the hook in south Hood Canal and is relatively far removed from the other known populations of summer chum. Results of genetic analysis show the Union River population is significantly different from the other populations. Also, the summer chum of Union River show earlier run timing, measured by appearance in spawner surveys, than summer chum of other streams in the region. For all these reasons, the Union River is categorized as a separate native summer chum stock

**Stock Status -** The records show annual escapement estimates of 100 or less spawners during the 1970s (Appendix Table 1.1). Since that time, the estimates have been considerably higher most years, with the highest estimate being almost 1,900 spawners in 1986. The Union River is the only non-supplemented summer chum population that has increased since the 1970s.

**Origin and Type** - A **native** stock with **wild** production.
**Status - Healthy.**

**Table 1.7.** Results of log-likelihood G-tests (Sokal and Rohlf, 1981) between Hood Canal and Strait of Juan de Fuca summer chum salmon populations using only loci that were variable in at least one of the two collections in each comparison. N = sample size, NS = not significant (*P* > 0.05), * = 0.05 > *P* > 0.01, ** = 0.01 > *P* > 0.001, *** = *P* < 0.001.

| | | Population | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Population (years sampled) | N | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1) Snow Cr. ('86) | 50 | | | | | | | | | |
| 2) Salmon Cr. ('86,'97) | 150 | NS | | | | | | | | |
| 3) Jimmycomelately Cr. ('86) | 100 | ** | *** | | | | | | | |
| 4) Duckabush R. ('85,'86,'92) | 124 | *** | *** | *** | | | | | | |
| 5) Quilcene Bay/NFH ('97) | 58 | *** | *** | *** | * | | | | | |
| 6) Hamma Hamma R. ('85,'86,'94,'95,'97) | 101 | *** | *** | *** | NS | ** | | | | |
| 7) Quilcene Bay & R. ('92,'93,'94) | 262 | *** | *** | *** | *** | ** | NS | | | |
| 8) Union R. ('85,'86,'92,'93,'97) | 152 | *** | *** | *** | *** | *** | *** | *** | | |
| 9) Lilliwaup Cr. ('85,'86,'92,'93,'97) | 268 | *** | *** | *** | *** | *** | *** | *** | *** | |
| 10) Dosewallips R. ('86,'92) | 102 | ** | *** | *** | *** | *** | *** | *** | *** | *** |

## Lilliwaup Creek

**Stock Definition** - The native summer chum of Lilliwaup Creek are shown to be significantly different from other summer chum populations in Hood Canal based on analysis of genetic samples (Table 1.7). This genetic data and the geographic separation from the other populations lead to Lilliwaup being categorized as a separate stock.

**Stock Status** - Prior to 1979, estimated annual escapements have ranged from several hundred to over one thousand spawners. Since that time no single year's estimated escapement has exceeded 300 spawners and for the majority of years has been less than 100 spawners. The short-term severe decline after 1978, followed by chronically low escapements since, indicates the stock status is critical.

**Origin and Type** - A **native** stock with **wild** production.
**Status - Critical** based on chronically low escapements.

## Hamma Hamma

**Stock Definition** - Genetic analysis shows samples from native summer chum of the Hamma Hamma River to be significantly different from samples of other Hood Canal areas, except for Quilcene Bay/River (Table 1.7). The relatively large geographic distance between the Hamma Hamma River and Quilcene Bay (with both the Dosewallips and Duckabush rivers located in between) argues against the possibility of the Hamma Hamma and the Quilcene Bay populations being a single stock.

**Stock Status** - Before 1980, the Hamma Hamma River has had annual escapements in the 1,000s (Appendix Table 1.1). Beginning in 1980, the numbers have declined to the 100s per year. During the 1990s, the annual numbers of estimated spawners have fluctuated from below 100 to several hundred. The most recent 5 years of escapements have averaged less than 10% of the escapements of the 1970s, and this stock is considered to be depressed.

**Origin and Type** - A **native** stock with **wild** production.
**Status - Depressed** due to chronically low escapements.

### Duckabush

**Stock Definition** - An examination of genetic information for the native Duckabush summer chum stock indicates it is significantly different from other Hood Canal summer chum populations except for the Hamma Hamma (Table 1.7). The finding of no significant difference does not necessarily mean these two populations are of the same stock. There may be significant differences not detectable at the loci examined. Genetic results tend to be more definitive in confirming differences between samples (e.g., the finding of a significant difference based on results showing 95% probability that the samples are not from the same randomly sampled population), as opposed to indicating they are from the same population. If no difference is indicated by these analyses, it is not necessarily appropriate to assume the tested groups are from the same population. It is only an indication that they might be from the same population. In these cases, other factors are also considered in making a determination of whether or not the two sampled groups are of the same stock. In the case of Duckabush, geographic distance between the Duckabush and the Hamma Hamma, and between the Duckabush and other summer chum populations, appears sufficient to categorize Duckabush as a separate stock. The geographic differences between the Duckabush and other summer chum streams appear sufficient when comparisons are made with geographic distances between other stocks identified as significantly different by genetic analysis (e.g., between the Dosewallips and the Big Quilcene/Little Quilcene stocks).

**Stock Status** - The record of escapement estimates (Appendix Table 1.1) shows the Duckabush falling from escapements in the thousands during the 1970s to less than one hundred spawners in the late 1980s. In the 1990s, the escapement estimates have increased into the low hundreds of spawners, but are still substantially less than what has been estimated for the 1970s.

**Origin and Type** - A **native** stock with **wild** production.
**Status** - **Depressed** due to chronically low escapements.

### Dosewallips

**Stock Definition** - Analysis of genetic sampling data shows Dosewallips to be significantly different from other Hood Canal summer chum populations, including the two most proximal populations on the west side of Hood Canal; that is, Quilcene to the north and Duckabush to the south (Table 1.7). Dosewallips is categorized as a separate native stock for this reason and because of the geographic separation from these other populations..

**Stock Status** - Escapement estimates for Dosewallips (Appendix Table 1.1) have decreased in the 1980s to less than 100 spawners in some years and several hundred in other years. During the 1970s, most escapements are over 1,000 spawners, extending up to over 3,000. Escapements appear to be rebounding in the 1990s with the highest escapement on record of almost 7,000 spawners in 1996. However, the 1997 escapement is only 47 spawners, lower than expected given the apparent increasing trend. This one year's severely low escapement could be an aberration in the pattern of recovery. Resolution of what is happening with this stock should be forthcoming as escapements continue to be monitored.

**Origin and Type** - A **native** stock with **wild** production.
**Status** - **Depressed** due to chronically low escapements.

### Big Quilcene/Little Quilcene

**Stock Definition** - The Big Quilcene and Little Quilcene rivers enter salt water close to each other at the extreme northern end of Quilcene Bay. No genetic analysis of the spawning population in the Little Quilcene River has been conducted. Only the bay and Big Quilcene River have been adequately sampled, and the bay genetic samples may have included native chum from Little Quilcene as well as Big Quilcene river - the only two summer chum streams in the bay. No assessment of potential genetic differences between populations of the two streams is possible with the current data. Because of the close proximity of the two streams and the likelihood of mixing of spawners, Big and Little Quilcene summer chum salmon are designated as a single native stock.

**Stock Status** - While estimated escapements initially drop beginning in 1979, an even more substantial drop occurs in both Big Quilcene and Little Quilcene rivers during the middle 1980s (Appendix Table 1.1). By the early 1990s, escapement estimates are in single digits in both streams. The numbers of spawners subsequently improve in the Big Quilcene River probably due at least in part to harvest management protection measures. The Big Quilcene River population substantially rebounds beginning in 1995 as a result of the supplementation project begun in 1992. The escapement levels remain extremely low from 1989 through 1994 in the Little Quilcene River, with a high annual estimate of 12 spawners and with estimates of one or no spawners in four of these years. More recently the escapement numbers in the Little Quilcene River have begun to rise, but are still low compared to the historical numbers.

The recent escapement numbers for this stock are high relative to documented historical numbers, but 1) because these high numbers likely are primarily the result of supplementation releases rather than natural production and 2) because the Little Quilcene River escapements are still low, and finally 3), because habitat conditions are poor and may constrain natural production in both rivers, the status of the stock is judged to be depressed.

**Origin and Type** - A **native** stock with **composite** production.
**Status - Depressed**.

### Snow/Salmon

**Stock Definition** - Salmon and Snow creeks are located at the northern end of Discovery Bay on the Strait of Juan de Fuca. The mouths of the creeks are close to each other and at one time Snow Creek flowed into Salmon Creek before it entered the bay. The streams were separated by a man-made diversion early in the twentieth century. Results of genetic sampling (log-likelihood G-tests) from analysis of summer chum protein samples (Table 1.7), do not show a significant difference between Snow and Salmon creeks. The close proximity of the two streams, the absence of an indicated difference from the genetic sampling results, and the streams' geographic history support categorizing the Snow Creek and Salmon Creek populations as a single native stock.

**Stock Status** - The historical escapement record (Appendix Table 1.1) shows Salmon Creek to be fairly stable over the last nine years and within the approximate historical range. On the other hand, Snow creek escapements have dropped to extremely low levels in the late 1980s and early 1990s, with 33 or fewer spawners per year from 1989 through 1995. In each of the last two years (1996 and 1997), escapements of approximately 150 spawners have been estimated for Snow Creek, perhaps due at least in part to spawners returning from the Salmon Creek supplementation project (summer chum fry are released from net pens in the bay). The escapement data suggest that the stock is fairly stable, at least in Salmon Creek and may be beginning to recover in Snow Creek. However, the returns to Snow Creek are far below the historical escapement estimates (Appendix Table 1.1).

**Origin and Type** - A **native** stock with **composite** production.
**Status** - **Depressed** due to chronically low escapements.

### Jimmycomelately

**Stock Definition** - Genetic analysis indicates that summer chum of Jimmycomelately Creek are significantly different from the Snow/Salmon summer chum stock (Table 1.7). Jimmycomelately Creek is located in a separate bay where no other summer chum populations are known to have existed. The geographic isolation and genetic results support categorizing Jimmycomelately as a separate native stock.

**Stock Status** - The record of escapement estimates (Appendix Table 1.1) shows Jimmycomelately to have escapements fluctuating from several hundred to 1,000 in the 1980s, with only one year below 100 total spawners. However, in the 1990s, the escapement numbers have generally dropped with three of the last five years (1994-1998) having escapement estimates of 61 or less.

**Origin and Type** - A **native** stock with **wild** production.
**Status** - **Critical** based a short term severe decline in escapements.

### Dungeness

**Stock Definition** - Summer chum have been periodically observed during the months of September and October in the Dungeness River in the course of monitoring and collecting chinook and pink salmon data. No escapement estimates for Dungeness summer chum have been made but indications are that a modest sized, self-sustaining run is present in the system. The Dungeness River appears sufficiently separated geographically from the closest known population of summer chum (Jimmycomelately in Sequim Bay) to be categorized as a separate native stock. For a more detailed discussion of the evidence of summer chum salmon in the Dungeness River, see Appendix Report 1.1 and Plan Supplemental Report No. 1 (Haymes 2000).

**Stock Status** - Spawning ground survey effort in the Dungeness in September and October is focused on chinook and pink (odd-years only) salmon. Summer-timed chum salmon are consistently seen during surveys of the lower Dungeness River mainstem. The highest count representing summer chum salmon is 199 fish observed in the lower 3.2 miles of the river on September 22, 1976. Survey conditions are typically rated as poor to fair during these surveys and the emphasis on other species sometimes results in incomplete coverage of potential summer chum holding and spawning areas. Since 1987, however, summer-timed chum salmon have been observed in the Dungeness River every year, with partial peak counts ranging between 1 and 60 fish. The incomplete nature of the existing count data prohibits the development of total escapement estimates, however, the data do indicate the presence of a small self-sustaining stock of unknown status. A high priority should be placed on additional spawning ground surveys on the lower Dungeness River during the months of September and October to determine the status of summer chum salmon.

**Origin and Type** - A **native** stock with **wild** production.
**Status - Unknown**.

### 1.7.2.2 Recently Extinct Stocks

Known, recently extinct stocks are those stocks where there is strong evidence to show that a stock formerly existed but has now been extirpated from its former stream. Of the 16 stocks identified (Table 1.8), seven are recent extinctions. The determination that these were distinct stocks is based solely on past distribution and presumed past reproductive isolation. Four of the seven extinctions occurred in Kitsap Peninsula streams.

#### Big Beef

**Stock Definition** - Geographic distance from other stocks is the basis for separating this recently extinct native stock.

**Stock Status** - The record (Appendix Table 1.1) shows Big Beef escapement estimates exceeding 1,000 spawners in 1975 and 1976, though in most years immediately before and after, the escapements appear far less and generally in the low hundreds. Summer chum all but disappear after 1981 and except for an estimated 22 spawners in 1984, zero spawners have been estimated in all years since.

**Origin and Type** - A **native** stock with **wild** production.
**Status - Extinct.**

#### Anderson

**Stock Definition** - Geographic distance from other stocks is the basis for separating this recently extinct native stock.

**Stock Status** - Estimated escapements for Anderson Creek (Appendix Table 1.1) show a small population of just over 200 spawners occurring in the 1970s. That population does not appear to have been stable, with estimates of 0 and 16 spawners during 1974 and 1978 respectively. Estimated escapement drops to zero in the early 1980s and the stock has ceased to exist.

**Origin and Type** - A **native** stock with **wild** production.
**Status - Extinct.**

### Dewatto

**Stock Definition** - Geographic distance from other stocks is the basis for separating this recently extinct native stock.

**Stock Status** - Estimated escapements for the Dewatto River (Appendix Table 1.1) show a gradual reduction of spawners over time, from escapements of more than a thousand in the early 1970s, to hundreds in the later 1970s, to less than 100 in the 1980s, and finally, to zero or near zero in the 1990s.

**Origin and Type** - A **native** stock with **wild** production.
**Status - Extinct.**

### Tahuya

**Stock Definition** - Geographic distance from other stocks is the basis for separating this recently extinct native stock.

**Stock Status** - The record (Appendix Table 1.1) shows escapements of Tahuya River summer chum spawners have dropped from estimates ranging between the high hundreds and thousands during the 1970s, down to below two hundred during the 1980s. Beginning in the early 1990s, the estimates have been essentially zero.

**Origin and Type** - A **native** stock with **wild** production.
**Status - Extinct.**

### Skokomish River

**Stock Definition** - No escapement estimates exist for the Skokomish River. Spawner surveys generally have not been specifically directed at native summer chum in this river system until recently. However, surveys for other species, notably chinook, would be expected to have reported any observations of summer chum and, in fact, reports of summer chum in late September and in early to mid October do exist in the historical spawner survey record. The tribal fishery catches recorded for the Skokomish River are within the expected time frame for the summer run (i.e., prior to October 15); however, in recent years the numbers have been very low. Currently, only small, occasional numbers of summer chum, and not a sustainable population, are believed to occur in the Skokomish River.

**Stock Status -** A number of factors have likely contributed to the demise of summer chum. Summer chum habitat has been severely degraded by human developments in the Skokomish River watershed. The summer chum population may also have been impacted by local commercial fisheries, though the fisheries have been primarily directed at other species. Even though documentation of summer chum occurrence in the Skokomish River is sparse, the size of the river, and likelihood that natural habitat conditions would have supported summer chum, leads to the conclusion that summer chum have been eradicated as a result of human activities. It appears reasonable that a population of summer chum in the Skokomish River would have been a separate stock, at least based on geographic separation from other stocks. The Skokomish is therefore judged to be a recently extinct stock.

**Origin and Type** - A **native** stock with **wild** production.
**Status - Extinct.**

### Finch Creek

**Stock Definition -** Geographic distance from other stocks is the basis for separating this recently extinct native stock.

**Stock Status** - The Hoodsport Salmon Hatchery began trapping chum salmon at Finch Creek in 1953. Rack counts show a bimodal chum run in the creek during the 1950s and 1960s, with the first peak occurring in early October. Since this timing is consistent with summer chum spawning, it is reasonable to conclude that Finch Creek supported a modest summer chum run. By 1970, this summer spawning stock had been extirpated in Finch Creek.

**Origin and Type** - A **native** stock with **wild** production.
**Status - Extinct.**

### Chimacum

**Stock Definition -** Geographic distance from other stocks is the basis for identifying this recently extinct native population as a separate stock.

**Stock Status -** No escapement estimates exist for Chimacum Creek and few spawner surveys by WDFW or tribal staffs have occurred until recent years; however, several surveys that have been made during early October in the middle 1970s and early 1980s have reported small numbers of summer chum. Summer chum surveys also have been made in the 1970s as part of a local high school project sponsored by teacher Ray Lowrie. Summer chum counts of over 100 have been made in several years but there are no escapement estimates (Ray Lowrie, pers. comm.) The summer chum run disappeared by the middle 1980s. The run's demise is believed due to a combination of habitat degradation and poaching.

**Origin and Type** - A **native** stock with **wild** production.
**Status - Extinct.**

**Table 1.8.** Summary of Hood Canal and the Strait of Juan de Fuca summer chum salmon stocks, including existing and recently extinct stocks and stock origin

| Stock | Status | Origin |
|---|---|---|
| Big Beef | Extinct | Native |
| Anderson | Extinct | Native |
| Dewatto | Extinct | Native |
| Tahuya | Extinct | Native |
| Union | Healthy | Native |
| Skokomish | Extinct | Native |
| Finch | Extinct | Native |
| Lilliwaup | Critical | Native |
| Hamma Hamma | Depressed | Native |
| Duckabush | Depressed | Native |
| Dosewallips | Depressed | Native |
| Big/Little Quilcene | Depressed | Native |
| Chimacum | Extinct | Native |
| Snow/Salmon | Depressed | Native |
| Jimmycomelately | Critical | Native |
| Dungeness | Unknown | Native |

### 1.7.2.3 Possible Additional Historic Distributions

A “possible historic distribution” category is used for groups of fish where there is some evidence of former summer chum occurrence in a stream but the evidence is insufficient to determine whether or not there was a distinct stock. A distinction is made here between stock and historic distribution, where a stock is defined under SASSI as being (or formerly has been) self-sustaining and reproductively isolated from other stocks based on available evidence.

The determinations of existing and extinct stocks have been made based upon relatively strong evidence that the stocks either currently exist or previously had existed. It is likely that summer chum were historically distributed among additional streams within the region. For several streams, relatively recent evidence indicates that summer chum were historically present. However, this evidence is fragmentary and judged insufficient to identify stocks. For example, one survey in Eagle Creek on September 25, 1952, reports a total of 112 chum counted in the lower 0.7 mile of the stream. Escapement surveys during the summer chum spawning period were not conducted again in Eagle Creek until 1978. Since 1978, numerous surveys during September and October have found no evidence of a summer chum salmon population.

Another example is Stavis Creek, where a survey count of 45 live and 30 dead chum salmon was made October 18, 1972. Were these fish (at least a portion of them) summer chum, or early returns of the fall run? In the same stream, over several later years (1977, 1981, 1983), a few summer chum (counts of four or less) were observed in late September and early October. It is not known whether these fish represent the last of a summer population that formerly existed, are strays from another stream, or possibly are early returns of fall run fish. Similar kinds of observation also exist for Little

Lilliwaup and Fulton creeks in Hood Canal, and Morse and Johnson creeks in the Strait of Juan de Fuca.

The identification of the above streams as possibly being part of the historic distribution of summer chum salmon is based on limited information that happened to be collected for these streams. Other streams that were not surveyed may also have supported summer chum at one time; e.g. Seabeck Creek. Absent the evidence, the specific possible historic distributions noted here, as well as any additional distributions that might be suggested for other streams, must fall into the category of unknown, but possible, former occurrences of summer chum salmon. The assessment of the historic use of these streams by summer chum salmon could change as more information becomes available.

The question of summer chum having existed in Big and Little Mission creeks has been reexamined during this process. In both streams, and particularly in Big Mission Creek, chum salmon have been observed in early to mid October and even in late September. The numbers in Big Mission appear relatively large with counts in the tens and even over one hundred by mid October in some years. However, a fairly large "early fall run" (as categorized by WDFW) exists in these two streams, with peak spawner abundance typically observed in early November. The annual survey counts of live chum typically rise steadily over the course of the season from the initial observations of fish entry in late September to mid-October, until the early November peak spawning activity period. There is no "bi-modality" in the survey counts through time that would indicate the possible existence of a discrete "summer timed" spawning population in these streams prior to the November peak timed spawning population. Genetic sampling indicates these populations are most closely associated with Hood Canal fall chum stocks.

## 1.7.3 Annual Abundance Evaluation

Annual abundance evaluations will be performed for both management units and stocks. Management units are made up of one or more stocks that are aggregated in recognition of practical and biological limitations to available data and how fisheries can be effectively managed (see section 3.5.2). In the case of HC-SJF summer chum, all of the management units contain only one stock except the Mainstem Hood Canal Management Unit.

Critical status[1] thresholds are defined for management units, for both total run size and spawning escapement, and critical status flags are defined for the stocks within the Mainstem Management Unit (Tables 1.9 and 1.10) below which additional actions will be taken as necessary (see sections 3.6.1 and 3.5.6.2). A description of the derivation of these thresholds is included in Appendix Report 1.5.

### 1.7.3.1 Management Units

---

[1] Note that "critical status" in the context of annual abundance evaluation is a different definition and application (as described) than the definition and application for SASSI stocks shown in section 1.7.2.

Numerical abundance and escapement thresholds have been derived for each management unit against which the post-season estimates of run size and escapement and the pre-season forecast parameters will be compared in annually assessing plan performance (Table 1.9). A management unit is considered to be in critical status when its abundance or escapement in the most recent past return year is less, or its forecast run size for the coming return year (or that of one of the parental broods) is projected to be less than the appropriate threshold value.

**Table 1.9.** Critical Thresholds for Hood Canal and Strait of Juan de Fuca Management Units.

| Management Units | Contributing Stocks | Critical Escapement Thresholds | Critical Runsize Thresholds |
|---|---|---|---|
| **Sequim Bay** | Jimmycomelately | 200 | 220 |
| **Discovery Bay** | Snow/Salmon | 850 | 930 |
| **Mainstem Hood Canal (Hood Canal Bridge to Ayres Point)** | Lilliwaup<br>Hamma Hamma<br>Duckabush<br>Dosewallips | | |
| | Total | 2,660 | 3,980 |
| **Quilcene/Dabob Bays** | Big/Little Quilcene | 1,110 | 1,260 |
| **SE Hood Canal** | Union | 300 | 340 |
| **Total** | | **4,750** | **5,400** |

## 1.7.3.2 Status of the Mainstem Hood Canal Management Unit

Escapement Distribution and Minimum Escapements Flags for each of the stocks within the Mainstem Management Unit have been derived which are designed to protect the population structure within this management unit (Table 1.10). The Escapement Distribution Flags (EDF) are mean historical threshold proportions of the Mainstem escapement, attributed to each of the contributing stocks. The Minimum Escapement Flags (MEF) have been calculated by multiplying the Critical Escapement Threshold for the Mainstem Management Unit by the EDF for each of the stocks. These flags are useful benchmarks to check for poor performance of any one stock's escapement based on historical distribution of stock escapements within the Mainstem Management Unit. This is necessary for years when the overall management unit abundance is sufficiently high that the Critical Abundance Threshold would not be triggered but escapement of one or more individual stocks may be extremely low. If a given stock's proportion of the Mainstem Management Unit escapement or the stock's actual estimated escapement fall below the values in Table 1.10, a review of the stock's status will be conducted. The conclusions from the review will be documented and its recommended actions will be implemented as described in section 3.6.1. An example of how the Mainstem Management Unit threshold and escapement flags function when they are applied to abundances of past years is shown in Appendix Report 1.5.

**Table 1.10.** Critical Status Flags for stocks making up the Mainstem Hood Canal Management Unit.

| | Escapement Distribution | | | |
|---|---|---|---|---|
| | **Mean Proportion of MU total** | **1 Standard Deviation** | **Distribution *Flag* (Mean-1 SD)** | **Min. Escape. *Flag*** |
| Dosewallips | 0.277 | 0.130 | 0.147 | 736 |
| Duckabush | 0.263 | 0.083 | 0.180 | 700 |
| Hamma Hamma | 0.392 | 0.199 | 0.193 | 1,042 |
| Lilliwaup | 0.069 | 0.026 | 0.043 | 182 |

## 1.7.4 Stock Extinction Risk

### 1.7.4.1 Introduction

The level of extinction risk of summer chum populations (assuming no intervention) can be a primary factor for determining priorities for recovery planning. Unfortunately, there is not consensus on how to conduct a risk assessment, or on an easy way to calculate a threshold abundance level that should trigger certain levels of recovery effort. Ideally, a risk assessment would consider all factors that potentially could lead to the loss of a stock or a group of stocks. For example, a recent paper by Lee and Rieman (1997) lists eleven different factors used to develop a viability assessment procedure. These are: number of eggs per adult female, spawning and incubating success, fry survival at low density, asymptotic parr capacity, juvenile survival, adult survival rate, age at maturity, coefficient of variation in fry survival, mean immigrants per generation, initial number of adult females, and expected time between catastrophes. Most of these factors have not been quantified for summer chum salmon, or most other wild salmon populations. Given the lack of consensus on levels for extinction risk, many assessment approaches use a judgement on whether or not the population is likely to recover without intervention. This has been the approach used by NMFS in the chum status review (Johnson et al.1997).

A threshold number for extinction risk has been presented by Nehlsen et al. (1991). They consider a population under 200 (or if abundance has declined and is continuing to decline) to be at high risk of extinction. NMFS, in the chum status review, does not present any specific threshold numbers, but relies on abundance trends and abundance relative to historical levels. Allendorf and Ryman (1987) recommend that at least 100 of each sex be used to maintain a hatchery strain (again, a 200 fish value).

Two measurements of population size that are used to consider extinction risk are total population size *(N)* and effective population size ($N_e$). Total population size is the number of spawners cumulated over a number of years equivalent to one generation (3.6 years for summer chum salmon). The effective population size is a lower value that provides an estimate of the number of spawners that represent successful reproduction and considers such factors as; sex ratios, prespawning mortality, fertility rates, etc. Effective population size is equivalent to the total population size times a factor representing the ratio between effective *($N_e$)* and total *($N$)* population size. There has been much discussion about the relationship of the total population size to the realized effective population size ($N_e/N$). Pacific salmon effective population size has been variously estimated to be from 10% to 25% of total population size. Allendorf et al. (1997) assume a $N_e/N$ value of 20% for wild Pacific salmon populations, based on the authors' personal communications with Robin Waples (NMFS).

**Measurements of Population Size**

**Total population Size (*N*)**: ***The total population size for summer chum can be calculated; N = Average escapement times 3.6 (generation length), where 3.6 is the average age of Hood Canal summer chum salmon.***
**Effective Population Size ($N_e$)*:*** ***The effective population size per generation is equivalent to the effective number of breeders per year times the generation length (from Waples 1990). This can be calculated;*** $N_e$ ***= Average escapement times 3.6 (generation length) times 0.2*** **($N_e/N$).**

Effective population values of 50 and 500 fish have been suggested as threshold criteria for extinction risk. Allendorf and Ryman (1987) report that less than 1 % of the genetic variation is lost each generation if $N_e$ is greater than 50. That is because the rate of loss of genetic variation is equal to the inverse of 2 times $N_e$. It has also been suggested that the long-term adaptive potential of an isolated population (without migration into it) is conserved when $N_e$ is on the order of 500 individuals (FAO - UN 1981, Nelson and Soule 1987).

Allendorf et al. (1997) present a set of procedures for rating extinction risk and for providing an estimation of the possible consequences of extinction for Pacific salmon stocks. The methods for estimating extinction risk use either population viability analysis (PVA) or a set of surrogate measures that include current population size parameters and population trends. Allendorf et al. (1997) have also looked at the consequences of extinction on a genetic and evolutionary basis, and have considered potential loss of adaptive genetic diversity and ecological function.

The following risk assessment for summer chum stocks uses the procedures for measuring extinction risk as presented by Allendorf et al. (1997). It is recognized by the co-managers that this methodology does not include all potential risk factors (as discussed in Wainwright and Waples 1998), however, the use of both minimum population size and population trend criteria does provide a basis for ranking extinction risk. From a practical point of view, much of the information needed to assess additional sources of extinction risk is either not available or is subject to a variety of interpretations. For example, if the amount or quality of available habitat has been severely impacted, this could impose a limitation on one or more life stages and increase risks of extinction. The process for prioritizing the consequences of extinction from Allendorf et al. (1997) has not been used in this recovery plan because the co-managers consider avoidance of extinction to be of equal priority for all summer chum stocks.

The co-managers will periodically review summer chum salmon extinction risk, because these risks can change over time as a consequence of actions taken under this plan, or because of natural or unanticipated variations in survivals.

## 1.7.4.2 Assessing Risk

The methods provided by Allendorf et al. (1997) to assess extinction risk, result in the ranking of individual stocks into one of four categories; very high, high, moderate, and special concern (Table 1.11). They present specific definitions of various measures of population size and decline that are summarized below, and are used in the summer chum risk assessment. For the purposes of this assessment, a "low" category has been added for defining stocks that do not fit any of the above categories and are not at risk of extinction.

### Population Viability Analysis

While the risk of extinction can potentially be determined by a quantitative population viability analysis such as those described by Emlen 1995 or Ratner et al. 1997 for chinook salmon, the data do not exist to conduct this type analysis for summer chum salmon. For a detailed discussion of the use of PVA and the quantitative criteria used below, see Allendorf et al. (1997).

### Population Size Criteria

Allendorf et al. (1997) offer several precautions for the use of salmon spawner census numbers. First, that $N$ represents spawning fish, not total run size, and is not an annual escapement value but is calculated by multiplying annual escapement by generation length. Second, the population numbers should account for any contribution to spawning by precocious males (not generally applicable for chum salmon). Finally, if only census numbers are available to rank extinction risk, either $N_e$ or $N$ can be used, but not both.

### Population Decline Criteria

Each of the following criteria represent a specific risk category (see Table 1.11).

> ***Precipitous Decline*** *- A stock that has undergone recent decline (within the last two generations) to annual escapements below 500 fish, and has a recruit/spawner ratio of less than one. Historically small but stable stocks are not included in this category.*
>
> ***Chronic Decline or Depression*** *- A stock whose annual escapements are at or below 500 fish and appears to be stable, but has previously declined more than can be accounted for by known variation.*
>
> ***Decline Apparent or Probable*** *- A stock whose annual escapements have not reached the above thresholds, but, after allowing for known variation, appear to be declining at about 10% to 20% per year over the last 2 to 4 generations.*

***Order of Magnitude Decline Within One Generation*** *- A stock whose escapement numbers are reduced quickly and dramatically (by catastrophic event or disturbance) by an order of magnitude in a single generation (i.e., a 90% decline).*

***Smaller But Significant Decline*** *- A stock that suffers a lesser but significant reduction in escapements due to a single event or disturbance.*

**Table 1.11.** Criteria for assessing the level of risk of extinction for Pacific salmonid stocks (from Allendorf et al. 1997).

| | *Risk of extinction* | | | |
|---|---|---|---|---|
| *Risk of extinction criteria* | *Very high* | *High* | *Moderate* | *Special Concern* |
| Probability using population viability analysis | 50% within 5 years | 20% within 20 years | 5% within 100 years | Historically present, believed or known to still exist but no current data |
| | -- OR --<br>any **TWO** of the following criteria | -- OR --<br>**ONE** very high risk criterion<br>-- OR --<br>any **TWO** of the following | -- OR --<br>**ONE** high risk criterion<br>-- OR -- | Not applicable |
| Effective population size per generation | $N_e$ 50 or less<br>-- OR -- | $N_e$ less than 500<br>-- OR -- | Not applicable | Not applicable |
| Total population size per generation | $N$ 250 or less | $N$ less than 2500 | Not applicable | Not applicable |
| Population decline | Precipitous decline | Chronic decline or depression | Decline apparent or probable | Not applicable |
| Catastrophe, rate and effect | Order of magnitude decline w/in one generation | Smaller but significant decline | Not applicable, stocks rate at least high risk | Not applicable |

## Risk Assessment

The following risk assessments are based on the criteria described above in Table 1.11, and the results of the risk assessments are summarized in Table 1.12.

### *Union River*

Estimated escapements to the Union River show no declining trend over the period of record and, in fact, appear to have increased somewhat since the 1970s. This population has shown more stability than any other stock in the region. This is not to say that the size of the population has not been larger prior to the period of record; the river may have been impacted by human developments affecting habitat conditions in the earlier part of the twentieth century or even in the latter part of the previous century, and consequently run sizes have been reduced. Escapements over the last four years have ranged from 223 to 721, averaging 462 spawners. The effective population size *($N_e$)* equals 333 for the 1995-98 return years, and total population size *($N$)* is 1,667 fish for the same years

(Table 1.12). This stock meets only one high risk criterion (population size), and the risk of extinction is rated as moderate.

### *Lilliwaup Creek*

Estimated escapements to Lilliwaup Creek range from 4 to 79 over the last four years, averaging only 33 spawners. This is 3.5% of the annual average 937 spawners estimated for the years 1974 through 1978 (i.e., from the first year of relatively reliable estimates to the year before the general summer chum escapement decline in Hood Canal; see Part Two - Region-wide Factors for Decline). The effective population size *($N_e$)* equals only 24 fish for the 1995-98 return years, and total population size *(N)* is 120 for the same years (Table 1.12). Because the population meets one very high risk criterion (low population size) and is in a chronic decline situation, the risk of extinction is judged to be high.

### *Hamma Hamma River*

The annual average estimated Hamma Hamma system escapement over the past four years is 374, ranging from 104 to 774 spawners. The wide range of escapements extending back to the mid 1980s, and dipping to less than 100 spawners in some years, raises questions about the stability of the population, however, average escapement has increased in recent years. The average of 374 spawners is 7% of the 1974 through 1978 average of 5,465 spawners. The effective population size *($N_e$)* equals 269 fish for the 1995-98 return years, and total population size *(N)* is 1,347 for the same years (Table 1.12). Because the population meets one high risk criterion (population size) and is currently increasing, the risk of extinction is judged to be moderate.

### *Duckabush River*

The estimated escapement in the Duckabush River ranges from 226 to 2,650 over the last four years, averaging 1,044 spawners. This average is 32 % of the 1974 through 1978 annual average of 3,254 spawners. The effective population size *($N_e$)* equals 752 fish for the 1995-98 return years, and total population size *(N)* is 3,758 for the same years (Table 1.12). Though escapements have declined substantially since the 1970s, the current escapement levels appear to be relatively stable and this stock exceeds the population size criteria, indicating that the risk of extinction is low.

### *Dosewallips River*

The 1974 through 1978 annual average escapement is 2,846 spawners, ranging from 1,901 to 3,593. The escapement numbers decrease substantially during the 1980s, dropping below 200 spawners in five of ten years. However, since the early 1990s, the numbers have rebounded and, over the last four years, escapement estimates have ranged from 47 to 6,976, averaging 2,537 spawners (89% of the 1974 through 1978 annual average). The estimate of 47 spawners in 1997 is a cause for concern, but this may be an aberrant year within the recovery period. The effective population size *($N_e$)* equals 1,827 fish for the 1995-98 return years, and total population size *(N)* is 9,133 for the same years (Table 1.12). Because escapements have increased substantially in recent years and exceed the population size risk criteria, the risk of extinction is judged to be low.

### *Big/Little Quilcene Rivers*

Escapement estimates averaged 1,689 spawners (range of 795 to 2,978) in the Big Quilcene River and 918 spawners (range of 44 to 1,816) in the Little Quilcene River from 1974 through 1978. For the last four years (1995-1998), the Big Quilcene River's average estimated escapement is 5,523 spawners (range of 2,244 to 8,479) while the average of the Little Quilcene River is 153 spawners (range of 29 to 265). The combined total effective population size *($N_e$)* equals 4,087 fish for the 1995-98 return years, and the total population size *($N$)* is 20,434 for the same years (Table 1.12). The most recent estimated returns (1995-1996) likely have been affected by the existing supplementation project begun in 1992. Based on an increasing escapement trend and the large recent escapements, the current extinction risk for this stock is low.

The risk of extinction and its effect on the decision to supplement this stock beginning in 1992, is probably best judged by examining escapements just prior to initiation of the supplementation project. The four year average estimated escapement from 1988 through 1991 is only 89 spawners for this stock (including both Big and Little Quilcene rivers), with annual escapements ranging from 2 to 297 fish. The effective population size *($N_e$)* equals 64 fish for the 1988- 91 return years, and total population size *($N$)* is 320 for the same years (Table 1.12). Habitat conditions in both streams are poor and represent a threat to the survival of the stock. At the time supplementation was begun, this type of risk assessment would have rated this stock to be at high risk of extinction because the high risk criteria for population size and chronic decline were exceeded.

### *Snow/Salmon Creeks*

From 1974 through 1978, escapement estimates average 584 spawners (range of 327 to 818) in Snow Creek and 831 spawners (range of 512 to 1,664) in Salmon Creek. During the last four years, Snow Creek's average estimated escapement is 70 spawners (range of 25 to 160) and the average of Salmon Creek is 768 spawners (range of 538 to 1,023). The total average escapement for the stock in the last four years is 838 spawners, with a range of annual escapements between 563 and 1,051 fish. The effective population size *($N_e$)* equals 603 fish for the 1995-98 return years, and total population size *($N$)* is 3,017 for the same years (Table 1.12). The most recent return estimates (1995-1998) likely have been affected by returns to the existing supplementation project begun on Salmon Creek in 1992. Since the stock (with two streams combined) has experienced increasing overall escapements in recent years and average escapement exceeds the population size risk criteria, the current risk of extinction is judged to be low.

As with the Quilcene stock, the risk of extinction and its affect on the decision to supplement this stock should be judged by examining escapements just prior to initiation of the supplementation project in 1992. The four year average estimated escapement from 1988 through 1991 is 829 spawners for this stock, with annual escapements ranging from 184 to 2,638 fish. The four-year average is heavily influenced by the 1988 escapement of 2,638 spawners, however, the three subsequent years (1989 - 1991) have an average escapement of only 226 fish, with a range from 184 to 278 spawners. Using the 1989 to 1991 three year average of 226 fish, the effective population size *($N_e$)* equals 163 fish, and total population size *($N$)* is 814 for the same years (Table 1.12). Habitat impacts are moderate to high and potentially are a threat to the survival of the stock. At the time supplementation was begun, this type of risk assessment would have rated this stock to be at high risk of extinction, because the very high risk criterion of precipitous decline and the high risk criterion for population size were exceeded.

### *Jimmycomelately Creek*

Escapements for Jimmycomelately Creek for the past four years annually have averaged 103 spawners (range of 30 to 223). Sufficient in-stream spawner survey data to estimate escapement have not been collected on Jimmycomelately Creek before 1982. However, for the seven year period of 1982 through 1988 (the latter year being the start of the general decline for Strait of Juan de Fuca stocks), annual escapement estimates average 441 spawners (range of 61 to 1,052). The recent four year average is 23% of the historical seven year average. The effective population size $(N_e)$ equals 74 fish for the 1995-98 return years, and total population size $(N)$ is 371 for the same years (Table 1.12). Because of the chronic decline of this stock and population sizes meeting the high risk criteria, the risk of extinction is judged to be high.

### *Dungeness River*

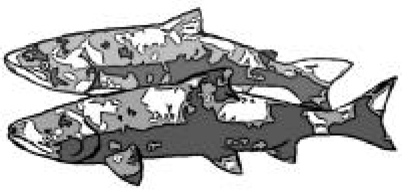
Historically, surveys of summer chum spawners have not been performed in the Dungeness River and no escapement estimates are available. Only recently has it been recognized that summer chum persist in the river. This information comes from observations made in the course of collecting data on chinook and pink salmon as part of ongoing recovery efforts for these two species. Habitat conditions are relatively poor and may pose a threat to the summer chum stock. Little information is available through which judgements can be rendered regarding the status of the Dungeness stock, if it exists. More information is needed before recovery activities are contemplated and the Dungeness River stock  risk rating is special concern.

**Table 1.12.** Extinction risk assessment for summer chum salmon (based on Allendorf et al. 1997).

| Stock | Escapement (Mean 95-98) | Effective Population Size $(N_e)$ [1] | Total Population Size $(N)$ [2] | Recent Population Trend | Risk Rating |
|---|---|---|---|---|---|
| Union | 462 | 333 | 1,667 | Increasing | Moderate |
| Lilliwaup | 38 | 27 | 137 | Chronic decline or depression | High |
| Hamma Hamma | 366 | 264 | 1,318 | Increasing | Moderate |
| Duckabush | 1,044 | 752 | 3,758 | Increasing | Low |
| Dosewallips | 2,537 | 1,827 | 9,133 | Increasing | Low |
| Big & Little Quilcene | | | | | |
| Current status | 5,676 | 4,087 | 20,434 | Increasing | Low |
| Pre-project status | 89 [3] | 64 | 320 | Precipitous decline | High |
| Snow/Salmon | | | | | |
| Current status | 835 | 601 | 3,006 | Increasing | Low |
| Pre-project status | 226 [4] | 163 | 814 | Precipitous decline | High |
| Jimmycomelately | 103 | 74 | 371 | Precipitous decline | High |
| Dungeness | No data | Not available | Not available | Not available | Special Concern |

[1] Effective population size $(N_e)$ = Average escapement x 3.6 (generation length) x 0.2 $(N_e/N)$.
[2] Total population size $(N)$ = Average escapement x 3.6 (generation length).
[3] Big/ Little Quilcene average escapement for 1988 through 1991 return years.
[4] Snow/Salmon creeks average escapement for 1989 through 1991 return years (see text).

# Part Two
# Region-wide Factors For Decline



## 2.1 Introduction

> ***"The basic approach is to examine a variety of region-wide factors potentially affecting production, both natural and human caused, to identify those that change in concert with the recent summer chum salmon decline."***

Like all Pacific salmon, summer chum salmon are influenced by a variety of factors, with both positive and negative consequences for their overall survival. Part Two provides a general analysis of those factors that most likely have been responsible for the abrupt decline in summer chum salmon abundance that has occurred in Hood Canal streams in the late 1970s and in Strait of Juan de Fuca streams a decade later. The basic approach is to examine a variety of region-wide factors potentially affecting production, both natural and human caused, to identify those that change in concert with the recent summer chum salmon decline. Part Three of this recovery plan will identify more specific factors for decline and will present recovery strategies, under the general categories of artificial production, ecological interactions, habitat, and harvest management.

While this discussion focuses on individual factors for decline, the observed reductions in the numbers of summer chum salmon in the region are the result of the combined impacts of a number of factors. When two or more impacts occur that negatively affect the survival or the resilience of a salmon population there may be a synergistic effect, where there is a greater overall loss than an observed change in an individual survival factor. An example of such an amplification of impacts might be if a habitat alteration substantially reduces the incubation survival of the eggs and alevins in a stream (e.g., through increased siltation or flooding), and the subsequent predation on the surviving fry becomes higher than normal because predators take an increased proportion of the reduced prey population. The combined impact (total mortality) would be higher than just the change in incubation survival would suggest.

The factors identified here may not include all of the elements that need to be addressed for recovery of these summer chum stocks. Those factors implicated in the recent abrupt decline of summer chum salmon will not necessarily include those effects that over time, gradually and cumulatively impact salmon survivals. For example, there has been a long history of negative anthropogenic habitat-related impacts affecting salmon populations, and many of these have occurred prior to the period of decline addressed here (section 3.4). Additionally, nearly two decades have passed since the beginning of the decline of summer chum, and a broader range of negative conditions now exist. All known negative factors must be addressed to effect the recovery, stability, and sustainability of Hood Canal and the Strait of Juan de Fuca summer chum salmon stocks.

# 2.2 Negative Impacts On Abundance

## 2.2.1 Introduction

The following section will examine those factors that can influence summer chum salmon abundance in an attempt to identify specific sources of mortality that have contributed to the declines of Hood Canal and the Strait of Juan de Fuca summer chum salmon. There are several general conclusions, however, that can be reached through a simple examination of the escapement data and run size data in Table 1.5 and Table 1.6 (see section 1.5, Period of Decline discussion in Part One). First, the factors for decline are probably different for the two regions involved; Hood Canal and the Strait of Juan de Fuca. The drop in abundance of summer chum salmon has occurred ten years apart in the two regions; 1979 for Hood Canal streams, versus 1989 for Strait of Juan de Fuca streams. This is probably because of differences in these regions; they have distinctly different climates, stream habitat types, habitat problems, and fishery exploitation patterns. The second observation is that the data suggest that the factors for decline affect every chum salmon return year, and do not seem to have a short term cyclic component. This information is useful because short term cyclic effects can be discounted in the following examination of limiting factors (e.g., the every other year presence of pink salmon can be eliminated as a potential negative impact). If there is a cyclic element involved in the decline of summer chum salmon, it likely has a decadal or longer pulse.

Potential factors affecting production will be examined individually in the following four categories: 1) climate, 2) ecological interactions, 3) habitat, and 4) harvest. This section will end with a conclusions discussion that will examine the combined impacts of factors for decline, and will evaluate the relative importance of various factors.

## 2.2.2 Climate

The weak returns of summer chum salmon in 1979 to both Hood Canal and Strait of Juan de Fuca streams reflected a broad failure of nearly all Washington State wild summer and fall chum stocks. All regions of the state experienced record low returns of chum salmon, and the statewide harvest in 1979 was the lowest recorded for the species in 60 years (Johnson et al. 1997). The Strait of Juan de Fuca and Union River (Hood Canal) summer chum salmon stocks immediately recovered from the low returns in 1979, but the other populations of summer chum salmon in Hood Canal failed to recover and in most cases declined further over the next several years. The Strait of Juan de Fuca stocks began to decline a decade later. This pattern of major decline and subsequent continuing low population abundance beginning in Hood Canal in 1979 was relatively consistent across a number of streams with varying environments and habitat types. The uniform nature of these declines suggests the need to assess the possibility of a regional environmental impact, in fresh and/or marine waters.

Local stocks of summer chum salmon may be particularly susceptible to changes in climate. These fish are the southernmost representatives of summer-timed chum salmon in the northeast Pacific region, may naturally lead a somewhat tenuous existence, and may be less resilient when facing a changing environment. Changes in ocean, estuarine, or freshwater conditions that may have a modest impact on fall chum salmon could be a major limiting factor for summer chum salmon.

#### 2.2.2.1 Ocean Effects (ENSO and PDO)

The phenomena of the El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO) have received a great deal of recent attention in the Pacific Northwest (PNW) fisheries community because of increasing evidence that these fluctuations in ocean conditions can have profound effects on the growth and survival of Pacific salmon and other types of fish (see Emmett and Schiewe 1997).

El Niño-Southern Oscillation events begin as warming episodes in the tropical Pacific zone and can result in large scale intrusions of anomalously warm marine water northward along the PNW coastline. The effects of these warm water intrusions are felt along the Washington and British Columbia coast for a one to two year duration in an irregular periodicity of every two to seven years (Mysak 1986). ENSO episodes vary greatly in intensity, and have been shown to impact salmonid marine growth and survival (e. g. food abundance and predator impacts change), and can additionally affect the freshwater environment. ENSO impacts on salmonid growth and survival can vary by species and locale (e. g., negative for Oregon coastal coho salmon (Pearcy 1992), positive for British Columbia sockeye salmon (Mysak 1986)). ENSO conditions are associated with generally warmer and drier weather conditions along the PNW coastal zone, and can cause reduced snow pack and lower stream flows in western Washington State (Mantua, undated).

**El Niño-Southern Oscillation (ENSO)**

***A climate event that begins as a warming episode in the tropical Pacific zone and can result in large scale intrusions of anomalously warm marine water northward along the PNW coastline.***

The Pacific Decadal Oscillation is a pattern of climate and ocean condition regimes occurring in the north Pacific Ocean (associated with the Aleutian low pressure system) that results in shifts in sea surface temperatures and plankton abundance on a decadal time scale (Mantua et al. 1997). The 20 to 40 year regimes in the PDO have been shown to relate directly to the abundance of Alaskan pink and sockeye salmon (Francis and Hare 1997). The most recent shift occurred in 1977 (Ebbesmeyer et al. 1989), and resulted in warmer coastal sea temperatures, cooler central Pacific sea temperatures, and more abundant plankton resources which contributed to

**Pacific Decadal Oscillation (PDO)**

***A pattern of climate and ocean condition regimes occurring in the north Pacific Ocean (associated with the Aleutian low pressure system) that results in shifts in sea surface temperatures and plankton abundance on a decadal time scale.***

strong returns of Alaskan salmon in the last two decades (Francis and Hare 1997). The most recent PDO shift has been shown to relate to general increases in production of pink, chum and sockeye salmon in the North Pacific Ocean (Beamish and Bouillion 1993), and more specifically to Fraser River sockeye salmon (Beamish et al. 1997). While the PDO can have a substantial effect on the growth and survival of salmon during their migrations and feeding in the north Pacific Ocean, the phenomenon can also have a major influence on the freshwater environment along the PNW coast, including Washington State. Air temperatures, wind conditions, and precipitation are locally affected by the PDO (Mantua et al. 1997).

The influence of PDO regime shifts on the abundance of zooplankton and on subsequent salmon production in the North Pacific Ocean has been demonstrated (Francis and Hare 1997). The available data for Hood Canal and Strait of Juan de Fuca summer chum salmon are insufficient to examine the possibility of impacts of PDO changes on the marine survivals of these fish. However, naturally produced fall chum stocks in Puget Sound and Hood Canal have increased in abundance since 1977, and now approach historic levels (Johnson et al. 1997). Additionally, returns of fall chum salmon to established Puget Sound hatchery facilities (e.g., Hoodsport, and Minter Creek), show that marine survivals following the PDO shift in 1977 ranged from normal to above normal. If we assume fall and summer chum salmon are subject to similar ocean effects, the success of fall chum salmon would suggest that unusual ocean mortality has not contributed to the summer chum salmon declines. The success of fall chum salmon also seems to discount the possibility that ENSO events have negatively impacted marine survivals, and thus it appears to be unlikely that ENSO related ocean survival conditions are a significant contributor to the decline of summer chum salmon.

### 2.2.2.2 Estuarine Effects

Ebbesmeyer et al. (1989) has described the relationship between PDO regimes and conditions in the Puget Sound region; showing linkages with patterns of precipitation, freshwater runoff, saltwater temperatures, and currents in Puget Sound. Since 1977, the PDO has been in a positive state, which correlates with less precipitation in western Washington, decreasing freshwater runoff, and faster inflow of marine water into the Puget Sound basin from mid-depth to bottom. These factors could change conditions in estuarine areas of Hood Canal and Strait of Juan de Fuca, and alteration of conditions that potentially affect the survivals of summer chum salmon (e.g., estuarine temperature, salinity, or food production), may have contributed to the observed declines. There are, however, no data available to measure such change, and like ocean effects, the influence of estuarine conditions on summer chum survivals is currently not known.

### 2.2.2.3 Freshwater Effects

Stream flows are a primary force controlling the survival of salmon in the stream environment. For summer chum salmon, the critical periods are during spawning (September - October) and during the intragravel incubation of eggs and alevins (November - March). Since chum salmon juveniles do not typically rear in freshwater, stream flows during the spring and summer months presumably have less impact on survivals, possibly influencing fry emigration (February - April) and the upstream migration of the earliest arriving adults in August. The following examination of stream flow impacts on summer chum salmon will focus on the spawning and incubation periods.

Because adult summer chum salmon enter streams and spawn during the lowest flow period of the year, they are particularly vulnerable to any reductions in stream flow. Severely low flows can limit access to the better spawning sites within the stream channel; causing spawning salmon to utilize sub-optimum areas, which can result in reduced egg to fry survivals (Ames and Beecher 1995). The possible negative consequences of poor redd site selection can be reduced egg and alevin survivals because of factors like inadequate intergravel flow and increased exposure to the effects of winter floods.

Winter stream flows can have substantial adverse effects on chum salmon survival, associated with the mortality of incubating eggs and alevins caused by streambed scouring and increased siltation. The nature of flow related impacts on incubating chum salmon eggs and alevins has been defined for chum salmon at Big Qualicum River, British Columbia by Lister and Walker (1966) (see Table 2.1). They demonstrate an inverse relationship between incubation survival and the peak flow that occurs during incubation, with egg to fry survivals at Big Qualicum varying fivefold; from 25% with no flood, to 5% with flood conditions. The authors identify instream flow and resultant streambed scour to be the major factor influencing the freshwater survival rate of chum salmon.

The same flow/survival relationship has also been shown for salmonids in Washington State; sockeye salmon in the Cedar River (Thorne and Ames 1987), and chinook and coho salmon in the Skagit and Clearwater rivers respectively (Dave Seiler, WDFW, personal communication). The mechanics of stream bed scour and the effects on chum salmon egg pockets and intergravel survival are described by Montgomery et al. (1996) from studies on Kennedy Creek in southern Puget Sound. Any changes in the magnitude of winter flows can have a direct effect on the success of summer chum salmon.

**Table 2.1.** Chum salmon survival from actual egg deposition to fry migration in relation to discharge extremes during incubation, Big Qualicum River, 1959-64 (from Lister and Walker 1966).

| Maximum daily discharge (cfs) during incubation | Percent survival | (brood year) |
|---|---|---|
| 393 | 25.2 | (1964) |
| 800 | 25.9 | (1963) |
| 1,260 | 17.8 | (1961) |
| 1,360 | 18.2 | (1959) |
| 2,000 | 9.6 | (1962) |
| 3,200 | 5.3 | (1960) |

For the present analysis, U.S. Geological Survey (USGS) stream discharge records have been examined to look for possible relationships between summer chum salmon abundance and the effects of climate on critical stream flows (Appendix Table 2.1). Several stream discharge data bases have been examined for 1) any evidence explaining the abrupt drop in Hood Canal summer chum salmon in 1979, 2) any relationship between flows and the 1989 drop in Strait of Juan de Fuca summer chum salmon abundance, and 3) any general changes in stream flows that relate to the PDO shift in 1977. The absence of survival rate data for summer chum salmon precludes the use of traditional correlation analyses to examine the possible relationships between stream flows and the survivals of summer chum salmon. Instead, variations in mean flows for periods of years before and after observed changes in the climate or summer chum salmon abundance have been examined. Any evidence of change, or lack of change, in the stream flow data has been tested for statistical significance (one tailed t-test).

**Puget Sound Stream Flow Index** - Gallagher (1979) has developed a data base of freshwater and marine environmental variables for his study of the factors affecting the life histories of Puget Sound chum and pink salmon. WDFW annually updates, and in some cases modifies, this database for use in forecasting annual returns of chum and pink salmon to Puget Sound. One of the more useful stream discharge parameters that has been developed by Gallagher is the percent deviation from the mean of the lowest and highest ten consecutive days of stream flow, derived from stream discharge data from a number of USGS stream gages on major river systems in the Puget Sound region. This Puget Sound Stream Flow Index (PSSFI) data base has not been updated in recent years, however the 1959 through 1991 water years are represented (Appendix Table 2.1). The current PSSFI assembles stream flow data from nine stream gages (Table 2.2) for several periods corresponding to summer chum salmon spawning (September 15 - November 14), and incubation stages (November 15 - February 14).

**Table 2.2.** USGS stream gages included in the Puget Sound Stream Flow Index.

North Fork Nooksack River at Glacier
Skagit River at Concrete
Skykomish River at Gold Bar
Snoqualmie River at Carnation
Puyallup River at Orting
Puyallup River at Puyallup
Skokomish River at Potlatch
North Fork Skokomish near Potlatch
Duckabush River near Brinnon

The PSSFI shows changes in low flows (spawning) that may relate to the recent PDO shift. The average 10-day low flows (Sept. 15 - Nov. 14) coinciding with the summer chum salmon spawning period dropped in the mid-1970s (Appendix Figure 2.1). A comparison of the low flows during the first 18 years (1959-1976) of the PSSFI data base with the most recent 15 year period (1977- 1991) shows a statistically significant change (Appendix Figure 2.1). The average pre-1977 low flows are higher than normal (+9.5% deviation from the mean), while the 1977-1991 low flows are substantially lower than the overall mean (-11.5% deviation from the mean). For post-1976 years 11 of 15 years have 10-day low flows below the 1959-1991 average. For the winter high flow period (Nov. 15 - Feb. 14), the PSSFI shows a weaker potential response to the PDO shift. The higher average 10-day flows from 1959 to 1976 (+6.4% deviation from the mean), change to lower average flows for the post-1976 years (-7.7% deviation from the mean) (non-significant; Appendix Figure 2.2). Nine of 15 years are below the mean during this later period.

These shifts to lower Puget Sound stream flows during the summer chum salmon spawning and incubation periods appear to occur in concert with the 1977 regime shift in the ocean climate cycle, and also seem to correspond with the decline of Hood Canal summer chum salmon. Another measure of stream flow, peak momentary discharge from the same nine USGS gaging stations (1959-1991), does not appear to relate to the PDO regime shift, showing an approximately equal frequency of above average peak flow events before and after 1977.

**Hood Canal and Strait of Juan de Fuca stream flows** - While the PSSFI data seem to show a link between the PDO and stream flows during the summer chum salmon spawning season, a more direct examination of local Hood Canal and Strait of Juan de Fuca stream flows is needed to identify specific conditions affecting summer chum salmon stocks. There are just three USGS stream gages on the region's streams that are pertinent to summer chum salmon, and have been in operation from the 1960s to present; Big Beef Creek, the Duckabush River, and the Dungeness River.

***Spawning flows*** - Mean monthly stream discharge data for the September-October summer chum salmon spawning period have been examined for the three streams. The 1968 through 1993 years have been selected for this analysis because that range of years encompasses the period of the chum salmon data base available for these streams. There are two missing years for Big Beef Creek (1968 and 1982), while the Duckabush and Dungeness rivers have a continuous record for the period (Appendix Table 2.1). Even though these are the only streams with available stream flow records, they can be considered to be representative of the summer chum salmon streams in Hood Canal and the Strait of Juan de Fuca.

Big Beef Creek is a small lowland stream that originates in the central Kitsap Peninsula at an elevation of just under 500 feet, and flows northwesterly for ten miles to enter the east shore of Hood Canal. Mean annual stream discharge ranges from 30 to 50 cfs (Williams et al. 1975). The watershed has undergone past logging, and is now experiencing substantial road and home construction. In contrast, the Duckabush River has its origin high in the Olympic Peninsula, at an elevation of over 5,200 feet. The river flows for just over 24 miles in an easterly direction, entering the west shore of Hood Canal. The upper 12.6 miles (RM 11.5-24.1), and numerous tributaries, are located in the Olympic National Park, 9.2 miles (RM 2.3-11.5) are in the Olympic National Forest, and the lower 2.3 miles flow through mostly private lands. Average annual stream flow is slightly more than 400 cfs (Johnson et al. 1997). Below the Park boundary, logging has prevailed on Forest Service land, and some home development has occurred along the lower river.

There are no USGS flow gages on the summer chum salmon streams of Discovery and Sequim bays. To examine eastern Strait of Juan de Fuca stream flow patterns, two sources of data have been used; the USGS gage on the Dungeness River, and stream flow data collected at the WDFW Snow Creek Research Station for the years 1977-1992 and 1994 (Appendix Table 2.1, provided by T. H. Johnson and R. Cooper, WDFW).

Both Snow Creek and the Dungeness River support summer chum salmon, however, the two streams are very different in character. Snow Creek is a small, lowland stream that originates in the foothills of the Olympic Mountains at an approximate elevation of 2,900 feet, and flows east and north for 10.1 miles to its confluence with Discovery Bay. The creek is characterized by low stream flow resulting from the influence of the rain shadow effect of the Olympic Mountain range. The headwaters of Snow Creek (above RM 6.75) are in the Olympic National Forest and are subject to periodic logging impacts (Williams et al. 1975). Lower basin land use includes farmland and rural home development. The Dungeness River originates at an elevation of approximately 6,600 feet in the Olympic Mountains and flows north for nearly 32 miles to its mouth on the Strait of Juan de Fuca. Average annual Dungeness River flow is just under 400 cfs (Johnson et al. 1997). A major tributary, the Gray Wolf River, joins the Dungeness 15.8 miles above its mouth. Both streams originate high in the Olympic Mountains, and snow melt contributes to summer and early fall stream flows. The entire basin above RM 13.4 is in the Olympic National Forest and Park

(Williams et al. 1975). Land use patterns include substantial logging on Forest Service lands, and rural farm and home development in the lower basin.

The mean September-October flows for Big Beef Creek, and the Duckabush and Dungeness rivers do not drop in 1977 in relationship to the PDO shift, but instead display relatively uniform flows until a substantial reduction in 1986 and subsequent years. Average September-October stream flow declines from 10.8 cfs (1968-1985) to 4.6 cfs (1986-1993) at Big Beef Creek, from an average of 241 to 122 cfs for the same time periods at Duckabush River, and from 203 to 134 cfs at the Dungeness River. The changes in spawning flows after 1986 are statistically significant for each of the three streams (Appendix Figures 2.3-2.5). The Snow Creek data begin in 1977 and cannot be used to examine the PDO effect.

Table 2.3 partitions the mean September-October flows into three periods for comparison; 1968-1976, 1977-1985, and 1986- 1993. The flows for the two periods, 1968-1976 and 1977-1985, are not statistically different for Big Beef Creek, the Duckabush River, and the Dungeness River (Appendix Table 2.2). The drop in discharge during the 1986-1993 period is severe; Big Beef Creek down 57%, the Duckabush River down 49%, and the Dungeness River down 34%. These differences are statistically significant (Appendix Figure 2.3-2.5). Snow Creek follows the same pattern with a statistically significant drop from a mean flow of 6.6 cfs (1977-1985) to an 1986-1993 mean flow of 3.6 cfs (Appendix Figure 2.6), a 45% decline. With the very different geomorphology and land use patterns of the four basins, the similar magnitude of the changes in flow in the individual streams suggests a broad climatic change as the primary cause for the reduction in discharges.

**Table 2.3.** Mean flow in cfs during September and October in four steams in the Hood Canal and Strait of Juan de Fuca region (1968-1993), with (n) = number of years available data.

| **Stream** | | **Mean flow 1968-1976** | **Mean flow 1977-1985** | **Mean flow 1986-1993** |
|---|---|---|---|---|
| Big Beef Cr. | - mean | 10.9 (8) | 10.7 (8) | 4.6 (8) |
| | - range | 5.0 - 35.8 | 5.4 -24.6 | 3.1 - 6.5 |
| Duckabush R. | - mean | 210.0 (9) | 272.9 (9) | 121.9 (8) |
| | - range | 101 - 489 | 90 - 376 | 54 -214 |
| Snow Cr. | - mean | no data | 6.6 (9) | 3.6 (7) |
| | - range | | 1.4 - 13.6 | 1.8 -7.7 |
| Dungeness R. | - mean | 194.8 (9) | 211.0 (9) | 134.0 (6) |
| | - range | 133 - 320 | 149 - 260 | 99 - 167 |

***Incubation flows*** - For Hood Canal and Strait of Juan de Fuca summer chum salmon streams, only the USGS gages on the Duckabush and Dungeness rivers provide a continuous year-round discharge record for time periods before and after the PDO shift. It is assumed that the Dungeness River is reasonably representative of flow patterns for eastern Strait of Juan de Fuca summer chum salmon streams. Snow Creek flow data are not suitable for this analysis because the flow record begins in 1977.

The annual peak instantaneous discharges for both rivers (Appendix Table 2.2) have been examined for evidence of changes in incubation period (October-March) flow patterns during the 1968-1995 span of years. The average Duckabush River peak instantaneous flow during the nine years preceding the 1977 PDO shift (3,864 cfs) is lower than the same value calculated for the 19 years following the shift (5,064 cfs) (Appendix Figure 2.7). The Dungeness River has an average peak flow of 2,437 cfs for the 1968-1976 period that increases to an average peak flow of 3,776 cfs from 1977 to 1995 (Appendix Figure 2.8). The pattern of peak flows is similar for both rivers; substantially higher average peak flows for the years since the regime shift. The flow change for the Duckabush is not statistically significant, while the change in Dungeness River flow is statistically different (Appendix Table 2.2).

Table 2.4 splits the peak flow data into three periods (1968-1976, 1977-1985, and 1986-1995) to examine the relationship between pre-PDO shift flows and two time periods for subsequent years. Average peak flows are substantially higher for both time periods following the regime shift, however, there is no indication of a shift in peak flows in 1986 corresponding to the observed change in spawning flows (Appendix Table 2.2). This result seems to contradict the pattern of positive PDO regimes causing warmer, drier weather conditions in the PNW region, and is also contrary to the PSSFI data (see above) which shows a reduction in 10-day winter high flows after the regime shift. It may be that during warmer conditions, precipitation from major Pacific storms takes the form of more intense rain events with less snow fall, resulting in faster runoff and greater peak stream flow events.

**Table 2.4.** Mean and range of peak instantaneous flows in cfs in the Duckabush and Dungeness rivers occurring between October and March (1968-1995), with (n) = number of years available data.

| **Stream** | | **Peak flow 1968-1976** | **Peak flow 1977-1985** | **Peak flow 1986-1995** |
|---|---|---|---|---|
| Duckabush R. | - mean | 3,864 (9) | 5,364 (9) | 4,793 (10) |
| | - range | 1,360-6,090 | 2,160-7,820 | 1,910-9,240 |
| Dungeness R. | - mean | 2,437 (9) | 3,768 (9) | 3,783 (10) |
| | - range | 597-5,150 | 1,460-6,550 | 1,300-7,120 |

## 2.2.2.4 Conclusions

Climate and its effects on ocean processes and weather is a complex subject, and the above analysis is only intended to identify general patterns of climate that may have contributed to the changes in summer chum salmon status. The following discussion and Table 2.5 are summarizations of the possible effects of climate change and the potential effects on summer chum salmon.

### Ocean Effects

Because of the lack of specific summer chum salmon survival data, the potential impacts of changes in ocean productivity related to ENSO events and PDO regime shifts cannot be determined at this time.

**Table 2.5.** Summary of observed changes in Puget Sound (PSSFI), Hood Canal, and Strait of Juan de Fuca stream flows.

**The 1977 PDO regime shift -**
Ocean productivity effects on summer chum salmon survivals are not measurable due to lack of stock production data.

Stream flows that changed with the 1977 PDO regime shift:

- 10-day low spawning flows declined (Sept. 15 - Nov. 14) for PSSFI.
- 10-day high incubation flows declined (Nov. 15 - Feb 14) for PSSFI.
- Peak instantaneous incubation flows increased in the Duckabush and Dungeness rivers (Oct.-Mar.).

**The 1986 flow reductions -**
Stream flows that changed in 1986:

- Mean spawning flows declined in Big Beef and Snow creeks, and Duckabush and Dungeness rivers (Sept.-Oct.).

### Estuarine Effects

Regional climate patterns (e.g., rainfall and air temperatures) have been shown to be affected by changes in ocean conditions related to ENSO events and shifts in the PDO. These are the type of changes that can influence the productive capacity of estuaries, however, at this time it is not known to what degree these climate shifts may or may not have contributed to the decline of summer chum stocks.

### Freshwater Effects

***Spawning flows*** - Along with major ocean changes, shifts in the PDO have been shown to affect Puget Sound weather, precipitation, and run-off (Ebbesmeyer et al. 1989). In the current "positive" PDO state, precipitation and resultant stream discharges would be expected to be lower than average. While the Puget Sound Stream Flow Index shows a drop in spawning season low flows that corresponds to the 1977 PDO regime shift, Hood Canal and Strait of Juan de Fuca streams have had stable September-October mean flows through this period of climate change. A notable drop in stream flows in the region has occurred, however, in 1986 and flows have continued to be lower in subsequent years.

Two obvious questions are: 1) why does the PSSFI spawning flow index correlate with the PDO shift while the Hood Canal and Strait of Juan de Fuca streams do not show a similar relationship, and 2) do PSSFI spawning flows show the 1986 drop in stream flows?

The PSSFI percent deviation from the mean 10-day low flow statistic is dominated by measurements from large river systems (e.g. the Skagit and Puyallup rivers) whose late summer spawning flows may be largely influenced by a combination of snow melt, precipitation, and groundwater. In contrast, Big Beef Creek and the Duckabush River September and October flows are more likely to result from precipitation and groundwater, and without a substantial contribution from snow melt, may be less affected by the PDO climate shift. Summer stream flows in the Dungeness River are affected by snow melt runoff, but September-October flows are lower and likely more the result of local precipitation and groundwater contributions.

The 1986 drop in stream discharge during the spawning season is apparent in the PSSFI flows. As discussed above, there has been a clear drop in the PSSFI after 1976 (see Appendix Figure 2.1), however, the two greatest negative deviations from the mean flow occurred in 1986 and 1987, -31.73% and -45.43% respectively. The PSSFI does not continue at this lower level, however, showing values averaging -4.9% for the four year period of 1988-1991. The 1986 drop in streams flows may not be evident in the PSSFI as a continuing condition because of the influence of late summer snow melt in the large streams included in this index.

***Incubation flows*** - A fundamental change in peak winter flows has occurred in concert with the 1977 PDO shift in Hood Canal and Strait of Juan de Fuca streams. Peak instantaneous discharge during the summer chum salmon incubation period (October-March) has increased substantially, as measured on the Duckabush (+31%) and Dungeness (+ 55%) rivers. As stated above, this outcome seems opposed to the expected pattern of warmer, dryer weather with the current positive PDO regime, but this apparent anomaly may result from differences in the amount of precipitation that falls in the form of rainfall (and less as snowfall) from individual storm events.

### Climate Impacts on Summer Chum Salmon

***Hood Canal*** - The decline of Hood Canal summer chum salmon begins with the 1979 adult return, which is primarily composed of 1976 brood age-3 fish and 1975 brood age-4 fish. Hood Canal summer chum salmon from the 1975 and 1976 broods were at sea for 2-3 years after the regime shift, and it is possible that their marine survivals were negatively impacted. There are no direct summer chum salmon data available to support or refute the possibility of lower marine survivals, however, the recent success of fall chum salmon in the region suggests that it is unlikely that changes in marine survival significantly contributed to the decline.

The increase in peak incubation flows after the PDO shift is substantial (+31% for the Duckabush River), and increased flow related mortalities of incubating eggs and alevins is a likely result. The elevated incubation flows may well have been a contributing factor to the lack of recovery and continued decline of Hood Canal summer chum salmon in the early 1980s. Since ENSO events have the same type of effects as the current positive PDO state on regional weather patterns (warmer and drier conditions), both conditions could affect stream flows.

Increased intra-redd mortality resulting from higher incubation flows could have been exacerbated by the major reduction in spawning flows that occurred in 1986 and subsequent years. The major decline in average stream flows that occurred in September/October stream flows (-57% at Big Beef Creek and -49% at Duckabush River) has several potentially serious consequences for summer chum salmon. The early return and spawning timing of summer chum salmon makes them particularly vulnerable to reductions in stream flow. Low flows and elevated water temperatures could delay the entry of the fish to spawning streams, which could increase their susceptibility to fishery exploitation and predation. Once in the stream, they would be forced to spawn in mid-channel areas, exposing resulting eggs and alevins to increased levels of mortality during subsequent high flow events. A continuation of the combination of low flow patterns during spawning and elevated incubation flows of recent years could slow the recovery rate of Hood Canal summer chum salmon.

***Strait of Juan de Fuca*** - The summer chum salmon stocks of the eastern Strait of Juan de Fuca have recovered quickly from the low 1979 return, and have displayed good returns until the major decline in 1989. As with Hood Canal streams, the Dungeness River shows no change in September/October flows coinciding with the 1977 PDO shift. The 1986 severe drop in spawning flows seen in the Hood Canal region also has occurred in Strait of Juan de Fuca streams, and may have substantially impacted local summer chum salmon stocks. Stream discharge data from Snow Creek show a drop in September/October flows of 45%, and Dungeness River flows for the same months have declined 34%.

Snow, Salmon, and Jimmycomelately creeks are small streams that are located in the rain shadow of the Olympic Mountain range, and experience extremely low flows during the summer chum salmon spawning season. For example, the mean September/October flow on Snow Creek from 1977 to 1985 is only 6.6 cfs. The reduction in Snow Creek spawning flows to an average of 3.8 cfs from 1986 to 1993, has the potential to cause a major reduction in summer chum salmon survivals and returns. Extreme low flows during the spawning period can jeopardize survival by:

- increasing prespawning mortality of adults by restricting or delaying access to freshwater;
- increasing prespawning mortality of adults in the stream through exposing the spawners to higher than normal predation levels;
- increasing prespawning mortality of adults in the stream because of elevated water temperatures; and
- increasing mortality of incubating eggs and alevins because of limited spawner access to optimum spawning sites.

The offspring of the summer chum salmon that spawned in eastern Strait of Juan de Fuca streams in 1986 first returned as age-3 fish in 1989. For the 1990 return, and subsequent years, the returning fish have all been subjected to the impacts of the reduced spawning and increased incubation flows. The limited nature of the freshwater habitat in the region, the small size of the individual spawning streams, and the early run-timing of the summer chum stocks, combine to give the observed changes in local stream flow regimes the potential to have had a strong negative impact on the success of the summer chum salmon. It is likely that the effects of climate on Strait of Juan de Fuca stream flows has contributed to the decline in summer chum salmon stock status.

As with Hood Canal summer chum salmon, there are insufficient data available for the Strait of Juan de Fuca fish to evaluate potential PDO and ENSO effects on marine survivals.

### Climate in Relation to Human Caused Impacts

Any analysis of climate change in relation to stream flow and summer chum populations cannot be isolated from a consideration of human-caused habitat alterations. It is significant to note that prior to significant human impact to their habitat, summer chum populations have persisted in the face of natural climate fluctuations. Over the last 150 years, however, human development impacts have produced incremental and gradual, but cumulatively significant changes to Hood Canal and Strait of Juan de Fuca watersheds. These changes have altered the resiliency of salmon habitat in the face of these climate fluctuations. Historically, diverse and resilient habitats buffered summer chum populations against the effects of deleterious climate shifts. Stream channels contained abundant LWD with sufficient stable spawning, incubation, and migration habitats. Riparian forests, intact floodplains, wetlands, and alluvial aquifers moderated stream flows against seasonal extremes.

The climate-driven changes in hydrology described above (decreases in spawning season stream flows since 1986 and increases in instantaneous peak discharge during the incubation period since 1977) are even more significant when we consider how they interact with human impacts to summer chum habitat. Water withdrawal from streams or aquifers that are in hydrologic continuity with summer chum streams has further increased the severity of low flows. Removal of streamside vegetation has reduced the thermal insulating capacity of riparian zones and resulted in elevated water temperatures during the summer chum spawning season. In addition, loss of wetlands and critical aquifer recharge areas to development has likely further exacerbated low flows by eliminating natural groundwater recharge that augments stream flows during the summer.

Floodplain development and stream bank armoring has altered the impact of peak flow events on incubating summer chum salmon through the loss of flood storage capacity and the confinement of flood flows to the main channel. Removal of LWD from stream channels has reduced bed stability and scour resistance. Both LWD removal and the confinement of flood flows to the main channel have increased the frequency and severity of streambed scour with negative consequences for summer chum incubation survival.

Human changes to Hood Canal/Strait of Juan de Fuca stream ecosystems have thus diminished the natural resiliency of summer chum habitat, rendering populations more vulnerable to climate shifts. Climate shifts like those observed in the past 30 years, with their associated stream flow changes, likely have posed little threat to summer chum populations before the cumulative effects of habitat changes from human development became manifest. There are no streams within the region that have escaped such mistreatment, thus disentangling climate from human-induced impacts is highly problematic.

## 2.2.3 Ecological Interactions

The interactions of summer chum salmon with various species of fish, birds, and mammals is a normal part of their life history, and usually are in a state of dynamic equilibrium with co-evolved species. While these interactions include factors like nutrient contribution and cover, this discussion will focus only on competition for living space and food resources, and predation of one species on another. Fresh (1997) points out that extraordinary competition or predation impacts on salmonids are often the consequence of an alteration of the natural life history processes of the interacting species. For example, hatchery programs can increase the numbers of potential competitors and/or predators, or over-harvest can reduce population abundance to the point that predation mortality becomes depensatory, and holds prey populations at a very low level.

In a review of the available literature dealing with the effects of competition and predation on Pacific salmon, Fresh (1997) reports that; "... 33 fish species, 13 bird species, and 16 marine mammal species are predators of juvenile and adult salmon." Emmett et al. (1991) state about juvenile chum salmon: "In freshwater and estuarine environments, this species' primary predators are probably other salmonids." Salo (1991) reviews a variety of studies which showed freshwater predation mortality rates for chum salmon fry averaging from 22-58%, with extreme ranges of 2-85%. Major freshwater predator species identified include; coho salmon, cottids, trout, and char. Predation is the primary cause of chum fry mortality in the estuarine environment; with major predators being other salmonids, various nearshore marine fish species, and a variety of predatory birds (Emmett et al. 1991). At sea, lamprey, shark, other large predatory fish, and several types of marine mammals are the most significant predators (Emmett et al. 1991).

A variety of fish species potentially can compete for food resources with chum salmon, however, Bakkala (1970) states that the other species of Pacific salmon are principle competitors of chum salmon. The effects of this competition between salmon species can be substantial, as evidenced by the strong two year cycles in chum salmon abundance when the juvenile chum salmon compete for common food resources with biennially abundant pink salmon juveniles (Gallagher 1979, Ames 1983, Salo 1991, Johnson et al. 1997). Salmonids can also compete for spawning sites when adult run timing and spawning distributions overlap (Bakkala 1970).

Conspecific competition with fall chums, of both wild and hatchery origin, can be a major concern. Wild fall chum salmon are currently very abundant in Hood Canal streams, and although they do not directly compete with summer chum salmon for spawning sites because of temporal separation, the construction of redds by fall chum could potentially cause the loss of previously deposited summer chum eggs and alevins because of redd disturbance.

The large magnitude of the hatchery fall chum salmon program in Hood Canal has raised concerns about the potential impact on summer chum salmon (WDFW and WWTIT 1994, Johnson et al. 1997). The combined numbers of wild and hatchery produced chum fry entering Hood Canal in recent years likely exceeds past historic, wild-only juvenile population levels. Both the numbers and timing of releases suggest that there may be possible negative competitive impacts on summer chum salmon stocks. Hatchery programs for other species of salmonids have in some cases been intense, and the potential for both competitive and predatory impacts on summer chum salmon juveniles has been identified (WDFW et al. 1993, Johnson et al. 1997, Tynan 1998).

Beginning with the 1992 brood, summer chum salmon supplementation programs were initiated at the USFWS hatchery on the Big Quilcene River and by Wild Olympic Salmon on Salmon Creek. Since summer chum salmon have not been artificially propagated in the Hood Canal or Strait of Juan de Fuca regions during the 1970s and 1980s, hatchery propagated summer chum could not have contributed to the recent decline of the wild populations.

The following section reviews existing information on the possible effects of competition and predation on Hood Canal and Strait of Juan de Fuca summer chum salmon populations. Various wild and hatchery salmonids, marine fish, birds, and marine mammals are discussed.

### 2.2.3.1 Wild Fall Chum Salmon

Fall chum salmon populations are present in each of the Hood Canal streams currently supporting summer chum salmon. Of the streams used by summer chum salmon in the eastern Strait of Juan de Fuca, only the Dungeness River also has a fall chum salmon population. In Hood Canal, the differences in timing between the summer and fall chum adult return and spawning periods precludes direct interactions in the spawning streams between adults of the two run timings (WDFW and WWTIT 1994). The later spawning fall fish, however, could cause negative impacts on summer chum salmon, by physically disrupting their redds and increasing the mortality of the incubating eggs and alevins.

**Fall Chum Salmon**

***Stocks of chum salmon that return from October through December, and spawn from November to January in Hood Canal streams. Fall chum stocks are genetically distinct from summer chum salmon.***

Hood Canal fall chum salmon generally spawn farther upstream than summer chum salmon, but, there is overlap of spawning grounds in all streams. In the case of streams with migration barriers the degree of overlap can be extensive. The much higher stream flows that are typical of the November-January spawning period of fall chum can result in the selection of individual spawning locations away from the low water, mid-channel, redd sites of summer chum salmon. As stream flows increase, preferred spawning depths and velocities occur nearer to the shoreline, and spawners tend to select spawning sites closer to the margins of the stream, away from center channel (Ames and Beecher 1995). This type of partitioning of spawning riffles can moderate the effects of redd superimposition, and may in part explain how summer and fall spawning chum salmon can coexist in the same stream. Another factor mitigating the impacts of the disturbance of summer chum redds, is that the eggs of summer chum salmon should have developed to the eyed stage by the time that native fall chum arrive to spawn, and should be able to physiologically tolerate a modest amount of shifting and movement caused by redd superimposition.

Another type of potential competition between the two forms of chum salmon would occur during the juvenile estuarine and inshore marine waters feeding and growth phases. It has been suggested that artificially produced fall chum salmon may pose an ecological risk to summer chum salmon because of increased competition for food resources (Johnson et al. 1997). Wild fall chum salmon could potentially have an impact if sizeable populations have substantial temporal and spacial overlaps with summer chum salmon in estuarine or inshore marine waters. This is not the case, however, since there are distinct temporal variations in the early life histories of the summer chum and wild fall chum stocks in this region.

For wild fall chum salmon to have contributed significantly to the observed decline of Hood Canal summer chum salmon, either as adult or juvenile competitors, a major increase in population size over pre-decline levels would be necessary. Table 2.6 presents the 1974-1997 escapements of Hood Canal summer and fall chum salmon in common streams summarized as five-year averages (more detailed descriptions are provided in Table 1.2 and Appendix Table 1.1). For the 1974-1978 periods, average escapements to common streams, are similar for both chum salmon forms, but during the 1979-1983 years both summer and fall chum escapements have dropped precipitously. Fall chum bottom out with a low escapement of 2,766 spawners to summer chum streams in 1983, and then begin to display an increasing trend (Appendix Table 2.3). During the most recent five years, escapements of fall chum have averaged over 88,000 spawners. The similar performance of the two forms of chum salmon, in terms of escapements, during the periods immediately before and after the summer chum salmon decline does not suggest a major change in the potential interactions between the summer and fall fish. The large 1994-1998 increase in fall chum escapements that has occurred in concert with the improved summer chum escapements during the same years also suggests that competition between wild summer and fall fish is not a significant limiting factor. It is likely that the differences in life history timing are sufficient to allow the two forms to coexist in the freshwater and marine environments (see discussion of timing differences in the Hatchery Fall Chum section below).

**Table 2.6.** Five year average escapements of Hood Canal summer and fall chum salmon to those streams with summer chum populations (1974-1998).

| Return years | Summer chum escapements | Fall chum escapements |
|---|---|---|
| 1974-78 | 17,773 | 20,006 |
| 1979-83 | 3,238 | 5,257 |
| 1984-88 | 1,760 | 16,919 |
| 1989-93 | 978 | 29,816 |
| 1994-98 | 9,078 | 88,599 |

The abundant fall chum may have an unique positive interaction with summer chum salmon, by helping to stabilize stream beds and minimize flood effects on summer chum salmon. In a study of chum salmon spawning in Kennedy Creek (south Puget Sound), Montgomery et al. (1996) has found that the sorting of stream gravels by mass spawning of chum salmon stabilizes the stream-bed, which leads to a reduced probability of erosion during subsequent high flow events and reduces the loss of chum salmon eggs and alevins. These authors also point out that the feedback system between mass spawning and streambed stability can be interrupted by a declining spawner population trend, adding to the difficultly of recovering a depressed salmon stock. In the case of Hood Canal summer chum salmon, it may be that the abundant mass-spawning fall chum salmon are contributing to stream-bed stability conditions, benefitting both summer and fall populations.

### 2.2.3.2 Hatchery Fall Chum

The artificial propagation of fall chum salmon at hatcheries in the Hood Canal region over the last 20 years has been very successful, producing adult returns numbering from 100,000 to over 600,000 fish each year (Tynan 1998). The large returns result from chum salmon propagation programs at five hatcheries that release juveniles into the waters of Hood Canal (two WDFW hatcheries, one USFWS hatchery, and two tribal hatcheries). In addition to the formal hatchery programs, numerous Volunteer Enhancement Program remote site incubators (RSI) release unfed fry into a number of Hood Canal streams.

As reported by Johnson et al. (1997), the artificial propagation of chum salmon began in 1905 at a state hatchery in the Skokomish system, and expanded in 1911 and 1912 at USFWS hatcheries on the Duckabush and Big Quilcene rivers. The USFWS program originally included both summer and fall chum salmon, however, summer chum production was dropped at the two stations after 1937 at Big Quilcene and after 1942 at Duckabush (Cook-Tabor 1994). The Hoodsport fall chum salmon program began in 1953, when the hatchery facility first became operational, and has been built solely from native Finch Creek fish (Tynan 1998). In 1976, George Adams and McKernan hatcheries (WDFW) began to release fall chum salmon (Finch Creek stock) into the Skokomish system. In 1977, Enetai Hatchery (Skokomish Tribe) began to release Quilcene stock fall chum salmon into a small independent stream located just north of the mouth of the Skokomish River. That same year, the Port Gamble Hatchery (Port Gamble S'Klallam Tribe) initiated releases of Quilcene stock fall chum but switched to Finch Creek stock by 1979.

The WDFW Hoodsport Hatchery on Finch Creek has been the largest fall chum salmon program in Hood Canal over the last three decades. During the early years, the hatchery's goal was to take enough chum eggs to keep a maintenance run at the station, however, in 1968 the objectives changed to take as many eggs as possible (Schwab 1974). Current goals for the WDFW Hood Canal fall chum salmon hatchery program are to enhance tribal and all-citizen commercial fisheries, enhance a local Hoodsport vicinity recreational fishery, and provide eggs in support of the Skokomish system hatcheries and Volunteer Enhancement Program cooperative projects (Tynan 1998).

Annual egg take goals, as specified in the 1986 Hood Canal Salmon Management Plan, are for sufficient eggs for the release of 40 million fry (subsequently reduced to approximately 36 million fry), plus additional eggs (if available) to support the operations of local enhancement groups. The annual releases of all Hood Canal WDFW hatchery produced fall chum salmon (1969-1993 brood years) range from a low of approximately 984,000 fish for 1969 brood to a high of 50,330,000 fish from the 1984 brood, and average 24,042,000 fish over the entire period (see Appendix Table 2.4). An average of approximately 5 million additional juvenile chum salmon are released from the tribal and federal hatcheries (Johnson et al. 1997), and the Volunteer Enhancement Program has released of an average of 5.25 million fish between 1990 and 1994 (Tynan 1998). In total, these large numbers have generated concerns that the fall chum salmon hatchery program in Hood Canal could have a potentially negative competitive impact on summer chum salmon (WDFW and WWTIT 1994, Johnson et al. 1997).

There is a general correlation between the increasing hatchery fall chum salmon program and the decline in summer chum salmon. The 1975 and 1976 brood years of Hood Canal summer chum salmon declined abruptly in abundance, as evidenced by adult escapements in 1979. The WDFW hatchery fall chum salmon program expanded substantially in the early-1970s, increasing from a 1972 brood release of 1.0 million, to 3.4 million for the 1973 brood, and 9.4 million for the 1974 brood (Table 2.7). Another major production jump occurred with the release of 29.6 million 1978 brood fall chum salmon.

While these expansions of hatchery fall chum releases have occurred during the general time frame of the summer chum collapse, they are out of synchronization by several years. The increased hatchery releases of 1973 and 1974 broods should have directly impacted the returns of age-3 and age-4 summer chum salmon in 1976, 1977, and 1978, and the 1978 hatchery increase should have affected the 1981 and subsequent broods (Table 2.7). The 1979 summer chum salmon decline falls between these two periods of change in hatchery fish abundance. One possible explanation for this lack of direct synchrony is that it may have taken two years of increased hatchery releases to depress invertebrate prey abundance to the point that summer chum salmon juveniles were affected. If this scenario actually occurred, the 1974 brood releases of 9.4 million fall chum salmon would have over-cropped invertebrate prey resources in the canal, contributing to lowered prey reproduction the following spring, and reduced production of food resources for the competing 1975 brood hatchery fall (8.5 million release) and wild summer chum juveniles.

Countering the theory of hatchery fall chum salmon competitive impacts is survival data for Hoodsport Hatchery fall chum salmon showing that both the 1974 and 1975 broods experienced above average marine survivals. If food resources had become limiting to the point of causing the observed decline in 1975 brood summer chum salmon, the hatchery fish should have displayed a corresponding drop in survival. Another argument that counters the general negative correlation between hatchery fall chum releases and summer chum salmon status is that the returns of summer chum salmon have increased substantially in recent years, with roughly four times as many hatchery chum released into Hood Canal as was the case in the mid-1970s (Table 2.7).

Since the hatchery and summer chum discussion above does not clearly resolve the issue of the possible contribution of the hatchery fall chum program to the summer chum salmon decline, the following section will review the available research on the ecological relationships of chum salmon in Hood Canal.

**Juvenile chum salmon in the Hood Canal estuary** - A considerable body of scientific literature exists on the subject of the ecological relationships of chum salmon in Hood Canal. Nearly all of these studies have been conducted by researchers from the University of Washington, in part to determine the potential impacts of the construction and operation of the Bangor Naval Base. While these studies are not always able to specifically look at differences between summer and fall chum salmon, they do offer a broad picture of juvenile chum salmon life history in Hood Canal.

**Table 2.7.** Total brood year releases of WDFW hatchery fall chum to the waters of Hood Canal, and return years as age-3 and age-4 adults (1969-1998 broods).

| Brood year | Total releases | Return years (age 3 & 4 fish) |
|---|---|---|
| 1969 | 938,788 | 1972, 1973 |
| 1970 | 1,447,406 | 1973, 1974 |
| 1971 | 1,363,110 | 1974, 1975 |
| 1972 | 1,039,168 | 1975, 1976 |
| 1973 | 3,374,966 | 1976, 1977 |
| 1974 | 9,408,285 | 1977, 1978 |
| 1975 | 8,465,125 | 1978, 1979 |
| 1976 | 13,679,756 | 1979, 1980 |
| 1977 | 7,939,467 | 1980, 1981 |
| 1978 | 29,606,329 | 1981, 1982 |
| 1979 | 39,110,094 | 1982, 1983 |
| 1980 | 36,340,223 | 1983, 1984 |
| 1981 | 16,859,884 | 1984, 1985 |
| 1982 | 35,905,744 | 1985, 1986 |
| 1983 | 28,325,669 | 1986, 1987 |
| 1984 | 50,330,002 | 1987, 1988 |
| 1985 | 36,535,000 | 1988, 1989 |
| 1986 | 40,400,100 | 1989, 1990 |
| 1987 | 40,122,500 | 1990, 1991 |
| 1988 | 35,217,100 | 1991, 1992 |
| 1989 | 34,521,500 | 1992, 1993 |
| 1990 | 19,619,100 | 1993, 1994 |
| 1991 | 38,639,100 | 1994, 1995 |
| 1992 | 39,652,200 | 1995, 1996 |
| 1993 | 33,205,650 | 1996, 1997 |
| 1994 | 37,860,000 | 1997, 1998 |
| 1995 | 34,324,091 | 1998, 1999 |
| 1996 | 34,508,783 | 1999, 2000 |
| 1997 | 25,388,986 | 2000, 2001 |
| 1998 | 24,344,935 | 2001, 2002 |

The following quotations are from a WDFW discussion of the subject (Crawford 1997).

***Spatial overlap or separation during migration*** - Historical release strategies (fed vs. unfed fry) and release sizes (size range from swim-up to 1.2 gm) during the pre-April 1 time period (see Appendix Table 2.4) are important factors to adequately assess the likelihood for the co-occurrence, and hence competition, of hatchery fall chum and summer chum in the Canal.

> "Schreiner (1977) reported that migrating chum fry in Hood Canal remained in near-shore areas until reaching a length of 45-50 mm, when the chum were observed to move to deeper off-shore areas. Other authors also reported that chum released from Hood Canal hatcheries at or near this size range early in the season tended to migrate rapidly northward and into offshore areas (Whitmus and Olsen 1979; Prinslow et al. 1979; Prinslow et al. 1980; Salo et al. 1980; Bax and Whitmus 1981; Whitmus 1985). A 45 mm chum weighs 0.73 grams (or 622 fpp), which is comparable to the 0.66 gram (686 fpp) average size of fed fall chum released prior to April 1 from the Hood Canal hatcheries (Table I). Bax (1983) observed that wild chum migrating prior to April showed little

> change in length as time progressed, averaging 35-44 mm in fork length (Schreiner 1977; Bax et al. 1978). The best scientific information would suggest that fed fall chum fry of the average size released from Hood Canal hatcheries pre April 1 do not share the same feeding and/or migratory areas as summer chum. Unfed fry groups released from the hatchery facilities prior to April 1 have a greater likelihood for interaction with summer chum, as they are of similar, if not the same size, and likely use the same nearshore areas for foraging during migration."

***Food item overlap during migration*** - The differences in types of prey that are predominantly taken by chum fry of differing sizes (and foraging in differing areas) must be considered to adequately assess the potential for competition between hatchery fall chum and wild summer chum.

> "Bax et al. (1978) and Simenstad et al. (1980) reported that immediately upon entry into Hood Canal small (30-40 mm fl) juvenile chum fry (of naturally-producing populations or from the Big Beef Creek spawning channel) captured in nearshore areas during out- migration in Hood Canal fed primarily on epibenthic organisms, mainly harpacticoid copepods, gammarid amphipods, polychaete annelids, and crustacean eggs. After the fish grew larger than 45-55 mm fl (or entered the Canal at this size from hatchery facilities) and moved to off-shore areas, they fed mainly upon pelagic organisms, such as euphausids, calanoid copepods, and hyperiid amphipods. Simenstad et al. (1980) also reported on the effect of fish size upon selection of foraging habitat by illustrating comparative prey spectra of chum fry captured via beach seine in shallow sublittoral habitats with the prey spectra of tow-net caught chum (recognizing that the size of chum increases with increasing distance from shore). Larvaceans and harpacticoids comprised over 60 % of the total prey spectrum of chum captured in nearshore areas, whereas over 85 % of chum captured off-shore was euphausids, calanoid copepods, and hyperiid amphipods (Simenstad et al. 1980). The best scientific information would suggest that fed fall chum fry of the average size released from Hood Canal hatcheries before April 1 and wild summer chum have a low likelihood of diet overlap during migration."

***Rapid out-migration during February-March time period*** - The tendency of juvenile chum entering the Canal before April 1 to outmigrate rapidly should be considered in any assessment of the likelihood for resource competition.

> "As reported in Simenstad et al (1980), chum fry entering the Canal early in the outmigration period (February-March - the summer chum fry migratory period) generally encounter a naturally low abundance of prey resources, and rapid outmigration may be one behavioral response to this low availability. Salo et al (1980), Prinslow et al. (1980), Bax (1982), and Bax (1983) all report rapid out- migration and short residence time for juvenile chum in the Canal during this time period. The fact that chum entering the estuary during February and March migrate out of the Canal quickly does not lend well to an argument for resource competition between summer chum and hatchery-origin fall chum. The likelihood is that the duration of interaction between these groups is minimal."

**Timing of fall chum releases -** Prior to the late 1970s, the releases of fed (reared) fall chum fry for Hood Canal hatcheries all have occurred after April 1 (Appendix Table 2.4), with average release dates in the first week of May (Tynan 1998). This release schedule has provided substantial separation between summer and hatchery fall chum juveniles; with the summer fish having a peak Hood Canal exodus timing of April 1- April 3, and completing emigration from the canal around the first of May (Tynan 1997). In 1992 and 1993, pre-April hatchery chum fry releases into Hood Canal total 19.7 million and 28.6 million fish respectively (Appendix Table 2.4 - note that release year is the year following brood year shown in table).

Again, the following quotations are from Crawford (1997):

> "The primary annual production objective of fall chum hatcheries in Hood Canal is the release of one gram fed fry after 30 to 60 days of rearing (50 mm average fl, or 450 fpp) in April or May. Chum released at this size have been shown to have higher survival rates to adult return in Hood Canal (H. Fuss, WDFW personal communication 4/1/97). The April-May release timing of these fish into Hood Canal coincides with the emergence and marine out-migration timing of wild fall-run chum, which enter seawater at a smaller size (0.37 gram avg. (Koski 1975), or 35-40 mm avg. fl (Schreiner 1977)). During years of good hatchery growth (warm rearing water, good husbandry practices), or in years when hatchery pond space used for fall chum was limiting, fed fall chum have been released earlier than April. Out of an average total fall chum fed fry release from WDFW hatcheries in Hood Canal of 20,899,836 (1970-94 data, range of 795,040 - 45,955,845), an average of 6,125,158 (range 0 - 20,073,200) or 29.3 % of the total annual production (range 0 % - 64.9 %) have been released prior to April 1. These pre-April 1 release fed fry have ranged in size from 0.36 to 1.2 grams (39 - 54 mm fl) and have averaged 0.66 grams (44 mm fl) between 1970 and 1994.
>
> Hood Canal hatchery facilities also have produced unfed fall chum fry. These fish have generally been produced in remote site incubators, and released without any rearing at a size of 0.34 to 0.38 grams (35-40 mm) upon swim-up. On average, 49.2 % (1970-94 data, range 0 % - 100 % of the unfed fry groups have been released in February or March. Annual unfed fry releases in Hood Canal have averaged 3,142,224 (range 0 - 8,744,000), with 1,545,856 (range 0 - 8,494,000) of the total released prior to April 1 on average.
>
> In the NMFS document "Review of Information on Hood Canal Summer Chum Salmon ESU collected in 1995 and 1996", it is noted that 1992 brood year summer chum returns to the western tributaries and Quilcene Bay were very strong, exhibiting some of the highest apparent recruit per spawner rates that have been documented for Puget Sound chum. As discussed above, hatchery release data for 1992 brood fall chum indicate that over 20,000,000 fed fry and over 8,400,000 unfed fry were released from Hood Canal hatcheries prior to April 1, 1993, coincident with the out-migration of this extremely successful 1992 summer chum brood. The pre-April 1 fall chum liberations that year were 3.3 times greater than 1970-94 average fed fry levels and 5.5 times greater than 1970-94 average unfed fry release levels. Collectively, the pre-April 1 fall chum fed and unfed fry releases coincident with the migration period of 1992 brood summer chum in 1993 were the largest on record (see attached Appendix Table 2.4).
>
> The fact that 1992 brood wild summer chum exhibited such high survival in the midst of the largest pre-April 1 fall chum hatchery releases into Hood Canal on record does not support an argument for negative impacts of competition between wild summer chum and hatchery fall chum during this time period. Based upon the performance of the 1992 brood summer chum, we could in turn speculate that the magnitude of pre-April 1 hatchery fall chum releases in 1993 effectively minimized the effects of predation on commingled 1992 brood wild summer chum by swamping potential predators with alternative prey."

**Remote site incubators -** Enhancement of chum salmon using remote site incubators (RSI) has occurred within the region, with 17 sites identified on Hood Canal and Strait of Juan de Fuca streams by Johnson et al. (1997). Summer chum have not generally been included in the RSI program; the exceptions being the recovery projects at Salmon Creek, Lilliwaup, and Hamma Hamma, and the efforts to reintroduce summer chum salmon to Chimacum and Big Beef creeks.

The RSI program began to release substantial numbers of fall chum salmon unfed fry into Hood Canal streams in 1978. For brood years 1978 through 1993, an average of just under 5 million (range 0 - 8.7 million) fall chum unfed fry were released annually from all facilities, including RSIs (Appendix Table 2.4). While the RSI releases have not been totaled separately, they make up approximately 6% of the overall unfed fry released annually. Not all of the RSI release sites are on summer chum salmon streams. For example, in review of fall chum salmon RSIs on the streams of west Kitsap Peninsula, only half of the projects are located on summer chum salmon streams (Turner 1995). The first major releases occurred in 1978 (adults returning in 1981-1983), which does not match with the summer chum decline beginning with the 1975 and 1976 broods.

The numbers of unfed fry released are small when compared to the tens of millions of fed chum fry produced in Hood Canal hatcheries. It is unlikely that the RSI program have contributed to the observed decline of summer chum salmon, because of the relatively small release numbers, and because the inception of the program is several years out of synchronization with the decline.

**Conclusions** - The recent success of summer chum, in the face of very large hatchery releases of fall chum, suggests that competitive interactions have not been a significant contributor to the decline of summer chum salmon. Additionally, the lack of direct synchrony between hatchery releases and changes in summer chum abundance, and the ecological differences between summer and fall chum in marine waters, support the likelihood of minimal interactions. A possibility that must be considered is that the apparent negative correlation between hatchery fall chum salmon and the decline of summer chum salmon may simply be a coincidence. There is still uncertainty surrounding the issue of juvenile fall and summer chum interaction, and further investigation may be warranted.

### 2.2.3.3 Other Salmonids

Summer chum salmon share spawning streams, estuaries, and nearshore marine waters with a number of other salmonids in addition to fall chum salmon. These other salmonids include wild and hatchery origin chinook, coho, and pink salmon, and steelhead and cutthroat trout. The wild populations of these species have not increased during the periods of summer chum salmon decline (pink salmon excepted), and it is unlikely that they have contributed substantially to the observed changes in summer chum status. However, there has been a general concern expressed about the possible effects of outplanting of hatchery chinook, coho, and trout in summer chum streams (WDFW and WWTIT 1994, Johnson et al. 1997, Tynan 1998). There are several levels of concern; adult competition for spawning sites, juvenile competition for food, and predation on juvenile summer chum.

There have been several investigations into the interaction between salmonid species in the region (Schreiner et al. 1977; Simenstad and Kinney 1978; Prinslow et al. 1980; Bax et al. 1980; Simenstad et al. 1980; Whitmus 1985 among others). Based on studies in Hood Canal, Simenstad and Kinney (1978) and Prinslow et al. (1980) conclude that predation on chum salmon by other species, including salmonids, in the open waters of Hood Canal is insignificant. However, a number of authors studying early marine migration behavior for chum in Hood Canal report significant, high mortality levels during the first few days of residence in the estuary that may be caused by predation.

Fluorescent pigment-marked chum salmon released from Big Beef Creek during February in 1978 and 1979 had mortality rates of 29 % and 49 % of the population, respectively, during the first two days in the estuary (Salo et al. 1980). Prinslow et al. (1980) reported a survival rate of 44 % (mortality rate of 56 %) for the 1978 brood chum migrating from Big Beef Creek after four days. Whitmus (1985) documented a mortality rate of 58 % and 74 % over 2 days for 45 mm chum fry released in two groups during early

May from Enetai Hatchery in Hood Canal. Bax (1983a) reported average daily mortality rates for Enetai fall chum of between 31 % and 46 % over a two and a four day period. Predation by cutthroat trout and marine birds was thought to account for the mortality of chum juveniles released from Enetai (Whitmus 1985), and Bax (1983) hypothesized that high susceptibility to predation and attraction of predators to the chum fry release location were responsible for high mortality rates estimated in his study.

Considerable uncertainty exists regarding the adverse effects of species released in regional hatcheries on chum salmon through competition. Chum and pink salmon have been shown to use the same nearshore beach environment during their initial period of residence and prey upon the same sublittoral epibenthic crustacean populations during emigration (Schreiner et al. 1977). Ames (1983) has conducted a preliminary examination of the interactions between the salmon species in Hood Canal, and has identified only pink and chinook salmon as possibly having a negative impact on chum salmon survivals. This is a limited study that examines only short-term data sets from before 1979, and does not include the trout species.

The following discussion will consider the general interactions known to occur between the various species. The risks to summer chum of hatchery programs producing other salmonid species in the region are assessed in a separate section of this plan (3.3 Ecological Interactions). The following text summarizes information more fully detailed in section 3.3 regarding hazards, interactions, and potential effects to summer chum that may result from the hatchery production of chinook, coho, and pink salmon, and trout species within the Hood Canal and Strait of Juan de Fuca regions.

**Summer chum juvenile timing** - The potential impacts on summer chum salmon associated with the releases of hatchery origin salmonids are largely controlled by the degree of overlap in the timing of releases compared to the timing of juvenile chum life history stages. Many releases of hatchery fish are timed to avoid significant interactions with sensitive species.

The critical survival periods for summer chum salmon are the incubation, emergence and emigration stage in freshwater, and the early marine emigration period. Tynan (1997) has summarized, and estimated from available field studies, juvenile timing of Hood Canal and Strait of Juan de Fuca summer chum salmon, and the following information is taken from that assessment. The ranges of dates presented below represent the earliest beginning date and latest ending date observed (or estimated), and chum of a particular life stage would not necessarily be present through the full range of these dates every year (see Tynan 1997). Summer chum eggs are estimated to be present in the "tender stage" in stream gravels from early September through early November in an average year. This period can be viewed as the time when summer chum eggs are most vulnerable to disturbance during incubation. Estimated emergence timing for Hood Canal summer chum salmon ranges from February 7 to April 14, with an average peak of March 18 for east side stocks, and March 27 for westside stocks. For Strait of Juan de Fuca stocks, the emergence timing ranges from February 15 to May 26, with a April 5 average date for the peak. Since nearly all chum salmon fry emigrate to sea immediately following emergence from the gravel, the same dates represent both emergence and emigration. Estimated summer chum salmon juvenile departure dates from Hood Canal range from February 21 to April 28, with an April 2 average peak date. Strait of Juan de Fuca summer chum are estimated to be present in inshore waters ranging from February 28 to June 8, with an April 17 average peak.

**Steelhead and cutthroat trout -** Because of major differences in the life histories of chum salmon and the trout species, substantial juvenile and adult competition between chum salmon and trout is unlikely. It is known, however, that sea-run cutthroat trout are predators on juvenile salmonids in the marine environment (Simenstad and Kinney 1978; Cardwell and Fresh 1979; Whitmus 1985). Steelhead trout released as yearling smolts during the summer chum emigration period are also viewed as posing a high predation risk in the freshwater and marine environments due to their large size relative to the chum fry (Fresh et al. 1984).

Most summer chum streams in the region have received steelhead out-plants within the past thirty years, and during the period of decline for summer chum in Hood Canal (Tynan 1998). The number of steelhead smolts planted has been reduced in recent years, from a 1965-98 average of 94,000 in Hood Canal to under 80,000 (1995-1998 release levels) (Appendix Figure 2.9). Steelhead releases in the Strait of Juan de Fuca region have been similarly reduced, to about 13,000 from a 1955-97 average of 19,000 (Appendix Figure 2.10). Also, steelhead are now released into only four watersheds within the Hood Canal and Strait of Juan de Fuca region: Skokomish River, Dosewallips River, Hamma Hamma River, and the Dungeness River. In Hood Canal streams, the normal release size for steelhead smolts has been 4-7 fish per pound (fpp) or 180 - 230 mm and this large size at release makes this species a potential predator on newly emerged chum salmon fry (Tynan 1998). The release of only smolts in the steelhead hatchery program enhances their tendency to immediately migrate to marine waters, which may extend the period of potential predation on chum salmon fry into the nearshore marine areas. Steelhead released in Strait of Juan de Fuca streams are of a similar size (3-6 fpp).

Sea-run cutthroat trout were released into several Hood Canal summer chum streams from the mid-1980s through the early 1990s, but, commencing in 1992, are no longer released into anadromous areas within the region (Appendix Figure 2.9). No streams in the Strait of Juan de Fuca region have been planted with sea-run cutthroat within the past 42 years (Tynan 1998). In previous years, an annual (1985-91) average of 27,000 sea-run cutthroat were released into Hood Canal streams at a size of 4-16 fpp (128-230 mm). The piscivorous nature of the species and the large size at release relative to emigrating summer chum elevates the likelihood that the species preyed on emigrating chum, including summer chum. Several studies in Hood Canal document predation on chum salmon fry by sea-run cutthroat (Simenstad and Kinney 1978; Prinslow et al. 1980; Whitmus 1985).

The cessation of all hatchery sea-run cutthroat releases into anadromous waters within the region eliminates the need to consider their predation effects on summer chum. In large part the potential for hatchery steelhead predation on chum fry is mitigated by timing of releases. Steelhead smolt releases occur in April and May in both Hood Canal and the Strait of Juan de Fuca (Tynan 1998). In some years, when summer chum fry emergence extends until mid-April, steelhead smolts are released in summer chum streams while chum fry are still present. Additionally, these steelhead releases can have access to summer chum fry in marine waters until the end of April.

**Chinook and coho salmon -** Annual fall chinook salmon smolt releases from Hood Canal region hatcheries have averaged 6.1 million sub-yearlings and 226,000 yearlings since 1990 (Appendix Figure 2.11). Releases of this species into Hood Canal were quite low during the late 1970 period of summer chum decline relative to late 1980 levels. Chinook smolt out-plants in the region have declined significantly since 1989. Strait of Juan de Fuca region chinook production was low to non-existent between 1974 and

1994. Recent year chinook releases into summer chum streams (the Dungeness River) have been 975,000 sub-yearlings, 200,000 fingerlings, and 800,000 fed fry Appendix Figure 2.12). Appendix Figures 2.13 and 2.14 present annual coho salmon juvenile release levels into the same summer chum regions. Annual coho juvenile release levels have remained quite stable across the last twenty years, with the exception of unfed fry releases, which were discontinued in the early 1990s.

Hatchery-origin chinook and coho salmon smolts are thought to pose a high risk of a significant negative impact on wild chum salmon due to predation in freshwater and nearshore estuarine areas where the species co-occur (Fresh et al. 1984). Coho salmon are of special concern for predation effects due to their large size at release as yearling smolts (average release size 10 - 17 fpp, or 130 - 160 mm) relative to the size of emigrating wild summer chum (1,000 - 1,200 fpp, or 35-39 mm) (Tynan 1998). Most chinook salmon are released from hatcheries as sub-yearlings, averaging 65-80 fpp, or 80 - 86 mm), making predation on emigrating chum salmon unlikely. Yearling chinook salmon released from net-pens in Hood Canal at an average size of 5 fpp (195 mm) likely pose a predation risk to summer chum fry if present in estuarine areas during the summer chum emigration period.

Extensive stomach content analysis of coho and chinook salmon smolts in Hood Canal show only minimal evidence of predation on other salmonids, including chum salmon (Simenstad and Kinney 1978; Whitmus 1985). Although these species were captured in the same seine sets during the predation studies, they may not have been occupying the same area, leading to the observations of no predation by coho and chinook smolts (Whitmus 1985). Visual observations prior to seining in the Whitmus (1985) study indicate a potential for horizontal segregation of chum and coho smolts when coho are very abundant in areas where chum are also present.

Due to a freshwater entry timing similar to summer chum, non-indigenous-origin fall chinook adults planted in, or straying into, summer chum streams may compete for spawning sites, and may disrupt summer chum survival through redd superimposition. Although there are no direct studies to evaluate actual effects on summer chum productivity, hatchery-origin fall chinook have been routinely observed spawning in the same areas used by indigenous summer chum populations (R. Egan, WDFW, pers. comm., August 1999).

Like hatchery steelhead releases, the risk of predation by hatchery-origin chinook and coho salmon yearling smolts is largely mitigated by the late timing of yearling and sub-yearling releases from regional hatchery facilities relative to the estimated summer chum emigration period. Yearling sub-yearling chinook salmon smolt releases occur in early May and early June respectively in Hood Canal, where all of the fall chinook within the summer chum region are produced. Dungeness native-origin chinook sub-yearling smolts are released into Strait of Juan de Fuca waters between mid-June and mid-July, a period well past the March-April summer chum fry emigration (Tynan 1998). The risk of competition posed by fall chinook on the spawning grounds can be minimized by discontinuance of fall chinook releases that are not part of a formal recovery program into summer chum streams.

**Pink salmon** - The Dosewallips, Duckabush, and Hamma Hamma rivers support separate stocks of pink salmon, and limited numbers of this species are occasionally observed in the Big Quilcene River and Lilliwaup Creek. Pink salmon spawn in these streams (odd-years only) in September and October; the same spawning period as summer chum salmon. Potential interactions between the two species would include competition by adults for spawning sites, redd superimposition, and competition for food resources in the estuary and marine waters. Since pink salmon are only present every other year, any significant negative impact on summer chum salmon should result in a biennial pattern in the survival and return rates of summer chum. The ecological similarities in the life histories of pink and chum salmon do result in lower returns of chum salmon in dominant pink return years throughout the range of the two species (odd-years for southern populations and even-years in northern areas). Competition between juveniles in marine waters is the most likely explanation for this effect (Gallagher 1979, Ames 1983, Salo 1991). For local summer chum salmon stocks, however, there is no obvious short-term cyclic effect in the years following the 1979 summer chum decline, i.e. no changes in the return rates of just the odd-year chum salmon brood years. To the contrary, Hood Canal summer chum salmon are currently the most successful in streams that they co-habit with pink salmon, which argues against a substantial change in the competitive interactions between these species.

There is an artificial propagation program for pink salmon at the WDFW Hoodsport Hatchery that has operated since 1953. This program has released an average of approximately 1.5 million pink fry per year (Tynan 1998) (Appendix Figure 2.15). There is no indication that these releases have contributed to the summer chum decline. However, to minimize the likelihood for adverse effects, attempts are being made to minimize interactions between hatchery pink salmon releases and summer chum by delaying pink salmon releases until after April 1.

**Current Hatchery Programs** - As addressed in the previous section, the hatchery-induced hazard that has had the highest potential to have negatively affected summer chum is competition in the estuary posed by fall chum salmon released during the summer chum emigration period. Although no adverse effects on summer chum survival resulting from past early liberations of fall chum are readily evident, it is possible that fall chum compete for limited food resources available in Hood Canal during their early spring migration.

Although steelhead smolts are currently truck-planted into several summer chum streams within the region, the late planting date of the fish relative to the summer chum emigration period likely prevents interaction between the two species, and adverse effects. Due to their piscivorous nature and continuous presence in nearshore estuarine areas, past production of sea-run cutthroat may have had negative predation effects on summer chum. The cutthroat program has been discontinued and adverse effects posed to summer chum are therefore no longer a concern.

Releases of fall chinook and coho salmon smolts, as presently practiced in the region, are judged to not pose risks of predation to summer chum. These two species are released from regional hatcheries much later than the summer chum emigration period, reducing the likelihood for interaction. Extensive stomach content analyses of coho salmon smolts collected during University of Washington Fisheries Research Institute studies in Hood Canal, as well as those in northern Puget Sound, the Strait of Juan de Fuca, and Nisqually Reach do not substantiate any indication of significant predation upon juvenile salmonids in Puget Sound marine waters (Simenstad and Kinney 1978). Similarly, Hood Canal, Nisqually Reach, and north Puget Sound data show little or no evidence of predation on juvenile salmonids by juvenile and immature chinook (Simenstad and Kinney 1978). Although available studies indicate that predation on juvenile salmonids, including summer chum fry, is not of great concern, release practices that ensure spatial and temporal separation between hatchery fall chinook and coho and summer chum should be continued.

Further studies are needed in nearshore areas to fully evaluate the risk of predation to summer chum emigrants posed by resident chinook and coho resulting from the Hood Canal hatchery programs.

Pink salmon released from Hoodsport Hatchery in March may pose risks to summer chum fry through competition for food resources. Risks of adverse competitive effects posed by hatchery pink salmon are proposed to be addressed by delaying releases of these species until after the summer chum emigration period (post April 1). This practice may reduce the likelihood for interactions between the two species, minimizing the risk of food resource competition. However, it is unclear if this measure can be practically met due to the early timing of pink egg takes and emergence periods in the hatchery, which makes holding pink salmon through April 1 problematic. Also, benefits to emigrating summer chum afforded by "swamping" of predator populations by hatchery pink releases will be forgone with this practice.

**Conclusions** - While there are uncertainties about the effects of competition and predation by salmonids on summer chum salmon, because of the magnitude of hatchery releases during the 1970s and early 1980s these types of interactions likely have contributed to the decline of the summer chum stocks of Hood Canal. There is a low likelihood that Strait of Juan de Fuca summer chum stocks have been affected by releases of hatchery salmonids.

### 2.2.3.4 Marine Fish

Most marine fish species that inhabit the same waters as chum salmon are potential predators and/or competitors, particularly during juvenile chum salmon life stages. However, diet studies have shown that other salmonids are usually the principal predator/competitor species affecting chum salmon (Bakkala 1970, Emmett et al. 1991).

The status of bottom fish species in Hood Canal and the Strait of Juan de Fuca has been the subject of two separate WDFW stock status inventories; for bottomfish (Day et al. 1995), and for forage fish (Lemberg et al. 1997). These inventories tracked trends in marine fish populations using catch and effort statistics from recreational and commercial catches.

Most bottomfish species in the region have declined over the last three decades, possibly influenced by some of the same climate changes that have affected chum salmon. Catches of several species briefly increased in the late 1970s (e.g., dogfish and lingcod), however, this was due to higher exploitation rates in trawl fisheries and was not the result of increased abundance (Greg Bargmann, WDFW, pers. comm.).

The forage fish species are predominately represented by Pacific herring in the marine waters of the region. Herring assessment surveys have been conducted in multiple index areas in both Hood Canal and the Strait of Juan de Fuca since 1977, and show either stable (Hood Canal) or declining (Strait of Juan de Fuca) trends in abundance. The initiation of these surveys coincides with the PDO regime shift, and there are no quantitative data from earlier years to indicate if herring abundance changed at that time. Anecdotal information suggests that regional herring populations have had similar abundances before and after the 1977 climate change (Greg Bargmann, WDFW, pers. comm.).

As pointed out above, the various local marine fish species are potential summer chum competitors and/or predators. However, based the abundance trends of these species over the past two decades, it is unlikely that extraordinary levels of predation or competition by bottom fish or herring have been a significant factor in the observed decline of summer chum salmon in Hood Canal or the Strait of Juan de Fuca.

### 2.2.3.5 Birds

Common Mergansers are well-known to feed on juvenile salmon during their downstream migration and could be taking summer chum fry. In marine waters, chum fry, including summer chum fry, in shallow near-shore areas are likely to be preyed upon by mergansers and double-crested cormorants and possibly by western and horned grebes (Dave Nysewander, WDFW, pers. comm.). Common mergansers have been observed herding chum fry into shallow water and feeding in McAllister Creek (south Puget Sound) (Bill Tweit, WDFW, pers. comm.). As chum fry grow and move away from the near-shore area, they are likely to be preyed upon by double-crested and pelagic cormorants, mergansers, pigeon guillemots, gulls (especially Bonaparte's), terns, loons, grebes, and rhinoceros auklets. Marbled murrelets are not considered to pose any significant threat to chum fry, because they are currently at depressed population levels, and because they are plankton and larval fish specialists. When juvenile chum enter the open ocean, deep-water bird predators include common murres, shearwaters, Brandt's cormorants and puffins. Only bald eagles and osprey are likely to prey on adult summer chum.

Very little is known about the extent of bird predation on chum salmon. A study of marks made by predators on juvenile chum captured by beach seine, purse seine, and trawl at a range of depths in Masset Inlet, British Columbia has found marks attributed to birds in 6% of chum juveniles captured (Dawe, unpublished results). The proportion of chum in this study which did not escape bird predators is unknown. Dawe reports pigeon guillemots preying on schools of juvenile pink salmon but does not mention observing them preying on chum.

The majority of information on long-term sea bird population trends within Washington State has been collected on the outer Washington Coast and at Protection Island (near Discovery Bay). Little information exists for the Hood Canal or Sequim Bay areas. On the outer Washington coast, common murres underwent a population crash from about 30,000 birds to 2,400 birds in 1983-84, as a result of the 1983 El Niño (Wilson 1991). The population has increased since then to perhaps 7,000 birds (Ulrich Wilson, USFWS, pers. comm.). The trend in the murre population on Tatoosh Island differs from that of the rest of the coast in that it peaked at about 3,100 birds in 1991 but has declined since then. Double-crested cormorants on the outer coast have had a sharp decrease in breeding success, if not in numbers of adult birds, from between 400 and 500 nests in 1982 to essentially none in 1983-84. They experienced another decline associated with a milder El Niño in 1987-1988 (Wilson 1991), but since have rapidly recovered in number both on the outer coast and in Puget Sound (Ulrich Wilson, USFWS, pers. comm.). Brandt's cormorants nesting success during the 1980s has been similar to that of double-crested cormorants, however, during the 1987-1988 El Niño, Brandt's cormorants crashed and recovered a year earlier than double-crested cormorants, presumably because they nest later than double-crested cormorants (Wilson 1991). The effects of the 1987-1988 El Niño may have occurred too late to affect nesting by double-crested cormorants in 1987 but in time to affect Brandt's. Similarly, the waning of El Niño effects in 1988 may have occurred too late for double-crested cormorants but in time to permit Brandt's to nest successfully. Pigeon guillemot numbers on Protection Island increased from 1976 to 1989 and have decreased since then. There has been a large reduction, perhaps as much as 95%, in the numbers of horned and red-necked grebes in the Strait of Juan de Fuca over the last ten years. Gulls on Protection Island have shown a small but probably non-significant increase in recent years (Ulrich Wilson, USFWS, pers. comm.). During the 1960s, the rhinoceros auklet population on Protection Island was low (5,000-6,000 breeding pairs) until sheep were removed from the island. The population has since increased, peaking at 17,000 breeding pairs in 1976, but has declined to about 12,000 pairs today (Ulrich Wilson, USFWS, pers. comm.).

Hodges et al. (1996) has compiled Alaska water bird population trend data based on aerial surveys from 1957 through 1994. Potential chum predators monitored include mergansers and loons. Pacific, arctic, common, and red-throated loons have all declined in number since 1977, while merganser numbers have increased since 1977. It is not known if the Alaska data are applicable to Washington.

Most sea bird populations in the Strait of Juan de Fuca and Washington Coast have experienced declines or declines and recoveries during the time that summer chum have been declining. Given the relatively low numbers of summer chum relative to numbers of fall chum, it is unlikely that sea birds were a significant cause of summer chum decline.

### 2.2.3.6 Marine Mammals

Since the passage of the Federal Marine Mammal Protection Act in 1972, the populations of seals and sealions in Washington and other coastal states have steadily increased. Observations of predation by California sea lions (*Zalophus californianus*) and Pacific harbor seals (*Phoca vitulina*) on various salmonids have also increased, raising concerns about the impacts on depressed and other salmonid populations (NMFS 1997b).

**Hood Canal** - Pacific harbor seals are the primary pinniped species in Hood Canal, with an estimated current year-round population of over 1,500 individuals (Jeffries et al. 1999). Annually, peak abundance occurs in October, and the greatest concentrations are in the vicinity of the mouths of the larger river systems. Index counts of harbor seals have been conducted in Hood Canal by WDFW since 1983, and between 1983 and 1996 seal populations have increased approximately 5% annually (Steve Jeffries, WDFW, pers. comm.). Other pinneped populations in the region include an estimated 10-50 California sea lions and less than 10 Steller sea lions which also occur in Hood Canal (NMFS 1997).

Because of their small size, out-migrating chum salmon fry are not thought to be vulnerable to harbor seal or sea lion predation (NMFS 1997). Substantial chum fry predation by seals under unusual circumstances has been observed at the Puntledge River in British Columbia. Lighting on bridges near the river mouth illuminates outmigrating chum fry, and in one study harbor seal predation between April and June of 1995 has been estimated to be 3.1 million fry, or 7-31% of the year's production (NMFS 1997). Since similar conditions are not present in Hood Canal, harbors seals are unlikely to be significant predators on the region's chum salmon fry.

The predation by seals and sea lions on adult salmon has been well documented. NMFS (1997) reviews a variety of pinniped food habits studies for both harbor seals and sea lions, which show differing salmonid consumption rates depending on salmon abundance and the availability of alternate prey species. As an example, one 1980-82 study has shown that the percentage of seal scat samples containing salmonid remains was 10% in Grays Harbor and 28% in Willapa Bay (Reimer and Brown 1996). Estimates of salmonid consumption by pinnipeds in Oregon by Kaczynski and Palmisano (1992) have used rates of 10.8% of total biomass consumed for harbor seals and 10% for California sea lions.

NMFS (1997) presents an estimate of the annual prey biomass consumption (956 metric tons) by 1,036 harbor seals in Hood Canal. Using these consumption rates, the current harbor seal population of 1,500 animals in Hood Canal would consume 1,385 metric tons of prey biomass per year. If salmon constitute 10.8% of the diet (Kaczynski and Palmisano 1992), Hood Canal harbor seals could be taking a substantial number of salmon each year. Since summer chum salmon currently make up only about 1% of the total return of salmon (all species) to Hood Canal, seal predation rates on summer chum might be considered to be modest, unless seals are specifically targeting summer chum populations.

In the summer of 1998, WDFW began a multi-year study of harbor seal predation on adult salmon near the mouths of a number of Hood Canal summer chum salmon spawning streams; Big and Little Quilcene, Dosewallips, Duckabush, and Hamma Hamma rivers (Jeffries et al. 1999). Direct observations of seal/salmon interactions have been made in the vicinity of the river mouths on a three day per week schedule, beginning in the first week of September, and ending just before the Thanksgiving holiday. Preliminary results from this study indicate that harbor seals have taken substantial numbers of adult salmon during the summer chum migration period. Estimated daylight total salmon predation numbers for each observation area are: 243 fish in Quilcene Bay, 113 fish at Dosewallips River, 96 fish at Duckabush River, and 277 fish at Hamma Hamma River. These predation observations could potentially include summer chum salmon, fall chum salmon, coho salmon, and chinook salmon (pink salmon were not present in 1998). For two systems, Quilcene Bay and the mouth of the Dosewallips River, estimates have been made of the percent chum salmon taken by seals during predation events when prey species could be identified; 73% chum salmon at Quilcene Bay (11 of 15 kills), and 62.5% at Dosewallips River. While the high chum salmon predation rates include both summer and fall chum (there are insufficient observations to reliably estimate just summer chum predation), there clearly has been substantial seal predation on the 1998 return of adult summer chum salmon in Hood Canal.

The lack of census data for harbor seals and sea lions in Hood Canal during the 1970s makes a direct examination of the possible relationship of pinniped predation to the decline of summer chum salmon impossible. The evidence for the substantial increase in the Hood Canal seal population since 1983, indicates that in the late 1970s, seals were in much lower abundance in Hood Canal. Sea lions have a relatively minor presence in Hood Canal.

In conclusion, it seems unlikely that pinniped predation has been a significant contributor to the original decline of Hood Canal summer chum salmon. It is apparent, however, that because of the now locally abundant seal populations and the 1998 study preliminary results, showing substantial salmon predation at the mouths of summer chum streams, harbor seals may be an important factor that could slow the recovery rate of Hood Canal summer chum salmon.

**Strait of Juan de Fuca** - The NMFS (1997b) report does not provide estimates of pinniped population sizes for the eastern Strait of Juan de Fuca. They do identify Harbor seals and Steller sea lions as being present in marine areas adjacent to summer chum streams in the region. There have been no reports of unusual levels of pinniped interactions with summer chum salmon, and it is unknown if seals or sea lions have contributed to the observed summer chum salmon decline. However, pinniped predation may slow the recovery of summer chum salmon in this region.

### 2.2.3.7 Conclusions

**Competition and predation impacts on summer chum salmon -** Fresh (1997) offers insight into the difficulties in measuring the impacts of competition and predation, and observes that "... available data will rarely if ever be unequivocal." The above review supports that assessment. There is little direct evidence available to either document or refute the possibility of substantial competition or predation effects on summer chum salmon. Of the various potentially competitive or predatory species discussed above, only the increased abundance of hatchery origin fall chum salmon comes close to matching the period of decline in the summer chum salmon populations. However, even this potentially negative relationship is contradicted by a lack of direct synchrony, ecological differences between summer and fall juvenile chum in marine waters, and the recent increases in summer chum salmon. While the currently available information suggests that the hatchery fall chum salmon program is not having a major impact on summer chum salmon survivals, uncertainty still exists and may warrant further investigation. The generally high numbers of other hatchery salmonids released into Hood Canal streams during the period of decline are likely to have contributed to the decline of summer chum stocks in that region.

A second important conclusion relating to potential competition and predation effects on Hood Canal and Strait of Juan de Fuca summer chum salmon, is that increases in abundance of two species ***after the decline*** may currently be affecting the survivals of summer chum salmon, and may ultimately slow recovery. Wild fall chum salmon have recently been very successful in Hood Canal, with some annual escapements exceeding 100,000 spawners. There is a possibility that redd superimposition by fall chum salmon could reduce intergravel survivals of the earlier spawned eggs and alevins of summer chum salmon. A second species with the potential to affect the recovery of summer chum salmon is the Pacific harbor seal. Over the last 25 years, harbor seal populations in Hood Canal and the Strait of Juan de Fuca have increased at about 5% per year and are now very abundant. Additionally, preliminary results from a 1998 WDFW seal predation study in Hood Canal shows that there are substantial levels of seal predation occurring on depressed summer chum salmon populations.

## 2.2.4 Habitat

Of the four general topics included in this discussion of factors for decline, habitat issues have a different relationship to changes in survival and production of summer chum salmon. The basic approach of Part Two is to document and evaluate any changes in factors affecting summer chum production that have occurred in concert with the specific recent periods of decline in Hood Canal and the Strait of Juan de Fuca regions. In general, habitat loss is a long-term, cumulative process that leads to gradual reductions in the productivity of fish and wildlife species. It is rare for abrupt habitat change to occur on a regional scale and affect salmon in multiple streams across a number of watersheds. Examples of large scale natural habitat disruptions would be the recent volcanic eruption of Mount St. Helens, and the forest fire that burned at least half of the Olympic Peninsula in the year 1308 (USFS and WDNR 1994). Nearly all human-caused habitat loss occurs at a much smaller scale; at the watershed, stream, or stream reach level. Some types of habitat impact can cause substantial local losses to the productive capacity of the freshwater environment, e.g. dam construction, or forest road building and logging. Other impacts like land clearing, stream bank armoring, and increases in impervious surfaces have smaller immediate incremental effects, but added together and over time they can have a major negative impact. For a discussion of local habitat impacts on individual streams see Part Three, section 3.4 Habitat.

There are no observed region-wide changes in habitat that correspond in timing to the 1979 decline of summer chum salmon in Hood Canal, or to the 1989 decline in the Strait of Juan de Fuca. Cumulative habitat impacts have contributed to the decline, however, and habitat restoration must be a major part of the recovery of summer chum salmon in the two regions. Short- and long-term changes in habitat on a local scale have reduced the range of summer chum salmon, have affected their survival and productivity in streams and estuaries, and have caused or contributed to the extirpation of populations of summer chum salmon from streams in the region. These habitat related impacts have reduced the resiliency of summer chum salmon, and in combination with the other factors for decline, have led to the current depressed status of these stocks of fish. The primary objective of this recovery plan, to have healthy and harvestable stocks of summer chum salmon, cannot succeed without a strong and comprehensive habitat protection and restoration effort.

The following discussion will provide a review of the general habitat needs and factors limiting production for summer chum salmon. Two case studies from Hood Canal streams are also presented to show how habitat alterations can cause severe impacts on the survival and production of summer chum salmon. This section ends with a discussion of the contribution of habitat change to the decline of summer chum salmon in the region.

### 2.2.4.1 General Summer Chum Habitat Overview

Suitable salmonid habitat, including that of summer chum salmon, needs to provide for six key life requirements for them to be productive and successful. Salmonids need adequate quantity and quality of water. They need food for survival and growth. They need forms of shelter that provide protection from predators and allow them to minimize energy loss. Salmonids need to be able to move within and between habitat types to fulfill their life requirements. They need clean and relatively stable gravel areas to reproduce. These life requirements are affected by both natural processes and human influences on those natural processes.

Many reviewers have summarized the life histories and habitat requirements of salmon, and the effects of natural and human events and activities on salmonid survival and production. Palmisano et al. (1993), NRC (1996), and Spence et al. (1996) all provide good reviews of these issues and all have been utilized in the preparation of this plan.

Summer chum salmon habitat includes all of the places where they spawn, feed, grow, and migrate. In the broadest sense, maintaining and protecting this habitat also protects the habitat of the prey species that make up the salmonid diet, and those upland areas that directly affect the waters where salmonids actually live. Summer chum salmon are generally found in the lowermost reaches of streams, however, their habitat is affected by overall watershed habitat conditions. Some streams like the Skokomish River have fairly big watersheds, while others like Big Beef Creek and Snow and Salmon creeks are only medium sized watersheds. Estuaries, near and off shore marine areas of Hood Canal, the Strait of Juan de Fuca and the open ocean are all part of summer chum salmon habitat.

Streams in the HC-SJF region course through wilderness areas and national parks, industrial and non-industrial forests, agricultural land, and rural and suburban residential landscapes. Land uses adjacent to nearshore marine areas range from state and county parks, federal refuges to rural and urban residential development to industrial harbors. All of these land uses affect the survival and productivity of summer chum salmon and must be considered in the recovery effort.

The life requirements for chum salmon are influenced through a combination of interrelated physical, chemical and biological processes, and habitat conditions occurring over both short- and long-time scales, and across a variety of land forms. Many of these relationships are not well understood. Quite often it is very difficult, if not impossible, to draw quantitative relationships between habitat conditions and salmonid survival and production. Further, freshwater habitat/production relationships can be confounded by ocean survival conditions, inter- and intraspecific competition and predation relationships, and by a variety of fishery impacts. Nonetheless, chum salmon life requirements appear to be affected by habitat conditions in the following manner:

C Water quantity (flow regime) is affected primarily through basin hydrology, which is manifested as instream flows. Instream flows are affected by: 1) natural climatic, topographic geologic, soils, and vegetative conditions; 2) land use activities; and 3) other in-and out-of-stream uses of water (hydropower, irrigation).

C Water quality is affected in part by basin hydrology and instream flows. It is also influenced by: 1) upslope events such as soil erosion and land slides; 2) by the condition and extent of riparian (near water) vegetation; 3) by the extent and function of wetlands; 4) by a variety of natural and chemical contaminants; 5) by stream channel and marine habitat stability and complexity; and 6) by in-water activities such as dredging.

C Food supply and availability is affected by: 1) instream flows; 2) sediment quality, delivery and routing; 3) water quality; 4) riparian, wetland, and marine vegetation; 5) stream, lake and marine habitat complexity; 6) the numbers of returning adult anadromous or resident spawning salmonids; and 7) by predator-prey and species competition relationships.

- Shelter for rest and cover is influenced by hydrology, water quality, sediment quality, delivery and transport, and by the extent and condition of riparian vegetation. Stream channels which possess varied and complex habitat features such as large woody debris, rocks and boulders, and channel features such as overhanging banks, and a variety of water depths and velocities, provide abundant resting and hiding shelter.

- Fish access and passage are affected by hydrology, water quality, sediment quality, delivery and routing, riparian and wetland condition and extent, and floodplain connectivity. Fish passage is further influenced by natural obstacles such as waterfalls and human structures such as dams, dikes, and culverts, and by some docks, breakwaters and piers in marine areas.

- Reproduction is influenced by all the above, but primarily by instream flows, sediment transport, and water quality.

To sustain and recover summer chum salmon populations, functional and accessible fish habitat is essential. This includes both existing salmonid habitat in its present condition, as well as degraded habitat in need of restoration. It will also require protection and restoration of the productive capacity of habitat. Areas used by summer chum salmon to complete their life history needs must be protected or restored, including instream, riparian, estuarine, and wetland ecosystems, and the upland activities and processes that affect them.

Protection of the existing habitat base should be the first priority for habitat actions. Such protection is usually the most cost-effective initial mechanism available to ensure summer chum sustainability. It is immediate, efficient, and can slow or stop the trend of habitat loss. It also retains current summer chum production capacity, and provides a foundation for future recovery and growth. Protection is also relatively inexpensive when compared to the cost of restoring summer chum salmon habitat.

However, given the current degraded state of summer chum habitat in the region, restoration must also be initiated. Restoration is a long-term activity. In this region there are many actions that could be initiated in the short term, however others may take many years to accomplish because of the cost and because often a period of natural watershed healing is needed. Habitat restoration is a relatively new and experimental science, and is more costly than protection. Restoration will be critical in those areas where the existing habitat base is insufficient to sustain summer chums, or where habitat degradation or loss is a key cause of stock decline.

Protection and maintenance of wild salmonid habitat requires recognition of the continuum of aquatic and terrestrial physical and chemical processes, biological systems, and human influences on that continuum (Vannote et al. 1980). The stream continuum exists in a longitudinal fashion from the smallest rivulet, down through increasingly larger streams and rivers, into estuaries and eventually to the open ocean. Downstream processes are linked to upstream processes through routing of water, sediment, and organic matter. Chum salmon in particular, since they spawn and rear very near stream mouths, are especially susceptible to the entirety of habitat conditions and processes that occur within a watershed, and those that affect estuarine, marine and open ocean habitats within their migratory range.

### 2.2.4.2 Historical Habitat Impacts On Summer Chum Salmon

The following discussion reviews two examples of Hood Canal streams that have been affected by substantial habitat alterations; resulting in serious reductions in summer chum salmon survivals in one stream, and contributing to the extirpation of summer chum salmon in the other stream. These examples are presented here only to provide an overview of how changes in habitat quality and quantity can impact summer chum salmon, and are not meant to be an examination of all habitat problems in these streams. A comprehensive assessment of habitat-related factors affecting summer chum salmon in these two streams, and in all other summer chum streams in the region is provided in Part Three, section 3.4 Habitat and in detailed watershed descriptions in Appendix Report 3.6.

**Big Quilcene River Summer Chum Salmon** - The Big Quilcene River flows in a south easterly direction from its headwaters in the Olympic Mountains for 18.9 miles to its confluence with Dabob Bay and Hood Canal. The basin has a drainage area of about 70 square miles (Williams et al. 1975). With the exception of a small section of the extreme upper watershed, the entire drainage above river mile 4.0 is in the Olympic National Forest (USFS and WDNR 1994), and is managed for forestry and recreational uses. Below river mile 4.0, land uses are predominately residential, and some shellfish culture and limited agriculture.

***Big Quilcene River habitat impacts*** - The habitat conditions of the watershed are described in detail in the Big Quilcene Watershed Analysis (USFS 1994), and the following are selected quotations regarding habitat impacts from the Executive Summary of that report.

> "Pre-management disturbance regimes dictating vegetation patterns, sediment flow, and hydrologic response were influenced by wildfires. These fires covered thousands of acres at a time with frequencies of every 100-200 years. Large pulses of sediment routed through the watershed after fires from landslides on steep slopes. These sediment pulses most likely caused dramatic changes in channel location of the lower mainstem as the Big Quilcene River deposited this sediment. High intensity storms, such as rain-on-snow may have produced smaller sediment peaks as the watershed was recovering from these fires, particularly from landforms noted as being less resilient to changes in hydrology. Road construction and timber harvest since the 1930s has produced sediment disturbances similar to those after wildfires but without recovery intervals between disturbances. Urban development and in-stream removal of large wood along the lower mainstem have reduced channel habitat diversity by straightening the channel and removing roughness in the channel. Water diverted from the upper watershed and sediment deposition in the lower mainstem may have reduced pool volume and channel depth. Vegetation removal has altered temporal and spacial distribution of vegetation changing the character of habitat structure and distribution.
>
> Present day demands for high quality and quantity of water for a variety of uses is a major issue in the watershed, particularly during low flow periods. The Big Quilcene River supplies water for municipal and commercial uses and as well for aquatic species including salmon.
>
> This assessment shows a generally poor condition of physical stream habitats, and thus, productive capacity, within locally significant reaches of stream. Habitats within the WAU are poorly distributed and quite dynamic under natural conditions. It is not possible to correlate fish populations (either

> standing crop or smolt output) with habitat conditions due to the effect of hatchery production. Instream flows during the low-flow periods likely create a bottleneck in fish production, particularly for highly valued anadromous fishes in the lowest reaches of streams in the WAU. Water management and conversion of existing uses of the forest lands to urban areas or interfaces may be more critical to the conservation and management of fish habitat and populations than patterns of forest disturbance."

The above quotation details only the effects of sedimentation on the river channel. Part Three, section 3.4 Habitat and the Big Quilcene River watershed description in Appendix Report 3.6 provide more detailed descriptions of sedimentation and other habitat problems in the basin.

The above described habitat conditions cause major problems for summer chum salmon in the lower Big Quilcene River. Sediments from the upper watershed are transported downstream by high flows, and aggregate in the low gradient reaches of the lower river. As the channel fills with sediments, local flooding impacts are exacerbated, resulting in landowner desires to channelize the river, armor stream banks, and install levees. Unfortunately, these are the same stream reaches used by summer chum salmon for spawning and the subsequent incubation of eggs and alevins. Most of the remedial measures used to control flood impacts result in reduced habitat quality, affecting the survival of the local summer chum salmon population.

***Habitat impacts on summer chum salmon*** - A recent example demonstrates the type of impact that even a single flood control project can have on the salmon using the stream. In December of 1993, an intense rain storm resulted in flooding on the Big Quilcene River, and caused a breech in a levee on the lower river. The affected landowner, fearing damage to adjacent structures, conducted an unauthorized channelization project, removing stream bottom materials from approximately a third of a mile of the channel. This project took place at a time period when the eggs and alevins of summer chum salmon were incubating in the stream gravels. An on-site inspection by WDF staff found that the entire stream bottom in the affected reach had been severely disrupted, resulting in the total loss of all incubating eggs and alevins. A subsequent evaluation determined that 29% of the total production of the 1994 summer chum salmon spawning in the river had been destroyed by this project (Uehara 1994). This unfortunate impact on the survival of summer chum salmon in the Big Quilcene River occurred in a year when only 89 total spawners had returned to the river (Uehara 1994), and when the stock was considered to be in critical status (WDF et al. 1993).

**Skokomish River Summer Chum Salmon -** The Skokomish River is the largest stream system in Hood Canal, and historically has produced a major portion of Hood Canal salmon runs (Smoker 1952). Two large tributaries, the North and South forks, come together at river mile 9.0 to form the mainstem Skokomish River. Because of the extensive amount of habitat potentially provided by the Skokomish system, it is likely that with pristine conditions (pre-development) this watershed was the largest producer of summer chum salmon in Hood Canal. Most of the system has under gone extensive habitat alterations, however, with negative consequences for indigenous stocks of salmon. The following example will discuss only the impacts of a single limiting factor (water withdrawal) on the summer chum salmon of the North Fork Skokomish River. For a more detailed discussion of the habitat limiting factors in the entire Skokomish River basin, see Part Three, section 3.4 Habitat and the Skokomish River watershed description in Appendix Report 3.6.

***North Fork Skokomish River habitat impacts*** - The North Fork Skokomish River flows for 41.9 miles out of the Olympic Mountains in a generally southerly direction to its confluence with the South Fork (Williams et al. 1975). Over 100 tributary streams join the mainstem of the North fork to form a watershed of 118 square miles (FERC 1996). Two major features in the system are lakes Cushman and Kokanee which are formed by hydroelectric dams, and represent the upper limit of anadromous fish utilization. The area above Lake Cushman is almost entirely within the Olympic National Park, which maintains the watershed and adjacent lands in a protected, natural condition. Below the reservoirs, land use is predominately forestry, with some residential and agriculture uses near the confluence with the South Fork (FERC 1996).

The two hydroelectric dams were built on the North Fork by the city of Tacoma; Dam No. 1 at river mile 19.6 was completed in 1926, and Dam No. 2 at river mile 17.3 was finished in 1930. The upper dam inundated the pre-existing Lake Cushman and increased its size from about 322 surface acres to its present 4,010 acres. Mean annual stream flow at the lower dam site has been estimated to be approximately 748 cfs. After the construction of the North Fork dams, virtually all flow was diverted from the system at the lower dam until 1988, when 30 cfs was provided below the project (FERC 1996). This lack of water discharge from the dams combined with a partial diversion of the largest downstream tributary (McTaggert Creek), reduced the flows in the North Fork to the point that at certain times of the year all of the water disappeared into the ground, and portions of the stream were dry (WDF 1957). The 1957 WDF report also documented a specific observation of a section of the North Fork with no surface flow in August 1954, going dry first at a point about a half mile above the mouth. These conditions of extreme low flow likely occurred most often in late summer, at the time when summer chum salmon needed to access the stream for spawning.

***South Fork and mainstem Skokomish River habitat impacts*** - The South Fork Skokomish River flows for 27.5 miles in a southeasterly direction to its confluence with the North Fork. From the joining of these two major tributaries, the mainstem flows in a generally easterly direction for nine miles to its mouth on the southern end of Hood Canal (Williams et al. 1975). Most of the 124 square miles of drainage area are in the Olympic National Forest, with private forest lands, agriculture, and residential uses in the lower watershed and along the mainstem (FERC 1996).

The same habitat alteration processes described above for the Big Quilcene River (USFS and WDNR 1994) have also occurred in the South Fork and mainstem Skokomish, only on a much larger scale. Stream flows exhibit tremendous volatility; with extreme flows during the period of record (1931-1996; South Fork Skokomish USGS gage 12060500) varying from a high discharge of 21,600 cfs to a low of just 62 cfs (Wiggins et al. 1997).

Massive downstream sediment transport occurs from the South Fork, filling the mainstem Skokomish River channel. These sediments are being released from heavily logged areas of the upper watershed (FERC 1996). Over the years, an extensive system of levees has been constructed along the lower river to protect low-lying, flood prone lands. As the river channel between the levees has filled with sediments from upstream, river bed elevations have risen, and flooding of lands adjacent to the lower river have increased in frequency (FERC 1996). Multiple, damaging floods now occur virtually every year in the Skokomish River lowlands.

***Habitat impacts on summer chum salmon*** - Summer chum salmon probably ceased to exist as a self-sustaining stock in the Skokomish River system in the late-1960s or early 1970s. Only limited information on the population size prior to that time period exists. Between 1935 and 1953 annual tribal net catches of summer chum salmon in the river in September ranged from 61 to 986 fish (Smoker et al. 1952). An estimated 3,000 to 4,000 summer chum spawners were observed in the South Fork and mainstem on October 1, 1954 (WDF 1957). A WDF assessment of Puget Sound salmon escapements for the years 1966-1971 estimated the Skokomish summer chum salmon average escapement to be approximately 300 spawners, and characterized the population as having "a negligible level of abundance" (Williams et al. 1975). In 1974 a WDF salmon status review listed Skokomish summer chum salmon adult returns as "few," with escapement levels "unknown" (WDF 1974). By the following year, summer chum salmon were no longer included as a viable stock in the Skokomish system in annual WDF status assessments (WDF 1975). A state-wide inventory of salmon and steelhead stocks in 1992 (WDFW and WWTIT 1994), did not find evidence of a viable, self-sustaining summer chum stock in the system. The question of the status of the small numbers of summer-timed chum salmon that are sporadically observed in the Skokomish has been reexamined for this recovery planning effort, and the same conclusion has been reached; there is currently no evidence of a viable summer chum stock in the system (see discussion in Part One).

North Fork summer chum salmon were likely extirpated from that stream as early as 1956. A Skokomish tribal elder, Joe Andrews Sr., documented this loss of summer chum salmon in the North Fork Skokomish River in a 1991 interview conducted by the British Columbia Indian Language Project. Speaking of the North Fork Skokomish River:

> "Frank Allen, however, especially liked to smoke a summer run of dog salmon, a yellowish-colored salmon that came upriver between July and September. Apparently this run was no longer available after around 1956." (Bouchard and Kennedy 1997).

Supporting this account is a 1957 WDF report which stated:

> "The chum salmon population now using the North Fork would not be especially affected by this extreme low flow and dry stretch. The chum salmon enter in mid-November after the river has recovered and the dry period is over." (WDF 1957).

This reference indicates that only fall-timed chum salmon were using the North Fork in 1957. The lack of adequate migration and spawning flows in the North Fork after the construction of the dams presumably has been a major contributor to the loss of summer chum salmon in that stream.

The impacts of habitat alteration have been devastating for those species or stocks of salmon that spawn in the South Fork and mainstem Skokomish in late summer or early fall months. In 1961, WDF staff began to conduct regular spawning ground surveys on the South Fork and mainstem Skokomish during September and October. Since that time, summer chum have been only rarely observed; and over the last 20 years the numbers observed are considered to be too low to represent a self-sustaining stock. The extreme low flows during the early spawning periods, followed by severe flooding and massive sediment movement have created a situation where eggs deposited by early spawning chum salmon using riffles in the main river channels have little chance of survival. These conditions have likely played a major role in the extirpation of the summer chum salmon of the Skokomish system.

### 2.2.4.3 Conclusions

Although no single region-wide habitat alteration is apparent during the periods of summer chum salmon decline in Hood Canal or the Strait of Juan de Fuca streams, the cumulative impacts of habitat loss has been a significant factor in the lowered survival and production of these fish. As shown in the case studies above, disturbance of critical habitat elements can cause reductions in survivals, and in the worst case, extirpation of stocks. Local summer chum salmon may be more vulnerable to these kinds of impacts than other salmonids, because they are at the southern extent of their distribution and probably lead a more tenuous existence than more northern stocks.

While the examples presented for the Skokomish and Big Quilcene rivers are extreme cases, similar but smaller scale habitat loss has occurred on all summer chum salmon streams in the region. These habitat impacts lower the resiliency of the summer chum populations, exacerbating any additional negative impacts on the survivals of these fish. Habitat change has been a major contributor to the decline of summer chum salmon in Hood Canal and the Strait of Juan de Fuca (see section 3.4 and Appendix Report 3.6).

## 2.2.5 Harvest

The early history of fisheries in Hood Canal and Strait of Juan de Fuca is summarized above in the Harvest Data discussion of Part One (section 1.4.3). The "modern" era of regional salmon management began with the 1974 Boldt Decision on Indian fishing rights. Traditional Puget Sound fisheries changed in 1974 from a mixed-stock harvest approach to a more terminal pattern of fishing, to accommodate the necessary allocation of returning fish to tribal and non-tribal fisheries, and to provide for better fishery management. This resulted in the movement of new and intensive non-Indian and tribal net fisheries into the Hood Canal terminal area, which was previously a salmon preserve that was closed for net fisheries and open for sport fishing. The two summer chum stocks in Discovery and Sequim bays have been almost completely protected from harvest within the bays (terminal areas). The summer chum stocks of both regions, however, are affected by harvest in pre-terminal areas, including catches in the Strait of Juan de Fuca by both U.S. and Canadian fishers.

Of the various activities that can affect the success of a salmon population, harvest is usually the only factor for which the numbers of fish taken from the population are routinely quantified. The effort to account for the numbers of fish taken in various fisheries has a number of problems, one of which is the allocation of mixed stock catches to their appropriate stock of origin. In an attempt to deal with this problem for the purposes of this recovery planning process, an improved runsize data base has been developed (see Part One, 1.4.4 Run Size). These summer chum salmon runsize data will be used in section 3.5, Harvest Management, to estimate exploitation rates to evaluate the contribution of fishery impacts to the decline of summer chum salmon. These harvest data are thought to provide a reasonable measure of the general impacts of fishing activities on summer chum salmon.

## 2.2.5.1 Pre-terminal Harvest

**Pre-terminal Area**

***Marine waters where specific stocks (or groups of stocks) are mixed with fish returning to other regions. These areas for summer chum salmon include all marine waters of Admiralty Inlet, the Strait of Juan de Fuca, and the Pacific Ocean seaward of Hood Canal and Discovery, Sequim, and Dungeness bays.***

The pre-terminal management areas for summer chum salmon include all marine waters seaward of Hood Canal and Discovery and Sequim bays. Summer chum salmon are harvested in these areas during fisheries for other species of salmon, primarily pink and sockeye salmon. During the time period that summer chum salmon are present, management authority is vested in the Pacific Salmon Commission (PSC) for most of the pre-terminal areas (Admiralty Inlet excepted). Since these PSC fisheries are directed at Fraser River pink and sockeye stocks, seasons and exploitation rates are based on the annual abundance of those species. Summer chum salmon have been incidentally harvested during these fisheries at exploitation rates based on the needs of Fraser River runs.

Accounting for all harvests of summer chum salmon has been a desired objective of the on-going restoration planning effort. Accordingly, beginning in 1995, tissue samples for genetic profiling of summer-timed chum have been collected from a major Strait of Juan de Fuca fishery (Canadian Area 20). The WDFW Genetic Lab analyzed the resulting samples using allozyme electrophoresis techniques, and estimated that for the 1995-1997 seasons Hood Canal and Strait of Juan de Fuca summer chum salmon contributed an average of 49% of the chum salmon sampled. Annual results were; 31% in 1995, 68% in 1996, and 49% in 1997 (Larry LeClair, WDFW, personal communication). The sample data were used to estimate total annual catch of Hood Canal and the Strait of Juan de Fuca summer chum salmon in PSC fisheries prior to September 16 for each year from 1974 through 1997 (see Appendix Report 1.3 for methods). Admiralty Inlet summer chum harvests were apportioned to Hood Canal and the Strait of Juan de Fuca using run-reconstruction methods.

An examination of 1974-1997 U.S. pre-terminal exploitation rate on an annual basis (Table 2.8) shows that there has been no meaningful change in the exploitation rates on summer chum salmon corresponding to the decline of Hood Canal summer chum stocks in 1979 and subsequent years, or for Strait of Juan de Fuca stocks beginning in 1989.

**Table 2.8**. Annual U.S. pre-terminal exploitation rates and harvest for Hood Canal and the Strait of Juan de Fuca summer chum salmon stocks, 1974 to 1998.

| Return years | Pre-terminal exploitation rate | Estimated harvest | Return years | Pre-terminal exploitation rate | Estimated harvest |
|---|---|---|---|---|---|
| 1974 | 0.023 | 378 | 1987 | 0.024 | 147 |
| 1975 | 0.019 | 600 | 1988 | 0.032 | 310 |
| 1976 | 0.045 | 3,383 | 1989 | 0.081 | 426 |
| 1977 | 0.042 | 785 | 1990 | 0.022 | 45 |
| 1978 | 0.025 | 719 | 1991 | 0.088 | 230 |
| 1979 | 0.098 | 1,025 | 1992 | 0.027 | 129 |
| 1980 | 0.031 | 557 | 1993 | 0.065 | 98 |
| 1981 | 0.095 | 666 | 1994 | 0.026 | 80 |
| 1982 | 0.036 | 428 | 1995 | 0.006 | 66 |
| 1983 | 0.059 | 279 | 1996 | 0.005 | 103 |
| 1984 | 0.014 | 73 | 1997 | 0.004 | 46 |
| 1985 | 0.101 | 487 | 1998 | 0.008 | 41 |
| 1986 | 0.018 | 167 | | | |

A substantial increase in Canadian Area 20 exploitation rates is apparent during the four year period from 1989 through 1992 (Table 2.9). The 1989 and 1990 Area 20 exploitation rates were respectively the highest (43.2%) and third highest (33.4%) in the 24 year data base. The two following years had exploitation rates of 18.5% (1991) and 20.6% (1992); both years well above the 25 year average rate of 11.1%. Since 1989, the Canadian Area 20 fishery harvested an average of 76% of the total pre-terminal catch. For the 1993-1998 period, Area 20 pre-terminal exploitation rates returned to lower levels, averaging 4.7% and ranging from 1.5 to 14.2% annually. The relatively high exploitation rates between 1989 and 1992 coincided with the severe drop in escapements of Strait of Juan de Fuca summer chum salmon beginning with the 1989 return year.

**Table 2.9**. Annual Canadian Area 20 exploitation rates and harvest for Hood Canal and the Strait of Juan de Fuca summer chum salmon stocks, 1974 to 1998.

| Return years | Area 20 exploitation rate | Estimated harvest | Return years | Area 20 exploitation rate | Estimated harvest |
|---|---|---|---|---|---|
| 1974 | 0.086 | 1,399 | 1987 | 0.063 | 390 |
| 1975 | 0.034 | 1.064 | 1988 | 0.075 | 738 |
| 1976 | 0.075 | 5,705 | 1989 | 0.432 | 2,273 |
| 1977 | 0.049 | 913 | 1990 | 0.334 | 696 |
| 1978 | 0.025 | 701 | 1991 | 0.185 | 438 |
| 1979 | 0.057 | 591 | 1992 | 0.206 | 980 |
| 1980 | 0.053 | 980 | 1993 | 0.044 | 67 |
| 1981 | 0.131 | 915 | 1994 | 0.142 | 451 |
| 1982 | 0.187 | 2,219 | 1995 | 0.042 | 458 |
| 1983 | 0.006 | 28 | 1996 | 0.015 | 338 |
| 1984 | 0.062 | 314 | 1997 | 0.019 | 198 |
| 1985 | 0.336 | 1,620 | 1998 | 0.018 | 98 |
| 1986 | 0.088 | 796 | | | |

### 2.2.5.2 Terminal and Extreme Terminal Harvest

As defined by the co-managers, the terminal fishery management areas for the region include most of the marine waters of Hood Canal (Management Areas 12, 12B, and 12C). Extreme terminal management areas include marine areas 12A, 12D, Discovery and Sequim bays (Management Area 6B), Dungeness Bay (6D), and all rivers where summer chum salmon are present. Hood Canal is intensively fished by tribal and non-tribal net fishers, while the Strait of Juan de Fuca terminal area bays are essentially regulated for no net fishing. Because of these patterns of regulation and fishing, the following discussion will focus on Hood Canal terminal area harvest.

**Terminal Area**

***Marine waters near the ultimate freshwater destination of specific salmonid stocks (or groups of stocks) where they have separated from fish returning to other regions.***

**Extreme Terminal Area**

***Marine or freshwater areas where salmonids of a single stock or management unit have separated from fish of other stocks.***

As tribal and non-tribal net fisheries moved into Hood Canal in the years following the 1974 Boldt Decision, fishery exploitation rates changed dramatically for most salmon stocks in the region. Four salmon species were present as both wild and hatchery populations in Hood Canal (sockeye excepted), and fishery managers were faced with the problem of run timing overlaps throughout the fishing season. In an attempt to deal with this problem, the wild and hatchery components of each species were designated as having either "primary" or "secondary" management status (HCSMP 1986). Primary stocks would be managed for directed fisheries in mixed stock fishing areas. Secondary stocks would be subjected to seasons and exploitation rates in mixed stock areas that were suitable for primary stocks present in the same areas. The co-managers designated Hood Canal summer salmon to have a "secondary stock" management status, which meant that any harvest would be incidental to fisheries directed at other species; mainly coho and chinook salmon which had a primary management status. Mixed stock exploitation rates and seasons were established annually based on the abundance of coho and chinook salmon, resulting in high exploitation rates on summer chum salmon in some management areas. Tynan (1992) examined the effect of terminal harvest on summer chum escapements for the years 1968-1991, and concluded that high exploitation rates had contributed substantially to reduced escapements.

The issue of harvest impacts has been reexamined as a part of this restoration planning effort (see Part Three, section 3.5 Harvest Management). The newly derived runsize and exploitation rate estimates are described in Appendix Report 1.3, and are used in the following discussion.

Pre-terminal exploitation rates did not show a meaningful change in the years before and after 1979, but Hood Canal terminal exploitation rates went from essentially zero to rates that ranged between 14.7% to 71.9% for the years 1975-1991. Total exploitation rates (including pre-terminal harvest) ranged from 21.4% to 80.6% for the same span of years (Table 2.10). During the first six years of the Hood Canal fisheries (1974-1979), summer chum salmon total exploitation rates averaged 30.8%, and ranged from a low in 1974 of 11.1% to a high of 59.7% in 1976. The return in 1976 was in excess of 74,000 fish, and even with the high exploitation rate, over 27,000 spawners escaped to Hood Canal streams. From 1980 through 1991 Hood Canal summer chum salmon were subjected to high total exploitation rates (averaging 57.1%), with the majority of the impact occurring in the terminal area fisheries (average 46.9% exploitation rate).

Hood Canal summer chum escapements began to decline precipitously in 1979. Total exploitation rates in 1979 were a relatively modest 30.2%, and the period of consistently high exploitation rates began the following year (Table 2.10). The 1979 escapement was likely depressed by environmental conditions that resulted in record low returns of chum salmon statewide in that year (see discussion in section 2.2.2 Climate). After 1979, summer chum escapements and runsizes dropped in concordance with the increased total exploitation rates imposed on the returns (Table 2.11). In 1992 co-managers began to adopt protective harvest management provisions, which included time and area closures and mandatory release of summer chum salmon in most fisheries. The result was the elimination of nearly all terminal area harvest, with exploitation rates ranging from 0.3% to 2.1% for the 1993-1998 seasons (Table 2.10). With virtually all of the terminal run escaping, the number of summer chum spawners in Hood Canal streams averaged over 9,000 fish per year over the last five years (Table 2.11).

**Table 2.10.** Annual terminal and total exploitation rates for Hood Canal summer chum salmon stocks, 1974 to 1998. [1]

| Return years | Terminal exploitation rate | Total exploitation rate | Return years | Terminal exploitation rate | Total exploitation rate |
|---|---|---|---|---|---|
| 1974 | 0.002 | 0.111 | 1987 | 0.719 | 0.806 |
| 1975 | 0.254 | 0.308 | 1988 | 0.367 | 0.474 |
| 1976 | 0.476 | 0.597 | 1989 | 0.352 | 0.864 |
| 1977 | 0.224 | 0.316 | 1990 | 0.347 | 0.702 |
| 1978 | 0.164 | 0.214 | 1991 | 0.388 | 0.660 |
| 1979 | 0.147 | 0.302 | 1992 | 0.064 | 0.296 |
| 1980 | 0.624 | 0.708 | 1993 | 0.021 | 0.130 |
| 1981 | 0.348 | 0.574 | 1994 | 0.011 | 0.179 |
| 1982 | 0.448 | 0.671 | 1995 | 0.003 | 0.052 |
| 1983 | 0.685 | 0.750 | 1996 | 0.006 | 0.026 |
| 1984 | 0.490 | 0.567 | 1997 | 0.019 | 0.043 |
| 1985 | 0.300 | 0.737 | 1998 | 0.007 | 0.003 |
| 1986 | 0.565 | 0.671 | | | |

[1] Summer chum salmon returning to the Hood Canal terminal area experience varying exploitation rates in the various management units. See Part Three - section 3.5 Harvest Management for discussion.

**Table 2.11.** Five year average summer chum salmon pre-terminal, terminal, and total exploitation rates and escapements for Hood Canal stocks, 1974 to 1998.

| Return years | Pre-terminal rates (%) | Terminal rates (%) | Total exploitation rates (%) | Hood Canal escapements |
|---|---|---|---|---|
| 1974-78 | 8.5 | 22.4 | 34.3 | 17,773 |
| 1979-83 | 15.1 | 45.0 | 61.1 | 3,238 |
| 1984-88 | 16.3 | 48.8 | 65.8 | 1,760 |
| 1989-93 | 29.6 | 23.4 | 53.6 | 978 |
| 1994-98 | 5.7 | 0.9 | 6.7 | 9,028 |

### 2.2.5.3 Conclusions

Exploitation rate estimates for Hood Canal and the Strait of Juan de Fuca summer chum stocks show increases in exploitation rates that relate to the declines in both regions. In the case of Hood Canal summer chum salmon, the added impacts of indirect harvests in the terminal area fisheries (after 1974) combined with a relatively consistent level of pre-terminal catch have contributed substantially to the decline and subsequent continuing low production levels. The fact that these stocks are at the southern limit of summer spawning chum salmon may mean that they have a naturally lower level of productivity, making them less able than wild fall chum stocks to be successful with levels of exploitation rates shown in Table 2.11 (34% to 66%).

Strait of Juan de Fuca summer chum salmon declined abruptly in 1989, which was the same year that the Canadian pre-terminal exploitation rate peaked at 43.2% (Table 2.9), a fourfold increase from the 1974 to 1998 mean of 11.1%. Canadian pre-terminal exploitation rates in the following three years ranged from 18.5% to 33.4%, and were substantially higher than average. These higher exploitation rates likely contributed to the lowered escapements of summer chum salmon in the streams of Discovery and Sequim bays after 1988.

# 2.3 Rating of Factors For Decline

## 2.3.1 Introduction

The above discussions of factors for decline have considered the impacts of individual factors as if no other impacts were occurring. It is clear, however, that the declines of summer chum salmon in Hood Canal and the Strait of Juan de Fuca have been the result of the cumulative impacts of a number of factors. This section will rate the various factors for decline and discuss the cumulative impacts. There will also be a discussion of factors identified above that will influence the recovery of summer chum salmon. Some of these factors for recovery have been involved in the reductions in summer chum salmon survivals and run sizes, while others are more current in origin and likely did not contribute to the declines.

## 2.3.2 Ratings

Among the factors for decline, only the effects of harvest can be readily quantified. Because of this, the ranking of the various factors for decline is necessarily a subjective process. The following four categories are used to rate the various factors for decline discussed above: 1) major impact, 2) moderate impact, 3) low or not likely impact, or 4) undetermined impact.

Those factors categorized as having a major impact are ones of such significance that individually they could have caused substantial long-term reductions in survivals and run sizes. The reversal of factors in this category would likely lead to rapid recovery of the summer chum stocks. Moderate rated factors are ones that individually could cause short-term reductions in survivals and run sizes, but in the absence of other negative factors are not likely to have a long-term impact. Low or not likely ratings are factors considered to be within the range of normal survival factors for summer chum salmon. The undetermined category is used for those factors that may have negative consequences, but supporting data are not available. The ratings of factors for decline are discussed below and are presented in Table 2.12.

**Table 2.12.** Ratings of region-wide factors for decline of summer chum salmon in Hood Canal and Strait of Juan de Fuca streams.

Impact ratings: **UUU** Major **UU** Moderate **U** Low or not likely ? Undetermined

| Factor | Hood Canal | Strait of Juan de Fuca |
|---|---|---|
| Climate | | |
| Ocean conditions | ? | ? |
| Estuarine conditions | ? | ? |
| Freshwater conditions | UU | UUU |
| Ecological Interactions | | |
| Wild fall chum | U | U |
| Hatchery fall chum | U? | U |
| Other salmonids (including hatchery) | UU | U |
| Marine fish | U | U |
| Birds | U | U |
| Marine mammals | U | U |
| Habitat | | |
| Cumulative impacts | UUU | UUU |
| Harvest | | |
| Canadian pre-terminal catch | U | UU |
| U.S. Pre-terminal catch | U | U |
| Terminal catch | UUU | U |

## 2.3.3 Climate

The effects of climate on the success of summer chum salmon has three broad components; ocean, estuarine, and freshwater survival. The impacts on salmon survivals in each of these areas is influenced by climate regimes of decadal length periodicity in the North Pacific Ocean. The last documented ocean regime shift occurred in 1977, and relates to changes in local weather patterns. The Pacific northwest has experienced warmer, dryer weather conditions since 1977, and for the Hood Canal and the Strait of Juan de Fuca region, this has resulted in lower stream flows during the summer chum spawning period (September/October) and higher flood flows during incubation (October through March). These conditions have likely resulted in reduced egg to fry survivals for summer chum salmon in region streams. The impact of climate on summer chum salmon freshwater survivals is rated as moderate for Hood Canal stocks, primarily because there is substantial variability in the observed stream flows and not all years have had flow patterns consistent with negative impacts for these fish, and because the reductions in spawning flows did not occur until 1986. The concordance of the 1986 reduction in spawning flow in Strait of Juan de Fuca streams results in a major impact rating for summer chum stocks in that region. The increased frequency of damaging flows during spawning and incubation contributes to lower survivals, and is a factor that potentially will slow the recovery of naturally spawning summer chum salmon.

The impacts of ocean climate conditions on the survival of summer chum salmon during their period of estuarine and ocean residence is also important. The current ocean regime shift has changed patterns of temperature and freshwater runoff, which likely influence conditions in estuaries. Ocean water temperatures and plankton abundances in the North Pacific also have changed, contributing to strong returns of many Alaskan and Canadian salmon stocks. It is assumed that the ocean survivals of Hood Canal and the Strait of Juan de Fuca summer chum salmon stocks also have been affected, however, the data do not exist to determine the nature and degree of change. The effects of ocean conditions on summer chum salmon in both the estuaries and ocean have been rated as undetermined.

The major reduction in stream flows shown for the 1986 and later years likely has been the result of climatic change, but may still be exacerbated by water withdrawals or other human caused impacts on specific streams. Many water withdrawals and other flow altering events have occurred prior to 1968, and current stream flow patterns represent the residual water supply available after any permanent flow alterations. This analysis examined the evidence for recent changes in stream flow patterns, but did not address the overall issue of adequacy of flow for fish production.

## 2.3.4 Ecological Interactions

Of the various potential competitor or predator species considered, none are thought to have played a significant roll in the decline of summer chum salmon. Data relating to various salmonid, marine fish, predatory bird, and marine mammal populations have been examined for evidence of changes coincident with the decline of summer chum salmon. Only hatchery fall chum have shown a change in abundance that generally related to the period of decline in Hood Canal. Because of the large magnitude of releases of hatchery salmonids into the streams of Hood Canal during the period of summer chum decline, and because of the high potential for negative interactions resulting from these releases, hatchery salmonids have been rated as having a moderate impact on Hood Canal summer chum stocks. All Strait of Juan de Fuca potential competitor or predatory species have been rated as having a low or not likely impact. Because of recent increases in abundance, wild fall chum salmon and marine mammals have been identified as potential factors that may impede recovery.

There is a very large hatchery program for fall chum salmon in Hood Canal, and it has been posited that juvenile hatchery fall chum may have a negative competitive effect on summer chum salmon survivals. The existing evidence suggests that there is no substantive negative interaction between these two types of chum salmon, however, the question must be considered to be unresolved at this time. The potential impact of hatchery fall chum salmon has been placed in the undetermined category.

### 2.3.5 Habitat

The impact of habitat alteration on the summer chum stocks of the region has an unique relationship to the survival and runsize changes in these populations of fish. Habitat degradation and loss is usually the result of the cumulative impacts of changes in the land and aquatic environments. It is relatively unusual for a single habitat alteration to have a region-wide impact, and in Hood Canal and the Strait of Juan de Fuca no wide-spread habitat impacts have been observed during the recent periods of summer chum salmon decline. Individual streams have experienced cumulative reductions in habitat capacity and productivity from a variety of sources like forestry, road building, residential construction, stream flow alteration, channelization and diking, etc. Over the years this has resulted in the loss of populations (e.g., Skokomish) and caused habitat related reductions in survivals which have combined to lower the overall resiliency of the existent summer chum salmon populations. This effect has contributed to increased vulnerability of the stocks and has played a major part in the declines. The cumulative effects of habitat change have been rated as a major impact on summer chum salmon. See section 3.4 and Appendix Report 3.6 for more detailed discussion of habitat decline.

### 2.3.6 Harvest

Two different types of harvest have contributed to the decline of summer chum salmon of the region; pre-terminal fisheries in the Strait of Juan de Fuca, and terminal fisheries in Hood Canal. For Hood Canal summer chum stocks, pre-terminal harvests occur annually, primarily in fisheries for pink and sockeye salmon in the Strait of Juan de Fuca. The impact of these fisheries during the period of decline of Hood Canal stocks has been rated low. After 1974, an added level of fishery exploitation began to occur in the terminal area, resulting in high exploitation rates through the 1980s. Terminal harvest has been rated as a major impact on Hood Canal summer chum salmon.

For Strait of Juan de Fuca summer chum stocks, pre-terminal harvests have been rated as having a moderate impact. Exploitation rates have increased substantially in Strait of Juan de Fuca fisheries in concert with the 1989 drop in summer chum salmon escapements to region streams. There have been no meaningful terminal area harvest of these stocks, which results in a low or not likely impact rating.

### 2.3.7 Cumulative Impacts

Three primary factors have combined to cause the decline of summer chum salmon in both Hood Canal and Strait of Juan de Fuca streams; habitat loss, fishery exploitation, and climate related changes in stream flow patterns. An unusual feature of the declines is that the summer chum salmon of the two regions have been affected by similar factors, but the declines have occurred ten years apart. The summer chum salmon of both regions have experienced concurrent changes in critical stream flows and increased fishery exploitation rates. While this discussion has focused on region-wide change, individual stocks likely have been differentially impacted by the identified factors for decline. More detailed assessments at the stock, watershed, and management unit level are presented in Part Three.

### 2.3.7.1 Hood Canal

The continuous and cumulative reduction in habitat productivity and capacity influences summer chum salmon by lowering survival rates (population resiliency) and reducing potential population size. Thus it appears that when Hood Canal summer chum salmon began to experience the added pressures from climate change and new fishery exploitation, the populations collapsed. In 1979, summer chum run sizes and subsequent escapements were very low because of the effects of unfavorable stream flows on the 1975 and 1976 brood production. This poor performance was evident in chum salmon stocks statewide. The Hood Canal summer chum populations (with the exception of Union River) were the only chum stocks that did not immediately recover from the low return levels of 1979. The new post-Boldt net fisheries in Hood Canal, when combined with pre-terminal harvests, began to impose high exploitation rates on summer chum salmon in 1980, contributing to low escapements through the 1980s. At the same time, oceanic climate changes influenced regional weather patterns, resulting in unfavorable stream flows during the summer chum salmon egg incubation seasons. Spawning flows also dropped substantially in 1986 (likely climate related), and contributed to the continuing poor status of these stocks. The current low production of Hood Canal summer chum salmon appears to be the result of the combined effects of lower survivals caused by habitat degradation, climate, increases in fishery exploitation rates, and the impacts associated with the releases of hatchery salmonids.

### 2.3.7.2 Strait of Juan de Fuca

The pattern of decline of summer chum salmon in Strait of Juan de Fuca streams was similar to the Hood Canal experience, however, the drop in escapements occurred ten years later, in 1989. The impact of habitat alteration likely had similar negative impacts on stock survivals and resiliency. These summer chum stocks were also affected by a coincidental concurrence of changes in stream flows and exploitation rates. Regional stream flows during the spawning season dropped substantially in 1986, and likely contributed to lower returns beginning in 1989. There were no terminal area harvests of summer chum salmon in this region, however, these fish were harvested in pre-terminal fisheries for other salmon species. In 1989, the pre-terminal exploitation rates increased substantially, reducing the numbers of summer chum salmon escaping to Strait of Juan de Fuca streams. The combined effects of reductions in habitat quality, stream flows, and fishery exploitation resulted in low summer chum salmon production in the region.

# 2.4 Factors Affecting Recovery

This general assessment of factors for decline of summer chum salmon has focused specifically on changes in fish production and potential survival factors that occurred twenty years ago in Hood Canal and ten years ago in the Strait of Juan de Fuca. Several factors have been surmised to have had a major negative impact on summer chum salmon survivals and runsize, and others have had moderate or low impacts. Because of the time that has passed since the declines in the two regions, recovery may not involve just the factors that contributed to the decline. Some of the factors discussed above may not have had major, or even moderate impacts on the declines of summer chum salmon, but now may be factors that will slow recovery.

An example of such an impediment to recovery is the current high abundance of marine mammals in Hood Canal. Twenty years ago, harbor seals were in low abundance in Hood Canal, and are unlikely to have significantly contributed to the summer chum salmon decline. In the intervening years, the local seal population has expanded to the point that a recent NMFS review of marine mammal predation on salmonids (NMFS 1997b) has stated the possibility that pinniped predation may affect the recovery of summer chum salmon. Preliminary results from a 1998 pinniped predation study on a number of Hood Canal summer chum streams show substantial predation on returning adult salmon, and that a considerable portion of this predation is occurring on summer chum stocks.

Climate change and its affect on stream flows is another factor that has the potential to slow the recovery of summer chum stocks. The noted reductions in average spawning flows coupled with the increases in peak flows during incubation, undoubtably have had a negative impact on survivals. While not all years experience flows that are negative for survivals, the overall effect may slow the potential rate of recovery.

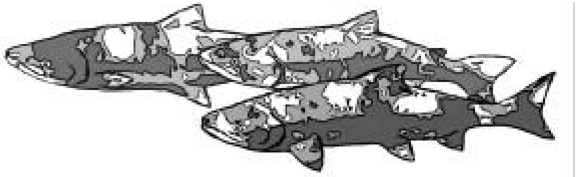
**Depensatory Mortality**

***Mortality is depensatory when its rate (i.e., proportion of population that dies) increases as the size of the population decreases. This is in contrast to compensatory mortality where the mortality rate decreases as the population size decreases.***

Depensatory mortality (where mortality rates increase as population size declines) is a biological factor that may also slow recovery, particularly for very small populations. Peterman (1977) has demonstrated the existence of multiple domains of stability in salmon populations, where depensatory mortality can cause population abundance to stabilize at low levels after a collapse. Predation and fishery exploitation are two factors that can affect depensatory mortality and cause a salmon population to stabilize in a lower domain, and it can be difficult for a depressed population to recover to a higher level if the depensatory processes can not be changed. Density dependent mortality may in part explain why some populations do not recover after a short term reduction in survival (e.g., the decline of Strait of Juan de Fuca summer chum salmon after four years of high pre-terminal exploitation rates). Fishery exploitation rates can be lowered in favor of the depressed population, but, it may not be possible to reduce the natural levels of predators or to rapidly restore degraded habitat that may be holding a population in a lower domain. This situation may substantially slow recovery of some small summer chum salmon populations, and in the worse cases may require that active intervention (e.g. supplementation) be used to help the population to recover.

There have also been a number of factors that are positive for summer chum salmon recovery. One is the successful reduction in Hood Canal terminal area exploitation rates, beginning with the 1993 return year. The average terminal area harvest has been just over 1% during the 1993-1997 seasons. Successful supplementation projects on two stocks are increasing the numbers of returning summer chum adults to two streams. There have also been meaningful changes in the management and culture of hatchery salmonids in the region, designed to reduce negative interactions with summer chum juveniles. The combined effects of these changes in summer chum salmon management have contributed to the increased escapements in recent years. However, additional measures, particularly with respect to habitat protection and restoration, are required for successful recovery of summer chum salmon.

# Part Three Evaluation and Mitigation of Factors for Decline



## 3.1 Introduction

Part Two of this summer chum salmon conservation plan examined factors affecting major declines of summer chum in Hood Canal and Strait of Juan de Fuca within the last 30 years. The intent was to identify from a region-wide perspective the likely most important negative impacts on summer chum. For Hood Canal stocks, major factors for decline were found to be habitat deterioration and terminal area fishery harvest while climate effects on stream flow, interactions with hatchery salmonids, and pre-terminal harvests were identified as having moderate impacts. Major impacts on Strait of Juan de Fuca summer chum stocks were cumulative habitat impacts and climate effects on stream flow, and pre-terminal harvest had a moderate impact.

Ten to 20 years have passed since the recent declines began and there have been some changes in the factors affecting summer chum salmon production. For example, harbor seal predation was not identified as a significant contributor to the summer chum declines, primarily because of the relatively low seal numbers during the periods of decline. However, harbor seal populations have increased to the point that their levels of predation on summer chum has become a major factor that may affect recovery. On the positive side, recent changes in harvest management and salmonid hatchery programs have substantially reduced the impacts of these activities on summer chum stocks.

Part Three of the plan evaluates factors for decline for summer chum salmon at the watershed and management unit levels, and provides specific strategies for recovery. It is arranged in five sections; Artificial Production, Ecological Interactions, Habitat, Harvest Management, and Program Integration and Adaptive Management. Each of these sections provides specific recommendations for strategies and actions to aid the recovery of summer chum stocks. The co-managers will implement summer chum salmon recovery activities in the areas of artificial production, ecological interactions, and harvest management. The Habitat section, however, has a somewhat different approach. Because the co-managers do not control land and water use, the Habitat discussion identifies the habitat problems faced by summer chum salmon, and recommends

> ***"The co-managers will implement summer chum salmon recovery activities in the areas of artificial production, ecological interactions, and***

various recovery strategies. The selection and implementation of specific habitat recovery actions will ultimately be the responsibility of land-use management agencies, major land holders, and private citizens. The co-managers will work with these local entities to provide technical support and foster an integrated approach to addressing factors for decline. The section, Program Integration and Adaptive Management, describes how the components of the plan will integrated and adapted to achieve summer chum recovery. Following are thumbnail descriptions of the content of the five sections that make up Part Three.

> ***"The selection and implementation of specific habitat recovery actions will ultimately be the responsibility of land-use management agencies, major land***

The Artificial Production section (3.2) assesses the need for supplementation on a stock by stock basis, provides a supplementation risk assessment for individual projects, and identifies appropriate supplementation projects to be implemented under this plan.

The Ecological Interactions section (3.3) provides strategies to be implemented to minimize the impacts of artificial production programs for fall chum and other salmonids, and recommends that the impacts of local marine mammal populations on summer chum be assessed and mitigated if necessary.

The Habitat (section 3.4) discussion focuses on the freshwater and estuarine habitats. It discusses individual watershed assessments of factors for decline, provides strategies for protection and recovery of habitat, and identifies methods for setting priorities and performance standards, and for monitoring and evaluation.

The Harvest Management section (3.5) describes harvest management issues, relates harvest to other factors for decline, identifies monitoring and evaluation needs, and identifies harvest management strategies and performance standards for implementation under this plan.

The Program Integration and Adaptive Management section (3.6) describes both a review process that evaluates performance criteria for summer chum populations and a process for adaptive management that integrates the various components of the larger plan.

# 3.2 Artificial Production

## 3.2.1 Introduction

Artificial production techniques may be used to supplement currently depressed wild summer chum populations, or to reintroduce summer chum into streams where the original population no longer exists. When properly implemented, supplementation and reintroduction can be powerful tools, contributing to the recovery or restoration of naturally-producing populations (Cuenco et al. 1993; Fuss 1997). The parties to this recovery plan initiated supplementation programs for natural Hood Canal summer chum populations during the 1992 brood year. More recently, efforts have also been directed toward reintroduction of summer chum into streams where populations have been extirpated.

This section of the recovery plan describes the basis for decisions to supplement or reintroduce summer chum, including projects already being implemented and those that are planned. The approach to, and implementation planning for, specific projects or actions are also described. Following are goals for artificial production, which are directed at ***only*** those populations identified as ***at risk of extinction*** in this plan, and also are directed at ***selected***, extirpated populations within the region:

> ***"Restore naturally-producing, self-sustaining populations to their historic localities and levels of production, and minimize the risk of further declines, while conserving the genetic and ecological characteristics of the supplemented and***

### 3.2.1.1 Rationale

Supplementation is viewed as an effective tool, in combination with other management actions, for restoring natural production of summer chum to healthy levels within Hood Canal and the Strait of Juan de Fuca region. By the early 1990s, summer chum populations had declined to such low levels that the risk of extinction to portions of the region on the short term was high. Furthermore, with the recent extirpation of four populations, the need for hatchery-based actions was identified to reintroduce summer chum into vacant habitat that, based on stock assessment data, appeared unlikely to be colonized naturally within a reasonable time frame. The need to quickly boost the population sizes above critically low levels, and the fact that some factors limiting production, such as harvest and habitat degradation, were in the process of being addressed also contributed to the decision to use supplementation.

### 3.2.1.2 Intent

The intent of supplementation efforts within this region is to reduce the short term extinction risk to existing wild populations and to increase the likelihood of their recovery to a healthy status. These objectives can be accomplished through the establishment of supplemented populations using indigenous broodstock, and through reintroductions of appropriate populations into streams now lacking summer chum. In keeping with the intended ephemeral nature of this form of artificial production, the proposed supplementation strategy will be limited in duration and designed to help maintain the populations while potential factors for decline are identified and being addressed. Monitoring and evaluation activities proposed for the programs will provide important new scientific information regarding the effectiveness of supplementation as it relates to chum salmon. Contribution to the re-establishment of naturally functioning ecosystems through the recovery or restoration of summer chum populations, is also an intent.

The supplementation focus at this time is on recovery of "at risk" stocks and reintroduction of extirpated populations. This current emphasis is in response to the generally poor condition of the stocks of HC-SJF summer chum. In the future, as the stocks recover, consideration may also be given to enhancement of summer chum for fisheries benefit. However, specific conditions, criteria, and guidelines will need to be defined before artificial production would be pursued for that purpose. This plan currently addresses artificial production only as it applies to population recovery and reintroduction.

**Artificial Production Definitions**

**Supplementation:** ***"The use of artificial propagation to maintain or increase natural production while maintaining the long term fitness of the target population, and keeping the ecological and genetic impacts to non-target populations within specified biological limits."***
**Reintroduction:** ***"The transfer and release of progeny from an appropriate broodstock into a watershed where the target species or race has been extirpated, for the purpose of reintroducing the species or race and creating a self-sustaining return."***
**Enhancement:** ***"The use of artificial propagation to produce fish that are primarily intended to be caught in fisheries."***

The co-managers intend to integrate supplementation actions with other recovery measures to provide optimum benefit to the summer chum populations. A system-wide approach to recovery will be pursued, in recognition that supplementation applied alone likely will not improve the status of summer chum. In many cases, summer chum declines can be partially attributed to habitat degradation and over harvest in fisheries. Concurrent improvements in habitat conditions, including riparian conditions, channel complexity and watershed flow characteristics, and in fisheries management, are needed to effect recovery of summer chum salmon.

### 3.2.1.3 Anticipated Benefits of Supplementation Approach

The above described recovery objectives will be achieved through the propagation and release of fed chum salmon fry originating from indigenous regional broodstocks. For "at risk" populations chosen through this program for supplementation, hatchery production of fed fry of large size relative to natural fry, released at the proper migration time, will provide a survival advantage that will improve the status of the populations more rapidly than is possible through natural production alone. The immediate objective for these populations will be to boost the population abundance as quickly as possible, increasing natural spawner densities to sustainable levels that will alleviate the risk of extinction to the populations. For selected, extirpated populations, seeding of usable habitats will be accomplished through reintroduction strategies developed specifically for each recipient watershed. Reintroduction planning strategies will include selection of the most appropriate donor stock, acclimation to the recipient location, and release of fed chum fry to maximize the likelihood for the establishment of a population.

### 3.2.1.4 Potential Hazards and Limitations

The parties recognize that uncertainty exists regarding the risks and benefits of supplementation. Specifically, it is acknowledged that supplementation actions may pose significant ecological and genetic hazards to the remaining wild summer chum populations. Ecological hazards may include disease transfer, facility failure leading to fish loss, and increased resource competition (Steward and Bjornn 1990). Genetic hazards may include loss of genetic variability within and among populations, domestication, and extinction (Busack and Currens 1995). These hazards are discussed within this plan. Strategies are proposed to minimize the risk of these hazards on supplemented and non-supplemented summer chum populations. Risk aversion strategies will include the preservation of a substantial fraction of the natural summer chum populations in the region in a state that is unaffected directly by supplementation. The benefits of supplementation are weighed against potential risks in determining the appropriateness of intervention measures. Monitoring and evaluation programs are also proposed to help resolve uncertainties regarding supplementation, and to allow for adaptive management of programs proposed within this plan.

The co-managers also recognize that there are major ecological factors that are outside of human control within the summer chum biome that will affect summer chum survival and the success of supplementation efforts. The factors include inter-annual variability and long term trends in estuarine and marine productivity, flood events, and droughts. These factors may limit the effectiveness of attempts to increase the abundance of both supplemented and unsupplemented populations through proposed regional stock recovery actions. In addition, it is acknowledged that Hood Canal and Strait of Juan de Fuca summer chum are among the southernmost representatives of summer-time spawning chum in the Northeast Pacific region, and they may be especially sensitive to disturbances, including habitat degradation. There is a heightened likelihood that natural environmental regime shifts, including El Niños and decadal scale changes in environmental conditions, may therefore periodically lessen the suitability of freshwater and marine habitat for the successful production of summer chum salmon in this portion of their range.

### 3.2.1.5 Overview of Contents

Included within the Artificial Production section are detailed descriptions of when, how, and where supplementation will be used to assist in the recovery of summer chum populations in the Hood Canal and eastern Strait of Juan de Fuca regions. Elements will be presented as follows:

**Supplementation Approach:**

- When to supplement or reintroduce, including an initial project selection process and a discussion of benefits and risks.
- When to modify or stop a supplementation program.
- ***General*** criteria regarding how to supplement under this plan.
- Identification of monitoring and evaluation objectives, and needed research associated with the supplementation programs.

**Project Selection and Implementation:**

- Summary of on-going supplementation activities within the regions (Appendix Report 3.2).
- Project selection process, including methods to assess potential hazards.
- Project implementation plans, based on and consistent with the preceding supplementation and reintroduction guidelines. Regional actions by watershed, including population status information and prioritized objectives for recovering or restoring populations within each present and historically documented summer chum stream or river.
- ***Specific*** criteria regarding how supplementation will be conducted (Appendix Report 3.1).

**Funding Priorities:**

- Criteria for prioritizing funding needs and projected funding needs by watershed affect.

## 3.2.2 Supplementation/Reintroduction Approach

This section describes the general approach to supplementation and reintroduction of summer chum. Details of application are described below in section 3.2.3: Project Selection and Implementation.

### 3.2.2.1 When to Supplement and When to Reintroduce

Deciding when to reintroduce or supplement a summer chum population requires careful consideration of the need and consequences of such an action. Supplementation should only be done to rebuild a population when that population is at risk of extinction, or to develop a brood stock for reintroduction. Also, supplementation and reintroduction should occur as part of a comprehensive effort to understand and effectively address factors for decline or extirpation of a population.

> “***Supplementation should only be done to rebuild a population when that population is at risk of extinction, or to develop a brood stock for reintroduction.”***

A structure or process is needed to assess supplementation and reintroduction options relative to program objectives, provide a strategy for prioritizing potential actions, and clearly show the basis for decisions. Following is a description of the objectives and decision process for summer chum supplementation and reintroduction. Factors included in assessing the options and in evaluating risks and benefits as part of the decision process are also discussed.

#### Objectives

Our objectives in developing supplementation and reintroduction projects are: 1) to rebuild summer chum populations at risk of extinction, 2) to restore summer chum to streams where a viable spawning population no longer exists, 3) to maintain or increase summer chum populations of selected streams to a level that will allow their use as broodstock donors for streams where the summer chum population has been lost, and 4) to avoid and reduce the risk of deleterious genetic and ecological effects. The following process is used to address these objectives.

## Decision Process

By the early 1990s, local summer chum populations were at high risk of extinction and at least four populations had been extirpated (see Part One). Spawner escapements in the region had declined to totals under 1,000, and several populations escaped under 25 fish in consecutive years. It was determined that immediate action was required and, therefore, supplementation and reintroduction projects were initiated to address the immediate problems. These projects were begun based on the resource need and also opportunity, given available funding, facilities and participants. At about the same time, measures were started to control negative effects on summer chum caused by fisheries harvest and habitat degradation.

The process for selecting projects is summarized as follows. First, existing summer chum stocks and recently extinct stocks (identified in Part One, sections 1.7.2.1 and 1.7.2.2 and shown here in Table 3.1) are generally evaluated as candidates for supplementation and reintroduction, considering several factors affecting benefits and risks (Part One also presents a discussion of existing information regarding possible past distribution of summer chum spawners in other areas within the region). The candidate stocks are then subject to more focused assessments of potential risk from hatchery failure, ecological hazards, and genetic hazards. Based on this general evaluation, and the subsequent assessments of risk, a list of selected supplementation and reintroduction projects is generated. Stocks with existing supplementation and reintroduction projects are included in this selection process (assuming wild population statuses that existed prior to adult returns from the projects) to show how they would fare in comparison to the other streams. Detailed descriptions of the general evaluation, assessments of risks, and selection of projects, are provided in section 3.2.3. More general discussions of the general assessment, and determination of risks and benefits, follow.

## General Assessment of Supplementation and Reintroduction Alternatives

The general assessment of alternatives considers a number of factors bearing on the need, urgency and practicality of supplementation/reintroduction in each stream. The assessment also serves to rank the streams by numerical scoring of each factor. The factors to be assessed include: 1) the extinction risk rating for the stock assigned from consideration of the mean escapement level and the recent population trend (applies to supplementation candidates only); 2) potential population size, reflecting on the magnitude of the stream's historical production relative to the historical overall production of the region; 3) knowledge of habitat effects on the population and what, if any, habitat recovery actions are ongoing or planned; 4) availability of brood stock for the supplementation or reintroduction action; and 5) available resources to implement such an action. Details of this assessment and ranking process, and the results, are described in section 3.2.3.

**Table 3.1.** Summary of Hood Canal and the Strait of Juan de Fuca summer chum salmon stocks and their current status, including existing and recently extinct stocks.[1]

| Existing Stocks | | |
|---|---|---|
| **Stock** | **Extinction Risk Rating** | **Known Recently Extinct Stocks** |
| Union | Moderate | Finch |
| Lilliwaup | High | Skokomish |
| Hamma Hamma | Moderate | Tahuya |
| Duckabush | Low | Dewatto |
| Dosewallips | Low | Anderson |
| Big & Little Quilcene | High[2] | Big Beef |
| Snow/Salmon | High[2] | Chimacum |
| Jimmycomelately | High | |
| Dungeness | Special Concern | |

[1] The list of existing and known, recently extirpated stocks and extinction risk ratings are carried over from the Stock Definition and Status section 1.7.2 in Part One - Life History and Stock Assessment.

[2] "Extinction Risk Ratings" indicated are based on pre-supplementation project summer chum escapement levels.

## Assessing Benefits and Risks

Summer chum populations identified as candidates for supplementation or reintroduction are subject to risk and benefit assessments to help determine whether the potential benefits of a proposed program outweigh potential deleterious effects. A product of such assessments is the indication of whether the risk to the target population of using supplementation (including potentially adverse genetic and ecological effects) outweighs the risk of foregoing supplementation (potentially leading to extinction, limited stock distribution, or unacceptably slow recovery). The assessment procedures and results for each candidate stock are presented in section 3.2.3 of this plan.

## Potential Benefits and Hazards of Supplementation

Waples (1996) and Cuenco et al. (1993) developed outlines and characterizations of potential benefits and hazards of supplementation that should be considered within the context of a rebuilding program. The benefits and hazards identified within these documents will be included herein as factors that, when objectively weighed and considered, will help indicate the appropriateness of a proposed supplementation program. The list of potential benefits is augmented by specific benefits anticipated for the summer chum populations in the region, and positive results of supplementation observed thus far. Hazards outlined below are characterized in detail within the two referenced documents, and those details are therefore not repeated here. Methods that will be employed to help address risks of those supplementation programs determined through this framework to be appropriate will be presented in following sections, which describe general and specific information regarding *how* to supplement.

## i. Potential Benefits

The following descriptions use Quilcene and Salmon Creek summer chum supplementation programs to illustrate how potential benefits may be realized.

### 1. *Reduce short-term extinction risk.*

Supplementation may be used to reduce the risk that a population on the verge of extirpation will be lost by expeditiously boosting the number of emigrating juveniles in a given brood year. The supplementation program implemented at Quilcene NFH in 1992 has reduced the risk of extinction of the Big Quilcene summer chum salmon, increasing average natural spawning escapements from 164 (range: 6-349) for the five years prior to program returns (1990-94), to 5,523 fish for the recent four years (1995-98 range: 2,244-8,479).

### 2. *Preserve population while factors for decline are being addressed*.

Supplementation may be used to preserve or increase summer chum populations while other factors causing decreased abundances are addressed. The Quilcene NFH supplementation program has increased summer chum abundance, while using strategies to minimize genetic divergence between the hatchery fish and the wild fish by using representative samples of the indigenous Quilcene wild population as hatchery broodstock, by avoiding artificial selection, and by minimizing differences between the natural and hatchery environments. The program has achieved these objectives while impacting fisheries were adjusted and degraded habitat was being remedied.

### 3. *Speed recovery.*

Supplementation may be used to accelerate recovery of populations by increasing abundances in a shorter time frame than may be achievable through natural production. The Quilcene NFH supplementation program accelerated recovery of the Big Quilcene River spawning population from the rate that would have occurred as a result of the natural spawning of 49 fish in 1991, 320 fish in 1992, and 97 fish in 1993. The supplementation programs may produce up to 36 adults per spawning pair, compared to approximately 2.5 adults per spawning pair for wild spawning fish (assuming fecundity and survival parameters presented in Appendix Report 3.1, Table 3.1.1).

### 4. *Establish a reserve population for use if the natural population suffers a catastrophic loss.*

Supplementation programs may be used to create an additional reservoir for a particular summer chum genome. Natural spawning areas in the Big Quilcene River have been illegally bull-dozed during channelization work twice within the past five years (1993 and 1996) during the incubation period for summer chum eggs. The establishment of a reserve hatchery population in Quilcene NFH reduced the effects of these catastrophic actions on the population. The Quilcene and Salmon Creek summer chum stocks are also being spread to Big Beef Creek and Chimacum Creek respectively, creating additional reserve populations where native genomes of HC-SJF summer chum can be preserved and future risks lessened.

### 5. *Reseed vacant habitat capable of supporting salmon*.

Summer chum populations may be reintroduced to streams where populations have been extirpated and the causes of extirpation are being addressed. Eyed eggs from Quilcene NFH and from Salmon

Creek have been transferred to incubation and rearing locations at Big Beef Creek and Chimacum Creek respectively, to reintroduce summer chum to two streams where populations have been extirpated and where harvest management and habitat restoration actions are either being implemented or are expected to occur.

6. ***Provide scientific information regarding the use of supplementation in conserving natural populations.***

Valuable information indicating the effectiveness and effects of supplementation in the recovery of summer chum can be collected. The Salmon Creek, Big Beef Creek and Quilcene NFH programs are being used to develop valuable information regarding hatchery and wild-origin summer chum productivity, hatchery-origin chum contribution rates, and hatchery-origin chum straying rates.

**b) Hazards to Natural Populations**.

Following is a list of potential hazards to targeted and non-supplemented natural populations that may result from a supplementation or reintroduction program. Within subsequent sections (e.g. section 3.2.3.3.), each hazard is described in detail and weighed in terms of its consequence to the natural population, considering steps presented within this plan to mitigate and/or minimize the effects of each hazard.

**Potential Hazards Attached with Supplementation Programs**

1. ***Partial/total hatchery failure (potential for catastrophic loss)***
2. ***Ecological effects***
    a. Predation
    b. Competition
    c. Disease transfer
3. ***Genetic effects***
    a. Loss of genetic variability *between* populations
        1. Out-breeding depression
    b. Loss of genetic variability *within* populations
        1. Inbreeding depression
        2. Genetic drift
        3. Selection
4. ***Risks to donor stock (e.g. numerical reduction or selection effects)***
5. ***Risks to other salmonid populations and species (e.g., redd superimposition impacts on wild pink salmon).***

Waples (1996) suggests guiding principles for the analysis of the above risks and potential benefits after they are enumerated and individually evaluated. Evaluation of potential benefits and risks should not focus solely on their likelihood of occurrence, but also on the consequences of the particular effect (positive or negative) on the population. A region-wide risk/benefit assessment rather than only an assessment of each individual project, is also suggested, as inclusion of all affected populations may lead to different conclusions regarding risks and benefits than what might be derived from analyzing each situation individually. Lastly, evaluation of supplementation risks/benefits should be conducted within the context of the potential benefits and risks of alternative conservation and recovery measures, including consideration of comparative response time frames and relative flexibility to adopt adaptive management approaches.

The approach assumed in this plan is directed at preservation and rebuilding of summer chum stocks, which are the individual components of the Hood Canal summer chum ESU constructed by NMFS for ESA consideration. The stock by stock supplementation and risk/benefit assessment approaches pursued in this plan are viewed by the co-managers as the most effective means to assess and recover "at risk" stocks, which are the primary focus. However, the immediate need to preserve and recover these individual "at risk" summer chum stocks is viewed as more important than a prolonged consideration of the likelihood for the occurrence of risks or benefits. The view carried in the plan is the need to act, accepting potential risks of negative consequences associated with artificial propagation practices (the likelihood of which are minimized through measures proposed here), rather than allowing further extirpations.

The co-managers have endeavored to meet recommendations contained in Waples (1996) that are aimed at region-wide risk considerations through a focus on only "at risk" stocks for supplementation, and application of risk aversion measures that are responsive to among population genetic diversity concerns (e.g., use of broodstocks only once for reintroductions, maintaining key populations without supplementation, and monitoring aimed at assessment of straying). Section 3.2.3 describes anticipated risks to HC-SJF summer chum (considered in aggregate) that may result from the supplementation approach, and how those risks may be minimized. Again, the stock by stock approach assumed in the plan is viewed as the most appropriate means to assess risks, and to preserve and recover the individual populations that comprise the ESA-listed summer chum.

Finally, the co-managers believe the status of several summer chum stocks warrants immediate intervention using supplementation to prevent further extirpations. Although other actions directed at harvest and habitat management are proposed through the overall plan to act on recovery, the extremely poor status of some stocks calls for an immediate significant increase in abundances; a response only available through the use of artificial production. The supplementation approach suggested is flexible, incorporating monitoring and evaluation to allow for any changes needed under the context of adaptive management.

#### 3.2.2.2 When to Modify or Stop a Supplementation or Reintroduction Program

Of critical importance in the development of a stock supplementation or reintroduction plan is agreement on criteria that will be used to determine when programs will be modified or terminated. By definition, supplementation and reintroduction are to be used as much as possible as short term means to preserve, rebuild, or restore a naturally producing population through the use of artificial propagation. The design is to limit the duration of the programs to minimize the risk that adverse effects on the wild population result from the use of artificial propagation. On the other hand, the program must be allowed to progress for a sufficient duration of time to allow the population targeted for rebuilding or reintroduction to be sufficiently recovered or established. Also, as the program progresses there should be an allowance for adequate evaluation of whether the program is effective and for adaptive management of the program as a result of evaluation findings.

The duration of a supplementation or reintroduction program may be based on genetic impact reduction objectives, established abundance criteria, or an adaptive framework that will allow adjustment of the duration of the program based upon performance.  The preferred method for defining when a supplementation or reintroduction program should be modified or terminated will be an adaptive approach, combining genetic impact reduction and numerical return goal approaches with the tenets of adaptive management.

## Adaptive Management Approach

The selected approach includes decision factors that may be applied as the program progresses, and as data from the program are collected, to allow adjustment of a program (e.g., scaling back of hatchery release numbers as natural origin recruits (NORs) increase), or termination sooner than defined through genetic or numerically-based elements.  This approach is generally consistent with factors presented within Hard et al. (1992) that indicate parameters to be considered in assessing the utility of a supplementation program.  The following standards ("a" through "f") will be applied to determine when a supplementation or reintroduction program will be terminated or modified:

**f)** ***The maximum duration of regional supplementation programs will be based on criteria that minimize the likelihood that potentially deleterious genetic changes occur in the wild population.***

This objective will be met by applying a three generation maximum duration (12 years) for summer chum supplementation programs for all projects.  It is believed that a three generation maximum duration will limit the risk of adverse within and among population genetic effects that could harm the target or conspecific wild populations (S. Phelps, WDFW, pers. comm., April, 1998).  This limit will also provide two generations (eight years) of adult returns to assess the program, prior to stopping egg takes.

An exception to this three generation maximum, leading to an increase in the duration of a program, may be acceptable if there have been catastrophic declines in habitat condition, or if other uncontrollable factors affecting summer chum survival emerge during the course of a supplementation effort, making sustainable natural production unlikely.  In such a situation, the risk of the project would be re-evaluated and measured against jeopardy to the status of the targeted stock that is likely if the program were terminated.  A consideration of whether the supplementation program should be shifted to a gene pool conservation or captive brood program would be made.

If, for any reason, a project is proposed to extend longer than the three generation maximum, the standards for conducting the project will default to the more rigorous criteria provided in Appendix Report 3.3, Genetic Hazards Discussion.  These standards (the "or" criteria required when the three generation rule is exceeded *and* it therefore no longer applies) are designed to further minimize the risk of adverse effects of the project to the target and neighboring summer chum populations.  With deferral from the three generation maximum project duration, application of  more rigorous standards becomes necessary to avoid substantial domestication pressure on target populations, and to minimize the risk of masking of wild fish population status. Compliance with these standards will require changes in summer chum mating, rearing and release methods used in the operation to closely mimic spawning, rearing, and migrational traits observed in the wild. Limits on the numbers of hatchery-origin fish allowed to spawn naturally, and on the areas within a watershed where they are allowed to spawn, will also need to be applied. This plan defines supplementation methods that allow projects to be integrated with a low risk of perturbing the target and non-target summer chum populations. Artificial production methods necessary to effect operational changes required for a project proposed to extend beyond the three generation maximum are beyond the scope of this plan.

**g)** ***If adult return targets are met before the three maximum generation limit is reached, then the program may be reconsidered, and may be reduced or terminated.***

Adult return targets, defined specifically for each project, will be based on the magnitude of total adult escapements to consider program reductions, and on escapement of only natural origin recruits (NORs) resulting from the supplementation program and wild-origin fish to consider program termination. Program reduction or cessation determinations may therefore be made as follows:

1. When the total summer chum adult escapement meets or exceeds 1974-78 average escapement for the stock (see Appendix Table 1.1) for four consecutive years, the desired number of juvenile hatchery-origin fish produced for the program will be reduced, after considering circumstances bearing on the sustainability of the population (such as habitat condition). The 1974 through 1978 reference period was chosen because relatively reliable escapement estimates (that serve as the basis for run size reconstruction - see Part One) were not generally available before 1974 and because substantial declines in escapement and run size occurred in Hood Canal following 1978 (see Part Two, Region-wide Factors for Decline);

2. When the total number of NORs resulting from the supplementation program escaping to the production stream and wild-origin fish meets or exceeds 1974-78 average escapement for the stock (see Appendix Table 1.1) for four consecutive brood years, the supplementation program will be terminated, after considering circumstances bearing on the sustainability of the population;

3. When the adult return target used to indicate when a supplementation program should be reduced or terminated is based on another number that will assume precedence over the goals defined in "1." above. This adult return target may be derived from additional assessments, including productivity relative to available habitat or further consideration of what constitutes recovery in future years.

h) ***Supplementation and reintroduction programs may be terminated if they are no longer believed to be necessary for timely recovery, for reasons other than the success of supplementation or reintroduction, including improvements in ocean survival or habitat condition.***

i) ***The supplementation program will be modified or terminated if appreciable genetic or ecological differences between hatchery and wild fish have emerged during the recovery program.***

j) ***The supplementation program will be modified or terminated if there is evidence that the program is impeding recovery.***

k) ***The supplementation and reintroduction programs will be modified or terminated if there is evidence that the program is negatively impacting a non-target ESA-listed population.***

### 3.2.2.3 How to Supplement - *General Guiding Principles*

Included within this section are ***general*** criteria describing how supplementation and reintroduction programs will be conducted. A presentation of ***specific*** criteria, expanding on the general guidelines provided below is included in Appendix Report 3.1. The appendix describes in detail the criteria and methods to be used in structuring summer chum supplementation and reintroduction programs proposed within this plan.

#### General Approach

The desired strategy will be to phase implementation of individual and regional programs, rather than commence programs at maximum levels. Phased implementation, including step-wise initiation of supplementation programs within the region or the initial release of lower than goal numbers of supplemented fish into a specific watershed, will allow assessment of the initial effects of each program in achieving goals, while minimizing risk to wild populations. Programs can be adaptively managed in this manner, allowing for adjustments to be made through evaluation of different levels of production. The parties will assemble a regional program initiation schedule and annual fish release schedules for each program to implement this desired adaptive approach.

#### Populations Not Subject to Supplementation

In developing this plan, the importance of maintaining non-supplemented wild populations that comprise a representative spectrum of existing diversity will be recognized. As a result of the proposed risk assessment process, certain wild summer chum populations will be maintained in a natural state without the assistance of supplementation. Consistent with the desire to avoid further loss of populations within the region, all stocks are subject to the above described assessment process that prioritizes stocks as candidates for supplementation and reintroduction projects. Populations at risk will rank high as candidates. The more stable and larger populations will rank lower, and these populations will not be subject to supplementation. The status of all populations will be monitored, and following the principle of adaptive management, any observed changes in status will elicit a review of the situation and appropriate management action consistent with the goals and objectives of the plan.

Stocks not selected for supplementation will be identified in section 3.2.3.4, which sets forth specific supplementation program implementation plans for each summer chum population. Relatively strong wild populations maintained through the above approach may still be used as donor stocks to reintroduce summer chum into watersheds where the original population has been extirpated to help maintain among population diversity in the region. Procedures applied to collect broodstock for this purpose will be consistent with restrictions developed to protect founding populations under this plan.

## Strategies For Minimizing Potential Deleterious Effects

This section describes measures that will be taken to minimize potentially adverse effects on wild populations that may result from the supplementation programs. Strategies described in Busack and Currens (1995), Cuenco et al. (1993), Kapuscinski and Miller (1993), Waples (1996) and Hard et al. (1992) were used as guidance for defining risk aversion methods.

### a) Partial/total hatchery failure

Catastrophic loss of summer chum under propagation in a hatchery may occur as a result of de-watering due to power failure or screen fouling, flooding, or poor fish cultural practices. One method that may be used to minimize the risk of catastrophic loss to the supplemented population is propagation of the population at more than one location. Spreading the risk by culturing the stock at another location, including for the purposes of reintroduction, will increase the likelihood that the genome will be retained in the event of a catastrophic loss at one facility.

Additional methods may be employed to minimize the likelihood of hatchery failure. Examples may include propagation of summer chum at facilities having the following characteristics:

- Hatchery personnel live on-site to allow rapid response to power or facility failures.
- Low pressure/low water level alarms are functioning for water supplies serving summer chum rearing areas.
- Back-up generators are available on-site in the event of power loss.
- All hatchery personnel responsible for rearing summer chum are trained in standard fish propagation and health methods.
- The requirement that new hatchery facilities propagating summer chum be sited in areas with a low risk of flooding.

Summer chum hatcheries relying on gravity-fed water supplies will be mainly concerned with flooding, low water events, or plugged intake screening. Although these facilities lack power loss risks, the sites should be monitored on a twice daily basis (and continuously during flood events) to guard against fish loss. Remote site incubators at either gravity-fed or well water sites may be stocked with eyed eggs only, allowing rearing from fertilized egg to eye-up to occur at larger hatchery facilities where flow conditions and water quality may be better controlled.

### b) Predation

Chum salmon are opportunistic feeders, and may prey on fish as sub-adults when in the ocean (Salo 1991). However, predation on wild-origin chum fry by juvenile, supplemented summer chum released at the life stage and time proposed in the regional supplementation program is an unlikely event during their fresh or marine water migration period in Hood Canal and the Strait of Juan de Fuca. Juvenile chum salmon migrating out of Hood Canal at a size characteristic for hatchery-origin fish (> 45 mm) generally feed upon neritic zooplankton in open water areas, and fish of any life stage have not been shown to be an important prey item (Simenstad et al. 1980). In addition, salmonid predators prey on food items less than or equal to one-third of their length (Witty et al. 1995). The average size range for supplemented fed chum fry liberated at 390-450 fpp (fish per pound) is 50-53 mm (Fuss 1997), compared to a size of 37-41 mm for newly emerged and migrating wild summer chum fry (Tynan 1997). Supplementation programs will continue to release summer chum at a target average size of 53 mm as a strategy to ensure that predation on wild fry is not likely.

Large concentrations of migrating juvenile or adult hatchery-origin summer chum originating from the proposed programs may attract predators (birds, fish, and seals) and consequently contribute indirectly to predation of wild fish (Steward and Bjornn 1990). The presence of large numbers of hatchery fish may also alter wild summer chum behavioral patterns, potentially influencing their vulnerability and susceptibility to predation. Alternatively, a mass of hatchery-origin summer chum migrating through an area may overwhelm established predator populations, providing a beneficial, protective effect to co-occurring wild-origin fish. Proposed juvenile release levels from each summer chum program are of a small magnitude (< 500,000 fed fry per year) relative to the area into which the fish are being released (the marine waters of Hood Canal or the Strait of Juan de Fuca). Also, the hatchery-origin fish leave freshwater areas where they might intermingle at relatively high densities with wild fish within hours post-release, and, due to their larger size, hatchery-origin fed fry will not likely migrate in the same estuarine areas as wild fry. It is unlikely that the release of hatchery summer chum will lead to an increased attraction of predators to wild fish. (See also section 3.3; Ecological Interactions.)

### c) Competition

The risk that supplemented chum will compete with wild summer chum fry for food will be minimized through the release of hatchery fish at a larger size than the wild fry. Larger (>50 mm) chum fry have been shown to prey predominately on pelagic organisms in Hood Canal, whereas newly emerged, smaller chum fry feed on epibenthic organisms in the estuary. Larger hatchery-origin chum have also been shown to migrate and forage within a different estuarine realm (offshore) than wild fry, which initially migrate in very shallow nearshore areas (as summarized in Tynan 1997). These differential migration behavior patterns have been reported in beach seine and tow net studies conducted in Hood Canal throughout the February through June summer and fall chum emigration periods (Schreiner 1977; Bax et al. 1978; Bax et al. 1979; Bax et al. 1980). Spatial separation between the larger hatchery chum and smaller wild fry minimizes the likelihood for competition for food between hatchery-origin and wild chum fry during emigration.

Hatchery-origin adults may compete with wild-origin chum for spawning sites or access to mates. This interaction is not viewed as negative in the context of this plan, as intermixing between supplemented and wild broodstock of the same stock on the spawning grounds is an anticipated and desirable consequence of the supplementation program. This inter-mixing on the spawning grounds meets the objective of the supplementation program of increasing natural production in the region. Straying of non-indigenous, supplemented adult summer chum between watersheds is not expected to be a significant concern regarding competition. Naturally-produced chum may exhibit straying levels ranging from 2-46% (Tallman and Healey 1994). However, hatchery-origin chum salmon in Hood Canal have demonstrated a high fidelity for their stream of origin (Fuss and Hopley 1991; WDFW data for QNFH-origin marked summer chum 1997). In addition, selective breeding that may occur in hatcheries using gametes from returned migrants has been shown to result in a decrease in straying with time (Tallman and Healey 1994).

### d) Disease

Under certain conditions, hatchery effluent has the potential to transport fish pathogens out of the hatchery, where natural fish may be exposed to infection. Interactions between hatchery fish and natural fish in the environment may also result in the transmission of pathogens, if either the hatchery or natural fish are harboring a fish disease. This latter impact may occur in watersheds where hatchery fish are planted and throughout the freshwater and marine migration corridor where hatchery and wild fish may interact.

As the pathogens responsible for fish diseases are present in both hatchery and natural populations, there is some uncertainty associated with determining the source of the pathogen (Williams and Amend 1976, Hastein and Lindstad 1991). Hatchery-origin fish may have an increased risk of carrying fish disease pathogens because of relatively high rearing densities that the fish are subjected to in the hatcheries and resultant stresses to the fish. Under natural, low density conditions, most pathogens do not lead to a disease outbreak. When fish disease outbreaks do occur, they are often triggered by stressful hatchery rearing conditions, or by a deleterious change in the environment (Saunders 1991). Consequently, it is possible that the release of hatchery fish may lead to the loss of natural fish, if the hatchery fish are carrying a pathogen, if that pathogen is transferred to the natural fish, and if the transfer of the pathogen leads to a disease outbreak. Although hatchery-origin populations may be considered to be reservoirs for disease pathogens because of their elevated exposure to high rearing densities and stress, there is little evidence to suggest that diseases are routinely transmitted from hatchery to wild fish (Steward and Bjornn 1990).

Supplementation projects implemented under this conservation plan will be conducted in a manner that is consistent with Pacific Northwest Fish Health Protection Committee (PNFHPC 1989) and Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State (NWIFC and WDFW 1998) guidelines. These guidelines define rearing, sanitation, and fish health practices that minimize the incidence of disease outbreaks in propagated populations, thereby decreasing the risk of fish pathogen transmission to co-occurring wild populations. All hatchery-origin fish will be inspected by WDFW or USFWS fish pathologists to certify their disease status and health condition prior to liberation. The release of viable healthy summer chum smolts is promoted through compliance with these fish health maintenance guidelines.

### e) Loss of genetic variability between populations

There is a concern that remaining locally adapted wild summer chum populations in the region may be replaced by a smaller number of relatively homogenous populations as a result of supplementation. This replacement may occur when hatchery-origin fish mate with wild fish that are unrelated or distantly related. This consolidation and possible homogenization of the populations may lead to decreased fitness, limiting the potential of the species to adapt to new environmental conditions, thereby reducing its capacity to buffer the total productivity of the resource against periodic or unpredictable changes (Cuenco et al. 1993 quoting Riggs 1990).

An objective of this supplementation plan is to maintain existing diversity among the region's summer chum populations. Diversity-based management measures will be implemented to meet this objective for each supplementation program that is proposed. These measures will minimize the likelihood for outbreeding depression and potential negative effects on wild fish fitness.

Loss of genetic variability between populations, and the potential for and consequences of outbreeding depression, will be minimized through application of the following measures:

1. Supplementation program for streams selected under this plan will propagate and release only the indigenous population.
2. The transfers of each donor stock for reintroduction will be limited to only one target watershed outside of the range of the donor stock to avoid the situation that one or few stocks within the region predominate.
3. Supplemented and reintroduced populations will be acclimated to the watershed desired for out-planting to ensure that the summer chum retain a high fidelity to the targeted stream;
4. For reintroduced populations, where logistically and technically feasible and in accordance with the tenets of this plan, local adaptation should be fostered by using returning spawners rather than the original donor population as broodstock if the reintroduction program is still in progress.
5. Unsupplemented populations will be recognized, representing significant proportions of the existing total abundance and diversity.
6. All summer chum produced in hatchery programs will be marked to allow for monitoring and evaluation of adult returns.

### f) Loss of genetic variability within populations

An additional concern regarding the effects of supplementation on wild populations is the loss of genetic variability within a population as a result of inbreeding depression, genetic drift, or domestication selection. Within population diversity loss may occur when mating of related individuals leads to an increase in the number of homozygotes at the expense of heterozygotes. Pairing of deleterious recessive alleles may result, potentially leading to a loss in fitness of the supplemented or natural population (inbreeding depression). Diversity within a population may be altered or lost through non-random selection or inadequate collection of broodstock for use in a supplementation program, potentially leading to changes in gene frequencies (genetic drift). Diversity may also be altered or lost through artificial selection that may occur when the population is in the hatchery, causing selection for hatchery production traits that reduce the fitness of the population for the natural environment (domestication) (Berejikian 1995; Reisenbichler and Brown 1995).

The following diversity-based management methods will be implemented to reduce the potential for alteration or loss of genetic diversity within the supplemented population:

1. The duration of each supplementation program will be limited to a maximum of three chum salmon generations (~12 years) to minimize the likelihood for divergence between hatchery broodstocks and target natural stocks.
2. Adults for broodstock will be collected so that they represent an unbiased sample of the naturally spawning donor population with respect to run timing, size, age, sex ratio, and any other traits identified as important for long term fitness. Special emphasis will be placed on ensuring that the age group structure and sex ratio of collections are as similar as possible to those of adult returns of the founding population for the given week of the run.
3. Returning adults produced by a supplementation program will be used, with natural chum, as broodstock over the duration of the program (9 years post initial return of three year olds). The three generation limit for the duration of a program is intended to address the concern that repeated enhancement of the same population segment will result in a decrease in effective population size. It also limits to a few generations, the exposure of natural fish to the potentially deleterious selective effects of hatchery conditions (i.e. domestication effects).
4. Spawning protocols, including collection of broodstock proportionally across the breadth of the natural return, randomizing matings with respect to size and phenotypic traits, application of at least 1:1 male-female mating schemes (Kapuscinski and Miller 1993 - “Spawning Guidelines”), and avoidance of intentional selection for any life history or morphological trait (Appendix 3.1), will be applied that ensure that hatchery broodstocks are representative of wild stock diversity. Spawning protocols will equalize as much as possible the contributions of parents to the next breeding generation.
5. Table 3.2 presents broodstock collection objectives, based on donor population size, that will be applied to help retain genetic diversity. Minimum broodstock collection objectives are set to allow for the spawning of the number of adults needed to minimize loss of some alleles and the fixation of others (see “Table 2" in Kapuscinski and Miller 1993). Maximum collection levels are set to allow for at least 50% of escaping fish to spawn naturally each year (populations > 200). For small populations, no maximum is set as an emergency measure.

**Table 3.2** Allowable broodstock collection levels as determined by donor stock population size.

| **Donor Population Size**<br>**(Number of individual fish)** | **Allowable Broodstock Collection Levels**<br>**Minimum** | <br>**Maximum** |
|---|---|---|
| < 100 | 25 pairs | none |
| 100 - 200 | 25 pairs | 50 pairs |
| > 200 | 50 pairs | 50 % of total return |

6. Hatchery methods will mimic the natural environment to the extent feasible (e.g. use of substrate during incubation and exposure to ambient river water temperature regimes during rearing). Hatchery rearing will be limited to a maximum of 75 days post swim-up, to minimize the level of intervention into the natural chum life cycle, ensuring that the potential for domestication selection is minimized.
7. All summer chum produced in hatchery programs will be marked to allow for monitoring and evaluation of adult returns.

## Allowable Release Levels

The scale of juvenile chum release levels from each supplementation program will be guided by the broodstock collection principles outlined above and the condition of the natural summer chum population. Chum release levels may be determined by juvenile production needed to achieve adult returns judged adequate, based on productivity assessments of habitat critical for summer chum in the target watersheds. The number of chum fry to be stocked must match the biological productivity of the habitat to ensure an adequate, but not excessive level of seeding with respect to the capacity of the natural environments of the fish (Cuenco et al. 1993). For juvenile summer chum, this latter objective would also apply to the nearshore, estuarine habitat, which is an important, limiting factor determining chum fry to adult survival (Bakkala 1970; Salo 1991). In the absence of habitat productivity assessments for critical summer chum habitat in the region, a target production level for each watershed based on achieving historical adult run sizes is used to set the upper limit of supplementation and reintroduction program release levels.

### a) Basis for determining target planting levels.

Target planting levels will be set for each program based on specific considerations of broodstock collection and the desirability of a phased development over time. In certain cases, addressing the risk of extirpation for a supplementation program that is scaled too small for an extremely depressed founding population may take precedence over the desire to preserve genetic diversity of the founding natural-spawning population in setting target levels. The target numbers of chum fry for release into individual watersheds would be defined as follows:

1. The number of fry estimated to produce historical run size levels upon return as adults; that is, the number of fry needed to produce the number of returning adults that will equate to the 1974-78 average run size for the watershed (from Appendix Report 3.1, Appendix Table

3.1.1). It is recognized that actual release levels may be less, commensurate with staging of production that may be necessary before the target release level can be met.

2. For small populations (<700 escapement), the number of fry needed to assure a minimum population size equaling or exceeding 700, which is 43,000 - 86,000, depending on assumed fry to adult return survival rates (see "Footnote 1", Appendix Report 3.1, Appendix Table 3.1.1 for an explanation of how 700 fish population size break-point was derived).
3. Monitoring and evaluation results for each supplementation program will be used to adaptively manage production strategies, potentially leading to changes in annual production levels.

**b) Year-to-year consistency of the supplementation programs.**

Consistent with the objective of applying supplementation as a temporary measure, the parties shall endeavor to produce fish for supplementation programs at consistent levels, at or near goals between years, leaving no "holes" in production for the term of the program. This strategy will help ensure the effectiveness of the program in quickly boosting abundances, and should assist in maintaining the genetic character of the population between brood years.

## Disposition of Excess Individuals

Annual adult broodstock collection and juvenile fish release levels associated with each supplementation or reintroduction program shall be targeted within +/- 10% of levels derived through application of adult collection and fry release criteria in this plan (Table 3.2 and Appendix Report 3.1, Appendix Table 3.1.1). In the event that circumstances such as unanticipated high adult returns or high egg to fry survival rates lead to the possession of fish in excess of program objectives determined by genetic and ecological risk assessments, supplementation program operators will adhere to the following procedures:

**a) Adult fish**

1. Fish collected at weirs, or captured through other broodstock collection procedures,in excess of 10% of daily, weekly, or total program goals shall be returned to the natural environment at the point of capture. The sex ratio of fish returned must be equivalent to the ratio observed at the time of escapement, collection, or capture.
2. If enabled by identification of hatchery fish through mass marking, measures may be applied to cull surplus hatchery-origin fish returning to a watershed in excess of program needs.

**b) Juvenile fish**

1. In the event that the total number of eyed eggs or juvenile fish are projected to result in a release in excess of the fish release goal (>110% of the target production number), surplus eggs or fish shall be removed from the population in a random manner and destroyed.
2. Surplus fish will be randomly removed in a manner that accounts for the need to retain a population that is representative and proportionate with the timing and spawning dates of adult returns contributing to egg takes. The potential for inadvertent selection for specific traits

during collection of fish for transfer or culling will be minimized by following surplus fish removal procedures presented in Kapuscinski and Miller (1993).

## Maintenance of Ecological and Genetic Characteristics of the Natural Population

For summer chum, the technologies used to propagate fish will be designed to ensure that rearing units and procedures are as non-invasive into the natural life cycle of the fish as possible. The duration of rearing within the hatchery environment will be short, extending from incubation through early fry rearing. Incubation and rearing structures and procedures will mimic natural processes, while maintaining the survival advantage anticipated for fish produced in a controlled environment.

Following are ***general principles*** that will be applied to meet objectives calling for maintenance of natural population characteristics for fish taken into the hatchery environment (generally from Kapuscinski and Miller 1993). ***Specific guidelines***, describing actions that will be applied to meet genetic and ecological hazard reduction and population rebuilding strategies, are presented in Appendix Report 3.1.

### a) Broodstock collection and spawning procedures:

Collect and spawn broodstock that are fully representative of the genetic and ecological characteristics of the target population (supplementation) or that show the greatest possible similarity in genetic lineage, life history patterns, and ecology of the originating environment (reintroductions). Numbers to collect and procedures for spawning will be consistent with risk aversion measures to be implemented to minimize potentially deleterious genetic effects to the target population (see Loss of genetic variability within populations, page 120).

1. Collect an appropriate number of fish in a manner that minimizes creating genetic differences between the hatchery and wild spawning portions of the population and potential future genetic alterations of the overall population.
   a. Determine the minimum sample size required to measure if allele frequencies will only vary by a given proportion, or;
   b. Where applicable, collect the number of spawners for use as broodstock defined in Table 3.2, gauged by donor population size.
2. Use fish collection methods that will help ensure that broodstock are collected in an unbiased manner. This objective will be best met through the use of a fish weir that enhances the potential for encountering and handling the extent of the annual run. An acceptable alternative is the capture of broodstock through season-wide selective fisheries at the mouth of the donor river.
3. Limit the number of fish removed for use as broodstock from a drainage to ensure that the number remaining to spawn in the natural environment will meet minimum population size estimates (see Table 3.2).

### b) Incubation procedures:

Incubate eggs and alevins under density, substrate, light, temperature, and oxygen conditions that simulate, or improve upon natural intergravel survival.

1. Maintain green eggs, eyed eggs, and alevins at densities and flow levels that produce the highest survivals and quality to the fry stage.
2. Provide artificial substrate in all incubation trays or containers.
3. Incubate embryos under dark or low-light conditions.
4. Maintain temperature levels and regimes (daily and monthly, seasonally), and oxygen concentrations, to mimic conditions in the natural rearing environment as closely as possible.
5. Immediately transfer fry to rearing areas upon volitional swim-up or yolk absorption.

### c) Juvenile rearing procedures:

Although freshwater rearing upon swim-up has not been shown to be a natural characteristic for summer chum in the region, rearing environments and procedures applied should attempt to simulate attributes of natural conditions that may promote the development of fitness-related behaviors. Attributes addressed in this regard should include rearing water quality, hydraulic characteristics of rearing areas, feeding conditions, feeding behavior, and health and nutritional status at release. Desirable production strategies for maintaining similarity to the wild population may include rearing all fish of a population under the same conditions and mixing families randomly so that unintentional differences in rearing conditions will affect all families equally. Guidelines directed at meeting the above objectives are as follows:

1. Rear fish at densities that will lead to the production of high quality, healthy fed fry;
2. Rear fish under semi-natural habitat and feeding conditions to the extent feasible, especially with regard to flow velocities (exercise) and feed application and distribution practices.
3. Rear fish in a sufficient depth of water to enable chum fry to sound when startled, allowing for the retention of standard predator avoidance behavior exhibited by the fish during migration/rearing in the estuary.
4. Introduce feed frequently, and during daylight hours only, to mimic the natural environment (constant food availability) and chum fry behavior within it (continuous feeding during migration, predominantly during daylight hours).
5. Minimize direct human contact with fish during feeding and pond maintenance in order to minimize adverse effects on the population regarding association of humans with food and increased vulnerability to predation.
6. Maintain temperature levels and regimes (daily and monthly, seasonally), and oxygen concentrations, to mimic conditions in the natural rearing environment as closely as possible.
7. Monitor fish health during rearing, and apply approved therapeutics if necessary to suppress pathogens.

### d) Smolt release procedures:

Release procedures should mimic natural migrational characteristics for the life stage at release, including release location, nocturnal timing, and seasonal timing.

1. Assess the fish health status of all groups prior to release to ensure that their quality, and likelihood for survival, is high.
2. Fish should be released as fed fry at a size that promotes the highest smolt to adult survival rates, that reduces ecological interactions with co-occurring wild summer chum, and that fosters rapid seaward migration. The targeted release size should be achieved quickly

(although in deference to natural out-migration timing parameters) to decrease the likelihood for deleterious genetic effects that may be incurred by extended hatchery residence.

3. Match fish release dates with the time period when naturally-produced fish are known to be present as migrants in the estuary.
4. From data provided by existing WDFW, tribal, or private industry monitoring programs, assess estuarine productivity conditions to match releases with the onset of spring-time plankton blooms in the estuary occurring during the summer chum migration period.
5. Releases should be made as close to the estuary as is feasible to mimic lower river migrational distances experienced by natural fish. This objective should be balanced against the need to spread spawners homing to the stream of release across all available habitat.
6. Releases should be timed to occur after dusk, but before mid-night to mimic the natural stream emigration period exhibited by natural chum fry.
7. Fish reintroduced into stream where the indigenous population has been extinguished should be reared in, and acclimated to, the recipient location prior to liberation.
8. Chum fry populations produced under this plan will be mass-released, leading to the arrival of large, instantaneous volumes of fish in the estuary, "swamping" standing freshwater and nearshore predator populations. This strategy also promotes schooling of fish in the estuary for migration, adhering to a "safety in numbers" fodder fish survival strategy.

### 3.2.2.4 Monitoring and Evaluation

Monitoring and evaluating the effects of supplementation on the natural summer chum population, and the performance of the overall program in effecting the recovery of summer chum, shall be critical objectives of this conservation plan. The basic approach to monitoring and evaluation will be to collect information that will help determine 1) the degree of success of each project; 2) if a project is unsuccessful, why it was unsuccessful, 3) what measures can be implemented to adjust a program that is not meeting objectives set forth for the project (Cuenco et al. 1993); and, 4) when to stop a supplementation project (addressed in section 3.2.2.2).

## Elements of the Monitoring and Evaluation Program

a) Implementation of a monitoring and evaluation program will involve responding to concerns regarding the uncertainty of summer chum supplementation and reintroduction effects. To respond to this uncertainty, the above described basic approach for monitoring and evaluation activities under this plan is refined to specifically address the following four elements (generally from Hard et al. 1992):
   1. The estimated contribution of supplementation/reintroduction program-origin chum to the natural population during the recovery process;
   2. Changes in the genetic, phenotypic, or ecological characteristics of populations (target and non-target) affected by the supplementation/reintroduction program;
   3. The need and methods for improvement of supplementation/reintroduction activities in order to meet program objectives, or the need to discontinue a program because of failure to meet objectives; and
   4. Determination of when supplementation has succeeded and is no longer necessary for recovery.

b) The following framework is the basis for development and application of a monitoring and evaluation program for the above elements:
   1. Restate supplementation/reintroduction goal in context of application. For example, survival monitoring is initially to provide basis for assessing success of hatchery returns and ultimately for assessing success of natural origin returns.
   2. Identify performance measures.
   3. Develop experimental and sampling design.
   4. Uniquely mark all hatchery production.
   5. Collect and analyze data.
   6. Interpret results.
   7. Adjust/correct ineffective or inefficient parts of plan.
   8. Determine how (by what mechanism) revisions will be applied.

## Monitoring and Evaluation - Response to Elements

Monitoring and evaluation of summer chum supplementation actions in the region have been underway since 1992. Studies have included juvenile marking (ad clip/CWT, adipose clip only, or otolith banding) for fisheries contribution and survival evaluations, stream surveys to enumerate spawners and evaluate straying, genetic stock identification work, and fishery interception monitoring. Broodstock collection and fish cultural practices have also been monitored and evaluated, including fish health monitoring and disease-status certification; monitoring of spawner age, sex ratio, fecundity, and length data; and egg, alevin, and fry mortality, size and growth monitoring. These studies and monitoring activities are expected to continue.

The basis for the monitoring and evaluation program proposed here is to address elements a) 1-4 set forth above. Monitoring and evaluation responses for some of these elements will provide programmatic information regarding the effectiveness of supplementation within the region. In consideration of implementability and funding concerns, certain monitoring and evaluation activities providing program-wide benefit will occur only for selected programs. Other elements provide program-specific information, and should be accomplished for each supplementation and reintroduction effort. Methods proposed to address each element are therefore listed below, presented as applicable to either Selected Programs or All Programs.

### *Selected Programs*

a) ***Element 1: Estimate the contribution of supplementation/reintroduction program-origin chum to the natural population during the recovery process. Affected programs: Quilcene and Big Beef Creek.***

1. Differentially mark all hatchery-origin summer chum fry to allow for distinction from natural-origin fish upon return as adults in fisheries, at hatchery racks, and on the spawning grounds. This should be accomplished by fin-clipping, otolith (thermal) marking, or another permanent, effective method.
2. Conduct spawning ground surveys throughout the summer chum return to enumerate spawners, and to collect information regarding fish origin (via ad-clip fish observation or random sampling of fish heads for otoliths), and age class composition through scale sampling.
3. Estimate the number of naturally spawning hatchery-origin summer chum contributing to each supplemented population's annual escapement.
4. Monitor escapements of non-supplemented populations to determine the level of straying of supplementation program-origin fish to other drainages.
5. Conduct focused studies to help identify productivity levels (swim-up fry per adult spawner) that can be expected for hatchery-origin fish spawning in the wild (Big Beef Creek research only). Compare these estimates with fry per spawner levels reported for wild summer chum salmon spawners in the region, or in other regions.
    a. Enumerate natural escapement of $F_1$ generation reintroduced fish.
    b. Use $F_1$ chum collected as broodstock to obtain age structure, fecundity, and sex ratio data. Then determine egg retention of spawned out fish that have been allowed to spawn naturally. From this information, estimate natural deposition of eggs in stream.
    c. Enumerate progeny (out-migrating fry) of $F_1$ adults to estimate egg to fry survival and to establish the baseline number of fry contributing to subsequent brood year returns.
    d. Capture, sample and pass upstream resultant $F_2$ generation spawners (three, four, and five years later) to assess survival and reproductive success of naturally-spawning hatchery-origin fish.
6. Estimate the total recruitment (fisheries contribution and escapement) of supplementation program origin chum. Compare hatchery fish fry to adult survival rates with estimates for wild fish to measure the effectiveness of each program (Big Beef research program).

**b)** ***Element 2: Monitor and evaluate any changes in the genetic, phenotypic, or ecological characteristics of the populations presently affected by the supplementation program. Variably affected programs and populations.***

1. Collect additional GSI data (allozyme or DNA-based) from regional summer chum adult populations to determine the degree to which discrete populations exist in the individual watersheds.
2. Continue GSI allozyme collections of summer chum spawners throughout the region for comparison with past collections to monitor changes in allelic characteristics, and with the intent to assess whether the supplementation program has negatively affected the genetic diversity of natural populations (after Phelps et al. 1997 with steelhead).
3. To assess the effect of past or on-going supplementation activities on the heterozygosity of target populations, collect tissue samples from representative juveniles for GSI analysis, allowing for a comparison of the genetic diversity of progeny samples to the existing baseline population profile.
4. Continue collecting and archiving DNA samples for future analysis.
5. Monitor natural spawner abundance and distribution of wild and hatchery-origin fish. Determine spawner densities and identify locations of preferred areas. Define annual and long-term changes in spawning distribution of the populations.
6. Determine if spawning ground distribution, timing, and use by hatchery-origin fish is consistent with traits exhibited by wild-origin spawners.
7. If possible, monitor fry emigration behavior upon release to assess whether natural migratory patterns (timing, migration rates, areas used) change.

### *All Programs*

### c) *Element 3: Determine the need, and methods, for improvement of supplementation or reintroduction operations or, if warranted, the need to discontinue the program.*

1. Mark all hatchery summer chum juveniles produced through the supplementation or reintroduction programs to allow for assessments of contribution and NOR rates.
2. Determine the pre-spawning and green egg to released fry survivals for each program at various life stages.
   a) Monitor growth and feed conversion for summer chum fry.
   b) Determine green egg to eyed egg, eyed egg to swim-up fry, and swim-up fry to released fry survival rates for summer chum.
   c) Maintain and compile records of cultural techniques used for each life stage, such as: collection and handling procedures, and trap holding durations, for chum broodstock; fish and egg condition at time of spawning; fertilization procedures, incubation methods/densities, temperature unit records by developmental stage, shocking methods, and fungus treatment methods for eggs; ponding methods, start feeding methods, rearing/pond loading densities, feeding schedules and rates for juveniles; and release methods for one gram fry.
   d) Summarize results of tasks for presentation in annual reports.
   e) Identify where the supplementation program is falling short of objectives, and make recommendations for improved fry production as needed.
3. Determine if broodstock procurement methods are collecting the required number of adults that represent the demographics of the donor population with minimal injuries and stress to the fish.

    a) Monitor operation of adult trapping operations, ensuring compliance with established broodstock collection protocols (Appendix Report 3.1) for each station.
    b) Monitor timing, duration, composition, and magnitude of each run at each adult collection site.
    c) Maintain daily records of trap operation and maintenance (e.g., time of collection), number and condition of fish trapped, and environmental conditions (e.g., river stage, tide, water temperature).
    d) Collect biological information on collection-related mortalities. Determine causes of mortality, and use carcasses for stock profile sampling, if possible.
    e) Summarize results for presentation in annual reports. Provide recommendations on means to improve broodstock collection, and refine protocols if needed for application in subsequent seasons.
4. Monitor fish health, specifically as related to cultural practices that can be adapted to prevent fish health problems. Professional fish health specialists supplied by WDFW (or USFWS for federal agency operations) will monitor fish health.
    a) Fish health monitoring will be conducted by a fish health specialist. Significant fish mortality to unknown causes will be sampled for histopathological study.
    b) The incidence of viral pathogens in summer chum broodstock will be determined by sampling fish at spawning in accordance with procedures set forth in the Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State (NWIFC and WDFW 1998).
    c) Recommendations on fish cultural practices will be provided on a monthly basis, based upon the fish health condition of chum fry.
    d) Fish health monitoring results will be summarized in an annual report.

### d) *Element 4: Collect and evaluate information on adult returns.*

This element will be addressed through consideration of the results of previous “Elements 1, 2, and 3,” and through the collection of information required under adaptive criteria presented in section 3.2.2.2 that will be used as the basis for determining when to stop a supplementation or reintroduction program.

1. Collect age, sex, length, average egg size, and fecundity data from a representative sample of broodstock used in each supplementation program for use as baseline data to document any phenotypic changes in the populations.
2. Commencing with the first year of returns of progeny from naturally-spawned, hatchery-origin summer chum, evaluate results of spawning ground surveys and age class data collections to:
    a) Estimate the abundance and trends in abundance of spawners;
    b) Estimate the proportion of the escapement comprised by chum of hatchery lineage, and of wild lineage;
    c) Through mark sampling, estimate brood year contribution for hatchery lineage and wild-origin fish.
3. Using the above information, determine whether the population has declined, remained stable, or has been recovered to sustainable levels. The ability to estimate hatchery and wild proportions will be determined by implementation plans, budgets, and assessment priorities.

4. Compare newly acquired electrophoretic analysis data reporting allele frequency variation of returning hatchery and wild fish with baseline genetic data. Determine if there is evidence of a loss in genetic variation (not expected from random drift) that may have resulted from the supplementation program.
5. Collect GSI and run timing information in summer chum streams where Finch Creek-lineage fall chum have been introduced to evaluate the risks of genetic introgression and spawning ground interaction between the two races.

### Annual Monitoring and Evaluation Report

Annual reports describing monitoring and evaluation actions, findings and recommendations will be assembled for each supplementation or reintroduction program. The report will summarize data collected through monitoring and evaluation activities, provide an analysis of the data and an interpretation of results, and suggest mechanisms for applying revisions necessary to adjust ineffective or inefficient portions of the program. The annual report will be consistent in content, structure, and detail with annual reports currently required by NMFS for hatchery projects authorized for the incidental or direct take of ESA-listed species under Section 10 of the Act.

Each year, annual monitoring and evaluation reports will be reviewed and evaluated by the co-managers and USFWS to assess the effectiveness and effects of the supplementation and reintroduction programs. Adjustments that are needed, if any, will be discussed and implemented as determined to be necessary to meet the objectives of this plan.

## 3.2.2.5 Additional Research Needs

Further research, beyond studies included in the plan, are needed to further scientific understanding regarding the effects of summer chum supplementation, the characteristics of the wild population (including its productivity), and how supplementation efforts can be improved to minimize any adverse effects. Cuenco et al. (1993) identify eleven research topics that should be pursued to answer concerns regarding the effectiveness, and ecological and genetic impacts, of supplementation in general. These topics were used to prepare the following list of questions to address critical concerns regarding the use of supplementation or reintroduction for recovering summer chum populations.

a) Are there significant differences between the hatchery-reared and natural summer chum populations of the same stock post out-migration, regarding performance traits such as survival, growth, reproduction, and migration?
b) Is the level of intervention into the natural life cycle comprised by summer chum supplementation sufficient to alter, and negatively affect, the fitness of the hatchery-produced fry to survive and reproduce in the wild? Is that level of intervention sufficient to incur changes in the genetic character of total population of fish that survive to adulthood and return to spawn?
c) In a natural summer chum population, which genotypes and gene frequencies comprise the percent of deposited eggs that survive to swim-up in the natural environment? Do the survivors represent a random sample of the total eggs deposited or are they the result of natural selection in the wild? Is the occurrence of survivors happenstance?

d) To what degree do juvenile wild and hatchery-origin summer chum overlap with wild and hatchery-origin fall chum during estuarine migration. Are there any negative consequences of such overlap?

e) What is normal estuarine migration behavior for summer chum juveniles, including preferred areas, migration rates, feeding behavior, and preferred food items?

f) When is the most advantageous time for summer chum wild and hatchery-origin juveniles to be present in the estuary?

g) What are straying rates for natural and hatchery-origin summer chum?

Some data that may help answer portions of the above research topics may be collected through monitoring and evaluation programs proposed in this plan. However, at the present time, funding is lacking to adequately answer the above topics. It is hoped that this research will be conducted in the near future by either the co-managers or other management or research entities, pending the availability of funding.

## 3.2.3 Project Selection and Implementation

### 3.2.3.1 Introduction

All existing and recently extirpated summer chum stocks (Table 3.1) are initially considered as candidates for supplementation or reintroduction. This section describes the history of supplementation and reintroduction projects already initiated. It also describes the procedure for the review and selection of streams for supplementation/reintroduction actions. Finally, an overall strategy for the region is described that provides for implementation of supplementation or reintroduction projects for some streams and designation of other streams as not recommended for supplemental or reintroduction.

### 3.2.3.2 Existing Supplementation and Reintroduction Activities

Supplementation has been applied as a strategy to help recover summer chum populations in Hood Canal and the eastern Strait of Juan de Fuca since 1992. Programs initiated that year included Big Quilcene River, Lilliwaup Creek, and Salmon Creek supplementation projects. By 1996, the regional population recovery strategy had evolved to the point that reintroductions of fish into streams where summer chum populations were extirpated became feasible. Transfers of progeny from appropriate broodstocks to reintroduce summer chum into Chimacum Creek and Big Beef Creek began in 1996. All of these summer chum recovery programs are on-going.

Descriptions of each existing supplementation and reintroduction program, including program objectives, broodstock collection numbers, fry production data, and operating procedures and objectives are presented in Appendix Report 3.2. It is important to note that these programs were instituted prior to the full development and completion of this plan. Existing programs may therefore have included objectives, methods, and strategies that are not fully consistent with the tenets of the plan. However, the intent is to adjust existing programs to comply with the objectives, risk minimization methods, and strategies presented herein.

### 3.2.3.3 Proposed Supplementation/Reintroduction

This section describes how the stocks are assessed and selected for supplementation and reintroduction projects. The assessments and criteria used in the selection process are consistent with the guidelines previously described in section 3.2.2, Supplementation/Reintroduction Approach. The selection process is a four-step procedure that provides assessments leading to project selection. The four steps are as follows:

- *Selection of supplementation and reintroduction candidate stocks*: Candidates are selected based on Stock Definition and Status in section 1.7.2 of this plan.
- *General assessment of supplementation and reintroduction candidate stocks*: A general assessment of the candidates is made, based on extinction risk (supplementation candidates only), potential population size, watershed habitat conditions, availability of brood stock, availability of operational resources and project siting. The assessment takes into account risk associated with low levels of escapement, potential benefits and current prospects for a successful project. Candidates are scored by category and receive a total assessment score.
- *Assessment of risks*: Risks from hatchery failure, ecological hazards, and genetic hazards are assessed for the selected candidates.
- *Selection of supplementation and reintroduction projects*: A list of supplementation and reintroduction projects proposed for implementation is provided, based on the above assessments.

The selection process includes those summer chum stocks for which projects have already been initiated. The application and results of each step in the process are described below in detail.

### Selection of Candidates

The candidates for supplementation are all the stocks determined to be currently existing as described under Stock Definition and Status in section 1.7.2 and listed in Table 3.1. These stocks include Union, Lilliwaup, Hamma Hamma, Duckabush, Dosewallips, Big Quilcene/Little Quilcene, Salmon/Snow, Jimmycomelately and Dungeness. Candidates for reintroduction are the known recently extinct stocks (identified in the section 1.7.2) and include Big Beef, Anderson, Dewatto, Tahuya, Skokomish, Finch and Chimacum (Table 3.1).

## General Assessment

Following is a description of the factors used in the general assessment and how they are rated. The relative importance of each factor is reflected in the ranges of rating scores.

*Extinction Risk*: As escapements decline, risks to a population increase, including the risks of losing genetic integrity and of extinction. This part of the assessment is based on the assessment of extinction risk described in section 1.7.4 and summarized in Table 3.1. Each stock receives a score based on the current extinction risk ratings. Two exceptions are Big Quilcene/Little Quilcene and Snow/Salmon where supplementation projects were initiated in 1992. For these two stocks, pre-project risk ratings are used (Table 3.1).

- If the risk rating is "very high", the score is 12. (Note that none of the stocks were rated "very high" in the current assessment of extinction risk.)
- If the risk rating is "high", the score is 6.
- If the risk rating is "moderate", the score is 3.
- If the risk rating is "low" or "special concern", the score is 1.

*Potential Population Size*: Currently no assessments exist of potential summer chum production within watersheds. However, estimates of run sizes before the major recent declines of summer chum may serve as indices of at least recent potential production. This component therefore compares average estimated total run sizes among candidate stocks within the region during the 1974 through 1978 reference period. This period is chosen because relatively reliable escapement estimates (that serve as the basis for run size reconstruction - see section 1.4) were not generally available before 1974 and because substantial declines in escapement and run size occurred in Hood Canal following 1978 (see <u>Part Two, Region-wide Factors for Decline</u>). For each stock, the average run size for 1974-78 is compared to the average run size for all stocks in the region (2,863 salmon). The following procedure is used (see also Table 3.3).

- If the specific stream's average run size is greater than 2,863, it is judged to have a relatively high potential production and receives a rating of 3.
- If the stream's average is greater than 50% (1,416) but less than or equal to 100% of 2,863 salmon, it is judged to have a relatively moderate potential production and receives a rating of 2.
- If the stream's average is less than or equal to 50% (1,416) of 2,863 salmon, it is judged to have a low potential production and receives a rating of 1.
- If there is insufficient information to assess the population, the rating is 1.

*Stream Habitat Impacts*: Existing stream habitat impacts on summer chum are rated "relatively low," "relatively high," and "relatively moderate" (that is, between low and high). This determination of habitat impacts is based on the assessment of factors for decline described in the Habitat section of this plan (section 3.4) and reflects the habitat's potential to support a self-sustaining natural population of summer chum once it is restored by a supplementation or reintroduction effort. Generally, if habitat impacts are relatively low, it is assumed that the currently existing habitat will support a population that is restored and the stream is given a rating of 3. If the habitat impacts are high, then it is assumed that there is a risk that the habitat will not support a restored population and the rating is 1. Finally, if the habitat impacts are moderate, then a lesser risk to the restored population exists and the rating is 2. If habitat impacts are currently high, but a habitat recovery program has been initiated and there is reasonable certainty that the habitat will be restored to the point where impacts are low or moderate within ten years, then the low or moderate score should be applied.

*Brood Stock Availability*: This component is addressed here primarily as a practical consideration; that is, how difficult it may be to develop or, in the case of reintroduction, procure a broodstock for the stream in question. For supplementation candidates, only instream broodstocking opportunities using the indigenous stock are considered. If the broodstocking opportunities are well defined and appear to have good prospects for success, a project will be given a rating of 2. If the potential for success of the opportunities are uncertain or unknown, a rating of 1 is assigned. Genetic implications of broodstocking are addressed in Step 3 of the selection process, below under Supplementation Risks.

*Operational Resources and Project Siting*: This is also a practical consideration of operational infrastructure, based on current knowledge of what sites, facilities and operational resources are known to be available for a project. If sites, facilities and operational resources are identified and appear adequate, the rating is 2; if not, the rating is 1.

**Table 3.3.** Estimates of relative production potential for summer chum streams based on estimates of total run size for the 1974-1978 reference period.

| Stream | Run size Estimates (August 2, 1999 run reconstruction)[1] | | | | | | Percent Comparison[2] | Relative Potential[3] |
|---|---|---|---|---|---|---|---|---|
| | **1974** | **1975** | **1976** | **1977** | **1978** | **Ave. '74 -'78** | | |
| Lilliwaup | 693 | 1,737 | 8,999 | 1,344 | 2,886 | 3,132 | 109% | High |
| Dewatto | 203 | 1,508 | 4,136 | 720 | 1,179 | 1,549 | 54% | Moderate |
| Tahuya | 991 | 3,542 | 21,206 | 2,345 | 577 | 5,732 | 200% | High |
| Union | 76 | 215 | 663 | 242 | 139 | 267 | 9% | Low |
| B. Quil./L. Quil. | 944 | 3,235 | 11,206 | 1,918 | 5,554 | 4,571 | 160% | High |
| Anderson | 0 | 239 | 284 | 31 | 19 | 115 | 4% | Low |
| Big Beef | 84 | 1,409 | 1,555 | 358 | 788 | 839 | 29% | Low |
| Dosewallips | 4,044 | 2,752 | 3,968 | 3,811 | 2,202 | 3,355 | 117% | High |
| Duckabush | 4,030 | 2,745 | 7,394 | 2,908 | 2,199 | 3,855 | 135% | High |
| Hamma Hamma | 2,755 | 8,979 | 9,279 | 1,985 | 9,518 | 6,503 | 227% | High |
| Snow/Salmon | 1,494 | 1,360 | 1,264 | 1,364 | 2,413 | 1,579 | 55% | Moderate |
| Total | 15,314 | 27,721 | 69,954 | 17,026 | 27,474 | 31,498 | | |
| Average | 1,392 | 2,520 | 6,359 | 1,548 | 2,498 | 2,863 | | |

[1] Solely for use in this section of the plan, the total run size has been approximated for each stream by extrapolating that stream’s reconstructed terminal run size based on assumed average interception rates outside the terminal area. See Part One for description of run reconstruction.

[2] Percent comparison among streams is derived by dividing average annual run size of the specific stream by the average annual run size of all streams and multiplying by 100. For example, with Lilliwaup: (3,132/2,863) x 100 = 109%.

[3] Relative production potential is based on percent comparisons within the 1974-1978 reference period. A stream's relative potential is low if its 1974-78 average run size is equal to or less than 50% of the overall 1974-78 average, moderate if greater than 50% but equal to or less than 100%, or high if greater than 100%.

As a result of this general assessment, a total rating score is obtained for each stock that may be useful in prioritizing supplementation and reintroduction projects. The following narrative descriptions provide details of the assessment for each of the supplementation and reintroduction candidates.

### a) Supplementation Candidates

Union

*Extinction Risk*: Union has a risk rating of “moderate” and the category rating is 3.

*Potential Population Size:* Estimated run size annually averaged 267 salmon from 1974 through 1978, equal to 9% of the average annual run size for individual streams of the region (Table 3.3). This comparison suggests Union has a relatively low potential production and a category rating of 1.

*Stream Habitat Impacts:* The assessment of factors for decline within the watershed suggest Union River may be vulnerable to habitat impacts from rapid urbanization around the City of Belfair (see 3.4 Habitat and Appendix Report 3.6). But for the present, impacts appear relatively moderate for summer chum. The category rating is 2.

*Broodstock Availability:* Prospects for broodstocking are uncertain owing to lack of knowledge about how in-river conditions may affect broodstock collection. The rating for this category is 1.

*Operational Resources and Project Siting:* Undetermined at this time. Category rating is 1.

*Total Rating Score:* The total rating score is 8.

Lilliwaup

*Extinction Risk*: Lilliwaup’s risk rating is “high” and the category rating is 6.

*Potential Population Size:* Estimated run size annually averaged 3,132 salmon from 1974 through 1978, which is 109 % of the average annual run size for individual stocks of the region (Table 3.3). This comparison suggests Lilliwaup Creek has a relatively high potential production. The rating for this category is 3.

*Stream Habitat Impacts:* The assessment of factors for decline within the watershed suggest the habitat of Lilliwaup Creek is somewhat degraded with areas of good habitat (see 3.4 Habitat and Appendix Report 3.6). For the purpose of this assessment, habitat impacts appear relatively low. This category rating is 3.

*Broodstock Availability:* Currently, the population is relatively small but an impassable barrier at approximately RM 0.7 limits distribution of the spawners and would seem to enhance broodstocking prospects. A supplementation project begun on this stream in 1992 had limited success in collecting spawners until the 1998 season. A new weir placed in the stream in 1998 was effective in capturing available fish, and resources are available to continue use of a weir in 1999 and beyond. The rating for this category is 2.

*Operational Resources and Project Siting:* A privately-owned hatchery built in 1994 and operated by Long Live the Kings is located on a tributary near the mouth of Lilliwaup Creek. Incubation and rearing facilities are available at the hatchery. Long Live the Kings hatchery staff provide primary operational support for the summer chum supplementation project, in cooperation with the Hood Canal Regional Enhancement Group. Thus, good project siting and operational support exist for this stream. The category rating is 2.

*Total Rating Score:* The total rating score is 16.

Hamma Hamma

*Extinction Risk*: Hamma Hamma has a risk rating of "moderate" and the category rating is 3.

*Potential Population Size:* Estimated run size annually averaged 6,503 salmon from 1974 through 1978, equal to 227% of the average annual run size for individual streams of the region (Table 3.3). This comparison suggests Hamma Hamma has a relatively high potential production and a category rating of 3.

*Stream Habitat Impacts:* The assessment of factors for decline within the watershed suggest Hamma Hamma River habitat impacts are relatively moderate for summer chum (see 3.4 Habitat and Appendix Report 3.6). The category rating is 2.

*Broodstock Availability:* The prospects for broodstock collection are uncertain. A supplementation project begun in 1997 was able to collect only a few adults for broodstocking. The co-occurrence of pink salmon in the river severely hampered collection efforts that year. A larger number of spawners were collected as broodstock in the non-pink year, 1998; however, the collection was not effective in systematically sampling broodstock throughout the run. The means for effective future collection of broodstock has not been determined. The category rating is 1.

*Operational Resources and Project Siting:* A proven site for incubation and rearing, established for other species, exists on John Creek. Local support from Long Live the Kings staff and the Hood Canal Salmon Enhancement Group exists. Thus good project siting and operational support exist for this stream. The rating for this category is 2.

*Total Rating Score:* The total rating score is 11.

Duckabush

*Extinction Risk*: Duckabush has a risk rating of "low" and the category rating is 1.

*Potential Population Size:* Estimated run size annually averaged 3,855 salmon from 1974 through 1978, equal to 135% of the average annual run size for individual streams of the region (Table 3.3). This comparison suggests Duckabush has a relatively high potential production and a category rating of 3.

*Stream Habitat Impacts:* The assessment of factors for decline within the watershed suggest habitat is somewhat degraded with areas of good habitat (see 3.4 Habitat and Appendix Report 3.6). For this assessment, Duckabush River habitat impacts appear to be relatively moderate. The category rating is 2.

*Broodstock Availability:* Prospects for broodstocking are uncertain owing to lack of knowledge about how in-river conditions may affect broodstock collection. The rating for this category is 1.

*Operational Resources and Project Siting:* Undetermined at this time. Category rating is 1.

*Total Rating Score:* The total rating score is 8.

### Dosewallips

*Current Stock Status*: Dosewallips has a risk rating of "low" and the category rating is 1.

*Potential Population Size:* Estimated run size annually averaged 3,355 salmon from 1974 through 1978, equal to 117% of the average annual run size for individual streams of the region (Table 3.3). This comparison suggests Dosewallips has a relatively high potential production and a category rating of 3.

*Stream Habitat Impacts:* The assessment of factors for decline within the watershed suggest habitat is somewhat degraded with areas of good habitat (see 3.4 Habitat and Appendix Report 3.6). For this assessment, Dosewallips River habitat impacts appear to be relatively moderate. The category rating is 2.

*Broodstock Availability:* Prospects for broodstocking are uncertain owing to lack of knowledge about how in-river conditions may affect broodstock collection. The rating for this category is 1.

*Operational Resources and Project Siting:* Undetermined at this time. Category rating is 1.

*Total Rating Score:* The total rating score is 8.

### Big Quilcene/Little Quilcene

*Extinction Risk*: Big/Little Quilcene has a pre-project risk rating of "high." The category rating is 6.

*Potential Population Size:* Estimated escapement annually averaged approximately 4,571 salmon from 1974 through 1978, equal to 160% of the average run size for the individual streams of the region (Table 3.3). This comparison suggests Big Quilcene/Little Quilcene stock has a relatively high potential production and a category rating of 3.

*Stream Habitat Impacts:* The assessment of factors for decline within the watersheds suggests the Big Quilcene/Little Quilcene habitat impacts are relatively high and, though mitigation efforts have begun in Big Quilcene watershed within the last five years, the conditions have not yet improved or stabilized for summer chum and the prospects for successful habitat recovery within the next 10 years is uncertain (see 3.4 Habitat and Appendix Report 3.6). The category rating is 1.

*Broodstock Availability:* The availability of broodstock is very good. Broodstock collection goals have been met each year of the supplementation project's operation. Sources have been the tribal coho fishery in the bay, in-river collection and returns to the Quilcene National Fish Hatchery. The criterion of allowing at least 50% of the run into the bay to escape to the rivers has been met every year. The in-river natural escapement to the Big Quilcene River has been very high in recent years and escapement to the Little Quilcene River has improved. The category rating is 2.

*Operational Resources and Project Siting:* The U.S. Fish and Wildlife Service operates the Quilcene National Fish Hatchery located on the Big Quilcene River. Dedication of these facilities and hatchery staff to the summer chum supplementation project, along with support provided by the Tribes and Washington Dept. of Fish and Wildlife, has resulted in strong operational support and effective project siting. The category rating is 2.

*Total Rating Score:* The total rating score is 14.

Snow/Salmon

*Extinction Risk*: Snow/Salmon has a pre-project risk rating of "high". The category rating is 6.

*Potential Population Size:* Terminal run size annually averaged 1,579 salmon from 1974 through 1978, equal to 55% of the average annual run size for individual streams of the region (Table 3.3). This comparison suggests the Snow /Salmon stock has relatively moderate potential production and a category rating of 2.

*Stream Habitat Impacts:* The assessment of factors for decline within the watersheds suggest habitat impacts in Snow and Salmon creeks are relatively high (see 3.4 Habitat and Appendix Report 3.6). Within the last five years, cooperative efforts have begun with local landowners to improve habitat conditions near the mouth of Snow Creek and Salmon Creek. Some improvements have been made but overall, impacts remain high. The rating is 1 for this category.

*Broodstock Availability:* Broodstock availability is good in Salmon Creek. A permanent weir exists at RM 0.2 and has been successfully used to collect broodstock for the existing supplementation project and serves as a broodstock source for the existing Chimacum reintroduction project. A permanent weir also exists at RM 0.8 on Snow Creek and would facilitate collecting instream broodstock should that be advisable in the future. The category rating is 2.

*Operational Resources and Project Siting:* Good local support and project siting exist for the Salmon Creek supplementation project. The project is operated by two local volunteer groups (Wild Olympic Salmon and the North Olympic Salmon Coalition) that are supported and guided by the Washington Department of Fish and Wildlife. Category rating is 2.

*Total Rating Score:* Total rating score is 13.

Jimmycomelately

*Extinction Risk*: Jimmycomelately has a risk rating of "high" and the category rating is 6.

*Potential Population Size:* Because there are no reliable escapement estimates for Jimmycomelately during the reference period of 1974 -1978, a direct comparison of run sizes between Jimmycomelately and other regional stocks within this period is not appropriate. However, the average run size for Jimmycomelately, for the period of 1982 - 1988 (equal to 441 salmon), when compared to the average individual run sizes of other stocks, for the reference period of 1974-1978 (equal to 2,863 salmon, Table 3.3), shows the Jimmycomelately average to be only 15% of the average. On this basis, Jimmycomelately would appear to have a relatively low potential production and a category rating of 1.

*Stream Habitat Impacts:* The assessment of factors for decline within the watershed suggest Jimmycomelately habitat impacts are relatively high (see 3.4 Habitat and Appendix Report 3.6). The category rating is 1.

*Broodstock Availability:* Prospects for broodstocking are uncertain because of the low spawner numbers and lack of knowledge about how in-river conditions may affect broodstock collection. The rating for this category is 1.

*Operational Resources and Project Siting:* Undetermined at this time. Category rating is 1.

*Total Rating Score:* The total rating score is 10.

Dungeness

*Extinction Risk*: The Dungeness risk rating is "special concern" and the category rating is 1.

*Potential Population Size:* No assessment was made for lack of information. The category rating score is 1.

*Stream Habitat Impacts:* The assessment of factors for decline within the watershed suggest Dungeness river habitat impacts are relatively high (see 3.4 Habitat and Appendix Report 3.6). Category rating is 1.

*Broodstock Availability:* Broodstocking prospects are uncertain for lack of information on the Dungeness River summer chum population. Experience gained by agencies and the tribe in trapping adults of other species in the Dungeness River could facilitate developing a broodstocking plan for summer chum in the river if such a plan were merited. Also, the existing pink salmon trapping operation in the lower river (in support of a fall pink salmon recovery effort) could possibly be expanded to capture summer chum as well. The rating is 1 for this category.

*Operational Resources and Project Siting:* Undetermined at this time. Category rating is 1.

*Total Rating Score:* Total rating score is 5.

### b) Reintroduction Candidates

Big Beef

*Potential Population Size:* Estimated run size annually averaged 839 salmon from 1974 through 1978, equal to 29% of the average annual run size for the individual streams of the region (Table 3.3). This comparison suggests Big Beef has relatively low potential production. The category rating is 1.

*Stream Habitat Impacts:* The assessment of factors for decline within the watershed suggest Big Beef Creek habitat impacts are relatively moderate (see 3.4 Habitat and Appendix Report 3.6). The category rating is 2.

*Broodstock Availability*: The apparent success of the Big Quilcene River supplementation project has resulted in broodstock being available from that source. A Big Beef experimental reintroduction project began with brood year 1996 using broodstock from the Big Quilcene/ Little Quilcene stock (see description of existing projects in Appendix Report 3.2). The category rating is 2.

*Operational Resources and Project Siting:* Incubation and rearing facilities have been made available at the University of Washington research station near the mouth of the creek. Project operation is accomplished though the cooperative effort of Washington Department of Fish and Wildlife, U.S. Fish and Wildlife Service and the Hood Canal Salmon Enhancement Group. Good operational resources and siting exist for this project. Additional factors to consider are the research weir and new spawning channel, near the mouth of the stream, that provide an effective means to monitor returning adults and support studying the success of a reintroduction program. The category rating is 2.

*Total Rating Score:* Total rating score is 7.

### Anderson

*Potential Population Size:* Estimated run sizes annually averaged 115 salmon from 1974 through 1978, equal to 4% of the average annual run size for the individual streams of the region (Table 3.3). This comparison suggests Anderson has a relatively low potential production and a category rating of 1.

*Stream Habitat Impacts:* The assessment of factors for decline within the watershed indicates that degradation of habitat conditions with impacts on summer chum exists but, in comparison to the other streams, impacts are relatively moderate (see 3.4 Habitat and Appendix Report 3.6). The category rating is 2.

*Broodstock Availability:* Unknown. The category rating is 1.

*Operational Resources and Project Siting:* Undetermined. The category rating is 1.

*Total Rating Score:* The total rating score is 5.

### Dewatto

*Potential Population Size:* Run size annually averaged 1,549 salmon from 1974 through 1978, equal to 54% of the average annual run size for the individual streams of the region (Table 3.3). This comparison suggests the Dewatto stock has relatively moderate potential production. The category rating is 2.

*Stream Habitat Impacts:* The assessment of factors for decline within the watershed suggest Dewatto habitat impacts are relatively low for summer chum (see 3.4 Habitat and Appendix Report 3.6). The category rating is 3.

*Broodstock Availability:* Unknown. The category rating is 1.

*Operational Resources and Project Siting:* Undetermined. Category rating is 1.

*Total Rating Score:* The total rating score is 7.

### Tahuya

*Potential Population Size:* Run size annually averaged 5,732 salmon from 1974 through 1978, equal to 200% of the average annual run size for the individual streams of the region (Table 3.3). This comparison suggests the Tahuya stock has relatively high potential production. Category rating is 3.

*Stream Habitat Impacts:* The assessment of factors for decline within the watershed suggest Tahuya River habitat impacts are relatively low for summer chum (see 3.4 Habitat and Appendix Report 3.6). The category rating is 3.

*Broodstock Availability:* Unknown. Category rating is 1.

*Operational Resources and Project Siting:* Undetermined. Category rating is 1.

*Total Rating Score:* Total rating score is 8.

Skokomish

*Potential Population Size:* Since there are no 1974-78 Skokomish stock escapement estimates, a comparison with the average run size of all streams is not possible. However, information from historical run reconstruction (Appendix Report 1.3) suggests that the Skokomish stock falls into the category of high relative production potential for the reference period of 1974 - 1978 (projected average annual total catch of 1,994 salmon for Skokomish stock compared to projected average annual total catch for an individual stream of 1,051 salmon). These catch projections together with the large size of the Skokomish River would indicate it has had a relatively high production potential and should be rated 3 in this category.

*Stream Habitat Impacts:* The assessment of factors for decline within the watershed suggest Skokomish River habitat impacts are relatively high for summer chum. The rating is 1 for this category.

*Broodstock availability:* Broodstock source is unknown at this time. The rating is 1 for this category.

*Operational resources and project siting:* The potential exists for use of existing WDFW facilities and personnel in support of a supplementation project; however, the operational resources and project siting remain undetermined at this time, indicating a category rating of 1.

*Total Rating Score:* Total rating score is 6.

Finch

*Potential Population Size:* Unknown. Category rating is 1.

*Stream Habitat Impacts:* There is no assessment of factors for decline for this watershed. Habitat impacts are unknown. Category rating is 1.

*Broodstock Availability:* Unknown. Category rating is 1.

*Operational Resources and Project Siting:* The potential exists for use of existing WDFW facilities and personnel in support of a supplementation project; however, the operational resources and project siting remain undetermined at this time, indicating a category rating of 1.

*Total Rating Score:* Total rating score is 4.

Chimacum

*Potential Population Size:* Unknown. Category rating is 1.

*Stream Habitat Impacts:* The assessment of factors for decline within the watershed suggest habitat is somewhat degraded with areas of good habitat (see section 3.4 Habitat and Appendix Report 3.6). For this assessment, Chimacum Creek habitat impacts appear to be relatively moderate. The category rating is 2.

*Broodstock Availability:* The apparent success of the Salmon Creek supplementation project has resulted in broodstock being available from that source. A Chimacum Creek reintroduction project began with brood year 1996 and has been successful in obtaining broodstock from Salmon Creek (see description of existing projects, Appendix Report 3.2). Category rating is 2.

*Operational Resources and Project Siting:* Incubation and early rearing facilities have been developed on the stream by the Wild Olympic Salmon and North Olympic Salmon Coalition groups, under the supervision of Washington Department of Fish and Wildlife. Good operational resources and siting exist for this project. Category rating is 2.

*Total Rating Score:* Total rating score is 7.

### c) Summary of General Assessment

Rating scores of the supplementation and reintroduction candidates are summarized in Table 3.4. The candidate streams are shown in order of decreasing total scores within each of the supplementation and reintroduction categories.

Total scoring for the supplementation candidate stocks ranges from 16 to 5. Lilliwaup has the highest score at 16, followed by Big/Little Quilcene and Snow/Salmon with scores of 14 and 13 respectively. Dungeness is the lowest scoring supplementation stock at 5. Separation by total scoring among the reintroduction candidate stocks is much less than with the supplementation candidates, largely because of the absence of the current stock status category; scores range from 7 to 4.

Although total scoring may be similar among either supplementation or reintroduction candidate stocks, component scoring differences exist. For example, the total score for Dewatto is 7 and is supported primarily by moderate production potential (2) and low habitat impacts (3). Whereas the total score for Chimacum is also 7, and is supported by moderate habitat impacts (2), good availability of broodstock (2) and good resources and siting (2).

**Table 3.4.** Summary of rating scores from the general assessment of supplementation and reintroduction candidate stocks. Range of scores available within each category is shown in parentheses.

| Stocks | Extinction Risk (1,3,6) | Potent. Pop. Size (1-3) | Habitat Impacts (1-3) | Broodstock Availability (1-2) | Resources and Siting (1-2) | Total Score (5-16) |
|---|---|---|---|---|---|---|
| **(1) Supplementation Candidates** | | | | | | |
| Lilliwaup | 6 | 3 | 3 | 2 | 2 | 16 |
| Big / Little Quilcene | 6 | 3 | 1 | 2 | 2 | 14 |
| Snow / Salmon | 6 | 2 | 1 | 2 | 2 | 13 |
| Hamma Hamma | 3 | 3 | 2 | 1 | 2 | 11 |
| Jimmycomelately | 6 | 1 | 1 | 1 | 1 | 10 |
| Duckabush | 1 | 3 | 2 | 1 | 1 | 8 |
| Dosewallips | 1 | 3 | 2 | 1 | 1 | 8 |
| Union | 3 | 1 | 2 | 1 | 1 | 8 |
| Dungeness | 1 | 1 | 1 | 1 | 1 | 5 |
| **(2) Reintroduction Candidates** | | | | | | |
| Tahuya | N.A. | 3 | 3 | 1 | 1 | 8 |
| Big Beef | N.A. | 1 | 2 | 2 | 2 | 7 |
| Dewatto | N.A. | 2 | 3 | 1 | 1 | 7 |
| Chimacum | N.A. | 1 | 2 | 2 | 2 | 7 |
| Skokomish | N.A. | 3 | 1 | 1 | 1 | 6 |
| Anderson | N.A. | 1 | 2 | 1 | 1 | 5 |
| Finch | N.A. | 1 | 1 | 1 | 1 | 4 |

## Supplementation Risks

Potential hazards to natural salmon populations that may result from supplementation and reintroduction projects are described in section 3.2.2.1. Guidelines and criteria that will be applied to help address these hazards are presented and discussed in sections 3.2.2.3. and Appendix Report 3.1. The risks generally fall into three categories: risk of hatchery failure, risk of ecological effects, and genetic risks. Projects proposed through this plan will minimize the effects of these hazards by following the indicated risk aversion guidelines and criteria when designing and operating projects, by monitoring (see section 3.2.2.4) to ensure the guidelines and criteria are being met, and by modifying or terminating projects as appropriate in response to the monitoring results.

The risk of hatchery failure can be effectively minimized through application of the recommended hatchery design and operation measures presented in this plan. Recommended hatchery design measures include siting of projects in areas that are not flood-prone, the use of reliable, clean water sources, and the use of effective incubation and rearing apparatuses. Operational measures that can be applied to minimize the risk of hatchery failure include full-time, on-site staffing, and employment of appropriate egg incubation and pond rearing densities. These safeguards, when incorporated into projects, will lessen the risk of catastrophic loss to propagated fish.

Ecological hazards to wild summer chum populations, and to other salmonid species, are assumed not to be a major concern. Currently, summer chum populations in the region are substantially reduced from their historical population levels. Therefore, the potential for negative impacts from release of relatively small numbers of hatchery-origin fish, in attempting to build populations back up to historical levels, appears negligible. The small size at release for summer chum salmon produced under this plan makes the likelihood for predation on wild fish remote. Summer chum released through the proposed programs are more likely to be a prey species for other salmonids, rather than a predator species. Competition with natural populations for food or for spawning areas are potential concerns. The risk of food resource competition with wild chum will be minimized by releasing hatchery fish at a larger size than co-occurring wild fish. The hatchery fish will migrate quickly into offshore areas, focusing largely on pelagic, rather than epibenthic prey preferred by emigrating wild fry. Spatial and temporal overlap between the two groups for preferred food items will be minimal. Competition between hatchery and wild fish of the same stock for spawning sites and access to mates is not viewed as an undesirable consequence of the supplementation programs because the objective of supplementation is to increase the number of spawners producing in the wild. Competition between wild summer chum and stray hatchery fish from another watershed is not likely a major concern due to the high fidelity of hatchery-origin chum to their home stream (Fuss and Hopley 1991). The practice of rearing fish to release size within the watershed targeted for supplementation or reintroduction will act to minimize straying, further reducing the risk of spawning ground competition posed by non-natal hatchery fish. Effective monitoring of the progress and results of each project will allow for the detection of potential ecological effects and application of the appropriate management response.

Genetic hazards associated with summer chum supplementation and reintroduction are a potential concern. Depressed, wild summer chum populations may be vulnerable to adverse genetic effects that could result from hatchery-related measures. Also, genetic effects may not be apparent, at least initially, but may affect the long-term fitness and survival of summer chum populations. Consideration of genetic hazards, and suggested guidelines to address them, are included in sections 3.2.2.3 of this plan. One hazard is the loss of variability among populations. The risk of this hazard would largely depend on the broodstock source for each program, the amount of straying, and outplanting practices for cultured fish. Outplanting of progeny from one stream to another is to be limited to reintroduction projects only, and then donor stocks should not be used for more than one stream. Again, straying does not appear to be a major risk with hatchery-origin chum salmon because of their strong fidelity to the stream of origin. Marking of project fish releases and monitoring returns will provide specific information on summer chum straying. Projects may be modified or terminated in response to indications of deleterious genetic effects. Section 3.2.2.3. provides additional criteria/guidelines that will be applied to minimize loss of among population diversity.

Another hazard is loss of diversity within populations, which may lead to a reduction in the fitness of the supplemented populations. Adverse project effects may potentially develop if broodstock collection is biased and not representative of the characteristics of the native population, including timing, fish size, age class structure, and sex ratio. Culture practices including incubation, rearing, and release methods may also select for traits divergent from those selected under natural conditions, potentially diminishing the fitness of the hatchery fish for survival in the wild. Again, these concerns are addressed through risk aversion measures included in the criteria/guidelines of sections 3.2.2.3 and Appendix Report 3.1. Definitions of terms applicable to genetics risk assessment are provided in the glossary of the overall plan. A discussion of the background on the genetics hazards and criteria used to evaluate risks is contained in Appendix Report 3.3.

The above indicated risks of implementing a supplementation project must be weighed against the risk of the population's extinction without intercession of a project. Alternative means of recovery are a part of considering the extinction risk. The previous initial assessment and ranking of candidate stocks includes factors bearing on the risks faced by each stock.

### a) Assessing the Likelihood of Hazards

Compliance with guidelines, operational criteria, and monitoring measures in this plan will be assumed for all proposed projects. The likelihood for hazards resulting from supplementation or reintroduction efforts under this plan will therefore be assessed by gauging the risk of a particular hazard for a project that will be operated as defined herein. Following is a list of the hazards that will be assessed in this section.

1. Hatchery failure hazards to be assessed are:
    - a. Loss of eggs or fish as a result of water (power) system failure.
    - b. Loss of fish as a result of inappropriate incubator or pond loading densities.
    - c. Catastrophic loss resulting from fish disease outbreaks.
    - d. Siting of hatchery incubation and rearing facilities in flood-prone areas.

1. Ecological hazards to be assessed include:
    - a. Predation on wild summer chum populations.
    - b. Competition with wild summer chum for food and spawning sites.
    - c. Transfer of fish diseases to wild summer chum.

2. Genetic hazards to be assessed are:
    - a. Reduction in effective population size; is a consequence of a supplementation action, that decreases the abundance of the natural summer chum population that successfully reproduces. Judgements regarding the acceptability of this risk may be based on whether the target population is believed to be in substantial danger of extinction within the next 36 years. This duration is derived from an average summer chum life span of 3.6 years applied to a 10 generation risk standard set forth by the Federal Court in judging extinction risk (Oregon Natural Resources Council *v*. NMFS and the State of Oregon 1998).
    - b. Loss of within population diversity; is the result of the selective pressures of hatchery practices and the hatchery environment on the genetic make-up of a population.
    - c. Loss of among population diversity; is caused by actions that break down the naturally occurring isolating mechanisms which foster local adaptation and diversity among populations.
    - d. Masking of population status; is where, through lack of proper assessment procedure, the monitoring of effects or measurement criteria of natural populations is inadequate and wild summer chum population status is therefore masked.

For projects proposed under this plan, and consistent with guidelines and criteria set forth herein, determining the likelihood of each hazard is accomplished by considering specific criteria. A judgement is made as to the probability that each criterion will be met, given this plan's risk aversion guidelines. The criteria associated with each hazard are shown in Table 3.5.

The assessment procedure is facilitated by a set of worksheets that must be filled out for each project. In the assessment, probability of success in meeting each criterion is defined as a value selected from the following range: low, moderate, high. The worksheets include the provision for commentary explaining how the probability of successfully meeting the criterion is determined.

Results of the risk assessments including existing and potential projects are presented in worksheets that have been filled out and included in Appendix Report 3.4. Table 3.6 summarizes the results from the completed worksheets.

**Table 3.5.** Criteria for the assessment of hazards. (Additional discussion in Appendix Report 3.3).

**Hazard I. Hatchery failure.**

a. Hatchery personnel live on-site to allow rapid response to water source or power failures.
b. Low pressure/low water alarms functioning for water supplies serving summer chum rearing areas.
c. All hatchery personnel responsible for rearing fish trained in standard fish propagation and fish health methods.
d. Incubation and rearing facilities are sited in areas that are not prone to flooding.

**Hazard II. Ecological effects**.

a. Propagated summer chum are released at a life stage (1 gram fed fry) and time (March-April) that will reduce the risk of predation and competition effects on wild fish.
b. Summer chum are reared to release size on ground or surface water within the watershed targeted for supplementation or reintroduction.
c. Fish health practices developed by the co-managers are applied in all hatchery activities to minimize the risk of fish disease occurrence, transmittal, and catastrophic loss.

**Hazard III. Reduction of effective population size**.

a. Hatchery fish are marked to accurately estimate the proportion of hatchery fish spawning naturally in target population.
b. Natural spawning is regularly sampled to accurately estimate proportion of hatchery-origin fish spawning in target population.
c. In the target population, the proportion of natural spawners that are hatchery-origin fish will be approximately equal to the proportion of wild fish that were taken into the hatchery the previous generation **OR** In the target population, the proportion of natural spawners that are hatchery-origin fish is larger than the proportion of wild fish that were taken into the hatchery the previous generation **and** the wild population is increasing in abundance at a rate equal at least to the proportion of naturally spawning hatchery-origin fish **OR** The target population is believed to be in substantial danger of extinction within the next **36** years **and** the effective number of breeders in the hatchery is as large as possible given the available stock **OR** The project is to reintroduce fish to a location removed from the target population with likelihood of less than 5-15 % return to the target population.

**Table 3.5.** Criteria for the assessment of hazards (continued).

**Hazard IV. Loss of within population diversity**

a. Broodstock selection: Broodstock source is not already substantially domesticated.
b. Broodstock collection:
   - S Distribution of morphological, behavioral or life-history traits will be recorded for target population.
   - S Multi-trait distribution of broodstock closely matches that of target population, in terms of migration timing, age class, sex ratio, and morphology.
   - S Broodstock collection is technically and logistically feasible.
   - S The effective population size will be maintained through broodstock size of at least 50 pairs for all but those populations where the total population size is less than 200 fish.
c. Mating, rearing and release methods:
   - S At a minimum, one male to one female matings will be standard.
   - S Mating and rearing methods are similar enough to those observed in the wild to avoid substantial domestication selection pressure **OR** Hatchery program will be of short duration (no longer than approximately three generations or 12 years) **OR** The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%.
   - S Hatchery progeny will be released at essentially the same sizes and life-history stages as observed in the out-migrating target population **OR** Hatchery program will be of short duration (no longer than 12 years) **OR** The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%.
d. Genetic Swamping (Ryman-Laikre Effect (Ryman and Laikre 1991)):
   - S Hatchery induced genetic swamping will be avoided.

**Hazard V. Loss of among population diversity**

a. Broodstock Selection:
   - S All discrete populations within watershed have been identified.
   - S Selected broodstock source is substantially genetically similar to target population.
   - S Each broodstock will only be used to reintroduce one stock.
b. Broodstock Collection:
   - S It will be possible to collect at a location and time such that only the target population will be subject to collection.
c. Straying:
   - S Hatchery fish will be reared to release size in the watershed targeted for supplementation or reintroduction.
   - S Hatchery fish will be marked to provide effective estimation of straying.
   - S Adjacent spawning populations will be effectively monitored to detect straying.

**Hazard VI. Masking**

a. A sufficient proportion of hatchery-origin fish are marked to estimate hatchery/wild ratios on the spawning grounds.
b. Natural spawning is regularly monitored to accurately estimate proportion of hatchery-origin fish spawning in target population.
c. Proportion of hatchery-origin fish on spawning grounds will be less than 5-15% **OR** Hatchery program will be of short duration (no longer than 12 years) **OR** Returning hatchery- origin fish will spawn primarily in habitat currently not utilized by natural spawners of the same species.

In Tables 3.5 and 3.6, although the criteria for fish marking and monitoring tagged spawners may be repeated within different hazards, the context of the criterion changes with the hazard. Also, in Table 3.6, a specific criterion is assigned a "high" probability estimate where the project, or the procedure required by the criterion, is well understood and there is certainty that the resources and knowledge are available to meet the criterion. A "moderate" probability is assigned where there is less certainty that the resources or knowledge is, or will be, available. Finally, when there is a high level of uncertainty, a “low” probability ranking is assigned.

As indicated in Table 3.6, most criteria are judged to have a moderate or high probability of being met. The majority of the moderate assessments are owing to lack of knowledge and thus uncertainty about whether the criterion can be met; though in each case, should the project proceed, the intent would be to meet the criterion. For existing projects, a moderate probability assessment is made in cases where there has not yet been experience with the criterion or where that experience is incomplete. Low probability assessments are given in several instances but most notably regarding the likelihood of detecting straying; the probability is assigned as “low” because the funding and resources to adequately sample for straying is currently inadequate (Appendix Report 3.4). The results shown in Table 3.6 are incorporated into the final consideration of each project, leading to the final selection of projects, shown below.

### b) Detection of Hazards and Actions to Take Should They Occur

Table 3.7 describes in general for each hazard, how failure to meet the hazard’s criteria is to be detected and what adaptive management actions shall be taken in the event of such failure. For example, in the first entry of the table, it is shown that under the hazard of reduction in effective population size (and/or the hazard of masking), if the criterion of marking adequate hatchery releases (to determine proportion of hatchery-produced adults on spawning grounds) is not met, the trigger to action (second column) will be the record showing that the number of tagged fish did not meet the specified objective. The resulting management action (third column) will be to determine why the objective was not met and then, implement changes in procedure or protocol to ensure the objective is met in the future. Also, if the prospects are not good for correcting the problem, or if the objective is not met a second time, then the project shall be reconsidered based on the increased risk associated with this failure. Table 3.7 is a reflection of the intended adaptive management procedure to be used for all components of the summer chum plan; that is, monitoring of the management action, assessment of its success, review of objective(s), and corrective action.

**Table 3.6.** Likelihood of meeting criteria to minimize or avoid hazards (see Appendix Report 3.4 for rating details in watershed worksheets).

| | I. Hatchery Failure | | | II. Ecological Effects | | | III. Reduction in Effective Population Size | | | IV. Loss of Within Population Diversity | | | | | | | | V. Loss of Among Population Diversity | | | | | VI. Masking of Population Status | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Watershed** | **Water Supply Response** | **Trained Site Personnel** | **Flood-safe Site** | **Limit Predat. /Competit.** | **Rear within Watershed** | **Avoid Disease Transfer** | **Fish** | **Monitoring Tagged** | **Proportion of Natural Spawners** | **Broodstock not** | **Monitoring Broodstock** | **Broodstock Matches Nat. Spawners** | **Broodstock Collection** | **Minimum broodstock** | **Mating & Rearing** | **Hatchery Release** | **Avoid genetic swamping** | **Populations** | **Broodstock Source is Target Pop.** | **Only Target Population Broodstocked** | **Fish Marking** | **Detection of Straying** | **Fish** | **Monitoring tagged** | **Spawner Proport. Or Project** |
| **Supplementation** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Union | M | H | M | H | H | H | H | M | L | H | H | M | M | M | H | H | M | H | H | H | H | L | H | M | H |
| Lilliwaup[1] | H | H | H | H | H | H | H | M | H | H | H | M | M | M | H | H | M | H | H | H | H | L | H | M | H |
| Hamma Hamma[1] | M | H | M | H | H | H | H | L | L | H | L | M | L | L | H | H | M | H | H | H | H | L | H | L | H |
| Duckabush | M | H | M | H | H | H | H | M | L | H | H | M | M | M | H | H | M | H | H | H | H | L | H | M | H |
| Dosewallips | M | H | M | H | H | H | H | M | L | H | H | M | M | M | H | H | M | H | H | H | H | L | H | M | H |
| Big Quilcene[1] | H | H | H | H | H | H | H | H | L | H | M | M | H | H | H | H | H | H | H | H | H | H | H | H | H |
| Salmon[1] | H | H | H | H | H | H | H | H | M | H | H | H | H | H | H | H | H | H | H | H | H | M | H | H | H |
| Jimmycomelately | M | H | M | H | H | H | H | M | M | H | H | M | M | M | H | H | M | H | H | H | H | L | H | M | H |
| Dungeness | M | H | M | H | H | H | H | M | L | H | H | M | M | M | H | H | M | L | M | M | H | L | H | M | H |
| **Reintroduction** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Big Beef[1] | H | H | M | H | H | H | H | H | H | H | M | M | H | H | H | H | H | H | H | H | H | L | H | H | H |
| Chimacum1 | H | H | H | H | H | H | H | M | H | H | H | H | H | H | H | H | H | H | H | H | H | L | H | M | H |
| Tahuya | M | H | M | H | H | H | H | M | M | H | M | M | M | M | H | H | M | H | H | H | H | L | H | M | H |
| Dewatto | M | H | M | H | H | H | H | M | M | H | H | M | M | M | H | H | M | H | H | H | H | L | H | M | H |
| Skokomish | M | H | M | H | H | H | H | M | M | H | H | M | M | M | H | H | M | H | H | H | H | L | H | M | H |
| Anderson | M | H | M | H | H | H | H | M | M | H | H | M | M | M | H | H | M | H | H | H | H | L | H | M | H |
| Finch | M | H | M | H | H | H | H | M | M | H | H | M | M | M | H | H | M | H | H | H | H | L | H | M | H |

[1] Existing project.

Note: Low probability = L, moderate probability = M, high probability = H

**Table 3.7.** Process that will be applied to reduce losses if a hazard occurs.

| Hazard and associated criteria | Monitoring or other trigger | Resulting management action |
|---|---|---|
| **Reduction in effective population size and/or Masking**<br>a. Inadequate marking of hatchery releases<br>b. Inadequate monitoring of natural spawning<br>c. Proportion of hatchery natural spawners exceeds criterion or alternative related criterion not met. | a. Marking record does not meet marking objective.<br>b. Sampling record shows objective not reached.<br>c. Monitoring of spawners shows criterion not met. | a. b. & c. Assess reason for failure. Implement corrective measures. If prospects for correction are poor or if second failure occurs, reconsider whether to continue the project. |
| **Loss of within population diversity**<br>d. <u>Broodstock</u>: Traits of hatchery fish differ from natural fish.<br>e. <u>Broodstock:</u> Collection is either technically or logistically not successful.<br>f. Mating, rearing or release methods do not meet criteria.<br>g. Criteria not met to avoid hatchery-induced genetic swamping. | a. Traits are measured at broodstocking. Monitoring from year to year shows any differences.<br>b. Failure to meet broodstocking objectives for technical or logistic reasons.<br>c. Records of mating, rearing and release are kept and checked for consistency with guidelines and criteria.<br>d. Failure to meet broodstocking objectives and successful culture and release of fish in one or more years. | a. b. c & d. Assess reason for failure. Implement corrective measures. If prospects for correction are poor or if second failure occurs, reconsider whether to continue the project. |
| **Loss of among population diversity**<br>e. Straying of hatchery releases exceeds criterion.<br>f. Suitable broodstock can not be found or collection is not feasible. | g. Sample adjacent spawner populations for hatchery marks and check to see if straying criteria is exceeded.<br>h. Assumptions about selection or collection are found to be false. | i. If criterion is not met, reconsider whether to continue the project.<br>j. Review broodstocking alternatives. Reconsider whether to continue the project. |

An effective project selection process requires that all the factors bearing on the stock and associated with project implementation be considered. That attempt has been made with the above assessments. Following is a review by project of the above assessments. For each project, a conclusion as to its selection is provided.

### a) Supplementation Candidates

Union

The Union extinction risk is estimated to be moderate based on the risk criterion of population size; that is the average effective population size (measured as escapement) over the last four years is 333 which is less than the minimum of 500 specified by the risk criterion (see section 1.7.4 Stock Extinction Risk). Despite the small population size, Union River spawner escapements have been more stable than for any other stock and have increased since the 1970s (see Appendix Table 1.1). This stability was the major factor in the determination of stock status as healthy (see Stock Status in Part One). Habitat impacts appear relatively moderate and potential production is relatively low. Our assessment of hazards for supplementation (Table 3.6) shows Union River to have moderate to high probability of avoiding most hazards. The exceptions are for proportion of hatchery-origin fish on the spawning grounds (difficult to control) and for detection of straying (currently inadequate surveying capability).

*Conclusion:* The relative stability of the Union River population leads to a recommendation of no supplementation at this time, notwithstanding the rating of a moderate risk of extinction based on population size. The population should be closely monitored and supplementation be reconsidered should a decreasing trend or pattern of instability develop. Another reason to reconsider supplementation would be to develop the Union stock as a donor for reintroduction.

Lilliwaup

The Lilliwaup stock is judged to be at high risk of extinction. Habitat impacts are relatively low and thus improvement of habitat, while merited, would not appear to be a major alternative means of effecting recovery. Potential production appears relatively high, good project facilities exist and there is strong operational support. The assessment of supplementation hazards indicates high to moderate probability of meeting most criteria to avoid genetic hazards (Table 3.6). The exception is the low probability of success determined for the detection of straying fish, owing primarily to lack of current resources for adequate sampling to detect straying. A supplementation project has been in operation in Lilliwaup Creek since 1992, but because of difficulties encountered in collecting broodstock, production levels have been relatively low, not exceeding 20,000 fry in any one year (for detailed description see Appendix Report 3.2). Beginning in 1998, WDFW led an effort to build a weir for more effective broodstock collection and sampling of summer chum returning to Lilliwaup Creek. This effort was successful and the majority of the small returning run was collected for broodstock as intended.

*Conclusion:* The high extinction risk, together with good project facilities and operational support recommends for continuation of the supplementation project. Since WDFW has begun working with Long

Live the Kings and the Hood Canal Salmon Enhancement Group in deploying and operating a weir, prospects for successful broodstocking and mark sampling of the summer chum returns appear to be good.

Hamma Hamma

The stock is at moderate risk of extinction and has a history of questionable escapement stability. Habitat impacts appear to be relatively low, suggesting improvements to habitat alone will not ensure recovery. Potential production based on historical escapement records is high, and adequate project facilities and strong operational support exist for this project (for detailed description see Appendix Report 3.2). However, there are significant problems with collecting broodstock and potentially with sampling spawners for marks. The broodstocking goals were not met for brood years 1997 and 1998, the first two years of the project, and prospects for future collection are uncertain. This situation poses a high risk for: 1) project failure in general (not able to effectively collect broodstock); 2) the genetic hazard of reduction in effective sample size (where a small, non-representative component of the population is enhanced because broodstocking objectives are not met); and 3) the genetic hazard of domestication (where monitoring traits to assess project effects is affected).

*Conclusion:* The project is merited based on the moderate risk of extinction, potential production and operational support. However, the existing project should not continue unless and until an effective means of broodstocking and mark sampling of spawners is found.

Duckabush

The stock is at low risk of extinction. However, its current escapement estimates are chronically low and substantially less than the historical estimates. Habitat impacts are relatively low and potential production is high. Prospects for project support, facility siting and broodstock collection have not been determined.

*Conclusion:* Because Duckabush does not currently appear to be at risk of extinction, no supplementation project is recommended. The stock should be monitored to assess recovery and change in status.

Dosewallips

Dosewallips is at low risk of extinction. Its current escapement estimates are chronically low and substantially less than the historical estimates. Habitat impacts are relatively low and potential production is high. No determination has been made of prospects for project support, facility siting or brood stock collection. Current escapement estimates average 2,537 over five years (1995-1998); however, in 1997 escapement was estimated to be only 47 spawners. This low estimate suggests the stream should be monitored for a downward trend or increased instability in future years.

*Conclusion:* Because Dosewallips does not appear to be at risk of extinction, no supplementation project is recommended. The stock should be monitored to assess change in status and risk.

Big and Little Quilcene

In 1992, the stock was in critical condition (WDF et al. 1993). Escapement had fallen to extremely low levels and habitat conditions had become very poor in the lower river where summer chum spawned (see section 1.7.2 Stock Definition and Status). The combination of the critical population and habitat impacts appeared to present a high risk of extinction. (Our current assessment shows a high pre-project extinction risk - see section 1.7.4 Stock Extinction Risk) Because there was strong support from the agencies and tribes, and since parallel efforts were also begun to manage the terminal fisheries for the protection of summer chum and to begin planning habitat recovery, a supplementation project was begun in the Big Quilcene River and has for the most part been successful (see Appendix Report 3.2 for detailed description of project). Though escapements to the Big Quilcene River have increased substantially in recent years, the status of the stock is currently judged to be "depressed" because the higher escapements are likely due to the supplementation effort, Little Quilcene River escapements - though beginning to increase - are still relatively low, and habitat impacts are still relatively high.

Since inception of the supplementation project, there has been only limited marking of hatchery releases with the result that differentiation between hatchery-origin and natural-origin fish on the spawning grounds has not been feasible. However, all brood year 1997 and 1998 hatchery releases were marked with adipose fin clips and it is expected that such marking will continue for the duration of the project. A moderate probability of successfully monitoring marks and thus identifying origin of returning spawners has been identified because effective sampling has not yet been demonstrated. This indicates a moderate risk for the potential genetic hazards of reduction in effective population size and masking of population status. The genetic risk assessment indicates a high probability of meeting all other criteria to avoid genetic hazards (Table 3.6). The Little Quilcene River is not being supplemented as the population has been deemed to be the same as the Big Quilcene population, and recent natural escapements have begun to improve.

*Conclusion:* High risk to the summer chum population led to the initiation of a supplementation project. The project is recommended to continue because 1) the project has been successful in all areas except identifying origin of returning spawners, 2) an effective marking program has been implemented to address this issue, 3) sampling for marked spawners is expected to be adequate, and 4) Big and Little Quilcene is the donor stock for the Big Beef reintroduction. Habitat conditions must still be stabilized and improved, and harvest management measures to protect summer chum should also continue.

### Salmon/Snow

The Salmon/Snow stock does not currently appear at risk of extinction based on recent fairly stable escapement estimates, at least in Salmon Creek. However, the stock status is judged to be depressed because total escapements are still substantially less than historical estimates (see section 1.7.2 Stock Definition and Status). A supplementation project was begun on Salmon Creek in 1992 with the primary objectives to recover the stock from its then "critical" status (WDF et al. 1993), and to develop a broodstock source for Chimacum Creek where summer chum had been extirpated (see Chimacum project under "Reintroduction Candidates" below). (Our current assessment shows a high pre-project extinction risk - see section 1.7.4 Stock Extinction Risk) Strong local support for the Salmon Creek project exists, there is good broodstocking and rearing capability, and the project has been relatively successful (see Appendix Report 3.2). Probabilities for meeting genetic risk criteria are all high. The exceptions are for proportion of hatchery-origin fish on the spawning grounds (difficult to control) and for detection of straying.

All fish have been otolith marked successfully since 1993. Snow Creek is not proposed for supplementation at this time as the population has been deemed to be the same as the Salmon Creek population. Natural repopulation of Snow Creek through straying from Salmon Creek will be given priority over supplementation using Snow Creek broodstock on the short term.

*Conclusion:* The Salmon Creek project should be continued with the purpose of providing broodstock for the Chimacum Creek reintroduction project.

Jimmycomelately

The Jimmycomelately stock is at a high risk of extinction. Habitat impacts are high and may be contributing to the risk. Jimmycomelately Creek is the only stream known to presently support a summer chum population in Sequim Bay. High and moderate probabilities of success are generally indicated for genetic risk criteria. The moderate ratings indicated in Table 3.6 were assigned because project design and planning have not yet been done, and therefore uncertainty exists regarding some criteria. The single low probability rating applies to detection of straying owing to currently inadequate sampling capability.

*Conclusion:* Because the population is at risk, a supplementation project is recommended for Jimmycomelately Creek. Genetic risks should be considered in the course of designing and planning the project. Measures for protection and recovery of habitat should be addressed concurrent with project development.

Dungeness

The status of the Dungeness stock is unknown. Little knowledge about the population exists, making it difficult to assess the prospects and risks of a supplementation project.

*Conclusion:* No project is recommended until sufficient knowledge about the summer chum population is collected to make an adequate assessment of the risks and potential for successful implementation.

### b) Reintroduction Candidates

Big Beef

Summer chum have not been observed in Big Beef Creek since 1984. The University of Washington research station at RM 0.25 can provide a water source and site for a reintroduction project. A fish weir is maintained at the same location by WDFW for monitoring upstream and downstream coho migrants. The weir can also be used for monitoring reintroduced, summer chum adult returns and natural production of fry resulting from those returns. These advantages led to the selection of Big Beef Creek as an experimental site for the assessment of a reintroduction project in Hood Canal beginning with brood year 1996 and using Big Quilcene summer chum as the broodstock source (see Appendix Report 3.2 for detailed description). Stream habitat impacts are presently relatively high, but efforts have begun to improve general habitat conditions in the watershed (see 3.4 Habitat. Generally high probabilities of success are indicated for meeting genetic risk criteria.

*Conclusion:* The Big Beef experimental reintroduction project should be continued. Measures for protection and recovery of habitat should continue to be addressed concurrent with project development.

Chimacum

No summer chum have been observed in Chimacum Creek since 1983 (R. Lowrie, pers. comm., 1998; WDFW escapement data, 1998). Habitat impacts in the creek are relatively high and likely were a major factor in the demise of summer chum (see section 3.4 Habitat). A reintroduction project was begun in brood year 1996 with the broodstock source from Salmon Creek (see detailed description of Chimacum project in Appendix Report 3.2). A good project site has been selected and there is strong operational support. High probabilities for meeting genetic risk criteria are indicated, except for a moderate probability of successfully monitoring marked spawners.

*Conclusion:* The Chimacum project should be continued. A specific plan for monitoring marked spawners should be developed prior to the first return of hatchery-origin summer chum salmon to the stream. Measures for protection and recovery of habitat should be addressed concurrent with project development.

Tahuya

No significant numbers of summer chum have returned to the Tahuya River since the late 1980s. Habitat impacts appear to be relatively low. High and moderate probabilities of success are indicated for genetic risk criteria. Moderate ratings were assigned because project design and planning have not yet been done and therefore uncertainty exists regarding some criteria.

*Conclusion:* Reintroduction may be considered in the future. Initiation of a project is delayed pending determination of an available broodstock, and acquisition of funding and resources to pursue a project (see below).

### Dewatto

A population of summer chum has been absent from the Dewatto River since 1991. Habitat impacts are relatively low. High and moderate probabilities of success are indicated for genetic risk criteria. Moderate ratings were assigned because project design and planning have not yet been done and therefore uncertainty exists regarding some criteria.

*Conclusion:* Reintroduction may be considered in the future. Initiation of a project is delayed pending determination of an available broodstock, and acquisition of funding and resources to pursue a project (see below).

### Skokomish

Relatively few summer chum have been observed in spawner surveys over the years and there are no escapement estimates. Habitat impacts are extremely high in this watershed. Catch records suggest that at one time relatively large numbers of summer chum returned to the Skokomish River. However, observations of recent years have lead to the assumption that currently there remains no sustainable stock of summer chum in the Skokomish River (see section 1.7.2 Stock Definition and Status). High and moderate probabilities of success are indicated for genetic risk criteria. The moderate ratings were assigned because project design and planning have not yet been done and therefore uncertainty exists regarding some criteria.

*Conclusion:* The Skokomish River may be considered for supplementation in the future.

### Anderson Creek

No returning population of summer chum has been observed in Anderson Creek since the 1970s. Production potential appears to be relatively low and habitat impacts appear relatively moderate in comparison to other streams. There is little insight to genetic risks since there has been no project design or planning upon which to base the assessment.

*Conclusion:* Reintroduction may be considered in the future. Initiation of a project is delayed pending assessment of ongoing reintroduction projects, determination of an available broodstock, and acquisition of funding and resources to pursue a project. Because of its smaller production potential and moderately rated habitat impacts, Anderson Creek would have lower priority for reintroduction than the Tahuya or Dewatto rivers.

### Finch

Little is known about the summer chum in Finch Creek. Our knowledge is restricted to observations made of returns to the WDFW Hoodsport Hatchery rack following construction of the hatchery in 1953. Adult returns were relatively small, averaging approximately 470 fish per year over 13 years, from 1953 through 1965. Occasionally, one or two adults entered the rack in subsequent years; however, these may have been spawners destined for other streams that wandered into Finch Creek but were prevented by the hatchery rack from leaving. Until recent years, no adults that entered the hatchery facilities were returned to the stream.

*Conclusion:* Reintroduction may be considered in the future. However, the effects and limitations of the hatchery facilities on a natural summer chum run should first be evaluated.

### c) Project Selection Summary

Supplementation is recommended for five candidate stocks in the region; three in Hood Canal and two in the Strait of Juan de Fuca (see below). The recommendation for Hamma Hamma is qualified; that is, the existing supplementation project should not continue unless and until an effective means of broodstocking is found. Existing supplementation projects are recommended to continue for Big Quilcene/Little Quilcene, Lilliwaup and Snow/Salmon and a new supplementation project is recommended on Jimmycomelately. These project recommendations are based on judgements of high to moderate extinction risk (at least immediately prior to the beginning of projects), and the assessment of acceptable levels of risk from project implementation.

Our assessment indicates projects for all seven reintroduction candidates may be acceptable. Two of these, Big Beef and Chimacum, have existing projects. Because of the facilities and other resources available at Big Beef, an experimental project designed to evaluate the success of a reintroduction effort has begun. The results of the project will be useful in planning and implementing future reintroduction projects. Monitoring of the Chimacum project will also be helpful in this way.

Ultimately, summer chum may be restored to most if not all former summer chum streams capable of sustaining a natural population. As a part of this plan, there will be a periodic review of streams to consider newly available information bearing on their candidacy as reintroduction streams (see section 3.2.2.4, p. 130). After the two aforementioned streams with existing projects, the current two primary candidates for reintroduction are Tahuya and Dewatto. The Skokomish, Anderson and Finch also remain candidates, but have lower priority at this time. Projects on the Tahuya and Dewatto are deferred pending determination and availability of a broodstock source, and acquisition of adequate funding and other resources. Projects on the other three streams are deferred for at least four years to allow time for assessing the success of existing projects, further review and evaluation of the candidate streams, determination of broodstock sources, and acquisition of adequate funding and other resources.

The selection of projects is summarized as follows:

<u>Existing Projects</u>:

*Recommended to Continue*:
Supplementation: Big Quilcene, Lilliwaup, Salmon Creek
ReintroductionBig Beef, Chimacum

*Recommended with Qualification*:
Supplementation: Hamma Hamma (requires effective broodstocking capability)

<u>New Projects</u>:

Supplementation: Jimmycomelately
ReintroductionNone

<u>Potential Future Projects</u>:

Supplementation: Union (for the purpose of developing as a donor stock)
Reintroduction:Tahuya, Dewatto

<u>Projects Not Recommended at this time</u>:

Supplementation: Dungeness, Dosewallips, Duckabush
ReintroductionSkokomish, Anderson, Finch

### 3.2.3.4 Implementation Plans

This section provides agreed goals and strategies for using supplementation in the recovery of Hood Canal/Strait of Juan de Fuca summer chum salmon. These implementation plans for each watershed indicate the general approach to be used. Stocks are grouped under the following categories: **1) selected** for supplementation or reintroduction, **2) not recommended at this time**, pending further assessment, and **3) not recommended** for supplementation or reintroduction under this plan. Background information, and details regarding specific supplementation implementation plans, such as number of fish to be collected as broodstock, or produced as fry, are included as appropriate. These plans will be implemented consistent with general and specific criteria presented within this plan.

#### Hood Canal Region

Following are goals, objectives and strategies for the use of supplementation and reintroduction for the individual stocks within the Hood Canal region.

**d) Selected Projects**

<u>Big Quilcene/Little Quilcene</u>

A supplementation program using indigenous spawners was implemented at QNFH in 1992 as a strategy for preventing extirpation of the population. The judgement to supplement was based on an observed severe downward trend in wild escapement levels, the low effective population size resulting from consecutively low escapements, and the occurrence of intercepting coho-directed fisheries in the terminal areas. In addition, complementary fisheries protection actions taken in terminal areas, and habitat management actions designed to protect the summer chum population, contributed to the decision to implement a supplementation program. Broodstock used for the supplementation program have been collected predominately from the spawning population returning to Quilcene Bay, and hatchery-origin fish have been incorporated annually with natural-origin chum since the first returns of hatchery chum in 1995. The following are objectives for the recovery of this population:

Objective 1: Stabilize or increase the number of summer chum returning to the rivers to retain future options for the continued recovery of the natural population. Maintain the naturally spawning population in the rivers and, for up to 12 years (beginning in 1992), maintain a summer chum release program at Quilcene National Fish Hatchery based on the indigenous stock.

Objective 2: Boost the numbers of naturally produced fish in the population returning to the Quilcene Bay area using hatchery and natural origin fish as donors. Procure up to 170 spawning pairs to produce an initial fed fry release level of 389,000 into the Big Quilcene River each year. This initial 389,000 fish release level is the maximum of the Big Quilcene recommended annual fry supplementation range presented in Appendix Report 3.1, Appendix Table 3.1.1.

Objective 3: Monitor and evaluate the effectiveness of the supplementation program, as measured by consistency with criteria set forth in section 3.2.2.3. Report the results of the program each year.

Objective 4: Decrease fed fry release levels into the Big Quilcene River when combined hatchery and wild-origin returns have averaged or exceeded 2,607 adults over four consecutive brood years, as achieved in 1998, when the recent four year average was 5,500. Cease production when combined natural-origin recruit (NOR) and wild-origin return levels have exceeded 2,607 over four consecutive brood years.

Objective 5: Future consideration will be given to the option of continuing supplementation at a level that will support tribal treaty fishing opportunity in Quilcene Bay. In this instance, the project would change from a supplementation program with the primary objective of stock recovery to a harvest enhancement program with the primary objective of maintaining fishing opportunity. Specific conditions, criteria, and guidelines will need to be defined before such a program will be pursued.

Objective 6: Monitor returns to the Little Quilcene River to determine if supplementation from the QNFH is appropriate and warranted in the future.

Objective 7: Manage the Little Quilcene population as a wild fish production area, with escapement levels affected by straying fish and broodstocking efforts associated with the supplementation program for the Big Quilcene River. Supplementation in this watershed is an option in the future if this portion of the population is not able to recover on its own.

Objective 8: Support reintroduction of summer chum into Big Beef Creek, where the species has been extirpated. Procure an additional 45 spawning pairs to produce 100,000 eyed eggs each year for transfer to Big Beef Creek.

Objective 9: Establish Quilcene stock in Big Beef Creek to reduce the risk of extirpation by spreading that risk between the two watersheds. Successful establishment will be considered to be a range extension for the Big Quilcene stock.

Hamma Hamma

Beginning in 1997, a supplementation program was initiated using indigenous fish. Although modest in scale thus far, this program may be used in future years to boost the abundance of summer chum spawning in the watershed. Problems in collecting adequate broodstock have existed due to the lack of an effective trapping mechanism. The future of this project will depend upon the development of broodstock collection methods that conform to the criterion in this plan. The following are objectives for using supplementation in the recovery of this population.

Objective 1: Determine if effective broodstock collection methods can be developed that will conform to the criterion in this plan.

Objective 2: Develop and maintain, for 12 years (beginning in 1997), a population comprised of supplemented and naturally spawning fish using hatchery and wild-origin broodstock.

Objective 3: Boost the numbers of naturally produced fish in the Hamma Hamma using the indigenous population as the donor.

Objective 4: Distribute production throughout appropriate areas within the drainage to ensure that available summer chum spawning habitat is utilized (e.g., John Creek).

Objective 5: Monitor and evaluate the effectiveness of the supplementation program, as measured by consistency with criteria set forth in section 3.2.2.3. Report the results of the program each year.

Lilliwaup

Beginning in 1992, a supplementation program was initiated using indigenous fish as a cooperative between Long Live The Kings, the Hood Canal Salmon Enhancement Group and WDFW. The program has remained modest in scale due mainly to low total adult return levels in recent years and the lack of access to broodstock. Recent placement of a fish weir in the lower creek will help this program become more successful in capturing broodstock for supplementation in subsequent years. Progeny produced will be used to boost the abundance of summer chum spawning in the watershed. The following are objectives for using supplementation in the recovery of this population, and other appropriate populations.

Objective 1: Develop and maintain, for 12 years (beginning in 1992), a population comprised of supplemented and naturally spawning fish using hatchery and wild-origin broodstock.

Objective 2: Boost the numbers of naturally produced fish in the Lilliwaup using the indigenous population as the donor.

Objective 3: Monitor and evaluate the effectiveness of the supplementation program, as measured by consistency with criteria set forth in section 3.2.2.3. Report the results of the program each year.

Big Beef

A reintroduction program was initiated in 1996 using Big Quilcene River summer chum to re-establish a population in Big Beef Creek. The reintroduction program was continued in 1997 and 1998, and approximately 524,000 fed fry have been released thus far as a result of this effort. Research projects investigating wild and hatchery-origin summer chum productivity in Big Beef Creek will commence with the first adult returns resulting from the reintroduction program. If successful in establishing a self-sustaining adult return, this re-introduction will represent a range extension of the Big Quilcene River stock. The following are objectives for using supplementation in the re-establishment of a summer chum population in Big Beef Creek:

Objective 1: Release Quilcene River-origin fry into the historical habitat of the Big Beef Creek population. Monitor adult returns from the initial releases and evaluate the natural spawning success of these adults, where success is measured by return of naturally produced adult off-spring.

Objective 2: Determine if a self-sustaining, viable population has been established through the reintroduction program from QNFH.

Objective 3: Develop and maintain, for up to 12 years (beginning in 1996), a population comprised of supplemented and naturally spawning fish using hatchery and wild-origin broodstock.

Objective 4: Implement a study to identify and compare wild and hatchery-origin chum spawner productivity, and survival from out-migration to adult return. Monitor and evaluate the effectiveness of the supplementation program, as measured by consistency with criteria set forth in section 3.2.2.3. Report the results of the program each year.

### e) Projects Not Recommended at This Time, Pending Further Assessment

Tahuya

The current level of observed escapements in the Tahuya River are not indicative of the existence of a self-sustaining summer chum population (see section1.7.2 Stock Definition and Status). Production historically depended on wild spawners only, and no hatchery programs using summer chum were implemented in the watershed. The following are objectives for using supplementation to reintroduce summer chum to the Tahuya River in future years.

Objective 1: Transfer southern Hood Canal-origin eyed eggs from an appropriate stock for incubation, rearing and release of fry into the historical habitat of the Tahuya River population. Monitor adult returns resulting from the initial releases and assess the natural spawning success of these adults, where success is measured by return of the naturally produced adult off-spring.

Objective 2: Determine if a self-sustaining, viable population has been established through the reintroduction program. If return levels are below desired recovery levels after an indigenous population has been established, use it as broodstock to supplant transfers, fostering local adaptation. If a self-sustaining population is successfully established, the population will represent a range extension of the donor southern Hood Canal stock.

### Union

In contrast to other summer chum production streams within the region, the Union River summer chum population has been stable or has increased in abundance in recent years relative to historic levels. Production has depended on wild spawners only, and no hatchery programs using summer chum have been implemented in the watershed. The population is currently considered to be "healthy" in status, due to stable, increased brood year escapements relative to historical levels. However, because of its relatively low population size, this stock was rated at "moderate" risk of extinction. Although small in population size, this stock was not selected for supplementation because of the relative stability of spawner abundance observed over the last 24 years. The following objective addresses managing the Union River population under this plan.

Objective 1: Maintain the Union River as a wild fish production area, retaining the population in its natural state. No supplementation is planned for this population, excepting as may be deemed appropriate to build the population for use as a donor stock for a reintroduction program.

### Dewatto

The Dewatto River summer chum population has been functionally extirpated since 1991. Production has historically depended only on wild spawners, and no hatchery programs using summer chum were implemented in the watershed. The following are objectives for using supplementation to reintroduce summer chum into the Dewatto River in future years.

Objective 1: Transfer southern Hood Canal-origin eyed eggs from an appropriate stock for incubation, rearing and release of fry into the historical habitat of the Dewatto River population. Monitor adult returns from the initial releases and assess the natural spawning success of these adults, where success is measured by return of the naturally produced adult offspring.

Objective 2: Determine if a self-sustaining, viable population has been established through the reintroduction program. If return levels are below desired recovery levels after an indigenous population has been established, use it as broodstock to supplant transfers, fostering local adaptation. If a self-sustaining population is successfully established, the population will represent a range extension of the donor stock.

### Skokomish

A viable, self-sustaining summer chum population does not exist in the Skokomish River. Analysis of historical data is needed to determine the abundance and distribution of the past population and the desirable rebuilding objectives that might be pursued through the use of supplementation in the watershed. The following are objectives for the reintroduction of summer chum to the Skokomish system:

Objective 1: A detailed assessment of the status of the habitat pertaining to its to sustain summer chum is needed prior to any attempts at reintroduction. If suitable habitat is found, retain future options for reintroduction.

Objective 2: If the habitat is deemed suitable, consider the development and maintenance, for up to 12 years, a population comprised of reintroduced summer chum from an adjacent watershed and naturally spawning fish using hatchery and wild-origin broodstock. This establishment will be considered to be a range extension for the founding population.

Objective 3: Monitor and evaluate the effectiveness of any reintroduction program, as measured by consistency with criteria set forth in section 3.2.2.3. Report the results of the program each year.

Anderson

The Anderson Creek summer chum population was extirpated in the early 1980s, and no spawners have been observed in the creek since 1985. The following are objectives for reintroducing a summer chum population in Anderson Creek:

Objective 1: Transfer in eyed eggs from an appropriate summer chum stock for incubation, rearing and release of fry into the historical habitat of the Anderson Creek population. Monitor adult returns from the initial releases and assess the natural spawning success of these adults, where success is measured by return of the naturally produced adult offspring.

Objective 2: Determine if a self-sustaining, viable population has been established through the reintroduction program. If return levels are below desired recovery levels after an indigenous population has been established, use it as broodstock to supplant transfers, fostering local adaptation. If a self-sustaining population is successfully established, the population will represent a range extension of the donor stock.

### f) Stocks Not Recommended for Supplementation or Reintroduction

Dosewallips

Production in the Dosewallips River has depended on wild spawners only, and recent year abundances do not appear to have been influenced by hatchery-origin strays. This population is not being considered for supplementation because of an increasing population abundance trend and an assigned “low” extinction risk rating. The following objective addresses recovery of the Dosewallips River population.

Objective 1: Maintain the Dosewallips River as a wild fish production area, retaining the summer chum population in its natural state. No supplementation is planned for this population, and recovery is expected through promotion of natural rebuilding, commensurate with habitat protection and fisheries protection initiatives.

Duckabush

No supplementation of summer chum in the Duckabush River watershed has occurred over the past 57 years, and production depends entirely on natural spawners. This population is not being considered for supplementation because of an increasing population abundance trend and an assigned "low" extinction risk rating. The following objective addresses recovery of the Duckabush River population.

Objective 1: Maintain the Duckabush River as a wild fish production area, retaining the summer chum population in its natural state. No supplementation is planned for this population, and recovery is expected through promotion of natural rebuilding, commensurate with habitat protection and fisheries protection initiatives.

Finch

Examination of rack return data for Hoodsport Hatchery indicates that the indigenous chum populations in Finch Creek likely included a summer race (Tynan and Ames 1997). The annual summer chum return to the creek numbered up to 550 fish, according to these rack count data. The November spawn-timing for the present return qualifies it as a fall run race. Few or no fish now return to the creek during the summer chum migration period, and it is believed that the original summer chum population in Finch Creek has been extirpated. The following are objectives for managing Finch Creek for summer chum under this plan:

Objective 1: Manage Finch Creek above the Hoodsport Hatchery rack as a wild production area, allowing for the potential establishment of a naturally-producing population through straying of adult fish from neighboring creeks.

Objective 2: Chum returning to the Hoodsport Hatchery rack during the summer chum migration period shall be passed upstream for natural spawning to assist in meeting the above objective.

### Miscellaneous Streams Not Selected for Supplementation or Reintroduction

Eagle Creek, Fulton Creek, Little Lilliwaup Creek, Stavis Creek, and Seabeck Creek

Although no historical spawner escapement estimates are available, summer chum were historically observed during spawning ground surveys in a number of smaller Hood Canal streams. It is unknown whether indigenous, naturally producing populations existed in these watersheds, or if observed, sporadic escapements were the result of straying from other Hood Canal streams supporting viable populations. The following objective applies to the summer chum populations in these tributaries:

Objective 1: Manage these miscellaneous tributaries where summer chum spawners have historically been observed as wild production areas, allowing for the potential establishment of naturally-producing populations through straying of adult fish from neighboring creeks.

## Strait of Juan de Fuca Region

Following are goals, objectives and strategies for the use of supplementation and reintroduction for the individual stocks within the Strait of Juan de Fuca region.

### g) Selected Projects

Salmon/Snow

Broodstock has been collected from Salmon Creek for a supplementation program starting in 1992, and natural-origin fish have been incorporated annually since that year. Prior to the 1992 brood year, production has depended only on wild spawners, and no hatchery programs using summer chum were implemented in the watershed. A weir located at R.M. 0.2 on Salmon Creek is currently used to trap broodstock for the supplementation program, and to enumerate spawners passed upstream. The supplementation program was implemented as a strategy for boosting the abundance of the population to allow for transfers of surplus fish for a reintroduction program on Chimacum Creek. This reintroduction shall represent a range extension of the Salmon/Snow stock. Removals of summer chum females for use as broodstock for the supplementation program are limited to 20% of the total Salmon Creek return. A WDFW research facility on Snow Creek has collected spawner abundance and fry out-migration timing data in past years. Following are objectives for using supplementation in the recovery of this stock:

Objective 1: Retain future options for recovery of the Salmon/Snow stock. Develop and maintain, for 12 years (beginning in 1992), a population comprised of supplemented and naturally spawning fish using hatchery and wild-origin broodstock on Salmon Creek.

Objective 2: Boost the numbers of naturally produced fish in Salmon Creek using the indigenous population as the donor. Procure no greater than 20% of the total annual number of returning females when the spawning population exceeds 250 fish. If the spawning population is less than 250, follow broodstock removal criteria set forth herein (Table 3.2) for small population sizes. Produce approximately 60,000 fed fry each year for release from net-pens situated adjacent to the mouth of Salmon Creek in Discovery Bay.

Objective 3: Monitor and evaluate the effectiveness of the supplementation program, as measured by consistency with criteria set forth in section 3.2.2.3. Report the results of the program each year.

Objective 4: Support reintroduction of summer chum into Chimacum Creek. Procure an additional 32 spawning pairs to produce 80,000 fed fry each year for release into Chimacum Creek.

Objective 5: Manage Snow Creek as a wild production area. Supplementation in this watershed is an option in the future if this portion of the population is not able to recover on its own.

Chimacum

Summer chum spawners have not been observed in Chimacum Creek since 1983 (see section 1.7.2 Stock Definition and Status). When a summer chum population was present, production was based entirely on wild spawners, and no hatchery programs using summer chum were previously implemented.

A reintroduction program was initiated in 1996 using Salmon Creek summer chum to re-establish a population in Chimacum Creek. The reintroduction program was continued in 1997 and 1998, and approximately 141,000 total fed fry have been released as a result of this effort. The first adult returns from the reintroduction program are expected in 1999. The following are objectives for using supplementation in the re-establishment of a summer chum population in Chimacum Creek:

Objective 1: Release 80,000 Salmon Creek-origin fry reared on Chimacum Creek into the lower watershed or the immediate estuary. Monitor adult returns from the initial releases and evaluate the natural spawning success of these adults, where success is measured by return of the naturally produced adult offspring. This re-introduction will represent a range extension of the Salmon/Snow stock.

Objective 2: Develop and maintain, for up to 12 years, a population comprised of supplemented and naturally spawning fish using hatchery and wild-origin broodstock.

Objective 3: Monitor and evaluate the effectiveness of the supplementation program, as measured by consistency with criteria set forth in section 3.2.2.3. above. Report the results of the program each year.

Jimmycomelately

Summer chum production In Jimmycomelately Creek has historically depended only on wild spawners, and no hatchery programs using summer chum have been implemented in the watershed. The following are objectives for using supplementation in the recovery of this population:

Objective 1: Initiate a supplementation program using the indigenous Jimmycomelately Creek broodstock, thus retaining future options for recovery of the Jimmycomelately population.

Objective 2: Boost the numbers of naturally produced fish in Jimmycomelately using the indigenous population as the donor. Develop and maintain, for 12 years, a population comprised of supplemented and naturally spawning fish using hatchery and wild-origin broodstock.

Objective 3: Monitor and evaluate the effectiveness of the supplementation program, as measured by consistency with criteria set forth in section 3.2.2.3. above. Report the results of the program each year.

### h) Projects Not Recommended at This Time, Pending Further Assessment

Dungeness

The status of summer chum in the Dungeness River is unknown, and an "of special concern" extinction risk rating has been assigned for this stock. Analysis of recent and historical stream survey and rack count data, and further assessment work during the likely spawner return period, are needed to determine the abundance and distribution of the population and to identify the desirable rebuilding objectives that might be pursued through the use of supplementation in the watershed. The following are objectives for using supplementation in the recovery of this population:

Objective 1: Collect information to better determine stock status and provide a basis for a decision on supplementation.

Objective 2: Eventually initiate a supplementation program using the indigenous Dungeness River broodstock if the population appears to be at a low abundance level where intervention is warranted, thus retaining future options for recovery.

### Miscellaneous Streams Not Selected for Supplementation or Reintroduction

Miscellaneous Strait of Juan de Fuca Tributaries: Johnson Creek and Morse Creek

Although no historical spawner escapement estimates are available, summer chum were historically observed during spawning ground surveys in two small Strait of Juan de Fuca streams. It is unknown whether indigenous, naturally producing populations existed in these watersheds, or if observed, sporadic escapements were the result of straying from other Strait of Juan de Fuca streams harboring viable populations. The following objective applies to these streams:

Objective 1: Manage Johnson and Morse creeks as wild production areas, allowing for the potential establishment of naturally-producing populations through straying of adult fish from neighboring creeks.

## 3.2.3.5 Specific Criteria Guiding Supplementation Program Operations

Specific methods, practices, and parameters that will be employed in the recovery of summer chum for selected supplementation and reintroduction projects are presented in Appendix Report 3.1. These criteria are consistent with general principles presented in section 3.2.2.3. of this report, which includes methods for maintaining the ecological and genetic characteristics of the natural populations. In some cases, no refinements of those general principles are indicated in Appendix Report 3.1, and reference is made to the appropriate criteria within section 3.2.2.3. But in most instances, detailed criteria such as loading factors, actual numbers of fish, and fish release methods are prescribed to provide more specific guidance for the artificial propagation of summer chum.

## 3.2.4 Funding Priorities

Within this section, programs and actions, and the level of funding needed for each, are identified. This information is intended to provide support to NMFS, the Washington State Legislature, and to over-arching, watershed organizational/action groups such as the Governor's Joint Natural Resources Cabinet (JNRC), the Governor's Salmon Recovery Office (also known as the Salmon Team), the Puget Sound Action Team, the Hood Canal Coordinating Council, the affected counties, and other local entities regarding activities that should receive immediate attention and prioritization for funding.

### 3.2.4.1 Criteria

Criteria used to prioritize funding needs to effect summer chum recovery programs using supplementation or reintroduction strategies will include the following, listed by priority:

i) Recommended supplementation projects with populations at higher risk;
j) On-going programs supporting summer chum recovery that do not have designated funding from any agency for operation;
k) New actions that will benefit summer chum region-wide, including monitoring and evaluation;
l) Reintroduction.

### 3.2.4.2 Supplementation Plan Priorities

Table 3.8 identifies funding needs for effectively implementing this supplementation and reintroduction plan. Items are listed in descending order of priority. It is recommended that the following projects be implemented as soon as possible to allow for effective and timely action directed toward recovery of the summer chum populations.

**Table 3.8.** Funding priorities for summer chum supplementation and reintroduction projects.

| Watershed Affected | Actions Identified | Annual Costs (approx.) | Purpose |
|---|---|---|---|
| Jimmycomelately Creek | Initiate supplementation program | unknown | Supplementation |
| Lilliwaup Creek | Construct and operate temporary weir; collect sufficient broodstock; Monitor and assess supplementation program. | $30,000/yr | Broodstock collection and project assessment. |
| Hamma Hamma River | Develop and conduct effective broodstock collection program; assist in program monitoring and evaluation | $50,000/yr | Broodstock collection; effective program monitoring |

**Table 3.8.** (Continued) Funding priorities for summer chum supplementation and reintroduction projects.

| Watershed Affected | Actions Identified | Annual Costs (approx.) | Purpose |
|---|---|---|---|
| Entire region - | GSI Sampling - fisheries and escapement; sample/analyze 800 fish per year. | $40,000/yr | Monitoring and evaluation |
| Entire region - | Implement otolith marking program to assess project returns to all supplemented streams. Otolith mark all supplementation program fish; collect and analyze otoliths from adult returns. | $50,000/yr | Monitoring and evaluation |
| Big Beef Creek | Evaluate Hatchery and wild summer chum productivity and survival | $36,845 | Monitoring and evaluation |
| Big Quilcene River | Mass mark hatchery production with visibly identifiable mark (e.g. ad-clip). | $9,000/yr | Production and survival assessment; assessment of degree of straying. |
| Entire region - | Assess straying of supplementation fish; sample fish on spawning grounds. | $40,000/yr | Monitoring and evaluation |

# 3.3 Ecological Interactions

There are complex sets of interactions that occur between organisms that share an ecosystem. Summer chum salmon are affected in both positive and negative ways. Such ecological interactions can include factors like; competition for food and space, direct predation, sources of nutrient input to the ecosystem, etc. Section 3.3 only addresses those negative competition and predation impacts that were identified in Part Two as; 1) potentially contributing to the summer chum decline (hatchery salmonids), and 2) possibly impacting recovery (marine mammal predation).

## 3.3.1 Impacts of Supplemented Summer Chum

Like pink salmon, chum salmon have an unique relationship with the other salmonid species. In most circumstances, because of their small size and relative abundance at out-migration, they have a positive impact as prey for other salmon and trout. They are also prey for many other species, including piscivorous birds and marine mammals. Chum salmon have not been identified as predators on other salmonids (Fresh 1997), and the risk that these species will have a significant negative impact on other salmonids through predation is low (Fresh 1984). They may have some competitive impact; however, differences in diets and life histories probably minimize any potential competition. Fresh (1984) reported a low risk that competition between enhanced chum and wild salmonids would have a significant negative impact on the productivity of wild salmonids, with the exception of pink salmon during early marine life. The discharge of hatchery effluent and interactions between supplemented and wild-origin summer chum in freshwater and estuarine areas may lead to fish pathogen transmission. Although hatchery-origin populations are considered to be reservoirs for disease pathogens because of their elevated exposure to high rearing densities and stress, there is little evidence to suggest that diseases are routinely transmitted from hatchery to wild fish (Steward and Bjornn 1990).

Because of the above, summer chum salmon are unlikely to exert a negative influence on the ecosystem. However, to be conservative in implementing summer chum supplementation and reintroduction programs, measures to mitigate for any potential summer chum impacts on other species are included in this recovery plan.

### 3.3.1.1 Predation

Juvenile chum salmon released at the life stage and time proposed in the regional supplementation program do not pose a predation risk to other salmonids, including wild chum fry, during their fresh or marine water migration period in Hood Canal and the Strait of Juan de Fuca. Juvenile chum salmon migrating out of Hood Canal at a size characteristic for hatchery-origin fish (> 45 mm) feed upon neritic zooplankton in open water areas, and fish of any life stage have not been shown to be an important prey item (Simenstad et al. 1980). In addition, salmonid predators prey on food items less than or equal to one-third of their length (Witty et al. 1995). The average size range for supplemented fed chum fry liberated at 390-450 fish per pound is 50-53 mm (Fuss 1997b), compared to a size of 37-41 mm for newly emerged and migrating wild summer chum fry (Tynan 1997). Supplementation programs will continue to release summer chum at an average size no greater than 53 mm as a strategy to ensure that predation on wild fry is not likely.

Large-scale hatchery releases may attract predators, potentially leading to increased predation on co-occurring wild fish (Steward and Bjornn 1990). The sporadic nature of annual hatchery releases (one or two release events per year at a given location) and the mass release of hatchery fish during night-time hours are strategies that will decrease the likelihood for the concentration of dependent predator populations that might negatively affect wild chum.

### 3.3.1.2 Competition

Enhanced chum salmon have been judged to have a highly significant risk of negative impact on the productivity of wild chum through competition for food during early marine life (Fresh 1984). The risk that supplemented chum liberated during the summer chum out-migration period (March) will compete with wild summer chum fry for food will be minimized through the release of hatchery fish at a larger size than the wild fry. This differentiation in size leads to niche separation between the two summer chum groups. Larger (>45-50 mm) chum fry have been shown to prey predominately on pelagic organisms in open water areas of Hood Canal, whereas newly emerged, smaller chum fry feed on epibenthic organisms in shallow, sublittoral habitats (Simenstad et al. 1980). The larger hatchery-origin chum migrate and forage within a different estuarine realm (offshore) than wild fry, which adhere to shallow nearshore areas during migration (as summarized in Tynan 1997). This spatial separation minimizes the likelihood for competition for food between hatchery-origin and wild chum fry.

Hatchery-origin adults may compete with wild-origin chum for spawning sites or access to mates. This interaction is not viewed as negative in the context of this plan, as intermixing between supplemented and wild broodstock of the same stock on the spawning grounds is an anticipated and desirable consequence of the supplementation program. This inter-mixing on the spawning grounds meets the objective of the supplementation program of increasing natural production in the region. Straying of non-indigenous, supplemented adult summer chum between watersheds is not expected to be a significant concern regarding competition. Naturally-produced chum may exhibit straying levels ranging from 2-46 % (Tallman and Healy 1994). However, hatchery-origin chum salmon in Hood Canal have demonstrated a high fidelity for their stream of origin (Fuss and Hopley 1991; WDFW data for QNFH-origin marked summer chum 1997). Selective breeding that may occur in hatrcheries using gametes from returned migrants has been shown to result in a decrease in straying with time (Tallman and Healy 1994).

### 3.3.1.3 Disease Transmission

Supplementation projects implemented under this conservation plan will be conducted in a manner that is consistent with Pacific Northwest Fish Health Protection Committee (PNFHPC) (1989) and <u>Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State</u> (NWIFC and WDFW 1998) guidelines. These guidelines define rearing, sanitation, and fish health practices that minimize the incidence of disease outbreaks in propagated populations, thereby decreasing the risk of fish pathogen transmission to co-occurring wild populations. All hatchery-origin fish will be inspected by fish pathologists to certify their disease status prior to liberation. The release of viable healthy summer chum smolts is promoted through adherence to these fish health maintenance guidelines.

## 3.3.2 Impacts of Other Species on Summer Chum Salmon

The ecological risks of artificially propagating summer chum are low. However, there is a need to recommend mitigative measures to reduce the potential impacts of predator and competitor species that could affect the recovery of summer chum salmon; notably other salmonids and marine mammals (see Part Two).

### 3.3.2.1 Hatchery Salmonids

#### Background

The use of hatcheries for the artificial production of anadromous salmonids by WDFW, the Tribes, USFWS, and volunteer fish enhancement groups administered by WDFW in the Hood Canal and Strait of Juan de Fuca regions is long-standing and important. Hatchery programs have been implemented to provide surplus fish for harvest in Washington commercial and recreational fisheries and to mitigate for natural salmonid production losses due to habitat degradation. Hatcheries within the Hood Canal and Strait of Juan de Fuca regions annually release fall chinook, coho, fall chum, steelhead and, in odd years, pink salmon juveniles to increase run size and provide fisheries enhancement. In particular, fall chum salmon hatchery production in Hood Canal is the largest in the state, with annual releases of 30 million fry producing adult returns to the Canal averaging 416,000 fish in recent years (1987-94 WDFW run reconstruction data, June 27, 1995). The USFWS's Quilcene National Fish Hatchery (QNFH), and cooperative projects on the Lilliwaup River, Hamma Hamma River, Big Beef Creek, Salmon Creek, and Chimacum Creek rear indigenous summer chum for wild stock supplementation and reintroduction purposes. Critically depressed and depressed pink, chinook, and coho salmon stocks are also supplemented in the Strait of Juan de Fuca region through WDFW hatchery programs centralized within the Dungeness Hatchery Complex.

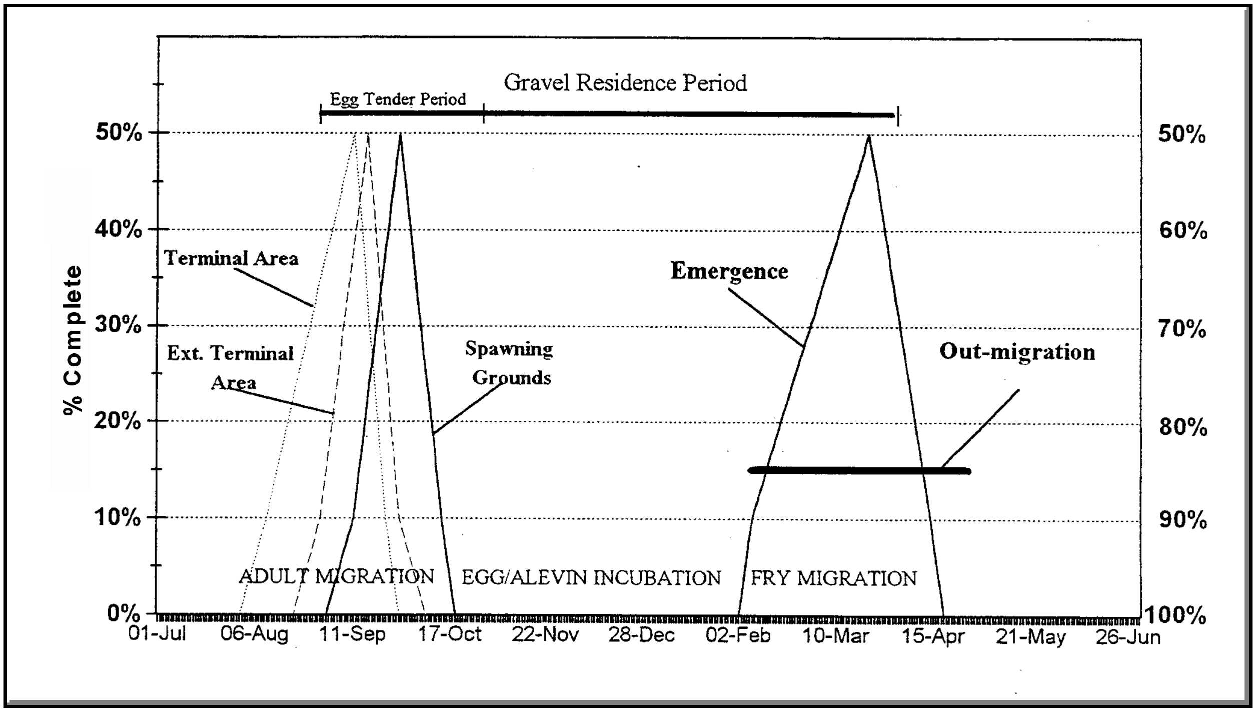
The effects of hatchery program activities in the region have been cited within the NMFS West Coast chum salmon stock ESA status review as potential factors for the decline of ESA-listed wild summer chum stocks (Johnson et al. 1997). Possible competition for food resources posed by hatchery fall chum juveniles, and incidental harvest in Washington fisheries targeting more abundant salmonid species commingled with summer chum in migration areas were identified as of particular concern regarding the status of summer chum. Current commercial and recreational fisheries in which summer chum are taken are focused on other adult salmon species, including those produced in Puget Sound hatcheries. However, the volume of hatchery salmonid production, the physical location and operation of hatchery facilities, and fisheries enabled by hatchery production may be negatively impacting Hood Canal and Strait of Juan de Fuca summer chum incidentally and directly. The first two factors will be assessed in this section. Harvest management impacts, and measures proposed to minimize effects on summer chum, are addressed in section 3.5.

Assessments of the potential effects of regional hatchery production of other anadromous salmonid species on Hood Canal and Strait of Juan de Fuca summer chum populations can be made through review of hatchery locations, and evaluation of salmonid production and release practices. Potential adverse effects addressed in this section fall within two categories: 1) direct impacts on wild summer chum caused by the physical operation of the hatchery; and 2) ecological impacts occurring as a result of interactions between liberated hatchery salmonids and summer chum. The potential for adverse effects resulting from direct physical effects of hatchery operations can be evaluated through a determination of the location of hatchery facilities within the region relative to summer chum production areas. To gauge potential deleterious ecological effects, it is necessary to determine the potential level of interaction between hatchery salmonid species and wild summer chum. Specifically, the spatial and temporal occurrence of hatchery-produced salmonids within regional waters needs to be characterized, for comparison with like information developed for summer chum. Through this comparison, and subsequent analyses of the degree of overlap with summer chum rearing and migratory areas, the potential ecological hazards to wild summer chum posed by other hatchery-origin fish species can be generally assessed.

Regional watersheds harboring existing and reintroduced summer chum populations are indicated in Part One and the locations of hatchery programs within the region that may affect those populations are indicated in Tynan (1998). For ecological impact assessment purposes, estimates of wild summer chum migrational timing in Hood Canal and Strait of Juan de Fuca freshwater and marine areas can be used (Tynan 1997). Juvenile and adult chum salmon spatial and temporal occurrence timings in the regions were estimated in the latter report from available studies. Adult summer chum enter freshwater spawning areas predominately during the month of September. As reported in section 1.3.3.2 Emergence and Downstream Migration, the majority of summer chum fry emerge in Hood Canal streams during the month of March, entering Hood Canal marine waters by early April. Summer chum fry in Strait of Juan de Fuca streams are estimated to emerge predominately in April, entering estuarine waters by early May. Figure 3.1, taken from Tynan (1997), presents annual migration, spawning, incubation, and emigration timing estimates for Hood Canal and eastern Strait of Juan de Fuca summer chum populations.

The above wild summer chum emergence and mitigation timing estimates can be compared with average release data and migration timing estimates derived for hatchery-origin anadromous salmonids produced in the region to assess the likelihood for interactions. Overlaps between summer chum and hatchery release groups can be assessed, taking into account information in the literature reporting the risk of ecological hazards posed by hatchery fish by species and age class, to assign risks of negative effects to summer chum. Evaluation of the likely effects of interactions, and assignment of risk levels, can then allow for the development of general risk aversion measures that can be applied where appropriate to minimize the likelihood for negative effects to summer chum resulting from hatchery salmonid production within the region. The general intent will be to minimize ecological risks by releasing hatchery fish to avoid the predominant summer chum fry egression and early marine arrival periods. For hatchery fall chum and pink salmon programs, these practices will include delaying releases until after April 1 to allow summer chum fry first access to the estuary, reducing competition and behavioral modification risks. For hatchery programs producing larger salmonids that may pose predation risks, an additional delay in allowable release timing through April 15 will be imposed to allow some progression in the migration of summer chum fry seaward and out of the estuary.

**Hood Canal Region**



**Strait of Juan De Fuca Region**

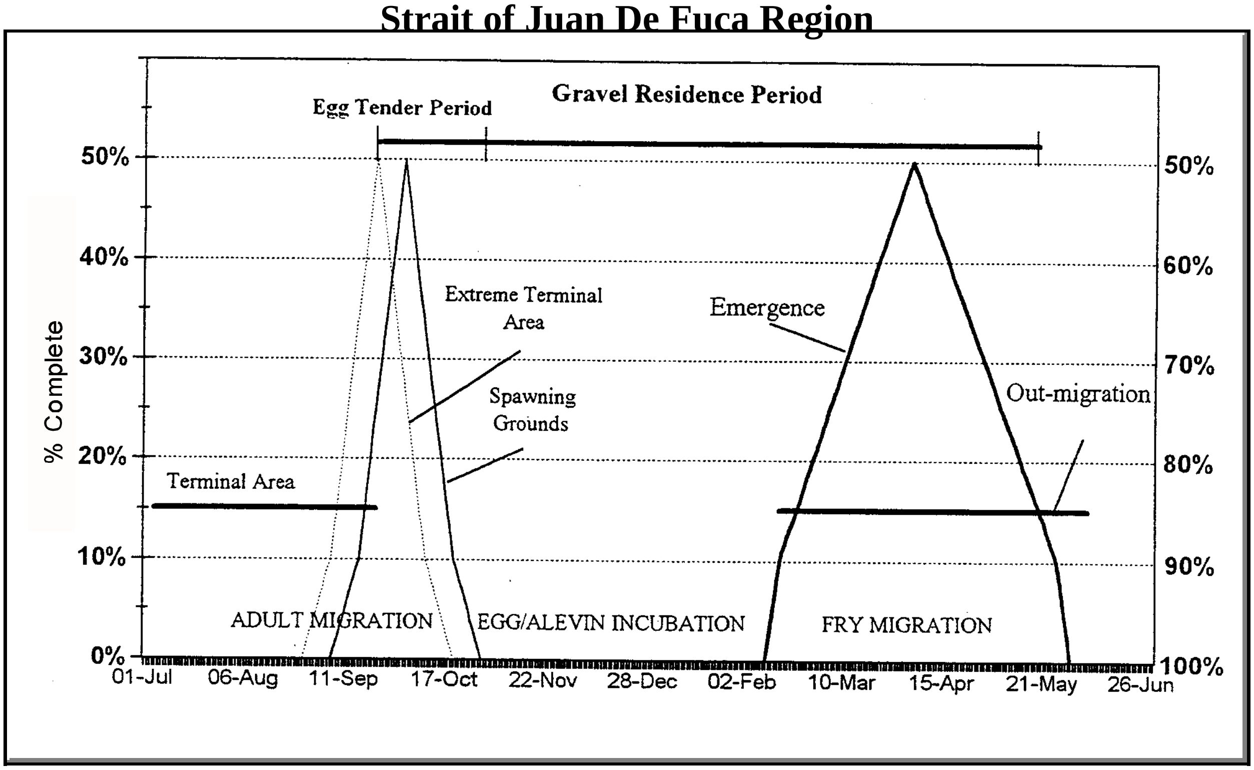


**Figure 3.1.** Estimated summer chum stream utilization and migration timing in Hood Canal and Strait of Juan de Fuca region freshwater and marine waters (based on Tynan 1997). The 0% to 50% timing is shown on left hand axis and 50% to 100% timing is shown on right hand axis.

The basis for examining the likelihood for hatchery-origin salmonid interactions with wild summer chum is the summer chum stock geographic distribution imformation provided in section 1.7.2, and a report summarizing WDFW and WDFW-cooperative anadromous salmonid production within the HC-SJF summer chum geographical area prepared by WDFW (Tynan 1998). The following format was used in Tynan (1998) to profile regional hatchery programs, and to describe salmonid production for each regional facility:

**Baseline facility information**

- the physical location of each facility or hatchery complex, noting their proximity to summer chum production, rearing and migration areas.
- duration of facility operation and history of production;
- institutional and legal drivers of production;
  - guidelines, permit requirements and policies determining practices; and
  - hatchery effluent and fish health status for each hatchery.

**Salmonid production characterization for each species produced**

- purpose/objectives of production;
- stocks used, release strategy;
- adult return data, including return timing to Washington marine and freshwater areas;
- historical Puget Sound return levels (1968-95) and homing behavior;
- historical and current annual production levels by class;
- historical and current release timing by class;
- efforts to minimize wild stock interactions; and
- a literature review of migration information for released fish, leading to characterization of out-migration timing to coastal water masses for currently practiced production.

The focus of the salmonid hatchery program characterization was on operational and production strategies currently applied at those facilities producing species of potential concern regarding the status of summer chum. It was recognized that hatchery programs in Washington have evolved greatly over the past twenty years to maximize hatchery fish survival upon release, meet changing harvest and production needs identified by the public and the tribes, and minimize negative effects on wild salmonid stocks using the same ecological resources.

This section responds to potential risks of the artificial production of other anadromous salmonid species within the geographical area encompassed by the HC-SJF summer chum. In addition to production for fisheries enhancement purposes, hatchery activities within the region include “formal recovery programs”, directed at the recovery of other ESA-listed or severely depressed stocks, including Dungeness River chinook salmon, Dungeness River pink salmon, Snow Creek coho salmon, and Hood Canal region fall chinook salmon populations. The discussion of risks and proposed risk aversion measures included here is not limited by the status of the propagated stock nor the intent of the program.

Artificial production programs implemented for recovery of other ESA-listed or critically-depressed anadromous salmonid populations may lead to adverse impacts to summer chum. Conservation plans implementing formal recovery programs should therefore consider potential effects of the programs on summer chum. However, risks to summer chum will be weighed against benefits imparted to the recovery of the target population in determining its acceptability, and hence, those practices applied to implement the program. Exceptions to the risk aversion criteria presented below may therefore be allowed when two formal recovery programs for separate stocks are in the same watershed, striking a balance between summer chum protection and the recovery needs of other salmonid species.

For the purposes of this assessment, resident trout plants within the region are assumed to not pose significant risks of adverse ecological impacts to summer chum, and programs producing trout are therefore not characterized here. No resident trout plants are made into anadromous waters, nor into areas providing a high likelihood of access to those waters. The majority of resident trout produced in the region are rainbow trout that are planted into land-locked lakes.

### Hatchery-origin Anadromous Salmonid Production Summary

Table 3.9 summarizes, for each anadromous salmonid species produced through regional hatcheries, total recent year annual average release numbers, size/age class at release, and release timings (from data summarized in Tynan 1998). Spawning ground entry and migrational timing estimates, and the locations of hatchery fish releases relative to summer chum production areas, are also indicated. This information will be compared with summer chum occurrence and migrational data to determine the likelihood for spatial and temporal interaction between each species produced in the hatchery program and summer chum salmon.

**Table 3.9.** Recent year average annual salmon and steelhead production within the HC-SJF summer chum region.

| Species | Agency (Complex) | Stock Origin/ Lineage | Release Numbers (`86-94 avg.) | Release Class | Release Size (avg. fl) | Release Timing (avg./range) | Juvenile Marine Migrational Timing | Freshwater Entry Timing (avg. adults) | Presence of Summer Chum [1] |
|---|---|---|---|---|---|---|---|---|---|
| Fall Chinook | **WDFW** (Hood Canal) | Hoodsport | 6,123,000 | Fing. Smolt | 80-86 mm | June 1 | June 1 - June 22 | Aug 12 -Sep 20 | No |
| | | Hoodsport | 226,000 | Yearlg. | 195 mm | May 2 | May 2 - June 4 | " " | Net-pens [2] |
| | **Citizen Groups** | Hoodsport | 480,000 | Fing. Smolt | 80-86 mm | June 1 | June 1 - June 22 | " " | Yes [3] |
| | | Hoodsport | 398,000 | Unfed Fry | 37-40 mm | ~Dec - Jan | unknown | " " | Yes [4] |
| | | Hoodsport | 90,000 | Yearlg. | 195 mm | June | June | " " | Yes [3] |
| | **Pt. Gamble Tribe** (L. Boston Ck) | Hoodsport | 120,000 | Fing. Smolt | 75 mm | May 20 | May 20 -June 10 | " " | No |
| | **Skokomish Tribe** | Hoodsport | 314,000 | Fing. Smolt | 65- 91 mm | May 20 | May 20 -June 10 | " " | No |
| | (Enetai Ck) | Hoodsport | 208,000 | Fing. | 39 - 53 mm | March-May | May-June | " " | No |
| Chinook | **WDFW** | Native | 975,000 | Fing. Smolt | ≥ 57 mm | Jun 15-Jul 15 | June 15 -Aug 30 | Aug 8 - Sep 14 | Yes [5] |
| | (Dungeness) | Native | 200,000 | Fingl. | 48-56 mm | " " | July-August | " " | Yes |
| | | Native | 800,000 | Fed fry | 47 mm | " " | July-August | " " | Yes |
| Coho | **WDFW** | Purdy Ck. | 422,000 | Yearlg. | 131-156 mm | June 11 | June 11-July 16 | Sept 18 - Nov 6 | No |
| | (Hood Canal) | Purdy Ck. | 157,000 | Fingl. [6] | 35-42 mm | Feb-March | April-May | " " | No |
| | (Dungeness) | Native | 447,000 | Yearlg. | 131 mm | May 30 | May 30 -June 10 | Sept 22 - Nov 2 | Yes [7] |
| | " | Native | 315,000 | Fingl. [6] | 40-46 mm | June 1 | April-May | " " | Yes [7] |
| | " | Native | | Un. fry [6] | 35-38 mm | mid-March | " " | " " | Yes [7] |
| | (Snow Creek) | Native | 16,000 | Fingl. | 75-100 mm | Nov, March | " " | " " | Yes [8] |
| | " | Native | 16,000 | Unfed fry | 35-38 mm | mid-March-mid April | " " | " " | Yes [8] |

**Table 3.9.** Continued

| Species | Agency (Complex) | Stock Origin/ Lineage | Release Numbers (`86-94 avg.) | Release Class | Release Size (avg. fl) | Release Timing (avg. / range) | Juvenile Marine Migrational Timing | Freshwater Entry Timing (avg. adults) | Presence of Summer Chum [1] |
|---|---|---|---|---|---|---|---|---|---|
| Coho (cont.) | **Skokomish Tribe**<br>(Quil. Bay) | Quilcene | 242,000 | Delayed | 131-167 mm | April 23-May 30 | April 23-June 19 | Sept 1 - Nov 9 | Net-pens [9] |
| | **Pt. Gamble Tribe**<br>(Pt. Gamble Bay) | Quilcene | 361,000 | Delayed | 131-167 mm | April 23-May 30 | April 23-June 19 | Sept 1 - Nov 9 | Net-pens [9] |
| | **USFWS** - QNFH [10] | Native | 445,639 | Yearlg. | 154 mm | May 2- May 14 | May 2-June 3 | Sept 1 - Nov 9 | Yes |
| | | Native | 42,974 | Fingl. | 79 mm | March-Nov | April-May | Sept 1 - Nov 9 | |
| Pink | **WDFW**<br>(Hood Canal) | Hoodsport | 4,500,000 | Fed fry | 50 mm | March 15 | Feb 16 - Apr 25 | Sept 15- Oct 15 | No |
| | (Dungeness) | Native | 500,000 | Fed fry | 40-50 mm | March-Apr | Mar 17 - Apr 25 | “ ” | Yes [11] |
| | **Pt. Gamble Tribe**<br>(L. Boston Ck) | Hoodsport | 200,000 | Fed fry | 50 mm | April 5 | April 5 - ? | “ ” | No |
| Fall chum | **WDFW** | Native | 15,000,000 | Fed fry | 48-52 mm | Mar 24 - Apr | Mar 24 - May 10 | Nov 7 - Dec 7 | No |
| | (Hood Canal) | Finch Ck. | 13,100,000 | Fed fry | 42-52 mm | Mar 17 - Apr | Mar 17 - May 12 | “ ” | No |
| | **Citizen Groups** | Finch Ck. | 1,000,000 | Unfed fry | 38 mm | Feb-Mar (?) | Feb - Mar (?) | “ ” | Yes [12] |
| | **Pt. Gamble Tribe**<br>(L. Boston Ck) | Finch Ck. | 730,000 | Fed fry | 41-66 mm | Apr 23-30 | Apr 23 - May 5 | “ ” | No |
| | **Skokomish Tribe** | Wolcott Sl | 1,380,000 | Fed fry | 43-56 mm | Apr 9-May 15 | Apr 16 - June 1 | Dec 1 - Jan 11 | No |
| | (Enetai Ck) | Wolcott Sl | 263,000 | Unfed fry | 38-40 mm | Mar ?-April 22 | Apr. 7 - May 4 | Dec. 1 - Jan 11 | No |
| | **USFWS** - QNFH | Native | 1,856,121 | Fed fry | 47 mm | Apr 22-June 9 | Apr 22 - June 26 | Dec. 1 - Jan 11 | Yes |
| Steelhead | **WDFW** | | | | | | | | |
| | (Dosewallips R.) | Chambers | 12,500 | Yearlg. | 180-230 mm | Apr 15-May 15 | Apr 15 - June 14 | Dec 7 - Apr 14 | Yes 13 |
| | (Duckabush R.) | Chambers | 10,000 | Yearlg. | 180-230 mm | “ ” | Apr 15 - June 14 | “ ” | Yes 13 |
| | (Skokomish R.) | Chambers | 50,000 | Yearlg. | 180-230 mm | “ ” | Apr 15 - June 14 | “ ” | Yes 13 |

**Table 3.9.** Continued.

| Species | Agency (Complex) | Stock Origin/ Lineage | Release Numbers (`86-94 avg.) | Release Class | Release Size (avg. fl) | Release Timing (avg. / range) | Juvenile Marine Migrational Timing | Freshwater Entry Timing (avg. adults) | Presence of Summer Chum [1] |
|---|---|---|---|---|---|---|---|---|---|
| Steelhead (cont.) | **Citizen Groups** | | | | | | | | |
| | (Hamma Hamma) | Native | 200 | Adults | 620 mm | Mar-April | --- | March-April | Yes |
| | “ ” | Native | 4,400 | 2+ Yearlg. | 165 mm | May | May-June | Dec 7 - Apr 14 | Yes |

[1] Determination made from review of “existing stocks” and “known recently extinct stocks” presented in section 1.7 Stock Evaluations and summarized in Table 1.8.

[2] Fall chinook yearlings are released from marine area net-pens at Sund Rocks, Hoodsport Marina, and Pleasant Harbor Marina. These fish may stray at unknown rates to adjacent summer chum streams.

[3] Hoodsport-origin fall chinook underyearling smolts are released into several summer chum streams in Hood Canal, including the Union River, Big Beef Creek, Duckabush River, and the Hamma Hamma River. Hoodsport-lineage chinook are also planted into three streams where self-sustaining summer chum runs are no longer present: Dewatto River, Tahuya River, and Skokomish River.

[4] Hoodsport-origin fall chinook unfed fry are released from RSIs into regional summer chum streams including the Tahuya and Dewatto rivers.

[5] Dungeness chinook are planted as underyearling smolts, fingerlings and fry as part of a formal recovery program. The status of the summer chum stock that may be affected by these releases is unknown.

[6] Coho fingerling out-plants into regional streams were discontinued from George Adams Hatchery in 1996, and from Dungeness Hatchery in 1995.

[7] The status of the summer chum stock that may be affected by these coho releases is unknown.

[8] These coho originate from indigenous stock planted as pre-smolts into Crocker Lake to acclimate and emigrate 2-5 months after release.

[9] Coho yearlings are released from marine area net-pens in Quilcene and Port Gamble bays. These fish may stray at unknown rates to regional summer chum streams.

[10] Quilcene NFH average release range for 1992-96 for yearlings and 1994-96 for fingerlings.

[11] Dungeness fall run pink salmon are produced as part of a formal recovery program.

[12] Finch Creek stock fall chum are released from RSIs into several regional summer chum streams, including the Union River and the Tahuya River.

[13] Steelhead yearlings of Chambers Creek lineage are truck-planted into three regional streams, two of which have known summer chum populations.

[14] Steelhead yearlings of Chambers Creek lineage are transferred into Dungeness Hatchery for two months of rearing prior to release. The status of the summer chum stock that may be affected by these releases is unknown.

### Risk Assessment of Hatchery Salmonid Releases on Summer Chum

Based on regional production information presented in Tynan (1998) and summarized in Table 3.9, an assessment of each hatchery species program is made to assign likely risks of deleterious effects to wild summer chum. The format for conducting this risk assessment is similar in structure to the ecological risk assessment template provided in section 7.6 of the draft Artificial Production chapter of the Comprehensive Chinook Management Plan (WDFW and WWTIT 1999). This template has been modified to comport with the purpose of this section, which is to assess operational and ecological risks posed by regional hatchery programs. In this instance, wild Hood Canal/SJF summer chum in freshwater and proximate regional marine waters are the "non-target taxa of concern." The focus of this assessment will be on overlap between hatchery operations and salmonid juveniles and adults that they produce, with summer chum of the same life stages.

Potential hazards assessed for effects on summer chum are presented below. For each species and program, the risk of deleterious effects for each hazard will generally be identified as "high," "moderate," or "low." In some instances, risks will be assigned as either "high" or "low," and no "moderate" rating judgement is viewed as applicable. Criteria that were used to assign risk levels for each hazard are indicated. One, or a combination of, the listed criteria may be used to assign a hazard risk level for an artificial propagation program.

## Hatchery Operations

This hazard includes risks to wild summer chum associated with salmonid trapping operations (weir placement/operation, fish handling, migrational delay or blockage effects), hatchery water intakes (dewatering, fry mortality), screening (fry entrainment), and effluent discharge (adverse water quality effects). Assignment of risk for this hazard will result from consideration of a number of factors bearing on the likelihood that adult trapping and hatchery operations for a program will contact adult summer chum and whether the programs are appropriately operated to minimize the risk of adverse effects to summer chum within a watershed. Table 3.10 presents risk ratings for hatchery operational effects on summer chum.

Fish capture operations, including weirs, traps, beach seining, and hand collection during snorkeling can adversely affect summer chum adults through physical injury, migrational delay, changes in migrational or spawning behavior, increased susceptibility to predation and poaching, and migration blockage. Negative effects to summer chum may include: physical harm that may result from capture and retention in the fish holding area within a weir trap, or from snagging or seining methods used for certain programs; harm that may result from delay in upstream migration, if the fish is reluctant to enter the trap, or as a result of capture and excessive holding durations; harm resulting from handling prior to release upstream; damage or mortality resulting from entrainment on the face of weirs, if upstream-released fish drop back downstream; incidental, immediate mortality resulting from the above impacts; and increased susceptibility after release to displacement downstream by current, and to predation, as the summer chum recovers from handling.

**Table 3.10.** Basis for "Hatchery Operations" risk ratings assigned to regional hatchery programs for summer chum effects.

| Risk Level | Criteria |
|---|---|
| **"High"** | **Risk is "high" if any one of the following five criteria are met:**<br>1. Broodstock collection weir is directed at other species, and is located at or near mouth of summer chum stream, affecting majority (> 50 %) of the return, AND any one of the following:<br>x. Broodstock collection weir is checked less than twice daily;<br>y. Summer chum incidentally collected in weir held for longer than 24 hours before passage upstream;<br>z. Staff operating fish weir not trained in proper fish handling techniques.<br>2. Hatchery water intakes and outlets do not prevent fish from entering, or are not screened;<br>3. Water withdrawal for the hatchery operation reduces flows with substantial negative impact on a portion of the stream accessible to, and used by, summer chum;<br>4. Hatchery facility regularly out of compliance with NPDES permit effluent limitations and best management practices;<br>5. No information is available for the hatchery and/or broodstocking operation. |
| **"Moderate"** | **Risk is "moderate" if no "high" criteria are met and any one of the following two criteria is met:**<br>1. Broodstock collection weir is directed at other species, and is located on a summer chum stream, affecting 10- 50% of the return, AND any one of the following:<br>a. Weir is checked at least twice daily, but not staffed full time;<br>b. Weir is located on private land in remote location and is not staffed full time;<br>c. Summer chum incidentally collected at weir held for between 12 and 24 hours before passage upstream.<br>2. Other method besides weir used to collect broodstock, including seining, snagging, or dip-netting. |
| **"Low"** | **Risk is "low" if none of the "high" or "moderate" criteria are met and any one of the first four criteria, and all of the subsequent criteria are met.**<br>1. The broodstock collection facility is located on a stream that lacks an existing summer chum population;<br>2. The artificial production facility is located on a stream with existing summer chum population, but no weir is used;<br>3. Broodstock weir used is directed at summer chum collection as a primary purpose;<br>4. Broodstock collection weir is directed at other species, and is located above major summer chum spawning areas or is operated outside of the summer chum migration period, affecting ≤ 10% of the return, AND all of the following:<br>a. Broodstock collection weir location is checked at least twice daily and is staffed full time; AND<br>b. Fish collected in weir are held for no longer than 12 hours before upstream passage; AND<br>c. Hatchery personnel trained in proper fish handling methods.<br>5. Hatchery intakes and outlets are properly screened;<br>6. No stream sections used by summer chum are dewatered through hatchery water withdrawal;<br>7. Hatchery facility complies with NPDES permit effluent limitations and best management practices. |

The risks of the above hazard will be assessed as "high" for programs on summer chum streams that collect fish using weirs or traps not attended and operated in a manner that ensures safe capture, minimal holding, and careful handling and release of incidentally captured summer chum. Potential, negative impacts can generally be minimized through continuous staffing of the weir site by hatchery personnel, frequent removal of fish collected using weirs and traps (e.g. minimizing fish holding times in traps boxes to under 12 hours), careful handling and upstream release of incidentally collected summer chum by personnel trained in proper fish handling procedures, and release of captured fish into areas where the risk of predation by birds and mammals is not enhanced. The risk of this hazard will generally be assessed as "low" for trapping operations that follow these risk minimization measures.

Water withdrawals within spawning and rearing areas can diminish stream flow from points of intake to outflow and, if great enough, can impede migration and affect spawning behavior of listed fish. Water rights issued for regional hatcheries must be conditioned to prevent dewatering of salmon migration, rearing, or spawning areas. All hatcheries must be designed to be non-consumptive; the water will be returned back to the source after it flows through the facility near the point of withdrawal to minimize risks to wild fish. Water withdrawals may have impacts to other stream-dwelling organisms important as food for juvenile salmonids as well, including habitat loss and displacement, and physical injury at intake locations. Screening of hatchery intakes is critical to ensure that fish are not injured through impingement or permanently removed from streams. All water intakes associated with regional hatchery programs must be adequately screened. The risk of these hazards will be assigned as "low" for hatchery operations that are in compliance with water right permits and NMFS water intake screening criteria.

Hatchery effluents may change water temperature, pH, suspended solids, ammonia, organic nitrogen, total phosphorus, and chemical oxygen demand in the receiving stream's mixing zone (Kendra 1991). To reduce the potential for adverse effects to receiving waters, hatchery effluent should be monitored periodically, with results reported to the Washington Department of Ecology, which is the state agency with authority for administering Clean Water Act NPDES permits. The level of impact or the precise effect of hatchery effluents on fish and other stream-dwelling organisms is usually unknown. The magnitude of the receiving water flow volume relative to the discharge volumes from the hatcheries determines the level of impact to receiving waters. Any adverse effects of hatchery effluent are probably localized at the immediate point of discharge. The risk of this hazard will generally be assigned as "low" for hatchery operations that are in compliance with applicable NDPES permit requirements.

## Predation

This hazard category includes risks to summer chum attributable to direct predation (direct consumption) or indirect predation (increases in predation by other predator species due to enhanced attraction) resulting from regional hatchery salmonid releases in freshwater and estuarine areas. In an assessment of the potential ecological effects of hatchery fish production on wild salmonids, Fresh (1984) reported that there is a high risk of a significant negative impact on wild chum salmon due to predation by hatchery-origin chinook, coho, and steelhead in freshwater and nearshore estuarine areas where the species co-occur. The group assigned a low risk of predation impacts to wild chum for hatchery pink and chum release groups where they interact in freshwater and estuarine migrational areas. Fresh (1984) noted that predation may be greatest when large numbers of hatchery smolts encounter newly emerged fry or fingerlings, or when hatchery fish are large relative to wild fish.

Data collected by WDFW personnel in the Yakima River watershed, and data from hatchery salmonid migration studies on the Lewis River (Hawkins and Tipping in press) provide evidence of hatchery coho yearling predation on salmonid fry in freshwater. In addition, Bakkala (1970 - quoting Hunter 1959 and Pritchard 1936) reported that young coho salmon in some British Columbia streams averaged two to four chum fry per stomach sampled. However, extensive stomach content analyses of coho salmon smolts collected during University of Washington Fisheries Research Institute studies in Hood Canal, as well as those in northern Puget Sound, the Strait of Juan de Fuca, and Nisqually Reach do not substantiate any indication of significant predation upon juvenile salmonids in Puget Sound marine waters (Simenstad and Kinney 1978). Similarly, Hood Canal, Nisqually Reach, and north Puget Sound data show little or no evidence of predation on juvenile salmonids by juvenile and immature chinook (Simenstad and Kinney 1978).

Salmonid predators are generally thought to prey on fish approximately 1/3 or less their length (USFWS 1994; NMFS 1999). Coho and chinook salmon, after entering the marine environment, generally prey upon fish one-half their length or less and consume, on average, fish prey that is less than one-fifth of their length (Brodeur 1991). Juanes (1994), in a survey of studies examining prey size selectivities of piscivorus fishes, showed a consistent pattern of selection for small-sized prey. Hargreaves and LeBrasseur (1986) reported that coho salmon smolts ranging in size from 100-120 mm fl selected for smaller chum fry (sizes selected 43-52 mm fl) from an available chum fry population including larger fish (available size range 43-63 mm fl). Ruggerone (1989; 1992) also found that coho smolts (size range 70-150 mm fl) selected for the smallest sockeye fry (28-34 mm fl) within a available prey population that included larger fish (28-44 mm fl). Summer chum in the region emerge at an approximate size of 1200-1300 fpp, or 35-39 mm fl (Bakkala 1970; Salo 1991; Tynan 1997; Fuss 1997b; S. Schroder, Wash. Dept. Fish. and Wild., pers. comm., 1999). For “0” age and yearling hatchery salmon and steelhead release classes, the “1/3 size criteria” will be applied to the minimum chum fry size from the above range (35 mm) to assess risk. Hatchery fish released at a size equal to or larger than 106 mm fl, or attaining that size after release as fry through freshwater rearing, during the Hood Canal summer chum fry egression and early marine emigration period (prior to April 15) are therefore judged to pose an elevated, direct predation risk to emigrating summer chum fry.

Due to their location in the lower portions of regional watersheds and relatively early time of emergence, wild summer chum fry will not generally be vulnerable to predation by hatchery salmon smolts. Yearling coho, steelhead, and chinook smolts produced in hatcheries that, due to their relatively large size at release, have the greatest potential to impact juvenile wild fish through predation are liberated into mainstem river areas beginning in late April or early May, separating them spatially and temporally to a significant degree from emerging and migrating summer chum fry. Hatchery coho and steelhead planted into summer chum watersheds as fry or fingerlings may have an elevated potential to prey on emerging summer chum fry the subsequent year as yearlings if they are rearing in lower stream areas. Although available studies indicate that predation on juvenile salmonids, including summer chum fry, is not of great concern, release practices that ensure spatial and temporal separation between hatchery fall chinook salmon, coho salmon, and steelhead smolts, and summer chum, should be implemented. The critically depressed status of summer chum calls for a conservative approach to hatchery fish release practices and the assessment of their effects. Further studies are needed in nearshore areas to fully evaluate the risk of predation to summer chum emigrants posed by resident chinook and coho resulting from the Hood Canal hatchery programs.

Large concentrations of migrating hatchery fish may attract predators (birds, fish, and seals) and consequently contribute indirectly to predation of emigrating wild fish (Steward and Bjornn 1990). The presence of large numbers of hatchery fish may also alter wild summer chum behavioral patterns, potentially influencing their vulnerability and susceptibility to predation (Hillman and Mullan 1989). Hatchery fish, including pink salmon and fall chum salmon, released as fry during the summer chum emigration period may pose an elevated, indirect predation risk. Alternatively, a mass of hatchery fry migrating through an area may overwhelm established predator populations, providing a beneficial, protective effect to co-occurring wild summer chum. In addition, Hargreaves and LeBrasseur (1985) demonstrated that coho salmon prey selectively on pink salmon even when intermingled chum salmon are both significantly smaller and more abundant than pink salmon. Thus, hatchery pink salmon fry releases during the summer chum fry emigration period may attract and occupy potential chum predators. For the purpose of this assessment, large magnitude releases of these species (>1.0 million per facility) during the Hood Canal summer chum fry egression and estuarine arrival period (prior to April 1) in close proximity to summer chum stream (1000 yds or less distance), or fall chum or pink fry releases at any level into a summer chum stream before April 1, will be considered to pose an elevated risk to emigrating summer chum fry through predator attraction.

## Summary

Direct predation risks will be assessed as "high" for hatchery-origin juvenile salmonids released prior to April 15 at a size that may enable chum fry predation (≥ 106 mm fl). The indirect predation risk from potential enhanced predator attraction will be assessed as "high" for pre-April 1 releases of fall chum or pink fry at levels greater than 1.0 million within 1000 yds of a summer chum stream, and for fry released directly into a summer chum stream at any level. Risks of predation will be viewed as "low" for salmonid releases made after April 15 for "large" smolts ($ 106 mm fl) that may pose a direct predation risk, and for conspecific fish species releases in or near summer chum streams that might pose indirect predation effects made after April 1. Table 3.11 presents risk ratings assigned for predation effects by hatchery salmonid releases.

**Table 3.11.** Basis for "Predation" risk ratings assigned to regional hatchery programs for summer chum effects.

| Risk Level | Criteria |
|---|---|
| "High" | **Risk is "high" if any one of the following criteria are met:**<br>**"Direct" predation effects**<br>1. Hatchery fish are released as yearlings into summer chum streams or the estuary during the estimated wild summer chum fry emigration period (pre-April 15).<br>2. Hatchery fish are released at an average size $ 106 mm prior to April 15.<br>3. Any salmonids released into a summer chum stream that will grow to a size $ 106 mm and be present during the summer chum egression period;<br>4. Release timing of hatchery fish is unknown;<br><br>**"Indirect" predation effects**<br>5. Fall chum or pink salmon fry released from individual projects into marine waters at levels greater than 1.0 million within 1000 yds of a summer chum stream prior to April 1, enhancing predator attraction risks.<br>6. Fall chum or pink salmon fry released at any level into a summer chum stream prior to April 1. |
| "Low" | **Risk is "low" where the following applicable criteria are met:**<br>**"Direct" predation effects**<br>1. Seaward-migrating hatchery fish of any species or size released after April 15.<br>2. Sub-yearling life history fall chinook released as unfed fry or fingerlings into a summer chum stream.<br>3. Chinook, coho, or steelhead fry or fingerlings released into a stream that does not support a summer chum population.<br><br>**"Indirect" predation effects**<br>4. Fall chum or pink salmon fry released into marine waters greater than 1000 yds distance from a summer chum stream<br>5. Fall chum or pink salmon fry released at any level after April 1. |

## Competition and Behavioral Modification

### Competition Effects

Competition occurs when the demand for a resource by two or more organisms exceeds the available supply. If the resource in question (e.g., food or space) is present in such abundance that it is not limiting, then competition is not occurring, even if both species are using the same resource. Hazards associated with adverse competitive effects of hatchery salmonids on summer chum may include food resource competition, competition for spawning sites, and redd superimposition. Fresh (1984) reported a low risk that competition between hatchery salmonids and wild chum in freshwater will have a significant negative impact on the productivity of wild chum. For early marine life, a high risk of adverse competitive impacts between wild chum and hatchery-origin pink and chum was assessed, with other salmonid species produced by hatcheries viewed as having an unknown impact (Fresh 1984). In general, hatchery-produced smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile wild fish in freshwater (Steward and Bjornn 1990). Impacts from competition are assumed to be greatest in the spawning areas where competition for redd sites and redd superimposition may be concerns, and at release locations where hatchery fish densities are highest (USFWS 1994). Any competitive impacts likely diminish as hatchery-produced fish disperse, but resource competition may continue to occur at some unknown, but lower level as summer chum fry and any commingled hatchery fry emigrate seaward. Steward and Bjornn (1990) concluded that hatchery fish kept in the hatchery for extended periods before release as smolts (e.g., yearling salmon) may have different food and habitat preferences than wild fish, and that hatchery fish will be unlikely to out-compete wild fish.

Hatchery-origin adult salmonids, including non-indigenous stocks of fall chinook, fall chum, or pink salmon that may home to, or stray into, summer chum production streams during the summer chum spawning or egg incubation period are viewed as posing an elevated competitive and behavioral modification risk to wild summer chum productivity. These returning or straying fish may compete for spawning gravel, or adversely affect summer chum survival through redd superimposition. Superimposition of redds by later spawners removes previously deposited eggs from the gravel, and has been identified as an important source of chum mortality in some areas (Bakkala 1970).

The risk of straying by these hatchery-produced species may be minimized through acclimation of the fish to their stream of origin, or desired stream of return. Acclimation can be instilled through the use of locally adapted stocks, and by rearing of the fish for an extended duration (e.g., eyed egg to smolt) in the “home” stream prior to release or transfer to a marine area net-pen site for further rearing. Of the above three species, fall chum incubated, reared, and released into streams not harboring summer chum populations are viewed as the least likely to stray from the home stream, and thus posing low risks of competition and behavioral modification hazards. Several sources indicate that chum salmon homing to hatchery release sites is quite strong. Salo (1991), reporting on a 1952 study of tagged fall chum released from, and returning to, Minter Creek Hatchery in south Puget Sound, noted no strays into adjacent streams in two seasons of monitoring. Studies of fall chum released from Wolcott Slough by USFWS showed the same result, with no strays reported in adjacent streams (Salo 1991, citing Wolcott 1978). Studies by Fuss and Hopley (1991) corroborated the above work indicating the high fidelity of chum salmon to their stream of origin, finding that over five consecutive brood years, an extremely small percentage of returning adult coded wire tagged fall chum released from Hoodsport Hatchery strayed to streams adjacent to the release site. Out of 6,600 tagged fish recovered over the five brood years studied, only four were recovered in Hood Canal streams outside of the hatchery. None of the tagged fish released at Hoodsport Hatchery during this study were recovered at other adjacent southwest Hood Canal hatcheries producing fall chum salmon (Enetai, McKernan, and George Adams).

Many summer chum streams in the region record lowest flows during the summer chum spawning period. Low flows tend to constrain spawning of all species to center channel, lower river areas, especially in smaller creeks, where the effects of non-indigenous fish spawning in summer chum areas may impact chum survival. Wild summer chum spawners in streams with greater channel widths and flows during the summer chum spawning period (e.g., certain west-side Hood Canal rivers) may be less affected by non-indigenous salmon spawners, as fish may be able to disperse over larger areas. Hatchery releases of indigenous salmonid stocks, and adult returns resulting from them, are assigned a decreased risk rating through assumption of some measure of co-adaptation that has led to resource partitioning between the "native stock-origin" hatchery fish and summer chum. It is assumed that the indigenous salmonid species within a watershed have evolved mechanisms for segregating their use of limited resources that act to prevent or reduce interspecific competition.

Simenstad et al. (1980) hypothesized that limited prey resources and inadequate foraging success in the estuary were responsible for higher mortality rates for emigrating summer chum fry relative to later migrating fall chum stocks. They also suggested that even expanded populations of zooplankton present later in the Hood Canal chum fry emigration period could be over-exploited given high enough densities of juvenile chum salmon. Research and experimentation toward development of hatchery release strategies that minimized the potential effects of competition and food limitation and increased total survival to adult return were suggested (Simenstad et al. 1980).

Analysis of historical Hood Canal hatchery fall chum and wild summer chum production and abundance data summarized by WDFW (1997b) indicated the speculative nature of judgements regarding the competitive effects, either positive or negative, of fall chum releases on summer chum fry survival. Hatchery fall chum releases during the summer chum emigration period (pre-April 1) in some recent years likely exceeded the probable numbers of wild summer chum salmon fry that resulted in any one year from escapements that have occurred between 1968 and 1996. This was especially true for brood year 1992, when early releases of fall chum salmon from the Hood Canal hatcheries totaled 28.6 million fry, compared to an estimated summer chum fry emigration of 420,000. If adverse competitive impacts to summer chum result from fall chum releases, hatchery fall chum fry production of brood year 1992 should have had the greatest, most observable impact on summer chum success of any year in the WDFW data base. However, the 1992 brood year summer chum were highly productive, making up the majority of adults in the large returns to Hood Canal in 1995 and 1996 (WDFW 1997b), suggesting that the hatchery fall chum releases had minimal, if any, adverse effects on summer chum survival.

The majority of fall chum fry releases from southwest Hood Canal hatcheries are now made after the estimated summer chum out-migration period, and therefore interaction with summer chum is likely limited. However, to meet hatchery programming schedules, some fall chum groups (e.g., McKernan Hatchery), and most pink salmon cohorts in Hood Canal, are still released in mid- to late March in most years. Although these releases may overlap with wild summer chum in the estuary temporally, the degree to which the hatchery fish and wild summer chum interact is affected by the estuarine realm used by the groups during seaward emigration. The smaller, wild summer chum fry likely migrate in shallow waters along the shoreline, until the fish reach a larger size (45-60 mm) that decreases their susceptibility to predation, enabling off-shore movement. Fed chum and pink salmon fry released from hatcheries at a size of 50 mm and larger tend to be found in pelagic areas during migration, separating them spatially from wild summer chum fry. Unfed fall chum and pink salmon releases from hatcheries during the summer chum emigration period are of greater concern, because of their greater propensity to use the same nearshore feeding and migratory areas within the estuary as wild summer chum fry. Unfed fry release may therefore have a greater potential for interaction, posing an increased risk of adverse competitive effects. As noted above, researchers have postulated that food resources preferred by chum salmon may be limited during the summer chum emigration period (Simenstad et al.1981). Any level of hatchery fall chum or pink salmon present in the estuary during the summer chum emigration period may pose risks to summer chum.

### Behavioral Modification Effects

Interactions with hatchery-origin salmonids may lead to behavioral changes to summer chum that are detrimental to productivity and survival. Hatchery fish might alter wild salmon habitat use, making them more susceptible to predators (Hillman and Mullan 1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter wild salmonid migratory responses or movement patterns, leading to a decrease in foraging and/or spawning success (Steward and Bjorrn 1990; Hillman and Mullan 1989). A negative change in growth and condition of summer chum through a change in their diet or feeding habits could occur following the release of hatchery salmonids during the summer chum emigration period. Effects on wild fish, including summer chum, would depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjorrn 1990).

Hatchery chum and pink salmon fry releases of large magnitude could potentially cause displacement of migrating/rearing wild summer chum from normal migratory areas, leading to abandonment of advantageous feeding areas. The presence of large numbers of hatchery fish may also alter wild fish behavioral patterns, which may increase their vulnerability to predation (USFWS 1994). Non-indigenous hatchery-produced fall chinook, pink, and early-timed fall chum salmon adults returning to a summer chum at the same time as summer chum may cause displacement of summer chum spawners from preferred, advantageous spawning areas.

### Summary

The likelihood for high spatial and temporal overlap and, therefore, potentially significant interaction with summer chum on the spawning grounds or during fry emigration will be used to assign a “high” risk rating for hatchery release programs. For the purposes of this assessment, it is assumed that there is some as yet undefined, but critical food resource carrying capacity in Hood Canal that limits chum and pink salmon fry population survival during the summer chum emigration period (March). To identify practices that may result in adverse competitive effects to summer chum, a “high” risk ranking is assigned for releases of fall chum and pink salmon from individual hatcheries during the main portion of the Hood Canal summer chum egression and estuarine arrival period (prior to April 1). Fall chum and pink salmon fry releases after April 1 will be assigned a “low” risk rating. The risk of adverse competitive and behavioral modification effects will also be assessed as “high” in instances where the release timing is unknown.

Risks will be assessed as “high” for hatchery-origin adult fall chinook, fall chum, or pink salmon that are not part of a formal recovery program returning to, or straying into, summer chum spawning areas during the summer chum adult migration, spawning or egg incubation period. “Moderate” ratings will be assigned where spatial and temporal overlap with summer chum is lower, or tempered by hatchery management actions. Ratings will be assigned as “low” in instances where little overlap on the spawning grounds or in the estuary between the hatchery fish and summer chum is expected, and the risk of adverse interactions with summer chum are considered insignificant. Table 3.12 rates competition and behavioral modification risks to summer chum posed by adult and juvenile hatchery-origin salmonids within the Hood Canal and Strait of Juan de Fuca regions.

**Table 3.12.** Basis for "Competition and Behavioral Modification" risk ratings assigned to hatchery programs for summer chum effects.

| Risk Level | Criteria |
|---|---|
| "High" | **Risk is "high" if any one of the following criteria are met:**<br>***Risks posed by adult fish -***<br>1. Hatchery fall chinook, coho, fall chum, or pink salmon that are not a part of a formal recovery program are released into a summer chum stream without avenues for removing $ 90% of returning spawners.<br>***Risks posed by juvenile fish -***<br>2. Unfed or fed fall chum or pink salmon fry are released prior to April 1;<br>3. Release timing of hatchery fish is unknown; |
| "Moderate" | **Risk is "moderate" if no "high" criteria are met <u>and</u> any one of the following criteria is met:**<br>***Risks posed by adult fish -***<br>1. Hatchery fall chinook, coho, fall chum, or pink salmon that are not a part of a formal recovery program are released into a summer chum stream with high likelihood for removing ≥ 90% of returning spawners.<br>2. Unacclimated hatchery fall chinook, fall chum, or pink salmon are released into a stream lacking summer chum.<br>3. Fall chinook salmon are released from marine area net-pens. |
| "Low" | **Risk is "low" where the following applicable criteria are met:**<br>***Risks posed by adult fish -***<br>1. (a) Hatchery fall chinook, coho, fall chum, or pink salmon that <u>are</u> part of a formal recovery program, <u>or</u> (b) <u>are not</u> a part of a formal recovery program and are released into a summer chum stream with high likelihood for removing 100% of returning spawners.<br>2. Hatchery chinook, fall chum or pink salmon are acclimated and released as smolts into a stream where no summer chum population exists.<br>3. Hatchery chinook, fall chum or pink salmon are acclimated and released into a large river system where timing overlap with summer chum adults exists, and spatial separation during spawning is known to exist.<br>***Risks posed by juvenile fish -***<br>4. Unfed or fed fall chum or pink salmon fry are released after April 1.<br>5. Coho and steelhead are released as fingerling or smolts.<br>6. Acclimated chinook, coho, or steelhead fry or fingerlings are released into a stream that lacks a summer chum population. |

### Fish Disease Transfer

This category addresses the risk of acute or chronic mortality, or elevated susceptibility to predation, resulting from the potential transfer of fish diseases from hatchery-origin fish species to summer chum. The risk of this hazard will be assessed through consideration of operational practices applied to minimize the likelihood for disease outbreaks at a hatchery facility, and of disease transfer to wild fish.

Under certain conditions, hatchery effluent has the potential to transport fish pathogens out of the hatchery, where natural fish may be exposed to infection. Interactions between hatchery fish and natural fish in the environment may also result in the transmission of pathogens, if either the hatchery or natural fish are harboring a fish disease. This latter impact may occur in tributary areas where hatchery fish are planted and throughout migration corridors where hatchery and wild fish may interact. As the pathogens responsible for fish diseases are present in both hatchery and natural populations, there is some uncertainty associated with determining the source of the pathogen (Williams and Amend 1976; Hastein and Lindstad 1991). Hatchery-origin fish may have an increased risk of carrying fish disease pathogens because of relatively high rearing densities that increase stress and can lead to greater manifestation and spread of disease within the hatchery population. Under natural, low density conditions, most pathogens do not lead to a disease outbreak. When fish disease outbreaks do occur, they are often triggered by stressful hatchery rearing conditions, or by a deleterious change in the environment (Saunders 1991). Consequently, it is possible that the release of hatchery fish may lead to the loss of natural fish, if the hatchery fish are carrying a pathogen, if that pathogen is transferred to the natural fish, and if the transfer of the pathogen leads to a disease outbreak. Although hatchery populations can be considered to be reservoirs for disease pathogens because of their elevated exposure to high rearing densities and stress, there is little evidence to suggest that diseases are routinely transmitted from hatchery to wild fish (Steward and Bjornn 1990).

To address concerns of potential disease transmission from hatchery salmonids to wild fish, the co-managers developed a Fish Health Policy, which established guidelines to ensure that fish health is monitored and that hatchery fish are reared and released in good condition, thus minimizing impacts to natural fish (NWIFC and WDFW 1998). WDFW has also developed a Fish Health Manual that sets forth policies and procedures for the production of quality, healthy fish by the Department's Hatcheries Program (WDFW 1996). The WDFW manual also serves as a guide for training Fish Hatchery Specialists in fish culture and fish health practices. Compliance with NPDES permit provisions at hatcheries also acts to minimize the likelihood for disease epizootics and water quality impacts that may lead to increased wild fish susceptibility to disease outbreaks. Full compliance with the co-manager's Salmonid Disease Control Policy is used to assign a "low" risk rating for fish disease transfer. Degree of deferral from Policy guidelines will be used to assign a "high" or "moderate" risk rating. Table 3.13 presents criteria used to assign risk ratings for this hazard category.

**Table 3.13**. Basis for "Fish Disease Transfer" risk ratings assigned to regional hatchery programs for summer chum effects.

| Risk Level | Criteria |
|---|---|
| **"High"** | **Risk is "high" if the following criterion is met:**<br>1. Co-manager Salmonid Disease Control Policy procedures not followed, e.g.:<br>a. Hatchery fish health condition is not monitored and recorded during broodstock spawning and juvenile fish rearing.<br>b. Hatchery fish not examined and certified as free of regulated pathogens prior to release.<br>c. Fish released during disease outbreak.<br>d. Transfers of fish not documented or out of compliance with transfer policies specified in co-manager's Salmonid Disease Control Policy. |
| **"Moderate"** | **Risk is "moderate" if the following criterion is met:**<br>1. Co-manager Salmonid Disease Control policy procedures are not consistently followed, e.g.:<br>a. Broodstock certified by Fish Health professional but fish health during rearing is monitored only by hatchery staff.<br>b. Hatchery fish not fish health certified prior to release.<br>c. Fish released in good health with relatively low (<0.1%) daily mortalities in previous week. |
| **"Low"** | **Risk is "low" if the following criterion is met:**<br>1. Co-manager Salmonid Disease Control policy procedures are consistently followed, e.g.:<br>a. Hatchery broodstock and juvenile fish health is monitored by fish health professional during operation.<br>b. Hatchery fish health are examined and certified by fish health professional as free of regulated pathogens prior to release.<br>c. Fish transfers documented and in compliance with transfer policies specified in co-manager's Salmonid Disease Control Policy. |

## Risk Rating Summary

The risk of the above hatchery operational and ecological hazards to summer chum are assigned based on the preceding text for each of the hatchery programs listed in Table 3.9. A summary of assigned risk levels for the programs is presented in Table 3.14.

Risk levels are assigned for each age class produced through the programs, and grouped by species produced. Criteria set forth in Tables 3.10 through 3.13 were used to determine risk levels. Criteria applied from the tables to assign the risk level for each hazard are identified by number.

**Table 3.14.** Assessment of risks to wild summer chum juveniles and adults posed by the production and release of anadromous salmonids by artificial propagation programs in the HC-SJF summer chum region.

| Species |  | Hazard Categories and Assigned Risk (criteria # from risk ranking within category applied) |  |  |  |  |
|---|---|---|---|---|---|---|
| **Agency** | **Project** | **Release Class** | **Hatchery Operations** | **Predation** | **Competition and Behavioral Modification** | **Disease Transfer** |
|  | ***Fall chinook*** |  |  |  |  |  |
| **WDFW** | Hoodsport FH | Fingl. | Low (1, 5, 6, 7) | Low (1) | Low (2) | Low (1 a-c) |
|  | George Adams FH | Fingl. | Low (1, 5, 6, 7) | Low (1) | Low (2) | Low (1 a-c) |
|  | Sund Rocks Net-pens | Yearl. | Low (1, 7) | Low (1) | Moderate (3) | Low (1 a-c) |
| **Port Gamble Tribe** | L. Boston | Fingl. | Low (1, 7) | Low (1) | Low (2) | Low (1 a-c) |
| **Skokomish Tribe** | Enetai | Fingl. | Low (1, 7) | Low (1) | Low (2) | Low (1 a-c) |
| **Citizen Groups** | Union River | Fingl. | Low (2, 5, 6, 7) | Low (1) | High (1) | Moderate (1 a, b) |
|  | Tahuya River | Fing. | Low (1, 5, 6, 7) | Low (1) | High (1) | Moderate (1 a, b) |
|  |  | Unfed Fry | Low (1, 5, 6, 7) | Low (2) | High (1) | Moderate (1 a, b) |
|  | Dewatto River | Fingl. | Low (1, 5, 6, 7) | Low (1) | High (1) | Moderate (1 a, b) |
|  | Big Beef Creek | Fingl. | Low (3, 5, 6, 7) | Low (1) | Low (1) | Moderate (1 a, b) |
|  | Skokomish River | Yearl. | Low (1, 5, 6, 7) | Low (1) | Low (2) | Low (1 a-c) |
|  |  | Fingl. | Low (1, 5, 6, 7) | Low (1) | Low (2) | Low (1 a-c) |
|  | Hamma Hamma River | Fingl. | Moderate (2) | Low (1) | Low (3) | Low (1 a-c) |
|  | Johnson Ck. (Duckabush) | Fingl. | Low (2, 5, 6, 7) | Low (1) | Low (3, 5) | Moderate (1 a, b) |
|  | Unnamed tribs. | Unfed Fry | Low (1) | Low (3) | Low (6) | Moderate (1 a, b) |
|  | Pleasant Harbor Net-Pens | Yearl. | Low (1, 7) | Low (1) | Moderate (3) | Low (1 a-c) |
|  | HC Marina Net-Pens | Yearl. | Low (1, 7) | Low (1) | Moderate (3) | Low (1 a-c) |
|  | ***Chinook*** |  |  |  |  |  |
| **WDFW** | Dungeness FH | Fry | Low (4, 5, 6, 7) | Low (2) | Low (1, 3) | Low (1 a-c) |
|  |  | Fingl. | Low (4, 5, 6, 7) | Low (2) | Low (1, 3) | Low (1 a-c) |
|  |  | Fingl. smolt. | Low (4, 5, 6, 7) | Low (1) | Low (1, 3) | Low (1 a-c) |

**Table 3.14.** Continued

| Species | | Hazard Categories and Assigned Risk (criteria # from risk ranking within category applied) | | | | |
|---|---|---|---|---|---|---|
| **Agency** | **Project** | **Release Class** | **Hatchery Operations** | **Predation** | **Competition and Behavioral Modification** | **Disease Transfer** |
| | ***Coho*** | | | | | |
| **WDFW** | Dungeness FH | Yearl. | Low (4, 5, 6, 7) | Low (1) | Low (5) | Low (1 a-c) |
| | Pt. Gamble Net-pens | Yearl. | Low (1, 7) | Low (1) | Low (5) | Low (1 a-c) |
| | Quilcene Net-pens | Yearl. | Low (1, 7) | Low (1) | Low (5) | Low (1 a-c) |
| | George Adams FH | Yearl. | Low (1, 5, 6, 7) | Low (1) | Low (5) | Low (1 a-c) |
| | Tarboo Ck. | Fingl. | Low (1) | Low (3) | Low (6) | Low (1 a-c) |
| | Snow Ck. | Unfed fry | Low (4) | High (3) | Low (1) | Low (1 a-c) |
| | | Pre-smolts | Low (4) | High (3) | Low (1) | Low (1 a-c) |
| **USFWS** | Quilcene NFH | Yearl. | Low (3, 5, 6, 7) | Low (1) | Low (1) | Low (1 a-c) |
| | | Fing. | Low (3, 5, 6, 7) | High (3) | Low (1) | Low (1 a-c) |
| | ***Pink*** | | | | | |
| **WDFW** | Hoodsport FH | Fed fry | Low (1, 5, 6, 7) | Low (4) | High (2) | Low (1 a-c) |
| | Dungeness FH | Fed fry | Moderate (1) | High (6) | Low (1, 3) | Low (1 a-c) |
| | ***Fall Chum*** | | | | | |
| **WDFW** | Hoodsport FH | Fed fry | Low (1, 5, 6, 7) | Low (4) | High (2) | Low (1 a-c) |
| | George Adams FH | Fed fry | Low (1, 5, 6, 7) | Low (5) | Low (2) | Low (1 a-c) |
| | McKernan FH | Fed fry | Low (1, 5, 6, 7) | Low (4) | High (2) | Low (1 a-c) |
| **Skokomish Tribe** | Enetai FH | Fed fry | Low (1, 5, 6, 7) | Low (5) | Low (2) | Low (1 a-c) |
| **Pt. Gamble Tribe** | Pt. Gamble FH | Fed fry | Low (1, 5, 6, 7) | Low (5) | Low (2) | Low (1 a-c) |
| **USFWS** | QNFH | Fed fry | Low (3, 5, 6, 7) | Low (5) | Low (2) | Low (1 a-c) |

**Table 3.14.** Continued

| Species |  | Hazard Categories and Assigned Risk (criteria # from risk ranking within category applied) |  |  |  |  |
|---|---|---|---|---|---|---|
| **Agency** | **Project** | **Release Class** | **Hatchery Operations** | **Predation** | **Competition and Behavioral Modification** | **Disease Transfer** |
| ***Fall chum - continued*** |  |  |  |  |  |  |
| **Citizen Groups** | Mills Ck. | Unfed fry | Low (1) | Low (4) | High (2); Low (2) | Moderate (1 a, b) |
|  | Tahuya R. | Unfed fry | Low (1, 5, 6, 7) | High (6) | High (1, 2) | Moderate (1 a, b) |
|  | Union R. | Unfed fry | Low (1, 5, 6, 7) | High (6) | High (1, 2) | Moderate (1 a, b) |
|  | L. Mission Ck. | Unfed fry | Low (1) | Low (4) | High (2); Low (2) | Moderate (1 a, b) |
|  | Skull Ck. | Unfed fry | Low (1) | Low (4) | High (2); Low (2) | Moderate (1 a, b) |
|  | Sweetwater Ck. | Unfed fry | Low (1) | Low (4) | High (2); Low (2) | Moderate (1 a, b) |
|  | Unnamed 14.0124 | Unfed fry | Low (1) | Low (4) | High (2); Low (2) | Moderate (1 a, b) |
|  | Chinom Pt. (Ck.) | Unfed fry | Low (1) | Low (4) | High (2); Low (2) | Moderate (1 a, b) |
|  | Unnamed 14.0136 | Unfed fry | Low (1) | Low (4) | High (2); Low (2) | Moderate (1 a, b) |
|  | Skokomish R. | Unfed fry | Low (1) | Low (4) | High (2); Low (2) | Moderate (1 a, b) |
|  | Jump-off Joe Ck. | Unfed fry | Low (1) | Low (4) | High (2); Low (2) | Moderate (1 a, b) |
| ***Steelhead*** |  |  |  |  |  |  |
| **WDFW** | Skokomish R. | Yearl. | Low (2) | Low (1) | Low (5) | Low (1 a-c) |
|  | Dosewallips R. | Yearl. | Low (2) | Low (1) | Low (5) | Low (1 a-c) |
|  | Duckabush R. | Yearl. | Low (2) | Low (1) | Low (5) | Low (1 a-c) |
|  | Dungeness FH | Yearl. | Low (4, 5, 6, 7) | Low (1) | Low (5) | Low (1 a-c) |
| **Citizen Groups** | Hamma Hamma R. | 2+ Yearl. | Low (2) | Low (1) | Low (5) | Low (1 a-c) |

### Risk Aversion and Monitoring and Evaluation Measures Proposed to Reduce the Risks of Hatchery Operational and Ecological Hazards to Summer Chum

Following are risk aversion and monitoring and evaluation measures proposed to reduce the risk of hazards to wild summer chum productivity that may result from regional hatchery salmonid production programs. These measures were designed to compliment risk aversion and monitoring and evaluation measures included in section 3.2 of this plan that pertain to summer chum-directed supplementation programs. Proposed measures are included here to minimize risks, as needed, of the aforementioned operational and ecological hazards posed by hatchery programs producing other anadromous species in the Hood Canal and Strait of Juan de Fuca summer chum region. These measures are also set forth to identify monitoring and evaluation work needed to answer critical questions regarding hatchery program impacts to the summer chum populations. Monitoring and evaluation results will be used to adaptively manage the hatchery programs to reduce the risk of hazards to summer chum that may be affected.

Generally, risk aversion measures are proposed for application in instances where risks of hazards to summer chum are assigned as “high” or “moderate.” Monitoring and evaluation programs are also proposed to address risks judged as “high” or “moderate,” or where the uncertainty of the effects on summer chum associated with a particular release program is high. The intent is to adjust assessed “high” and “moderate” impact programs through application of the following measures, as appropriate, so that the risk of adverse effects on wild summer chum becomes “low.” Requirements for monitoring and evaluation will allow for the adaptive management of programs, if needed, as new information regarding the occurrence and effects of each hazard is gathered.

The assignment of risk aversion and monitoring evaluation measures to programs judged as potentially hazardous to summer chum productivity is consistent with the approach applied by NMFS in biological assessments of hatchery salmonid production in the Columbia River Basin (NMFS 1999). In forming biological opinions regarding whether or not Basin hatchery programs jeopardize the survival of listed fish, “reasonable and prudent alternatives” are developed and applied as requirements for certain hatchery operations and practices to minimize or avert perceived risks to listed fish. Similarly, NMFS also applies “conservation measures” within the biological opinions as required or suggested methods to reduce the risk of negative effects or to study their potential for impacting ESA-listed fish. These alternatives and measures included in the NMFS hatchery biological opinions serve the same risk minimization purpose as the risk aversion and monitoring and evaluation measures set forth in this plan. All are mechanisms for reducing the likelihood that the hatchery programs will negatively affect ESA-listed or depressed salmonid populations requiring protection.

## Hatchery Operations

The following proposed measures and programs should apply to all hatchery programs in the region. The risk aversion approach will be directed towards minimizing harm to summer chum that may be encountered during adult salmonid trapping directed at other species, and ensuring compliance with state, tribal, and federal hatchery operational and reporting guidelines and laws designed to minimize adverse effects on wild fish attached with hatchery operational practices.

**Risk aversion measures**

1. All weirs used to capture non-ESA-listed anadromous salmonid adults will be designed and operated with a primary intent of passing incidentally captured summer chum upstream with minimal harm or delay in migration. Handling of summer chum will be minimized to the extent feasible to meet this measure.
2. All weirs will be operated by individuals trained in proper and safe fish handling procedures that will be protective of any summer chum adults encountered.
3. All fish weirs where summer chum may be captured incidentally will be monitored continuously to ensure that captured fish are held under safe conditions, including maintenance of adequate flow in fish holding boxes and protection from poaching.
4. Summer chum captured incidentally in fish weir or broodstocking operations shall be held for no longer than 12 hours prior to release upstream to minimize delay in migration.
5. All fish weirs will be placed and removed in a manner that does not lead to adverse changes in summer chum spawning areas, spawning distributions, or to summer chum redds upstream or downstream of the weir location.
6. All fish weirs and hatchery operations, including annual fish removal, egg take, and juvenile production criteria set forth for the weir or hatchery in the Future Brood Document, should be consistent with the provisions of this plan..
7. All hatchery intakes and other structures shall be operated to prevent dewatering of adjacent spawning or migration areas that may be used by summer chum.
8. All hatchery intake and outfall screens shall be maintained to prevent harm to summer chum adults or juveniles.
9. All hatcheries producing over 20,000 pounds of fish production or applying more than 5,000 pounds of feed per calendar month shall be operated in accordance with NPDES permits issued to minimize adverse water quality effects resulting from hatchery effluent.

**Monitoring and Evaluation Programs**

1. All fish weir or trapping programs will record the daily number by species of salmonids captured, the disposition of all fish trapped (i.e. passed upstream, downstream, or removed as broodstock), and trap mortalities by species. These data will be provided to the WDFW Hatcheries Program weekly through the seasonal duration of trapping. Similar data for Tribal and Federal agency hatchery programs should also be provided.
2. Broodstock removal data by date, including number and sex of fish by species and estimated egg take will be reported to the WDFW Hatcheries Program weekly over the duration of the trapping season. Similar data for Tribal and Federal agency hatchery programs should also be provided.
3. To address hatchery effluent quality concerns, the release of harmful fish pathogens into downstream waters will be controlled by monitoring the fish health status of all salmonids reared in summer chum

watersheds, or destined for release into summer chum watersheds, on a regular basis by State, Tribal, or Federal agency fish health professionals.
4. Fish production data for each species released from regional hatcheries, including fish health certification data, release numbers, age class at release, size at release, date of release, and location of release will be reported to the WDFW Hatcheries Program during the month in which the release occurred. Similar data for Tribal and Federal agency hatchery programs should also be provided.
5. Data regarding hatchery effluent monitoring will be recorded and reported consistent with NPDES permits that may be required and issued for each hatchery operation.

## Predation

The following measures and programs are either species-specific or applicable to all artificial propagation operations. Risk aversion measures will be based on the concept that the risk of predation can be minimized by reducing the likelihood for interaction between hatchery fish and wild summer chum using spatial and temporal separation measures. Therefore, the size, timing, and location of hatchery salmonid releases are the factors subject to control through the risk aversion measures. Monitoring and evaluation measures are included to help address uncertainties regarding hatchery fish effects, and to ensure compliance with standing, required hatchery practice and reporting standards.

### Risk aversion measures

1. All steelhead, coho, and chinook smolt releases from regional hatcheries, truck-plants, or marine area net-pens will occur no earlier than April 15 to allow for the clearance of juvenile wild summer chum from freshwater and Hood Canal estuarine areas, minimizing the likelihood of interaction between the hatchery fish and summer chum. A maximum coefficient of variation in average smolt length of 10% shall be pursued to help ensure that the majority of fish meet target smolt size criteria, minimizing the likelihood for migration delay or residualization resulting from the release of undersize fish.
2. Releases of coho, chinook, or steelhead fry, fingerlings, or sub-yearlings into summer chum streams that are not part of a formal recovery program, and that will have a high likelihood of residualizing or being present as yearling fish in freshwater during the summer chum egression period, shall be avoided.
3. All salmonids released from regional hatcheries or transferred from out-of-watershed facilities for planting into summer chum streams will be volitionally-migrating smolts that are acclimated to the stream of release to reduce the risk of residualization, and straying as returning adults, respectively.
4. Hatchery fall chum and pink salmon (George Adams, McKernan, or Hoodsport lineage) fed and unfed fry populations should be released after April 1 each year to reduce the risk of predator attraction to summer chum fry in estuarine areas where they may aggregate with hatchery fish. Releases that are part of a formal recovery program are exempt from this measure.
5. Resident trout shall only be released into lakes, ponds, or stream sections within the HC-SJF summer chum region that are land-locked or have screened outlets, or where access to anadromous waters is unlikely.

### Monitoring and evaluation programs

1. Fish production data for each species released from regional hatcheries, including fish health certification data, release numbers, age class at release, size at release, date of release, and location of release will be reported to the WDFW Hatcheries Program during the month in which the release occurred. Similar data for Tribal and Federal agency hatchery programs should also be provided.
2. Yearling fish resulting from the planting of indigenous-origin, chinook, coho, and steelhead fry and fingerlings, or other resident fish, released into a summer chum stream as part of a formal recovery program shall be monitored to identify survival rates, distribution within the stream, and potential predation effects on wild summer chum.

## Competition and Behavioral Modification

The following measures and programs are either species-specific or applicable to all artificial propagation operations. Risk aversion measures will focus on application of timing and area of release criteria for hatchery juveniles, and return area and removal criteria for non-indigenous hatchery adults, to minimize adverse competition and behavioral modification effects that may result from the release and adult return of hatchery fish. Suggested monitoring and evaluation measures are directed towards collection of data to address uncertainties regarding the competitive and behavioral modification effects of a hatchery fish release program on summer chum productivity.

### Risk aversion measures

1. No fed fall chum salmon or Hoodsport Hatchery pink salmon fry will be released from individual hatcheries prior to April 1 each year to minimize the risk of food resource competition with emigrating summer chum fry in estuarine areas and to reduce the risk of adverse behavioral modifications, including changes in summer chum fry feeding behavior, predator avoidance, and preferred migration areas.
2. No unfed fall chum or pink salmon fry shall be released from all artificial production facilities prior to April 1 to reduce the risk of food resource competition from hatchery fish that may utilize the same estuarine realm as wild summer chum fry.
3. No Finch Creek lineage (George Adams, Hoodsport, or McKernan) fall chum or pink salmon fry shall be released into existing summer chum watersheds where there is no ability to remove 100% of returning spawners, or where it is not advisable to do so (i.e. where removal would impose further risks to summer chum by trapping fish), to reduce the risk of spawning ground space competition, redd superimposition, and behavioral modification posed by early-returning hatchery-origin adults, and to reduce the risk of genetic introgression by early-returning fall chum.
4. Unless part of a formal stock recovery program, no fall chinook salmon shall be released into eastside Hood Canal or Strait of Juan de Fuca summer chum streams in instances where there is no ability to capture 100% of adults upon freshwater return, or where it is not advisable to do so (i.e., where removal would impose further risks to summer chum by trapping fish). This provision is necessary to reduce the risk of spawning ground space competition, redd superimposition, and behavioral modification to summer chum.

5. Fall chinook, fall chum, and pink salmon released into streams with no existing summer chum populations shall be fully acclimated to the stream of release to minimize the risk of adult straying to summer chum streams.
6. Hatchery under-yearling chinook, fall chum, or pink salmon that are indigenous to a summer chum watershed and are part of a stock maintenance or formal recovery program shall be released after April 1 to minimize overlap with summer chum fry.
7. Net-pen fall chinook and coho salmon shall be acclimated to a freshwater or marine return location to minimize the risk of straying to summer chum streams.

**Monitoring and evaluation programs**

1. Fall chinook, fall chum, pink, and coho salmon originating from artificial propagation programs that are allowed to spawn naturally will be monitored to determine the location of spawning relative to summer chum streams or spawning areas and the effects of any spawning on summer chum spawning success and redd integrity.
2. All RSIs producing unfed fall chum and fall chinook fry for direct release will be monitored to determine the timing of emergence and number of fish emigrating from the incubators.
3. Smolts resulting from the planting of indigenous-origin, non-migrant chinook, coho, and steelhead fry and fingerlings released into a summer chum stream shall be monitored to identify survival rates, stream distribution, and to evaluate potential competitive effects on wild summer chum.

## Fish Disease Transfer

The following measures and programs are applicable to all artificial propagation operations. Proposed risk aversion and monitoring and evaluation measures are designed to ensure compliance with accepted fish health monitoring and management standards, and adherence to applicable NPDES permit conditions to protect downstream water quality.

**Risk aversion measures**

1. Hatchery broodstock and juvenile fish health will be monitored by a fish health professional during operation of broodstock capture and juvenile fish incubation and rearing programs.
2. Co-manager's of Washington Salmonid Disease Control procedures and WDFW Fish Transfer policy procedures will be followed for all hatchery practices, including broodstock capture, fish rearing and fish releases.
3. The condition and health of all anadromous salmonids reared by a facility will be certified by a fish health professional prior to release.
4. All fish shall be released in a healthy condition into regional waters.
5. The hatchery will be in compliance with permitted water rights, and with applicable NPDES permit conditions and best management practices.

**Monitoring and evaluation programs**

1. Hatchery broodstock and juvenile fish health will be monitored and evaluated by a fish health professional during operation of broodstock capture and rearing programs.

2. The fish health condition of hatchery fish over the duration of rearing and at release shall be reported to WDFW within one month after the time of release.

### Summary of Risk Aversion and Monitoring and Evaluation Measures Proposed to be Applied to Reduce Harm to Wild Summer Chum by Hatchery Program

Table 3.15 summarizes, by regional hatchery program, proposed risk aversion and monitoring and evaluation measures that will be applied to reduce the risk of harm to wild summer chum populations. As mentioned above, risk aversion and monitoring and evaluation measures are assigned to programs assessed as of "high" or "moderate" risk within a particular hazard category. In some instances where risks have been assessed as "low," monitoring and evaluation measures may be required, due to uncertainty of the effects on summer chum associated with a program or when a consistent, reliable avenue for receiving information regarding the project is viewed needed. If it is infeasible to adjust a program in accordance with these measures so that the risk of hazards to summer chum across hazard categories becomes "low," options including reduction in production levels or termination of the program shall be considered. In no instances shall a program be adjusted in a manner that reduces the risk of hazards in one category, while increasing the risk of adverse effects in another category.

Compliance with appropriate risk aversion and monitoring and evaluation measures shall be indicated in annual reports assembled for each program. Annual reports for regional hatchery production will be prepared by WDFW for WDFW-managed programs, the PNPT tribes for tribal programs, and by private and volunteer enhancement groups, with technical assistance from WDFW, for citizen-managed production programs.

**Table 3.15.** Summary of Risk Aversion (r. a.) and Monitoring and Evaluation (m&e) measures proposed to be applied to artificial propagation programs in the Hood Canal summer chum ESU.

| **Species** | | **Hazard Categories and Assigned Risk (criteria # from risk ranking within category applied)** | | | | |
|---|---|---|---|---|---|---|
| **Agency** | **Project** | **Release Class** | **Hatchery Operations** | **Predation** | **Competition and Behavioral Modification** | **Disease Transfer** |
| | ***Fall chinook*** | | | | | |
| WDFW | Hoodsport FH | Fingl. | — | — | — | — |
| | George Adams FH | Fingl. | — | — | — | — |
| | Sund Rocks Net-pens | Yearl. | — | — | r. a. #7; m&e#1 | — |
| **Skokomish Tribe** | Enetai | Fingl. | — | — | m&e#1 | — |
| **Port Gamble Tribe** | Little Boston | Fingl. | — | — | — | — |
| **Citizen Groups** | Union River | Fingl. | m&e #3-5 | m&e#1 | r. a. #4; m&e#1, 2 | r. a. #1-4; m&e 1, 2 |
| | Tahuya River | Fing. | m&e #3-5 | m&e#1 | r. a. #4; m&e#1, 2 | r. a. #1-4; m&e 1, 2 |
| | | Unfed Fry | m&e #3-5 | m&e#1 | r. a. #4; m&e#1, 2 | r. a. #1-4; m&e 1, 2 |
| | Dewatto River | Fingl. | m&e #3-5 | m&e#1 | r. a. #4; m&e#1, 2 | r. a. #1-4; m&e 1, 2 |
| | Big Beef Creek | Fingl. | m&e #3-5 | m&e#1 | r. a. #4; m&e#1 | r. a. #1-4; m&e 1, 2 |
| | Skokomish River | Yearl. | m&e #3-5 | m&e#1 | m&e#1 | m&e 1, 2 |
| | | Fingl. | m&e #3-5 | m&e#1 | m&e#1 | m&e 1, 2 |
| | Hamma Hamma River | Fingl. | r. a. #4, #6; m&e #1-5 | m&e#1 | m&e#1 | m&e 1, 2 |
| | Johnson Ck. (Duckabush) | Fingl. | m&e #3-5 | m&e#1 | m&e#1 | r. a. #1-4; m&e 1,2 |
| | Unnamed tribs. | Unfed Fry | m&e #3-5 | m&e#1 | m&e#1, 2 | r. a. #1-4; m&e 1,2 |
| | Pleasant Harbor Net-Pens | Yearl. | m&e #3-5 | m&e#1 | r. a. #7; m&e #1 | m&e 1, 2 |
| | HC Marina Net-Pens | Yearl. | m&e #3-5 | m&e#1 | r. a. #7; m&e #1 | m&e 1, 2 |
| | ***Chinook*** | | | | | |
| **WDFW** | Dungeness FH | Fry | — | m&e #2 | — | — |
| | | Fingl. | — | m&e #2 | — | — |
| | | Fingl. smolt. | — | — | — | — |

**Table 3.15.** Continued

| Species | | Hazard Categories and Assigned Risk (criteria # from risk ranking within category applied) | | | | |
|---|---|---|---|---|---|---|
| **Agency** | **Project** | **Release Class** | **Hatchery Operations** | **Predation** | **Competition and Behavioral Modification** | **Disease Transfer** |
| | ***Coho*** | | | | | |
| **WDFW** | Dungeness FH | Yearl. | — | — | — | — |
| | Pt. Gamble Net-pens | Yearl. | — | — | r. a. #7 | — |
| | Quilcene Net-pens | Yearl. | — | — | r. a. #7 | — |
| | George Adams FH | Yearl. | — | — | — | — |
| | Tarboo Ck. | Fingl. | — | — | — | — |
| | Snow Ck. | Unfed fry | — | m&e #2 | m&e #3 | — |
| | | Pre-smolts | — | m&e #2 | m&e #3 | — |
| **USFWS** | Quilcene NFH | Yearl. | — | — | — | — |
| | | Fing. | — | r. a. #2, 3 | — | — |
| | ***Pink*** | | | | | |
| **WDFW** | Hoodsport FH | Fed fry | — | r. a. #4 | r. a. #1, 2 | — |
| | Dungeness FH | Fed fry | r. a. #1-5 | — | r. a. #6 | — |
| | ***Fall Chum*** | | | | | |
| **WDFW** | Hoodsport FH | Fed fry | — | r. a. #4 | r. a. #1, 2 | — |
| | George Adams FH | Fed fry | — | — | — | — |
| | McKernan FH | Fed fry | — | r. a. #4 | r. a. #1, 2 | — |
| **Skokomish Tribe** | Enetai FH | Fed fry | — | — | — | — |
| **Pt. Gamble Tribe** | Pt. Gamble FH | Fed fry | — | — | — | — |
| **USFWS** | Quilcene NFH | Fed fry | — | — | — | — |

**Table 3.15.** Continued

| Species | | Hazard Categories and Assigned Risk (criteria # from risk ranking within category applied)[1] | | | | |
|---|---|---|---|---|---|---|
| **Agency** | **Project** | **Release Class** | **Hatchery Operations** | **Predation** | **Competition and Behavioral Modification** | **Disease Transfer** |
| | ***Fall chum - continued*** | | | | | |
| **Citizen Groups** | Mills Ck. | Unfed fry | m&e #3-5 | m&e #1 | r. a. #3; m&e #1, 2 | r. a. #1-4; m&e 1, 2 |
| | Tahuya R. | Unfed fry | m&e #3-5 | r. a. #4; m&e #1 | r. a. #3; m&e #1, 2 | r. a. #1-4; m&e 1, 2 |
| | Union R. | Unfed fry | m&e #3-5 | r. a. #4; m&e #1 | r. a. #2, 3; m&e #2 | r. a. #1-4; m&e 1, 2 |
| | L. Mission Ck. | Unfed fry | m&e #3-5 | m&e #1 | r. a. #2; m&e #2 | r. a. #1-4; m&e 1, 2 |
| | Skull Ck. | Unfed fry | m&e #3-5 | m&e #1 | r. a. #2; m&e #2 | r. a. #1-4; m&e 1, 2 |
| | Sweetwater Ck. | Unfed fry | m&e #3-5 | m&e #1 | r. a. #2; m&e #2 | r. a. #1-4; m&e 1, 2 |
| | Unnamed 14.0124 | Unfed fry | m&e #3-5 | m&e #1 | r. a. #2; m&e #2 | r. a. #1-4; m&e 1, 2 |
| | Chinom Pt. (Ck.) | Unfed fry | m&e #3-5 | m&e #1 | r. a. #2; m&e #2 | r. a. #1-4; m&e 1, 2 |
| | Unnamed 14.0136 | Unfed fry | m&e #3-5 | m&e #1 | r. a. #2; m&e #2 | r. a. #1-4; m&e 1, 2 |
| | Skokomish R. | Unfed fry | m&e #3-5 | r. a. #4; m&e #1 | r. a. #2; m&e #2 | r. a. #1-4; m&e 1, 2 |
| | Jump-off Joe Ck. | Unfed fry | m&e #3-5 | m&e #1 | r. a. #2; m&e #2 | r. a. #1-4; m&e 1, 2 |
| | ***Steelhead*** | | | | | |
| **WDFW** | Skokomish R. | Yearl. | — | r. a. #1-3 | — | — |
| | Dosewallips R. | Yearl. | — | r. a. #1-3 | — | — |
| | Duckabush R. | Yearl. | — | r. a. #1-3 | — | — |
| | Dungeness FH | Yearl. | — | r. a. #1-3 | — | — |
| **Citizen Groups** | Hamma Hamma R. | 2+ Yearl. | r. a. #4, #6; m&e #1-5 | r. a. #1-3; m&e #1 | m&e #3 | m&e #1, 2 |

[1] Risk aversion ("r.a.") and monitoring and evaluation ("m&e") measures indicated as required for each project are keyed by number to measures described in the preceding text under each hazard.

## Hatchery Program Effects on Individual Hood Canal and Strait of Juan de Fuca Summer Chum Populations and Measures Applied to Minimize the Risk of Adverse Effects

This section summarizes potential hatchery operation and fish release impacts to individual summer chum populations within the region, and risk aversion and monitoring and evaluation measures that will be applied to help address or alleviate the risk of those impacts. The list of summer chum populations included in this summary was taken from Table 1.12 of the overall summer chum conservation plan. Included are existing stocks, populations in the process of being reintroduced, and populations that were recently extirpated from watersheds that were major summer chum producers and have been identified for reintroduction programs in the near future.

The intent of this section is to indicate how specific hatchery programs may affect individual summer chum populations, both as adult and juvenile fish. The intent is also to specify those measures proposed to reduce the risk of harm to the each population, and to discuss why and how those measures will be applied. As stated previously, risk aversion measures are proposed for application in instances where risks of hazards are "high" or "moderate". Programs assessed as having a "high" and "moderate" risk of negative impact will be modified through application of these measures, as appropriate, so that the risk of adverse effects on wild summer chum becomes "low." Monitoring and evaluation measures are proposed when risks are "high" or "moderate," or where further information is needed in order to assess the effects of a program on summer chum. Requirements for monitoring and evaluation will allow for the adaptive management of programs, if needed, as new information regarding the occurrence and effects of each hazard is gathered.

There may be some instances where risk aversion measures proposed to address one hazard create a conflict by increasing risk of another hazard. Therefore, in some cases, a further assessment and judgement of risks and of the applicability and implementability of aversion measures will be presented. Risk minimization measures actually applied to hatchery operations or release practices may be adjusted based upon this assessment.

### Union

*Adult hatchery salmonid effects* - Hazards to Union River summer chum include a "high" risk of adverse competitive and behavioral modification effects resulting from interactions on the spawning ground with hatchery-origin fall chinook and fall chum adults. Adult fall chinook originating from volunteer enhancement group releases into the river, or from Hood Canal regional net-pen operations, that escape into summer chum spawning areas may compete for spawning sites and adversely affect summer chum productivity through redd superimposition. Redd superimposition concerns also apply for on-station or WDFW hatchery-origin Finch Creek lineage fall chum that return earlier in the season than indigenous fall chum. The risk of these hazards is exacerbated by the constrained spawning area available in the river due to low late summer-early fall stream flows and the relatively small size of the stream channel.

*Juvenile hatchery salmonid effects* - Moderate to high risks of adverse competitive and behavioral modification hazards have been assigned for hatchery fall chum and pink fry releases from on-station (fall chum) and WDFW southwest Hood Canal programs (fall chum and pink salmon). These risks are associated with competition for potentially limiting food resources, and behavioral changes effected by the releases that may adversely alter summer chum foraging success, posed by fall chum released into the river and/or estuary, and by pink salmon fry released from Hoodsport Hatchery, during the summer chum emigration period. Enhanced risks of predator attraction potentially caused by on-station fall chum liberations are of concern, as is the potential for disease transfer from Union River-based hatchery programs.

*Proposed risk aversion strategies* - Measures proposed to decrease the risk of adverse competitive and behavioral modification effects that may be caused by spawning hatchery-origin fall chinook and fall chum adults include cessation of on-station releases of stocks not a part of a formal recovery program. The existing hatchery fall chinook and fall chum projects on the Union River are therefore candidates for termination. Fall chinook released from Hood Canal marine area net-pen operations shall be imprinted so there is a high likelihood for their return as adults to Hoodsport or George Adams Hatchery. The intent of this measure is to minimize the risk of straying to summer chum streams, including the Union River. An alternative to acclimation, if not feasible, is elimination of the net-pen program. The above measures will be linked with monitoring and evaluation requirements to determine the location of spawning of hatchery fall chinook and fall chum escaping into the Union River, and the effects of any spawning on summer chum productivity. The results of monitoring and evaluation may be used to help determine the actual risks of hazards to summer chum spawners attached with non-indigenous fall chinook and fall chum escapement.

The risk of competition and behavioral modification hazards associated with hatchery juvenile fall chum interactions will be minimized by requiring that all fall chum and pink salmon fry releases in Hood Canal be made after April 1. This measure should minimize the likelihood for interactions with emigrating summer chum, allowing clearance of the majority of the fish from Hood Canal. Risks associated with fish disease transfer from hatchery-origin fish can be minimized through compliance with co-manager fish health monitoring and pre-release certification procedures.

*Discussion* - Union River summer chum have been judged to be at “moderate” risk of extinction (Table 1.12). If the current Union River fall chinook and fall chum programs are not considered formal recovery programs, further releases of these fish into the Union River will no longer be allowed. Measures to control releases from marine net-pen operations will be necessary to minimize risks to summer chum posed by fall chinook straying. A delay in hatchery fall chum and pink fry releases into Hood Canal marine waters until after April 1 will require changes in pond loading and fish production regimes at Hoodsport, McKernan, and George Adams hatcheries to maintain safe fish rearing densities. These changes may lead to reduced annual production levels of certain species at these hatcheries, potentially including pink salmon, yearling fall chinook, and fall chum salmon.

### Lilliwaup

*Adult hatchery salmonid effects* -Summer chum that are part of the regional recovery program are the only hatchery salmonids intentionally released into Lilliwaup River through the programmed hatchery operation. Any adverse competition or behavioral modification effects that may impact summer chum spawners would therefore originate from fall chinook or pink salmon that may stray into the watershed from Hood Canal marine area net-pen and other chinook hatchery projects, or from Hoodsport Hatchery, respectively. Adult chinook and pink salmon that escape into summer chum spawning areas may compete for spawning sites and adversely affect summer chum productivity through redd superimposition. These hazards are assessed as posing a "moderate" risk to summer chum. The risk of these hazards is exacerbated by the low available spawning area accessible to spawners below Lilliwaup Falls (~0.7 miles), low late summer-early fall stream flows, and the relatively small size of the stream channel. These factors act to limit the availability of spawning sites, and increase the risk of adverse competition and behavioral effects to summer chum spawners.

*Juvenile hatchery salmonid effects* - High risks of adverse competitive and behavioral modification hazards have been assigned for hatchery fall chum and pink salmon releases mainly from WDFW southwest Hood Canal programs. Neither of these species are released through the Lilliwaup Hatchery program. High risk levels were assigned based on potential competition for potentially limiting food resources posed by fall chum and pink salmon fry released into the estuary during the summer chum emigration period, and behavioral changes effected by the releases that may adversely alter summer chum foraging success.

*Proposed risk aversion strategies* - Measures proposed to minimize the risk of adverse competitive and behavioral modification effects that result from spawning in Lilliwaup River by straying hatchery-origin fall chinook and pink salmon adults may include removal of stray fish at the Lilliwaup weir, which is operated primarily to collect summer chum. Fall chinook released from Hood Canal marine area net-pen operations shall be imprinted so there is a high likelihood for their return as adults to Hoodsport or George Adams hatcheries. Pink salmon that are progeny of returning Finch Creek spawners, and that are reared and released from Hoodsport Hatchery, likely have a high fidelity to the Finch Creek, and straying risks should be minimal. The above measures will be linked with monitoring and evaluation requirements to determine the location of spawning of hatchery fall chinook and pink salmon escaping into Lilliwaup River, and the effects of any spawning on summer chum productivity. The results of monitoring and evaluation may be used to help determine the actual risks of hazards to summer chum spawners attached with non-indigenous fall chinook and pink salmon escapement. An alternative to acclimation, if not effective, is elimination of the net-pen program.

The risk of competition and behavioral modification hazards to summer chum fry will be minimized by requiring that all hatchery fall chum and pink salmon fry releases be made after April 1. This measure should minimize the likelihood for interactions with emigrating Lilliwaup summer chum in the estuary, allowing clearance of the majority of the fish from Hood Canal prior to release of the hatchery fish. It should also enhance acclimation and fidelity of returning adult fish to the hatcheries. Risks associated with fish disease transfer from hatchery-origin fish can be minimized through compliance with co-manager fish health monitoring and pre-release certification procedures.

*Discussion* - The need to minimize risks to Lilliwaup summer chum is heightened by an assessed "high" extinction risk status of the population (status designation from Table 1.12). As noted above, a weir on

Lilliwaup River directed at summer chum broodstock collection can be used to remove nearly all straying fall chinook and pink salmon adults to minimize risks to summer chum spawners. A determination should be made whether pink salmon observed on odd years are Hoodsport Hatchery strays or an indigenous stock before any decision regarding their removal is made. A delay in fall chum and pink fry releases until after April 1 may require changes in pond loading and fish production regimes at Hoodsport, McKernan, and George Adams hatcheries to maintain safe fish rearing densities. These changes could lead to reduced annual production levels of certain species at these hatcheries, potentially including pink salmon, yearling fall chinook, and fall chum salmon.

### Hamma Hamma

*Adult hatchery salmonid effects* - The potential need to conduct broodstocking operations for co-operative programs directed at fall chinook as part of a formal recovery program may pose a "moderate" risk to summer chum adults. The potential effects on summer chum resulting from trapping or capturing chinook were used to assign this risk rating. Adverse competition or behavioral modification effects that may impact summer chum spawners might originate from on-station fall chinook releases, or from fall chinook that may stray into the watershed from WDFW co-operative marine area net-pen projects. The Hamma Hamma River has an indigenous pink salmon population that is considered to be co-adapted with summer chum. The presence of pinks on the spawning grounds, regardless of origin, is therefore not considered to be a risk factor to summer chum. The Hamma Hamma River has a relatively large amount of spawning area, and interactions between summer chum and fall chinook are not expected to adversely affect summer chum productivity. The risks of spawning gravel competition and redd superimposition hazards posed by on-station origin (and straying) fall chinook have therefore been assessed as "low."

*Juvenile hatchery salmonid effects* - "High" risks of adverse competitive and behavioral modification hazards have been assigned for hatchery fall chum and pink salmon releases mainly from WDFW southwest Hood Canal programs. Neither of these species are released through the Hamma Hamma Hatchery program. High risk levels were assigned based on possible competition for potentially limiting food resources posed by fall chum and pink salmon fry released into the estuary during the summer chum emigration period, and behavioral changes effected by the releases that may adversely alter summer chum foraging success. Risks of predator attraction potentially caused by hatchery fall chum and pink liberations are judged "low" because of the geographical distance between the Hamma Hamma River and the nearest hatchery fall chum and pink release site.

*Proposed risk aversion strategies* - Measures proposed to minimize the risk of adverse competitive and behavioral modification effects that may result from spawning in the Hamma Hamma River by straying marine area net-pen-origin fall chinook include acclimation of fall chinook released from Hood Canal marine area net-pen operations to minimize the risk of straying. This measure will be linked with monitoring and evaluation requirements to determine the location of spawning of hatchery fall chinook escaping into Hamma Hamma River, and the effects of any spawning on summer chum productivity. The results of monitoring and evaluation may be used to help determine the actual risks of hazards to summer chum spawners attached with any stray, non-indigenous fall chinook escapement. An alternative to acclimation, if not feasible, is elimination of the net-pen program.

The risk of competition and behavioral modification hazards to summer chum fry will be minimized by requiring that all hatchery fall chum and pink salmon fry releases be made after April 1. This measure should minimize the likelihood for interactions with emigrating Hamma Hamma summer chum in the estuary, allowing clearance of the majority of the fish from Hood Canal. Risks associated with fish disease transfer from hatchery-origin fish can be minimized through compliance with co-manager fish health monitoring and pre-release certification procedures.

*Discussion* - The need to minimize risks to Hamma Hamma summer chum is heightened by an assessed "moderate" extinction risk status of the population (status designation from Table 1.12). A delay in fall chum and pink fry releases until after April 1 may require changes in pond loading and fish production regimes at Hoodsport, McKernan, and George Adams hatcheries to maintain safe fish rearing densities. These changes could lead to reduced annual production levels of certain species at these hatcheries, potentially including pink salmon, yearling fall chinook, and fall chum salmon.

### Duckabush

*Adult hatchery salmonid effects* - A modest fall chinook salmon enhancement program is the only source of on-station salmonid production in the watershed. The Duckabush River has an indigenous pink salmon population that is considered to be co-adapted with summer chum. The presence of pinks on the spawning grounds, regardless of origin, is therefore not considered to be a risk factor to summer chum. Potentially adverse competitive or behavioral modification effects to summer chum adults on the spawning grounds may result from homing hatchery-origin fall chinook. Adverse effects to summer chum spawners might also result from fall chinook that stray into the watershed from WDFW cooperative marine area net-pen projects. The Duckabush River has a relatively large amount of spawning area, and interactions between summer chum and fall chinook are not expected to adversely affect summer chum productivity. The risks of spawning gravel competition and redd superimposition hazards posed by straying fall chinook are therefore assessed as "low."

*Juvenile hatchery salmonid effects* - The volunteer group fall chinook program on Johnson Creek is judged to pose a "moderate" risk of disease transfer to summer chum, with a "low" risk of adverse effects assigned for other hazard categories. Steelhead that are truck-planted into the river are released as migrating smolts after the summer chum migration period and are judged to pose no significant threat to summer chum. "High" risks of adverse competitive and behavioral modification hazards have been assigned for hatchery fall chum and pink salmon releases mainly from WDFW southwest Hood Canal programs. "High" risk ratings were assigned based on possible competition for potentially limiting food resources posed by fall chum and pink salmon fry released into the estuary during the summer chum emigration period, and behavioral changes effected by the releases that may adversely alter summer chum foraging success. Risks of predator attraction potentially caused by hatchery fall chum and pink liberations are judged “low” because of the geographical distance between the Duckabush River and the nearest hatchery fall chum and pink release site.

*Proposed risk aversion strategies* - Measures proposed to minimize the risk of adverse competitive and behavioral modification effects that may result from spawning in the Duckabush River by straying marine area net-pen-origin fall chinook include acclimation of fall chinook released from Hood Canal marine area net-pen operations to minimize the risk of straying. This measure will be linked with monitoring and evaluation requirements to determine the location of spawning of stray hatchery fall chinook, and the effects of any spawning on summer chum productivity. The results of monitoring and evaluation may be used to help determine the actual risks of hazards to summer chum spawners attached with stray, non-indigenous fall chinook escapement. An alternative to acclimation, if not feasible, is elimination of the net-pen programs.

The risk of competition and behavioral modification hazards associated with hatchery juvenile fall chum interactions will be minimized by requiring that all fall chum and pink salmon fry releases be made after April 1. This measure should minimize the likelihood for interactions with emigrating Duckabush summer chum, allowing clearance of the majority of the fish from Hood Canal. Risks associated with fish disease transfer from hatchery-origin fish can be minimized through compliance with co-manager fish health monitoring and pre-release certification procedures.

*Discussion* - Duckabush River summer chum have been judged to be at “low” risk of extinction (status designation from Table 1.12). Risks to these summer chum may include disruption of spawning by homing and straying hatchery fall chinook adults, potential fish disease transfer from the Johnson Creek fall chinook program, and negative effects in the estuary that may result from southwest Hood Canal hatchery fall chum and pink salmon fry releases during the summer chum emigration period (pre-April 1 in the Canal). Risks associated with fall chinook competition and behavioral modification are assessed as “low” due to the relatively large size of the river, and the likelihood that interactions between summer chum and fall chinook adults will be minimal. The risk of fish disease transfer can be minimized through compliance with co-manager Salmonid Disease Control Policy procedures. A delay in fall chum and pink fry releases until after April 1 may require changes in pond loading and fish production regimes at Hoodsport, McKernan, and George Adams hatcheries to maintain safe fish rearing densities. These changes could lead to reduced annual production levels of certain species at these hatcheries, potentially including pink salmon, yearling fall chinook, and fall chum salmon.

### Dosewallips

*Adult hatchery salmonid effects* - No hatchery programs are located on the Dosewallips River. Any hatchery-induced, adverse competitive or behavioral modification effects to summer chum adults on the spawning grounds would be attributable only to straying fish. Adverse impacts to summer chum spawners might emanate from fall chinook that may stray into the watershed from WDFW co-operative marine area net-pen projects. Straying pink salmon from Hoodsport Hatchery were not considered a risk factor, as the Dosewallips River has an indigenous pink salmon population. The Dosewallips River has a relatively large amount of spawning area, and interactions between summer chum and fall chinook are not expected to adversely affect summer chum productivity. The risks of spawning gravel competition and redd superimposition hazards posed by straying fall chinook was therefore judged as "low."

*Juvenile hatchery salmonid effects* - "High" risks of adverse competitive and behavioral modification hazards have been assigned for hatchery fall chum and pink salmon releases mainly from WDFW southwest Hood Canal programs. High risk levels were assigned based on potential competition for potentially limiting food resources posed by fall chum and pink salmon fry released into the estuary during the summer chum emigration period, and behavioral changes effected by the releases that may adversely alter summer chum foraging success. Risks of predator attraction potentially caused by hatchery fall chum and pink liberations are judged "low" because of the geographical distance between the Dosewallips River and the nearest hatchery fall chum and pink release site.

*Proposed risk aversion strategies* - Measures proposed to minimize the risk of adverse competitive and behavioral modification effects that may result from spawning in the Dosewallips River by straying marine area net-pen-origin fall chinook include acclimation of fall chinook released from Hood Canal marine area net-pen operations to minimize the risk of straying. This measure will be linked with monitoring and evaluation requirements to determine the location of spawning of escaping hatchery fall chinook, and the effects of any spawning on summer chum productivity. The results of monitoring and evaluation may be used to help determine the actual risks of hazards to summer chum spawners attached with stray, non-indigenous fall chinook escapement. An alternative to acclimation, if not feasible, is elimination of the net-pen program.

The risk of competition and behavioral modification hazards associated with hatchery juvenile fall chum interactions will be minimized by requiring that all fall chum and pink salmon fry releases be made after April 1. This measure should minimize the likelihood for interactions with emigrating Dosewallips River summer chum, allowing clearance of the majority of the fish from Hood Canal.

*Discussion* - Dosewallips River summer chum have been judged to be at "low" risk of extinction (status designation from Table 1.12). No hatchery programs are located on the Dosewallips River, and risks to summer chum spawners are posed only by straying hatchery-origin adult fish. These risks are assessed as "low" due to the relatively large size of the river, and the likelihood that interactions between summer chum and fall chinook adults will be minimal. Potentially adverse competition and behavioral modification effects to summer chum fry can be minimized through a delay in fall chum and pink fry releases until after April 1. This delay in release timing may require changes in pond loading and fish production regimes at Hoodsport, McKernan, and George Adams hatcheries to maintain safe fish rearing densities. These changes could lead to reduced annual production levels of certain species at these hatcheries, potentially including pink salmon, yearling fall chinook, and fall chum salmon.

### Big and Little Quilcene

*Adult hatchery salmonid effects* - During the summer chum migration period, the Quilcene NFH weir is directed mainly at the capture of returning indigenous origin hatchery coho salmon. Some summer chum produced at the hatchery return to the weir during the same period as the early-returning coho, and the weir is now operated with summer chum as a primary concern and as part of the formal recovery program for the species. The focus on summer chum collection, and the location of the weir in the upper portion of the Big Quilcene River watershed (~R.M. 2.8) act to limit the significance of any impacts to summer chum survival and spawning distribution. The operation of the weir is therefore assessed as of "low" risk to summer chum.

Adverse competition or behavioral modification effects that may impact summer chum spawners might result from on-station coho salmon releases, and from coho returning to the Big Quilcene River from the Quilcene Bay net-pens. These coho are of early-run, indigenous stock origin, and some spawning ground resource partitioning between the coho and summer chum can be expected. The hatchery coho also have a tendency to migrate rapidly to the Quilcene Hatchery weir, rather than spawn in the lower river used by summer chum. The risks of spawning gravel competition and redd superimposition hazards posed by on-station origin and straying coho salmon in the Big Quilcene River have therefore been assessed as "low." Quilcene NFH and net-pen-origin coho salmon may stray into the Little Quilcene River. Although these coho may be similar to the native stock, increased coho escapement levels resulting from these strays may negatively impact summer chum. Adverse impacts to summer chum spawners might emanate from fall chinook straying into the watershed from WDFW co-operative marine area net-pen projects in the Canal. Straying pink salmon from Hoodsport Hatchery were not considered a risk factor, as the Big Quilcene River has an indigenous pink salmon population. The Big Quilcene River has a relatively large amount of spawning area, and interactions between summer chum and any fall chinook strays are not expected to adversely affect summer chum productivity. The risks of spawning gravel competition and redd superimposition hazards posed by straying fall chinook may therefore be assessed as "low".

*Juvenile hatchery salmonid effects* - Coho salmon smolts produced at Quilcene NFH and the Quilcene Bay net-pens are released after completion of the estimated summer chum emigration period in the Canal. Ecological risks to summer chum fry associated with these smolt releases have been assessed as "low." The Quilcene NFH program also produces coho fry for release upstream of the hatchery to seed a portion of the watershed not accessible to adult fish. These fry releases are judged to pose a "high" risk to summer chum productivity through potential predation when the fish rear to yearling size. "High" risks of adverse competitive and behavioral modification hazards to Quilcene summer chum have been assigned for hatchery fall chum and pink salmon releases mainly from WDFW southwest Hood Canal programs. These "high" ratings were assigned based on possible competition for potentially limiting food resources posed by fall chum and pink salmon fry released into the Hood Canal estuary during the summer chum emigration period, and behavioral changes effected by the releases that may adversely alter summer chum foraging success. Enhanced risks of predator attraction potentially caused by hatchery fall chum and pink liberations are judged as of "moderate" concern.

*Proposed risk aversion strategies* - Risks to Big and Little Quilcene summer chum posed by the Quilcene NFH and Quilcene Bay net-pen coho programs are judged to be low. No risk aversion measures are therefore proposed for these programs. The Quilcene NFH coho fingerling production program should be modified to release only volitionally migrating smolts that will not remain in the river to potentially prey on emigrating summer chum. The risk of adverse competitive and behavioral modification effects that may result from fall chinook spawning in the rivers by straying marine area net-pen-origin fish may be minimized through acclimation of fall chinook released from Hood Canal net-pen operations to minimize the tendency for straying. Monitoring and evaluation programs may be used to determine the location of spawning of hatchery coho salmon and any stray hatchery fall chinook, and the effects of any spawning on summer chum productivity. An alternative to acclimation, if not feasible, is elimination of net-pen programs releasing fall chinook in the region.

The risk of competition and behavioral modification hazards associated with hatchery juvenile fall chum interactions will be minimized by requiring that all fall chum and pink salmon fry releases be made after April 1. This measure should minimize the likelihood for interactions with emigrating Big and Little Quilcene summer chum, allowing clearance of the majority of the fish from Hood Canal.

*Discussion* - Although at “high” risk prior to the implementation of conservation programs in 1992, Quilcene summer chum are presently judged to be at “low” risk of extinction (status designation from Table 1.12). Ecological impact risks to summer chum adults and juveniles posed by the Quilcene NFH and Quilcene Bay net-pen coho programs are assessed as “low.” A delay in Hood Canal regional hatchery fall chum and pink fry releases until after April 1 to minimize competition and behavioral modification risks could require changes in pond loading and fish production regimes at Hoodsport, McKernan, and George Adams hatcheries to maintain safe fish rearing densities. These changes may lead to reduced annual production levels of certain species at these hatcheries, potentially including pink salmon, yearling fall chinook, and fall chum salmon.

### Snow/Salmon

*Adult hatchery salmonid effects* - Indigenous-stock coho salmon are trapped at the Snow Creek trap to effect a formal recovery program. This operation is unlikely to adversely affect summer chum that are incidentally encountered, due to the location of the weir upstream of the majority of known summer chum habitat and on-site staffing by WDFW Snow Creek Station personnel. A “low” risk rating is therefore assigned.

Summer chum that are part of a recovery program are the only hatchery salmonids released into Salmon Creek. Due to the lack of any hatchery operations producing other species near-by, no significant adverse competition or behavioral modification effects that may impact summer chum spawners are expected from straying fall chinook or pink salmon. The risk of hatchery operation and release impacts to summer chum in Salmon Creek is judged to be “low.”

*Juvenile hatchery salmonid effects* - Snow Creek is planted with coho salmon fingerlings and sub-yearlings each year to help rebuild the indigenous population. “High” to “moderate” risks of predation to summer chum were assigned to these two coho release programs, due to the planting of fry, fingerlings, and pre-smolts, and the likelihood for interaction with summer chum fry during the coho’s one to five months of rearing in the Snow Creek watershed . No hatchery salmonids other than summer chum are planted into

Salmon Creek. No competitive and behavioral modification risk levels have been assigned for hatchery fall chum and pink salmon releases from Strait of Juan de Fuca or Hood Canal programs in other watersheds due to the isolation of this population in Discovery Bay, and the distance of the stock from other hatchery operations.

*Proposed risk aversion strategies* - The broodstock collection weir on Snow Creek will be operated for the handling of summer chum as a primary objective. Risk aversion measures identified for the safe operation of a fish weir directed at other species on a summer chum stream will be applied. Coho juveniles released into Snow Creek watershed are an indigenous stock, and the program is designed to rebuild the SASSI "critical" wild population. Rather than applying further risk aversion measures to the coho program, the value of the coho program and summer chum protection is balanced by requiring monitoring and evaluation to identify coho survival rates, distribution during rearing in the watershed, and potential predation effects on summer chum.

*Discussion* - Although at "high" risk prior to the implementation of conservation programs in 1992, Snow/Salmon summer chum are presently judged to be at "low" risk of extinction (status designation from Table 1.12). The few summer chum adults that will be encountered through operation of the Snow Creek weir will be trapped, handled, and released in a manner that reduces the risk of negative effects. Ecological impact risks to Snow/Salmon summer chum juveniles posed by the Snow Creek coho program are assessed as "low," with appropriate monitoring and evaluation to evaluate potential coho salmon predation effects on summer chum.

### Jimmycomelately

*Adult hatchery salmonid effects* - No hatchery salmonids are released into Jimmycomelately Creek. Due to the lack of any hatchery operations producing other species near-by, no significant adverse competition or behavioral modification effects on summer chum spawners are expected from straying fall chinook or pink salmon. The risk of hatchery operation and release impacts to summer chum in Jimmycomelately Creek is judged to be "low."

*Juvenile hatchery salmonid effects* - No hatchery salmonids are planted into Jimmycomelately Creek. No competitive and behavioral modification risk levels have been assigned for hatchery fall chum and pink salmon releases from Strait of Juan de Fuca or Hood Canal programs in other watersheds due to the isolation of this population in Sequim Bay, and the distance of the stock from other hatchery operations.

*Proposed risk aversion strategies* - Given the lack of hatchery programs within the watershed, or in the general vicinity, no risk aversion measures to protect this population are proposed.

*Discussion* - The Jimmycomelately summer chum population is at "high" risk of extinction (status designation from Table 1.12). Although no adverse hatchery effects have been assigned to this population, any future consideration of hatchery production of other species within the Sequim Bay area should take into account the need to minimize risks to this population.

**Dungeness**

*Adult hatchery salmonid effects* - Broodstock capture operations in the lower river directed at pink salmon may lead to the incidental capture, handling and release of summer chum adults. Hatchery-origin chinook are also trapped at Dungeness Hatchery. The trapping operations are part of two formal recovery programs for the indigenous chinook and pink salmon populations. The location of the pink salmon trap in the lower river poses a "moderate" risk of adverse hatchery operational effects on the summer chum population. Chinook and pink salmon adults returning to the river from the recovery programs will overlap in spawning areas and timing with summer chum. The indigenous origin of the chinook and pink stocks, and the large amount of spawning area available to salmon returning to the river led to a "low" risk assessment for negative competition and behavioral modification effects to spawning summer chum and their redds. Coho salmon adults returning through the Dungeness Hatchery are not expected to pose a significant risk to summer chum due to their later return timing and use of upper watershed areas for spawning.

*Juvenile hatchery salmonid effects* - Chinook fry and fingerlings have the potential to remain in the Dungeness River for up to one year prior to migrating seaward. Because these fish are part of a formal recovery program, and due to the low proportion of these fish that adopt a yearling life history pattern, a "low" risk of predation effects to summer chum fry is assigned. Although the program is currently quite small, pink salmon fry liberated from Dungeness Hatchery during the summer chum emigration period may pose "high" risks of predator attraction effects. Coho salmon are released as smolts well after the summer chum emigration period and no significant adverse impacts to summer chum are anticipated. No competitive and behavioral modification risk ratings have been assigned for hatchery fall chum and pink salmon releases from Strait of Juan de Fuca or Hood Canal region programs in other watersheds due to the isolation of this population in the mid-Strait-Dungeness Bay area, and the distance of the stock from other hatchery operations.

*Proposed risk aversion strategies* - As described above, risk aversion measures are being applied for the operation of the pink salmon capture weir in the lower river and the Dungeness Hatchery weir. No risk aversion measures are proposed to address spawning ground separation between summer chum and propagated chinook and pink salmon populations. All three populations are the subject of formal recovery programs and are given equal weight in considering rebuilding priorities and allowable effects. To address potential chinook predation effects, monitoring and evaluation is proposed to identify chinook and pink salmon survival rates, distribution during rearing in the watershed, and predation effects on summer chum. A delay in release timing for pinks until after April 1 is not required at this time in recognition of the extremely depressed status of the pink salmon population. Given the lack of other hatchery programs in the general vicinity, no risk aversion measures to protect this summer chum population are proposed for hatchery strays nor potential competitors for food, space, or migration areas.

*Discussion* - The Dungeness summer chum population is of "special concern" with regards to extinction risk (status designation from Table 1.12). Monitoring and evaluation measures may be used to determine the risks of adverse ecological impacts to summer chum posed by the other formal recovery programs in the watershed.

### Finch

The summer chum population in Finch Creek was extirpated by the late 1960s, and current hatchery program effects on the population are nil. Some summer chum stray each year to Finch Creek, and these fish may help re-establish a return.

*Adult hatchery salmonid effects* - The Hoodsport Hatchery weir located at the mouth of the creek, and hatchery fall chinook, pink salmon, and fall chum returning during the summer chum migration period and allowed to spawn naturally above the weir may pose risks to the future establishment of a summer chum population in Finch Creek.

*Juvenile hatchery salmonid effects* - If and when a summer chum population is re-established in Finch Creek, the release of pink and fall chum salmon from Hoodsport Hatchery, and from other southwestern Hood Canal hatcheries during the summer chum emigration period, may pose moderate to high risks of adverse ecological effects, including predator attraction, food resource competition, and behavioral modification hazards.

*Proposed risk aversion strategies* - Finch Creek summer chum are judged to have been recently extirpated (Table 1.18), and no risk aversion measures are proposed to specifically address impacts to this population.

*Discussion* - Risk aversion and monitoring and evaluation measures may be developed in the future to reduce the risk of hatchery operation or fish impacts, if and when a summer chum population is re-established.

### Skokomish

The summer chum population in the Skokomish River is extirpated, and current hatchery program effects on the population are nil. The watershed has been identified as a candidate for summer chum reintroduction, and risks to the reintroduced population are therefore assessed herein.

*Adult hatchery salmonid effects* - George Adams and McKernan hatchery fall chinook and fall chum returning during the summer chum migration period and allowed to spawn naturally in the river may pose risks to the future establishment of a summer chum population through competition for spawning sites and redd superimposition. The large amount of accessible spawning area in the river reduces the likelihood for these impacts to be of major consequence to summer chum productivity however.

*Juvenile hatchery salmonid effects* - If and when a summer chum population is re-established in the Skokomish River, the release of pink and fall chum salmon from Hoodsport Hatchery, and from other southwestern Hood Canal hatcheries during the summer chum emigration period, may pose moderate to high risks of adverse ecological impacts, including predator attraction, food resource competition, and behavioral modification hazards.

*Proposed risk aversion strategies* - Skokomish summer chum are judged to have been recently extirpated (Table 1.18), and no risk aversion measures are proposed to specifically address impacts to this population.

*Discussion* - Risk aversion and monitoring and evaluation measures may be developed in the future to reduce the risk of hatchery operation or fish impacts, if and when a summer chum population is re-established.

### Tahuya

The summer chum population in the Tahuya River has been functionally extirpated (Table 1.18), and current hatchery program effects on the population are nil. However, the watershed has been identified as a candidate for summer chum reintroduction, and risks to the reintroduced population are therefore assessed.

*Adult hatchery salmonid effects* - Hazards to adult summer chum when reintroduced to the river include a "high" risk of adverse competitive and behavioral modification effects resulting from interactions on the spawning ground with hatchery-origin fall chinook and Finch Creek lineage fall chum adults. Adult fall chinook originating from volunteer enhancement group releases into the river that escape into summer chum spawning areas, or stray fish from regional WDFW cooperative marine area net-pen operations, may compete for spawning sites and adversely affect summer chum productivity through redd superimposition. Redd superimposition concerns also apply for on-station hatchery-origin fall chum that return earlier in the season than indigenous Tahuya River fall chum. The risk of these hazards is exacerbated by the constrained available spawning area afforded in the river due to low late summer-early fall stream flows and the relatively small size of the stream channel.

*Juvenile hatchery salmonid effects* - At such time that a summer chum population may be re-established in the Tahuya River, the release of pink and fall chum salmon during the summer chum emigration period from the major Hood Canal hatcheries, and cumulatively, from regional RSI operations, may pose "moderate" to "high" risks of adverse ecological impacts. These impacts include predator attraction, food resource competition, and behavioral modification hazards. Hatchery programs located in the Tahuya River watershed are judged to pose a "moderate" risk to summer chum through disease transfer as presently operated.

*Proposed risk aversion strategies* - Upon reintroduction of summer chum salmon to the Tahuya River, risk aversion and monitoring and evaluation measures will be proposed to minimize the risk of hazards to a re-established population. Measures to minimize the risk of interaction and deleterious competitive and behavioral modification effects posed by non-indigenous fall chinook and fall chum in summer chum spawning areas could include removal of all returning adults not considered part of a formal recovery program, or cessation of fall chinook and fall chum releases. Risk aversion measures will also be proposed to improve fish health monitoring and reporting to reduce the risk of fish disease transfer. The risk of competition and behavioral modification hazards associated with hatchery juvenile fall chum interactions will be minimized by requiring that all fall chum and pink salmon fry releases within the region be made after April 1. This measure should minimize the likelihood for interactions with any future emigrating Tahuya summer chum, allowing clearance of the majority of the fish from Hood Canal. Monitoring and evaluation is proposed to provide additional information regarding Tahuya River hatchery operations in the basin and to further reduce their potential operational, predation, competition, and disease transfer effects on summer chum salmon.

*Discussion* - Placement and operation of a fish weir in the Tahuya River to remove fall chinook and Finch Creek lineage fall chum may pose additional hazards to summer chum when re-established, including delay in migration, injury or mortality resulting from holding and handling, and increased susceptibility to predation or poaching. The fall chinook and fall chum programs are not part of a formal recovery program. To address risks to summer chum, it is recommended that these programs be eliminated. A delay in allowable fall chum and pink fry releases until after April 1 may require changes in pond loading and fish production regimes at Hoodsport, McKernan, and George Adams hatcheries to maintain safe fish rearing densities. These changes could lead to reduced annual production levels of certain species at these hatcheries, potentially including pink salmon, yearling fall chinook, and fall chum salmon.

### Dewatto

The summer chum population in the Dewatto River has been extirpated (Table 1.18), and current hatchery program effects on the population are nil. However, like the Tahuya, the watershed has been identified as a candidate for summer chum reintroduction within the next few years, and risks to the reintroduced population are therefore assessed here.

*Adult hatchery salmonid effects* - Hazards to adult summer chum when reintroduced to the river include a “high” risk of adverse competitive and behavioral modification effects resulting from interactions on the spawning ground with hatchery-origin fall chinook adults. Adult fall chinook that escape into summer chum spawning areas originating from volunteer enhancement group releases into the river, or as stray fish from regional WDFW cooperative marine area net-pen operations, may compete for spawning sites and adversely affect summer chum productivity through redd superimposition. The risk of these hazards is exacerbated by the constrained available spawning area afforded in the river due to low late summer-early fall stream flows and the relatively small size of the stream channel.

*Juvenile hatchery salmonid effects* - At such time as a summer chum population may be re-established in the Dewatto River, the release of pink and fall chum salmon during the summer chum emigration period from the major Hood Canal hatcheries, and cumulatively, from regional RSI operations, may pose “moderate” to “high” risks of adverse ecological impacts. These impacts may include predator attraction, food resource competition, and behavioral modification hazards. Hatchery programs located in the Dewatto River watershed are judged to pose a “moderate” risk to summer chum through disease transfer as presently operated.

*Proposed risk aversion strategies* - Upon reintroduction of summer chum salmon to the Dewatto River, risk aversion and monitoring and evaluation measures will be proposed to minimize the risk of hazards to a re-established population. Risk aversion measures to minimize the likelihood of interaction and deleterious competitive and behavioral modification effects posed by non-indigenous fall chinook salmon in summer chum spawning areas could include removal of all returning adults not considered part of a formal recovery program, or cessation of fall chinook releases. Risk aversion measures will also be proposed to improve fish health monitoring and reporting to reduce the risk of fish disease transfer. The risk of competition and behavioral modification hazards associated with hatchery juvenile fall chum interactions will be minimized by requiring that all fall chum and pink salmon fry releases within the region be made after April 1. This measure should minimize the likelihood for interactions with any future emigrating Dewatto summer chum, allowing clearance of the majority of the fish from Hood Canal. Monitoring and evaluation is proposed to provide additional information regarding Dewatto River hatchery operations in the basin and to further reduce their potential operational, predation, competition, and disease transfer effects on summer chum salmon.

*Discussion* - Placement and operation of a fish weir to remove fall chinook salmon adults may pose additional hazards to summer chum when re-established, including delay in migration, injury or mortality resulting from holding and handling, and increased susceptibility to predation or poaching. The fall chinook program is not part of a formal recovery program. To address risks to summer chum, it is recommended that this program be eliminated. A delay in allowable fall chum and pink fry releases until after April 1 may require changes in pond loading and fish production regimes at Hoodsport, McKernan, and George Adams hatcheries to maintain safe fish rearing densities. These changes could lead to reduced annual production levels of certain species at these hatcheries, potentially including pink salmon, yearling fall chinook, and fall chum salmon.

### Anderson

The summer chum population in Anderson Creek is extirpated (Table 1.18), and current hatchery program effects on the population are therefore now nil. There are no plans, at present, to reintroduce a population through the use of artificial propagation.

*Adult hatchery salmonid effects* - No hatchery salmonids are released into Anderson Creek. If and when a summer chum population becomes re-established, straying fall chinook adults originating from regional marine net-pen operations may pose risks of competitive and behavioral modification hazards on the spawning grounds.

*Juvenile hatchery salmonid effects* - If and when a summer chum population is re-established in Anderson Creek, the release of pink and fall chum salmon during the summer chum emigration period from the major Hood Canal hatcheries, and cumulatively, from regional RSI operations, may pose “moderate” to “high” risks of adverse ecological impacts, including predator attraction, food resource competition, and behavioral modification hazards.

*Proposed risk aversion strategies* - Anderson summer chum are extirpated, and no risk aversion measures are proposed to specifically address impacts to this population.

*Discussion* - Risk aversion and monitoring and evaluation measures may be developed in the future to reduce the risk of hatchery operation or fish impacts, if and when a summer chum population is re-established.

### Big Beef

The original summer chum population in Big Beef Creek was extirpated (Table 1.18), and current hatchery program effects on the population are presently nil. However, summer chum are in the process of being reintroduced into the watershed, and risks to the reintroduced population are therefore assessed.

*Adult hatchery salmonid effects* - The volunteer enhancement group hatchery program on Big Beef Creek produces non-indigenous fall chinook that are removed at an existing fish weir in the lower creek upon adult return. Separation from summer chum that are carefully passed upstream and allowed to spawn naturally in the creek or in the renovated artificial spawning channel will be afforded by this practice. The risk of adverse competitive and behavioral modification effects to newly introduced summer chum adults posed by the operation is judged to be “low,” pending continuation of 100% removal practices for returning fall chinook adults. The potential of negative effects on summer chum spawning success below the weir will be evaluated and if a problem is found to exist, the returning adult chinook will be removed or the program will be terminated.

*Juvenile hatchery salmonid effects* - Fall chinook sub-yearling releases are made into Big Beef Creek in June, well after the summer chum emigration period. Due to this separation, adverse effects to summer chum fry that may result from predation, competition, or behavioral modification are judged to be “low.” A “moderate” risk of adverse effects to summer chum juveniles was assigned for the risk of fish disease transfer, due to the need to rear fall chinook, monitor, and to report fish health conditions in accordance with co-manager Salmonid Disease Contol Policy standards. The release of pink and fall chum salmon during the summer chum emigration period from the major Hood Canal hatcheries, and cumulatively, from regional RSI operations, may pose “moderate” to “high” risks of adverse ecological impacts, including predator attraction, food resource competition, and behavioral modification hazards, to Big Beef summer chum.

*Proposed risk aversion strategies* - Risks associated with fish disease transfer from Big Beef Creek hatchery-origin fish can be minimized through application of risk aversion measures leading to compliance with co-manager fish health monitoring and pre-release certification procedures. Monitoring and evaluation measures may also be employed to determine the location of any spawning of hatchery fall chinook returning to Big Beef Creek (e.g., downstream of the weir), and the effects of any spawning on summer chum productivity. The results of monitoring and evaluation may be used to help determine the actual risks of hazards to summer chum spawners attached with the non-indigenous fall chinook production program.

The risk of competition and behavioral modification hazards associated with hatchery juvenile fall chum interactions will be minimized by requiring that all fall chum and pink salmon fry releases be made after April 1. This measure should minimize the likelihood for interactions with emigrating summer chum, allowing clearance of the majority of the fish from Hood Canal.

*Discussion* - Risks to reintroduced summer chum have been judged to be generally "low" for the present fall chinook sub-yearling program at Big Beef Creek. This assessment was based on the assumption that the Big Beef Creek weir will be properly operated to exclude all returning fall chinook from the spawning grounds, while preventing harm to commingled summer chum adults. The assumption that the weir would be operated with summer chum as the primary concern during the summer chum migration period was also made in assigning a "low" risk level for the program. Fish disease transfer concerns can be addressed through compliance with the co-manager's Salmonid Disease Control Policy standards and practices. Potential interactions of chinook and summer chum spawners downstream of the weir will be evaluated and appropriate action will be taken to eliminate any negative impact on summer chum including, if necessary, termination of the chinook program.

### Chimacum

The indigenous summer chum population in Chimacum Creek was extirpated (Table 1.18), and current hatchery program effects on the population are therefore now nil. However, summer chum are in the process of being reintroduced into the watershed, and risks to the reintroduced population are therefore assessed here.

*Adult hatchery salmonid effects* - No hatchery salmonids are released into Chimacum Creek that may pose hatchery operational or ecological hazards to the reintroduced summer chum adult population. In addition, due to the lack of any hatchery operations producing other species near-by, no significant adverse competition or behavioral modification effects that may impact summer chum spawners are expected from straying fall chinook or pink salmon. The risks of adverse hatchery operation and release impacts to summer chum in Chimacum Creek are therefore judged to be "low."

*Juvenile hatchery salmonid effects* - No hatchery salmonids besides summer chum are planted into Chimacum Creek. No competitive and behavioral modification risk levels have been assigned for hatchery fall chum and pink salmon releases from Strait of Juan de Fuca or Hood Canal programs in other watersheds due to the isolation of this population in Port Townsend Bay, and the distance of the stock from other hatchery operations.

*Proposed risk aversion strategies* - Given the lack of hatchery programs within the watershed, or in the general vicinity, no risk aversion measures to protect this population are proposed.

*Discussion* - Summer chum have been recently reintroduced into Chimacum Creek. Although no adverse hatchery effects have been assigned to this population, any future consideration of hatchery production of other species within the Port Townsend Bay area should take into account the need to minimize risks to this population.

## Summary of Proposed Adjustments in Regional Salmonid Hatchery Production Programs to Minimize Adverse Ecological Effects on Summer Chum Salmon

As an outcome of the above assessment, certain fish production and operational practices applied through hatchery programs within the region are recommended for adjustment to minimize the risk of adverse impacts to summer chum. Fish production and hatchery operational practices for selected programs will also need to be monitored and evaluated to help determine hatchery-induced ecological impacts to summer chum, allowing for adjustments in the programs as needed consistent with an adaptive management approach. Adjustments in hatchery practices that will result from the implementation of risk aversion and monitoring and evaluation measures proposed herein are summarized below for each hatchery facility or program within the Hood Canal/SJF summer chum region.

### Washington Department of Fish and Wildlife Hatchery Programs

*Hoodsport Hatchery* - Pre-April 1 releases of fall chum and pink salmon fry at Hoodsport Hatchery have been judged to pose a high risk of adverse competition and behavioral modification impacts to emigrating summer chum. To reduce the risk level of this hazard, all releases of fall chum and pink salmon fry should be delayed until after April 1. Compliance with this measure will require adjustments in existing chum and pink growth and feeding rate regimes to meet this criterion for a later release date. Meeting this criterion may necessitate changes in total fish production programming levels at the hatchery, if safe pond loading densities can not be maintained, given available pond space and water for the two to three additional weeks of rearing that will be needed to hold pink fry and the earliest-spawned fall chum groups. If the hatchery is over-programmed as a result of this adjustment from a fish health and quality maintenance perspective, alternatives that should be investigated to meet this objective may include reduction of fall chum and pink salmon release size targets to reduce densities, or scaling back of fall chum, pink salmon, or yearling fall chinook production levels at the hatchery.

*Sund Rock Net-pens* - Yearling fall chinook salmon released from the net-pens may have an enhanced tendency to stray into summer chum streams upon adult return, potentially posing a high risk of adverse competitive or behavioral modification hazards to summer chum spawners. These hazards could include redd superimposition, competition for spawning gravel, and modification of summer chum spawning behavior through physical dominance. An enhanced level of acclimation to the parent hatchery responsible for producing the yearlings (e.g., Hoodsport Hatchery) may help maximize the number of in-migrating fall chinook adults that home to the hatchery rather than stray to other streams. It is uncertain what measures can be applied to further induce homing to Hoodsport Hatchery, given the low amount of attraction water available to fall chinook at the hatchery during the adult migration period. An alternative would be to produce the yearlings destined for transfer to the net-pens at George Adams Hatchery, which, due to its more terminal location near the Skokomish River and higher flow levels, may provide an enhanced attraction location for returning fall chinook adults. Monitoring and evaluation is also recommended to determine the level of net-pen origin fall chinook straying to summer chum streams, and the effects of any straying on summer chum spawning success. Implementation of these monitoring and evaluation measures will require increased funding to pay for staff time necessary to investigate straying levels and impacts. The option of terminating the program may also be considered.

*George Adams Hatchery* - George Adams Hatchery is located on Purdy Creek, which does not harbor a summer chum population. The species and classes produced under the current program, including sub-yearling smolt fall chinook, yearling coho smolts, and Finch Creek stock fall chum fry, have a low risk of interaction with summer chum as juveniles and adults. The program has been judged to have a low risk of adverse effects on Hood Canal summer chum. As presently operated and programmed, no changes in fish production or hatchery operational practices are proposed through this assessment for George Adams Hatchery.

*McKernan Hatchery* - Pre-April 1 releases of fall chum fry at McKernan Hatchery have been judged to pose a high risk of adverse competition and behavioral modification impacts to emigrating summer chum. To reduce the risk level of this hazard, all releases of fall chum fry should be delayed until after April 1. Compliance with this measure will require adjustments in existing fall chum growth and feeding rate regimes to meet target fish size at release criteria for a later release date. Meeting this criteria may necessitate changes in total fall chum production programming levels at the hatchery, if safe pond loading densities can not be maintained, given available pond space and water for the two to three additional weeks of rearing that will be needed to hold and rear fall chum. If the hatchery is over-programmed as a result of this adjustment from a fish health and quality maintenance perspective, alternatives that should be investigated to meet this objective may include reduction of fall chum fry release size targets to reduce densities, or scaling back of fall chum fry production levels at the hatchery.

*Eells Springs - Hood Canal Steelhead Truck-plant Program -* Steelhead truck-planted into Hood Canal region summer chum streams, including the Dosewallips, Duckabush, and Skokomish rivers, must continue to be liberated after April 15 to maintain a low risk of direct predation impacts on emigrating summer chum fry. In addition, pond management criteria should be employed to ensure that only volitionally migrating smolts are planted at a uniform fish length that helps ensure that the majority of fish migrate seaward rapidly at the time of release.

*Snow Creek Coho Salmon Recovery Program* - Coho salmon fingerlings and sub-yearlings produced through the Snow Creek program are part of a supplementation-based formal recovery program for the native population, which is designated as “critical” in status under SASSI (WDF et al. 1993). The need for risk aversion measures that could be applied to help minimize potential direct predation risks to summer chum, including a delay in sub-yearling releases until after April 15, were weighed against the value of the program for recovery of the indigenous coho population. A balance between actions needed to foster the recovery of both species was struck by leaving the coho release program unaltered, but requiring that coho juveniles rearing in Snow Creek as a result of the supplementation program be monitored to identify survival rates and in-stream distribution, and to evaluate likely predation effects on summer chum.

Dungeness Fish Hatchery - Chinook salmon fry, fingerlings, and sub-yearlings produced through the Dungeness Hatchery program are part of a joint-agency, supplementation-based formal recovery program for the ESA-listed native population. The need for risk aversion measures that could be applied to help minimize potential direct predation risks to summer chum, including delays in chinook releases until after April 1 (sub-yearlings) or April 15 (yearling fish), were weighed against the value of the Dungeness program for recovery of the listed chinook population. A balance between actions needed to foster the recovery of both species was struck by leaving the chinook release program unaltered, but requiring that chinook juveniles and smolts rearing in the Dungeness River as a result of the supplementation program be monitored to identify survival rates and in-stream distribution, and to evaluate likely predation effects on summer chum.

Pink salmon fry produced through the Dungeness program are part of a supplementation-based formal recovery program for the native fall population, which is designated as “critical” in status under SASSI (WDF et al. 1993). The need for risk aversion measures that could be applied to help minimize potential indirect predation, competition, and behavioral modification risks to summer chum were weighed against the value of the program for recovery of the indigenous pink population. A balance between actions needed to foster the recovery of both species was struck by requiring that pink salmon fry releases be made after April 1, and that fall pink salmon adults returning to spawn as a result of the supplementation program be monitored to determine the location of spawning relative to summer chum, and to evaluate the potential effects on summer chum spawning success and redd integrity.

Yearling coho salmon produced for fisheries enhancement purposes are from indigenous stock, released as yearling smolts after the estimated summer chum emigration period. Adult fish returning to the river have a tendency to return directly to the hatchery release site, segregating the fish from summer chum spawning areas. Temporal separation from summer chum fry afforded by the mid-late spring release timing for these fish minimizes the risk of interaction and predation by larger coho smolts. The coho program, as presently practiced, is viewed as a “low” risk to summer chum productivity.

Steelhead acclimated and liberated into the Dungeness River must continue to be released after April 15 to maintain a low risk of direct predation impacts on emigrating summer chum fry. In addition, pond management criteria should be employed to ensure that only volitionally migrating smolts are planted at a uniform fish length that helps ensure that the majority of fish migrate seaward rapidly at the time of release.

## Tribal Hatchery Programs

Enetai Hatchery - The Skokomish tribal hatchery is not located on a summer chum stream. “Late normal”-timed fed fall chum fry and fall chinook sub-yearling smolts have been released through the program. Fall chinook released from Enetai may stray to other watersheds upon adult return. The effects of this straying on summer chum salmon needs to be evaluated. The Wolcott Slough-stock fall chum program is judged to have a low risk of adverse ecological effects on summer chum. As presently operated and programmed, no changes in fish production or hatchery operational practices are proposed through this assessment for Enetai Hatchery, pending evaluation of fall chinook straying and potential effects.

*Quilcene Bay Net-pens* - QNFH stock delayed release coho salmon produced through the net-pen operation have a low likelihood for interaction with summer chum due to temporal separation afforded by a post-April 15 release schedule. The coho smolts are not present in the estuary during the summer chum fry emigration period. Returning adult coho are early-timed, and may interact with summer chum in the Big Quilcene River and Little Quilcene River when homing to the release area. Although some coho salmon are observed spawning each year in the lower Big Quilcene River, the tendency of the majority of Quilcene coho to proceed directly to the QNFH hatchery rack upon return limits the degree of interaction with predominantly downstream-spawning summer chum (L. Telles, USFWS, pers. comm. July, 1999). The ecological risks to summer chum in the Big Quilcene River posed by net-pen origin adult coho have therefore been judged to be low. Returning coho may enter the Little Quilcene River and may spawn within areas used by summer chum. The effects of net-pen-origin coho spawning on summer chum productivity in the Little Quilcene River needs to be evaluated. As presently operated and programmed, no changes in fish production or net-pen operational practices are proposed through this assessment for the Quilcene Bay net-pens. Operational changes may be proposed in future years pending evaluation of the effects of adult coho straying on Little Quilcene River summer chum. An alternative to acclimation to reduce straying, if proven detrimental to summer chum, is elimination of the net-pen program.

*Little Boston Hatchery* - The Port Gamble tribal hatchery is not located on a summer chum stream. The hatchery produces Finch Creek stock fed fall chum fry, which, given current production practices, are judged to have a low risk of adverse ecological effects on summer chum. As presently operated and programmed, no changes in fish production or hatchery operational practices are proposed through this assessment for the Little Boston Hatchery.

*Port Gamble Bay Net-pens* - QNFH stock delayed release coho salmon produced through the net-pen operation have a low likelihood for interaction with summer chum as juveniles due to the late time of coho release relative to the summer chum fry emigration period. Returning adult coho are early-timed, entering freshwater at approximately the same time as summer chum. The coho therefore could interact with summer chum if the coho stray into summer chum streams. However, since the coho release site is relatively far removed from summer chum streams and coho tend to spawn further upstream than summer chum, the ecological risks to summer chum posed by Port Gamble net-pen origin adult coho have been judged to be low. As presently operated and programmed, no changes in fish production or net-pen operational practices are proposed through this assessment for the Port Gamble Bay net-pens.

### USFWS Hatchery Programs

*Quilcene National Fish Hatchery* - Indigenous stock coho and fall chum salmon are released as yearling smolts and fed fry, respectively, each year through this hatchery program. Both species have a low likelihood for interaction with summer chum as juveniles due to the late time of coho and fall chum releases (late April through May) relative to the March summer chum fry emigration period. Returning adult coho are early-timed, and may interact with summer chum in the Big Quilcene River when homing to the hatchery. The tendency of the coho to proceed directly to the hatchery rack upon return limits the degree of interaction with predominantly downstream-spawning summer chum in the Big Quilcene River (L. Telles, USFWS, pers. comm. July, 1999). The ecological risks to summer chum posed by adult coho have therefore been judged to be low. Hatchery-origin fall chum adults return two months later than the summer chum native to the Quilcene River, and are not expected to adversely effect summer chum productivity through interaction on the spawning grounds. As presently operated and programmed, no changes in fish production or hatchery operational practices are proposed for the QNFH.

## Citizen Group Hatchery Programs

*Lilliwaup Hatchery* - The Long Live The Kings' hatchery on the Lilliwaup River is operated with the primary purpose of supplementing the indigenous summer chum population. Due to the poor status of summer chum returns, as an emergency measure, all summer chum spawners are currently being removed from the river for propagation in the supplementation program. A research program to assess the survival of progeny of captive brood coho salmon is currently in progress. These fish were released as smolts for one year only. With the exception of this modest research project, no other salmon species are intentionally released into the Lilliwaup River through the program. Fall chinook salmon reared at Lilliwaup, and transferred to the Skokomish River area for rearing and release may have an enhanced tendency to stray back to the Lilliwaup River. Fall chinook adult returns to the Lilliwaup River will be monitored to determine if straying from program releases is a legitimate risk factor. Given that most if not all summer chum adults are being used to supplement the population, and pending the results of the above monitoring, no changes in fish production or hatchery operational practices are proposed at this time for the Lilliwaup Hatchery. However, as a future management measure, straying adult chinook salmon will be removed upon return when summer chum are allowed to spawn naturally in the Lilliwaup River.

*Hamma Hamma Program* - The Hamma Hamma artificial production program is designed to rebuild indigenous salmonid populations, including summer chum, through supplementation. Hazards to summer chum that have been identified in association with the production of other species through the program include methods used to collect broodstock (in particular, the potential for installation of a weir) and potential predation by steelhead smolts. Chinook salmon produced through the program as sub-yearling smolts are not expected to adversely effect summer chum as adults returning during the same period as summer chum, due to the relatively large amount of available spawning area in the river, or as juveniles, due to the late time of hatchery chinook release (June release strategy) relative to the summer chum emigration period. Steelhead produced as age 2 smolts should be released into the Hamma Hamma River after April 15 to minimize the risk of predation to egressing summer chum fry. Collection of chinook and steelhead broodstock for the program should be conducted in a manner that minimizes adverse effects to summer chum adults and redds. Placement of a weir in the river to collect broodstock, if proposed, may pose additional hazards to summer chum, including migration delay, injury during trap holding and handling, and increased susceptibility to predation. If a weir is selected for use in the future, the weir should be operated for summer chum management/protection as the primary purpose.

*Union River Fall Chinook and Fall Chum Programs* - Non-indigenous-origin fall chinook adults produced through this program are judged to pose a high risk of adverse competitive and behavioral modification impacts upon return to summer chum spawners. These fall chinook adults have been observed to enter the Union River at the same time as summer chum, and due to the low flows available in September and early October, the two species have been observed to use the same spawning areas in the lower river (spawning ground survey information for R.M. 0 - 2.1 from R. Egan, WDFW, pers. comm., July 1999). The presence of spawning fall chinook in summer chum spawning areas enhances risks of spawning gravel competition and redd superimposition to summer chum. Early-returning Finch Creek lineage fall chum adults produced pose similar spawning ground competition and redd superimposition risks to summer chum spawners. Placement of a weir in the river to remove returning fall chinook and fall chum would pose additional hazards to summer chum, including migration delay, injury during trap holding and handling, and increased susceptibility to predation. If the current Union River fall chinook and fall chum programs are not considered formal recovery programs, further releases of these fish into the Union River will no longer be allowed.

*Skokomish River ("Old Hatchery Inn")* - Currently there is no self-sustaining population of summer chum in the Skokomish River, and there are therefore no impacts of the fall chinook sub-yearling and yearling release program on summer chum. If summer chum are reintroduced into the Skokomish in future years, the fall chinook program as currently operated is still judged to pose a low risk of adverse effects. Fall chinook adults returning to the river as a result of the program are not expected to adversely affect summer chum on the spawning grounds due to the large amount of available spawning area in the Skokomish River watershed, which should afford a large amount of separation between the two species. The current release timings for the two fall chinook age classes separate the hatchery fish from March-emigrating summer chum fry, making predation and competition unlikely. As presently operated, no changes in fish production or hatchery operational practices are proposed for this program.

*Tahuya River Fall Chinook and Fall Chum Programs* - Summer chum were functionally extirpated in the Tahuya River, and the effects of the non-indigenous fall chinook sub-yearling and fall chum fry production programs on summer chum are presently nil. However, the Tahuya River has been identified as a candidate for reintroduction of summer chum, and the effects of the present hatchery program have therefore been evaluated in light of potential reintroduction.

Non-indigenous-origin fall chinook adults produced through this program are judged to pose a high risk of adverse competitive and behavioral modification impacts upon return to summer chum spawners. Fall chinook adults enter freshwater at the same time as summer chum, and due to the low flows available in the Tahuya River in September and early October, the two species will be confined to the same spawning areas in the lower river. This interaction enhances risks of spawning gravel competition and redd superimposition to summer chum. Early-returning Finch Creek lineage fall chum adults produced through the program pose similar spawning ground competition and redd superimposition risks to summer chum spawners. Placement of a weir in the river to remove returning fall chinook and fall chum, if proposed, may pose additional hazards to summer chum, including migration delay, injury during trap holding and handling, and increased susceptibility to predation. If the current fall chinook and fall chum programs are not considered formal recovery programs, further releases of these fish into the Tahuya River will no longer be allowed.

*Dewatto River Fall Chinook Program* - Summer chum have been extirpated in the Dewatto River, and the effects of the non-indigenous fall chinook sub-yearling and fall chum fry production programs on summer chum are presently nil. Like the Tahuya River, the Dewatto has been identified as a candidate for reintroduction of summer chum within the next four years. The effects of the present hatchery program have therefore been evaluated in light of this planned reintroduction.

Non-indigenous-origin fall chinook adults produced through this program are judged to pose a high risk of adverse competitive and behavioral modification impacts upon return to summer chum spawners. Fall chinook adults enter freshwater to spawn at the same time as summer chum. The relatively small channel width and low flows available in the Dewatto River in September and early October will confine the two species to the same spawning areas in the lower river. Risks of spawning gravel competition and redd superimposition to summer chum are enhanced by these factors. Placement of a weir in the river to remove returning fall chinook and fall chum, if proposed, may pose additional hazards to summer chum, including migration delay, injury during trap holding and handling, and increased susceptibility to predation. In view of the likely adverse effects resulting from the presence of fall chinook in summer chum spawning areas, if the current fall chinook program is not considered a formal recovery program, further releases of these fish into the Dewatto River will no longer be allowed.

*Big Beef Creek Program* - Summer chum are in the process of being re-introduced to Big Beef Creek, and the present fall chinook hatchery program used for fisheries enhancement was evaluated assuming the presence of a summer chum population. Risks to summer chum posed by the fall chinook sub-yearling program were judged to be low as presently programmed and operated, with the exception of disease transfer hazards. This location currently hosts a variety of research oriented programs aimed at wild salmonid productivity assessment and ESA stock recovery, including Big Beef Creek wild coho and reintroduced summer chum. The existing weirs associated with these programs on lower Big Beef Creek allows for the removal of all returning adult fall chinook, preventing interactions with naturally spawning summer chum that could result in adverse competitive and behavioral modification effects. Fall chinook sub-yearlings are released in June, minimizing the likelihood for ecological interactions with March-migrating summer chum fry. The hatchery program does not presently follow co-manager fish health management guidelines. Fish health monitoring and certification practices presented in the co-manager policy will be applied to minimize the risk of disease transfer to summer chum.

*Pleasant Harbor Net-pens and Hood Canal Marina Net-pens* - Yearling fall chinook salmon released from the net-pens may have an enhanced tendency to stray into summer chum streams upon adult return, potentially posing a moderate risk of adverse competitive or behavioral modification hazards to summer chum spawners. These hazards could include redd superimposition, competition for spawning gravel, and modification of summer chum spawning behavior through physical dominance. An enhanced level of acclimation to the parent hatchery responsible for producing the yearlings (e.g., Hoodsport Hatchery) may help maximize the number of in-migrating fall chinook adults that home to the hatchery rather than stray to other streams. It is uncertain what measures can be applied to further induce homing to Hoodsport Hatchery, given the low amount of attraction water available to fall chinook at the hatchery during the adult migration period. An alternative would be to produce the yearlings destined for transfer to the net-pens at George Adams Hatchery, which, due to its more terminal location near the Skokomish River and higher flow levels, may provide an enhanced attraction location for returning fall chinook adults. Monitoring and evaluation is also recommended to determine the level of net-pen origin fall chinook straying to summer chum streams, and the effects of any straying on summer chum spawning success. Implementation of these monitoring and evaluation measures will require increased funding to pay for staff time necessary to investigate straying levels and impacts. The option of terminating these programs may also be considered, pending an evaluation of net-pen fall chinook straying to summer chum streams, and the effectiveness of measures implemented to reduce straying if proven to adversely affect summer chum.

Duckabush River (Johnson Creek) - The HCSEG fall chinook program in the Duckabush River watershed may pose risks to summer chum as a result of homing fall chinook adults and potential fish disease transfer. Risks associated with fall chinook competition and behavioral modification have been assessed as "low" due to the relatively large size of the river, and the likelihood that interactions between summer chum and fall chinook adults will be minimal. The risk of fish disease transfer can be minimized through compliance with co-manager Salmonid Disease Control Policy procedures. No other changes to this program are proposed through this assessment.

Miscellaneous Additional Hood Canal Region Projects - A number of programs in minor Hood Canal tributaries produce fall chinook fry and sub-yearlings, and fall chum fry. Only one of these programs is located on a summer chum stream - a very modest fall chum salmon educational project operated by the Hood Canal Elementary School on the Skokomish River. Although none of these other projects are located on a summer chum stream, they may pose elevated risks to summer chum after release in estuarine areas through predator attraction, competition, and behavioral modification. To reduce the risk of adverse predator attraction, competition and behavioral modification effects to emigrating summer chum fry, all fall chinook and fall chum produced in each program should be released no earlier than April 1. Disease transfer risks to summer chum have been judged "moderate" for the programs. Compliance with co-manager Salmonid Disease Control Policy guidelines and procedures will reduce the risk of disease transfer to summer chum to acceptable levels. Risks to summer chum may also be addressed by terminating projects.

### 3.3.2.2 Marine Mammals

#### Potential Risks

Certain marine mammal populations in Puget Sound have exhibited extraordinary increases in population abundance in recent decades. In particular, harbor seals (*Phoca vitulina*) and California sea lions (*Zalophus californianus*) have dramatically increased in number in marine waters of the state that serve as summer chum migration corridors and staging areas for spawning ground entry. The California sea lion population has been increasing at an annual rate of about 5% per year since the mid-1970s (NMFS

1997b). Two haul-out areas in Hood Canal are used by 10-50 sea lions from fall through spring, during the male sea lion residence period in Washington waters. Harbor seals are present year-round in the region, and their populations have been increasing in abundance at a rate of about 5-7% annually since the mid-1970s. Thirteen haul-out areas in Hood Canal are used by approximately 1,200 harbor seals year-round.

Both species are opportunistic feeders, with sea lions foraging on schooling fish and other prey that form dense aggregations and harbor seals preying on a wide variety of benthic and epibenthic fish and cehalopods (NMFS 1997b). Diets of the two pinniped species varies regionally, seasonally, and annually. Chum salmon have been documented as prey of pinnipeds in Washington. Adult salmonids are most vulnerable to pinniped predation during spawning migration through estuaries and river mouths, especially where salmonids concentrate or passage may be restricted.

NMFS (1997b) concluded that the presence of California sea lions and harbor seals in Pacific Northwest rivers and estuaries concurrent with migrations of depressed salmonid populations is a concern because pinniped predation can impact small runs of depressed salmonids. Predation by California sea lions and harbor seals may now constitute an additional factor in salmonid population decline and can affect recovery of depressed salmonid populations in some situations (NMFS 1997b). Summer chum adults returning to Discovery Bay tributaries are believed to be vulnerable to being impacted by pinniped predation, as are all Hood Canal summer chum populations (NMFS 1997b).

### Risk Minimization Measures

The impacts of pinniped predation on summer chum salmon requires further study. Summer chum are at high risk of predation because their early return timing relative to other salmonids, extended milling time in the estuary, entry into spawning grounds during low flow periods, and critically depressed abundance status enhance their vulnerability.

NMFS (1997b) reported that although substantial research is needed to fully address the issue, existing information on the seriously depleted status of many salmonid stocks is sufficient to warrant actions to remove pinnipeds in areas of co-occurrence where pinnipeds prey on depressed salmonid populations. Therefore, if predation on critical summer chum stock is identified as substantial, mitigative measures may be applied to control the predation, including institution of federally authorized pinniped removal programs.

# 3.4 Habitat

## 3.4.1 Introduction

Ample, high-quality habitat is critical to the recovery of wild, naturally-spawning summer chum populations in the Hood Canal and eastern Strait of Juan de Fuca region. To be effective, summer chum recovery efforts must consider the linked issues of habitat quality, life history diversity, and population resiliency. Summer chum in Hood Canal/SJF exhibit unique genetic, phenotypic, and behavioral diversity that has allowed them to survive and thrive in a fluctuating environment. At the southern terminus of the range of summer-run chum, these populations represent a unique and significant component of regional biological diversity worthy of full protection and recovery (Johnson et al. 1997). The distinctiveness of these populations is tied, at least in part, to the ecological setting of Hood Canal and eastern Strait of Juan de Fuca.

Summer chum populations rely on a complex of different habitat types, connected by seasonal migrations of different life stages. Spawning and egg incubation occur in freshwater, juveniles rear and find refuge in estuarine deltas and nearshore areas, while feeding and growth of subadults takes place in the open ocean. The timing of migrations between these different environments is closely tied to seasonal patterns of productivity, which summer chum populations have evolved to exploit. Adaptations of Hood Canal/SJF summer chum include early adult river entry, lower mainstem and intertidal spawning, small adult body size, high fecundity, and large egg size (relative to fall chum). Spatial and temporal variation in spawning, rearing, and migration (life history diversity) minimizes the impact of harmful factors and dampens extinction risk, conferring resiliency to whole populations. Individual watershed subpopulations or stocks also exhibit variation in life history strategies (e.g. adult freshwater entry timing) based on the range of physical characteristics in their natal watersheds. Regional differences in geology, climate, hydrology, landform, and estuarine conditions create potential for the evolution of different life history strategies within the Hood Canal/SJF region.

A major consequence of human land use over the last 150 years has been the degradation and fragmentation of these linked habitats. This has resulted in a contraction of expressed life history diversity that, in turn, has had consequences for summer chum population resiliency. Maintaining and rebuilding the full diversity of life history strategies is the dominant consideration in the design of the habitat portion of the summer chum recovery plan. Recovery efforts are focused on rehabilitating habitat conditions that will permit the full expression of diverse life histories. Our reasoning is that the spatial/temporal diversity of life histories expressed within a complex habitat structure is an important determinant of the health and adaptability of summer chum populations. Conversion of complex habitat to simplified, degraded conditions, or the complete loss of habitat can reduce life history diversity and compromise the natural occurrence and persistence of summer chum populations. Without this diversity, populations are unable to recover from natural variations in environmental conditions (e.g. drought, floods) or changes in environmental quality related to human activities (e.g. loss of riparian forests, dam or dike construction).

Our approach is to provide for the habitat requirements of each life stage (including adult migration, spawning, incubation and emergence, rearing, and juvenile migration) and for overall life history diversity to ensure the integrity and resilience of the entire region. The strategies outlined in the plan focus on protecting or restoring habitat conditions that appear to limit particular life stages. This approach utilizes the best available science currently available to define conditions necessary to sustain wild summer chum but it is intended to be updated as new information becomes available.

### Plan organization

The habitat section is organized around three primary habitat types, freshwater, subestuarine delta, and estuarine nearshore, that are utilized by summer chum salmon during their life cycle. A fourth habitat type, offshore and open ocean, is not discussed here because of limited information and a lack of expertise within the habitat workgroup. The ocean environment is generally discussed in Part Two - Region-wide Factors for Decline. Harvest management and artificial production practices also impact survival, and are addressed in detail in other chapters of Part Three.

Background information on summer chum life history and the ecology of their native watersheds within the wider estuarine landscape of Hood Canal and the eastern Strait of Juan de Fuca are presented in section 3.4.2 Background and Ecological Context. Using this information, the habitat workgroup developed a specific methodology for analyzing limiting factors of different life stages. The methodology and results of the analysis are outlined in section 3.4.3 Limiting Factors Analysis: Methodology and Results. Section 3.4.4 Protection/Restoration Strategy describes a protection and restoration strategy, including general principles, specific measures, and guidance for evaluating particular restoration projects. Monitoring and research priorities are defined in section 3.4.5 for the evaluation of habitat recovery planning effectiveness. Parties critical to the implementation of the habitat elements of the recovery plan and their respective roles are described in section 3.4.6. Appendix Report 3.5 includes a detailed description of the estuarine landscape. Appendix Report 3.6 - Summer Chum Watershed Narratives, provides detailed information on the results of the limiting factors analysis and recommendations for recovery specific to individual watersheds. Supporting documentation for the limiting factors analysis and methods used for the riparian forest evaluation are provided in Appendix Report 3.7, and channel habitat data background information is included in Appendix Report 3.8.

## 3.4.2 Background and Ecological Context

Abundant and self-sustaining summer chum populations require a mosaic of complex, dynamic, and interconnected habitats through which they move to complete their life cycle. This includes a variety of habitats within freshwater, estuarine, and marine environments that have been altered by human development during the last century. Before we can understand the magnitude of human impacts to summer chum habitat, we must have a comprehensive understanding of how summer chum life history is linked to particular habitats, appreciate critical ecological processes that sustain these habitats, and understand the historical context for present-day conditions.

This section details the connection between summer chum life history and the ecology of their native watersheds within the wider estuarine landscape of Hood Canal and the eastern Strait of Juan de Fuca.

We provide an overview of summer chum life history association with particular habitats, ecological processes and functions important to summer chum, and historical habitat conditions. This discussion is divided into three parts to emphasize specific connections between summer chum life history and the ecology of different environments. Sections 3.4.2.1 and 3.4.2.2 detail summer chum life history association, important ecological processes, and historical conditions within freshwater and subestuarine environments, respectively. Section 3.4.2.3 discusses summer chum life history association and ecological processes, in the nearshore environment and within the broader estuarine landscape of Hood Canal and eastern Strait of Juan de Fuca. The general discussion of historical conditions within Hood Canal and eastern Strait of Juan de Fuca watersheds and estuaries sets the stage for the analysis of specific impacts to individual watersheds, discussed in section 3.4.3 Limiting Factor Analysis: Methodology and Results.

## 3.4.2.1 Freshwater Environment

### Life History Association

Life history stages associated with freshwater habitat include adult migration and spawning, egg incubation, fry emergence and downstream migration. Freshwater conditions likely exert a greater influence on adult migration, spawning and egg incubation, given the extended time periods associated with these stages in contrast to relatively short freshwater residence time for fry emergence and emigration. Adults typically enter freshwater and spawn from late August through mid-October, usually choosing low gradient, lower mainstem reaches with adequate flow and suitable velocities. Egg incubation typically lasts 5 to 6 months. Eggs incubating in the gravel are particularly vulnerable to scour and channel disturbance associated with high winter flows for the first three months until they reach the “eyed” stage. Summer chum fry emerge from redds between January and April, and move rapidly downstream to subestuarine areas.

### Freshwater Processes and Functions Important to Summer Chum

Survival of freshwater life history stages are linked to a number of habitat parameters including water quantity (low and peak flows), water quality (primarily temperature), riparian forest conditions (width of riparian forest, age of trees, species composition), sediment conditions (aggradation, degradation, presence of fines), channel complexity (large woody debris quantities, channel condition, amount of side channel habitat), access to habitat, and presence of predators. Most factors are interrelated; a change in one parameter typically manifests itself in changes to other parameters. For example, reduced channel complexity is closely correlated with high rates of sediment transport and deposition as well as reduced channel interaction with the associated floodplain.

Survival during adult migration and spawning is largely a result of interactive processes between recruitment of suitable sized gravel, adequate stream flow, water temperature, and channel complexity such as the presence of large woody debris to create holding pools and provide cover from predators. Conditions conducive to successful egg incubation and rearing include: 1) the presence of adequate large woody debris (LWD) to reduce scour of incubating eggs and moderate peak winter flow velocities, 2) the absence of excessive fines within spawning gravel, 3) stable channel configuration, and 4) access to floodplain and off-channel areas. The excavation of redds by spawning adults may also contribute to streambed surface coarsening and sorting, and thereby reduce scour of incubating salmon embryos during winter high flow events.

Processes within the freshwater environment can also influence the condition of subestuarine and nearshore environments. Hydrologic regimes, as well as transport and supply of LWD, sediment, and nutrients from watersheds has a direct impact on both the quantity and quality of subestuarine and nearshore habitats used by summer chum.

## Historical Conditions

Historically, large intense prehistoric wildfires (at 200-400 yr. intervals) and smaller-scale windthrow played a major role in shaping upland vegetation habitat conditions in Hood Canal and the Strait of Juan de Fuca watersheds. Fire and windthrow disturbances episodically supplied large quantities of LWD and sediment to stream channels, but riparian forests and other protected areas may have escaped destruction and served to buffer aquatic habitats against disturbance. The infrequent nature of these disturbances moderated volumes of wood and sediment introduced to channels and allowed for habitat recovery. Natural flow regimes and periodic floods routed and stored LWD and sediment inputs through stream networks, contributing to high habitat diversity and complexity. Low gradient reaches and floodplains, where abundant quantities of LWD collected (frequently forming log jams), possessed complex flow patterns that formed side channel and backwater habitats, where fish found ample refuge from high flows. Rivers and streams interacted with their floodplains, dissipating the erosive energy of large floods. Riparian forests that provided shade and LWD to streams contained a mixture of tree species of varying ages, though older age classes and conifers were likely more prominent in riparian communities than at present. Unaltered upland drainage patterns, wetlands, and aquifers interacted with stream channels and moderated both winter peak flows and late summer low flows. Abundant large woody debris stabilized spawning gravel and created diversity in flow and cover characteristics for both juvenile and adult salmon. Stream habitat complexity and diversity provided summer chum with an environment for spawning and incubation that was resilient to natural disturbances. Fish access may have been temporarily limited by natural blockages such as beaver dams or log jams, but natural cycles of creation and collapse of these obstructions insured that summer chum had access to adequate amounts of high quality habitat.

## Variation in Watershed and Summer Chum Population Characteristics

Regional variation in environmental factors produce differences in freshwater habitat conditions that presumably shape unique life history characteristics of individual Hood Canal and eastern Strait of Juan de Fuca summer chum populations. Precipitation, forest communities, landform, underlying geology, and drainage area vary significantly among summer chum watersheds with important consequences for the hydrology, channel, and floodplain characteristics of individual watersheds. The larger and steeper gradient west side Hood Canal watersheds tend to have relatively few stream miles accessible to summer chum, and cooler water temperatures. In contrast, eastside Hood Canal watersheds have smaller drainage areas, extensive headwater wetlands, highly erosive glacial sediment regimes, and more accessible stream miles. Eastern Strait of Juan de Fuca streams are also steep with limited anadromous habitat, but lie in the rainshadow of the Olympic mountains and possess unique rainfall-runoff characteristics that distinguish them from Hood Canal streams.

In response to this variability, summer chum populations have evolved different freshwater habitat utilization patterns. For example, river entry of adult summer chum is earlier for the Union River population, as compared to other Hood Canal and Strait of Juan de Fuca summer chum populations. Similarly, the delay between river entry and spawning is more protracted in the Union River as compared to other Hood Canal populations, which in turn have longer adult freshwater residence times than Strait of Juan de Fuca populations. Earlier adult entry to the Union River has been hypothesized to be related to higher tidal flux during early fall, as compared to other rivers within the region. Recognizing the importance of this life history variation, the differences in habitat conditions across watersheds, as well as the linkages between freshwater and estuarine systems is essential if recovery is to be successful.

## 3.4.2.2 Subestuarine Environment

### Life History Association

Hood Canal and eastern Strait of Juan de Fuca subestuary deltas support a diverse array of habitats (tidal channels, mudflats, marshes, and eelgrass meadows) that serve as critical rearing and transition environments for summer chum. Summer chum fry migrate to subestuaries immediately after emergence where they may feed and rear for days to weeks before continuing seaward. Juveniles are thought to use subestuaries as temporary refuge areas during migrations out of Hood Canal and the Strait of Juan de Fuca (see Appendix Report 3.5). Returning adults congregate in subestuaries before ascending their natal streams to spawn and at least one extirpated population (Big Beef) was known to spawn in the intertidal zone.

### Subestuary Processes and Functions Important to Summer Chum

The importance of subestuaries for summer chum is linked to the placement of diverse, productive habitats in areas where summer chum fry are making dramatic transitions in physiology, feeding, and predator avoidance strategies. Diffuse networks of distributary channels allow fry migrating down rivers to access shallow-water wetlands such as tidal freshwater sloughs and salt marshes. In salt marshes, complex, branching networks of tidal channels serve as opportune feeding areas, as well as refugia from predators and migratory corridors linking the marsh to riverine and marine realms as well as other estuarine habitats. Juvenile chum salmon feed on invertebrate prey that depend on detritus. Marshes, mudflats, and riparian forests supply detritus to tidal channels, algal mats, and eelgrass meadows where summer chum and their invertebrate prey concentrate. Tidal channel and subtidal habitats provide resting and hiding places for summer chum, and expand salinity gradients to ease fish transition between fresh- and saltwater. The seasonal pulse in production of shallow-water invertebrate prey in subestuaries is thought to be an important resource for juvenile summer chum, enabling them to grow quickly and attain a large size to help them escape predation once they begin their migration through the open, deepwater of Hood Canal and Strait of Juan de Fuca.

Variation in winter-early spring estuarine conditions can impose constraints on juvenile feeding, growth, migration timing, and ultimately survival. Year-to-year variation in river temperatures and flows, timing of fry movement to subestuaries, and availability of prey in subestuaries likely have a large impact on mortality of early life stages. Diversity in the timing of fry emigration from rivers, both within and among summer chum populations likely confers resiliency to these populations, given the variability of estuarine conditions.

The integrity of subestuarine environments is closely linked to ecosystem processes in adjacent freshwater and nearshore areas. Subestuaries route and store riverine- and marine-derived LWD, sediment, and detritus. Rivers and longshore currents transport LWD to subestuarine deltas where it collects, serves as cover for fish, and acts as a berm or breakwater, slowing wave or current action and enhancing sediment accumulation. Sediment supply from river and nearshore cliffs transported by cross-delta and longshore currents determines available substrates for eelgrass and, in turn, invertebrate prey on which summer chum feed. A natural regime of freshwater inflow and tidal exchange is essential for maintenance of tidal channel networks and the highly productive, detritus-based food web upon which juvenile chum depend. Finally, tidal flushing transports sediment offshore and maintains subestuarine channel networks, contributing to stable, slowly evolving, complex and productive habitat for summer chum.

### Regional Variation and Historical Conditions

Hood Canal and Strait of Juan de Fuca subestuaries vary widely in size, complexity, and configuration. The Dungeness and westside Hood Canal watersheds (Skokomish, Hamma Hamma, Duckabush, Dosewallips, and Big/Little Quilcene) have extensive, complex subestuaries that likely serve a broader function than simply supporting their particular population of summer chum (see 3.4.2.3 Estuarine Landscape, below). In contrast, eastside Hood Canal subestuaries are relatively small, and frequently exhibit spit features.

Historically, summer chum had unimpeded access to a diverse array of these subestuarine habitats (tidal channels, mudflats, marshes, and eelgrass meadows). Subestuaries functioned as important pathways for the movement of fish, water, LWD, sediment, and nutrients between freshwater and marine realms, and productive subestuarine marshes and mudflats sustained rich foodwebs dependent upon these material fluxes. Natural tidal circulation and river flow regimes maintained supplies of LWD, sediment, and detritus and provided a structurally-complex rearing and transition environment for summer chum that was resilient to natural disturbances such as winter storms. In particular, tidal action in subestuaries was unimpeded by human structures and effectively transported sediment out of river mouths to offshore areas, maintaining structurally-complex channel networks where summer chum found abundant refuge.

## 3.4.2.3 Estuarine Landscape

### Life History Association

The "estuarine landscape" includes deepwater, nearshore and subestuarine delta environments used by summer chum as they feed and migrate through Hood Canal and the eastern Strait of Juan de Fuca (for a detailed description and assessment of the estuarine landscape, see Appendix Report 3.5). The above discussion of summer chum habitat use, processes, and historical conditions in subestuaries is thus also important for their effects on the broader estuarine landscape. Within the landscape, subestuaries function as stopover sites for juvenile chum during their outmigration, providing productive shallow water feeding and refuge areas. In addition to subestuarine deltas, the landscape includes the nearshore environment that largely functions as a movement corridor for smaller summer chum fry, as well as deepwater habitat used by larger fry. The nearshore environment is comprised of narrow, intertidal-shallow subtidal beaches with mixed cobble-gravel-sand substrates, which support near continuous bands of eelgrass. Other prominent habitats that are integrated with the eelgrass corridor include macroalgae and kelp beds, as well as mud- and sand-flats. Smaller juvenile chum (<50-55 mm in length) feed and migrate in or adjacent to this corridor, while larger fish will occupy deeper, open water habitats.

### Nearshore Processes and Functions Important to Summer Chum

Relatively little is known about summer chum habitat use in the nearshore environment though it may be presumed that smaller juveniles require relatively contiguous patches of eelgrass to feed and migrate in. Natural bluff and beach erosion, working in concert with longshore drift, maintains beaches within discrete ‘drift cells’. Eelgrass, which is confined to mud or sand substrates within a narrow intertidal-shallow subtidal zone, typically forms a continuous corridor within a drift cell but may fragment between cells where deeper water or coarse substrates prevent its establishment.

### Estuarine Landscape Features Important to Summer Chum

Since summer chum fry tend to migrate in shallow water during the early stages of their migration out of Hood Canal and the eastern Strait of Juan de Fuca, they are confined to particular areas distributed along the shoreline that meet their habitat requirements. Food availability and growth of smaller summer chum fry in subestuaries and shallow water, nearshore environments affects the timing of their transition to deep, open-water environments.

The broad expanses of intertidal delta habitats (emergent marsh, mudflat, eelgrass, tidal channels) at the mouths of major rivers comprise critical feeding, rearing, and stopover sites that are relatively dispersed along the fringes of the deeper water of Hood Canal and the Strait of Juan de Fuca. Eleven of the twenty deltas are less than 1 $km^2$ in area and only two are >2 $km^2$, yet the relatively small size of these habitat “patches” may mask their proportionately large importance to juvenile summer chum, given their specific habitat requirements during this early, vulnerable life stage. As patches of productive shallow water feeding areas, subestuarine deltas (including those that do not support indigenous summer chum populations) may attract juvenile summer chum from adjacent watersheds and thereby serve a larger landscape function. Similarly, shallow-water nearshore environments used by fry as a migration corridor are also of limited extent but likely play a disproportionately large role in the production of juvenile summer chum. Moreover, particular eelgrass corridors may be more important than others, simply due to their location or orientation which would influence their use by summer chum.

Together, the subestuarine deltas, shallow nearshore corridor, and deepwater environments function as interconnected systems that summer chum rely on for rearing and migration. The proximity or location of these different habitats may impact the overall integrity and productivity of the summer chum estuarine landscape as much as the quality and quantity of the individual component habitats.

## 3.4.3 Limiting Factor Analysis: Methodology and Results

Before specific protection and restoration actions could be developed to support the region-wide recovery of summer chum, detailed watershed-specific information was needed for each Hood Canal/SJF summer chum population. A standardized approach was developed to determine freshwater limiting factors in each watershed. Charles Simenstad, UW research scientist and expert on estuarine life history of salmon, was contracted to complete the analysis of subestuarine impacts. Species and life-stage specific freshwater and subestuarine processes important to summer chum (see 3.4.2), shaped the development of our methodology. The protection and restoration strategies (section 3.4.4) were developed from the details of each watershed assessment, and are the natural outgrowth of this work.

### 3.4.3.1 Methodology

Watersheds were used as the basic unit for the freshwater and subestuary limiting factor analyses. Each watershed contains a range of habitat condition related to past land-use and resource management. No watershed in Hood Canal/SJF contains pristine, pre-settlement conditions. All have been impacted in the past and are either at various stages of recovery or continued degradation.

Watersheds selected for this analysis include those with current summer chum populations, documented historical summer chum populations, and watersheds with sufficient late summer discharge that potentially could have supported summer chum. Watersheds with known current or recently extinct populations are: Dungeness, Jimmycomelately, Salmon, Snow, Chimacum, Little Quilcene, Big Quilcene, Dosewallips, Duckabush, Hamma Hamma, Lilliwaup, Skokomish, Union, Tahuya, Dewatto, Big Anderson, and Big Beef. After completing the analysis, it came to our attention that Finch Creek has an extirpated summer chum run.

Watersheds that historically could have supported a summer chum population were identified as: Stavis, Seabeck, Big Mission, Fulton, Eagle, Jorsted, Little Lilliwaup, Tarboo, Thorndyke, Shine, and Morse creeks. Due to time constraints only Stavis, Seabeck and Big Mission were included in this analysis. Some of these watersheds have spawning survey data over the previous 25 years that observe summer chum in some years and not in others; the occurrences of summer chum were not in sufficient numbers or frequency to indicate a viable population (Stavis, Fulton, Eagle, Little Lilliwaup, and Morse creeks, see Part One - Life History and Stock Assessment). The other basins contain sufficient late summer flows and habitat conditions that historically a population could have been present (Seabeck, Big Mission, Jorsted, Tarboo, and Shine creeks). Spawning surveys on both Big Mission and Seabeck have shown a summer chum run is not present. However both streams are degraded and our group felt that given flow conditions and proximity to summer chum watersheds, both could have historically supported a population.

#### Freshwater Assessment

Fish biologists with field knowledge of Hood Canal freshwater watershed conditions were gathered to identify factors that are determinants of the quality of freshwater summer chum habitat (Table 3.16). Habitat factors included: winter high flow and summer low flow; temperature; nutrient loading; fine and coarse sediment; LWD presence; channel condition; loss of side channels; channel instability; riparian forest size, extent and species composition; floodplain wetland loss; and fish access and passage. These habitat factors were used to determine habitat quality for the following life stages: freshwater migration, spawning, incubation, rearing, and saltwater migration.

For each watershed, the biologists as a group rated the condition of each habitat factor according to the severity of impact (none, low, moderate, and high). The potential impacts to summer chum from each limiting factor are described in Table 3.16. For each watershed, a narrative summary was prepared that identifies habitat-related factors for decline (Appendix Report 3.6). Data were used, when available, to rate habitat quality against that found in relatively unimpacted basins. Information gaps were filled with the habitat biologist's field knowledge of each basin. Ratings for riparian condition were based upon the results of the riparian assessment (Appendix Report 3.7). A summary of the available freshwater habitat data and how it was rated is found in Appendix Report 3.8. Each habitat factor was considered across the known or presumed range of summer chum within a watershed, however some (e.g. flow) had to be discussed at the watershed scale. Many habitat factors were closely correlated to other factors (e.g. winter high flow, LWD, and channel instability), however in the group discussion each factor was considered separately. The interaction of habitat factors as it impacts summer chum is discussed in section 3.4.3 (toolkit), and in the individual watershed narratives (Appendix Report 3.6). Background information for the ratings and watershed narratives included TFW ambient monitoring data; completed state and federal watershed analyses; and temperature, sediment, and stream discharge data.

**Table 3.16.** Habitat factors for decline and supporting information.

| Habitat Factors | Impacts to Channel Processes and Summer Chum | Life History Stages Affected * | Supporting Literature |
|---|---|---|---|
| Winter high flow | Redd scour through increased sediment transport | I | McNeil 1964, Tripp and Poulin 1986, Thorne and Ames 1987, Nawa et al. 1990, Chamberlain et al. 1991, Schuett-Hames et al. 1994, Montgomery et al. 1996 |
| Summer low flow | Prevention or delay of upstream passage, reduction of available spawning area | AM, S | Chamberlain et al. 1991, Johnson et al. 1997 |
| Water temperature | Elevated temperatures impede adult passage, cause direct mortality, and accelerate development during incubation leading to diminished survival in subsequent life stages | AM, S, I | Beschta et al. 1987, Holtby and Scrivener 1989, Bjornn and Reiser 1991, PNPTC unpublished data, |
| Dissolved oxygen | Low dissolved oxygen results in direct egg suffocation and diminished survival of subsequent life stages | I | Mason 1969, Koski 1975, Bams and Lam 1983, Chapman 1988, Bjornn and Reiser 1991, Peterson and Quinn 1994b |
| Fine sediment | Suffocation of developing embryos, entombment of fry in the gravel bed, compaction and cementing of spawning beds | S, I | Koski 1975 and 1981, Chapman 1988, Scrivener and Brownlee 1989, Salo 1991, McHenry et al. 1994, Peterson and Quinn 1994a |
| Coarse sediment | Channel aggradation leading to egg/fry entombment, redd dislocation | S, I | Madej 1978, Tripp and Poulin 1986 |
| LWD | Low levels may increase redd scour, contribute to channel instability, and limit availability of adult holding pools | AM, S, I | Bilby 1984, Sedell and Froggatt 1984, Dolloff 1986, Lisle 1986a and 1986b, Bisson et al. 1987, Bilby and Ward 1989, Montgomery et al. 1995 |
| Channel condition | Reduced holding pool quality and availability renders adults vulnerable to predation/harassment; reduced channel complexity increases frequency and severity of redd scour | AM, S, I | Orsborn and Ralph 1994, Beschta et al. 1995, Spence et al. 1996 |
| Loss of side channels | Limits adult holding areas, and confines spawning to main channel areas where redds are prone to scour | AM, S, I | Sedell and Luchessa 1982, Sedell and Froggatt 1984, Hirshi and Reed 1998 |
| Channel instability | Increased substrate mobility resulting in redd scour/entombment or de-watering of redds | I | Nawa and Frissell 1993, Orsborn and Ralph 1994, Beschta et al. 1995 |

**Table 3.16.** Habitat factors for decline and supporting information (continued).

| Habitat Factors | Impacts to Channel Processes and Summer Chum | Life History Stages Affected[1] | Supporting Literature |
|---|---|---|---|
| Riparian condition (species composition, age, and extent) | Removal and modification of native riparian forests increases water temperatures, reduces stability of floodplain landforms, and reduces LWD recruitment to stream channels (see above) | AM, S, I | Bisson et al. 1987, FEMAT 1993, Beschta 1995 |
| Floodplain and wetland loss | Concentrates flood flows in main channel, increases peak flow volumes, and results in increased redd scour; loss of wetlands reduce summer low flow volumes (see above) | AM, S, I | Henegar and Harmon 1971, Spence et al. 1996 |
| Fish passage and access | In-channel structures obstruct or impede adult passage; tidegates and dikes limit juvenile access to subestuarine rearing and feeding habitats | AM, R | Evans and Johnson 1980, Toews and Brownlee 1981, Furniss et al. 1991 |
| Estuarine habitat loss/modification | Dikes, ditches, and road causeways eliminate marsh habitats, limit tidal circulation, and reduce estuarine productivity | R, SM | Writght et al. 1973, Beemer and LaRock 1998, Levings 1980, Levy and Northcote 1981, Simenstad et al. 1982, Varanasi 1993, Waldichuk 1993, Thom et al. 1994 |
| Nearshore habitat loss/modification | Bulkheads eliminate natural sediment sources and contribute to coarsening of nearshore substrates, which reduces or eliminates eelgrass habitats used by chum fry | R, SM | Levings 1980, Waldichuk 1993, MacDonald et al. 1994, Thom et al. 1994 |

[1] AM is Adult migration, S is spawning, I is incubation, R is rearing, SM is saltwater migration

Summer chum range was determined from information supplied by WDFW, with changes made to a few watersheds when the biologists agreed that better information existed. Distribution for streams with known extirpated populations or those that may have had runs historically, was defined as the portion of fall chum range presumed to have adequate summer flow conditions.

*Limitations of the freshwater assessment.* While 14 of 20 watersheds had channel habitat data, few basins contained temperature or fine sediment data (Appendix Report 3.8). Scour chain data, or the effect of bed scour on redds, was also available for only a few basins. Data limitations will always be a problem. The habitat assessment was designed to utilize both field knowledge and quantitative data in determining limiting factors. In addition, the full range of impacts of some habitat factors to summer chum were not considered due to incomplete knowledge. For example, temperature was assessed only in terms of lethal or sub-lethal temperature to adult fish. Changes in the duration of embryo development due to altered stream temperature, with potential negative impacts of early or late emergence, was not considered. The upstream recruitment potential of LWD outside of the summer chum zone was also not considered. Large woody debris (LWD) was considered in terms of pool formation, stabilization of sediment, and formation of side channels. It was beyond the scope of the assessment to differentiate how LWD creates habitat relative to basin size. Refer to section 3.4.5 for further discussion of research needs.

### **Subestuarine assessment** (analyzed by Simenstad)

1997 aerial photos of 20 sub-estuaries were analyzed to provide estimates of anthropogenic impacts to estuarine rearing capacity and natural migratory corridors through delta habitat. Rearing capacity refers to the ability of delta habitat to supply prey to juvenile summer chum, along with providing cover to avoid predation. Disruption or elimination of migratory corridors can negatively effect chum if they are significantly delayed, moved away from productive rearing areas, or forced into areas of higher predation risk.

The delta was defined as all intertidal and shallow subtidal sediment accretions at the river mouth, while shrub-scrub and woody (forested) vegetation was used as the upland margin of the delta[1]. The outer margin of the delta was the apparent margin of the intertidal/shallow subtidal break, as evidenced by the outer margin of eelgrass (*Zostera marina*) or change in water color.

The following attributes were measured to identify and delineate sub-estuary deltas and anthropogenic changes: original delta area, diked area, filled area, dredged area, excavated pond and marina area, dock area, log storage area, aquaculture area, unidentified area, road and causeway length, jetty and piledike length, ditch and remnant dike length. Each feature was interpreted by examination of the aerial photograph, or its image scanned into a computer. Comparisons of computer images to USGS 7.5 minute quad maps were used to check the accuracy of measurements. Some features were verified with further discussions with field biologists. The historic landward extent of the intertidal area was often particularly difficult to

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[1] This cutoff is somewhat arbitrary but necessary because the upstream extent of salinity intrusion or tidal influence could not be interpreted from aerial photograph imagery. In fact, this imposes a non-trivial underestimate of the actual estuarine and tidal-freshwater habitat used by juvenile salmon because forested wetlands and sloughs above this arbitrary cutoff could not be included.

identify because of extensive alteration (diking, filling, and roads). While map and aerial photo measurements require further groundtruthing and historical analyses before they can be considered highly accurate, they provide a valuable starting point to evaluate impacts to individual subestuaries.

Impact ratings to individual subestuaries were based on changes to the 1) area of the historic delta (and specific habitat within the delta), 2) location of features within the delta, 3) vulnerability of impacted habitat, and 4) duration and intensity of impact to summer chum, were considered. Dikes, filling, excavations, marinas, and road causeways were considered of long duration and a high impact if they occupied greater than 20% of the historic delta. Ditches, remnant dikes, jetties and piledikes, and some road causeways, although not necessarily comprising a large proportion of the historic delta area, were rated as moderate or high impact if they potentially diverted fish away from remnant productive sub-estuarine rearing areas. Other structures such as docks were considered to be short duration and no to low impact, because fish are often able to migrate through these structures. Log storage and aquaculture were difficult to assess because the extent and intensity of disturbance could not easily be determined without field evaluation. These were assumed to be no to low impact unless they were extensive or other information suggested a greater effect. For several subestuaries (Dungeness, Jimmycomelately, Snow/Salmon, Big and Little Quilcene, Skokomish, and Big Anderson), field knowledge was used to upgrade or downgrade some of the ratings.

Indirect impacts to juvenile summer chum, such as those changes to estuarine circulation and sedimentation, were also considered when ranking. For example, following dike removal, drainage and borrow ditches may still inhibit tidal circulation and distribution of sediment within the marsh, thus potentially impacting rearing and migration habitat.

Estuarine landscape assessment: The estuarine landscape occurs at the scale of Hood Canal and the eastern Strait of Juan de Fuca, and includes those areas utilized by outmigrating summer chum. Very little information exists at this scale on the impacts of development on outmigrating summer chum. Indeed, no quantitative information exists on the quantity of shoreline development across Hood Canal/SJF. The results are presented as a discussion of potential nearshore and cumulative effects.

### 3.4.3.2 Results of Limiting Factor Analysis

#### Freshwater

Detailed description of the results in terms of habitat factors for decline and recovery for each watershed is found in the Watershed Narratives (Appendix Report 3.6). Please refer to that for a full discussion of limiting factors at the watershed scale. At the region-wide scale, protection and restoration strategies for each limiting factor for decline are found in section 3.4.4.

The habitat factors for decline were rated for each watershed (Table 3.17). When the summary of habitat ratings across all watersheds is compared to stock status (Table 3.17), it becomes apparent that for some watersheds degraded habitat alone did not cause the decline of summer chum. Habitat is just one element in the recovery plan. However, each watershed we analyzed contained several to many habitat factors negatively impacted by landuse. If recovery of summer chum to a healthy, fishable population status throughout the region is to occur (and the listing of other salmon prevented), then habitat condition must be returned to a functional state throughout the region.

Stream channels, in terms of LWD, pool density, riparian forest size, type and extent, and subestuaries, were with few exceptions, moderately to highly degraded throughout the region (Figure 3.2). In about half of the basins, peak and low flow, and sediment aggradation were also considered a moderate to high impact. During the past 150 years, logging, road building, rural development, agriculture, water withdrawal, and channel manipulations (stream cleanout, dredging, straightening) were common and widespread, especially within low gradient stream reaches utilized by summer chum.

Overall, fifteen of the 20 watersheds contained simplified, degraded channels surrounded by absent or small diameter, deciduous dominated riparian forests (Table 3.17, Figure 3.2). The Dungeness, Jimmycomelately, Snow, Salmon, Big Quilcene, Little Quilcene, Skokomish, and Seabeck were the most severely degraded. The Dungeness, Jimmycomelately, Snow and Skokomish all had severe problems with winter flow and sediment aggradation. In all these watersheds except Seabeck and Salmon, summer low flow was considered a severe problem. Channel, riparian forest, and subestuarine conditions for all the watersheds were moderately to severely degraded. Finally, most of these watersheds contained a high percentage of landuse within the riparian zone (Appendix Report 3.7). Close behind in terms of degraded habitat were Big Beef, Union, and Hamma Hamma. We considered the Union stock particularly vulnerable due to the rapid urbanization around Belfair, along with a degraded riparian forest and subestuary. The Union stock is the only stock rated “healthy.” A full description of the limiting habitat factors and needed action for recovery for each watershed is found in the watershed narratives (Appendix Report 3.6).

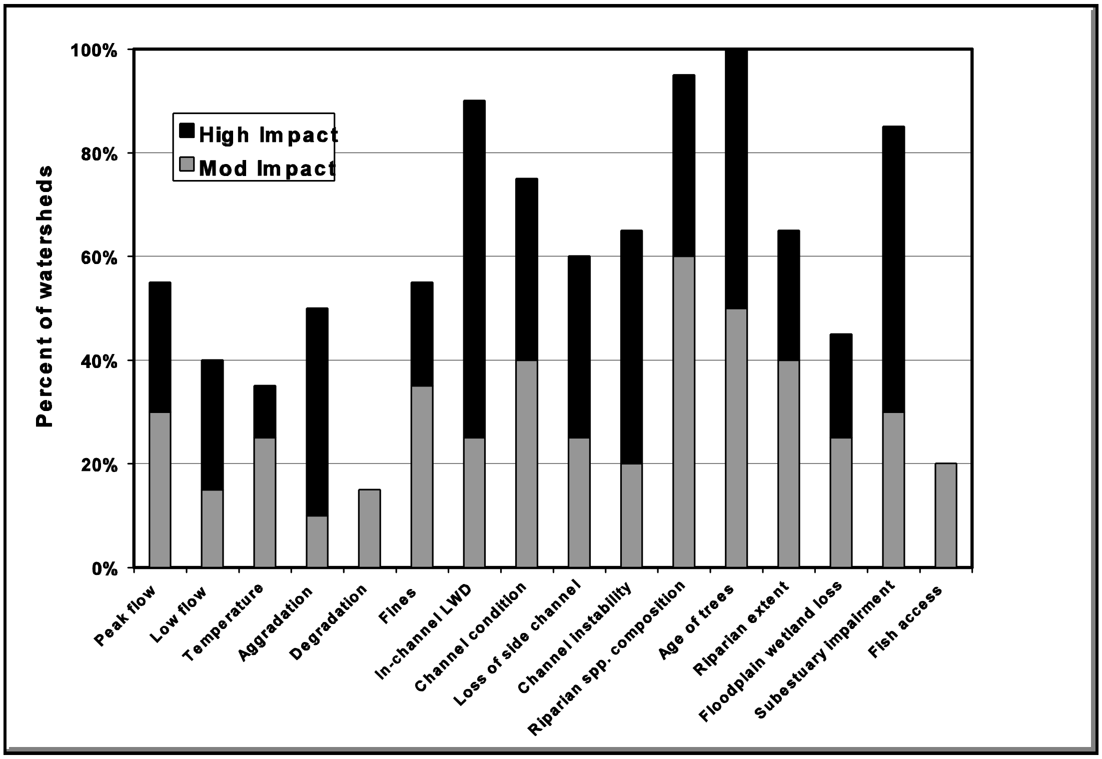
The Tahuya, Dewatto, and Stavis watersheds and subestuaries are recovering and in good condition. The Tahuya, however, is vulnerable to habitat degradation with a small, deciduous dominated riparian forest, and agricultural and residential development within the 100 year floodplain at several locations. Summer chum is extinct in all three watersheds. Moderately degraded with areas of good habitat are Chimacum, Dosewallips, Duckabush, Lilliwaup and Big Anderson watersheds. As described in the Watershed Narratives (Appendix Report 3.6), habitat protection in terms of floodplain and easements or outright purchase (along with the land bordering subestuaries) will be especially useful in all these watersheds. However, easements and purchase should be considered for any watershed if good quality remnant habitat exists. Overall, we recommend that habitat protection in terms of land-use regulation should be broadly applied in all watersheds across the region.

**Table 3.17**. Summary of ratings for habitat factors for decline. The ratings are 0-no impact to chum, 1-low impact, 2-moderate impact, and 3-high impact. A "?" by itself means not enough information existed to make a call. A number followed by a question mark means there was uncertainty over the call; the number represents an estimate. For stock status, potential habitat has adequate flows and habitat, but no surveyed historical run (see section 3.4.3.1 - Methodology for further information). Watersheds are organized by the geographic position within Hood Canal/SJF. *Skokomish includes the Miaistem/NF (RM 0-15.6), SF (0-5.0), Vance (0-3.0), Richert Springs (0-0.3), Purdy (0-1.5), Weaver (0-3.5), and hunter Ck (0-3.5).

| **WATERSHED** | **Dung.** | **JimCo** | **Salmon** | **Snow** | **Chim.** | **LitQuil** | **BigQuil** | **Dose.** | **Duck.** | **Hama** | **Lilli.** | **Skok.** | **Union** | **BigMis** | **Tahuya** | **Dewatt** | **Ander.** | **Stavis** | **Seabeck** | **BigBf** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Presumed FW Dist. (RM)** | 0-10.8 | 0-1.5 | 0-2.0 | 0.-3.0 | 0-3.0 | 0-3.0 | 0.4.8 | 0-4.3 | 0-3.0 | 0-2.0 | 0-0.7 | 0-15.6* | 0-6.0 | 0-1.5 | 0-8.0 | 0-4.0 | 0-1.8 | 0-0.6 | 0-0.9 | 0-6.0 |
| **Confidence Measure** | High | High | Mod | Mod | Mod | High | High | Mod | Mod | Mod | Mod | High | High | Mod | Mod | Mod | High | High | Mod | High |
| **Stock Status (Part 1)** | Unk. | Critical | Depr. | Depr. | Extinct | Depr. | Depr. | Depr. | Depr. | Depr. | Critical | Extinct | Healthy | Pot. | Extinct | Extinct | Extinct | Pot. | Pot. | Extinct |
| **HABITAT FACTORS:** | | | | | | | | | | | | | | | | | | | | |
| **Flow** | | | | | | | | | | | | | | | | | | | | |
| Winter | 3 | 2 | 3? | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 0 | 3 | 1? | 0? | ? | 0 | 2 | 1? | 2 | 3 |
| Summer | 3 | 1 | ? | 3 | 2 | 3 | 3 | 0 | 0 | 0 | 0 | 3 | 1? | 1? | 0 | 0 | 0 | 1 | 2 | 2 |
| **Water Quality** | | | | | | | | | | | | | | | | | | | | |
| Temperature | 2 | 2 | ? | 2 | 2 | 1 | 1? | 0 | 0 | 0 | 1? | 1 | 1? | 0? | 3 | 3 | 0 | 0 | 0 | 2 |
| Other (FC, nutrients, DO) | 3 | ? | 1 | 1? | 2 | 0 | 0 | 0 | 0 | ? | 0 | 1 | 1 | ? | 1? | 0 | 0 | 0 | 1? | 0 |
| **Sediment** | | | | | | | | | | | | | | | | | | | | |
| Aggradation | 3 | 3 | 1 | 3 | 1 | 2 | 3 | 1 | 1 | 1 | 0 | 3 | 0 | 1 | 0 | 0 | 3 | 2 | 3 | 3 |
| Degradation | ? | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | ? | 0 | 0 | 0 | 2 | 2 | 1 |
| Fines | 2? | 2 | 2 | 3 | 3 | 2 | 2 | 0 | 0 | 1 | 0 | 0 | 1 | ? | 1 | 2 | 2 | 1 | 3 | 3 |
| **Channel Complexity** | | | | | | | | | | | | | | | | | | | | |
| LWD | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 3 | 2 | 2 | 2 | 3 | 2 |
| Channel condition | 3 | 3 | 2 | 3 | 1 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 2 | 3 | 1 | 1 | 1 | 1 | 2 | 2 |
| Loss of side channel | 3 | 3 | 2 | 3 | 1 | 3 | 3 | 2 | 2 | 2 | 1 | 3 | 1? | 1? | 1 | 1 | 1 | 1 | 2 | 3 |
| Channel instability | 3 | 3 | 1? | 3 | 2 | 3 | 3 | 1 | 1 | 1 | 1 | 3 | 2 | 3 | 2 | 1 | 3 | 1 | 2 | 3 |
| **Riparian Condition** | | | | | | | | | | | | | | | | | | | | |
| Species Composition | 2 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 1 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 |
| Age | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 2 | 2 | 3 | 2 | 2 | 2 |
| Extent | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 1 |
| | | | | | | | | | | | | | | | | | | | | |
| **Floodplain loss** | 2 | ? | 1? | 2 | 3 | 3 | 3 | 2 | 2 | ? | 1 | 3 | 1? | 1? | 1 | 1 | 1 | 1 | 1? | 2 |
| **Subestuary** | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 3 | 3 |
| **Fish Access/Passage** | 2 | 2 | 2 | 1 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | ? |

**Table 3.18.** Summary of ratings for the subestuarine factors for decline. The ratings are 0-no impact to chum, 1-low impact, 2-moderate impact, and 3-high impact. A "?" by itself means not
enough information existed to make a call. A number followed by a question mark means there was uncertainty over the call; the number represents an estimate. The overall "subestuary" rating
in Table 3.17 is a synthesis of these ratings. Diking, road/causeways, ditches, filling, and dredging all influenced the overall rating in Table 3.17 to a greater extent than the remaining subestuary
habitat factors.

| **Subestuary** | **Dung.** | **JimCo** | **Snow/Salmon** | **Chim.** | **LitQuil** | **BigQuil** | **Dose.** | **Duck.** | **Hama** | **Lilli.** | **Skok.** | **Union** | **BigMis** | **Tahuya** | **Dewatt** | **Ander.** | **Stavis** | **Seabeck** | **BigBf** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **HABITAT FACTORS:** | | | | | | | | | | | | | | | | | | | |
| Diking | î | í | î | 0 | î | î | î ? | í ? | î | í | î ? | î | î | 0 | 0 | 0 | 0 | 0 | 0 |
| Roads/causeways | í | î | í | í | ì | 0 | ì | í | î ? | í ? | í | 0 | 0 | í | 0 | í ? | ì | 0 | î |
| Ditches or remnant dikes | ì | ì | 0 | 0 | 0 | 0 | ì | ì | 0 | 0 | 0 | î ? | ì | 0 | 0 | í | 0 | 0 | 0 |
| Filling | í ? | ì | í | í | 0 | í | í | ì | ì | ì | ì | í | ? | ì | ì | 0 | 0 | î ? | ì |
| Dredging | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | î | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Excavation or Marinas | 0 | 0 | ì | 0 | 0 | í ? | 0 | 0 | 0 | ì | 0 | ì | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Docks | ì | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ì | 0 | ì | 0 | 0 | 0 | 0 | 0 | 0 | ì | ì |
| Log Storage | ì | î | 0 | í | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aquaculture | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ì ? | 0 | 0 | 0 | 0 | 0 | 0 | ì | 0 | 0 | 0 |
| Jetties or piledikes | 0 | í ? | 0 | 0 | 0 | ì ? | 0 | 0 | ì | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |



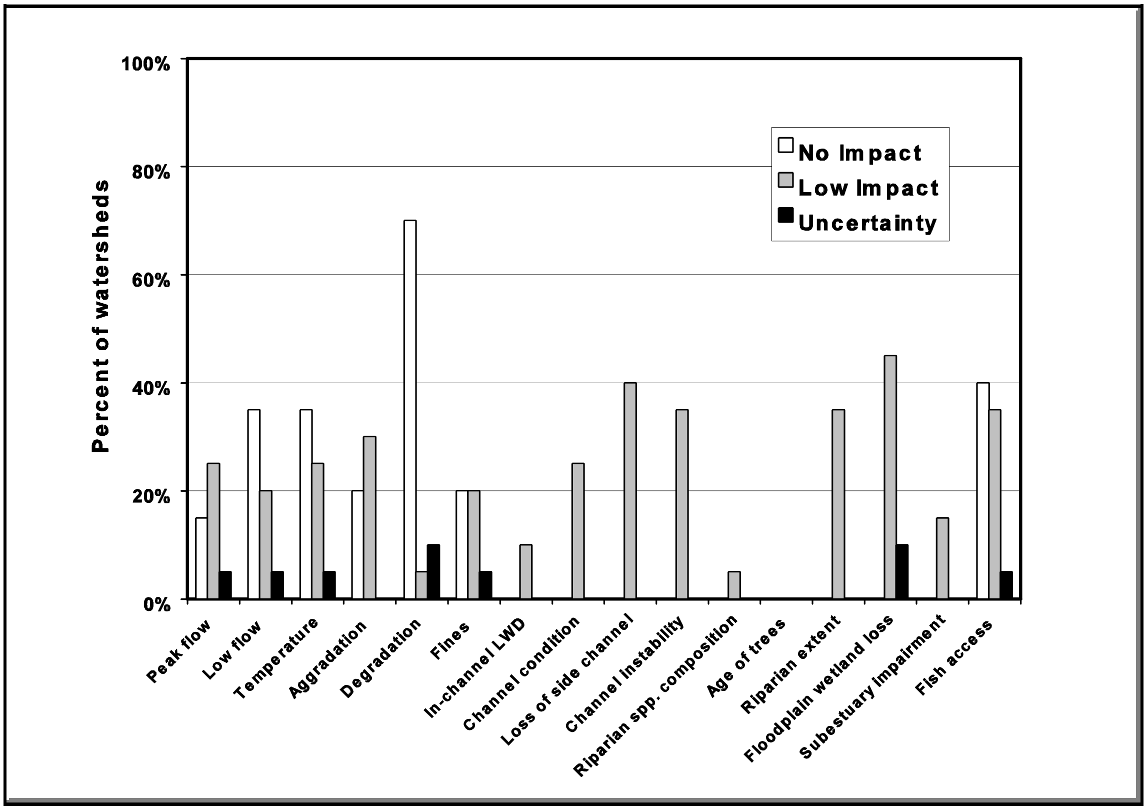


**Figure 3.2.** Habitat factors organized by impact for the entire summer chum region. Uncertainty highlights areas where further research is needed.

## Subestuaries

Nearly all subestuaries within Hood Canal and the eastern Strait of Juan de Fuca have been developed over the past 150 years. Eleven of the 20 subestuaries were severely degraded, with an additional five subestuaries moderately degraded (Table 3.18). Dikes, roads or causeways, remnant dikes or ditches, and fill were considered the most important impacts to summer chum. In the Dungeness, Snow, Big and Little Quilcene, Dosewallips, Hamma Hamma, Skokomish, Union, Big Mission, and Seabeck, dike construction and filling has eliminated productive marsh and tidal channel habitats. Road fill, jetty, and piledike construction has disrupted tidal circulation and restricted fish access in the Tahuya, Skokomish, Lilliwaup, Hamma Hamma, Anderson, Duckabush, Dosewallips, Big Beef, Snow, Salmon, Jimmycomelately and Dungeness. Altered river and tidal dynamics has likely undermined the productivity of the subestuarine food web and thus the carrying capacity of this environment for chum and other salmonids. In the Hamma Hamma, dredging, ditching, excavation, and oyster culture that involve frequent disturbance to substrates have modified the structure, configuration, and proportion of shallow- and deep-water habitats. For most subestuaries there is no data on changes to the areal extent and distribution of eelgrass through time. However, between 1987 and 1993, eelgrass declined by 31% in Dungeness Bay, in large measure due to the impact of ulvoid algae mats (Wilson 1993)[2]. Not considered, due to the lack of information, was the potential impact of water quality in the subestuary on summer chum. For example since 1985, Lynch Cove (Union River), Duckabush, Dosewallips and Quilcene Bay all have had shellfish closures for at least one summer (Cook-Tabor 1995).

**Landscape-nearshore** - Settlement and shoreline development has fragmented and degraded summer chum nearshore habitat. The installation of bulkheads (especially those built with rock or concrete) and docks, operation of boats, and destruction of shoreline vegetation have altered shoreline habitat structure. An enormous loss of marine riparian vegetation has occurred as a result of shoreline bulkhead construction and development. Bulkheads, nearly continuous along parts of Hood Canal, coarsen nearshore substrates through eliminating sources of beach sediment and increasing beach erosion from intensified wave energy. Summer chum <50-55 mm in length appear to be closely associated with the shallow eelgrass habitat that is lost with the coarsened beach sediment (Appendix Report 3.5). Shading from docks slows eelgrass growth/recruitment, and LWD removal from shorelines reduces immediate habitat structure, as well as sources of LWD for subestuaries. Bulkheads, fill, and docks in the lower intertidal zone also force chum fry into deep water where they may become more vulnerable to predation. Bulkheads may also reduce prey items and increase predator densities. How and when summer chum use these habitats needs further study. Continued shoreline development of Kitsap, Mason, Jefferson, and Clallam counties will impact summer chum and a whole community of organisms that utilize eelgrass habitat. Recovery of nearshore habitats for summer chum should emphasize protection of beach sediment sources, unaltered, natural shoreline areas, and intertidal-shallow subtidal vegetation habitats. A high priority for study is a detailed assessment of the location and amount of bulkheads and other shoreline structures throughout the region. See section 3.4.4.2, nearshore toolkit, for a full discussion of protection and restoration measures.

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[2] *Ulva sp.* is commonly found to respond positively to increases in nitrogen loading in marine waters. Furthermore, shifts from eelgrass to ulvoids are theorized to force ecosystem shifts by changing both water flow and substrate composition (Shaffer and Burge, in press).

**Landscape-cumulative -** The historic changes to integrity of subestuarine and nearshore environments must be considered within the wider context of the Hood Canal/SJF estuarine landscape. As patches of productive shallow water feeding areas, subestuarine deltas may attract juvenile summer chum from adjacent watersheds. Particular patches of nearshore eelgrass may be more critical than other patches simply due to their location or orientation. The importance of particular patches within the region needs further study. For example, the Skokomish subestuary may function as rearing habitat for juveniles originating in nearby watersheds or those east to the Union River The Skokomish is potentially the most productive subestuary in Hood Canal due to its size and location. The subestuary is degraded due to diking and roads. Residences and Highway 101 extend in a nearly continuous strip along the shoreline from the Skokomish River north to the Lilliwaup River Across Hood Canal, west of the Tahuya River to Rendsland Creek is another nearly continuous strip of road and houses. Both areas are substantially bulkheaded. It is not known what the regional impact of this development has on summer chum, however at a landscape scale it is likely important.

## 3.4.4 Protection/Restoration Strategy

The following section contains a restoration and protection strategy to address those habitat parameters found to be limiting summer chum production across critical life stages. Protection and restoration principles are first defined that provide the general framework for specific action strategies to protect and recover summer chum habitat. The action strategies are outlined in a “toolkit”. Priorities for action by individual watershed are addressed in watershed narratives (Appendix Report 3.6). Guidance on selection of specific restoration projects is also outlined. Implementation of these strategies is outlined by authority and jurisdiction in section 3.4.6.

### 3.4.4.1 Protection/Restoration Strategy Overview

The goal of the protection and restoration strategy is to maintain and recover the full array of watershed and estuarine-nearshore processes critical to the survival of summer chum across all life stages (Table 3.19). Key watershed processes include transport and deposition of sediment, riparian forest and floodplain interactions, a subestuary molded by tidal energy, and the hydrology necessary for creation and maintenance of key habitats. Key habitats for summer chum salmon include the lower mainstems and floodplains, subestuaries and nearshore environments.

Protection of existing habitat is generally the first level of defense in this strategy. The recommendations listed in the plan should be applied to all watersheds currently, historically, or with the potential to support summer chum to allow full recovery across the Hood Canal/Eastern Strait of Juan de Fuca region. Many of the recommendations address processes that originate above the summer chum zone, and as such, will involve actions throughout the watershed. Watershed scale protection will benefit not only summer chum but other aquatic resources as well. Protection strategies are of two general types: 1) regulatory standards to be implemented by the appropriate jurisdiction; and 2) habitat acquisition through direct purchase, conservation easements, and mitigation banking.

Protection standards are based on the most recent scientific literature, provide a margin of safety in the face of uncertainty, take into account natural disturbance regimes, and may be modified as new information becomes available.

**Table 3.19**. Recovery objectives by life stage.

| **Life Stage** | **Recovery objective** |
|---|---|
| Freshwater migration | Provide free and unimpeded access to migrating adult and emigrating juvenile chum through elimination of existing human caused barriers and maintenance of adequate flow and complex habitat. |
| Spawning | Improve the stability, quantity, and quality of spawning habitat by providing adequate streamflow; providing suitable quality and quantity of spawning gravel; restoring a stable channel bed through dike removal, floodplain reconnection, subestuarine tidal channel reconnection, and the placement of large woody debris; and providing favorable stream temperatures through the protection and restoration of adequate riparian buffers. |
| Incubation | Improve egg incubation success by providing stable, complex channel conditions that moderate peak winter flow effects. |
| Rearing | Protect or restore natural delta morphologies of Hood Canal tributaries to allow for unrestricted estuarine circulation, natural sediment transport/storage rates, and development of tidal channels. Protect and restore eelgrass beds in the subestuarine delta. |
| Saltwater migration | Protect beach sediment sources, unaltered, natural shoreline areas, and intertidal-shallow and subtidal eelgrass habitat. |

Given the degraded condition of many watersheds, restoration will be an important component of summer chum recovery efforts. For the purposes of this habitat section, restoration is defined as:

> ***"The return of an ecosystem to a close approximation of its condition prior to disturbance. In restoration, ecological damage to the resource is repaired. Both the structure and the functions of the ecosystem are recreated. Merely recreating form without the function, or the functions in an artificial configuration bearing little resemblance to a natural resource, does not constitute restoration. The goal is to emulate a natural, functioning, self-regulating system that is integrated with the ecological landscape in which it occurs."***
>
> ***National Research Council (1992)***

Habitat restoration is viewed as a complementary strategy rather than as a substitute for protection. In order to succeed, restoration must focus on re-establishing watershed processes rather than addressing simply symptoms of watershed degradation. Priorities for restoration include: 1) taking actions to further secure existing good quality habitat; 2) restoring watershed processes in areas deemed to have a high likelihood of success; 3) remedying site specific problems while considering upstream/downstream conditions. Due to the high cost and relatively new science involved in restoration, it is important that restoration activities be prioritized to make efficient use of limited restoration funds.

### 3.4.4.2 Tool Kit of Protection/Restoration Strategies by Habitat Parameter

The following presentation describes protection and restoration strategies for seven primary habitat features within the freshwater habitat (flow, water quality, channel complexity/floodplain, sediment, riparian forest, fish access/passage) and for estuarine and nearshore habitats. The purpose is to provide a "tool kit" of alternative strategies applicable to each habitat parameter.

Each habitat parameter is introduced with a problem statement that links the parameter to an associated life stage as well as defining sources of impairment. This is followed by an objective for recovery and description of protection and restoration strategies. Because of the interrelationship between factors, some strategies may overlap and some strategies may be more restrictive than others. In those cases, the most restrictive standard should apply. For each watershed, the appropriate strategies are found under the Factors for Recovery section of the watershed narratives in Appendix Report 3.6.

The strategies presented here are not totally exclusive; others strategies such as habitat conservation plans and other local agreements may be included as long as they achieve the stated objective.[3]

#### Flow

A. Low Flow

Problem Statement: Natural low stream flows from August to October are exacerbated by water withdrawals, sediment aggradation, forest management, extent of impervious surfaces, and alteration of floodplains and groundwater recharge areas. These impacts have hindered or prevented upstream migration, reduced the available area for spawning, caused dewatering of redds, or forced spawning in the mid-channel, an area that is more vulnerable to winter flows and associated scour of eggs.

Objective: Provide adequate stream flow to allow upstream migration and spawning within stable habitat, especially during natural drought cycles.

Protection Strategies:

1. Establish adequate instream flow levels to meet the stated objective. Department of Ecology should conduct studies, identify target instream flows and condition all water right applications consistent with

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[3] For lands and forest practice activities regulated by state forest practice regulations, WDFW is on record supporting the Forest and Fish Report and the protective provisions contained therein. Not all tribes endorse the Forest and Fish plan. WDFW continues to support this agreement as a reasonable approach to providing properly functioning habitat conditions on these lands, provided that the Forest Practices Board adopts all the necessary regulations to implement the agreement, adequate funding remains available to support the adaptive management provisions, and the co-managers are adequately funded to participate in implementing the agreement.

this standard.[4] Instream flows and closures have been established for WRIA 15, but not WRIA 16, 17, or 18.
2. For streams with completed flow studies but not yet adopted by rule, adopt recommended instream flow.
3. Water right compliance should be enforced and illegal users prosecuted.
4. Single family wells are currently exempt and unregulated by the Department of Ecology, but when considered as a whole for a watershed, with other issues such as watershed geology, these wells may impact streamflow, especially during summer low flow. The number of exempt wells in a watershed and their impact to streamflow needs to be quantified. Local governments may have to restrict building permits or use some other measures in areas where exempt wells are potentially in hydrologic continuity with streamflow.

Restoration Options:

1. To restore recommended flows to overappropriated streams (watersheds with a completed flow study and with water rights that exceed recommended flows), establish mandatory water conservation programs, enact emergency water conservation measures during critical low flow periods, and investigate the feasibility of trust water right programs or other water conservation measures such as purchase of existing water rights.
2. Restore lost, isolated, or degraded wetlands to promote hydrologic connectivity between streams and wetlands.
3. Reconnect and revegetate floodplains throughout summer chum watersheds to allow for greater long-term water storage and groundwater recharge.
4. Require stormwater management and reduce the extent of impervious surfaces to increase the contribution of rainwater to groundwater recharge, and ultimately summer baseflow (see Peak Flow).

B. Peak Flow

Problem Statement: Simplification of the drainage network has increased the frequency, magnitude, and duration of peak flows, affecting spawning success and egg incubation mortality. Modifications include increases in the amount of impervious surfaces, diking, clearing of vegetation for forestry and development, draining and ditching of wetlands, and improper routing of runoff from roads. The end result is horizontal and vertical instability in stream channels, loss of habitat complexity due to displacement of LWD, and increased depth of scour in streambeds due to increased hydrologic power. Increased peak flows have the greatest impact during the period when eggs are incubating in the gravel.

Objective: Prevent or minimize anthropogenic increases to peak flows which displace summer chum fry or scour redds.

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[4] WDFW, Washington Department of Ecology, and other state agencies have recognized the Watershed Planning process created under RCW 90.82 (HB 2514) as a reasonable approach to provide properly functioning habitat conditions with respect to the establishment of minimum instream flows. Not all tribes endorse the Watershed Planning process; some are participating under a specific set of conditions. Where local watershed groups organized through the HB 2514 process have failed to act, adopt, implement, or achieve the stated objective, then the strategies outlined in this section should be followed.

Protection Strategies:

1. Establish a maximum impervious area based on best available science for all basins and condition land use permits to be consistent with the stated objective. To minimize effects on stream ecosystems, establish 5% effective impervious area (EIA) as an interim threshold.[5] In basins with existing EIA >5% see restoration option #2.
2. Require stormwater management practices on *all* new development, at the scale of individual parcels. Minimize stormwater runoff by establishing low zoning densities in rural areas to minimize the amount of impervious surfaces, and retain 60% or more of a watershed in native forest vegetation[6]. In both rural and urban areas, require the use of innovative development[7] and zero-impact design[8] standards.
3. Ensure adequate cross drainage in ditchlines and mimic stormwater flow in undeveloped basins by infiltration of stormwater into retention ponds, grassy swales, forest floor, and constructed wetlands prior to entering the stream network.
4. New roads should be designed and constructed using techniques that minimize watershed-scale impacts. Such techniques include the use of narrow roads and limited overall road network density within the watershed.

Restoration Options:

1. To minimize channel instability associated with peak flows, re-vegetate degraded riparian zones.
2. For basins with existing EIA >5%, provide stormwater retention/detention facilities for development where it is currently lacking, and remove/refit unnecessary impervious surfaces.
3. To increase channel complexity and reduce the impact of peak flows, evaluate the potential to restore large woody debris in appropriate sites (see Channel Complexity section).
4. To increase floodwater storage capacity, restore wetlands within the entire basin.
5. Remove dikes to allow access of floodwater to the floodplain (see Channel Complexity).

## Water Quality

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[5] Threshold for effective impervious area is based on Booth and Jackson (1997); and May et al. (1997). We lack a precise understanding of the level of impervious surface development at which peak flows become a problem. In reality, the designation of a single threshold is highly problematic because variation in soils, rainfall, and the location of development can produce highly variable patterns of water delivery to stream channels at similar levels of development. However, we recognize that there is a pressing need for this information to direct local planning and we believe it is noteworthy that there are no basins with levels of development >5-10% where little or no impact exists. Consequently we use 5% EIA as a conservative threshold until further information becomes available.

[6] Retention of forest cover based on Horner and May (1998); King County (1989); Holtz et al (1998).

[7] Innovative design standards refers to new site planning techniques that utilize open space subdivision, cluster development, smaller lot sizes, narrower streets, greener and smaller parking lots, integration of unaltered forest and vegetated areas into developments to serve as zones of stormwater infiltration, stream buffers, stormwater practices, and other measures designed to reduce impervious surfaces and conserve natural areas (Holtz et al.1998)

[8] "Zero-impact" design is a series of techniques and practices directed at reducing the amount of effective impervious area. Examples of such techniques include eco-roofs (a green living roof composed of vegetation and soil), rain-barrels, bioretention, alternative paving surfaces, soils amendments, filter strips and filter-swale systems (Holtz et al. 1998).

## A. Temperature

Problem Statement: Adult summer chum enter subestuaries and rivers to spawn during or immediately following the period of annual thermal maxima and are thus vulnerable to peak temperatures, especially in streams with extensive groundwater or surface water extraction. Absent or degraded riparian corridors provide inadequate shading in many Hood Canal/SJF summer chum natal streams, and potential climate change poses a threat in many streams with current healthy thermal regimes. Secondary and potential impacts to stream temperature include channel widening which exposes a larger surface to solar radiation, and thermal heating of shallow groundwater related to vegetation clearing.

Objective: Promote or re-establish temperature regimes favorable for summer chum spawning and egg incubation life stages. Target temperature ranges are 7-12EC for spawning and 4-13EC for incubation (Bjornn and Reiser 1991).

Protection Strategies:

1. For perennial streams, provide a 250-foot, fully vegetated stream buffer measured from the edge of the channel migration zone or 100-year floodplain.[9] For seasonal streams, the buffer width should equal a site potential tree height (see Riparian Areas section). Alternative strategies must be site specific and use best available science to provide properly functioning habitat for summer chum salmon. The burden of demonstrating the sufficiency of an alternative strategy rests with the landowner (see footnote 3 in the introduction to section 3.4.4.2 regarding the Forest and Fish Report).
2. Prohibit additional surface water withdrawal and limit groundwater extraction in basins rated as moderate or high impact for temperature, unless the location is not in hydrologic continuity with the stream.

Restoration Options:

1. Re-vegetate degraded riparian areas (see Riparian Areas section). Farmers can enroll in the USDA/Washington State Conservation Enhancement Program (CREP).
2. Establish a trust for the conservation of instream flows (modeled after land trusts), and in water quality/quantity-limited streams, purchase existing instream water rights and pursue forfeited or abandoned rights for relinquishment.

## B. Toxics

Problem statement: Summer chum adults and juveniles migrate, spawn and rear in freshwater and estuarine habitats subject to soil and water contamination from toxic or hazardous substances. Sediment contamination and water quality impacts from these substances (heavy metals, volatile and semivolatile organics, radionuclides, etc.) may have direct and indirect effects on the ecology of the aquatic ecosystem, thereby reducing the ability of the habitat to support aquatic life.

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[9] Riparian buffer widths for maintaining stream temperatures are based on Brosofske et al. 1997, Pollock and Kennard, 1998.

Objective: Prevent the contamination of freshwater and marine aquatic ecosystems caused by toxic or hazardous chemicals through prevention, education and proper disposal strategies.

Protection Strategies:

1. Prohibit new industrial waste sites within summer chum watersheds.
2. Enforce current regulations regarding business use and disposal of toxic or hazardous materials. Encourage businesses that produce or use these materials to convert to non-toxic alternatives.
3. Educate the public about the use of toxic substances (including lawn and garden pesticides and fertilizers) and assure that adequate waste disposal systems are available to the general public.

Restoration Options:

1. Where contamination of surface water or sediments by toxic substances are known or suspected, conduct inventories to detect sources and volumes and implement clean-up programs.

C. Nutrients

Problem statement: Nutrient loading of surface and ground water can degrade freshwater and marine habitats used by summer chum and alter the food webs on which they depend. Increases in nutrient loads induce changes in primary productivity and the decay of organic matter. These changes frequently result in dissolved oxygen depletions that directly impact summer chum survival and fitness.

Objective: Prevent and mitigate the impacts to aquatic ecosystems utilized by summer chum salmon due to excessive nutrient loading attributed to inadequate septic systems, wastewater treatment facilities; improper disposal of domestic animal wastes; and poorly designed landfill sites.

Protection Strategies:

1. Prohibit the construction of new septic systems within the 100-year floodplain, adjacent riparian forests, and other areas with high ground water tables in hydrologic continuity with the channel network.
2. In sensitive areas or areas of high water tables require containment and pump-out septic systems that do not discharge to groundwater, and institute inspection and education programs to ensure compliance of on-site sewage system owners and users.
3. Restrict livestock from foraging and pasturing within riparian areas by fencing livestock out. Retain and plant native riparian vegetation.
4. Prohibit the construction of new landfills in summer chum watersheds within the region. While federal and state standards prohibit leachate or surface runoff from landfill facilities from contacting ground or surface waters, it is expected that landfills constructed in wet Northwest climates, using current technology, will eventually fail.

Restoration Options:

1. Institute regular on-site sewage system inspection, education, and maintenance programs in water-quality limited areas. Establish operating permits for failing, inadequate, or improperly maintained on-site sewage systems and condition their annual renewal on progress achieved towards meeting compliance.
2. Replace failing septic systems. Require that upgraded sewage disposal systems utilize containment and pump-out septic systems, or alternative systems in water-quality limited or high-risk areas.
3. Fence livestock out of riparian areas and plant riparian vegetation adjacent to streams currently dominated by farming and agricultural activities.
4. Eliminate surface water and ground water discharges from existing landfills to summer chum habitats and require extensive monitoring to evaluate performance of elimination strategies.

## Channel Complexity and Connection to Floodplain

Problem statement: A stream channel with complex habitat contains the best available chum habitat for their migration, spawning, and incubation life stages. Complex habitat includes deep pools (used for adult migration), stable riffles (spawning and incubation), side channels, and a sinuous channel form or enough LWD to slow water velocity and vary flow patterns (stabilizes riffles and creates pools). The floodplain should be fully connected to the channel and not confined by dikes, bridges, levees, bank hardening, or other man-made structures. Channel confinement leads to bed instability from increased velocities and eliminates sediment and water storage on the floodplain during floods. Man-made structures negatively impact fish habitat over time by reducing the area available for new habitat created by channel migration. Within the region, many streams have been simplified through LWD removal, ditching, diking, and bank armoring, which has negatively impacted summer chum.

Objective: Identify, protect, and restore channel segments to a complex habitat condition. Modifying land-use practices that degrade channel conditions, protecting key habitat, and restoring channel processes are emphasized in the strategies below.

Protection Strategies:

1. *Remnant habitat*- Identify floodplain areas (with a priority towards high quality remnant habitat[10]) for protection through floodplain easements, non-development agreements, or purchase.
2. *LWD*- Agencies and Counties with the authority to manage LWD (Department of Ecology, counties, USFS, DNR, Army Corps, WDFW), should preserve in-channel and floodplain LWD. For example, LWD moved for culvert maintenance should be passed downstream.
3. *Channel simplification*- Prohibit future bank armoring with riprap, diking, dredging, and gravel removal unless the project is shown to be consistent with a salmon habitat restoration plan. The State's Shoreline Management Act currently exempts bank armoring to protect single-family residences; this exemption should be removed. Local governments should implement more restrictive Shoreline Master Programs in summer chum streams. Where existing homes are threatened, relocation or government

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[10] High quality remnant habitat would include a naturally unconfined 100-year floodplain with multiple side-channels, a riparian forest of large mixed conifer/hardwood or conifer dominated, LWD frequency greater than 0.4 pieces per meter, and pools spaced less than 2-3 channel widths between each pool (Montgomery et al. 1995, Washington Forest Practices Board 1995).

purchase should be thoroughly evaluated. In instances where these are not options, LWD jams should be used to address channel stability problems.

4. *Riparian forest* - Retain riparian forests within the 100-year floodplain and adjacent riparian buffer of (250 ft or SPTH) to preserve future LWD sources to the channel and floodplain (see Riparian Areas section).
5. *Floodplain development* - Prohibit new housing, business, and road development within the 100-year floodplain. Upgrade Federal Emergency Management Agency (FEMA) floodplain maps to account for increased peak flows due to construction of roads and impervious surfaces. Floodproofing of existing homes within the 100-year floodplain should also be discouraged if such work further confines the river channel. Such projects shall be designed so as to result in no increased building footprint within the floodplain.
6. *Education* - Promote public education on the importance of LWD-rich, complex channels and the problems that occur when development and bank armoring occur within the floodplain.

Restoration Options:

1. *Floodplain and in-channel restoration* - Remove or setback dikes to allow the channel to meander, develop a pool-riffle morphology, and create a floodplain. The channel would naturally return to meandering morphology with minimal engineering assistance. Use LWD and other bioengineering systems to replace riprap. Remove spur-dikes, revetments, and othe man-made hard points.
2. *Riparian forest* - Identify channel segments where riparian forest restoration would provide a future source of LWD to the channel. This may include planting appropriate conifer species on agricultural or urban land, fencing livestock away from streams, conifer release through hardwood thinning, or conifer underplanting below thinned hardwood stands.
3. *LWD placement* - Identify channel segments where engineered logjams or LWD could be placed in the channel. This should be done only after a basin assessment has been completed for mass wasting and peak flows, and steps taken to reduce the impacts of these elements. Logjams that are fixed in place through cabling are less desirable since they create a fixed point in a dynamic system.
4. *Home buyout/relocation program* – Identify homes and businesses within the floodplain for buyout and relocation from willing citizens. Prioritize homes based on technical analysis of their impact to floodplain sediment transport and deposition processes and summer chum populations.

## Sediment

Problem statement: The development and stability of migration, spawning and incubation habitat for summer chum depends on the delivery rate, storage, routing, and composition of sediment. Landuse practices can increase the amount or type of sediment moving through the network through soil compaction or disturbance, changes to basin hydrology, ditches and impervious surfaces, vegetation removal or conversion, mass wasting (e.g. road fill failure), and a reduction in sediment storage through LWD removal or diking. The capacity to route and store sediment is decreased by channel straightening and LWD removal. In Hood Canal and eastern Strait of Juan de Fuca watersheds, unstable and aggrading stream channels and high levels of fine sediment, is a common problem, resulting in chum redd burial, scour, or suffocation of incubating eggs.

Objective: Re-establish sediment regimes to levels approximating historic variability by limiting landuse practices that increase the delivery rate and alter routing of sediment throughout the entire watershed.

Protection Strategies:

1. *Mass wasting*: Identify areas in a basin with high likelihood of mass wasting (landslides) using the Mass Wasting module in Watershed Analysis as a guide[11]. In these areas restrict development, road building, and logging. Pursue conservation easements or outright purchase for full protection of sensitive areas.
2. *Fine sediment*: Prevent the entry of anthropogenic fine sediment into any stream channel, wetland, or ditchline connected with the stream network through improved stormwater management, clearing and grading standards. Biofiltration swales or ditches designed to trap sediment that are not directly connected to the stream network should be capable of withstanding 100-year storm events.
3. *Large woody debris*: Protect intact riparian forests, especially those with large diameter conifer trees as a source of LWD to the channel (See Riparian Areas and Channel Complexity sections).

Restoration Options:

1. *Road and culvert upgrade*: Reroute road drainage away from stream channels into stable receiving areas such as retention ponds, grassy swales, forest floor, and constructed wetlands (see Peak flow section). Increase road cross drains to lower concentrated road drainage. Re-vegetate or stabilize road side-cast, vegetate or armor ditch lines, and harden road surfaces to reduce the creation of fine sediment. Upgrade all stream crossings to current WDFW regulations.
2. *Decommission forest roads*: For roads no longer used, remove culverts, de-compact roads, outslope and waterbar road surfaces, remove unstable fill and side-casting, and seed with native species. Prioritize decommissioning by the risk that a road will contribute sediment to a stream channel. Allow for adequate revegetation of the area prior to fall rains.
3. *Floodplains:* Reconnect floodplains through dike removal and re-vegetate with the appropriate conifer species to provide temperature regulation, future recruitment of LWD, and the stabilization of sediment (see Channel Complexity section).
4. *LWD introduction*: If necessary after the above measures are completed, re-introduce LWD to provide short-term channel structure and sediment storage (see Riparian Areas and Channel Complexity section).
5. *Channel sinuosity*: Restore channel form to areas where the channel has previously been straightened.

## Riparian Areas

Problem Statement: Riparian forests provide a variety of critical functions essential for all life stages of summer chum. These functions include: nutrient processing and retention, pollutant filtration and removal, microclimate modification and temperature regulation, fine and coarse sediment storage, bank stabilization, delivery of organic material to stream channels (leaf litter, small and large woody debris), and the creation and maintenance of off-channel habitat. When forests are cleared from riparian areas these critical

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[11] See the Kitsap County Critical Areas Ordinance for an example of standards that minimize mass wasting and protect aquatic habitat.

functions are lost and the stream environment becomes more susceptible to impacts from grazing, agriculture, residential development, road construction, and urbanization.

Riparian forests influence the survival of all summer chum life stages:

- Migration: Large woody debris forms pools, creates critical holding areas, and hiding areas for migrating adults and juveniles.
- Spawning: Debris jams and individual pieces of LWD route, store, and stabilize spawning gravel; the rooting strength of live trees promotes channel and bed stability; streamside vegetation filters nutrients and fine sediment before it enters the stream channel.
- Rearing: Large woody debris and log jams create overflow channels, side channels, and off channel ponds; LWD provides hiding cover for juveniles; live vegetation provides thermal protection for incubating eggs; leaf litter provides nutrient input and supports macroinvertebrate populations that are prey resources.

Many riparian areas have been cleared of native forest and their capacity to perform these ecological functions have been lost or severely degraded. Even where riparian forests remain relatively intact, their character and quality have been altered from past logging, causing shifts in age and species composition (largely to younger, deciduous-dominated forests), which has reduced their functional value.

Objective: Identify, protect, and restore healthy riparian forests within the channel migration zone or 100-year floodplain, and areas adjacent to the active stream channel. Riparian forests should contain a diversity of plant species, vegetation size classes, downed woody debris critical for tree seedling regeneration, and be of sufficient size to persist over time through natural disturbance events (fire, wind, drought).

Because of the longitudinal connectivity in riparian systems, consideration of the entire stream network is necessary. This network includes the primary summer chum zone, upstream reaches that do not directly support summer chum, and smaller seasonal tributaries that are non-fish bearing. These areas affect the quality of the primary summer chum zone by producing and transporting LWD, water, and sediment materials that create and maintain critical habitats in the lower gradient reaches inhabited by summer chum. For example, up to 48% of LWD found in low gradient stream channels comes from upstream sources rather than riparian forests immediately adjacent to the stream channel (McDade et al. 1990; Burnett and Reeves 1997; McGarry 1994).

Protection Strategies:

1. Protect riparian areas with a properly functioning buffer. A properly functioning buffer is defined as 250 ft measured horizontally from the landward edge of the channel migration zone or the 100 year floodplain (whichever is greater).[12] For seasonal streams, the buffer width should equal that of a site potential tree height (SPTH) measured horizontally from the edge of the ordinary high water mark. To maintain and restore habitat, it is necessary to retain properly functioning riparian forests in non-

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[12] Riparian buffer standards are based on an extensive literature review of riparian functions and recommended buffers (Pollock and Kennard, 1998).

developed portions of a watershed and recreate functional riparian forests where possible within developed portions of a watershed.[13]

2. Prohibit salvage, thinning of trees, or other manipulations of riparian vegetation within the defined buffer unless it can be demonstrated that the activity will result in a net improvement in riparian forest quality (see restoration option #3).
3. Restrict road building and development within the channel migration zone and reduce or eliminate these activities within the adjacent riparian buffer.
4. Prohibit all grazing within riparian areas.
5. Provide incentives and compensation to small landowners for buffers left for the benefit of ESA listed species (e.g. CREP, Public Benefit Rating System, or other tax incentives).
6. Identify priority riparian forest areas within the 100-year floodplain and associated wetlands, and acquire through purchase or donation, conservation easements or transfer of development rights. This may include acquisition of timber, farm/grazing, development rights, and/or restrictions on hydrological modifications.

Restoration Options:

1. Fence and replant riparian areas impacted by grazing or other agricultural activities.
2. Plant native trees and shrubs appropriate for site conditions within riparian forests to promote recruitment of young trees and restore native vegetation, species diversity, and large old trees.
3. Identify opportunities for silvicultural treatments to improve riparian forest composition in terms of species diversity and size of trees. A qualified biologist should be consulted for silvicultural treatments within the first 50 feet of the riparian buffer, or the channel migration zone. Silvicultural treatments include, but are not limited to: thinning of overstocked conifer stands, thinning hardwood stands to release understory conifer, and girdling to create snags or encourage recruitment of LWD. Silvicultural treatments should be regarded as experimental, include a monitoring plan to determine the effectiveness of the treatment, and be done in cooperation with tribal and state biologists.
4. Identify opportunities to abandon existing road grades and replanting with native species to restore riparian forests.

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[13] All four counties have commented on the difficulty in applying this strategy in areas where they have jurisdiction. This strategy received more comments than all others in a preliminary review. This strategy is biologically based and contains no economic considerations. Our recommendations are conservative and centered on habitat recovery. Alternative strategies must be site specific and use best available science to provide fully functional habitat for summer chum salmon. The burden of demonstrating the sufficiency of such a strategy rests with the landowner.

For lands and forest practice activities regulated by state forest practice regulations, WDFW is on record supporting the Forest and Fish Report and the protective provisions contained therein. Not all tribes endorse the Forest and Fish plan. WDFW continues to support this agreement as a reasonable approach to providing properly functioning habitat conditions on these lands, provided that the Forest Practices Board adopts all the necessary regulations to implement the agreement, adequate funding remains available to support the adaptive management provisions, and the co-managers are adequately funded to participate in implementing the agreement.

## Fish Access/Passage

Problem Statement: Roads, dikes, and causeways have reduced the production potential in summer chum riverine and estuarine habitats through modification and restricted access for spawning, incubation, migration, and rearing.

Objective: Provide adult summer chum salmon with free and unimpeded passage in all waters within their historic range and provide opportunities for juvenile chum to migrate from their natal streams downstream into historical estuarine and nearshore habitats.

Protection Strategies:

1. Restrict the placement of new roads and culverts within the channel migration zone adjoining the historic range of summer chum or provide adequate mitigation for unavoidable projects. Mitigation could include minimizing the placement of fill within the 100 year floodplain, reducing the extent of the road footprint, avoiding roads paralleling streams, and the use of bridges rather than culverts for stream crossings.
2. Prohibit the placement of dikes, the augmentation of existing dikes, and new development activities (including agriculture) in summer chum zones that may confine and restrict the development of side channels and complex channel segments.

Restoration Options:

1. Identify opportunities for removing existing dikes, roads, and causeways that prevent the establishment of side channels and complex stream channel characteristics.
2. Redesign existing dikes, roads or causeways to allow the free movement of water, wood and sediment and passage of summer chum adults and juveniles.

## Subestuarine Habitat

Problem Statement: Summer chum salmon rely on diverse, productive, and structurally-complex subestuaries as rearing, feeding, refuge, and transition habitat. Extant dikes, ditches, road causeways, and fill disrupt the linkage between stream channels, subestuaries and tidal energy. As a result, the productive capacity of Hood Canal and eastern Strait of Juan de Fuca tributary subestuaries is degraded or destroyed and mortality potentially increased at critical life stages. Subestuaries are truncated or sediment accumulates in subestuaries and the lower reaches of freshwater streams. Water quality degradation has led to deleterious shifts in marine vegetation communities. Remaining, high-quality subestuaries are threatened by agricultural and residential development.

Objective: Protect or restore natural delta morphologies of Hood Canal and eastern Strait of Juan de Fuca tributaries to allow for unrestricted estuarine circulation, natural sediment transport/storage rates, and development of tidal channels, tidal marshes, swamps and eelgrass beds, all of which maintain high quality summer chum rearing and transition habitat.

Protection Strategies:

1. Identify and acquire (through outright purchase or transfer of development rights) undeveloped, high-quality subestuarine habitats in Hood Canal and the eastern Strait of Juan de Fuca.
2. Prohibit further ditching, diking and road causeway construction in deltas of Hood Canal and the eastern Strait of Juan de Fuca, including but not limited to watersheds harboring summer chum populations.
3. Control water quality impacts (failing septic systems, livestock, etc.).

Restoration Options:

1. Remove or setback dikes in Hood Canal and eastern Strait of Juan de Fuca delta areas to restore summer chum rearing and production. Consider breaching if other options are not available and there is accessible and functional salt marshes or swamps behind breached dikes. One experimental method (to be tried on a limited basis) is to remove anthoprogenically caused channel sediment accumulations associated with dike construction into the subestuary.
2. Re-establish natural, branching tidal channels and patterns of inundation across the delta face.
3. Refit or remove road causeways to reconnect distributary channel and tidal slough habitats with mainstem river channels and restore the interface between freshwater and subestuarine habitats.
4. Restore sinuous stream channel morphology in the lower reaches of channelized streams.

## Nearshore Habitat

Problem Statement: Shoreline activities such as construction of bulkheads and piers, filling portions of the intertidal zone, shoreline armoring, and vegetation clearing have disrupted important shoreline processes and altered or destroyed critical rearing and migratory habitats. Water quality degradation has led to deleterious shifts in marine vegetation communities.

Objectives: Maintain or restore critical nearshore processes and conditions including: 1) sediment supply and transport necessary for the formation and maintenance of critical habitats (e.g. eelgrass and kelp beds); 2) critical migratory pathways free of impediments for juvenile and adult summer chum; 3) abundant and diverse native macroinvertebrate populations necessary for the growth and survival of juvenile summer chum; and 4) large woody debris recruitment processes, shoreline shading and cover, detrital inputs, and slope stability provided by mature shoreline vegetation.

Protection Strategies:

1. Prohibit the construction of new bulkheads along shoreline areas. If existing homes and infrastructure are threatened by erosion, use geotechnical analyses to develop alternative shoreline protection measures (in order of preference): relocation of threatened structure, drainage control, vegetation plantings, beach nourishment, or other reasonably protective measures.
2. Prohibit, or severely restrict the construction of new piers, docks, stair-towers, and recreational floats by private individuals. Require joint use facilities in areas away from critical habitat (i.e. eelgrass, kelp, baitfish spawning habitat).

3. Eliminate chemically-treated wood products, where these products can leach to adjacent marine waters (see City of Tacoma Shoreline Master Program for an example).
4. Establish *interim* minimum shoreline riparian buffers of 250 ft measured horizontally from the landward edge of the mean higher high water (MHHW) mark or salt marsh-forest transition zone, whichever is greater. No vegetation removal should be allowed within buffers, except for minor view clearing (<15% removal of stems over a ten-year period). For unstable and eroding shoreline segments, additional setbacks should be required to accommodate 50 years of erosion (determined by geotechnical analysis). In general, the higher and steeper the bank, the greater the additional setback requirements are needed to secure intact, fully functional riparian areas over the long-term.[14]
5. Identify critical nearshore migratory corridors and establish as marine reserve areas.
6. Purchase and permanently protect undeveloped shoreline areas.
7. Control water quality impacts (failing septic system, livestock, etc.).

Restoration Options

1. For unavoidable construction of new shoreline roads, bulkheads, docks or piers, require compensatory mitigation payments to a mitigation fund account, which would be used to fund purchase or restoration of shoreline and subestuaries.
2. For existing bulkheads that are failing, evaluate the need for replacement. If the structure is not necessary, remove it and restore shoreline. Where existing homes are threatened, relocation or government purchase should be thoroughly evaluated. In instances where these are not options, failing bulkheads should be replaced with an alternative lower-impact designs (e.g. “soft-bank” protection, beach nourishment).
3. Remove or relocate bulkheads and fill, and structures above extreme high water or higher to recover lost habitat and restore beaches.
4. Require revegetation of banks that have been damaged during shoreline construction projects.
5. Remove man-made structures that prevent erosion of natural marine sediment sources (feeder bluffs, etc.) and structures that interrupt sediment in the nearshore.

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[14] We adopt a conservative strategy with regard to protection of marine riparian areas, designed to be improved and refined as our understanding of this system expands. While we lack adequate scientific understanding of functions served by marine riparian areas, the demonstrated functional values of riparian areas in freshwater systems also apply along marine shorelines (Desbonnet et al. 1995): bank stabilization, shade, organic material inputs, pollutant removal, etc. Our choice of a conservative buffer width is also related to the intensity of land use typically found along developed portions of the Hood Canal and the eastern Strait of Juan de Fuca shoreline (e.g. residential development with on site septic systems), which necessitates prudence given the potentially profound impacts to nearshore and open-water environments used by summer chum.

## 3.4.4.3 Evaluation Criteria for Proposed Restoration Projects

The toolkit (section 3.4.4.2) describes strategies or general options for restoration actions. It is anticipated that specific projects will be developed out of the general strategies. The objective for individual restoration projects is to restore aquatic ecosystems and natural channel processes within the region that impact specific summer chum life history strategies. In pursuit of this objective, the following criteria should be used as an aid in making decisions about proposed projects, and in prioritizing and comparing proposed habitat restoration projects within the region.

Projects are evaluated relative to a set of criteria that test the scientific basis and validity of the proposal. The criteria are weighted based on the importance of the criteria in achieving the stated objective of restoring natural channel processes. A score on the low end of the defined range indicates a low probability of achieving the criteria. Conversely, a project that has a high probability of achieving the criteria should be awarded the high end of the defined range. The total score will help establish priorities for restoration actions across the region. Other factors such as funding and socio-political objectives may also be factored in to establish restoration priorities.

### Evaluation Criteria:

1. The proposal is linked to the factors for recovery identified in the watershed narrative and/or objectives in the tool kit and addresses the habitat factor(s) for decline and not just symptoms. **(1,5,10 pts)**
2. Extinction risk (from section 1.7.4 Stock Extinction Risk, Part One) of the local population within the targeted drainage. **(1,3,6,10 pts)** (Proposals in drainages with local populations at higher risk of extinction should be rated higher).
3. The proposal addresses the effect of the completed project on the upstream and downstream channel reaches including its effect on lateral channel migration, bed scour, gravel deposition and the connection of the channel to the floodplain (i.e., the proposal will have a positive impact outside of the project area). **(1-3 pts)**
4. The proposal is self sustaining and requires minimum maintenance and additional human intervention to the fullest extent possible or such maintenance and intervention is clearly provided for throughout the life of the project. **(1-3 pts)**
5. The project will function long enough to positively affect the targeted factor for recovery specified in a watershed narrative. **(1-3 pts.)**
6. The proposal includes sufficient evaluation and monitoring to assess its success or failure consistent with evaluation and monitoring guidelines outlined in section 3.4.5. **(1-3 pts.)**
7. The proposal will not prevent other actions from being implemented at or near the site that would provide greater benefit to the restoration of channel processes. **(1-3 pts)** For example: An access road in the estuary should not be removed until dikes or fills in the estuary have been addressed.
8. The proposal increases our knowledge of a specific option in the tool kit and utilizes adaptive management principles to incorporate the information gained into improved project selection and design. **(1-3pts.)**
9. The proposal provides benefits to other critical species (Puget Sound chinook, bull trout, etc.) **(1-3 pts)**

### 3.4.5 Strategy for Monitoring Population and Habitat Recovery

Currently, our understanding of the critical habitat needs of summer chum is incomplete, and, as such, recovery planning will require careful monitoring and research to evaluate its effectiveness and define future protection and restoration needs. The toolkit of options to achieve the diverse and functional habitat will need refinement to focus future recovery actions, as more information becomes available. In addition, implementation and effectiveness monitoring for individual restoration projects will be needed. Finally, validation monitoring will be required to understand the overall ecosystem or watershed context for restoration actions, and to determine if completed restoration actions are "rejuvenating" functional habitat and that it is being used by summer chum. Together, monitoring and research will provide feedback on our current understanding of summer chum and their habitats, which will be used to guide future planning and recovery efforts.

At present, we lack an integrated monitoring system for summer chum and their habitat in Hood Canal and the eastern Strait of Juan de Fuca with which to evaluate recovery efforts. Limited stream habitat survey data exist, but there is little interagency coordination and prioritization for the collection of additional information. There is little or no data for subestuarine or nearshore areas, despite the apparent importance of these environments in the life history of summer chum. Lastly, we lack a meaningful way to connect information on habitat and life history processes across scales to determine potential population "bottlenecks" and to evaluate the interrelationships among factors responsible for population decline and recovery. As a result of these deficiencies, our current ability to evaluate the importance of various habitat factors is limited.

In the past, targeted research and monitoring efforts of this kind have lacked rigor in their design and/or implementation, which has diminished their overall usefulness in later planning and evaluation. To be effective an overall research and monitoring strategy for summer chum will have to consider the habitat needs of particular life stages in the context of watershed, estuarine, and nearshore processes that create and maintain key habitats. To accomplish this, the strategy will have to be long-term, provide feedback on effectiveness, utilize a multi-scale approach, and involve both landowners and government agencies with regulatory/management authority over summer chum populations (or their habitat) in Hood Canal and the eastern Strait of Juan de Fuca. Each of these key components is discussed in more detail below:

- Long-term Focus - Both summer chum populations and their habitats are subject to natural variation, resulting from climate and natural disturbances, which may mask the detection of both positive and negative human impacts. Long-term monitoring is necessary because only through the collection of data across a number of years can effects of human actions be separated from "noise" associated with natural variation. Moreover, long-term monitoring is essential because recovery is necessarily a long-term proposition requiring frequent feedback and evaluation (see below).

- Multiscale Approach - Effective research and monitoring for summer chum habitat recovery will require explicit definitions of the appropriate scale of analysis and measurement of target parameters. Information collected at broader scales will guide analyses at finer scales, and information collected at finer scales provides feedback on cumulative effects at larger scales. For example, scour chain monitoring to measure the deleterious impacts of peak flows and mobile spawning substrates on incubating summer chum could be implemented along a single reach, within a single watershed. However, inference to other reaches or watersheds would be problematic, given that reach-scale hydrologic regimes are often a function of stream network position, and watershed or regional geoclimatic characteristics. To be effective and useful, recovery-oriented research and monitoring will have to employ spatially-nested sampling regimes to separate reach-, watershed-, and subregional-scale habitat effects on summer chum populations.

- Involvement of Diverse Entities - As noted in section 3.4.6, which discusses plan implementation, numerous federal, state, local and tribal governments have different mandates, goals, and regulatory/management authorities across the region. To efficiently allocate effort and monies for research and monitoring there needs to be coordination among involved parties. While priorities for research and monitoring do not necessarily have to be agreed upon, acceptable protocols must be established and adhered to by all parties if the collected data is to be useful. There must also be cooperation with data sharing among all parties, and efficient data storage and archiving structures to facilitate access and transfer to other parties. Private land owners and public land managers will also need to cooperate and participate in conservation monitoring.

- Adaptive Management Approach - As noted above, frequent feedback will be necessary to determine if conservation actions are being effective. Adaptive management formalizes this arrangement to maximize the usefulness of new information. Management actions are viewed as experiments, under a continuous cycle of monitoring, evaluation, planning and adjustment. Three types of monitoring will need to be employed to provide feedback on project design, effectiveness, and overall ecosystem context (Table 3.20). Each of these monitoring types will provide important information with which to revise future recovery action planning.

We provide examples of the types of questions that need to be answered in monitoring for particular restoration actions below. These examples are not intended to be exhaustive, but are meant to focus thinking on the requirements for effective restoration actions. We recommend the formation of a recovery monitoring and research workgroup to develop an integrated monitoring plan for habitat, harvest, and supplementation activities.

**Table 3.20.** Key monitoring questions and approach.

| Habitat Parameter of Concern | Key Monitoring Questions and Approach |
|---|---|
| Peak flows | 1. Stormflow runoff assessment: Calculate the amount of impervious surface (aerial photo/GIS analysis) and monitor the hydrograph in watersheds that are urbanizing to determine if stormwater detention/retention facilities and other mitigation measures meet the goal of not exceeding the 2-year and 10-year predevelopment floods. All of the summer chum watersheds need continuous real-time monitoring of stream discharge for both peak and low flow conditions (e.g. USGS stream gauging stations).<br>2. Upland drainage pattern assessment: Evaluate channel network extension as a result of forest road construction and determine if peak flow magnitude, timing, or frequency has changed as a result. If evidence exists for altered runoff regimes, examine upland mitigation actions. If standards are not being met, how are other in-channel restoration actions to be justified? |
| Low flow | 3. Low flow monitoring: Monitor low flow conditions via staff gauges (or USGS gauging |

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|---|---|
| | stations) and wetted area/depth to ensure that target stream flows are being met and |

**Table 3.20.** Key monitoring questions and approach (continued).

| **Habitat Parameter of Concern** | **Key Monitoring Questions and Approach** |
|---|---|
| | conservation measures are effective. If there is evidence of low flows, is temperature being monitored (see 5, below)? What is the seasonal pattern of low flow, and does it coincide with presence of summer chum spawning?<br>4. Wetland restoration planning: Evaluate potential for wetland restoration as a means to mitigate for low flow problems. Define existing site condition of wetland to be restored (soils, hydrology, wetland type, watershed relationship), source of degradation or isolation, and pre-disturbance conditions (if possible). Establish wetland plant objectives (vegetation density and type, hydrologic regime) and identify appropriate wetland reference site for comparison. Monitor to determine if desired wetland objectives (wetland hydrology, vegetation, and water quality) are achieved within a specified time period and compare to reference site conditions. |
| Water Quality-temperature | 5. Deploy thermographs in Hood Canal streams and subestuaries harboring summer chum. Prioritize streams for monitoring based on existing temperature data and known regional patterns (e.g. eastside Hood Canal should have a high priority given their naturally-warmer temperature regimes).<br>6. Low flow monitoring (see 3, above)<br>7. What is the frequency and extent of ulvoids in embayments? Quantify marine vegetation community shifts. |
| Channel complexity /floodplain | 8. Channel LWD loading assessment: Calculate the existing level of in-channel LWD and compare to recommended wood loading rates for the appropriate channel type. If levels are below target and short-term recruitment potential from adjoining stands is low, evaluate the potential for LWD placement. Establish LWD objectives and monitor implementation of plan to determine: 1) if LWD is retained during high flow events; 2) effectiveness in storing sediment and creating desired channel conditions; 3) changes in channel characteristics within and downstream of treated reach.<br>9. Channel stability assessment: Establish channel cross-sections (and analyze aerial photos) to monitor channel change each year. Evaluate the effectiveness of removal of dikes, roads and other bank hardening structures to increase the resilience and flexibility of the channel to respond to flood events and changing sediment loads. Methodology includes scour-chain monitoring and substrate assessment (Wolman pebble count). Factors such as an absence of stable spawning habitat, lack of quality pool habitat, and high flow refugia are believed to be the limiting factors to salmonids due to channel constriction and floodplain loss. Monitoring activities would also evaluate spawning and rearing success.<br>10. Riparian forest condition assessment: (see 13 and 14 below). |
| Sediment | 11. Sediment delivery sources: What are the existing or potential sediment sources in the watershed? Are areas of mass wasting likely to deliver sediment to stream channels? Has any mass wasting been initiated from decommissioned roads? Is follow-up work necessary? Is percent fine sediment increasing in spawning gravel? Monitoring tools includes aerial photo landslide inventories and field surveys.<br>12. Sediment routing: What is the capacity of the stream for transporting and storing sediment when and if it is introduced to channels as a result of landslides or road failures? How will this impact other restoration actions, such as in-channel placement of LWD (see 8 above)? Have altered flow regimes impacted sediment transport capacity of stream? |
| Riparian forest | 13. Acquisition and easements: Would riparian acquisition/protection provide for the long-term protection or restoration of channel processes and benefit one or more summer chum life stages? Are any involved private landowners aware of any property restrictions that |

| | |
|---|---|
| | may be involved? What are the legal obligations of involved parties? Who will be responsible for the routine inspection, management, and enforcement activities? Have maps or inventories been prepared? Is there a need for baseline inventory and mapping for future monitoring purposes? |

**Table 3.20.** Key monitoring questions and approach (continued).

| Habitat Parameter of Concern | Key Monitoring Questions and Approach |
|---|---|
| | 14. Riparian vegetation restoration: Are the plants growing and being maintained to ensure the establishment of an effective riparian corridor? What percent of the plant material survived after one year? Two years? Has the species mix changed? What was the survival relative to the landform it is rooted upon (e.g., the landform height above the channel)? What was the major cause of plant mortality? Is fencing effectively excluding livestock from the riparian area for the term of the agreement or the life of the project? What happens at the end of the agreement or the life of the fence? |
| Fish passage | 15. Evaluate the effectiveness of obstruction removal and the use of reclaimed habitats by fish. Are summer chum utilizing reclaimed habitats? What other additional protection and restoration actions in adjacent areas might further enhance the productivity of reclaimed habitats. |
| Subestuarine Habitat | 16. Measure salinity and tidal inundation in subestuaries before and after habitat alterations to track effectiveness of re-establishing natural estuarine processes.<br>17. Analyze 1:12,000 chronological (early 1940s to present) scale aerial photo record and other historical records (e.g., topographic 'T-sheet' surveys) of Hood Canal tributary estuaries and use to monitor changes in sediment dynamics, marsh vegetation, and tidal channel development resulting from natural processes and specific habitat alterations.<br>18. Standardize subestuarine sampling protocols and surveys for subestuarine function. |
| Nearshore Habitat | 19. What is the current rate of shoreline armoring in different areas of Hood Canal and how has this impacted nearshore habitat? Standardize subestuarine sampling protocols and surveys for subestuarine function.<br>20. Do summer chum utilize native understory kelp habitat, and what is the significance of these habitats in their life-history? |

General summer chum research needs: The following research and monitoring needs were identified in our watershed and subestuarine assessments:

- A system of stream classification that will allow for the appropriate stratification of streams for the purposes of protection, restoration, and monitoring. The Salmon and Steelhead Habitat Inventory and Assessment Project (SSHIAP) is currently at work on a database linked to a GIS that will provide recovery planners with a valuable tool for prioritizing protection and restoration work. However, technical support for GIS development and the linking of database and GIS interfaces is needed to make the promise of this tool a reality.
- Habitat surveys in streams for which little or no data exist. Surveys in anadromous reaches should be highest priority, followed by surveys of streams and reaches that are critical contributing areas for anadromous reaches. For many watersheds (e.g. Dosewallips, Duckabush, Lilliwaup, Seabeck) little or no habitat survey data exists. In most other streams, survey information is limited in scope or constitutes a single season survey.

- Surveys to identify additional streams within the region harboring summer chum. Spawning surveys now occur in watersheds that contain extant chum populations, and some watersheds with extinct populations (Dewatto, Tahuya, Skokomish). New surveys are needed to document recolonization of other watersheds (e.g. Big Anderson and Chimacum) to determine the relative stability of recently-founded populations. Surveys are also needed in the Dungeness, suspected of having a modest-sized, but self-sustaining population.
- Standardized sampling protocols and surveys for the assessment of estuarine function and condition relative to their rearing capacity for summer chum and their historical condition.
- Scour-chain monitoring in multiple watersheds with different hydrologic regimes and levels of human impact. Increases in peak winter flows, streambed mobility, and consequent redd scour is widely perceived as a major factor for decline of summer chum in Hood Canal and eastern Strait of Juan de Fuca. Scour chain monitoring could be matched with emergence trapping to link population processes with this important physical parameter.
- An assessment of cumulative impacts at the scale of the estuarine landscape. Quantitative data on shoreline impacts in Hood Canal and the eastern Strait of Juan de Fuca is needed, and must be connected to estuarine and nearshore habitat mapping efforts to understand the impacts of human modifications on critical summer chum habitats.
- A multi-scenario analysis of full buildout (completed by each respective county) using standard and alternative design and materials (refer to peak flow toolkit section). Increasing impervious surfaces from roads, residential development, and urbanization is an important indicator of loss of fisheries habitat potential (May et al 1997). An analysis evaluating the incorporation of innovative designs could identify potential ways to reconcile development pressures with habitat protection needs.
- A life history study of selected summer chum populations. Do summer chum spawn intertidally? How long do they rear in estuaries? There is substantial evidence that migration timing and habitat use differs between summer chum and fall chum in Hood Canal, yet most of our current life history information is derived from studies on fall chum. A detailed life history study is needed for summer chum to understand the connections between populations and their habitat.
- An analysis of hydrologic change. Channel shape and form result from the interaction of water, sediment, and gradient working together over many years. Channels modify their shape and form to accommodate different levels of sediment moving through rivers over time. Artificial constrictions in natural channels such as bridges or culverts interfere with a channel's ability to accommodate different sediment regimes, concentrating sediment and flow in confined channels. Increased flows have severe consequences for redds and rearing habitat such as pools while increasing bank erosion. Channel geometry needs to be investigated in conjunction with peak flow events to understand the ability of channels to handle peak flows.

### 3.4.6 Implementation of Habitat Elements of Summer Chum Recovery Plan

Authority and jurisdiction for habitat protection is shared by a multitude of agencies, including local, state, federal and tribal governments. Within the Hood Canal region there at least 25 separate agencies with some level of jurisdiction over habitat. These organizations vary widely in their mandate, available resources, expertise, and implementation abilities.

Numerous federal, state, and local laws currently exist to protect habitat (Table 3.21). Despite this fact, habitat conditions within the Hood Canal region continue to degrade based on the following factors:

- Many natural resource laws or policies were typically adopted only within the last 5-30 years, and the application and enforcement of earlier laws (e.g. the 1949 Washington State Hydraulics Code) was often sporadic at best. Many of the most egregious impacts were historical practices (e.g. splash dams, entire watershed logging) that continue to overshadow relatively recent improvements in habitat protection.
- The increasing decentralization of natural resource management authority from federal to state to local levels has not been matched with adequate funding, resulting in a lack of qualified staff to implement increasingly complex laws. For example, the Growth Management Act established extensive planning and regulation authority at the County level, yet implementation of its standards is often stymied by insufficient funding to hire qualified biological or enforcement staff.
- Enforcement of existing laws is often inconsistent, so that non-compliance penalties is seen as "a cost of doing business". For example, the penalty for removing trees within a riparian buffer is frequently less than the value of removed timber, creating little disincentive to potential violators.
- Many laws and policies are not strictly based on biology but instead represent a balancing act between political acceptability and science. In addition, many laws are enacted at geographic scales substantially different from those used by natural resources, especially for migratory species. For example, Hood Canal summer chum migrate through marine areas within the jurisdiction of four county governments with four different standards for shoreline protection.
- Many laws have categorical exemptions for smaller projects, such as those associated with single family residences. The cumulative impacts of these projects have not been considered, yet single family residences constitute the majority of development within the rural counties of the Hood Canal region.
- The effectiveness of adopted standards has not been consistently monitored, evaluated, or revised based on adaptive management principles, resulting in outdated policies that are difficult if not politically impossible to change.

Section 3.4.4 describes a broad protection and restoration strategy and implementation for the watersheds comprising the region (see also Appendix Report 3.6). This section outlines a procedural framework for plan implementation by defining the various important players, roles, and key implementation elements for those entities. It does not commit these parties to action, but rather identifies potential pathways for further policy debate and decision by the appropriate jurisdictions. Lacking a single authority with a habitat protection mandate, the success of the recovery plan regarding habitat objectives is largely dependent on mutual cooperation between various governmental and non-governmental entities.

### Regional policy groups (Hood Canal Coordinating Council)

The Hood Canal Coordinating Council (HCCC), composed of the three counties (Mason, Kitsap, Jefferson), two tribal governments (Port Gamble S'Klallam, Skokomish Tribe) and numerous ex-officio members (federal, state governments) has been identified as the lead entity for salmon habitat recovery planning under Washington State HB 2496. As such, the HCCC will be developing a strategic plan for implementation that should include the recommendations of this plan as well as other non-regulatory programs such as education, incentives, and voluntary protections. The Hood Canal Coordinating Council has also elected to be the lead entity for restoration planning through House Bill 2496, and as such, will be responsible for awarding prioritization of restoration and protection projects. Numerous technical issues will need to be addressed, and it is recommended a technical committee be formed to assist the HCCC.

Clallam County, which is not a member of the HCCC, will be the lead entity for actions within their jurisdiction, with the same relative roles and responsibilities described above for the HCCC. Coordination between Clallam County and the HCCC will be critical to ensure consistency.

Local governments (Counties, Cities, PUDs)

Local governments have primary authority over landuse decisions that affect habitat quality. As outlined in Table 3.21, numerous laws currently exist to protect habitat, but the following actions are recommended:

- Counties/Cities: Evaluate current regulatory and policy statements for consistency with specific recommendations provided in section 3.4.4.2 (Toolkit of Protection and Restoration Strategies). In particular, elements of Critical Areas Ordinances, Comprehensive Plans, Shoreline Master Programs, and Stormwater Ordinances, need to be evaluated and recommendations for changes made to local decision-making bodies. In addition, local tax codes need revision to remove economic incentives encouraging land development practices that are deleterious of critical salmon habitat (e.g. construction of bulkheads along shorelines).
- Local governments should identify timelines for changes, staffing/funding needs, and enforcement issues. In some cases improvements in landuse ordinances have not been accompanied by increased staff to enforce needed regulations.
- PUDs, cities, and other water purveyors: Ensure future water planning is consistent with recommendations relative to flow, integrate planning for future water appropriations with long-term development planning, and enact water conservation programs.
- The Conservation Districts work extensively with landowners to educate, promote stewardship and encourage voluntary restoration projects. They will play a key role in translating technical information contained within this plan to local landowners, gaining acceptance, and developing specific restoration projects for individual properties.

State agencies (DNR, DOE, WDFW, WADOT, PSWQAT, CTED, WA Conservation Commission)

No single state agency has authority over the complex array of processes that creates habitat quality. The Governor's salmon strategy provides a programmatic review of laws, agencies and activities that the state intends to coordinate and implement as part of the regional salmon strategy. Section 3.4.4.2, toolkit, and below provide direction for the Governor's task force and agencies, and identify key deficiencies in existing programs. The following actions are recommended:

- DNR (Department of Natural Resources): Evaluate the adequacy of forest practices rules, monitor effectiveness of completed watershed analyses and make changes as needed.[15] Implement appropriate protection and restoration measures, especially related to riparian protection, road upgrades or decommissioning, and hydrologic maturity. In some instances, modifications to existing standards and conditioning beyond current regulations are necessary to protect and restore habitat for summer chum.

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[15] For lands and forest practice activities regulated by state forest practice regulations, WDFW is on record supporting the Forest and Fish Report and the protective provisions contained therein. Not all tribes endorse the Forest and Fish plan. WDFW continues to support this agreement as a reasonable approach to providing functioning habitat conditions on these lands, provided that the Forest Practices Board adopts all the necessary regulations to implement the agreement, adequate funding remains available to support the adaptive management provisions, and the co-managers are adequately funded to participate in implementing the agreement.

Take a significant role in ensuring SMA compliance in forest practice applications within Shorelines of Statewide Significance. Continue funding the Jobs for the Environment, which has given conservation districts, tribes and others a resource to complete restoration projects.

- DOE (Department of Ecology): Implement recommendations related to establishing instream flows and processing of water rights requests, implement stormwater programs, investigate the impact of exempt wells on groundwater and surface flows, monitor effectiveness of water quality recommendations, enforce existing and new state water quality standards, provide information on and adopt updates to SMA jurisdictional areas, develop TMDLs for water quality and habitat parameters identified as limiting factors for summer chum, lead watershed planning efforts to integrate the TMDLs with salmon recovery, and assist local governments in evaluating and modifying Shoreline Master Plans.
- WDFW: Incorporate the plan recommendations into the review of the hydraulic code, review and condition hydraulics permits consistent with this plan's recommendations[16], provide technical assistance to local governments in evaluating and modifying GMA Comprehensive Plans and ordinances, provide technical assistance to local salmon enhancement groups in developing restoration projects, provide guidance on the selection of restoration projects.
- WSDOT (Washington Department of Transportation): Ensure all fish passage structures, bridges, and other transportation elements are consistent with recommendations in this plan, and develop restoration schedule for those structures that do not meet the recommendations of this plan. Work with other resource agencies and cities/counties to develop specific language to clarify which transportation projects are allowed shoreline permit exemption and those that are not allowed exemption.
- PSWQAT (Puget Sound Water Quality Action Team): While PSWQAT does not have jurisdictional authority, their water quality management plan provides a regional, coordinated approach to water quality improvements and protection. Their plan should be viewed as a general framework, with the more stringent recommendations of this report added on for salmon recovery.
- CTED (Department of Community, Trade and Economic Development): Responsible for Growth Management Act comprehensive planning. For most counties, their critical area ordinances (required under GMA) are inadequate in terms of protecting and restoring habitat for the recovery of ESA listed species (see Growth Management Act, Table 3.21).
- Conservation Commission: Under HB 2496 the Conservation Commission is charged with developing limiting factors analyses for all salmon species within the state. The Conservation Commission has used this plan's draft habitat chapter limiting factor analysis for summer chum as a component of its multi-species limiting factors analysis. It is anticipated that the restoration objectives, factors for recovery (Appendix Report 3.6) and evaluation criteria (section 3.4.4.3) will be utilized for restoration efforts directed at summer chum.
- HB 2496 and SB 5595 Lead Entities and Salmon Recovery Funding Board: HB2496, now codified as Chapter 75.46 RCW includes language that describes the lead entity process for soliciting and ranking salmon habitat recovery projects at the local level. Inititially, projects were solicited from local sponsors, ranked by the lead entities and forwarded to the Interagency Review Team. However SB5595, passed by the legislature in 1999 created a new funding process, with grants awarded by the Salmon Recovery Funding Board (SRF Board). The lead entity solicitation and ranking process was kept intact, but the grant review and award process was changed from the IRT to the SRF Board.

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[16] WDFW can only implement this recommendation to the extent of its legislative authority. The tribes recommend changes to the hydraulics code, RCW Chapter 75.20, that will support this recommendation.

The Hood Canal Coordinating Council is the lead entity for all Hood Canal streams. In addition, Clallam County is the lead entity for that part of WRIA 17 in Clallam County as well for WRIAs 18-20 (North Olympic Peninsula Lead Entity). Both lead entities forwarded habitat projects to the SRF Board that addressed summer chum habitat limiting factors as identified in this plan and both were successful in receiving grants. It is anticipated many other similar habitat projects will be submitted in subsequent SRF Board grant cycles.

- HB2514 Watershed Planning Act Local Planning Units: HB2514 addresses water allocation planning, but can include habitat protection elements and a link to HB2496 projects. Watershed planning grants within the summer chum ESU have been provided for all WRIAs whose streams flow into Hood Canal and the Strait of Juan de Fuca. Again, the habitat elements of the Summer Chum Conservation Initiative should be integrated into these planning efforts.

Federal Agencies (NMFS, EPA, USFWS, USFS, COE, NPS)

Federal agencies have authority over several key laws protecting habitat, including the Endangered Species Act, Clean Water Act, and National Forest Management Act. Their role in implementing the plan includes:

- NMFS (National Marine Fisheries Service): Responsible for judging adequacy of the plan, developing 4(d) rule or Section 7 and 10 permits after listings, providing consultation on individual projects, and assisting local governments in developing implementation strategies.
- EPA (Environmental Protection Agency): Oversight on water quality standards to meet Clean Water Act requirements.
- USFWS (U.S. Fish and Wildlife Service): Ensure national fish hatchery operations are consistent with habitat protection strategies.
- USFS (U.S. Forest Service): Implement appropriate protection and restoration strategies, especially related to riparian protection, roads, and hydrologic maturity on National Forest lands.
- COE (Army Corps of Engineers): Ensure that permits issued by COE are consistent with the recommendations of this plan, especially as it relates to landuse and restoration activities within floodplains and shoreline areas.
- NPS (National Park Service): Provide reference sites and monitoring to use as targets for sediment loading, riparian composition, and channel condition.

Non-governmental entities (local salmon enhancement groups and conservation organizations)

The Hood Canal Regional Fisheries Enhancement Group, the North Olympic Salmon Coalition and other conservation organizations play an important role in restoration. In recent years, the tribes, conservation districts, enhancement groups and conservation organizations have accounted for the bulk of the channel and riparian restoration projects in the region.

Tribes

The tribes have technical staff that work extensively within watersheds based on tribal usual and accustomed areas. Tribal staff have and will continue to contribute technical knowledge related to habitat conditions, assist in the development of strategic plans, implement restoration activities, and monitor the effectiveness of the conservation initiative.

**Table 3.21.** Summary of habitat protection laws.

| **Law** | **Mandate** |
|---|---|
| Clean Water Act | "Restore and maintain the chemical, physical, and biological integrity of the nation's waters" and to "eliminate all discharges of pollutants to these waters" |
| Federal Power Act | Licensing non-federal dams on navigable waters. "The protection, mitigation of damage to, and enhancement of fish and wildlife…." |
| Endangered Species Act | "To provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide programs for the conservation of these species, and to achieve the purposes of the treaties and convention set forth in the act". |
| Magnuson-Stevens Fisheries Conserv. Act | Designate and protect essential fish habitat for commercial and recreational fisheries |
| Coastal Zone Management Act | "Preserve, protect, and where possible, to restore and enhance the resources of the nation's coastal zone". |
| National Forest Management Act | "Develop plans to manage forests consistent with protection of soils, vegetation, water quality, and aquatic habitats needed to provide viable fish and wildlife populations." |
| Washington State Hydraulic Code | "Regulate construction, of any form, that will use, divert, obstruct, or change the natural flow or bed of any of the salt or fresh waters of the state to ensure the proper protection of fish life." |
| Washington State Forest Practices Act | Adopt regulation to "afford protection to forest soils and public resources by utilizing all reasonable methods of technology in conducting forest practices" and to "prevent material damage or the potential for material damage to a public resource." |
| Washington State Growth Management Act | Adopt regulations to "classify and designate resource lands and critical areas to assure the long-term conservation of resource lands and to preclude land uses and developments which are incompatible with critical areas". Critical areas include fish and wildlife habitat conservation areas. |
| Shoreline Management Act | "Ensure the development of shorelines in a manner which, while allowing for limited reduction of rights of the public in the navigable waters, will promote and enhance the public interest." |
| Water Resources Act | "The quality of the natural environment shall be protected and, where possible, enhanced as follows…Perennial streams and streams of the state shall be retained with base flows necessary to provide for preservation of wildlife, fish,…." |
| Water Pollution Control Act | "…protection of wildlife, birds, game, fish and other aquatic life, and the industrial development of the state, and to that end require the use of all known available and reasonable methods by industries and others to prevent and control the pollution of the waters of the state of Washington". |
| Instream Resources Protection Program | "Establish only base level flows to sustain fish life" |
| State Environmental Policy Act | "To encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent of eliminate damage to the environment and biosphere; and stimulate health and welfare of man; and to enrich the understanding of the ecological systems and natural resources important to the state and nation." |

# 3.5 Harvest Management

## 3.5.1 Introduction

The short-term goal of the harvest strategies outlined in this section is to protect the summer chum populations within Hood Canal and Eastern Strait of Juan de Fuca (HC-SJF) from further decline by minimizing the effect of harvest as a major factor to that decline. The long-term goal of these strategies is to assist in the restoration and maintenance of self-sustaining summer chum populations throughout the Hood Canal/Strait of Juan de Fuca while maintaining harvest opportunities on co-mingled salmon of other species.

In order to contribute to recovery, harvest management measures are designed to limit fishing mortality to a rate that permits a high proportion of the summer chum run to return to spawning grounds and thus accommodate the maintenance and rebuilding of self-sustaining populations (Table 3.22). Restrictions will be applied to regulate exploitation-based impacts to each management unit of HC-SJF summer chum (section 3.5.2). These harvest management measures are designed to apportion harvest impacts between or within management units based on population status and individual population characteristics, and to result in a broad distribution of spawners throughout all stocks in the HC-SJF region. These harvest management actions, when coordinated with habitat protection/restoration and supplementation actions, should lead to the maintenance and restoration of genetic and biological diversity within the HC-SJF region.

**Table 3.22.** Expected Base Conservation Regime incidental exploitation rates and ranges by fishery.

| Fishery | Lower Guideline | Expected Average Exploitation Rate | Upper Guideline |
|---|---|---|---|
| Canadian | 2.3% | 6.3% | 8.3% |
| U.S. pre-terminal | 0.5% | 2.5% | 3.5% |
| Hood C. terminal | 0.5% | 2.1% | 3.5% |
| Hood Canal Total[1] | 3.3% | 10.9% | 15.3% |
| SJF Total[2] | 2.8% | 8.8% | 11.8% |

[1] Total of Canadian, U.S. pre-terminal, and Hood Canal terminal exploitation rates.

[2] Total of Canadian and U.S. pre-terminal exploitation rates. There is no terminal area harvest of Strait of Juan de Fuca stocks.

These strategies are expected to result in significant reductions from total exploitation levels estimated for the period from the 1980s to the early 1990s which were the result of fisheries targeted at other species. The harvest management portion of the recovery plan, by establishing annual fishing regimes for Canadian, U.S. mixed-population, and Washington terminal area fisheries, is designed to greatly reduce incidental impacts to summer chum salmon, during fisheries conducted for the harvest of other species. The expected reduction in incidental interceptions, relative to the high rates observed during the 1985-1991 period, is approximately 71% for Canadian fisheries, 50% for U.S. pre-terminal, and 93% for Washington terminal area fisheries. The Base Conservation Regime is based on a series of management measures, which are expected to effectively and substantially reduce incidental impacts, in order to conserve, and not appreciably reduce the likelihood of survival and recovery of HC-SJF summer chum in the wild. At present, because of the lack of sufficient information on summer chum productivity, it is not possible to construct a regime based on more sophisticated biologically-based objectives such as maximum sustained yield (MSY). The combination of specific management actions and fishery specific exploitation rates comprising the Base Conservation Regime is based on a conservative integration of the existing data and management experience. However, the harvest management plan is designed to be responsive to feedback mechanisms, in order to provide for adaptive management towards meeting the goals of protection of summer chum, while maintaining harvest opportunities on other species.

Improvements in escapement, catch and abundance databases were made during the development of this plan. Historical escapements, run sizes, and run-timing and entry patterns were revised or re-computed, significantly improving the overall consistency, quality and reliability of the data from which the current management baselines are drawn. Harvest impacts were reassessed by accounting for mortality from all fisheries and incorporating the results of new technologies. This reassessment facilitated the use of exploitation rates in setting management objectives. The managers then used the entry patterns in conjunction with catch and exploitation rate information to develop harvest regimes in marine and freshwater areas that offered protection to the populations passing through these areas. These improvements underscore the contrast between the enhanced management detailed in this initiative and past management methods.

The management strategies described in the following sections will continue to evolve and adapt as additional information is collected, analyzed and incorporated. Programs to monitor and evaluate harvest actions and progress toward achieving the harvest management plan objectives are designed to maintain, at a minimum, current sampling and survey activities and, as funding becomes available, provide the additional information described in section 3.5.10 (Harvest Management, Monitoring and Assessment) and section 3.5.12 (Stock Assessment Information Needs). For example, collection of age-specific survival rate information will be essential to assess productivity and assist in the evaluation and establishment of abundance and escapement thresholds, exploitation rates and recovery levels, for the various management units.

This section is divided into five main components: 1) a description of the management units and their component stocks and their status; 2) review of harvest as a factor of decline; 3) a description of the harvest regimes, actions, and performance criteria; 4) a description of plan implementation including monitoring, evaluation and review, and; 5) a description of data and information needed to fill current knowledge gaps, improve management and facilitate recovery.

### 3.5.2 Description of Management Units, Stocks, and Their Status

Table 3.23 lists the management units, stocks, location and critical status[1] thresholds utilized for harvest management purposes. Management units are defined in this plan as “A stock or group of stocks which are aggregated for the purpose of achieving a desired spawning escapement objective”. Stocks, as used in this document, generally correspond with the definition for a “stock” as used in

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[1] Note that “critical status” as used here has a different definition and application (described in section 1.7.3) then the definition and application for SASSI stocks (shown in section 1.7.2).

the Puget Sound Salmon Management Plan, and in the Salmon and Steelhead Stock Inventory (SASSI)(WDF et al. 1993)[2]. Conceptually, the management unit approach is designed to recognize the practical and biological limitations to how we can manage fisheries for salmon populations (or meta-populations, or sub-populations). Considerations for defining management units include: 1) adequacy of information on which to separate and manage groups of fish on a finer resolution; 2) similarities in life history characteristics (e.g. entry pattern, body size, genetic similarity, etc.); and 3) practicality of managing fisheries separately for multiple populations or sub-populations.

The current plan defines management objectives only for extant populations. Extinct populations, identified in section 1.7.2.2, are included in Table 3.23 only to provide geographical and historical reference to the reader. Management will be revised as necessary to address re-introductions by incorporating rebuilding objectives of those programs.

**Table 3.23** HC-SJF summer chum management units, stocks and Critical Thresholds.

| Management Unit | Washington Commercial Catch Area | Stocks | Critical Thresholds | |
|---|---|---|---|---|
| | | | **Abundance** | **Escapement** |
| Sequim Bay | 6B | Jimmmycomelately | <220 | <200 |
| Discovery Bay | 6B | Snow Creek/Salmon Creek | <790 | <720 |
| Dungeness Bay | 6D | Dungeness River | Undetermined | |
| Port Townsend | 9 | Chimacum Creek | Reintroduction | |
| Mainstem Hood Canal (Hood Canal Bridge to Ayres Point) | 12/12B/12C | Lilliwaup Creek<br>Hamma Hamma R.<br>Duckabush River<br>Dosewallips River | <2,980 | <2,660 |
| | | Big Beef Creek | Reintroduction | |
| | | Anderson Creek<br>Dewatto Creek<br>Skokomish River<br>Finch Creek | Extinct | |
| Quilcene/Dabob Bays | 12A | Big Quilcene/Little Quilcene | <1,260 | <1,110 |
| SE Hood Canal | 12D | Union River | <340 | <300 |
| | | Tahuya River | Extinct | |
| Total ESU | | | <5,400 | <4,750 |

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[2] SASSI uses the Ricker (1972) definition of population (stock): “The fish [of the same species] spawning in a particular lake or stream(s) at a particular season, which fish to a substantial degree do not interbreed with any group spawning in a different place, or in the same place at a different season.” (WDF et al. 1993)

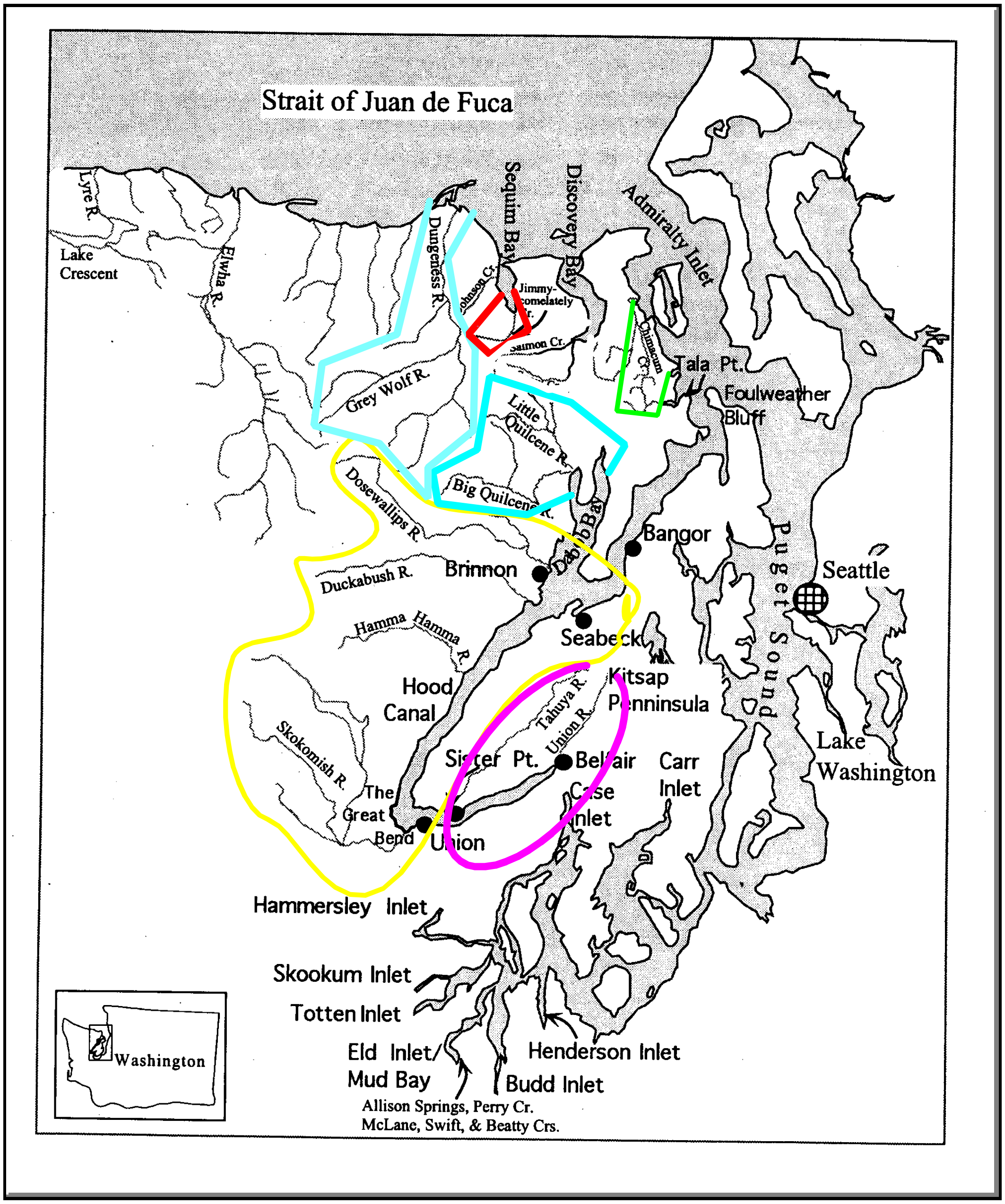

**Figure 3.3.** Strait of Juan de Fuca and Hood Canal management units and stocks.

All of the management units described in this plan contain only one stock (for the extant summer chum stocks described in Part One), except for the Mainstem Hood Canal Management Unit. The Mainstem Hood Canal Management Unit contains four currently existing stocks (Table 3.23). Unlike the other management units, the Mainstem Hood Canal Management Unit covers an area with multiple watersheds separated by a significant distance, and each stock corresponds with an independent stream draining into the mainstem area of Hood Canal (Figure 3.3). These stocks have been combined into a single management unit because: 1) there is insufficient confidence in our harvest and run size information to feel we can accurately manage each stock separately; 2) while there appear to be some genetic differences between populations, the consistency and significance of these differences has not been demonstrated, and all of these populations appear to have similar life history characteristics; and 3) they all drain into a single major terminal fishing area and none have discrete terminal marine areas where they could be harvested independently. Concerns for obtaining an adequate distribution of spawners across the stock within the Mainstem Hood Canal Management Unit are addressed through the Escapement Distribution Flags, which are defined in section 1.7.3.

When additional information becomes available, it may become possible and desirable to adjust management unit resolution. This could result in either separation or combination of stocks into management units. Any changes to management unit definition will be based on the considerations noted above. Following are descriptions of currently defined management units.

Table 3.24 presents estimates of the average time periods when 10%, 50% and 90% of the run entry to freshwater spawning areas is achieved for each summer chum salmon stock. These average values are derived from selected spawning ground survey data from 1974 through 1998, adjusted to reflect estimated timing of entry to freshwater areas. Two different methodologies were used to estimate entry timing (both presented in Table 3.24), and showed similar results. There can be significant annual variations from the average run entry timing for individual populations, where run entry can be substantially earlier or later than average.

**Table 3.24.** Summary of summer chum salmon average freshwater entry timing estimates (10%, 50%, and 90% completion) derived with two different methodologies. See Appendix Report 1.2 for a detailed discussion of the methodologies used.

| Management Unit | Stock | PNPTC timing estimate | | | | WDFW timing estimate | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | No. Yrs (N) | 10% date | 50% date | 90% date | No. Yrs (N) | 10% date | 50% date | 90% date |
| Sequim Bay | Jimmycomelately | 14 | 9/12 | 9/21 | 10/4 | 15 | 9/9 | 9/19 | 10/5 |
| Discovery Bay | Snow/Salmon | 20 | 9/14 | 9/24 | 10/8 | 20 | 9/13 | 9/24 | 10/11 |
| Mainstem Hood Canal | Dosewallips | 16 | 9/8 | 9/20 | 10/4 | 13 | 9/7 | 9/18 | 10/4 |
| | Duckabush | 24 | 9/14 | 9/23 | 10/6 | 16 | 9/12 | 9/24 | 10/6 |
| | Hamma Hamma | 23 | 9/12 | 9/22 | 10/3 | 21 | 9/9 | 9/22 | 10/5 |
| | Lilliwaup | 18 | 9/10 | 9/23 | 10/5 | 13 | 9/12 | 9/23 | 10/5 |
| Quilcene Bay | Big/Little Quilcene | 16 | 9/7 | 9/17 | 9/26 | 17 | 9/5 | 9/17 | 9/30 |
| SE Hood Canal | Union | 18 | 9/1 | 9/11 | 9/24 | 16 | 8/28 | 9/10 | 9/25 |

### 3.5.2.1 Management Unit: Sequim Bay

### Stock: Jimmycomelately

*Status: Critical*
*Critical Abundance Threshold: 220* *Critical Escapement Threshold: 200*
*Times below critical abundance threshold in last 4 years: 3* *in last 8 years: 7*
*Times below critical escapement threshold in last 4 years: 3* *in last 8 years: 6*

Summer chum spawn in the lower mile of Jimmycomelately Creek. Escapements in recent years (1995-1998) have been poor and declining, averaging 103 spawners(range = 30-223) compared to a 1974-88 average of 475 (range= 61-1326)[3]. Production from this system relies on wild production.

Adults generally enter freshwater from early September through mid to late October with mean date of entry occurring in the third week of September (Table 3.24 and Appendix Report 1.2).

## 3.5.2.2 Management Unit: Discovery Bay

### Stock: Snow Creek /Salmon Creek

*Status: Depressed*
*Critical Abundance Threshold: 790* *Critical Escapement Threshold: 720*
*Times below critical abundance threshold in last 4 years: 1* *in last 8 years: 5*
*Times below critical escapement threshold in last 4 years: 2* *in last 8 years: 6*

These streams were classified as a single unit due to the close proximity of the streams to each other, the lack of significant genetic difference and the fact that Snow Creek once flowed into Salmon Creek before separation by a man-made diversion early in the twentieth century. Summer chum adults spawn in the lower two miles of Salmon Creek and the lower mile of Snow Creek. Spawner abundance has declined, averaging 936 fish (616-1172) from 1995 through 1998, compared to a 1974-1988 historical average of 1,434 spawners (range = 171-3,783). The decline in abundance has been primarily due to a large decline in Snow Creek, which dropped to extremely low levels in the 1980s and early 1990s (less than 34 spawners/year). Recent escapement data suggests that the stock's escapement may be increasing and Snow Creek may be beginning to recover. A supplementation program was started in 1992 to boost natural production in Salmon Creek and use surplus in a re-introduction program for Chimacum Creek.

Adults enter freshwater from early September through October with peak spawning occurring in late September (Table 3.24). Entry timing is extremely variable, varying by several days to two weeks from the mean date of entry for an individual year (Appendix Report 1.2). The management actions described in the following sections take this variability into account to provide adequate protection for this stock.

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[3] Escapement for eight of the fifteen years included in the average were extrapolated from Discovery Bay system.

### 3.5.2.3 Management Unit: Hood Canal Mainstem

*Status: Depressed*
*Critical Abundance Threshold: 2,980* *Critical Escapement Threshold: 2,660*
*Times below critical abundance threshold in last 4 years: 2* *in last 8 years: 6*
*Times below critical escapement threshold in last 4 years: 2* *in last 8 years: 6*

The stocks in this management unit have historically been and continue to be the largest producers of unsupplemented summer chum in this region. Of the seven stocks historically comprising this management unit, four currently exist: Duckabush, Dosewallips, Hamma Hamma, Lilliwaup. The Duckabush, Dosewallips and Hamma Hamma stocks are considered depressed. The Lilliwaup stock is considered critical. A re-introduction program was implemented on Big Beef Creek beginning with brood year 1994. The harvest management strategy described in this plan (Tables 3.29-3.34) focuses on stabilizing and rebuilding the extant stocks. The strategy will be revised to incorporate objectives of re-introduction projects if it is necessary for their success.

Escapements for the extant populations fell from an average of 8,300 in 1974-82 (range = 1,839-18,626), to an average of 568 in 1983-1990 (range = 79-1,873). Escapements began to increase in the 1990s and recent year (1995-98) escapements have averaged 4,012 (range = 652-10,500). Production depends entirely on natural spawners.

Adults enter freshwater from the first week in September through mid-October with mean date of entry occurring in late September. Entry timing may vary up to 4 days from the mean in any year depending on the stock (Appendix Report 1.2).

#### Stock: Dosewallips

Summer chum adults spawn predominately in the lower mile of the watershed. The Dosewallips summer chum population has exhibited the highest number of spawning adults of any Hood Canal wild population in recent years. Recent escapements (1995-98) have averaged 2,537 (range = 47-6,976), compared to a 1974-81 average estimated escapement of 2,087 (range = 63-3,593) and an 1982-1989 average of 221 during the lowest period of escapements (range = 9-661).

Adults enter freshwater from early September through mid-October with the mean date of entry occurring in late September (Table 3.24). Entry is broad with two apparent peaks in spawning (Appendix Report 1.2).

#### Stock: Duckabush

Summer chum adults spawn predominately in the lower two miles of the watershed. Along with the Hamma Hamma and Dosewallips stocks, the Duckabush has historically been one of the largest producers of summer chum. Escapements fell from an average of 2,356 in 1974-81 (range = 557-6,095), to an average of 231 in 1982-1989 (range = 12-690). Escapements began to increase in the 1990s and recent year (1995-98) escapements have averaged 1,044 (range = 226-2,650). Production depends entirely on natural spawners.

Adults enter freshwater from early September through mid-October with the mean date of entry occurring in late September (Table 3.24). Entry timing may vary by 2-5 days in any year with generally more variability seen in the earlier portion of the run (Appendix  Report 1.2)

### Stock: Hamma Hamma

This stock consists of summer chum spawning in the Hamma Hamma River and a tributary, John Creek. Returning adult summer chum spawn predominately in the lowest mile of the watershed. The amount of spawning in John Creek is dependent on favorable flow conditions. Production has depended entirely on natural spawners, although first generation adults from the supplementation program are expected to contribute beginning with the 2001 return. Recent (1995-1998) escapements have averaged 374 fish (range= 104-774), compared to a 1974-81 average escapement of 3,960 (range= 329-8,215) and an 1982-1989 average of 256 during the period of lowest escapements (range= 16-801). This population is considered depressed in status relative to historic levels, which, with the Duckabush River, were among the highest recorded for summer chum in the region. The future of a supplementation program initiated in 1997 using indigenous fish is conditional on the implementation of reliable methods of broodstock collection (see 3.2 Artificial Production).

Adults enter freshwater from early September through mid-October with the mean date of entry occurring in late September (Table 3.24). Spawning timing may vary by up to a week between years (Appendix  Report 1.2).

### Stock: Lilliwaup

Spawning of the Lilliwaup Creek summer chum population is limited to the lower 0.7 miles of the watershed by an impassable falls. Prior to 1992, production depended entirely on natural spawners. Recent year (1995-1998) escapements have averaged 57 fish (range = 24-100), compared to a 1974-81 average escapement of 674 (range = 163-1,612), and an average of 104 (range = 18-275) in 1982-89. Because of its status, a supplementation program was initiated in 1992 using the indigenous stock (see section 3.2 Artificial Production).

Adults enter freshwater from early September through late October with the mean date of entry occurring in late September (Table 3.24). Spawning timing is fairly stable, generally varying by only 2-3 days (Appendix  Report 1.2).

## 3.5.2.4 Management Unit: Quilcene/Dabob Bays

### Stock: Big Quilcene/Little Quilcene

*Status: Critical*
*Critical Abundance Threshold: 1,260* *Critical Escapement Threshold: 1,110*
*Times below critical abundance threshold in last 4 years: 0* *in last 8 years: 2*
*Times below critical escapement threshold in last 4 years: 0* *in last 8 years: 4*

Summer chum spawn in the lower mile of the Little Quilcene River and the lower 2.8 miles of the Big Quilcene River downstream of the Quilcene National Fish Hatchery (QNFH). Because of the proximity of the two streams and the likelihood of mixing of spawners, the two streams have been designated as a single population. Spawning abundance declined significantly from an annual average of 1,780 spawners (1974-1981), to the lowest average of 139 fish in 1982-1989 (range = 2-297). Recent natural spawner escapements to the rivers (1995-98) have averaged 6,262 (range = 3,056- 9,515 fish), but many of the returning adults in the most recent four year period may be the result of first generation returns from a supplementation program implemented at the QNFH in 1992 (see 3.2 Artificial Production).

Adults enter from late August to early September, through October with mean date of entry occurring in about the third week of September (Table 3.24). Entry timing may vary by a few days to a week in any year (Appendix Report 1.2).

### 3.5.2.5 Management Unit: Southeast Hood Canal

Of the two stocks historically comprising this management unit (Union, Tahuya), only the Union River is considered extant.

#### Stock: Union River

*Status: Healthy*
*Critical Abundance Threshold: 340* *Critical Escapement Threshold: 300*
*Times below critical abundance threshold in last four years: 1* *in the last 8 years: 4*
*Times below critical escapement threshold in last four years: 1* *in the last 8 years: 4*

Summer chum spawn predominately in the lower mile of the watershed. In contrast to other summer chum production streams within the region, the Union River summer chum escapement has been stable in abundance in recent years relative to historical levels. The recent year (1995-98) average escapement is 462 (range = 223-721), compared to a 1974-81 average estimated escapement of 92 (range= 41-208). Production depends entirely on wild production. In the 1970s, the Union River summer chum were less abundant than in the Tahuya, increasing in abundance as the Tahuya declined. It is unclear why the Union run increased during the 1980s and 1990s while other stocks experienced significant declines, several becoming extinct.

Adults enter freshwater from mid-August through October with mean date of entry occurring in mid-September (Table 3.24). Entry timing is fairly stable, generally varying only 2-3 days (Appendix Report 1.2). Freshwater entry is earlier than that of stocks in other management units. The entry pattern appears to be truncated, with a more extended period of spawning in the latter half than in the first half. The reason for the truncation is not readily apparent, however, it could be that reduced flows in early September have either compressed entry timing in the earlier period, or extended entry in the latter period.

### 3.5.3 Description of Fisheries

A general description of the history and impacts of fisheries on summer chum is included in the Part Two, Region-wide Factors for Decline. Elements of that discussion are repeated in order to describe the general pattern and distribution of impacts, and a baseline against which to compare the recommended harvest management strategies. Regulation summaries for both tribal and non-tribal commercial fisheries are included in Appendix Report 3.9.

The entry pattern of HC-SJF summer chum overlaps those of chinook, coho, sockeye, and pink (odd-numbered years) salmon. Currently, HC-SJF summer chum salmon are caught incidentally to harvest of these other salmon species. The only fishery targeted on the HC-SJF summer chum occurred in 1976, in Hood Canal. In that year, the recruitment exceeded 70,000 summer chum and the survival was the highest observed. HC-SJF summer chum are harvested in pre-terminal, terminal and extreme terminal fisheries. Pre-terminal fisheries are those fishing areas where the catch consists of fish originating from multiple geographic regions, e.g., Skagit, Hood Canal, Strait of Juan de Fuca. Terminal fisheries are those fishing areas where fish originating from spawning streams or hatcheries within a discrete geographic region comprise most or all of the catch, e.g., Hood Canal. Extreme terminal areas are fishing areas where fish originating from individual management units (spawning streams or river systems, or hatcheries) within the geographic region comprise most or all of the catch, e.g., Quilcene Bay.

Prior to 1974, most recorded interceptions were in pre-terminal Washington and Canadian fisheries. This was due to a 1933 state law which prohibited commercial net fisheries within many of the inside waters of Puget Sound (“Initiative 77 line”). Prior to 1933 there were commercial net fisheries in Hood Canal, but adequate catch reports are not available. Beginning in 1974, with implementation of *U.S. v Washington*, terminal and extreme terminal fisheries for other species were implemented in Hood Canal, resulting in incidental harvest of summer chum in that area. Summer chum are caught incidentally in chinook, pink, sockeye and coho fisheries in pre-terminal areas; and incidentally in coho, chinook and pink fisheries in terminal areas. Significant changes in catch distribution and exploitation rates on HC-SJF summer chum have occurred since 1974 and have differed between populations in the Hood Canal and those in the Strait of Juan de Fuca. For instance, in the Strait of Juan de Fuca there are no fisheries in terminal areas affecting summer chum salmon, while in Hood Canal, fisheries have occurred in terminal areas annually since 1974. From 1974-1998, harvest impacts on HC-SJF summer chum ranged from 0.6% to 43.2% in Canadian fisheries, 0.4% to 10.1% in Washington pre-terminal fisheries and 0.3% to 51.1% in terminal fisheries The distribution of exploitation and fishery-related mortality by region is outlined in Table 3.25. Annual exploitation rates are summarized by fishery in Table 3.26 and by management unit in Table 3.27.

**Table 3.25**. Four year average Canadian, and Washington pre-terminal and terminal exploitation and escapement rates for HC-SJF summer chum, 1974-1998. Percentage of harvest mortality distribution is included in parentheses.

| Region | Return Years | Escapement | Terminal | Pre-terminal | Canadian |
|---|---|---|---|---|---|
| **Hood Canal** | 1974-77 | 0.667 | 0.239<br>(72%) | 0.033<br>(10%) | 0.061<br>(18%) |
| | 1978-81 | 0.551 | 0.321<br>(71%) | 0.063<br>(14%) | 0.066<br>(15%) |
| | 1982-85 | 0.319 | 0.481<br>(70%) | 0.053<br>(8%) | 0.148<br>(22%) |
| | 1986-89 | 0.296 | 0.500<br>(71%) | 0.039<br>(5%) | 0.165<br>(23%) |
| | 1990-93 | 0.553 | 0.205<br>(46%) | 0.050<br>(11%) | 0.192<br>(43%) |
| | 1994-98 | 0.934 | 0.009<br>(14%) | 0.010<br>(15%) | 0.044<br>(71%) |
| Strait of Juan de Fuca | 1974-77 | 0.880 | 0.030<br>(25%) | 0.029<br>(24%) | 0.061<br>(51%) |
| | 1978-81 | 0.872 | 0.000 | 0.062<br>(48%) | 0.066<br>(52%) |
| | 1982-85 | 0.800 | 0.000 | 0.052<br>(26%) | 0.148<br>(74%) |
| | 1986-89 | 0.797 | 0.000 | 0.039<br>(19%) | 0.165<br>(81%) |
| | 1990-93 | 0.758 | 0.000 | 0.050<br>(21%) | 0.192<br>(79%) |
| | 1994-98 | 0.943 | 0.000 | 0.010<br>(17%) | 0.044<br>(83%) |
| HC-SJF | 1974-1998 | 0.620 | 0.230<br>(60.0%) | 0.040<br>(11.0%) | 0.111<br>(29.0%) |

**Table 3.26.** Summary of harvest and exploitation rates by fishery.

| Run Year | Harvest | | | | | | | Total Run |
|---|---|---|---|---|---|---|---|---|
| | Esc. | Term. Area | Area 10 | Area 9 | Fraser Panel Areas | Canadian Area | Sub Total | |
| 1974 | 14,049 | 381 | 0 | 190 | 188 | 1,399 | 2,158 | 16,207 |
| 1975 | 19,678 | 9,498 | 0 | 54 | 546 | 1,064 | 11,162 | 30,840 |
| 1976 | 29,209 | 37,594 | 968 | 1,486 | 929 | 5,705 | 46,681 | 75,891 |
| 1977 | 12,355 | 4,435 | 1 | 73 | 711 | 913 | 6,134 | 18,488 |
| 1978 | 22,789 | 4,368 | 0 | 167 | 552 | 701 | 5,787 | 28,576 |
| 1979 | 7,315 | 1,483 | 2 | 134 | 889 | 591 | 3,098 | 10,413 |
| 1980 | 8,886 | 8,149 | 6 | 97 | 474 | 980 | 9,706 | 18,592 |
| 1981 | 3,258 | 2,158 | 6 | 63 | 597 | 915 | 3,739 | 6,997 |
| 1982 | 5,374 | 3,824 | 0 | 132 | 296 | 2,219 | 6,470 | 11,845 |
| 1983 | 2,002 | 2,409 | 2 | 131 | 146 | 28 | 2,716 | 4,718 |
| 1984 | 2,993 | 1,693 | 5 | 3 | 65 | 314 | 2,080 | 5,073 |
| 1985 | 1,341 | 1,373 | 2 | 40 | 445 | 1,620 | 3,481 | 4,822 |
| 1986 | 3,639 | 4,446 | 0 | 21 | 146 | 796 | 5,410 | 9,049 |
| 1987 | 2,748 | 2,862 | 0 | 0 | 147 | 390 | 3,399 | 6,147 |
| 1988 | 6,657 | 2,119 | 5 | 0 | 305 | 738 | 3,168 | 9,825 |
| 1989 | 986 | 1,583 | 1 | 4 | 421 | 2,273 | 4,281 | 5,267 |
| 1990 | 770 | 574 | 0 | 0 | 45 | 696 | 1,315 | 2,085 |
| 1991 | 1,054 | 852 | 0 | 59 | 171 | 483 | 1,566 | 2,620 |
| 1992 | 3,438 | 222 | 1 | 44 | 84 | 980 | 1,331 | 4,769 |
| 1993 | 1,324 | 20 | 0 | 45 | 53 | 67 | 185 | 1,509 |
| 1994 | 2,601 | 32 | 0 | 26 | 54 | 451 | 564 | 3,165 |
| 1995 | 10,301 | 31 | 0 | 0 | 68 | 458 | 557 | 10,858 |
| 1996 | 21,598 | 164 | 0 | 23 | 80 | 338 | 604 | 22,202 |
| 1997 | 9,933 | 180 | 0 | 0 | 46 | 198 | 424 | 10,357 |
| 1998 | 5,290 | 36 | 0 | 0 | 41 | 98 | 176 | 5,466 |

| Run Year | Escapement and Exploitation Rates | | | | Total ER |
|---|---|---|---|---|---|
| | Esc. | Term | US Pre-term | CDN | |
| 1974 | .867 | .024 | .023 | .086 | .133 |
| 1975 | .638 | .308 | .019 | .034 | .362 |
| 1976 | .385 | .495 | .045 | .075 | .615 |
| 1977 | .668 | .240 | .042 | .049 | .332 |
| 1978 | .797 | .153 | .025 | .025 | .203 |
| 1979 | .702 | .142 | .098 | .057 | .298 |
| 1980 | .478 | .438 | .031 | .053 | .522 |
| 1981 | .466 | .308 | .095 | .131 | .534 |
| 1982 | .454 | .323 | .036 | .187 | .546 |
| 1983 | .424 | .511 | .059 | .006 | .576 |
| 1984 | .590 | .334 | .014 | .062 | .410 |
| 1985 | .278 | .285 | .101 | .336 | .722 |
| 1986 | .402 | .491 | .018 | .088 | .598 |
| 1987 | .447 | .466 | .024 | .063 | .553 |
| 1988 | .678 | .216 | .032 | .075 | .322 |
| 1989 | .187 | .300 | .081 | .432 | .813 |
| 1990 | .369 | .275 | .022 | .334 | .631 |
| 1991 | .402 | .325 | .088 | .185 | .598 |
| 1992 | .721 | .046 | .027 | .206 | .279 |
| 1993 | .877 | .013 | .065 | .044 | .123 |
| 1994 | .822 | .010 | .026 | .142 | .178 |
| 1995 | .949 | .003 | .006 | .042 | .051 |
| 1996 | .973 | .007 | .005 | .015 | .027 |
| 1997 | .959 | .017 | .004 | .019 | .041 |
| 1998 | .968 | .007 | .008 | .018 | .032 |
| Avg | .602 | .230 | .040 | .111 | .380 |
| SE | .047 | .035 | .006 | .022 | .047 |
| Distrib | | .514 | .133 | .352 | |

**Table 3.27** Exploitation rates by management unit and fishery .

| Run Year | WA Pre-term (HC Units) | CDN20 (All Units) | SE Hood Canal | | | Quilcene/Dabob | | | Mainstem Hood Canal | | | WA Pre-term (SJF Units) | Discovery | | | Sequim | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total ER | Esc | Term | Total ER | Esc | Term | Total ER | Esc | Term | | Total ER | Esc | Term | Total ER | Esc | Term |
| 1974 | .023 | .086 | .111 | .889 | .002 | .111 | .889 | .002 | .111 | .889 | .002 | .023 | .110 | .890 | .000 | .110 | .890 | .000 |
| 1975 | .019 | .034 | .608 | .392 | .554 | .297 | .703 | .243 | .251 | .749 | .197 | .019 | .205 | .795 | .151 | .054 | .946 | .000 |
| 1976 | .045 | .075 | .849 | .151 | .729 | .685 | .315 | .565 | .414 | .586 | .294 | .032 | .107 | .893 | .000 | .107 | .893 | .000 |
| 1977 | .042 | .049 | .690 | .310 | .598 | .169 | .831 | .077 | .255 | .745 | .163 | .042 | .092 | .903 | .000 | .092 | .908 | .000 |
| 1978 | .025 | .025 | .539 | .461 | .489 | .137 | .863 | .087 | .224 | .776 | .174 | .025 | .050 | .950 | .000 | .050 | .950 | .000 |
| 1979 | .098 | .057 | .738 | .262 | .583 | .380 | .620 | .225 | .250 | .750 | .095 | .098 | .155 | .845 | .000 | .155 | .845 | .000 |
| 1980 | .031 | .053 | .819 | .181 | .735 | .726 | .274 | .642 | .677 | .323 | .593 | .031 | .083 | .917 | .000 | .083 | .917 | .000 |
| 1981 | .095 | .131 | .621 | .379 | .395 | .708 | .292 | .482 | .545 | .455 | .319 | .094 | .225 | .775 | .000 | .225 | .775 | .000 |
| 1982 | .036 | .187 | .750 | .250 | .526 | .812 | .188 | .589 | .619 | .381 | .396 | .036 | .223 | .777 | .000 | .223 | .777 | .000 |
| 1983 | .059 | .006 | .573 | .427 | .508 | .896 | .104 | .831 | .327 | .673 | .262 | .059 | .065 | .935 | .000 | .065 | .935 | .000 |
| 1984 | .015 | .062 | .331 | .669 | .254 | .904 | .096 | .827 | .269 | .731 | .192 | .013 | .075 | .925 | .000 | .075 | .925 | .000 |
| 1985 | .101 | .336 | .679 | .321 | .242 | .956 | .044 | .519 | .656 | .344 | .219 | .101 | .437 | .563 | .000 | .437 | .563 | .000 |
| 1986 | .018 | .088 | .599 | .401 | .493 | .982 | .018 | .875 | .591 | .409 | .485 | .018 | .106 | .894 | .000 | .106 | .894 | .000 |
| 1987 | .024 | .063 | .429 | .571 | .341 | .971 | .029 | .884 | .401 | .599 | .314 | .024 | .087 | .913 | .000 | .087 | .913 | .000 |
| 1988 | .032 | .075 | .154 | .846 | .046 | .883 | .117 | .776 | .134 | .866 | .027 | .031 | .106 | .894 | .000 | .106 | .894 | .000 |
| 1989 | .081 | .432 | .789 | .211 | .277 | .999 | .001 | .486 | .776 | .224 | .264 | .081 | .512 | .488 | .000 | .512 | .488 | .000 |
| 1990 | .022 | .334 | .513 | .487 | .157 | .990 | .010 | .635 | .452 | .548 | .097 | .022 | .355 | .645 | .000 | .355 | .645 | .000 |
| 1991 | .088 | .185 | .336 | .664 | .064 | .957 | .043 | .685 | .309 | .691 | .037 | .088 | .272 | .728 | .000 | .272 | .728 | .000 |
| 1992 | .027 | .206 | .235 | .765 | .002 | .401 | .599 | .169 | .235 | .765 | .002 | .027 | .232 | .768 | .000 | .232 | .768 | .000 |
| 1993 | .065 | .044 | .115 | .885 | .005 | .193 | .807 | .083 | .112 | .888 | .003 | .065 | .110 | .890 | .000 | .110 | .890 | .000 |
| 1994 | .026 | .142 | .172 | .828 | .004 | .193 | .807 | .025 | .172 | .828 | .004 | .026 | .168 | .832 | .000 | .168 | .832 | .000 |
| 1995 | .006 | .042 | .052 | .948 | .003 | .052 | .948 | .003 | .052 | .948 | .003 | .006 | .048 | .925 | .000 | .048 | .952 | .000 |
| 1996 | .005 | .015 | .024 | .976 | .004 | .028 | .972 | .008 | .024 | .976 | .004 | .005 | .020 | .980 | .000 | .020 | .980 | .000 |
| 1997 | .004 | .019 | .169 | .831 | .145 | .036 | .964 | .013 | .032 | .968 | .009 | .004 | .024 | .976 | .000 | .024 | .976 | .000 |
| 1998 | .008 | .018 | .109 | .891 | .084 | .029 | .971 | .013 | .026 | .974 | .000 | .008 | .026 | .974 | .000 | .026 | .974 | .000 |
| Avg | .040 | .111 | .440 | .560 | .290 | .540 | .460 | .389 | .317 | .683 | .166 | .039 | .156 | .844 | .006 | .150 | .850 | 0.000 |

### 3.5.3.1 Canadian Fisheries

A significant proportion of the estimated harvest mortality occurs outside U.S. waters. Specifically, commercial sockeye and pink fisheries in the Canadian Strait of Juan de Fuca (Area 20) are estimated to take significant numbers of chum salmon during the summer chum migration period (Figure 3.4)[4]. Canadian harvest from Area 20 has accounted for 1% - 82% of the annual harvest related mortality on HC-SJF summer chum, averaging 56.7% since 1989, and has comprised an increasing percentage of the catch as U.S. fisheries have been constrained in recent years (Table 3.25).

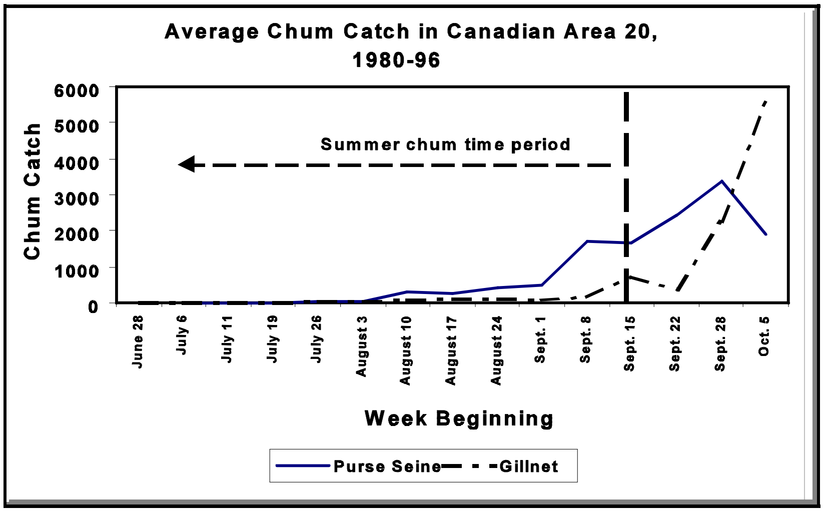

**Figure 3.4.** Temporal pattern of chum catch in Canadian Area 20 fishery, 1980-1996.

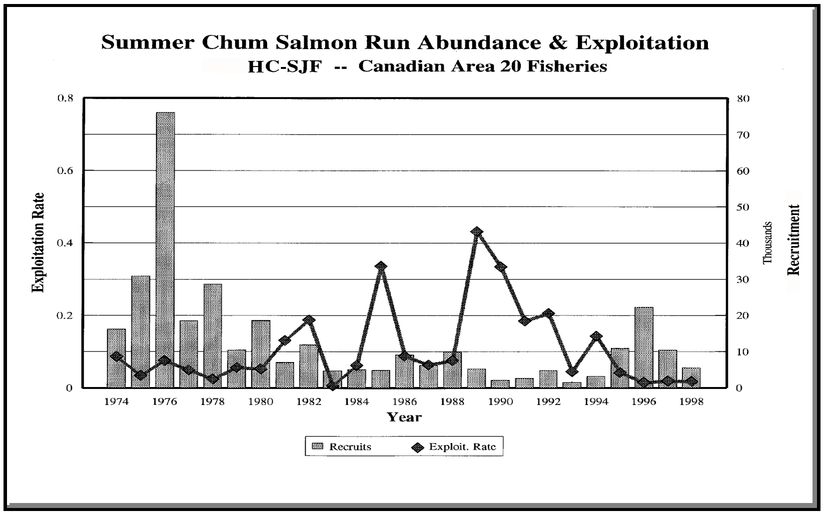

**Figure 3.5.** Pattern of Canadian exploitation rates on the HC-SJF summer chum.

Estimated exploitation rates on HC-SJF summer chum in Canadian fisheries during the period 1974-1998 ranged from 0.6% to 43.2% (Table 3.26, Figure 3.5 and Appendix Report 1.2). Impacts in the Canadian Area 20 fishery were generally low until the 1980s when effort increased significantly due to high sockeye and pink salmon abundance, a low diversion rate (high proportion of adults returning through the Strait of Juan de Fuca), and a Canadian management policy to emphasize fishing in this area. The average exploitation rate in this fishery peaked in 1989 at 43%, and for the period from 1989 through 1992 averaged 29%. Exploitation rates have declined from 1989-92, to less than 5% since 1994 due to a more northerly sockeye migration pattern, and more recently, significant restrictions to the fishery to reduce the incidental take of Canadian coho and chinook. These restrictions may be anticipated to continue for the foreseeable future given the continued depressed status of many Canadian chinook and coho populations and adoption of a more

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[4] These estimates are based on run reconstruction estimates derived from GSI data analysis applied to reported catches from Area 20. Impacts from other Canadian areas are unknown, but it is assumed that no HC-SJF summer chum are harvested north of Vancouver Island.

conservative approach to harvest management by Canada's Department of Fisheries and Oceans. These are probably minimum exploitation rate estimates since chum are easily mis-identified as other salmon species, especially in sockeye and pink fisheries where the ratio of chum to other salmonids in the catch is very low. At this time, the level of error, caused by mis-identified catch is unknown, but additional catch monitoring could provide an estimate of the bias.

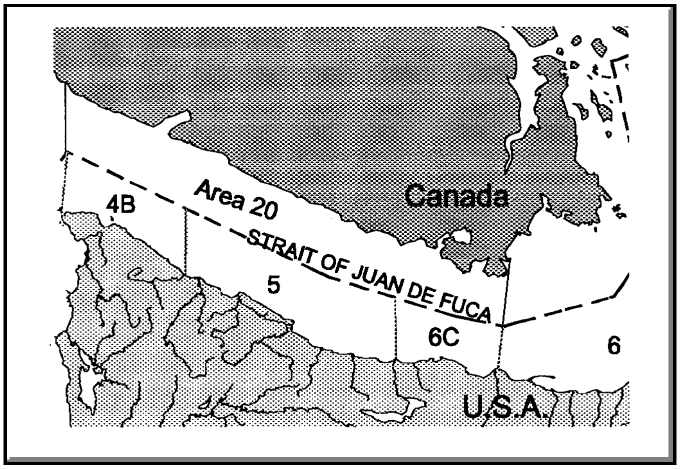

**Figure 3.6.** Location of Canadian Catch Area 20.

Area 20 fisheries for sockeye and pink salmon begin in late July or early August and may continue through mid September. Peak harvest occurs in mid-late August. In the past, coho fisheries occurred after the conclusion of the sockeye and/or pink salmon season, through the remainder of the month of September. However, Canadian coho fisheries in Area 20 have been closed since 1994. Chum, including HC-SJF summer chum, are caught incidentally in these fisheries (Figure 3.6). After September 15, it is assumed most of the summer chum salmon populations have moved into terminal areas, and U.S. and Canadian fall chum runs begin to dominate the fisheries. Fall chum fisheries are conducted in Area 21 (immediately west of Area 20) and in the westernmost portion of Area 20, targeting fall chum runs returning to Nitinat Lake, beginning in early October.

Genetic stock identification (GSI) data from 1995-1997 in August and early September indicate that Hood Canal and Strait of Juan de Fuca summer chum salmon comprise 14-68% (sd=7-12%) of the total chum catch in Canadian Area 20 sockeye and pink-directed purse seine fisheries with a higher proportion of the catch composed of summer chum in mid to late August (Table 3.28). Note that while the total chum catch increases significantly from July through September, the proportion attributed to HC-SJF summer chum declines rapidly between the end of August and mid-September.

**Table 3.28.** GSI estimates of the proportion of HC-SJF summer chum taken in Canadian Area 20 fisheries.

| Year | Sample Date | Number Sampled | % HC-SJF summer chum | Area 20 chum catch by sample period |
|---|---|---|---|---|
| 1995 | 8/22 | 57 | 37% (±12%) | 329 |
| | 8/28-8/29 | 76 | 45% (±11%) | 352 |
| | 9/5-9/6 | 88 | 14% (±7%) | 763 |
| | All samples pooled | 221 | 31% (±7%) | 1531 |
| 1996 | 8/14-8/15 | 98 | 68% (±10%) | 369 |
| 1997 | 8/22-8/26 | 80 | 49% (±10%) | 265 |

Troll fisheries on the west coast of Vancouver Island (WCVI) have reported significant chum catches in some years during the period of summer chum migration. Catch sampling programs and tagging efforts have been insufficient to indicate the magnitude of any impact to HC-SJF summer chum. WCVI troll fisheries begin in July and continue through early September. However, since 1994, WCVI troll fisheries for coho salmon have been severely curtailed. The Georgia and Johnstone Strait areas have significant sockeye and pink fisheries during the time when summer chum may be present in these fisheries. Again insufficient data exists to determine the magnitude of HC-SJF summer chum caught in these fisheries.

### 3.5.3.2 Washington Pre-terminal Area Fisheries

Harvest of Hood Canal and Strait of Juan de Fuca summer chum occurs incidentally to the harvest of other salmon species in U.S. pre-terminal fisheries (Washington Commercial Catch Reporting Area (commercial areas) 4B-7, 9 and 10), Figures 3.7 and 3.1.2). There is currently no population specific information on summer chum salmon caught incidentally in these fisheries. Stock composition for Washington pre-terminal fisheries in the Strait of Juan de Fuca and San Juan Islands was assumed to be similar to that in Canadian Area 20 since that fishery is adjacent to them[5]. Commercial fishery exploitation rates during the period 1974-1998 ranged from 0.4% to 10.1% (Table 3.26, Figure 3.8). Harvest rates in pink years were approximately twice that of non-pink years. Given this fishing pattern, rates remained relatively stable through 1994 (Figure 3.8). Exploitation rates have declined to less than 1% since 1994 due to unusually high proportions of sockeye adults returning through the northern corridor; generally lower treaty and non-treaty effort; and effects of shifting purse seine effort from Area 7 to Area 7A, where HC-SJF summer chum catch is thought to be negligible (Figure 3.9)

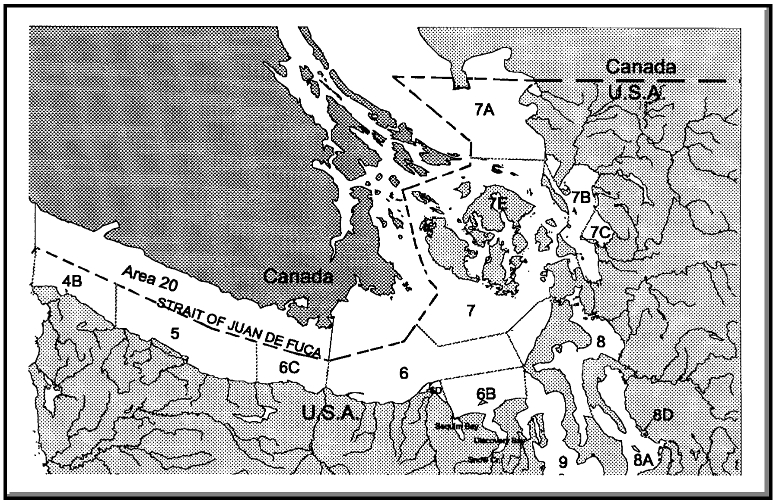

**Figure 3.7.** Washington State Commercial Catch Reporting Areas: Puget Sound Areas 4B-7A.

Recreational fisheries comprised 14% of the 1974-1996 U.S. pre-terminal harvest (Washington Catch Record Card Areas (sport areas) 5-7) of HC-SJF summer chum, with an average exploitation rate of 0.5%.

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[5] The only pre-terminal area for which stock composition data is available is Canadian area 20. These stock compositions have also been applied to U.S. areas 4B, 5, 6C and 7 as they are immediately adjacent to area 20 and are believed to have similar stock compositions. No data exists for other U.S. and Canadian pre-terminal areas which may also intercept HC-SJF summer chum (e.g. Southern Georgia Strait - U.S. area 7A and Canadian area 29), but it was felt to be inappropriate to extrapolate the area 20 data to these areas.

## Strait of Juan de Fuca

Tribal commercial sockeye and pink fisheries in the Strait of Juan de Fuca (sport Areas 4B, 5, 6C) (Figure 3.7) normally start in mid-July and may continue through early September depending on the abundance of different Fraser River and Puget Sound run components. Treaty nearshore set gillnet fisheries have traditionally occurred in July and August, but catch records indicate chum are not caught in these fisheries. No drift gillnet fisheries for chinook have occurred since the late 1970s. With few exceptions, tribal commercial coho fisheries throughout the Strait have not occurred since the mid to late 1980s in response to certain weak coho runs. Fisheries directed at fall chum can begin as early as October 10, but have been delayed in recent years to protect weak coho populations. As expected, GSI analysis has detected no summer chum in fisheries directed at fall chum, because they occur after most summer chum have entered freshwater (Appendix Report 1.2). Chum have averaged 0.21% (range = 0.02-0.48%) of the total number of salmon caught during the July through September time period from 1985 through 1995.

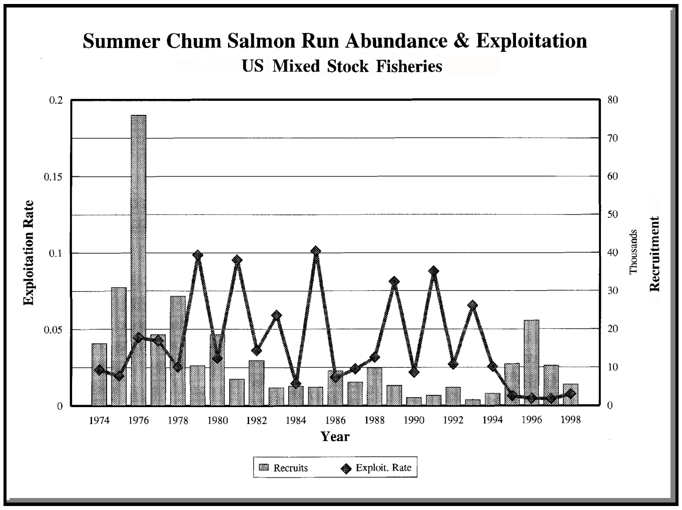

**Figure 3.8.** Pattern of U.S. exploitation rates in U.S. Convention Waters on HC-SJF summer chum 1974-97.

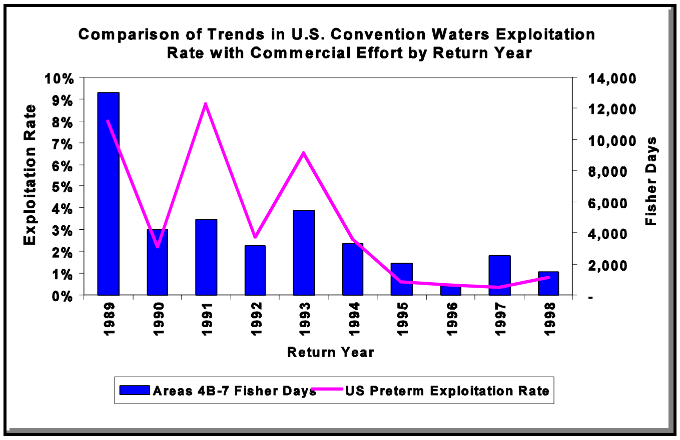

**Figure 3.9.** Pattern of U.S. exploitation rates in U.S. Convention Waters on HC-SJF summer chum and U.S. preterminal effort, 1989-1997.

Both non-treaty commercial and sport fisheries have occurred historically in the Strait of Juan de Fuca. However, non-treaty sockeye and pink commercial fisheries have not occurred there since the early 1980s. Non-treaty recreational salmon fisheries in the Strait of Juan de Fuca operate predominantly out of Sekiu and Port Angeles, with considerably lesser amounts of effort originating from John Wayne Marina in Sequim Bay and other launch sites. Interest is focused primarily toward coho and chinook salmon with minor, but increasing, attention on pink salmon. Chum salmon are estimated to have accounted for less than 0.16% of July through September recreational angler salmon catch in the Strait of Juan de Fuca, commercial areas 5 and 6, and the maximum chum catch in any single year has been estimated at 170 fish for this period. Over the 24-year period, 1974-1997, the average catch of chum for both areas combined is 50**,** representing 0.05% of the salmon catch of all species (or 1 out of every 2,000). Recreational effort, measured as angler trips, peaked in this area at approximately 225,000 angler trips annually during the 1989-1991 period, coinciding with the peak annual catch of approximately 278,000 salmon in 1990. However, effort and catch levels have declined precipitously since that time due to severe restrictions on fishing to protect coho and chinook. In the past, recreational fisheries occurred year around. A total closure was imposed in 1994 and limited seasons of between 20 and 38 days long have been enacted since. This has limited total annual salmon catch to about 55,000 or less, which is only 25 percent of peak level of the early 1990s. Efforts to maintain or restore sport salmon fishing opportunities in the Strait of Juan de Fuca will be contingent upon development and implementation of selective fishing measures. Beginning in 1998, the retention of chum salmon is not permitted by recreational fisheries during the period July through September in commercial areas 5 and 6.

## San Juans

Both treaty Indian and non-treaty commercial fisheries occur in the San Juans (commercial Areas 6, 7 and 7A[4]) (Figure 3.7). Commercial sockeye and pink fisheries begin as early as mid-July and continue as late as mid to late September. No commercial fisheries for chinook have operated in these areas since the late 1970s. In the past, commercial coho fisheries have occurred from mid-September through early October, but with minor exceptions, they have not occurred since the early 1980s, both in an effort to protect weak coho populations, and, in some years, as part of an agreement with Canada under the Pacific Salmon Treaty. Fisheries directed at fall chum may begin in early October, but have been delayed until mid-October in recent years to protect weak coho populations. Chum catches increase substantially after October 1, reflecting the entry of fall chum into the area (Figures 3.10 and 3.11). Chum have averaged 0.06% (range = 0.001-0.44%) of the total number of salmon caught during the July through September time period from 1980-1995. GSI analysis has detected no summer chum in fisheries on fall chum as would be expected since they occur after summer chum have entered freshwater (Appendix Report 1.2).

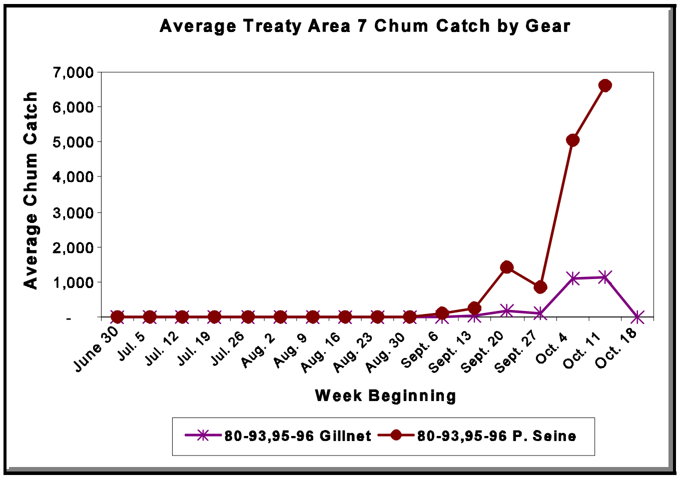

**Figure 3.10.** Temporal pattern of average Treaty catch in U.S. preterminal fisheries - Area 7, 1990-96.

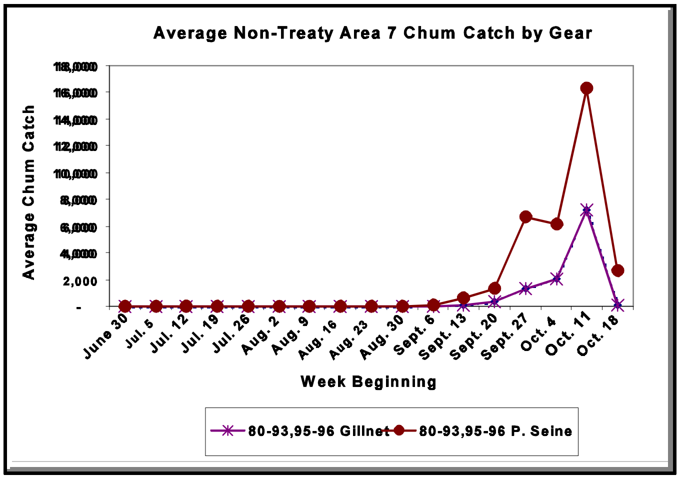

**Figure 3.11.** Temporal pattern average non-Treaty catch in U.S. preterminal fisheries - Area 7, 1980-96.

The recreational salmon fishery in the San Juan Islands sport area 7 is of lesser magnitude than that in the Strait of Juan de Fuca, with total annual salmon catch ranging from a low of 12,500 salmon in 1992 to an all-time peak catch of 55,000 fish in 1973. Effort, expressed as angler trips, peaked in 1970 with approximately 103,000 trips, but has declined throughout the 1980s and has remained below 45,000 trips per year during the 1990s. Like the Strait of Juan de Fuca, the sport fishery in the San Juan Islands is directed primarily on chinook and coho salmon with lesser catches (2,000-9,000) of pink salmon in odd numbered years. Chum are rarely taken in the San Juans. Since 1967, chum have been recorded during the July through September time period in only 5 years and, in all cases except one, accounted for less than 0.25 percent of the sport salmon catch. An unusually high number of chum (166) were estimated to have been caught in 1991; the next highest year was less than half that number. Area 7 had year-round salmon seasons until 1998 when significant area and time period closures were imposed to protect domestic chinook and Canadian coho populations. The continued need to protect chinook populations will remain a management factor for San Juan Islands recreational salmon fisheries.

## Admiralty Inlet

Prior to 1975, when commercial fisheries in more terminal areas were prohibited, significant chinook, coho and fall chum fisheries occurred regularly in commercial areas 6B and 9 (Figure 3.12). Fisheries in these areas, in the vicinity of Port Townsend diminished between 1975 and the early 1980s. No non-treaty or treaty commercial fisheries have been conducted since the early 1980s during the period when HC-SJF summer chum are present, and this pattern is expected to continue given intertribal agreements and recent court stipulated changes in tribal fishing patterns, and mixed population management issues associated with commercial fisheries in the area. HC-SJF summer chum have been less than one percent of the total number of salmon caught commercially during the July through September time period.

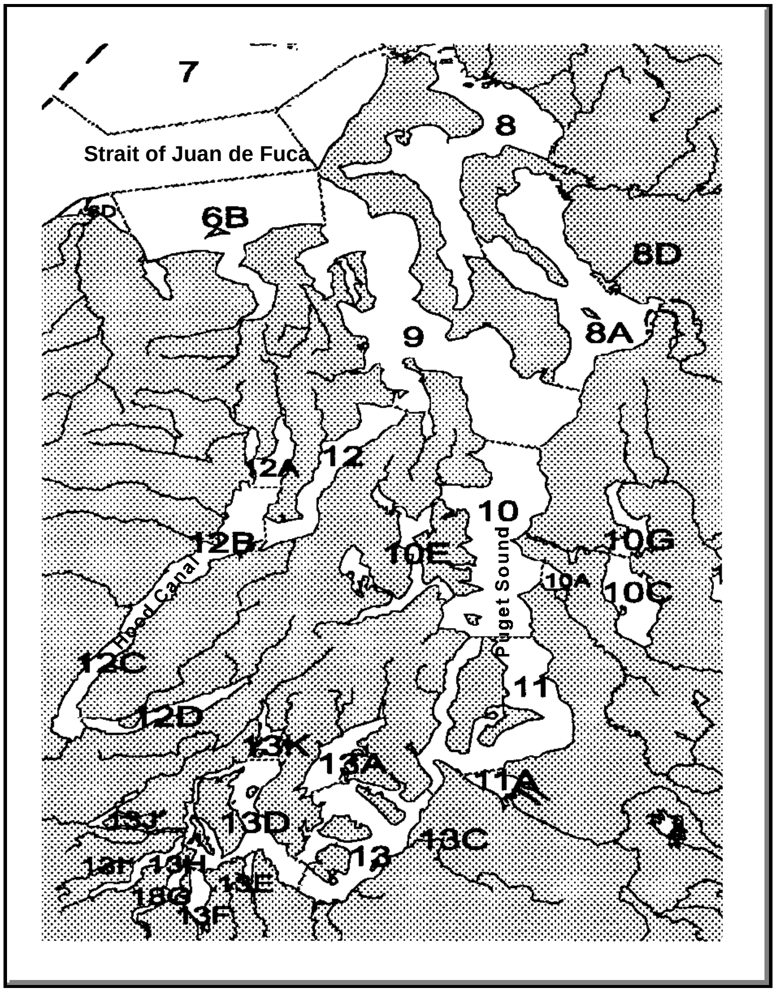

**Figure 3.12.** Washington State Commercial Catch Reporting Areas: Puget Sound Areas 6B-13B.

The recreational salmon fishery in Admiralty Inlet, sport Area 9, has been directed toward coho and chinook and, in odd numbered years, pink salmon. Historically the coho catch has been approximately twice the chinook catch, and four times that of pink. The 1974-1997 exploitation rate averaged 0.7% on HC-SJF summer chum in this area. Chum have been a very small component of the July through September salmon catch averaging 0.23 percent (range 0.0-0.68%) of the total salmon catch during this period. The 24-year average (1974-1997) chum salmon catch for this area is 50 fish (range 0-201). Area 9 has a decade long trend of increasing recreational fishery restrictions focused on the July through September period and designed to protect depressed coho and chinook populations. These regulatory restrictions have resulted in a decreasing trend in both salmon catch and angler effort. Catch and effort peaked in the early 1980s when up to 160,000 angler trips during the July though September period resulted in total salmon catch of approximately 60,000 salmon. During the 1990s catch and effort plummeted and bottomed out in 1994 when the entire area was closed during the July through September period. Annual catch levels have remained below 14,000 in recent years with a correspondingly low effort level of 28,000 or less angler trips. Since Admiralty Inlet is a passage corridor for mixed populations of chinook and coho, its future will be tied to the conservation needs of these two species and the course of selective fishing methods. Since 1998, retention of chum salmon has not been permitted during the July through September time period in this area.

No population-specific information exists on impacts of these fisheries to HC-SJF summer chum. Based on run reconstruction assumptions, impacts to summer chum in past Admiralty Inlet commercial fisheries have ranged from 0-3% over the entire 1974-1997 period, and averaged less than 1% since 1994 (calculated from Table 3.26).

### Seattle (Commercial Area 10)

HC-SJF summer chum salmon are not believed to be present in this area in significant numbers, after the first few days in September. Prior to that time, they could be intercepted during recreational and commercial fisheries directed at chinook salmon. However, no commercial chinook fisheries have occurred in commercial area 10 (Figure 3.12) since the late 1970s except in extreme terminal areas where HC-SJF summer chum are not believed to be present. Commercial fisheries for coho and fall chum occur from the second week in September through November. A small test fishery for South Puget Sound coho generally occurs during the first week of September to update the run size and refine the Area 10/11 fishing schedule agreed to preseason. Based on run reconstruction assumptions, exploitation rates on HC-SJF summer chum have been essentially 0% (estimated catch= 0-6 fish/yr), with the exception of 1976, when the survival rate and return rate of Hood Canal summer chum were high. In that year the estimated incidental exploitation in this fishery was 1.3%.

Treaty Indian fisheries directed at coho salmon in commercial area 10 occur in mid-late September and have been limited since 1993. Non-treaty commercial coho fisheries have been severely restricted since 1992 and were eliminated in 1994 due to concerns over depressed coho populations and mixed population management issues associated with commercial fisheries in the area. Both treaty and non-treaty fall chum fisheries still occur from mid-October through November.

Recreational fisheries were open year around until 1994 when salmon fishing was limited to small portions of the area. This region experienced severe restriction again in 1995 and 1996. Restrictions in 1997 and 1998 were focused especially on the northern portion of sport Area 10 and on Elliott and Shilshole bays. These restrictions have contributed to a severe reduction in total salmon catch and recreation effort. Chum salmon typically contribute fewer than 100 fish to the July through September recreational salmon catch in this area. Many of these are summer chum returning to South Puget Sound streams and migrate through this area to reach their spawning grounds.

Limited population-specific information exists on the specific impacts of these fisheries on HC-SJF summer chum salmon. GSI samples taken from test fisheries on coho and fall chum and fall chum fisheries confirmed that they are not present from late September on. Based on this information, impacts to HC-SJF summer chum in past commercial fisheries are estimated to have been insignificant even in years of extensive coho fisheries in this area.

### 3.5.3.3 Washington Terminal Area Fisheries

Terminal areas are those fishing areas where fish originating from spawning streams or hatcheries from more than one management unit, but within a discrete geographic area, comprise most or all of the catch. The only terminal area in Hood Canal or the Strait of Juan de Fuca is the Hood Canal mainstem area[6] (commercial Areas 12,12B,12C) (Figure 3.12) From 1974-1998, estimated exploitation rates have ranged from 0% to 61% on the summer chum management units passing through this area, averaging 16.8%. They have been <1% since 1992 because fisheries directed at commingled species have been restricted. Commercial fisheries occurring in these areas from early July through September target primarily coho and chinook. From 1978-1998, chum averaged <6.5% (range = 0.0-29%) of the total number of salmon caught in the mainstem fishery during the July through September time period. Exploitation rates in terminal recreational fisheries ranged from 0.0-3.1% in 1974-1997 (excluding 1989), averaging 0.33% over the same period.

Treaty fisheries for chinook occur in early July through early September in the north, and late September in the south. Treaty fisheries for coho salmon have also occurred annually in these areas all years except for 1988 and 1992-1996. These fisheries start in early September in the north and extend to mid-October. In the south they start in mid-September and extend through the end of October. Fisheries in these areas used set and drift gillnet gear exclusively until 1996 when beach seine gear use became significant. In 1976, a treaty fishery was directed at summer chum in what is now commercial Areas 12B and 12C. That was the only year since 1974 that such a fishery occurred. Closures around stream mouths have been in effect since the mid-1970s to avoid concentrated harvest on salmon milling in the vicinity.

Non-treaty commercial fisheries for chinook occurred annually until the late 1980s. No non-treaty fisheries are expected for chinook in the near future (Table 3.32 and 3.34). Non-treaty coho fisheries have followed the same pattern as treaty fisheries in the northern mainstem using drift gillnets and purse seines, but have not occurred in the southern area (12C) since the late 1980s.

Recreational fisheries operated year-round in Hood Canal through 1990. From 1991 through 1996 (excluding 1993), seasonal block restrictions became a part of annual management plans to protect depressed coho populations. Beginning in 1992, fishing for chum salmon has been restricted for some, or all, of the July through September period, and chum catch estimates for the period have been zero in all years except 1996. In that year an estimated 92 chum were harvested in September and only Quilcene Bay was open to recreational salmon angling during the period of concern. Beginning in 1998, retention of chum salmon is not permitted in recreational fisheries from July 1 through October 15.

The peak year for chum salmon shown in the recreational catch data base was 1989 when sport anglers were reported to have taken an estimated 917 chum representing 35% of the total estimated salmon catch for the July through September period. However, a review of the original fishery sampling data for Hood Canal found that no chum were observed during this time period. Excluding this aberrant data point, estimated chum catch averaged 54 fish (range 0-293) for the July-September

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[6] However, many references in this document to ‘terminal’ harvest or exploitation rates include both the Hood Canal mainstem and other, more extreme terminal areas. The extreme terminal areas are described in the following section 3.5.3.4.

period (1974-1993, excluding 1989). This represents 1.3% (range 0-13.0%) of the recreational salmon catch for sport area 12 during this time period.

### 3.5.3.4 Washington Extreme Terminal Area Fisheries

Extreme terminal areas are fishing areas where fish originating from spawning streams or hatcheries within the geographic area described by a single management unit comprise most or all of the catch: Sequim Bay, Discovery Bay, Quilcene/Dabob Bay, southeast Hood Canal and all freshwater areas where summer chum are present (Figure 3.13).

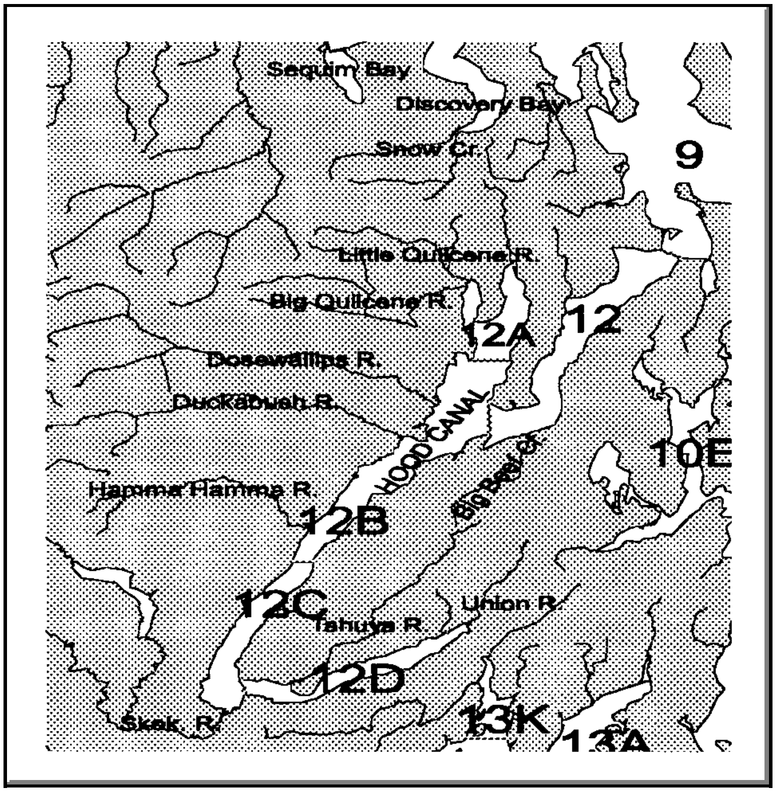

**Figure 3.13**. Hood Canal commercial catch reporting areas.

In Sequim Bay, no commercial fisheries have occurred in the 1974-98 period. Recreational fisheries management in these areas has followed that of sport area 6 with added restrictions beginning in 1987 (see Strait of Juan de Fuca in section 3.5.3.2).

In Discovery Bay, no non-treaty commercial fisheries have occurred in the 1974-98 period, and treaty fisheries have not occurred since 1978, as a result of the establishment of a research preserve at Snow Creek, and the nearby marine area. Recreational fisheries management in these areas has followed that of the sport area 6 with added restrictions beginning in 1987 (see Strait of Juan de Fuca in section 3.5.3.2).

In the Quilcene/Dabob area, treaty commercial fisheries occur in September for coho. In the past, treaty fisheries used set and drift gillnets but gear has largely been restricted to beach seines since 1992 with a requirement to release chum, as part of an overall package of measures designed to rebuild summer chum salmon in this management unit. The result has been a dramatic reduction in fishing effort. Limited Treaty Indian gillnet openings have occurred in recent years to harvest surplus coho, particularly when supplemented summer chum have been abundant.

A limited (five permits) non-treaty beach seine fishery for hatchery coho has occurred annually in Quilcene Bay (north of Fishermans Point/Point Whitney line) near the mouth of the Big Quilcene River, beginning in 1996. The fishery occurs during September under restrictive conditions, that include a requirement for release of chum salmon. Coho catch averaged a bit over 600 fish per year for the first three years of beach seine operations, but catch and interest fell off sharply in 1999, with only 43 coho being landed.

All citizen (non-treaty) commercial salmon fishing within Commercial Area 12A was closed prior to October throughout the period 1978 through 1983. From 1984 through 1991, coho directed commercial fishing openings for gill net and purse seine gear occurred annually in Commercial Area 12A during September, with established closure zones in effect northerly of a line from Fishermans Point to the Quilcene Boat Haven in Quilcene Bay, and north of a line drawn due east from Broad Spit in upper Dabob Bay. The number of days open to commercial fishing during September over the span of years 1984 through 1991 averaged 11 days a year, but interest in the fishery was very low. Landings typically numbered 10 or fewer in a year. Closures prior to October were again in place during the 1992, 1993, and 1995 seasons. A special skiff gill net fishery was open for six days in September 1994, and five landings produced a catch of 52 coho. Restrictions for the 1994 skiff gill net fishery required release of any chum encountered by cutting the mesh(es) that ensnared them. Since that time, the only non-treaty commercial fishing has been the limited beach seine fishery referenced above.

Recreational fisheries are managed under sport area 12 regulations (see 3.5.3.3 Terminal Area discussion above).

In southeast Hood Canal (Area 12D), no commercial fisheries have occurred since the late 1970s except for a small area adjacent to Area 12C, opened occasionally to provide harvest opportunity on coho and hatchery chinook in late August and early September.

Recreational catch of chum salmon is not specifically estimated for the rivers draining into Hood Canal. Catch estimates of “other” and “unknown” salmon are made, and these categories, even when combined, do not account for more than 57 fish during the July through October period, and generally represent less than 4% of the freshwater salmon catch and less than 0.2% exploitation rate. Two exceptions are the 1976 catch of 51 unknown salmon which represented 12.5 percent of the total salmon catch of only 409 fish, and 1992 when 34 other or unknown category salmon represented about 8.75 per cent of the 378 salmon harvested in freshwater. These percentages are probably an artifact of the small total salmon catch. In any event, it is unlikely that all the fish in the “unknown” and “other” categories were chum salmon, thus these figures may overestimate the chum component of Hood Canal freshwater salmon catch. Chum salmon retention has not been allowed in any Hood Canal tributaries during the July through October time period in recent years and this requirement is expected to continue (Tables 3.29 and 3.30).

## 3.5.4 Relationship of Harvest to Other Factors for Decline

Although harvest is thought to have been a factor in the historical decline of summer chum in Hood Canal and the Strait of Juan de Fuca, it should not be viewed in isolation of the other factors for decline discussed in Part Two and other sections of Part Three. The synergistic effects of dramatically reduced productivity and high harvest rates may have resulted in reduced abundance for some management units.

### 3.5.4.1 Climate

Abundance declined beginning in 1979, probably as a result of low productivity caused in part by increased winter flows effecting incubating eggs beginning in 1977, and increased exploitation rates in both terminal and pre-terminal areas (Figure 3.14). As productivity improved in the early 1980s, the sustained increase in harvest rates may have hindered the ability of the populations to rebuild. Productivity again declined with the significant decrease in mean spawning flows (September-October), beginning in 1986. This decline corresponded with the period of highest total exploitation rates and lowest abundances in the HC-SJF summer chum region (1989-92). Increases in exploitation rates during this time were primarily due to increased exploitation in Canadian fisheries. Both U.S. pre-terminal and terminal fishery exploitation rates had begun to decline from their peaks in the early to mid-1980s. The combined effects of high pre-terminal exploitation rates and unfavorable spawning conditions may have also impeded recovery. Terminal area exploitation rates did not increase, and in fact declined for most management units, after the decrease in spawning flows in 1986 (see Part One).

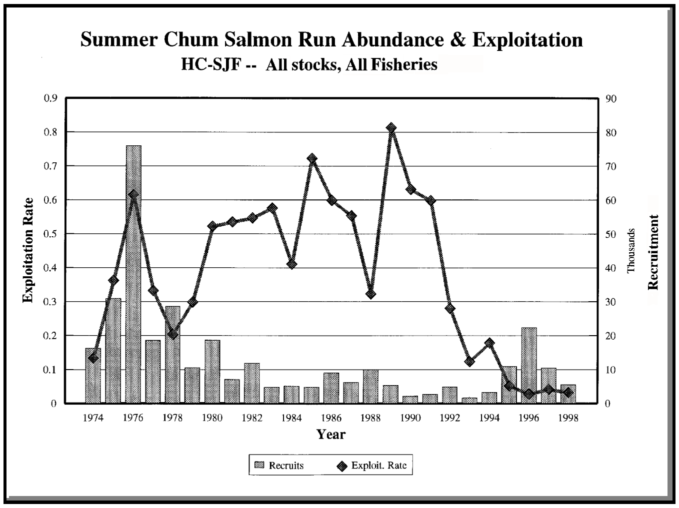

**Figure 3.14**. HC-SJF summer chum abundance and incidental fishing exploitation rates.

Beginning with the 1979 return, Strait of Juan de Fuca escapements reflected an increased variability due to the higher pre-terminal harvest rates in pink years but remained fairly robust. Strait of Juan de Fuca abundance and subsequent escapements were depressed beginning with the returns from the broods experiencing reduced spawning flows that began in 1986. The total abundance was the lowest up to that time and the increased exploitation rates in Canadian fisheries depressed escapements even further. Since then, exploitation rates have been significantly reduced. In recent years, Discovery Bay Management Unit escapements may have shown some favorable response to decreased exploitation rates, returning at levels within the range observed prior to 1989. However, the increased abundance may also be attributed in large part to the supplementation program operating on Salmon Creek since 1992. Sequim Bay Management Unit escapements have remained depressed at levels even lower than those of the 1989-92 period. Although these management units appeared to be robust to the 1976 regime shift in incubation flows which affected management units in the Hood Canal region, the added decrease in productivity brought on by the 1986 shift in spawning flows coupled with the increased pre-terminal fishery exploitation probably severely impacted abundance in this region.

Unlike the Strait of Juan de Fuca, Hood Canal populations experienced their period of highest sustained exploitation rates coincident with the first returns from the broods impacted by the climate shift in 1976, and continued through the mid-1980s. Rates on the Area 12D Management Unit increased even earlier, beginning in 1975 with implementation of the Boldt Decision. More than 70% of the harvest on the Area 12D Management Unit and 60% or more of the harvest on the Area 12/12B/12C Management Unit during this time was from terminal harvest. Although exploitation in terminal areas declined substantially beginning in 1988, overall rates did not immediately decrease due to increased exploitation in Canadian fisheries. In summary, high exploitation rates continued despite the decreased production of the Hood Canal Management Units that resulted from the climate regime shifts of the mid-1970s and 1980s. The combination of the two was a major factor leading to depressed abundance and escapements. The exception has been the Area 12D Management Unit where since the mid-1980s abundances and escapements have been above those of the late 1970s and early 1980s.

### 3.5.4.2 Ecological Interactions

Some scientists and members of the public have speculated that incidental harvest of summer chum has increased as a result of increasing survival and production of wild and hatchery fall chum. Although there may be summer chum caught in fisheries targeted on fall chums, the harvest is probably very low given that the difference in peak entry timing between summer and fall chum varies by a month or more. In addition, GSI sampling of commercial fall chum fisheries in Hood Canal and South Puget Sound indicate Hood Canal summer chum are not present at detectable levels during fall chum fisheries.

Another theory for a contributor to the decline of summer chum has been predation and competition from both conspecific fall chum and other species. Both the numbers and timing of both wild and hatchery-produced chum fry entering Hood Canal in recent years, and the indirect effects of overlapping spawning areas between the two races suggest the possibility of negative competitive impacts on summer chum salmon populations. Hatchery programs for other species of salmonids have in some cases been intensive, and the potential for both competitive and predatory impacts on summer chum salmon juveniles has been identified (WDF et al. 1993, Johnson et al. 1997, Tynan 1998). Although the evidence is not conclusive, the recent improvements in summer chum abundance suggest that these have not been significant contributors to the decline of summer chum (see section 2.2.3). However, what competitive and predation effects do exist may aggravate declines in freshwater productivity in those systems already impacted by the climatic regime shifts and habitat degradation.

### 3.5.4.3 Habitat Degradation

The reduction of stream and estuarine productivity and capacity caused by habitat degradation is accumulative with the negative effects of climate and excessive fishery exploitation. The effects of habitat degradation likely contributed to the decline in productivity in systems with summer chum, impacted by the regime shifts in 1976 and 1986. Some populations appear to have responded positively from the reduction in harvest rates and added supplementation. However, improved habitat conditions, coupled with these other management actions, will be essential to the ability of the HC-SJF summer chum to recover.

## 3.5.5 Stock Assessment Information and Limitations

The quality and quantity of data varies depending on the parameter. Little information is available regarding individual stocks. Additional information will be assessed and incorporated as it becomes available.

### 3.5.5.1 Abundance

Abundance estimates for the past twenty-five year period are considered to be reliable. Abundance estimates for each management unit were re-examined and the historical record of spawner surveys and spawning abundance estimates for each stock has been re-evaluated, as part of this planning effort. These improved estimates of abundance and escapements have been used to form the basis for further analysis. Details of the escapement estimation approach and procedures used can be found in Appendix Report 1.1.

Evaluation of the spawning data indicates that: 1) Revised annual spawning escapement estimates for most stocks have not changed dramatically from those previously derived; 2) Estimates prior to 1974 are generally not reliable, primarily because of the lack of survey data, as well as the quality of the available data; and 3) More information is needed regarding spawner separation in October, as well as regarding fishery contributions from late September through early October, in order to distinguish summer chum from fall chum and facilitate improved recruit assessment and abundance estimates.

Total abundance estimates represent a significant improvement over previous estimates for the following reasons: 1) Genetic stock identification (GSI) data and entry-pattern analysis has been used to provide population-specific estimates of harvest and to better differentiate between fall and summer chum; 2) harvest in Canadian fisheries was included in the estimates, and; 3) harvest from recreational gear was included in the estimates. Even though abundance estimates have been improved, there are still further improvements that could be made: 1) additional GSI information from terminal fisheries to estimate the contribution of summer versus fall chum populations; 2) improved catch reporting/estimation in some areas; and 3) additional GSI information in both terminal and pre-terminal areas to better estimate the contribution of HC-SJF summer chum to fisheries and to better describe passage through these areas.

### 3.5.5.2 Productivity

Information on productivity is extremely limited and no population specific information exists (see section 1.4.6.2). Data on age at maturity, sex ratio at maturity and habitat capacity, are essential in order to obtain estimates of recruits-per-spawner and production potential. Such information would allow us to develop Maximum Sustained Yield (MSY) estimates and better define limiting factors on a production or management unit-specific basis.

#### 3.5.5.3 Population Structure

Spawning generally occurs within the lower 2 miles of all the rivers to which HC-SJF summer chum return. Information on spawner run timing has been collected for the past thirty years and has been found to be similar in most systems (Appendix Report 1.2). No significant differences in body size have been observed but better information is needed. As discussed above, age structure and sex ratio data is extremely limited or non-existent. No other significant dissimilarities among life-history traits have been detected among the management units or stocks to date. The available genetic data describing population structure is summarized in Part One (section 1.7.2.1).

### 3.5.6 Harvest Management Strategies

Given the current lack of reliable information on which to base MSY estimates of appropriate escapement ranges or exploitation rates, interim management objectives have been defined, which seek to minimize incidental impacts to summer chum, during fisheries for other species. These shall be modified in response to new information as it becomes available. The harvest strategy described in the following sections forms the foundation of the Base Conservation Regime (BCR). Harvest activities conducted in accordance with this regime are expected not to appreciably reduce the likelihood of survival and recovery of HC-SJF summer chum in the wild and are expected to contribute to their recovery. Designing generic fishery regimes for the harvest of target species (coho, chinook, pinks, fall chum) based on both the biological requirements of HC-SJF summer chum and the target species, is expected to result in stable, reduced exploitation rates on co-mingled summer chum salmon, when fisheries for those target species occur. When additional fishery restrictions are implemented to protect those target species, it is expected to also result in further protection for HC-SJF summer chum.

This BCR is comprised of a conservative four-way control mechanism:

1. A base set of fishery-specific management actions for fisheries in pre-terminal (Canadian, U.S.),Washington terminal and Washington extreme terminal areas (section 3.5.6.1, Tables 3.29-3.34);

2. Management unit and stock abundance and escapement thresholds that trigger review of and possible adjustment of the management actions (section 1.7.3, Appendix Report 1.5);

3. Expected fishery specific exploitation rate targets and ranges based on the application of the BCR on the HC-SJF summer chum management units (section 3.5.6.1); and

4. Overall management performance standards based on natural production against which to assess success of the regime and make necessary adjustments (section 3.5.6.3). The actions required depend both on the status of the management unit and the stocks within them, with the most conservative controls prevailing.

Additional management actions will be taken as necessary should a management unit or stock fall below the escapement and abundance thresholds defined by the BCR. Although specific critical regime responses have not been defined at this time, the procedures for addressing such circumstances are addressed in sections 3.5.6.2 and 3.6.1.

Harvest of HC-SJF summer chum occurs incidentally in fisheries directed at other species. Therefore management actions to protect summer chum involve the shaping and regulation of fisheries for these other target species. During the initial years of implementation, while information is being gathered to assess the productivity and MSY of summer chum populations, exploitation rate expectations are set for three fishery groups: Canadian, Washington Pre-terminal and Washington Terminal. Management actions in addition to those described below will be implemented if necessary to meet exploitation rate and escapement objectives described in Tables 1.9, 1.10 and 3.35. These additional measures may include net length and mesh size restrictions, limited soak times and gillnet live release of chum, and additional time, area or gear restrictions. On-board live boxes may be used to monitor and estimate mortality associated with experimental actions such as selective fishing. If inseason conditions deviate significantly from the preseason expectations, the parties will meet prior to implementation of additional fisheries to reach agreement on an appropriate management strategy.

The BCR prescribes management actions across all fisheries thought to impact Hood Canal and Strait of Juan de Fuca summer chum, including Canadian fisheries. Authority to implement those actions is limited for fisheries outside the jurisdiction of Washington tribal and state managers. However, successful implementation of the BCR requires the parties and the U.S. government to actively pursue these recommendations with Canada. In 1999, the parties sought, through the Pacific Salmon Treaty (PST) process, to highlight the potential impacts of Canadian fisheries on depressed U.S. summer chum populations, and requested that by-catch reduction measures be implemented for those fisheries. As a result, Canada agreed to include most of the actions recommended for Canadian fisheries in this plan in the 1999 chum PST agreement, which is in effect through 2008. The parties will continue to seek additional protection from Canadian fisheries on depressed U.S. summer chum populations as necessary. Recent actions by Canada in response to coho, chinook and steelhead conservation concerns, and a high rate of northern migration of Canadian pink and sockeye salmon populations, have led to significantly reduced exploitation rates on HC-SJF summer chum. Continuation of these measures are expected to result in savings beyond those anticipated from the actions described in the PST chum agreement. Integration of U.S. and Canadian management for the fisheries that impact HC-SJF summer chum is important in achieving the exploitation objectives described herein. For example, Canadian catch is estimated to be 79-83% of the harvest mortality on summer chum in the Strait of Juan de Fuca region in recent years (Table 3.25).

### 3.5.6.1 Base Conservation Regime

The intent of this regime is to initiate rebuilding by providing incremental increases in escapement over time, while allowing a limited opportunity to harvest other species. Commercial and recreational fisheries shall be conducted under this regime when abundance and escapements are above the critical thresholds as described here. The fishery specific management measures comprising this regime are outlined in Tables 3.29-3.34. Actions include closure of summer chum-directed fisheries, delayed or truncated fishery openings for other salmonid species designed to protect approximately 90% or more of the run of each HC-SJF summer chum management unit, chum non-retention in fisheries directed at other species, and area closures around freshwater spawning tributaries.

In order to control impacts to summer chum salmon, as well as preserve opportunities to harvest other species, Management actions under the BCR (Tables 3.29-3.34) were designed as follows:

1. *Measures which are not expected to affect opportunity to harvest other species.* These require the release of all chum in commercial and recreational hook-and-line (troll, recreational and subsistence) fisheries, in times and places where HC-SJF summer chum salmon are likely to be present[7]. This measure has been proposed to be implemented in all impacting Washington fisheries and is included as part of the PST agreement for Canadian fisheries of concern.

2. *Measures which may have a small effect on the opportunity to harvest other species.* These measures require the release of all chum salmon in commercial net fisheries, capable of releasing them with a very high level of survival, in times and places where HC-SJF summer chum are likely to be present[7] and closures of freshwater spawning grounds where HC-SJF summer chum are present to protect spawning adults. Some impact to these fisheries is expected because of handling the catch in the process of selecting, brailing, and releasing chum salmon will entail additional delays and costs which will have an effect on the fishing opportunity. Closures in some freshwater areas will limit access to some commingled species in the vicinity of HC-SJF summer chum spawning areas. This measure has been proposed to be implemented in all impacting Washington fisheries and is included as part of the PST agreement for Canadian fisheries of concern.

3. *Measures which will result in significant reduction in opportunity to harvest other species.* These are comprised of time-area closures of fisheries which are not normally capable of releasing salmon with a high degree of survival, i.e., gillnet fisheries. Application of these measures is implemented, under the BCR, in terminal and extreme terminal U.S. fisheries (Hood Canal mainstem, Quilcene/Dabob Bays and southeast Hood Canal). This maximizes the potential savings to individual management units since these actions are taken where the HC-SJF summer chum are most concentrated and maximizes harvest opportunity in pre-terminal fisheries where HC-SJF summer chum are co-mingled with abundant runs of species returning to other terminal areas. The potential savings may also be significant enough to offset the potential loss of harvest opportunity for other species returning to Hood Canal and the Strait of Juan de Fuca.

Research activities are not restricted by the times, locations and actions described in Tables 3.29-3.34 if those restrictions would compromise the purpose of the research activity. However, research activities will be designed to minimize the take of summer chum as much as possible while gathering the necessary information. Mortality resulting from fishing related research activities will be included when evaluating the observed exploitation rates against the exploitation rate targets and ranges in Table 3.35.

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[7] In evaluating impact savings, no release related mortality was assumed since prior observations appear to indicate that release mortality for chum salmon, in general is very low (Eames et al. 1983). However, this assumption needs to be tested more thoroughly.

**Table 3.29.** Base Conservation Regime harvest management actions[1]

**TREATY Hook and Line Fisheries (Troll, Recreational, Subsistence)**

***Mixed Population Fisheries (Regime is applied when one or more MUs are at Conservation Level abundance)***

| | Start Date | End Date | Action |
|---|---|---|---|
| Canadian Areas 20-1, 3, 4, 5 | August 1 | September 15 | Release all chum salmon |
| Canadian Areas 29-2......29-7 | August 1 | September 15 | Release all chum salmon |
| Canadian Areas 18-1, 2, 4, 5, 9, 11, & 19-3, 4, 5 | August 1 | September 15 | Release all chum salmon |
| | | | |
| WA Ocean (Area 4) | August 1 | September 30 | Release all chum salmon[4] |
| WA Strait of Juan de Fuca (4B, 5, 6, 6A, 6B[2], 6C | August 1 | September 30 | Release all chum salmon[4] |
| WA San Juans (7, 7A) | August 1 | September 30 | Release all chum salmon[4] |
| Admiralty Inlet (9[3]) | August 1 | September 30 | Release all chum salmon[4] |
| ***Terminal Area Fisheries (Regime is applied when one or more Hood Canal MUs are at Conservation Level abundance*** | | | |
| Seattle Area (10) | August 1 | September 7 | Release all chum salmon[4] |
| Mainstem Hood Canal (12, 12B, 12C) | August 1 | September 30 | Release all chum salmon |
| Skokomish Delta to SR 106 | August 1 | September 30 | Release all chum salmon |
| Port Gamble (9A) | August 1 | September 30 | Release all chum salmon |
| ***Extreme Terminal Area Fisheries (Regime is applied and effects single MUs when at Conservation Level abundance*** | | | |
| Dungeness Bay (6D) to schoolhouse Bridge | August 1 | September 20 | Closed |
| | September 21 | October 15 | Release all chum salmon |
| Sequim Bay | August 1 | October 15 | Closed |
| Discovery Bay | August 1 | October 15 | Closed |
| Port Townsend Bay | August 1 | October 15 | Release all chum salmon |
| Quilcene/Dabob Bays | August 1 | August 20 | Closed |
| | August 21 | September 30 | Release all chum salmon |
| SE Hood Canal (12D) | August 1 | September 30 | Release all chum salmon |
| ***Freshwater Fisheries (Regime is applied and affects single stocks when at Conservation Level abundance*** | | | |
| Dungeness River (above Schoolhouse Bridge) | August 1 | October 15 | Release all chum salmon |
| Jimmycomelately Creek | September 1 | October 15 | Closed |
| Salmon Creek | September 1 | October 15 | Closed |
| Snow Creek | September 1 | October 15 | Closed |
| Chimicum Creek | September 1 | October 15 | Release all chum salmon |
| Big Beef Creek | September 1 | October 15 | Release all chum salmon |
| Little Quilcene River | September 1 | October 15 | Release all chum salmon |
| Big Quilcene River | September 1 | October 15 | Release all chum salmon, closed below Rogers St. |
| Dosewallips River | September 1 | October 15 | Release all chum salmon |
| Duckabush River | September 1 | October 15 | Release all chum salmon |
| Hamma Hamma River | September 1 | October 15 | Release all chum salmon |
| Lilliwaup River | September 1 | October 15 | Release all chum salmon |
| Skokomish River (above SR106 bridge) | September 1 | October 15 | Release all chum salmon |
| Dewatto River | September 1 | October 15 | Release all chum salmon |
| Tahuya River | September 1 | October 15 | Release all chum salmon |
| Union River | August 16 | October 15 | Release all chum salmon |

[1] Stream mouths closed to troll gear within 1,000' marine area radius from each stream mouth when that stream is closed to fishing.
[2] Outside Sequim and Discovery bays.
[3] Outside Commercial Area 9A and Port Townsend Bay/ Kilisut Harbor.
[4] Under discussion with affected tribes.

**Table 3.30.** Base Conservation Regime harvest management actions

| **NON-TREATY Hook and Line Fisheries (Troll, Recreational)**[1] | | | |
|---|---|---|---|
| ***Mixed Population Fisheries (Regime is applied when one or more MUs are at Conservation Level abundance)*** | | | |
| | **Start Date** | **End Date** | **Action** |
| Canadian Areas 20-1,3,4,5 | August 1 | September 15 | Release all chum salmon |
| Canadian Areas 29-2.....29-7 | August 1 | September 15 | Release all chum salmon |
| Canadian Areas 18-1,2,4,5,9,11&19-3,4,5 | August 1 | September 15 | Release all chum salmon |
| | | | |
| WA Ocean (Area 4) Sport and Troll | August 1 | September 30 | Release all chum salmon |
| WA Strait of Juan de Fuca (5,6) Sport | August 1 | September 30 | Release all chum salmon |
| WA San Juans (7) Sport | August 1 | September 30 | Release all chum salmon |
| Admiralty Inlet (9) Sport | August 1 | September 30 | Release all chum salmon |
| ***Terminal Area Fisheries (Regime is applied when one or more Hood Canal MUs are at Conservation Level abundance*** | | | |
| Seattle Area (10) Sport | August 1 | September 15 | Release all chum salmon |
| Mainstem Hood Canal (12) Sport | August 1 | October 15 | Release all chum salmon |
| ***Freshwater Fisheries (Regime is applied and affects single stocks when at Conservation Level abundance*** | | | |
| Dungeness River | August 1 | October 15 | Release all chum salmon |
| Jimmycomelately Creek | September 1 | October 31 | Closed |
| Salmon Creek | September 1 | October 31 | Closed |
| Snow Creek | September 1 | October 31 | Closed |
| Chimacum Creek | September 1 | October 31 | Closed below Ness' Corner Rd, closed for salmon above Ness' Corner Rd. |
| Big Beef Creek | September 1 | October 31 | Closed mouth to outlet of Lake Symington |
| Little Quilcene River | September 1 | October 31 | Closed below Hwy. 101 Brdg, closed for salmon above Hwy. 101 bridge |
| Big Quilcene River | September 1 | October 15 | Closed below Rogers St., release chum above Rogers St. |
| Dosewallips River | September 1 | October 31 | Release all chum salmon, closed mouth to powerline crossing |
| Duckabush River | September 1 | October 31 | Release all chum salmon, closed mouth to powerline crossing |
| Hamma Hamma River | September 1 | October 31 | Release all chum salmon, Closed mouth to falls |
| Lilliwaup River | September 1 | October 31 | Closed |
| Skokomish River | September 1 | October 15 | Release all chum salmon |
| Dewatto River | September 1 | October 15 | Release all chum salmon |
| Tahuya River | September 1 | October 15 | Release all chum salmon |
| Union River | August 16 | October 31 | Closed to salmon |

[1] Non-treaty troll gear used only in Washington Catch Areas 1-4.

**Table 3.31.** Base Conservation Regime harvest management actions[1]

**TREATY Purse Seine, Beach Seine, Reef Net, Roundhaul/Lampara, Traps, Weirs, Dipnets**

| | Start Date | End Date | Action |
|---|---|---|---|
| ***Mixed Population Fisheries (Regime is applied when one or more MUs are at Conservation Level abundance)*** | | | |
| Canadian Areas 20-1,3,4,5 | August 1 | September 15 | Release all chum salmon |
| Canadian Areas 29-2.....29-7 | August 1 | September 15 | Release all chum salmon |
| Canadian Areas 18-1,2,4,5,9,11&19-3,4,5 | August 1 | September 15 | Release all chum salmon |
| WA Strait of Juan de Fuca(4B,5,6,6A,6B[2],6C) | August 1 | September 30 | Release all chum salmon[4] |
| WA San Juans (7, 7A) | August 1 | September 30 | Release all chum salmon[4] |
| Admiralty Inlet (9[3]) | August 1 | September 30 | Release all chum salmon[4] |
| ***Terminal Area Fisheries (Regime is applied when one or more Hood Canal MUs are at Conservation Level abundance*** | | | |
| Seattle Area (10) | August 1 | September 7 | Release req. under discussion |
| Mainstem Hood Canal (12,12B) | August 1 | August 20 | Release all chum salmon |
| | August 21 | September 15 | Closed |
| | September 16 | September 30 | Release all chum salmon |
| Mainstem Hood Canal (12C) | August 1 | August 31 | Release all chum salmon |
| | September 1 | September 20 | Closed |
| | September 21 | September 30 | Release all chum salmon |
| Mainstem Hood Canal (12B, 12C)[5] | October 1 | October 10 | Rel. all chum, caught within 500' from w. shore |
| Skokomish Delta to SR106 | August 1 | September 30 | Release all chum salmon |
| Port Gamble (9A) | August 1 | September 30 | Release all chum salmon |
| ***Extreme Terminal Area Fisheries (Regime is applied and affects single MUs when at Conservation Level abundance*** | | | |
| Dungeness Bay (6D) to Schoolhouse Bridge | August 1 | September 20 | Closed |
| | September 21 | October 10 | Release all chum salmon |
| Sequim Bay | August 1 | October 15 | Closed |
| Discovery Bay | August 1 | October 15 | Closed |
| Port Townsend Bay | August 1 | October 15 | Closed |
| Quilcene/Dabob Bays | August 1 | August 20 | Closed |
| | August 21 | September 30 | Release all chum salmon |
| SE Hood Canal (12D) | August 1 | September 30 | Closed |
| ***Freshwater Fisheries (Regime is applied and affects single stocks when at Conservation Level abundance*** | | | |
| Dungeness River (above Schoolhouse Bridge) | August 1 | October 15 | Release all chum salmon |
| Jimmycomelately Creek | September 1 | October 15 | Closed |
| Salmon Creek | September 1 | October 15 | Closed |
| Snow Creek | September 1 | October 15 | Closed |
| Chimicum Creek | September 1 | October 15 | Closed |
| Big Beef Creek | September 1 | October 15 | Closed |
| Little Quilcene River | September 1 | October 15 | Closed |
| Big Quilcene River | September 1 | October 15 | Release all chum salmon, closed below Rogers St. |
| Dosewallips River | September 1 | October 15 | Release all chum salmon |
| Duckabush River | September 1 | October 15 | Release all chum salmon |
| Hamma Hamma River | September 1 | October 15 | Release all chum salmon |
| Lilliwaup River | September 1 | October 15 | Closed |
| Skokomish River (above SR106 bridge) | September 1 | October 15 | Release all chum salmon |
| Dewatto River | September 1 | October 15 | Release all chum salmon |
| Tahuya River | September 1 | October 15 | Release all chum salmon |
| Union River | August 16 | October 15 | Closed |

[1] Stream mouths closed to net gear except dipnets within 1,000' marine area radius from each stream mouth when that stream is closed to fishing.
[2] Outside Sequim and Discovery bays.
[3] Outside Commercial Area 9A and Port Townsend Bay/ Kilisut Harbor.
[4] Under discussion with affected tribes.
[5] 500' offshore closure along west shore of Area 12B and 12C, south, to a point 2,000' south of Lilliwaup.

**Table 3.32.** Base Conservation Regime harvest management actions[1]

| | | | |
|---|---|---|---|
| **NON-TREATY Purse Seine, Beach Seine, Reef Net, Roundhaul/Lampara, Traps, Weirs, Dipnets** | | | |
| ***Mixed Population Fisheries (Regime is applied when one or more MUs are at Conservation Level abundance)*** | | | |
| | **Start Date** | **End Date** | **Action** |
| Canadian Areas 20-1,3,4,5 | August 1 | September 15 | Release all chum salmon |
| Canadian Areas 29-2.....29-7 | August 1 | September 15 | Release all chum salmon |
| Canadian Areas 18-1,2,4,5,9,11&19-3,4,5 | August 1 | September 15 | Release all chum salmon |
| | | | |
| WA Strait of Juan de Fuca (4B,5,6,6A,6C) | August 1 | September 30 | Closed |
| WA Strait of Juan de Fuca (6B[2]) | August 1 | October 15 | Closed |
| WA San Juans (7, 7A) | August 1 | September 30 | Release all chum salmon |
| Admiralty Inlet (9[3]) | August 1 | September 30 | Closed |
| ***Terminal Area Fisheries (Regime is applied when one or more Hood Canal MUs are at Conservation Level abundance*** | | | |
| Seattle Area (10) | August 1 | September 7 | Closed |
| Mainstem Hood Canal (12)[4] | August 1 | October 10 | Release all chum salmon |
| Mainstem Hood Canal (12B/12C)[4] | August 1 | September 30 | Release all chum salmon |
| | October 1 | October 10 | Release chum; closed within 1,000' of western shore |
| Port Gamble (9A) | August 1 | September 30 | Release all chum salmon |
| ***Extreme Terminal Area Fisheries (Regime is applied and affects single MUs when at Conservation Level abundance*** | | | |
| Dungeness Bay (6D) | August 1 | September 20 | Closed |
| | September 21 | October 10 | Release all chum salmon; 1500' closure around Dung. R. mouth |
| Quilcene/Dabob Bays (12A) | August 1 | August 20 | Closed |
| | August 22 | October 10 | Release all chum salmon, except broodstock collection |
| SE Hood Canal (12D) | August 1 | October 15 | Closed |
| ***Freshwater Fisheries (Regime is applied and affects single stocks when at Conservation Level abundance*** | | | |
| Dungeness River | | | Closed; these gears not used here |
| Jimmycomelately Creek | | | |
| Salmon Creek | | | |
| Snow Creek | | | |
| Chimicum Creek | | | |
| Big Beef Creek | | | |
| Little Quilcene River | | | |
| Big Quilcene River | | | |
| Dosewallips River | | | |
| Duckabush River | | | |
| Hamma Hamma River | | | |
| Lilliwaup River | | | |
| Skokomish River (above SR106 bridge) | | | |
| Tahuya River | | | |
| Union River | | | |

[1] General stream mouth closure is within 1,000' marine area radius from each stream mouth.
[2] Includes Sequim and Discovery bays.
[3] Includes Port Townsend Bay/ Kilisut Harbor.
[4] Purse seines and gillnets closed within 1000' of eastern shore at all times.

**Table 3.33.** Base Conservation Regime harvest management actions[1]

**TREATY Drift Gillnets, Set Gillnets, Skiff Gillnets**

| | **Start Date** | **End Date** | **Action** |
|---|---|---|---|
| ***Mixed Population Fisheries (Regime is applied when one or more MUs are at Conservation Level abundance)*** | | | |
| Canadian Areas 20-1,3,4,5 | August 1 | September 15 | Time and possible gear mod.[4] |
| Canadian Areas 29-2.....29-7 | August 1 | September 15 | Time and possible gear mod.[4] |
| Canadian Areas 18-1,2,4,5,9,11&19-3,4,5 | August 1 | September 15 | Time and possible gear mod.[4] |
| WA Strait of Juan de Fuca (4B,5,6,6A,6B[2],6C) | August 1 | September 30 | Time and possible gear mod.[4] |
| WA San Juans (7, 7A) | August 1 | September 30 | Time and possible gear mod.[4] |
| Admiralty Inlet (9[3]) | August 1 | September 30 | Time and possible gear mod.[4] |
| ***Terminal Area Fisheries (Regime is applied when one or more Hood Canal MUs are at Conservation Level abundance*** | | | |
| Seattle Area (10) | August 1 | September 7 | Actions under discussion |
| Mainstem Hood Canal (12) | August 1 | September 24 | Closed |
| Mainstem Hood Canal (12B) | August 1 | September 30 | Closed |
| Mainstem Hood Canal (12C) | August 1 | August 24 | 7" minimum mesh |
| | August 25 | September 30 | Closed |
| Mainstem Hood Canal (12B, 12C)[5] | October 1 | October 10 | Closed 500' from west shore |
| Skokomish Delta to SR106 | August 1 | September 30 | Closed |
| Port Gamble (9A) | August 1 | September 30 | No regime based regulation |
| ***Extreme Terminal Area Fisheries (Regime is applied and affects single MUs when at Conservation Level abundance*** | | | |
| Dungeness Bay (6D) to Schoolhouse Bridge | August 1 | September 20 | Closed |
| | September 21 | October 10 | Release all chum salmon |
| Sequim Bay | August 1 | October 15 | Closed |
| Discovery Bay | August 1 | October 15 | Closed |
| Port Townsend Bay | August 1 | October 15 | Closed |
| Quilcene/Dabob Bays[6] | August 1 | August 31 | Closed |
| | September 1 | September 30 | 1d/wk if 1500<esc<2500, [close if esc<1500], 2 d/wk if 2500< esc<[3500] (this rule continues through Oct. 7 west of a line from Point Whitney to the southern point of the Bolton Peninsula). |
| | | | Closed |
| SE Hood Canal (12D) | August 1 | September 30 | |
| ***Freshwater Fisheries (Regime is applied and affects single stocks when at Conservation Level abundance*** | | | |
| Dungeness River | August 16 | October 15 | Release all chum salmon |
| Jimmycomelately Creek | | | Closed (this gear not used here) |
| Salmon Creek | | | Closed (this gear not used here) |
| Snow Creek | | | Closed (this gear not used here) |
| Chmicum Creek | | | Closed (this gear not used here) |
| Big Beef Creek | | | Closed (this gear not used here) |
| Little Quilcene Rvier | | | Closed (this gear not used here) |
| Big Quilcene River | September 1 | October 15 | Closed |
| Dosewallips River | September 1 | October 15 | Closed |
| Duckabush River | September 1 | October 15 | Closed |
| Hamma Hamma River | September 1 | October 15 | Closed |
| Lilliwaup River | September 1 | October 15 | Closed |
| Skokomish River (above SR 106 bridge) | | | No regime based regulation |
| Dewatto River | September 1 | October 15 | Closed |
| Tahuya River | September 1 | October 15 | Closed |
| Union River | August 16 | October 15 | Closed |

[1] General stream mouth closure is 1,000' marine area radius from each stream mouth.

[2] Outside Sequim and Discovery bays.

[3] Outside Commercial Area 9A and Port Townsend Bay/ Kilisut Harbor.

[4] Pursue within PSC process

[5] 500' offshore closure along west shore of Area 12B and 12C, south, to a point 2,000' south of Lilliwaup.

[6] Closed south of a line from Point Whitney to Tabook Point.

**Table 3.34.** Base Conservation Regime harvest management actions[1]

**NON-TREATY Drift Gillnets and Skiff Gillnets**

***Mixed Population Fisheries (Regime is applied when one or more MUs are at Conservation Level abundance)***

| | Start Date | End Date | Action |
|---|---|---|---|
| Canadian Areas 20-1,3,4,5 | August 1 | September 15 | Release all chum salmon |
| Canadian Areas 29-2.....29-7 | August 1 | September 15 | Release all chum salmon |
| Canadian Areas 18-1,2,4,5,9,11&19-3,4,5 | August 1 | September 15 | Release all chum salmon |
| | | | |
| WA Strait of Juan de Fuca (4B,5,6,6A,6C) | August 1 | September 30 | Closed |
| WA Strait of Juan de Fuca (6B[2]) | August 1 | October 15 | Closed |
| WA San Juans (7, 7A) | August 1 | September 30 | Possible gear mod. |
| Admiralty Inlet (9[3]) | August 1 | September 30 | Closed |
| ***Terminal Area Fisheries (Regime is applied when one or more Hood Canal MUs are at Conservation Level abundance*** | | | |
| Seattle Area (10) | August 1 | September 7 | Closed |
| Mainstem Hood Canal (12)[4] | August 1 | September 24 | Closed |
| | September 25 | October 10 | Closed unless Treaty opening[5] |
| Mainstem Hood Canal (12B)[4] | August 1 | September 30 | Closed |
| | October 1 | October 10 | Closed w/in 1000' of west shore |
| Mainstem Hood Canal (12C)[4] | August 1 | September 30 | Closed unless Treaty opening[5] |
| | October 1 | October 10 | Closed w/in 1000' of west shore |
| Port Gamble (9A) | August 1 | September 30 | Release all chum salmon[6] |
| ***Extreme Terminal Area Fisheries (Regime is applied and affects single MUs when at Conservation Level abundance*** | | | |
| Dungeness Bay (6D) | August 1 | September 20 | Closed |
| | September 21 | October 15 | No drift gillnets; 1500' closure around Dung. R. mouth; skiff gillnets use min. mesh size of 5 ½" and 90 meshes deep, 7am-7pm only; actively tend gear and release chum[6] |
| Quilcene/Dabob Bays (12A)[7] | August 1 | August 31 | Closed |
| | September 1 | October 7 | Closed unless Treaty opening[6] |
| SE Hood Canal (12D) | August 1 | October 15 | Closed |
| ***Freshwater Fisheries (Regime is applied and affects single stocks when at Conservation Level abundance*** | | | |
| Dungeness River | | | Closed; these gears not used here |
| Jimmycomelately Creek | | | |
| Salmon and Snow Creeks | | | |
| Chimicum Creek | | | |
| Big Beef Creek | | | |
| Big and Little Quilcene Rivers | | | |
| Dosewallips River | | | |
| Duckabush River | | | |
| Hamma Hamma River | | | |
| Lilliwaup River | | | |
| Skokomish River | | | |
| Tahuya River/Dewatto River | | | |
| Union River | | | |

[1] General stream mouth closure is 1,000' marine area radius from each stream mouth.
[2] Includes Sequim and Discovery bays.
[3] Includes Port Townsend Bay/ Kilisut Harbor.
[4] Gillnets closed within 1000' of eastern shore at all times.
[5] Gillnets may be used during this period if treaty gillnet gear is used and total non-treaty fishery impacts are expected to be less than 5% of the Washington run size. Use of gillnets would include mesh restrictions, active tending of gear and chum release.
[6] Chum must be removed from net by cutting the meshes ensnaring fish.
[7] Closed south of a line from Point Whitney to Tabook Point.

## Exploitation Rate Expectations

In total, these actions are expected to result in, on the average, a 10.9% total (range = 3.3-15.3%) exploitation rate on the Hood Canal management units and 8.8% (range=2.8-11.8%) exploitation rate on Strait of Juan de Fuca management units (Table 3.35). The Quilcene/Dabob Bay Management Unit will be managed for a stepped exploitation rate based on escapement thresholds. (The parties will review these exploitation objectives and may make adjustments as provided in the periodic plan reviews in section 3.6.)

As well as the overall exploitation rate, exploitation rates are defined for each of three fishery aggregates:

**Table 3.35.** Expected exploitation rates and ranges by fisheries and regions.

| Fishery | Lower Bound of Range | Average Expected Exploitation Rate | Upper Bound of Range |
|---|---|---|---|
| Canadian | 2.3% | 6.3 % | 8.3% |
| U.S. pre-terminal | 0.5% | 2.5% | 3.5% |
| Terminal | 0.5% | 2.1% | 3.5% |
| Regional Totals | | | |
| Total Hood Canal[1] | 3.3% | 10.9% | 15.3% |
| Total SJF[2] | 2.8% | 8.8% | 11.8% |

[1] Total of Canadian, U.S. pre-terminal, and Hood Canal terminal exploitation rates. Hood Canal terminal rates apply to Areas 12, 12B, 12C, and 12D. The extreme terminal Quilcene Bay Area (12A) is expected to have an additional 5% exploitation rate.

[2] Total of Canadian and U.S. pre-terminal exploitation rates. There is no terminal area harvest of Strait of Juan de Fuca stocks.

These estimates were derived from years when there was full treaty and non-treaty participation in fisheries for all species using historical information on reported catches for each fishery grouping. Current fisheries are not reflective of the pattern in the early years used to estimate the BCR target rates, and it is likely that effort will be substantially lower, based on observations in recent years (1994-1998). If so, the actual impacts on HC-SJF summer chum under this regime will be even lower than anticipated.

Fishing pattern assumptions will be re-examined as part of the Five Year Plan Review (section 3.6.3).

***Canadian Fisheries*****:** These fisheries are outside the control of co-managers but are subject to the framework of the Pacific Salmon Treaty. As discussed in a previous section (section 3.5.3), impacts occur incidentally to the harvest of other species and are distributed across all management units. Estimated exploitation rates on HC-SJF summer chum have ranged from approximately 0% to 43% (Table 3.26). The higher rates were observed during 1985 and 1989-92 when Canada fished aggressively for sockeye and pink salmon. Generally, however, rates have been less than 15%. As a result of the new PST agreement (specifically the by-catch controls of the chum annex, and continued actions by Canada in response to coho, chinook and steelhead conservation concerns), Canadian fisheries are expected to be successfully managed for an exploitation rate that averages approximately 6.3% over four years and annually to fall within a range of 2.3-8.3%. Figure 3.15 illustrates the time period during which actions will be taken to protect HC-SJF summer chum. If exploitation rates deviate from expectations, the co-managers will consult with Canada on taking management actions to bring exploitation rates within the expected range as soon as those deviations are detected.

***Washington Pre-terminal Fisheries*:** These fisheries are under the control of the co-managers with pink and sockeye fisheries subject to the framework of the Pacific Salmon Treaty. Impacts occur incidentally to the harvest of other species and generally affect all management units within the HC-SJF summer chum region. Exploitation rates on summer chum have ranged from 0.4% to 10.1%. Exploitation rates in years of Fraser pink fisheries have averaged 5.7% (range = 0.4-10.1%) and generally, are slightly more than double those of non-pink years which have averaged 2.4% (range = 0.5-4.4%) (Table 3.26). With more emphasis on the avoidance of impacts to summer chum from both recreational and commercial fisheries, i.e., release requirements, U.S. pre-terminal fisheries will be managed for an exploitation rate that averages approximately 2.5% over four years and annually to fall within a range of 0.5-3.5%. Figures 3.16 and 3.17 illustrate the time period during which actions will be taken to protect HC-SJF summer chum. If exploitation rates deviate from the expectations in Table 3.35, the co-managers will take management actions to bring exploitation rates within the expected range as soon as those deviations are detected.

***Strait of Juan de Fuca Terminal Fisheries*:** These fisheries are under the control of the co-managers and affect the Sequim Bay and Discovery Bay management units. In recent years,

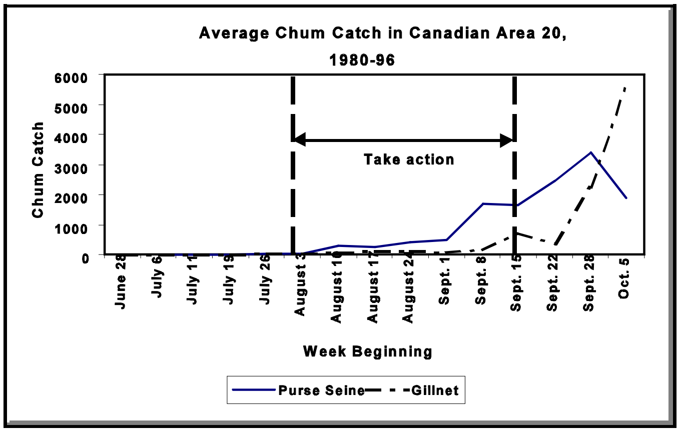

**Figure 3.15**. Timing of actions to protect HC-SJF summer chum in the Canadian Area 20 fishery compared with timing of 1980-1996 average chum catch.

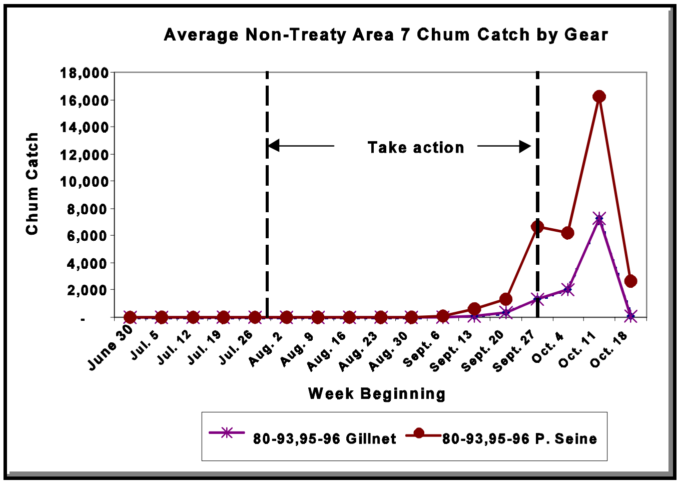

**Figure 3.16**. Timing of actions to protect HC-SJF summer chum in U.S. preterminal Treaty fisheries - Area 7 compared with timing of 1980-96 average chum catch.

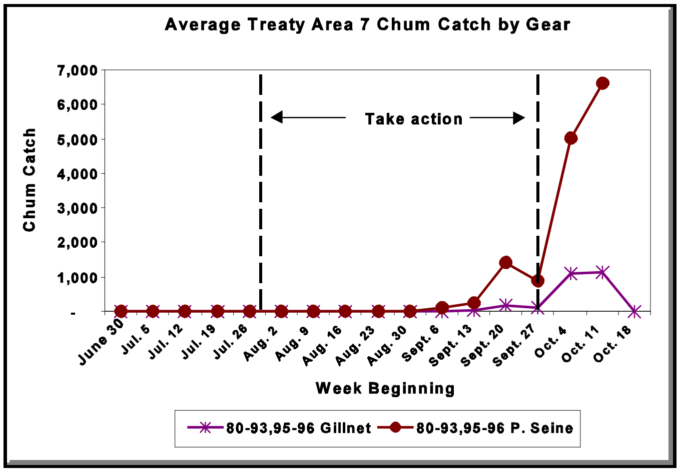

**Figure 3.17**. Timing of actions to protect HC-SJF summer chum in U.S. preterminal non-treaty fisheries - Area 7 compared with timing of 1980-96 average chum catch.

minimal incidental harvests have occurred and fisheries likely to impact summer chum will remain closed in most areas. Fishers in Dungeness Bay will be required to release chum salmon when summer chum are expected to be present.

***Hood Canal Terminal Fisheries:*** These fisheries are under the control of the co-managers and effect only the management units of the Hood Canal region.

*Hood Canal Mainstem Fisheries:* During the 1974-1998 period, when fisheries for chinook and coho salmon occurred in the Hood Canal mainstem, the average summer chum exploitation rate in the Area 12/12B/12C fishery was 24.1% (range = 0.2-59.3%) (Table 3.27). Fisheries in the years used to derive the expected exploitation rate for this fishery aggregate were relatively unrestricted and therefore the exploitation rate expected for this fishery is probably higher than will be observed. Reduction in fleet size, participation and restrictions on other species are anticipated to lower impacts even further. This regime is designed to provide limited fishing opportunity on other salmonid species. However, the opportunity to harvest other species is restricted in order to result in 94% or greater reduction in the summer chum exploitation rate observed in years when fisheries were fully open on other species. If exploitation rates deviate from the expectations in Table 3.35, the co-managers will take management actions to bring exploitation rates within the expected range as soon as those deviations are detected.

*Quilcene Bay Fishery*: During the 1974-1998 period, when fisheries directed at coho salmon occurred on the Quilcene Bay Management Unit, the average summer chum exploitation rate in the terminal area was 38.9% (range 0.2-88.4%). Incidental harvests of summer chum salmon, in this extreme terminal fishery occur during the fishery for coho salmon returning to the Quilcene National Fish Hatchery (QNFH) and the Quilcene Bay Pens. Only the Quilcene Bay Management Unit is directly affected by this fishery. A supplementation program is on-going at the QNFH, in an effort to support the restoration of this management unit.

This fishery consists primarily of the use of hook and line, gillnet, and beach seine gear. No fishery-specific exploitation rate is defined for this fishery. Instead, management relies on a stepped fishing schedule based on an inseason assessment of natural escapement. During each season, the escapement of both coho and summer chum salmon shall be assessed on a weekly basis, from the last week in the month of August through the first week in October. On or about September 10, an assessment of the natural summer chum escapement shall be made. If the escapement is projected to be below 1,500 then Gillnet gear will not be permited. One day per week of fishing with the use of gillnet gear is allowed for escapements between 1,500 and 2,500. If the escapement is projected to exceed 2,500[8], a decision will be made whether one or more additional days per week of gillnet fishing is necessary to provide sufficient opportunity to harvest returning coho salmon. This schedule regulates only the use of gillnet gear. Regulation of selective gears such as beach seine, dip nets and hook and line are described in Tables 3.29-3.32.

*Southeast Hood Canal Fishery:* Under the BCR, during the time that summer chum are present, area 12D is closed to commercial fishing and requires release of chum when using hook-and-line gear. During the 1974-1998 period, when fisheries for chinook and coho salmon occurred in the Hood Canal mainstem, the average summer chum exploitation rate on the Area 12D Management Unit was

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[8] Escapements were less than 2,500 in all but two of the historically documented levels in unsupplemented years.

40.9% (range = 0.2-73.5%) (Table 3.27). Under this regime, the extreme terminal fishery in Southeast Hood Canal is expected to have no effect on Hood Canal summer chum (i.e. near zero exploitation rate). If exploitation rates deviate from this the co-managers will take corrective management actions.

*Freshwater Fisheries:* Impacts on summer chum in these areas have been minimal in recent years. Under this regime, impacts to summer chum will continue to be minimized through the use of selective gear, chum non-retention regulations, and area closures.

### 3.5.6.2 Harvest Regime Modification

In any given year, the BCR will be applied except where additional harvest management measures are needed to respond to a critical situation affecting a management unit or stock, or where recovery of the populations merits a liberalization of harvest meaures.

#### Critical Response

If a management unit should fall below its Critical Abundance or Critical Escapement threshold in the previous year, is forecast to fall below these thresholds in the upcoming year, falls below the thresholds in the parent brood years: OR if a stock fails to meet its Critical Escapement Distribution Flag or Minimum Escapement Flag in the previous return year, as provided in section 1.7.3 and Tables 1.9 and 1.10, the co-managers will investigate any additional harvest management measures, as provided for in section 3.6.1, which may be necessary to assist in restoring the management unit or stock to non-critical status. If there are modifications to the BCR, they will be referred to as the Critical harvest response.

#### Recovered Response

The goal for recovered status for summer chum salmon is to achieve self-sustaining, harvestable run sizes on a regular basis. This will provide the fishery managers greater management flexibility and will allow them to relax restrictions imposed in the BCR, including expanded fishing opportunity for other species and in some cases directed harvest for summer chum.

Given current levels of escapement and run size, recovery is not expected to occur for a number of years. In addition, the existing stock assessment data are limited, making it difficult to determine with reasonable surety when recovery is achieved. Because of these current data limitations and the extended time frame that will be required to achieve recovered status, this plan does not at this time include specific population recovery goals. However, the co-managers are in the process of developing interim recovery goals which will likely be added to the plan as an addendum during 2000. All state and tribal fisheries will operate in compliance with the BCR, and with any modifications made in response to detecting critical status for one or more management units or stocks, until such time as the co-managers have determined how to incorporate the population recovery goals into the management structure and will discuss what terms of the existing plan will continue.

### 3.5.6.3 Fishery Performance Standards

By achieving the fishery performance standards described in this plan, the harvest element of this plan will contribute to the stability and recovery of the HC-SJF summer chum. To fully meet these standards, assessments must be performed with a high degree of confidence. Evaluation each year will assess compliance with the regulations and management strategy described above, effectiveness of the implementation of that strategy and whether the data demonstrates that the assumptions made in developing the plan were reasonable and supported by field data. The following performance standards will be used to assess whether the harvest management strategy is being successfully implemented. In addition to these harvest management performance standards, population performance standards are provided in section 3.6.4, upon which this entire recovery plan will be evaluated and modified, as appropriate.

#### Compliance

1. Regulations were adopted consistent with the management actions described in Tables 3.29 - 3.34 or as modified per section 3.5.6.2.

2. Enforcement patrols indicate a high level of compliance with regulations adopted consistent with this plan. For example, weekly or daily reports indicate no fishing occurring inside stream mouth closures.

#### Exploitation Rates

Exploitation rates must have been within the identified range in any year. At the time of plan review, the expected rates must be within the established range and are not clustered toward either extreme of the range (see Table 3.35).

#### Preseason Forecasts

1. Annual run size forecasts are a component of our performance standards for harvest regime assessment and modification, and efforts should be made to ensure they are as precise and accurate as possible. Forecasts should be accurate and precise enough to ensure that the correct management regime is applied 80% of the time.

2. Forecasts of abundance should be unbiased relative to the post-season estimates. Any identified bias will be corrected or management actions adjusted to account for it, unless it is shown not to effect achievement of exploitation rates, escapement or abundance management targets.

## 3.5.7 Implementation

Efficient and effective plan implementation requires the tasks and process for review to be clearly described. This section describes the annual plan implementation, defines the responsible agencies for specific stock assessment, harvest management planning, regulations and tasks, and includes a schedule for annual plan implementation, review and evaluation.

### 3.5.7.1 Annual Plan Implementation

The following are the tasks required for annual implementation of the harvest plan. The co-managers shall:

1. Develop preliminary estimates and analyses of escapement, catch and catch distribution, recruit abundance (run reconstruction), and exploitation rates for the previous year's summer chum return. These estimates should be made by fishery aggregate, management unit and stock, as appropriate, no later than January 15 of each year. When age composition information becomes available, it will be provided along with estimates of brood survival, when sufficient age data exists to make these estimates.

2. Evaluate the exploitation rates in each of the three fishery aggregates to evaluate whether any of them has exceeded its expected exploitation rate range for that fishery. For the Quilcene/Dabob Management Unit this would involve an assessment of whether the escapement corresponding to the stepped fishery regime had been met or exceeded. If, for whatever reasons, these management objectives were not met, the Parties will identify the causes for the deviation and take such harvest management measures necessary to maintain exploitation rate(s) within the expected range(s). When this involves the conduct of intercepting fisheries in Canadian areas, the co-managers shall work in cooperation with the members of the PSC , beginning with the January PSC meeting, to take the necessary harvest management measures to bring that fishery back within the expected range.

3. Complete preseason forecasts for each management unit by February 15 of each year and note whether any management unit's recruitment is projected to fall below its Critical Threshold, and those management units where the parental broods were below the Critical Threshold. In those cases, the co-managers will implement any additional necessary harvest management measures as described in section 3.6.1. In preparing preseason forecasts, managers will use conservative methods. For example, until age data are available on which to make recruit/spawner estimates, no forecasted returns from parent broods which fell below their Critical Thresholds may exceed a recruit/spawner ratio of 1.2. Similar management considerations will be defined for abundances above the Recovered Thresholds as those are developed.

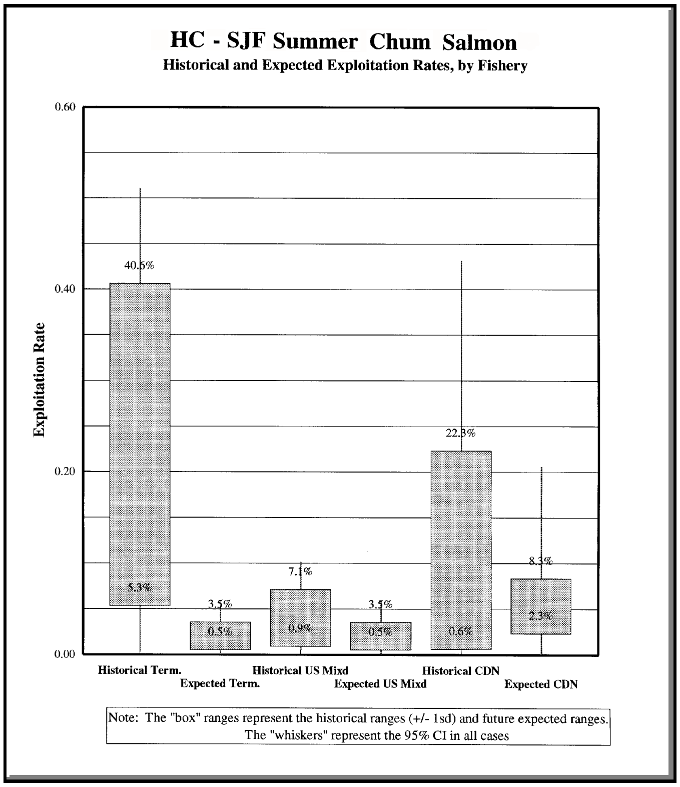

**Figure 3.19**. Comparison of proposed Hood Canal terminal exploitation rate with observed rates in 1989-1998.

4. Review by March 1 the pre-season forecasts for the current year, and the analysis of escapements and management performance of the previous year (post-season review), and parental brood escapements. Based on this information, the co-managers shall determine the appropriate fishing regime for the upcoming year. The management recommendations shall include any appropriate regime adjustments as well as regime modifications from the latest Five Year Review Report.

5. Adopt by April 15, an annual harvest management regime, as modified in number 4 above, in accordance with the procedures defined in the Puget Sound Salmon Management Plan (PSSMP) and through those forums involved with management of fisheries impacting HC-SJF summer chum such as the North of Falcon and Pacific Fisheries Management Council forums.

6. Finalize by May 31 details of monitoring, supplementation, and information gathering programs for the subsequent season, in cooperation with, and as appropriate, with the assistance of all Parties, using the procedures and requirements of this plan, as well as the PSSMP and Hood Canal Salmon Management Plan.

7. Coordinate and communicate with the NMFS during the conduct of the above activities to confirm that the regime will meet the requirements of this plan and satisfy NMFS' ESA obligations. The Parties will share documentation and data used in development and evaluation of the annual harvest regime. This should occur prior to May 31. As necessary, the co-managers will request assistance from NMFS and USFWS in carrying out the tasks described above.

8. Conduct inseason management activities relating to management, regulation filing and enforcement in accordance with the PSSMP and other relevant orders of the U.S. District Court.

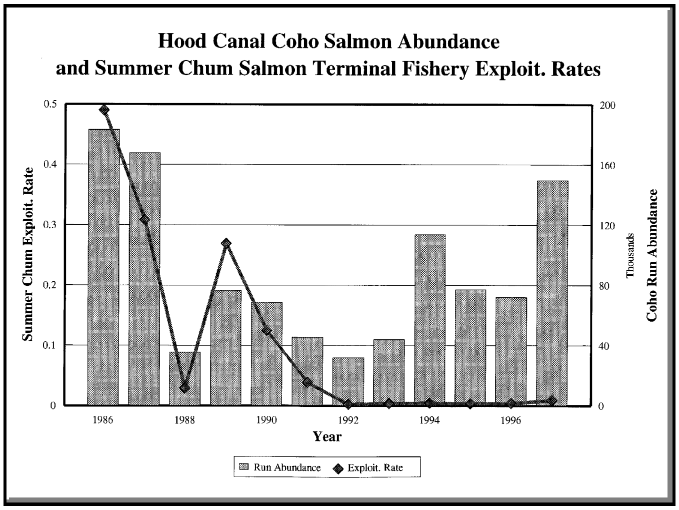

**Figure 3.18**. Comparison of Hood Canal coho abundance with HC-SJF summer chum terminal exploitation rates.

### 3.5.8 Expected Regime Effects on Recovery

The harvest management strategies described in this section are expected to result in significant reductions from total exploitation rates on HC-SJF summer chum observed in the period from the 1975 to 1992 which were the result of fisheries targeted at other species (Figure 3.14). This plan changes that by establishing annual fishing regimes for Canadian, Washington pre-terminal, and Washington terminal area fisheries, designed to minimize incidental impacts to summer chum salmon, while providing opportunity for fisheries conducted for the harvest of other species (Figures 3.18 and 3.19). The expected reduction in incidental interceptions, relative to the high rates observed during previous years is approximately 78% for Canadian fisheries (1989-92), 65% for U.S. pre-terminal (1976-93, odd years only), and 92% for Washington terminal area fisheries (1975; 1977-87; 1989-90). The BCR is based on a series of management measures, which are expected to effectively and substantially reduce incidental impacts, in order to conserve, and not appreciably reduce the likelihood of survival and recovery of this HC-SJF summer chum in the wild.

At present, given the limited data on summer chum productivity, it is not possible to construct a regime based on more technically sophisticated objectives such as MSY. The combination of specific management actions and fishery specific exploitation rate targets comprising the BCR is based on a conservative integration of the existing data and management experience. However, the plan is designed to be responsive to feedback mechanisms, in order to provide for adaptive management towards meeting the goals of protection of summer chum, while maintaining harvest opportunities. The regime has built in adaptive response mechanisms to respond to a management unit not meeting a critical abundance threshold, or an individual stock not meeting its escapement distribution flag (see 3.5.6.2).

The BCR has been constructed using a conservative approach that would pass through to spawning escapement on average, in excess of 95% of the HC-SJF summer chum recruitment to U.S. waters, and nearly 90% of the total recruitment of the run of each management unit. At the exploitation rates provided for in this harvest strategy, spawner replacement would be assured in each subsequent generation, if the average recruits-per-spawner ratio was at least 1.2:1 (replacement with an approximately 15% exploitation rate, the upper end of the BCR exploitation rate range). At this very restrictive maximum exploitation rate, harvest exerts very little effect on recovery of the populations. At recruits-per-spawner of less than 1.0, the population will decline regardless of harvest. At recruits-per-spawner greater than 1.2, the populations will increase regardless of harvest.

While the conservation regime is in place, forecasts for individual management units will be constrained by the assumption that the recruit/spawner ratio from parental brood escapements below the Critical Threshold, is no greater than 1.2:1. This constrains the forecast to be within the assumptions used in the development of the BCR, minimizes the effects of forecast and modeling error, and ensures that the regime remains conservative until predictions of sufficient abundance are confirmed. If average recruitment rates were found to be lower than this value, it would be an indication of severe productivity and productive capacity problems which cannot be remedied through harvest management actions.

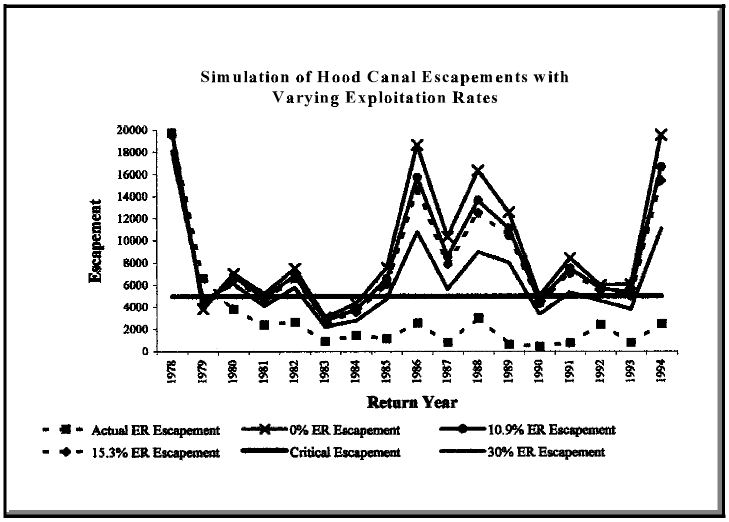

**Figure 3.20**. Simulated escapements of Hood Canal summer chum salmon with varying exploitation rates for the years 1978-1994.

Another way to look at the effect of the expected exploitation rates is through a simulation of what might have happened to summer chum populations and spawning escapement if these rates had been in effect in past years. While we do not have adequate age data from all years to allow estimation of the actual productivities that occurred in past years, we can use age data for the years they exist and the average age for all other years to create a set of productivities that can be used in a simulation for illustration purposes. Figure 3.20 shows the results of such a simulation. Starting with a given year's abundance, different exploitation rates are applied resulting in varying escapement levels. The simulated productivities are applied to these new escapements to arrive at new recruit abundances, and the process is repeated. The actual exploitation rate (ER) escapement is derived using the same simulation approach, but with the actual observed exploitation rates applied instead of a constant exploitation rate. What this set of simulations demonstrate is that, at the exploitation rates expected through this plan's harvest strategy (10.9% average; 15.3% maximum), there is very little difference in the realized adult spawning escapement whether these limited exploitation rates are applied or there is no harvest at all. Also, significantly, there is essentially no difference in the frequency of escapements below the critical abundance levels.

### 3.5.9 Compliance and Enforcement

In the context of this recovery plan, "compliance" is intended to mean adherence, by each of the parties, to the guidelines, mandates and performance standards of the plan, including adoption of any necessary rules to implement their responsibilities under the plan.

Compliance certainty shall be assured through the application of U.S. v Washington rules and procedures.

The annual and five year review processes, described in section 3.5.7.1 and sections 3.6.2 and 3.6.3, respectively, shall include a review of the level of compliance by each of the parties, and recommendations may be made as necessary for improvements in the level of compliance, to ensure the successful implementation of the plan.

In the context of this recovery plan, "enforcement" shall mean the efforts and means of each party to implement the guidelines, measures and standards of this plan, including the enforcement of rules and regulations adopted to implement the guidelines, measures and standards.

Guidelines and actions are generally detailed in the harvest BCR (Tables 3.29-3.34). Parties responsible for implementation of the BCR include the co-managers, and for international and ocean fisheries, NMFS.

For fisheries outlined in the BCR, the co-managers and NMFS shall ensure that, at least, current levels of fishery monitoring and on-the-water enforcement of fishing regulations shall be maintained. Additional monitoring may be necessary, however, its implementation may depend on the availability of sufficient funds.

The co-managers' and federal court systems are currently sufficient to ensure that enforcement is followed through with appropriate prosecution of violators.

## 3.5.10 Harvest Management Monitoring and Assessment

Specific, integrated monitoring programs shall be established to improve stock assessment methodologies as well as effectiveness of harvest management actions and objectives. These programs should include, at least:

1. consistent escapement monitoring methods;
2. identification and quantification of harvest contributions;
3. assessment of survival rates to recruitment by age; and
4. assessment of stock productivity and productive capacity.

The first two are critical to implementation of the plan, at its initial phase. The third and fourth are necessary to provide information that would allow managers to tailor harvest, supplementation, and habitat planning guidelines and actions, to the extent necessary to determine with acceptable accuracy the necessary steps, time horizon and likelihood of restoration. The fourth monitoring provision will also allow managers to better define survival parameters, thus, allowing us to better define recovery; what can be sustained over the long-term, and how to maximize benefits by stabilizing the HC-SJF summer chum resource. This information will also be essential to the integration and effectiveness of habitat and harvest management strategies by keying production to current estimates of habitat capacity and productivity. Current survey and monitoring programs are limited to quantitative monitoring of escapement and harvest. The others are included under research needs. As funding becomes available, monitoring must be expanded to include them.

Escapement and harvest monitoring form the core elements of the monitoring program. These programs are stable and will continue at or above current levels. Although information gained from the other suggested monitoring activities would improve management, the funding and resources to implement them is not currently available. The co-managers, therefore, have designed the management actions in this plan to provide sufficient protection for summer chum populations without them. The co-managers commit to maintain programs identified as core elements of the monitoring program at or above current levels, and recognize that additional monitoring programs are important over the long term and funding will be sought to support them.

### Escapement

Spawning ground surveys will be conducted in established index areas from mid-August through late October in systems comprising the known spawning distribution of current HC-SJF summer chum populations. In addition to spawner counts, carcasses will be sampled for marks and scales or otoliths will be taken to determine age structure where possible. At a minimum, monitoring will be maintained at current levels (Appendix Report 1.1 and Table 3.36). Currently spawning ground surveys cover 90% or more of the temporal and spatial distribution of summer chum. Additional surveys are conducted in less utilized areas. These surveys will occur at 7-10 day intervals to maintain the current level of sampling, unless weather or water conditions interfere. This level of sampling has been determined to be necessary to provide reliable escapement and spawn timing estimation. Surveys shall be expanded as necessary to refine or develop additional standards for determining the present and future abundance status of Hood Canal and Strait of Juan de Fuca summer chum. Spot surveys will be continued each year in extirpated systems to assess potential natural straying. These programs will evolve into standard surveys as re-introduction programs come on line.

**Table 3.36.** Spawning survey index reaches for summer chum in Hood Canal and the eastern Strait of Juan De Fuca[1]

| WRIA | Stream name | WRIA river miles | Comments |
|---|---|---|---|
| 15.0389 | Big Beef Cr. | 0.0-1.7 | Fixed rack passage - operated late summer to late fall. |
| 15.0412 | Anderson Cr. | 0.0-1.0 | |
| 15.0420 | Dewatto R. | 0.3-1.8 | |
| 15.0446 | Tahuya R. | 0.0-2.6 | |
| 15.0495 | Big Mission Cr. | 0.0-1.6 | Early fall run (peaks late Oct., early Nov.). |
| 15.0503 | Union R. | 0.3-2.1 | |
| 16.0001 | Skokomish R (mainstem and SF) | 9.0-13.3 | Summer chum data collected incidentally during chinook surveys. |
| 16.0230 | Lilliwaup R. | 0.0-0.7 | |
| 16.0251 | Hamma Hamma R. | 0.3-1.8 | |
| 16.0253 | John Cr. | 0.0-1.6 | |
| 16.0351 | Duckabush R. | 0.0-2.3 | |
| 16.0442 | Dosewallips R. | 0.02.3 | |
| 17.0012 | Big Quilcene R. | 0.0-2.8 | |
| 17.0076 | Little Quilcene R. | 0.0-1.8 | |
| 17.0219 | Snow Cr. | 0.0-1.5 | |
| 17.0245 | Salmon Cr. | 0.0-0.8 | Includes rack counts. |
| 17.0285 | Jimmycomelately Cr. | 0.0-1.5 | |
| 18.0018 | Dungeness R. | 0.0-18.9 | Pink and chinook surveys. |
| 18 0048 | Greywolf R. | 0.0-5.1 | |

[1] Surveys conducted late August to late October. On all streams except the Strait of Juan de Fuca tributaries directed chum survey effort is continued into the fall chum run period.

## Fishery Sampling

### *Canadian Commercial Fisheries (July through September)*

The co-managers will work with the Pacific Salmon Commission and Canadian Department of Fish and Oceans to implement monitoring programs to collect data on landed catch, species and stock composition, biological traits (sex, age, size), encounter rates and non-landed mortality of chum caught in fisheries in at least Canadian Areas 18, 19, 20 and 29 during the July through September time period.

### *Washington Pre-terminal Commercial Fisheries (July through mid-September)*

1. Landed catch ticket information will be the primary source for catch and species composition data from chinook, coho, sockeye and pink fisheries. Shore-based sampling, will be included as part of catch sampling to verify fish ticket information.

2. In fisheries utilizing non-retention strategies, data will be collected on the number of encounters and species composition. Monitoring will include logbooks and on-the-water observation of encounters and releases.

3. A target of 200 chum per stratum will be sampled for biological data such as sex, size, and age structure both as a component of the catch sampling and as part of genetic stock identification (GSI) sampling described below. Given the small numbers of summer chum present it may be unrealistic to obtain this sample in all desired strata, in which case the intent is to get the greatest sample size possible. The sample design and stratification will depend on the resolution of management action needed but will be no greater than a catch area. Where the sampling target is not met, samples may be pooled, but this may limit the development of fine resolution management strategies. This type of information is an important element in assessing exploitation rates and entry pattern analysis, and is essential to better estimates of recruit abundance.

*Recreational Fisheries (Sport Areas 5,6,7,(July-September) 9 (July -September) and 12; (July - mid-October))*

1. Shore-based sampling will be maintained at or above 1998 levels. Biological information such as age, sex and size will be collected as part of the shore-based sampling programs. Encounter rate data on all species will be collected from angler interviews and logbook programs. On-the-water monitoring programs will be implemented as necessary to verify the logbook and interview data.

2. Where non-retention strategies are implemented, data will be collected on the number of encounters and species composition. Monitoring will include logbooks and on-the-water observation of encounters and releases.

*Hood Canal and Strait of Juan de Fuca Extreme Terminal and Terminal Area Fisheries (August through mid-October)*

1. Commercial and recreational salmon harvests will be sampled annually at a minimum of 20% for species composition to obtain statistically valid estimates of species composition. Landed catch ticket information will be the primary source for commercial catch and species composition data in chinook, coho, sockeye and pink fisheries. Shore-based sampling, will be included as part of catch sampling to verify fish ticket information.

2. In fisheries utilizing non-retention strategies, data will be collected on the number of encounters and species composition. Monitoring will include logbooks and on-the-water observation of encounters and releases.
3. A target of 200 chum per stratum will be sampled for biological data such as sex, size, and age structure both as a component of the catch sampling and as part of the GSI sampling described below (M. Alexandersdottir, NWIFC, pers. comm. 1996). Given the low numbers of summer chum present in some strata, the intent will be to collect as many samples as possible. The sample design and stratification will depend on the resolution of management action needed but will be no greater than a catch area. Where the sampling target is not met, samples may be pooled, but this may limit its use in developing fine resolution management

strategies. This type of information is an important element in assessing exploitation rates and entry pattern analysis, and is essential to better estimates of recruit abundance.

### Catch Reporting

Commercial fish ticket and Ceremonial and Subsistence reporting systems and databases will be maintained at current levels. Recreational punch card and creel census reporting systems will be maintained at current levels. These will be the primary sources of catch information used to assess landed catch mortality.

### Stock Composition

Genetic stock identification baselines for Hood Canal and Strait of Juan de Fuca stocks will be completed prior to the first Five Year Plan Review. Subject to available funding, GSI sampling programs will be conducted annually in Puget Sound fisheries at times when HC-SJF summer chum are likely to be present. Initial efforts should be focused in commercial areas 5,6C, 6, 7, 7A,9, and 12-12C in order to improve impact assessment and cohort reconstruction data. Ideally, samples should be taken throughout the time HC-SJF summer chum would reasonably be expected to be in the area. U.S. managers will coordinate with the Canadian Department of Fish and Oceans to continue GSI sampling the Canadian Catch Areas 18,19, 20 and 29 during sockeye and pink salmon fisheries. Sampling design shall conform with the requirements of the PSC Chum Technical Committee recommendations.

A DNA baseline should be established and fin tissue collected from commercial and recreational fisheries as an alternative to lethal sampling for stock composition information.

If targets are not met, samples will be pooled for analysis, but pooling samples may limit development of fine resolution management strategies. At such time as sufficient data is available to detect patterns in stock composition in these fisheries, sampling may be discontinued, although sampling should be conducted occasionally to validate the assumptions.

## 3.5.11 Adaptive Management

As more information is collected and becomes available, harvest management strategies will be coordinated with habitat and hatchery strategies, with the intent to incrementally increase abundance and spawning escapements above recovered levels. These recovered levels represent the level at which management units are relatively stable and productive and pose little or no foreseeable risk of extinction to the populations (see Part One, section 1.7.4 Stock Extinction Risk). Recovery goals for each management unit will be developed in 2000, and the parties will subsequently determine how to incorporate the recovery goals into the management structure. In addition, fishery performance criteria will be revised to include the new information. As reintroduction programs are implemented and become effective, fishery performance criteria will be expanded to include the additional management targets if it is found that the current targets are insufficient to provide the necessary protection.

## 3.5.12 Stock Assessment Information Needs

Success of this management plan is dependent on application of the best current data and data analysis to the management of the summer chum salmon resource. The harvest management strategies described in this plan have been designed with the intent to provide sufficient protection to HC-SJF summer chum populations given current data limitations. However, better information and analyses will be necessary to make significant improvements to the Hood Canal and Strait of Juan de Fuca Summer Chum Salmon Conservation Initiative. The co-managers will include projects focused on gathering this information in their fishery management programs to the extent possible and will seek necessary funding for projects not currently a part of the agencies standard operations. The following outline of information gathering activities will be updated as needs are identified and as part of the Five Year Plan Review. Research programs should be designed to provide new information in time for the Review.

### Improvement of Sub-Populations Definitions

The management units and stocks form the basis of the harvest management strategies and recovery objectives described in this plan. The definitions are based on what we currently know about the similarities and differences of HC-SJF summer chum populations, and the level of management resolution the limitations of that information allow. Research programs should be designed to gather more definitive information on the structure of HC-SJF summer chum populations in order to simplify management where a single management strategy can meet the needs of multiple populations, to structure harvest opportunity, and to understand the contribution of each population to the overall health of HC-SJF summer chum.

### Age-Composition and Structure

Development of estimates of age-specific return information will provide important information about the degree to which escapement targets are providing sufficient production to protect and rebuild summer chum populations, and would allow reliance on better management techniques such as MSY exploitation rates for which we currently lack data. Consequently, it could allow the managers a greater ability to integrate conservation and harvest opportunity objectives. Collection of this information would lead to significant improvements to the current plan.

The success of harvest guidelines rely on accurate information regarding annual recruitment to each management unit (particularly when the recruitment may lie near the Critical Abundance Threshold) and, accurate estimates of mortality rates associated with those harvest regimes, and the escapement levels needed to sustain or rebuild the populations. Research and monitoring projects will be designed to obtain annual estimates of age-composition in the escapement for each management unit and stock using scales and/or otoliths. Fishery sampling programs will also include the collection of age-composition data.

Implementation of an exploitation rate based management strategy will depend on the availability of age-data to accurately assess brood specific contributions, and to relate the impacts of annual chum returns to the brood year production of management units and stocks.

## Improvement of Escapement Estimates

Methodology: The annual assessment of the number and distribution of fish that escape to spawn is the most important means of evaluating the progress and success of this plan. It is critical to forecasts and the choice of the appropriate management regime. It is also critical in assessing whether habitat management strategies are successful in maintaining or increasing natural production. Therefore, a critical area of research will be to review, and revise where necessary, escapement estimation methodologies in order to improve estimates for each management unit and stock.

Survey frequency: In order to reduce data induced inaccuracies to our estimates of escapement, and entry pattern definition, surveys should be conducted on a weekly basis, throughout the expected entry period, plus at least a week before the start of the expected entry, and a week after its expected end. Current estimates for numerous years are inadequate in this respect.

Summer chum definition: Current surveys use a cutoff date, and it is left to further data analysis to determine whether some early entering fall chum have been included. Surveys, after October 15, should provide field estimates of the proportion or numbers of spawners who appear to be recent entrants. This information is not available at this time.

Age composition: Since the capture of summer chum salmon in fisheries during the restoration period, is expected to be minimal, scales should be collected from spawned out chum in order to gain the information critical to estimation of survival rates from each brood. Such collections should be representative of the entire escapement, at least in each management unit, although samples sufficient to assess each stock would be preferable. This information is not available at this time.

Sex composition/distribution: At each survey, an estimate of the sex ratio of the enumerated spawners should be made. The need for this is twofold: to determine potential egg deposition, as well as to determine whether females enter the systems at different times than males, and therefore assess the need for customized protective measures. This information is not available at this time.

Stray rates and supplementation contribution: As re-introduction and supplementation programs are implemented, another critical component of the spawning escapement estimate will be to determine what portion of the spawning escapement was naturally produced and what portion was derived from supplemented production. This will provide valuable information on both the success of the supplementation programs and the response of the natural production. Marking programs are already in place to provide information for use in evaluation of the success and contribution of summer chum produced from the supplementation projects currently being implemented. This is an essential task, in order to determine the contribution, distribution and survival of supplementation fish. (If adipose fin clips are used as external marks, additional effort should be expended to assess the level of any additional mis-identification caused by the mark, during selective fisheries.) Currently, sampling for marks on the spawning grounds only occurs for the Quilcene and Salmon Creek supplementation projects. Resources for sampling other supplementation projects are not currently available. The intent is to seek funding to expand escapement surveys for mark sampling.

## Improvement of Productivity and Productive Capacity Estimates

Minimum population sizes, escapement and exploitation rate targets that form the basis for harvest management in this plan, critically depend on estimates of productivity and production capacity. This information is critical not only for evaluation of harvest management activities and stock status, but also for evaluation of habitat management and supplementation strategies. This information is currently lacking for all areas and so the interim harvest management targets are based on expert professional interpretation and extrapolation of historical escapement and abundance patterns. Research programs should be developed to estimate current productivity and production capacity, as well as potential productivity and capacity, on the stock level.

## Non-landed Mortality

Management actions under some regimes described in this plan, propose significant use of live release or selective gears. Information on the mortality associated with releasing chum is important in evaluating the effectiveness of the fishing regime and in assessing total recruitment available to recreational and commercial users. Some studies have indicated that significant mortality may occur over an extended time after release in non-retention fisheries (PSC 1997). Although several studies have been conducted to estimate release mortality within several hours of release (NRC 1994), studies on the magnitude of delayed mortality are rare and none have been conducted on Puget Sound chum. Research should be conducted to improve estimates of the non-landed mortality of HC-SJF summer chum salmon as a mortality-rate-per-fish-encountered such that the rate for each gear type is estimated with sufficient precision to meet the overall goals for precision of exploitation rate estimates and management action effectiveness. In some cases, estimates may differ for a single gear type. For example, hook-and-release mortality rates may be different for marine waters, estuaries and freshwater. Funding should be made available for studies to determine delayed mortality on released chum salmon.

## Catch Sampling

<u>Accuracy of estimates:</u> The scope of coverage and percentage of catch sampled for species and stock composition should be increased in both commercial and recreational fisheries in order to increase the accuracy of by-catch estimates and catch distribution. Ideally, sampling protocols would be designed to achieve an precision in the catch estimate of +/- 5% of the true catch number. However, in most cases, this is beyond the current level of resources. The co-managers will continue to seek the level of funding necessary to implement the appropriate protocols that would increase the accuracy of catch estimates.

<u>Species mis-identification</u>: Focused surveys of the landed catch, from commercial and recreational fisheries where summer chum salmon form a very low proportion of the landings, is needed to estimate the proportion of summer chum which may be mis-identified. These are primarily fisheries directed at sockeye and pink salmon in the San Juan Islands and Strait of Juan de Fuca. This information is currently unavailable, and is necessary in order to obtain increasingly accurate estimates of catch, fishing mortality rates, and recruit abundance (via reconstruction). Mark sampling, to estimate the relative contribution of marked supplementation fish is also necessary in order to increase the accuracy of survival estimates. Because the bycatch of summer chum in these fisheries is very small and the Base Conservation Regime further constrains these fisheries, it may take many years to collect sufficient samples. Samples will likely have to be pooled across years or time strata.

Species composition: GSI samples should be obtained on a weekly basis in Areas 5, 7, and 7A; as well as Canadian areas 18,19, 20 and 29. Current samples indicating the presence and relative contribution of HC-SJF summer chum salmon, are based on a handful of samples obtained over a short period of years. Increased accuracy in this estimate is essential in order to estimate the catch, exploitation rate, as well as annual recruitment of HC-SJF summer chum. Additionally, this information can be used to improve historical estimates.

# 3.6 Program Integration and Adaptive Management

This summer chum salmon conservation initiative is intended to be an integrated plan, with each element contributing in concert with the other elements, and leading to a successful outcome in restoring these summer chum populations. In developing the plan elements, and the strategies and specific actions that put the plan into effect, the parties to this plan specifically considered how these plan elements would work together. Each individual element - Habitat, Harvest, Artificial Production, Ecological Interactions - will not be successful alone in rebuilding summer chum.

Each of the preceding sections of Part Three presents one of the elements of the plan. Each section's specific actions and contributions to recovery are presented separately, and compliance with those actions is evaluated separately. However, it is the combination of strategies and actions across all elements that provides the confidence that this is a substantive and robust recovery plan with a high probability of success. The habitat element describes what conditions will allow the populations of summer chum to be productive. If the habitat strategies are implemented by those managers with the appropriate jurisdiction, we will see production from these populations which will allow recovery. The harvest element of the plan initially reduces harvest impacts to very low levels that clearly will not impede recovery, and will be maintained at these low levels or at higher levels which are consistent with the productivity of the populations. The ecological interactions element is designed to further examine the complex relationships between summer chum salmon and other species which share the same habitats, and to reduce or control those interactions which may be limiting recovery. These three elements, taken together, and properly implemented, should provide the conditions necessary for a diverse set of summer chum populations to be productive and to grow in abundance to levels where they are no longer at risk of extinction and can support healthy fisheries. Lastly, the artificial production element provides for carefully controlled supplementation that acts as a fail-safe mechanism for very small and/or unstable populations that are at a high risk of extinction, and as a boost to recovery for populations that have a long way to go.

Despite the efforts of the parties to integrate the strategies and actions included in this plan, full integration of the plan elements will only occur as a result of assessing the results of the plan implementation and modifying the plan through adaptive management approaches. There is much we don't know about summer chum salmon and adaptive management is a critically important feature of this plan. The parties believe that this plan is well thought out and addresses all likely factors for the decline of summer chum, but it is critically important that the plan's performance be carefully and promptly evaluated and that there is a quick response to any signs of failure.

Each of the preceding sections of Part Three addresses a specific element of the plan and defines how we will evaluate the performance (compliance and effectiveness) of the specific strategies and actions relevant to that element. However, the success of the overall plan can only be measured by how well the populations of summer chum respond. We can fully implement all of the actions defined in the elements and still fail to recover these fish if our understandings and assumptions about the factors limiting recovery are incorrect. Ultimately the plan must be evaluated as to whether it meets the overall goal "to protect, restore and enhance the productivity, production, and diversity of Hood Canal and Strait of Juan de Fuca summer chum and their ecosystems to provide surplus production sufficient to allow future directed and incidental harvests of summer chum salmon".

The following describes the measures that will be used to evaluate the performance of the plan relative to specific population criteria. It includes thresholds that would trigger immediate additional actions to protect specific management units and populations, describes periodic plan reviews with specific performance requirements, defines the process for responding to performance failures (adaptive management) and defines how we will assess success in meeting recovery.

## 3.6.1 Critical Thresholds and Response

Typically a resource management plan such as this would be evaluated after it has been in place for a number of years and there is an accumulation of data upon which to assess performance. It is reasonable to observe some variation in expected outcomes from the specific strategies and actions and an evaluation across years to assess average performance and the degree of variation provides the best assessment of performance and a basis upon which to make plan modifications. Procedures for conducting this type of evaluation are provided in the following sections.

However, when dealing with populations that are at very low abundance and at considerable risk of extinction it is appropriate to provide some annual checks on total abundance and/or spawner abundance which will detect any significant problems with the recovery strategy, and allow immediate emergency actions to be taken to avoid possible damage or extinction of populations. Section 1.7.3 provides annual abundance thresholds and spawning escapement distribution flags that will be used to identify management units or stocks that are in a critical status[1].

If any management unit falls below its critical abundance or escapement threshold, or if an escapement distribution flag is triggered for a Mainstem Management Unit stock, the co-managers will: 1) promptly identify any emergency actions that can be taken immediately to respond to the critical condition[2], and 2) within 6 months, prepare an assessment of the factors resulting in this failure and provide comprehensive recommended actions and modifications to the plan to promptly restore the management unit or stock to non-critical status. The assessment will also include an examination of stock extinction risk, as described in section 1.7.4, and utilized in section 3.2, to assist in developing recommended actions.

The emergency actions will include any actions that can be expected to have an immediate, short term effect on either productivity or mortality of the critical management unit or stock. They will be designed to avoid further declines in abundance while the causes for the failure are being evaluated and corrective actions developed. Actions might include additional harvest management actions to reduce fishing mortality. These should be designed to specifically benefit the management unit or stock that is in the critical condition (e.g. additional restrictions in the extreme terminal area for that management unit). Actions might include immediate response to a critical habitat problem through

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[1] Note that "critical status" in the context used here has a different definition (described in section 1.7.3 and Appendix Report 1.5) than the critical definition for SASSI stocks (shown in section 1.7.2).

[2] Actions taken will depend on the specific situation. In some cases, a management unit or stock may fall below a threshold but demonstrate that a declining trend has stopped or a recovery trend has begun, indicating that present management actions are currently sufficient.

a habitat restoration project where the benefits can be expected to accrue to the current or next year's spawners and their progeny. This will likely be a response to a specific event that may be having a dramatic effect on the success of the population (e.g. a landslide that is blocking access or radically degrading substrate conditions). Emergency collection of broodstock for supplementation purposes may be necessary when populations are at critically low abundance to provide a higher level of survival for the offspring of the few spawners available. Actions might also include emergency efforts to reduce predation effects of marine mammals such as removal of problem animals or taking measures to limit their access to the critical populations.

The assessment to be conducted within 6 months will attempt to assess the specific causes for the management unit or stock falling to or remaining at critical abundance levels, using the best available data. Recommended actions from the assessment will include any modifications to the emergency actions taken when the critical status was identified and any additional actions deemed necessary to quickly restore the abundance of the critical management unit or stock to non-critical status. The assessments and recommendations will specifically address productivity and habitat conditions, harvest and supplementation impacts and supplementation opportunities.

The assessment and recommended actions will also include an identification of conditions and criteria for the management unit or stock by which it will no longer be considered to be in critical status, and will define when the additional actions are no longer necessary. Curtailment or relaxation of actions will vary depending on the kind of actions that are recommended. For example, harvest actions may be relaxed once significant improvement in management unit or stock status is observed, while commitments to supplementation or habitat improvements may require a longer term.

### 3.6.2 Annual Plan Report

Annually, the plan is assessed for compliance with the specific plan provisions and to determine if any critical thresholds or escapement distribution flags have been triggered. In each of the preceding sections on Artificial Production (3.2), Ecological Interactions (3.3), and Harvest Management (3.5), there is a description of annual actions that must be taken to assess compliance with and effectiveness of the plan provisions. Sections 1.7.3, 3.5.7.1 and 3.6.1 describe the critical thresholds and escapement distribution flags and the actions to be taken, on an annual basis, when these thresholds are triggered.

By June of each year the co-managers will compile all of the annual assessments required in Part Three of this plan into an Annual Plan Progress Report. This report is intended to provide an overview of the plan's performance and may consist only of a summary of the actions and assessments conducted in the preceding calendar year. The Annual Plan Progress Report will be provided to all of the parties to the plan.

### 3.6.3 Five Year Plan Review

A five year plan review will assess whether progress towards recovery is being achieved and whether the results of monitoring and evaluation studies indicate a need to revise assumptions and/or strategies and actions. As management units are rebuilt, the plan review will assess whether the conservation and recovery criteria are being maintained, as well as incorporating the results of monitoring and evaluation studies. At the time of the review, results from the monitoring and evaluation studies will be used to modify the specific actions and strategies (harvest regime, supplementation projects, habitat restoration strategies, etc), modify the monitoring and evaluation programs, make recommendations for further research and provide guidance on other aspects of the plan. Strategies and actions described in this plan will be assessed, to the extent possible, at both the management unit and stock levels. The WDFW and tribes will conduct a plan review every five years and generate a report of the findings to be complete and available to state, tribal and federal agencies within one year of the review. The first review will occur in 2004 (to cover the five year period 1999-2003), with a report available by February of 2005 (subsequent reviews will occur every fifth year (i.e., 2009, 2014, etc.). However, this should not constrain the managers from introducing substantive new information for discussion and possible incorporation at any time.

The following are the steps required to complete review of the plan.

1. Review and describe performance of each element of the plan in meeting their specific compliance and effectiveness standards, as provided in previous sections (sections 3.2 - 3.5), by management unit and stock, since the last review period and since adoption of the plan.

2. Evaluate management unit and stock performance relative to the standards provided in section 3.6.4.

3. Determine which strategies and actions and conservation objectives were most effective and least effective and which management unit and stock did or did not see the desired improvement. Document the findings by management unit and stock and at the region-wide level, i.e., were successes concentrated geographically or were certain units chronically falling short of objectives.

4. Identify causes of successes and failures and categorize them according to type:

   *Compliance:* Actions were not implemented correctly or had a significant degree of non-compliance by user groups or governments.

   *Effectiveness:* Actions were implemented correctly and had high degrees of compliance but did not have the intended effect(s).

   *Assumptions:* Assessment methods or parameters were accurately or inaccurately estimated and applied.

5. Make adjustments to plan elements as provided in sections 3.2 - 3.5. Co-managers will incorporate new information from monitoring, evaluation and research studies in making adjustments as prescribed.

6. Make recommendations for plan changes or amendments. This information should be as specific as possible, including the watersheds, river systems, estuaries, management units, stocks, programs or projects, and fisheries affected, the type of suggested change and the time frame over which it should be implemented.

## 3.6.4 Performance Standards

By achieving the management unit and stock performance standards described in this plan, the elements of this plan will contribute to the stability and recovery of the HC-SJF summer chum. To fully meet these standards, assessments must be performed with a high degree of confidence. The measurement of several of the following standards (e.g. productivity) is dependent on the collection of representative age data.

As more information is gathered that effects our assessments of escapement and abundance, the following performance standards will be revised to include the new information. As reintroduction programs are implemented and become effective, the performance standards will be expanded to include additional criteria for those populations if it is found that the current criteria are insufficient to provide the necessary protection.

The following performance standards are meant to provide immediate criteria upon which to measure progress toward recovery of summer chum salmon populations. In addition, the co-managers are working on developing a set of population-based recovery goals that can be used to determine when full recovery is achieved. These recovery goals will address levels of abundance, productivity and diversity of summer chum populations that will achieve self-sustaining, harvestable run sizes on a regular basis. These HC-SJF summer chum recovery goals are scheduled for completion in spring 2000 and will be distributed as a supplement to this initiative (see also sections 4.4 and 4.6).

### 3.6.4.1 Abundance

As used in this plan, abundance refers to the annual total number of adult recruits or the adult run size prior to any fishing related mortality. Escapement refers to the portion of the abundance that has “escaped” through the various fisheries and arrived on the spawning grounds.

Progress toward recovery of abundance and escapement will be measured relative to the performance of natural-origin recruits (NOR) of each management unit and stock(s) within them. Such assessments will be made using post-season information for each stock. The following standards shall be used to evaluate the progress of harvest, artificial production, ecological interaction, and habitat management measures in recovering Hood Canal/Strait of Juan de Fuca summer chum:

1. Annual post season estimated abundance must be equal to, or greater than that of the parent brood abundance. When this is not the case, an investigation of the causes shall be made and remedial measures shall be formulated, when appropriate.

2. Annual abundance should be stable or increasing the 5-year and average abundance must be higher than the critical threshold. Annual abundances shall not fall below the critical threshold in more than two out of five consecutive years. Information concerning the productivity and productive capacity of the stock(s) shall be pursued to further refine the thresholds themselves.

3. Liberalization of actions under the Base Conservation Regime shall not be considered unless number 2 above is met.

### 3.6.4.2 Productivity

As used in this plan, productivity refers to the ratio of maturing recruits per parent brood spawner. This ratio shall initially be specific to each management unit, however it is the co-managers intent to obtain information necessary to estimate this quantity for individual stocks within management units as well.

Since the number of recruits produced by each spawner is affected by both density-dependent (biological) and density-independent (physical habitat) factors, the following elements shall be used to evaluate the progress of harvest, supplementation, and habitat management measures:

1. Five-year estimated mean productivity shall be greater than 1.2 recruits per spawner.

2. The number of recruits per spawner when management units are at or near critical threshold abundances, must be stable or increasing.

### 3.6.4.3 Escapement

1. The annual post season estimated NOR escapement rate of each run must be within or above the range specified by the Base Conservation Regime.

2. Annual NOR escapements shall be stable or increasing and 5-year average escapements must be higher than the critical thresholds. Information concerning the productivity and productive capacity of the stock(s) shall be used to further refine the thresholds themselves.

3. Expected escapement rates are based on numerous assumptions made during the formulation of the Base Conservation Regime. Annually estimated rates, for the period being evaluated, must be normally distributed across the Base Conservation Regime’s anticipated range. If this does not occur, the Base Conservation Regime, its underlying assumptions, and the application of the Regime shall be re-evaluated and remedial measures shall be formulated.

### 3.6.4.4 Management Actions

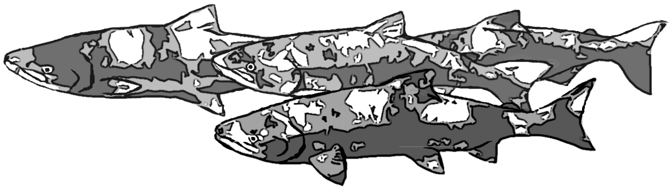
1. At a minimum, the plan strategies and actions shall result in stable recruit abundances at current levels, while ensuring that escapement rates are high. The plan’s strategies shall be considered successful if progress toward recovery is demonstrated by positive trends in NOR abundance.

2. Strategies and actions directed at management units or stocks, whose abundance is below their currently estimated critical thresholds, will be considered successful if they stop and reverse the decline in productivity and/or abundance.

3. Plan strategies and actions shall be considered successful when all management units are maintained, on average, above their critical abundance and escapement thresholds.

# Part Four

# Summary of Plan Elements



## 4.1 Introduction

This part of the Summer Chum Salmon Conservation Initiative provides a summary description of the plan elements, considering how they apply across the Hood Canal/Strait of Juan de Fuca summer chum region and to individual summer chum salmon stocks and watersheds. The intent is to show what and where specific objectives, strategies and actions are to be applied, and by whom, to meet the plan's goal of protecting and restoring the summer chum runs. In the course of summarizing information below, references are given to specific sections of this plan where more complete and detailed information exists. Part Four also provides discussions of how the goals of the recovery plan and ESA will be achieved, when population-based recovery goals will be available, and how the plan will be implemented by the co-managers and others.

## 4.2 Summary of Plan Objectives, Strategies, and Actions

The objectives, strategies and actions of the plan are summarized in Tables 4.1 through 4.7. These applications are applicable to all of the summer chum watersheds and estuaries. Specific objectives are described within section dealing with Artificial Production, Ecological Interactions, Harvest Management, Habitat, Monitoring and Evaluation, and Program Integration and Adaptive Management. For each objective, one or more actions/strategies are described, including the participants with jurisdiction/authority, additional partners, status of available resources/funding, and time frame.

Actions are differentiated from strategies in that an action is a specific measure or set of measures that directly addresses a problem, and is agreed to by the parties with jurisdiction. A strategy is meant to be an approach to developing specific actions. In this plan, a strategy is generally indicated where not all participants with jurisdiction/authority are yet involved; the idea being that specific actions can be developed from the strategy once all the appropriate parties are participating (e.g., with regard to habitat issues).

Parties with jurisdiction/authority pertaining to a given action or strategy and other partners are listed in describing the action/strategy even if they are not yet participating in this plan. The intent is to recognize the potential role of those parties and recommend their participation. But, of course, they are not necessarily bound by provisions set forth in this initiative.

The status of resources/funding to address a strategy or action is described in two categories, Phases 1 and 2. Phase 1 means the resources and funding required for the strategy or action are currently available. Phase 2 means the resources/funding are not currently available and, in some cases, may not yet be clearly identified.

The description of the time frame for an action/strategy is in general terms. Words such as continuing, immediate and undetermined are most often used to indicate the approximate timing for implementation. More specific information is provided when available.

## 4.2.1 Artificial Production

The artificial production program supplements production of severely depressed, at risk populations and reintroduces summer chum to watersheds where the historical populations have been lost. In the future, the program may also incorporate provisions for enhancing fishing opportunity. The program is coordinated with other management actions and is designed to minimize ecological and genetic risks. The program includes risk assessment leading to selection of projects, guidelines for effective and low risk operations, monitoring of implementation and success, and adaptive management (see Part Three, section 3.2). The following table summarizes the major actions of the co-managers under Artificial Production. Note that monitoring and evaluation measures are summarized separately below (see section 4.2.5).

**Table 4.1** Artificial Production objectives and action items.

***Objective:*** Conduct an annual evaluation of the risk of extinction for each extant summer chum stock.

| Action Items | Description | Jurisdiction/ Authority | Partners | Resources/Funding | Time Frame |
|---|---|---|---|---|---|
| 1. Update the plan's extinction risk evaluation with each year's escapement numbers. | See Part One, 1.7.4 - Stock Extinction Risk for discussion of assessment of extinction risk used in this recovery plan. The methodology (following Allendorf et al. (1997) uses recent population size and population trends to determine the risk of extinction for individual stocks. | WDFW, Tribes | NMFS, USFWS | Phase 1 | Annual |
| 2. Continually review literature for improved methods for extinction risk assessment | The science of risk assessment is rapidly evolving, and the co-manager's intent is to use the most current assessment techniques as they become available. | WDFW, Tribes | NMFS, USFWS | Phase 1 | Annual |

***Objective:*** Avoid the future extinction of any extant summer chum stock through the use of supplementation techniques.

| Action Items | Description | Jurisdiction/ Authority | Partners | Resources/Funding | Time Frame |
|---|---|---|---|---|---|
| 1. Continue the current supplementation projects for summer chum salmon. | Continuing projects include Big Quilcene, Salmon Creek, Lilliwaup and Hamma Hamma. | WDFW, Tribes, USFWS | HCSEG, NOSC, WOS, LLTK | Generally, existing projects fall within the category of Phase 1 projects. New projects and some identified monitoring and assessment needs for existing projects (section 4.2.5) fall within the category of Phase 2 projects. | Several projects are currently in operation and are expected to continue under a defined schedule (section 3.2.3.4). One new project is recommended for Jimmycomelately stock (section 3.2.3.3) where project implementation is expected to begin the summer of 1999. Additional projects may be considered in the future (section 3.2.3.3). |

**Table 4.1** Artificial Production objectives and action items (continued).

| Action Items | Description | Jurisdiction/ Authority | Partners | Resources/ Funding | Time Frame |
|---|---|---|---|---|---|
| 2. Initiate a new supplementation project for the Jimmy-comelately stock. | The Jimmycomelately stock has been identified in this plan as having a high risk of extinction, because of current low population size and a recent precipitous decline (see Part One, 1.7.4 - Stock Extinction Risk). Efforts are underway to improve habitat conditions in the stream, however, these remedies are long term. Immediate supplementation is recommended, and is expected to commence in the summer of 1999. | WDFW, Tribes | NOSC and/or WOS | Phase 1 | Immediate |
| 3. Operate all supplementa-tion projects to minimize potential deleterious effect. | All supplementation projects will follow the recovery plan criteria for minimizing potential deleterious effects in the following areas: partial/ total hatchery failure, predation, competition, disease, and loss of genetic variability within and between populations. | WDFW, Tribes, USFWS | HCSEG,<br>NOSC,<br>WOS,<br>LLTK | Phase 1 | Immediate. |
| 4. Initiate future supplementa-tion projects for any stock found to have a high risk of extinction. | Supplementation techniques to be used if assessment shows that the stock is in jeopardy of extinction and there are no other timely remedies. | WDFW, Tribes | Partners depend on stock location and interest of agencies and citizen groups | Phase 2 | As needed. |
| ***Objective:*** Reintroduce summer chum salmon to region streams as donor stocks become available. | | | | | |
| 1. Continue the current reintroduction projects for summer chum salmon. | Big Beef<br>Chimacum | WDFW, Tribes, USFWS | HCSEG,<br>NOSC,<br>WOS,<br>LLTK | Phase 1 | Immediate. |
| 2. Operate all reintroduction projects to minimize potential deleterious effect. | All supplementation projects will follow the recovery plan criteria for minimizing potential deleterious effects in the following areas: partial/ total hatchery failure, predation, competition, disease, and loss of genetic variability within and between populations. | WDFW, Tribes, USFWS | HCSEG,<br>NOSC,<br>WOS,<br>LLTK | Phase 1 | Immediate. |

**Table 4.1** Artificial Production objectives and action items (continued).

| Action Items | Description | Jurisdiction/ Authority | Partners | Resources/ Funding | Time Frame |
|---|---|---|---|---|---|
| 3. Initiate future reintroduction projects as donor stocks become available. | Stocks that are candidates for future reintroduction include: Tahuya Dewatto, Skokomish, and Anderson. Decisions to pursue reintroductions will be based on current status of donor stock (ability to contribute brood stock). Donor stocks will be limited to adjacent stocks not previously introduced to another streams. | WDFW, Tribes. | Partners depend on stock location and interest of agencies and citizen groups. | Phase 2 | When appropriate. |
| 4. Allow opportunity for natural reintroductions to occur on some streams through straying. | See Part One -1.7.2.3 for list of streams identified as possibly being part of the historic distribution of summer chum salmon. These streams will be allowed to repopulate naturally. | WDFW, Tribes. |  | Phase 1 | Immediate |

### 4.2.2 Ecological Interactions

Ecological interactions between summer chum and other species have been assessed as part of this initiative (see Part Three, section 3.3). There is little likelihood that summer chum (specifically, artificially produced summer chum) will substantially impact other species. The artificial production levels are relatively small, limiting competitive interactions with other juvenile salmonids, and since the production programs are intended to restore summer chum spawners to historical levels, competition on the spawning grounds should not be an issue. Because summer chum are released at a relatively small size, predation effects on other fishes is not a concern. More important to consider are the impacts of other species on summer chum. Primary sources of potential impact are other salmonids and marine mammals (see Part Two - Region-wide Factors for Decline). Potential impacts of other salmonids (with emphasis on hatchery produced fish) include effects from hatchery operations, predation, competition and fish disease transfer. The potential impact of marine mammals is predation on summer chum. Following are descriptions of actions to address these potential impacts.

**Table 4.2** Ecological Interactions objectives and action items.

***Objective***: Eliminate and reduce negative hatchery interactions with summer chum.

| Action Items | Description | Jurisdiction/ Authority | Partners | Resources/ Funding | Time Frame |
|---|---|---|---|---|---|
| 1. Assess risks to summer chum from producing hatchery salmonids. | See Part Three, 3.3 for description of risk assessment that includes hazards from hatchery operations (associated with broodstock collection, water withdrawal, hatchery intakes and outlets, and pollution), predation (direct and indirect effects), competition and behavioral modification (from juvenile and adult hatchery fish), and fish disease transfer. | WDFW,<br>Tribes | USFWS | Phase 1 | Completed as part of this initiative and updated periodically. |
| 2. Identify risk aversion measures to reduce risks of hatchery programs. | See Part Three, 3.3 for detailed description of risk aversion measures including protocol for broodstock collection, species-specific limitations on hatchery releases to reduce or eliminate potential for predation and competition, and protocol for fish disease management. | WDFW, Tribes, USFWS | | Phase 1 | Completed as part of this initiative. |
| 3. Implement identified risk aversion measures. | Apply risk aversion measures to hatchery programs as identified in 3.3.2 of Part Three. | WDFW, Tribes, USFWS | HCSEG, WOS, NOSC, LLTK | Phase 1 | Immediate. |
| ***Objective:*** Assess and respond to other potential negative species interactions with summer chum (see 3.3). | | | | | |
| 1. Evaluate impacts of fall chum spawning activity on summer chum. | Design and implement assessment of impacts from fall chum spawning within same stream reaches in which summer chum spawn. | WDFW,<br>Tribes | Agencies and others with funding resources. | Phase 2 | Undetermined. |
| 2. Assess impacts of pinniped predation on summer chum. | Continue study to assess pinniped populations and impacts on salmon within Hood Canal.. | NMFS, WDFW | Tribes and other agencies or entities | Phase 1 | Continuing. |
| 3. Implement appropriate management actions based on assessments of negative interactions. | Management actions may include control of individual seals or populations, and short-term limiting of fall chum escapement levels in designated streams. | NMFS<br>WDFW,<br>Tribes | Phase 1 or 2 | When appropriate. | |

### 4.2.3 Harvest Management

Harvest management provisions have been developed within this initiative to manage fisheries in a manner that will allow the rebuilding and maintenance of self-sustaining summer chum populations throughout Hood Canal and eastern Strait of Juan de Fuca, while maximizing harvest opportunities on co-mingled salmon species. The harvest management strategy utilizes a conservative four-way control mechanism: 1) a base set of conservative fishing regulations, 2) abundance and escapement thresholds that trigger adjustments to the fishing regime, 3) exploitation rate objectives that will result in changes to the harvest regime if not met, and 4) overall stock assessment criteria that will affect all plan provisions, including harvest, if not satisfactorily met at periodic plan reviews. Following is a summary of harvest management actions. Detailed descriptions may be found in Part Three, section 3.5.

**Table 4.3** Harvest Management objectives and action items.

| Action Items | Description | Jurisdiction/ Authority | Partners | Resources/ Funding | Time Frame |
|---|---|---|---|---|---|
| ***Objective:*** Define and implement a base conservation harvest regime that will halt the decline of summer chum and allow rebuilding. | | | | | |
| 1. Review and analyze existing data to determine basis for effective harvest management. | Escapement, catch and fisheries data have been compiled and analyzed (see Part One and Part Three, 3.5) and the structure of a base conservation harvest regime has been established (see Part Three, 3.5). | WDFW, Tribes | | Phase 1 | Completed as part of this initiative. |
| 2. Identify specific harvest management actions within the conservation based harvest regime. | Harvest management actions include no directed harvest on summer chum and specific time, area and gear restrictions on other species to reduce summer chum bycatch to very low levels (details in Part Three, 3.5). | WDFW, Tribes | | Phase 1 | Completed as part of this initiative. |
| 3. Implement harvest management actions. | Protective harvest management actions have been in effect since 1992. The base conservation harvest regime developed for this initiative more clearly defines and expands upon ongoing management actions. Implementation is effective immediately. | WDFW, Tribes | | Phase 1 | Continuing. |
| 4. Maintain summer chum exploitation rates substantially below levels observed during years of decline, and at levels that will not impede recovery. | Exploitation rates are evaluated each year and additional harvest management measures taken if rates fall outside defined range. Additionally, every 5 years, exploitation rates will be evaluated for longer term effects and actions taken as determined appropriate (see Part Three, 3.5 and 3.6). | WDFW, Tribes | | Phase 1 | Completed as part of this initiative. |
| ***Objective:*** Ensure that base conservation harvest regime is working effectively. | | | | | |
| 5. Evaluate the base conservation regime assumptions. | Exploitation rates are evaluated each year and additional harvest management measures taken if rates fall outside defined range. Additionally, every 5 years, exploitation rates will be evaluated for longer term effects and actions taken as determined appropriate (see Part Three, 3.5 and 3.6). | WDFW, Tribes | | Phase 1 | Continuing. |

**Table 4.3** Harvest Management objectives and action items (continued).

| Action Items | Description | Jurisdiction/ Authority | Partners | Resources/ Funding | Time Frame |
|---|---|---|---|---|---|
| 2. Evaluate stocks and harvest management units performance against minimum abundance and spawning distribution criteria. | Criteria (thresholds) are described in Part One, 1.7.3 and Appendix Report 1.5. Reviews occur annually (Part Three, section 3.6). If criteria are not met, causes for failure are evaluated and appropriate actions are taken applicable to harvest, habitat and supplementation programs. | WDFW, Tribes | Other agencies and entities | Phase 1 | Annual reviews begin with 1999. First five year review in 2004. |
| ***Objective:*** Determine what constitutes a recovery harvest regime. | | | | | |
| 1. Define recovery criteria and recovered harvest regime. | Within one year, criteria for recovered stocks and harvest management units should be developed upon which a recovery based harvest regime will be defined. The conservation based harvest regime will remain in effect until recovery criteria are met. | WDFW, Tribes. | | Phase 1 | Within one year. |

## 4.2.4 Habitat

Strategies for addressing habitat factors for decline have been identified by the co-managers (Part Three, section 3.4). The local governments and agencies with jurisdiction are expected to take the lead in selecting and implementing specific actions based on the strategies. The co-managers anticipate providing technical assistance in the process of determining specific habitat protection and recovery actions, to the extent available resources will allow. An overview of habitat objectives and strategies is presented in Table 4.4, followed immediately by Table 4.5 that describes specific objectives, strategies and potential actions for individual stocks and watersheds.

**Table 4.4** Region-wide habitat objectives and strategies.

***Objective:*** Develop a high level of certainty that the habitat component of plan will be completed and implemented.

| Strategy | Description | Jurisdiction/ Authority | Partners | Resources/Funding | Time Frame |
|---|---|---|---|---|---|
| 1. Engage local governmental bodies and other entities in continuing the development and implementation of the program for habitat protection and recovery. | Development of a habitat program has begun with this plan in the description of strategies for the protection and recovery of summer chum in response to specific habitat-related factors for decline (Part Three, section 3.4). To have an effective program, local governments and citizens must participate in its development because the local governments have the jurisdiction to implement the needed measures and because without local support, implementation will not succeed. This action requires presentation of this plan to the local governments and entities, who will then lead in developing additional planning and specific actions to address the habitat-related factors for decline (see also the immediately following strategy). Working through local groups, efforts should be made to educate the public about importance of functional habitats and associated management actions for the protection and recovery of summer chum and other species. | Mason, Kitsap, Jefferson and Clallam Counties, HCCC, DNR, DOE, DOT, USFS, WDFW, Tribes. | Local groups and citizens, other agencies. | Use existing funding and resources, Phase 1. | Immediate. |
| 2. Complete development and begin implementation of the habitat component of the plan. | The next stages of habitat program development involve the selection and implementation of specific measures or actions. These measures include broad-based regulatory actions affecting land use practices in the watersheds and estuaries (for example, establishing riparian protection zones, limiting development of impervious surfaces, more effective regulation of shoreline structures), and specific habitat recovery actions (for example, acquiring land or easements to protect habitat from development, removing or setting back dikes). An evaluation procedure for prioritizing specific local recovery actions is suggested in Part Three, section 3.4). Applications to specific watersheds are summarized in Table 4.5 and presented in detail within Appendix Report 3.6. | Mason, Kitsap, Jefferson and Clallam Counties, HCCC, DNR, DOE, DOT, USFS. | WDFW, Tribes, local groups and citizens, other agencies. | Phases 1 and 2. | Immediate. |

**Table 4.4** Region-wide habitat objectives and strategies (continued).

***Objective:*** Develop a high level of certainty that the habitat component of plan will be completed and implemented.

| Strategy | Description | Jurisdiction/ Authority | Partners | Resources/Funding | Time Frame |
|---|---|---|---|---|---|
| ***Objective:*** Maintain and restore critical subestuarine and nearshore/shoreline processes and conditions. | | | | | |
| 1. Prohibit further ditching, diking and road construction in subestuaries, and prohibit or severely restrict bulkheading as well as construction of new piers, docks and floats along shorelines. | Further degradation of estuarine habitats is to be avoided wherever possible. Exemptions for single family residences should be removed from the Shoreline Management Master Plan. Critical habitat areas especially require protection. Consideration should be given to requiring use of joint facilities (e.g., docks, floats) away from critical areas and use of alternatives to bulkheading. Sources of marine sediment (feeder bluffs, etc.) Must be allowed to provide sediment to the marine environment for the maintenance of spits, beaches, and other nearshore habitat features. Mitigation should be required for any unavoidable developments (see Part Three, 3.4). | Counties | Agencies, tribes and other interested parties | Phase 1, possibly Phase 2. | Immediate |
| 2. Identify and purchase from willing landowners property or easements of undeveloped, subestuarine and shoreline areas. | Summer chum rely on diverse, productive and structurally complex habitats in the estuarine areas. Undeveloped critical areas should be protected from future development by purchase of property or easements (see Part Three, 3.4). | Counties, agencies, non-profit organizations. | Agencies, tribes and other interested parties. | Phase 2 | As funding resources become available. |
| 3. Remove or set back dikes and refit or remove roads/causeways in subestuaries. Re-establish dendritic channels and patterns of inundation in deltas, and restore sinuous main-stream channels in subestuarine areas. | Restoration of habitat in the subestuaries is a critical component of summer chum recovery (see Part Three, 3.4). Restoration will provide unrestricted tidal and freshwater circulation, natural sediment transport and storage, and development of marshes, swamps and eel grass beds, all of which contribute to high quality summer chum rearing and migrating habitat. | Counties | Agencies, tribes and other interested parties. | Phase 2 | As funding becomes available. |
| 4. Establish vegetation buffer requirements for marine shorelines. Place critical nearshore migratory pathways in marine reserves. | Vegetation buffers protect natural shoreline processes and limit effects of development. Critical nearshore migratory pathways will need to be identified and given adequate protection (Part Three, 3.4). | Counties | Agencies, tribes and other interested parties. | Phase 1 | As soon as possible. |

**Table 4.5** Stock and watershed specific habitat objectives, strategies and potential actions.

| Strategy/Action | Description | Jurisdiction/ Authority | Partners | Resources/ Funding | Time Frame |
|---|---|---|---|---|---|
| **A. Dungeness Stock** (see also action to evaluate summer chum population in Table 4.6) | | | | | |
| ***Objective:*** Restore salmonid habitat in the Dungeness River (see Appendix Report 3.6). | | | | | |
| 1. Re-establish functional flood plain in the lower 2.6 miles of river (dike removal and constriction abatement).<br>2. Abate man-made constrictions above RM 2.6.<br>3. Create stable long-term log jams.<br>4. Manage sediment to stabilize channel and reduce flooding risk.<br>5. Construct and/or protect side channels.<br>6. Restore riparian vegetation.<br>7. Conserve instream flows.<br>8. Decrease water quality impacts in Dungeness Bay to control harmful ulvoid blooms.<br>9. Restore estuarine habitat and functions in Dungeness Bay and along juvenile summer chum migration corridors (e.g., Gierin Creek estuary). | The Dungeness River has been subject to numerous planning processes. A Watershed Council and technical workgroup have been working for several years on a comprehensive plan to guide salmonid restoration. The plan, which incorporates the seven actions/strategies listed here, was approved by the Watershed Council in 1998. These continuing efforts, assuming adequate funding, are expected to result in the restoration of habitat functions to the benefit of summer chum as well as other salmonid species. | Jamestown S'Klallam Tribe, Clallam County, state and federal agencies. | Property owners and others. | Phases 1 and 2. | Ongoing |
| **B. Jimmycomelately Stock** | | | | | |
| ***Objective:*** Re-establish estuary to freshwater linkages and functions (see Appendix Report 3.6). | | | | | |
| 1. Reconnect and expand existing connections between freshwater reaches of flood plain and tidal delta. | The poor connections and habitat conditions at the freshwater/estuary interface is viewed as the primary issue to be addressed in restoring summer chum habitat of Jimmycomelately Creek. An estuary technical workgroup has been established to determine the scope of restoration actions, and to identify funding sources and time lines. | Clallam County, DOT. | Clallam Conservat. District, WDFW, Jamestown S'Klallam Tribe, WSU Coop. Ext., land-owners and others. | Phases 1 and 2. | Early stages. |

**Table 4.5** Stock and watershed specific habitat objectives, strategies and potential actions (continued).

| Strategy/Action | Description | Jurisdiction/ Authority | Partners | Resources/ Funding | Time Frame |
|---|---|---|---|---|---|
| 2. Remove secondary roads and railroad grade that limit tidal circulation and fish movement.<br>3. Fill remnant ditches.<br>4. Mitigate and eliminate log storage and handling impacts.<br>5. Create stable logjams to increase channel complexity.<br>6. Restore estuarine habitat and functions in Sequim Bay and along juvenile summer chum migration corridors (e.g., Bell Creek estuary). | | | | | |
| **C. Salmon/Snow Stock - Salmon and Snow Watersheds** | | | | | |
| ***Objective:*** Restore stream habitat functions (see Appendix Report 3.6). | | | | | |
| 1. Return stream channel to sinuous morphology.<br>2. Control sediment inputs to natural levels.<br>3. Create stable logjams to increase channel complexity.<br>4. Restore riparian vegetation. | These measures address the major impacts assessed to be limiting habitat functions in Salmon and Snow creeks and affecting freshwater life stages of summer chum. Restoration activities were begun in 1995 in Snow Creek north of Highway 101 and west of State Road 20 to abate channel constriction, re-establish pools, lower streambed and place LWD in stream. A more comprehensive restoration effort can be built on these initial activities. Additional assessment may be needed to prepare for actions. | Clallam County, DOT | Clallam Conserv. District, WDFW, James-town S'Klallam Tribe, WSU Coop. Ext., landowners and others. | Phase 2 | As funding becomes available. |
| ***Objective:*** Re-establish estuary to freshwater linkages and functions (see Appendix Report 3.6). | | | | | |
| 1. Remove railroad grade.<br>2. Remove or set back dikes. | The railroad grade limits tidal circulation for both creek deltas and is located at the center of emergent marsh rearing habitat on Snow Creek. Dike removal on both creeks must be carefully planned because of the integration of diked areas with Highway 101 transportation corridor. Additional assessment may be required to prepare for actions | Clallam County, DOT | Clallam Conserv. District, WDFW, James-town S'Klallam Tribe, WSU Coop. Ext., land-owners and others. | Phase 2 | As funding becomes available. |

**Table 4.5** Stock and watershed specific habitat objectives, strategies and potential actions (continued).

| Strategy/Action | Description | Jurisdiction/ Authority | Partners | Resources/ Funding | Time Frame |
|---|---|---|---|---|---|
| **D. Chimacum Watershed** | | | | | |
| ***Objective:*** Recover summer chum habitat in lower stream reaches (see Appendix Report 3.6). | | | | | |
| 1. Replace road fill and culvert at Irondale Rd. crossing.<br>2. Re-establish riparian forest on east and west forks.<br>3. Restore wetlands.<br>4. Protect wetlands and riparian areas downstream of Irondale Rd.<br>5. Protect lower river floodplain and estuary.<br>6. Restore estuarine and nearshore habitat by removing fill from approximately 18 to 20 acres of former intertidal habitat located immediately south of the Chimacum Creek mouth.<br>7. Decrease water quality impacts to the estuary and associated nearshore areas. | These measures address the major limiting factors affecting summer chum in Chimacum Creek. The work at the Irondale Rd. crossing is to remove possibility of future culvert failure. Riparian restoration will help reduce high summer temperatures and input of fine sediment. Wetland restoration will help control summer and winter flow conditions. Assessment of winter and summer flow effects is also needed. The Jefferson Land Trust and WDFW are currently working to acquire conservation easements including riparian areas. The tidal floodplain and estuary are undeveloped and should be protected by acquisition and regulation. | Jefferson County | WDFW, Tribes and local groups. | Phase 2 | As soon as funding is available. |
| **E. Quilcene Stock - Big and Little Quilcene Watersheds** | | | | | |
| ***Objective:*** Determine instream flows needed to support summer chum during immigration and spawning life stages in the Big and Little Quilcene rivers (see Appendix Report 3.6). | | | | | |
| Perform instream low flow assessment and recommend summer instream low flow levels and associated habitat improvements. | Because of water withdrawals, summer low flows are believed to be limiting immigration and spawning life stages in the Big and Little Quilcene. An assessment of low flow needs should be performed using appropriate methodology and considering other factors (e.g. channel aggradation) that may affect summer chum habitat in conjunction with low flows. A recommendation of instream low flow levels and any associated habitat improvements should be developed based on the results of the assessment. | DOE, Jefferson County, WDFW. | Tribes, City of Port Town-send, other agencies and interested parties. | Undetermined - Phase 2 | As soon as funding /resources are available. |

**Table 4.5** Stock and watershed specific habitat objectives, strategies and potential actions (continued).

| Strategy/Action | Description | Jurisdiction/ Authority | Partners | Resources/ Funding | Time Frame |
|---|---|---|---|---|---|
| ***Objective:*** Meet and maintain recommended instream low flow levels and associated habitat improvements in the Big and Little Quilcene rivers. | | | | | |
| Develop and implement process to gain acceptance of instream low flow levels and associated habitat improvements, to seek needed funding and to follow-up with specific actions to meet objective. | The governing bodies with jurisdiction, directly affected parties and others should convene to review results of the instream flow assessment and develop a cooperative response to meeting instream flow needs and addressing associated habitat improvements. Funding requirements should be determined and a strategy developed to secure the funds. The funding strategy should be implemented and specific actions should be taken to ensure instream low flow levels are met and to secure associated habitat improvements critical to successful instream low flow conditions. | Jefferson County, City of Port Town-send, Dept. of Ecology, WDFW, any affected landowners. | Tribes, other agencies and interest-ed parties. | Undetermined - Phase 2 | Immediately following completion of instream flow assessment |
| ***Objective:*** Protect or improve channel complexity, reduce channel aggradation effects, and protect and improve riparian conditions in the lower rivers (see Appendix Report 3.6). | | | | | |
| 1. Purchase from willing landowners property and easements adjacent to stream reaches and in the flood plains of the lower rivers and subestuaries. | In the lower Big Quilcene River (downstream of RM 1.0), the exact location of the river is controlled in large part by the placement of dikes; natural lateral river movement is constrained and sediment aggradation occurs in a restricted area. The effect has been to reduce channel complexity and exacerbate negative effects of sediment aggradation. The purchase of property or easements in this reach of the river, complemented by removal and setting back of dikes (see below) and obtaining appropriate instream low flow conditions (see above) will return natural river and flood plains interactions and functions, will increase channel complexity, and will significantly improve summer chum habitat conditions in the lower river. The purchase of this land will eliminate the need to protect the existing land uses of the current landowners from effects of flooding and thus will allow for more natural river functions. The reach of the Big Quilcene River from RM 1.0 to 2.5 is constrained by farmers and residents who have armored the banks to restrict river movement. Purchase of property or flood plain easements will allow the river to move more naturally across the flood plain, will lead to improved riparian conditions and will increase channel complexity.<br>The lower Little Quilcene River contains a few remaining spawning areas with intact riparian forest and good instream habitat. Purchase of property or easements will protect these areas from degradation. | Jefferson County, willing land-owners. | Tribes, WDFW, other agencies and interest-ed parties. | Undetermined - Phase 2. | Immediately as funds become available |

**Table 4.5** Stock and watershed specific habitat objectives, strategies and potential actions (continued).

| Strategy/Action | Description | Jurisdiction/ Authority | Partners | Resources/ Funding | Time Frame |
|---|---|---|---|---|---|
| 2. Remove or set back dikes in the flood plain and estuary. | Removal and setting back of dikes could provide access to substantial amounts of the flood plains and estuaries of the Big and Little Quilcene rivers. Natural lateral river movement, accompanied by improved distribution of sediments, greater channel complexity and improved riparian conditions would result in much improved habitat to the benefit of summer chum. | Jefferson County, willing land-owners. | Tribes, WDFW, other agencies and interest-ed parties. | Undetermined - Phase 2. | As funds become available |
| 3. Reduce future development in the flood plain by restricting construction permits. | Permits should be restricted to not allow new construction of residences or other developments in flood plain areas that currently accommodate natural stream/flood plain interactions and functions. The purpose would be to avoid further diminution of natural processes that support desirable summer chum habitat conditions. The flood plain on the north side of the Little Quilcene River below RM 0.7 is a natural flood plain area that should be protected from development. | Jefferson County. | Other counties, agencies tribes and interest-ed parties. | Undetermined - Phase 2 if needed. | Immediate. |
| 4. Determine sources and extent of sediment aggradation and scouring problems. | The sources of sediment aggradation on the Little Quilcene should be determined using existing watershed analysis methods. The extent and dynamics of sediment aggradation and scouring effects should be assessed in the lower Big and Little Quilcene rivers. These assessments will provide a better understanding of the scope of the aggradation and scouring problems that exist in the lower rivers, and indicate what actions may be taken to rectify the problems, leading to improved habitat conditions for summer chum. | U.S. Forest Service (upper watershed sediment source areas), Jefferson County . | Other agencies tribes and interest-ed parties. | Undetermined - Phase 2 if needed. | As funds become available |
| 5. Restore natural levels of LWD to the anadromous use zones of both rivers. | The Big and Little Quilcene rivers are extremely deficient in stable LWD. Restoring LWD will contribute to channel stability and complexity. | U.S. Forest Service, Jefferson County | Other agencies, tribes and interested parties. | Phase 2 | As funds become available. |
| 6. Restore natural meandering configuration to the channelized reach of the Big Quilcene River between approximately river mile 2.5 and 2.8. | Channelization of this portion of river in 1950s has led to extremely simplified and impaired habitat ever since. Also, with the river being confined against the valley wall in this area, high rates of bluff erosion and sediment recruitment into the river have occurred. Restoring the channel to a meandering configuration will restore channel complexity, reduce stream energy and allow the river to move away from the highly erodible slopes. | Jefferson County | Other agencies, tribes and interested parties. | Phase 2 | As funds become available. |

**Table 4.5** Stock and watershed specific habitat objectives, strategies and potential actions (continued).

| Strategy/Action | Description | Jurisdiction/ Authority | Partners | Resources/ Funding | Time Frame |
|---|---|---|---|---|---|
| 7. Remove artificially aggraded sediments from the Big Quilcene and Little Quilcene river delta cones. | Channelization of these streams has caused the development of abnormal delta cones that have buried intertidal estuarine habitat at these stream mouths. These delta cones should be removed to restore estuarine habitat and contribute to the stability of the lower reaches of these streams. Similar consideration should be given to removing delta cones of other streams in Quilcene Bay estuary (i.e., Indian and Jakeway creeks). | Jefferson County | Other agencies, tribes and interested parties. | Phase 2 | As funds become available. |
| **F. Dosewallips Stock** | | | | | |
| ***Objective:*** Protect and improve summer chum habitat (see Appendix Report 3.6). | | | | | |
| 1. Purchase property or conservation easements in lower 3.0 miles of watershed. | Development pressures are highly concentrated in the lower 3.0 miles of river, where most summer chum use occurs. Acquisition of property or easements from willing landowners will ensure future protection and recovery of summer chum habitat. The potential also exists for planting conifers in the riparian zone and placing engineered logjams to improve channel complexity and stabilize spawning gravels. | Jefferson County and state/federal agencies | Tribes and other interested parties | Phase 2 | When funding is available |
| 2. Restore tidal circulation across the subestuary. | Existing and failed dikes have disconnected the wetlands across the delta. Removing or setting back the dikes would allow more natural tidal circulation and access to habitat. Tidal channels north of the river mouth could be reconnected to the mainstem river. | Jefferson County and state/federal agencies | Tribes and other interested parties | Phase 2 | When funding is available |
| 3. Restore natural levels of LWD to the anadromous use zones of the Dosewallips River. | The Dosewallips River if deficient in stable LWD. Restoring LWD will contribute to channel complexity and stability. | Jefferson County and state/federal agencies. | Tribes and other interested parties. | Phase 2 | When funding is available. |
| **G. Duckabush Stock** | | | | | |
| ***Objective:*** Protect and improve summer chum habitat (see Appendix Report 3.6). | | | | | |
| 4. Purchase property or conservation easements in lower 2.5 miles of watershed. | Development pressures are highly concentrated in the lower 2.5 miles of river, where most summer chum use occurs. Acquisition of property or easements from willing landowners will ensure future protection and recovery of summer chum habitat. The potential also exists for planting conifers in the riparian zone and placing engineered logjams to improve channel complexity and stabilize spawning gravels. | Jefferson County and state/federal agencies | Tribes and other interested parties. | Phase 2 | When funding is available. |

**Table 4.5** Stock and watershed specific habitat objectives, strategies and potential actions (continued).

| Strategy/Action | Description | Jurisdiction/Authority | Partners | Resources/Funding | Time Frame |
|---|---|---|---|---|---|
| 2. Restore tidal circulation across the subestuary. | Rerouting or refitting the Highway 101 road causeway across the delta would help restore tidal circulation and juvenile salmon migration and rearing in the subestuary. Removal or setting back of one of the dikes in the northern delta would reconnect additional delta area. | Jefferson County, DOT, state/federal agencies | Tribes and other interested parties | Phase 2 | When funding is available |
| **H. Hamma Hamma Stock** | | | | | |
| ***Objective:*** Protect and improve summer chum habitat (see Appendix Report 3.6). | | | | | |
| 3. Protect and restore riparian forests. | Logging and timber salvage in riparian zone has reduced LWD recruitment into the stream and has increased soil erosion and landslide hazards. Providing an adequate riparian forest buffer and avoiding harvest on steep slopes is recommended. Engineered logjams may be placed to improve channel habitat complexity. | Mason County, DOT, state / federal agencies. | Land-owner, tribes and other interested parties | Phases 1 and 2 | Immediate |
| 4. Restore tidal circulation across the subestuary. | Reconnecting the lower river with the north bank marsh would restore fish access to subestuarine habitat used for rearing and refuge. An assessment of this action and others in the delta area is needed to determine nature and feasibility of actions. | Mason County, DOT, state / federal agencies. | Land-owner, tribes and other interested parties | Phase 2 | Immediate |
| **I. Lilliwaup Stock** | | | | | |
| *Objective:* Protect and improve summer chum habitat (see Appendix Report 3.6). | | | | | |
| 1. Restore riparian forest in lower river. | Restriction of human activities associated with agricultural and residential developments would allow riparian forests to become reestablished, providing a source of LWD to increase channel complexity. | Mason County | Land-owners, tribes and other interested parties. | Phase 1 | Immediate |

**Table 4.5** Stock and watershed specific habitat objectives, strategies and potential actions (continued).

| Strategy/Action | Description | Jurisdiction/ Authority | Partners | Resources/Funding | Time Frame |
|---|---|---|---|---|---|
| 2. Protect wetlands in upper Lilliwaup valley. | The DNR-owned wetlands are believed to play a major role in sustaining summer flows. The land should be managed to ensure the wetlands are maintained. | DNR | Tribes and other interested parties. | Phase 1 | Continuing. |
| 3. Restore natural tidal channel system. | The natural tidal channel system of the subestuary is impacted by the Highway 101 road causeway. The causeway should be relocated or refitted to reduce impact. | DOT | Tribes and other interested parties. | Phase 2 | When funded. |
| **J. Skokomish Stock** | | | | | |
| ***Objective:*** Protect and improve freshwater natural habitat conditions (see Appendix Report 3.6). | | | | | |
| 1. Restore natural flows in the North Fork. | Substantial restoration of North Fork flows (currently diverted by the Cushman Hydroelectric Project) would restore historic habitat conditions, reduce or eliminate sediment aggradation in the main channel, and improve conditions for upstream adult salmon migration during the summer low flow months. | U.S. Dept. of Interior | City of Tacoma, state and federal agencies, Skok. Tribe | Phase 1 and possibly Phase 2. | In process. |
| 2. Improve hydrological conditions throughout watershed. | Reducing road densities through obliteration and decommissioning and improving drainage of remaining roads by installing larger and more frequent cross drains and water bars will help restore ecosystem processes and lessen peak flow impacts. By allowing the forest to mature, general hydrologic conditions will improve and rain on snow impacts will be reduced. | Federal and state agencies, Mason County | Skok. Tribe | Phases 1 and 2 | Immediate |
| 3. Restore riparian condition through revegetation | Revegetation of the riparian corridor together with decommisioning dikes and fencing livestock will improve the river connection with the floodplain and improve riparian benefits (e.g., provide source of LWD). | Mason County | Conserv. Dist. , state and federal agencies, Skok. Tribe, land-owners | Phases 1 and 2 | Immediate |

**Table 4.5** Stock and watershed specific habitat objectives, strategies and potential actions (continued).

| Strategy/Action | Description | Jurisdiction/ Authority | Partners | Resources/Funding | Time Frame |
|---|---|---|---|---|---|
| 4. Provide for natural movement of the river across the floodplain. | Removal of dikes and purchase of property or easements from willing landowners would allow the river to move across and integrate more naturally with the flood plain, creating improved habitat conditions. Habitat diversity may be improved by reconnecting isolated sloughs and side channels. | Mason County | State and federal agencies, Skok. Tribe, land-owners | Phase 2 | Depends on funding. |
| ***Objective:*** Restore delta functions. | | | | | |
| Convert lands back to estuarine wetlands with natural distributary channels. | Remove dikes and tide gates, and remove or relocate roads to provide unimpeded tidal circulation in river delta. A key part of the subestuary's recovery is the restoration of North Fork flows that strongly affect the delta's ecological processes and would reduce the long term sediment aggradation in the main channel. The actions will restore summer chum migration and rearing habitat. | Mason County | State and federal agencies, Skok. Tribe, land-owners | Phase 2 | Depends in part on funding. |
| **K. Union Stock** | | | | | |
| ***Objective:*** Protect and improve subestuarine habitat (see Appendix Report 3.6). | | | | | |
| 5. Purchase property or conservation easements in undeveloped subestuarine or shoreline areas. | Acquisition of properties or easements from willing landowners will secure permanent protection of undeveloped, natural areas that provide summer chum rearing and migratory habitat. | Mason County | Agencies, tribes, landowners | Phase 2 | Contingent on funding. |
| 6. Recover habitat through removal or setting back dikes and removal of unnecessary fills and bulkheads. | There is a need to assess the effectiveness of the dikes, fills and bulkheads and their impact on the subestuarine environment. Based on results of assessment, restoration opportunities may be explored and negotiated with the landowners. | Mason County | Agencies, tribes, landowners | Phase 2 | Contingent on funding. |

**Table 4.5** Stock and watershed specific habitat objectives, strategies and potential actions (continued).

| Strategy/Action | Description | Jurisdiction/Authority | Partners | Resources/Funding | Time Frame |
|---|---|---|---|---|---|
| ***Objective:*** Protect and improve stream habitat (see Appendix Report 3.6). | | | | | |
| 1. Restore riparian forest. | Encourage riparian revegetation throughout the stream corridor. Upgrade riparian protection through ordinances. Existing riparian forests may be improved by underplanting shade tolerant conifers. | Mason County | Agencies, tribes, landowners | Phases 1 and 2 | Immediate. |
| 2. Increase channel complexity. | Channel complexity may be improved by allowing natural input processes for woody debris to occur and by leaving LWD in the stream channel. Consider placing engineered logjams in channel. | Mason County | Agencies, tribes, landowners | Phases 1 and 2 | Immediate. |
| 3. Improve water quality. | Raise standards for best management practices utilized by industrial landowners, small farms and residential homeowners to reduce impacts on habitat and water quality. Enact effective stormwater protection measures. | Mason County | Agencies, tribes, landowners | Phase 1 | Immediate. |
| **L. Big Mission Watershed** | | | | | |
| ***Objective:*** Protect and improve subestuarine habitat (see Appendix Report 3.6). | | | | | |
| 4. Purchase property or conservation easements in undeveloped subestuarine or shoreline areas. | Acquisition of properties or easements from willing landowners will secure permanent protection of undeveloped, natural areas that provide summer chum rearing and migratory habitat. | Mason County | Agencies, tribes, land-owners | Phase 2 | Contingent on funding. |

**Table 4.5** Stock and watershed specific habitat objectives, strategies and potential actions (continued).

| Strategy/Action | Description | Jurisdiction/Authority | Partners | Resources/Funding | Time Frame |
|---|---|---|---|---|---|
| 2. Recover habitat through removal or setting back dikes and removal of unnecessary fills and bulkheads. | The condition and effectiveness of dikes, fills and bulkheads, and their impact on the subestuarine environment should be assessed. Based on results of assessment, restoration opportunities should be explored and negotiated with the landowners. Explore with Washington Parks Dept. the potential of reconfiguring the lower stream channel. | Mason County | Agencies, tribes, land-owners | Phase 2 | Contingent on funding. |
| ***Objective:*** Protect and improve stream habitat (see Appendix Report 3.6). | | | | | |
| 3. Restore riparian forest. | Encourage riparian revegetation throughout the stream corridor. Upgrade riparian protection through ordinances. Consider purchasing from willing landowners critical undeveloped properties or conservation easements on developed properties that can be enhanced. Existing riparian forests may be improved by underplanting shade tolerant conifers. Link the DNR riparian forests in the middle reaches of stream with riparian forests in the lower reaches. | Mason County | Agencies, tribes, land-owners | Phases 1 and 2 | Immediate. |
| 4. Increase channel complexity. | Channel complexity may be improved by allowing natural input processes for woody debris to occur and by leaving LWD in the stream channel. Consider placing engineered logjams in channel. Assess capacity of bridges/culverts to pass wood, water and sediment to lower reaches; replace or improve these structures where appropriate. Where possible, remove rip rap or replace with bio-engineered shoreline protection. | Mason County | Agencies, tribes, land-owners | Phases 1 and 2 | Immediate. |

**Table 4.5** Stock and watershed specific habitat objectives, strategies and potential actions (continued).

| Strategy/Action | Description | Jurisdiction/Authority | Partners | Resources/Funding | Time Frame |
|---|---|---|---|---|---|
| **M. Tahuya Watershed** | | | | | |
| ***Objective:*** Protect and improve stream habitat (see Appendix Report 3.6). | | | | | |
| 1. Protect and improve riparian condition. | Allowing existing forests to mature and providing adequate riparian buffers will over time protect and improve riparian processes. As riparian condition improves, potential effects of high water temperatures (i.e., limiting distribution of returning adults) will be mitigated. | Mason County, DOT | Agencies, tribes, landowners | Phases 1 and 2 | Immediate. |
| 2. Increase channel complexity. | Channel complexity will increase by allowing the river to migrate naturally across the 100 year floodplain. Opportunities for elimination of bank hardening and stream channelization that limit natural river movement should be pursued. | Mason County, DOT | Agencies, tribes, landowners | Phases 1 and 2 | Immediate. |
| 3. Protect instream flows. | Negative impacts on instream flows are likely with development in the watershed unless effective management is applied. Impervious surfaces should be limited, storm water control measures planned and implemented, and drainage structures sized to allow for 100 year storm events. | Mason County, DOT | Agencies, tribes, landowners | Phases 1 and 2 | Immediate. |
| 4. Protect and improve subestuarine habitat. | Efforts should be made to protect estuary from further development, especially bank hardening. Existing road causeways constrict water circulation and should be refitted to reduce impact. | Mason County, DOT | Agencies, tribes, landowners | Phases 1 and 2 | Immediate. |
| **N. Dewatto Watershed** | | | | | |
| ***Objective:*** Protect and improve stream habitat (see Appendix Report 3.6). | | | | | |
| 1. Protect and improve riparian condition. | Riparian functions will improve as the existing riparian forest matures over the next 25-50 years. Adequate protection through regulation and enforcement will ensure functions such as LWD recruitment, and moderation of water temperatures will naturally improve over time. | Mason County, DOT | Agencies, tribes, land-owners | Phases 1 and 2 | Immediate. |

**Table 4.5** Stock and watershed specific habitat objectives, strategies and potential actions (continued).

| Strategy/Action | Description | Jurisdiction/Authority | Partners | Resources/Funding | Time Frame |
|---|---|---|---|---|---|
| 2. Upgrade road conditions. | Fine sediments in spawning gravels may be reduced by routing road drainage away from stream channels, stabilizing sidecasts, hardening road surfaces, upgrading stream crossings to pass 100-year flood events and, where possible, decommisioning roads. | Mason County, DOT | Agencies, tribes, landowners | Phases 1 and 2 | Immediate. |
| 3. Improve channel complexity. | Restore natural function within the 100-year flood plain by removing or redesigning constraints to natural channel development. Such constraints include bank hardening and channelization. | Mason County, DOT | Agencies, tribes, landowners | Phases 1 and 2 | Immediate. |
| 4. Protect subestuary. | The subestuary is one of few relatively undisturbed deltas. Specific measures should be sought to ensure its protection; e.g., purchase of conservation easements and regulation of land use. | Mason County, DOT | Agencies, tribes, landowners | Phases 1 and 2 | Immediate. |
| **O. Big Anderson Watershed** | | | | | |
| ***Objective:*** Protect and improve stream habitat (see Appendix Report 3.6). | | | | | |
| 5. Protect and improve riparian condition. | Increase riparian buffer and provide adequate protection. Plant conifers throughout flood plain in lower one mile of stream. | Kitsap County, DOT | Agencies, tribes, landowners | Phases 1 and 2 | Immediate. |
| 6. Reduce unnatural instream sediment accumulation and reduce adverse peak flow effects. | Avoid logging on potentially unstable slopes and decommission or repair roads that have high surface erosion or landslide hazard. Limit new road construction. Increase water bars and cross drains on forest roads. Redirect roadside ditches to avoid direct routing of storm flows into stream channels. | Kitsap County, DOT | Agencies, tribes, landowners | Phases 1 and 2 | Immediate. |
| 7. Improve habitat in lower river flood plain and subestuary. | Relocate roads out of flood plain or replace road fill with structures that allow channel movement and passage of flood waters. Alternatively, roads may be set back or rerouted within flood plain to improve habitat. Remove abandoned railroad fill in subestuary. | Kitsap County, DOT | Agencies, tribes, landowners | Phase 1 and 2 | Immediate. |

**Table 4.5** Stock and watershed specific habitat objectives, strategies and potential actions (continued).

| Strategy/Action | Description | Jurisdiction/Authority | Partners | Resources/Funding | Time Frame |
|---|---|---|---|---|---|
| **P. Stavis Watershed** | | | | | |
| ***Objective:*** Protect and improve stream habitat (see Appendix Report 3.6). | | | | | |
| 1. Protect existing high quality habitat | Continue and expand acquisitions under the Hood Canal Salmon Sanctuary. Highest priority is estuary and adjacent uplands, but also important are adjoining shoreline areas, lower mainstem and flood plain, and wetland hydrologic source areas. | Kitsap County | Agencies, tribes, landowners | Phases 1 and 2 | Immediate. |
| 2. Protect and restore riparian forest. | For properties acquired in lower watershed, replant streamside areas lacking sufficient riparian forest or appropriate species and abandon any associated roads. Consider treatments to encourage conifer regeneration on WDFW properties. Reforest narrow riparian zones on upstream DNR lands. Establish appropriate riparian zone widths to provide long-term LWD recruitment. Assess West Kitsap Watershed Analysis prescriptions and modify as needed. | Kitsap County | Agencies, tribes, landowners | Phases 1 and 2 | Immediate. |
| 3. Establish hydrologic maturity targets. | Set forest harvest rates to ensure hydrologic maturity. Address growth management issues to limit effects (e.g., from impervious services) on hydrologic maturity. | Kitsap County | Agencies, tribes, landowners | Phases 1 and 2 | Immediate. |
| 4. Use Stavis Creek estuary as critical habitat template. | Establish long term monitoring programs to track estuarine quality. | Kitsap County | Agencies, tribes, landowners | Phases 1 and 2 | Immediate. |
| **Q. Seabeck Watershed** | | | | | |
| ***Objective:*** Protect and improve stream habitat (see Appendix Report 3.6). | | | | | |
| 1. Control sediment sources. | Improve road maintenance and surfacing on private roads, and ensure storm water runoff is not routed directly into stream channel. Evaluate effectiveness of slope stability standards. Control timing of clearing and grading activities adjacent to creek to avoid storm events. | Kitsap County | Agencies, tribes, landowners | Phase 1 and 2 | Immediate |

**Table 4.5** Stock and watershed specific habitat objectives, strategies and potential actions (continued).

| Strategy/Action | Description | Jurisdiction/Authority | Partners | Resources/Funding | Time Frame |
|---|---|---|---|---|---|
| 2. Improve channel complexity. | Place LWD jams in lower river if determined to be feasible. | Kitsap County | Agencies, tribes, land-owners | Phases 1 and 2 | Immediate. |
| 3. Protect flow conditions. | Prohibit new water withdrawals until instream flow requirements are established. Establish impervious surface limits and condition land use permits accordingly. Retrofit existing developments for storm water control. Maintain minimum 60% of watershed in forest cover. | Kitsap County | Agencies, tribes, land-owners | Phases 1 and 2 | Immediate. |
| 4. Protect and restore riparian habitat. | Acquire high quality riparian forest to protect habitat. Replant riparian buffers with native species to improve habitat. Review and revise critical area ordinance to meet recommended functional riparian buffer standards. | Kitsap County | Agencies, tribes, land-owners | Phases 1 and 2 | Immediate. |
| 5. Protect subestuary. | Prevent further development within subestuary by land acquisition or land use regulation. | Kitsap County | Agencies, tribes, land-owners | Phases 1 and 2 | Immediate. |
| **R. Big Beef Watershed** | | | | | |
| ***Objective:*** Protect and improve stream habitat (see Appendix Report 3.6). | | | | | |
| 1. Reduces sources of sediment aggradation. | Reduce mass wasting into lower five miles of stream by prohibiting logging and development on steep, unstable slopes. Address sediment contributions from existing abandoned and active roads (esp. Kidhaven Rd. at RM 3.2). Prohibit new roads on steep ravine slopes below Lake Symington. Monitor effectiveness of prescriptions for logging (West Kitsap Watershed analysis) and rural development (Critical Areas Ordinance). | Kitsap County, DOT | Agencies, tribes, land-owners | Phases 1 and 2 | Immediate. |
| 2. Increase channel complexity. | Remove service road located within flood plain & evaluate feasibility of restoring side channels and wetlands next to U.W. research facility. Assess role of WDFW weir in affecting sediment routing and investigate options for reducing its impact. Evaluate option of placing LWD jams in lower river. | Kitsap County, DOT | Agencies, tribes, land-owners | Phase 1 and 2 | Immediate. |

**Table 4.5** Stock and watershed specific habitat objectives, strategies and potential actions (continued).

| Strategy/Action | Description | Jurisdiction/Authority | Partners | Resources/Funding | Time Frame |
|---|---|---|---|---|---|
| 3. Reduce causeway impact on delta. | Retrofit causeway by removing fill and expanding bridge span to reduce its footprint in the historic delta, promote full tidal water exchange and allow natural habitat development in subestuary. | Kitsap County, DOT | Agencies, tribes, land-owners | Phases 1 and 2 | Immediate. |
| 4. Improve flow conditions. | Condition water applications to ensure minimum instream flow recommendations are met. Establish impervious surface limits and condition land use permits accordingly. Maintain minimum 60% of watershed in forest cover. Institute water conservation programs and seek opportunities to reduce number of shallow wells in watershed. Require on-site infiltration of runoff from impervious surfaces where soils are appropriate. Ensure road drainage is not routed directly into stream channels. | Kitsap County, DOT | Agencies, tribes, land-owners | Phases 1 and 2 | Immediate. |
| 5. Protect and restore riparian forests. | Continue riparian area acquisition efforts under the Hood Canal Salmon Sanctuary program. Replant degraded riparian zones with appropriate native species. Review and revise critical area ordinance consistent with recommendations for riparian buffers. | Kitsap County, DOT | Agencies, tribes, land-owners | Phases 1 and 2 | Immediate. |

### 4.2.5 Monitoring and Evaluation

Monitoring and evaluation are intended to document compliance with the management actions described in this initiative and to help verify whether or not the expected results of those actions actually occur. They also are used to validate critical assumptions upon which management actions are based and address identified information gaps. Monitoring and evaluation are necessary to demonstrate the effectiveness of the initiative in addressing the factors for decline, in stopping population declines, and ultimately in recovering summer chum. Table 4.6 summarizes monitoring and evaluation objectives, strategies and actions.

**Table 4.6** Monitoring and Evaluation - objectives, strategies and actions.

***Objective:*** Document compliance of specific projects and actions with applicable guidelines, criteria or rules.

| Strategy/Action | Description | Jurisdiction/ Authority | Partners | Resources/ Funding | Time Frame |
|---|---|---|---|---|---|
| 1. Monitor summer chum supplementation and reintroduction projects for consistency with provisions and guidelines under the initiative and in support of adaptive management (section 3.2). | Monitoring is accomplished by required recording of all project operations including brood stocking, incubation, rearing, health, transfer and release of fish. Records, including building of new facilities, are summarized and made available in annual reports. Projects may be modified or even terminated based on monitoring results. | WDFW, USFWS, Tribes. | HCSEG, NOSC, WOS, LLTK. | Phase 1. | Immediate. |
| 2. Monitor hatchery mitigation measures to reduce negative ecological interactions of other species with summer chum, consistent with provisions of section 3.3. | Hatchery records demonstrate level of compliance with identified mitigation actions. Results are summarized in annual report. | WDFW, USFWS, Tribes | Citizens and other participant organizations. | Phase 1. | Immediate. |
| 3. Monitor harvest regulations and fisheries for consistency with plan provisions (section 3.5). | Records of harvest regulations are kept. Tribal and state fisheries enforcement programs promote compliance with regulations and record violations. Results are reviewed annually. | WDFW, Tribes | | Phase 1. | Immediate. |
| 4. Include compliance monitoring as part of habitat protection and restoration measures (section 3.4). | Documenting compliance with land use permits and regulations, and with specifications of habitat restoration projects, should be required in the development of these actions. | Local governments and agencies with jurisdiction | WDFW, Tribes | Phases 1 and 2 | Immediate. |
| ***Objective:*** Measure effectiveness of actions and projects. | | | | | |
| 1. Monitor adult returns from supplementation and reintroduction projects. | All artificially produced summer chum are marked or tagged so that returning hatchery origin fish may be sampled. Because all currently planned projects are integrated recovery programs, the focus is on number and proportion of natural origin returns (NORs) as the primary measure of project success. (Adequate sampling resources are critical for effective monitoring.) Artificial production program may be reduced or even terminated based on monitoring results (Part Three, 3.2). | WDFW, USFWS, Tribes | HCSEG, NOSC, WOS, LLTK | Phases 1 and 2 | Immediate. |

**Table 4.6** Monitoring and Evaluation - objectives, strategies and actions (continued).

| Strategy/Action | Description | Jurisdiction/ Authority | Partners | Resources/ Funding | Time Frame |
|---|---|---|---|---|---|
| 2. Monitor catches, escapements, genetics, ages and fisheries exploitation rates. | Summer chum are not targeted in fisheries. However, catches of summer chum in fisheries for other species, with run timing that overlaps that of summer chum, are monitored, as are summer chum escapements to spawning grounds, genetic stock information, ages of summer chum and other biological data (see Part One). With this information, runs are reconstructed and exploitation rates estimated to measure the success of harvest controls and assess the condition of the summer chum management units and stocks. Population performance standards will be used to evaluate the effectiveness of all management actions in conserving and recovering summer chum (see also below, section 4.2.6). | WDFW, USFWS, Tribes | | Phases 1 and 2 | Immediate |
| 3. Verify that assumed effects of habitat restoration projects on habitat are what was assumed. | Projects should include post-construction monitoring for specific effects on habitat or fish (e.g., changes in habitat configuration or function (such as expansion of salt marsh) and/or improved fish access to restored habitat) (Part Three, 3.4). | Local governments and agencies with jurisdiction | WDFW, Tribes and other interested parties. | Phases 1 and 2 | As projects are implemented |
| ***Objective:*** Validate critical assumptions behind planning and actions. | | | | | |
| 1. Verify that under present guidelines artificial production projects do not affect genetic diversity of natural populations. | Continue to collect genetic information on natural summer chum. Collect genetic information over time from selected artificial production programs to monitor any changes and compare with natural populations (Part Three, 3.2). | WDFW, USFWS, Tribes | | Phases 1 and 2 | Immediate |
| 2. Verify that straying of hatchery summer chum out of watersheds of origin is at acceptably low levels. | Sample summer chum for marks during brood stocking operations. Also, sample summer chum carcasses for marks in watersheds of origin and in adjacent watersheds (Part Three, 3.2). | WDFW, USFWS, Tribes | | Phases 1 and 2 | Immediate |
| 3. Verify that regulatory measures for Hood Canal terminal fisheries based on run timing will control summer chum exploitation levels to expected low levels. | Catches in terminal fisheries will be monitored and genetic samples will be taken (to separate summer from fall chum) so that run timing assumptions are verified or modified, and associated regulatory measures are also adapted as needed (Part Three, 3.5). | Tribes, WDFW | | Phases 1 and 2 | Immediate |

**Table 4.6** Monitoring and Evaluation - objectives, strategies and actions (continued).

| Strategy/Action | Description | Jurisdiction/ Authority | Partners | Resources/ Funding | Time Frame |
|---|---|---|---|---|---|
| 4. Investigate whether controlled Hood Canal terminal fisheries impacts on summer chum do not disproportionately affect one or more stocks. | Results of monitoring summer chum catch distribution and associated genetics sampling information would address this issue (Part Three, 3.5). | Tribes, WDFW |  | Phases 1 and 2 | Immediate |
| 5. Verify that pre-terminal fisheries exploitation rates fall within bounds stipulated for conservation based fishing regime. | Monitoring of within state pre-terminal fisheries to estimate exploitation rates is planned. Agreements will be sought with Canada to monitor fisheries with likely impact (Part Three, 3.5). | WDFW, Tribes |  | Phases 1 and 2 | Immediate |
| 6. Verify and increase understanding of habitat factors for decline identified in this initiative. | Evaluations should be made in selected locations of factors (and associated parameters) currently identified as negatively affecting summer chum. Included are assessments of storm flow runoffs and upland drainage patterns that affect peak flows, low flow and temperatures, LWD loading and channel stability affecting channel complexity and floodplain function, sediment delivery and routing, riparian forest condition, and subestuarine habitat condition (Part Three, 3.4). | WDFW, Tribes | Other agencies and interested parties. | Phases 1 and 2 | As funding and resources become available. |
| ***Objective:*** Perform assessments that address additional identified information gaps. |  |  |  |  |  |
| 1. Plan and implement evaluation of Dungeness summer chum population | The Dungeness stock is known to exist in the Dungeness River but the abundance and condition of the stock is not known (Part One, section 1.7.2.1). An assessment of the population, including measurements of the distribution and levels of escapement, should be designed and implemented by the management agencies and tribes. The assessment should provide an understanding of the status of the stock and provide a basis for determining appropriate management actions. | WDFW, and Tribes | USFWS and other interested agencies and parties | Phase 2 | As soon as funding is available. |

**Table 4.6** Monitoring and Evaluation - objectives, strategies and actions (continued).

| Strategy/Action | Description | Jurisdiction/ Authority | Partners | Resources/ Funding | Time Frame |
|---|---|---|---|---|---|
| 2. Assess summer chum productivity and production capacity. | Obtain age and sex data from existing populations and develop estimates of productivity. Also perform more in depth investigations; for example, the research project has been initiated at Big Beef Creek (where summer chum are being reintroduced) to assess productivity from egg deposition to adult return and to follow production of consecutive generations spawning in the stream (Part Three, 3.2). | WDFW | Tribes, HCSEG and other interested parties. | Phases 1 and 2 | Continuing. |
| 3. Assess summer chum non-harvest mortality. | Research non-harvest summer chum mortality as a mortality rate per fish encountered such that the rate for each gear type is estimated with sufficient precision to match goals for accuracy of exploitation rate estimates and management effectiveness (Part Three, 3.5). | WDFW, Tribes | | Phase 2 | When funding becomes available. |
| 4. Develop stream habitat classification system and database. | The Salmon and Steelhead Habitat Inventory and Assessment Project (SSHIAP) is being developed by the co-managers and is expected to provide recovery planners a valuable tool for planning and prioritizing protection and recovery work (Part Three, 3.4). | Tribes, WDFW | Other agencies and interested parties. | Phases 1 and 2 | Continuing. |
| 5. Survey habitat in streams and estuaries where little or no data has been collected. | Systematically collected habitat data is lacking or limited in scope for several streams and the nearshore estuarine areas. Surveys will provide improved understanding of habitat conditions affecting summer chum (Part Three, 3.4). | WDFW, Tribes | Other agencies and interested parties. | Phase 2 | When funding or resources become available. |
| 6. Assess stream bed scouring effects on summer chum redds in selected watersheds. | Increases in peak winter flows, stream bed mobility and consequent scouring of salmon redds is perceived as a major factor of decline in several watersheds. Scour chain monitoring linked with spawning surveys and/or emergent fry trapping will help better define severity of effect on summer chum (Part Three, 3.4). | WDFW, Tribes | Other agencies and interested parties. | Phase 2 | When funding or resources become available. |
| 7. Perform multi-scenario analysis of full build-out in selected watersheds using standard and alternative designs and materials. | Analysis will help reconcile development pressures with habitat protection needs (Part Three, 3.4). | Counties, local governments | WDFW, Tribes | Unknown | As soon as practical. |

**Table 4.6** Monitoring and Evaluation - objectives, strategies and actions (continued).

| Strategy/Action | Description | Jurisdiction/ Authority | Partners | Resources/ Funding | Time Frame |
|---|---|---|---|---|---|
| 8. Perform analysis of hydrologic changes in selected watersheds. | Hydrologic changes such as artificial stream channel constrictions and increased peak flows dynamically interact to affect sediment regimes, bed stability and channel complexity impacting summer chum habitat. Analysis of these changes will help focus on appropriate summer chum protection and recovery measures (Part Three, 3.4). | Counties, local governments | WDFW, Tribes | Unknown | As soon as practical. |
| 9. Inventory and assess estuarine nearshore habitat and shoreline structures. | Little information currently exists on estuarine nearshore habitat or shoreline structures. A study is needed to survey the shoreline and evaluate effects of man-made structures on habitat and summer chum (Part Three, 3.4). | WDFW, Tribes | Other agencies and interested parties. | Phase 2 | When funding or resources become available. |
| 10. Perform estuarine life history study of selected summer chum populations. | Study would be to determine the distribution and timing, as well as the feeding and sheltering characteristics of juvenile summer chum in the subestuarine and nearshore environments (Part Three, sections 3.3, 3.4). | WDFW, Tribes | Other agencies and interested parties. | Phase 2 | When funding or resources become available. |

### 4.2.6 Program Integration and Adaptive Management

The summer chum salmon conservation initiative is an integrated plan, with each element contributing in concert with other elements to address the broad range of factors for decline and promote recovery. The plan elements of artificial production, ecological interactions, habitat and harvest management have been presented separately, each with specific objectives, strategies and actions intended to conserve and recover summer chum salmon. However, it is understood that the combination of effects from the individual strategies and actions, across all elements, is the key to success. To fully integrate the initiative's elements, the results must be assessed over time with existing management measures either adjusted or terminated, and possibly new measures added as is appropriate. While the previous descriptions of each of the elements address specifically applicable performance evaluations, the ultimate measure of overall success must include assessment of summer chum population performance. Table 4.7 describes the co-managers' approach to assessing and responding to summer chum population performance.

**Table 4.7** Program Integration and Adaptive Management - objectives and action items.

| Strategy/Action | Description | Jurisdiction/ Authority | Partners | Resources/ Funding | Time Frame |
|---|---|---|---|---|---|
| ***Objective****:* Define population performance criteria for periodic evaluation of summer chum populations. | | | | | |
| 1. Identify thresholds below which summer chum management units and stocks are at critical status. | Numerical critical thresholds or flags have been set for escapements and run sizes of management units and stocks (see Part One, 1.7.3 and Appendix Report 1.5). | WDFW, Tribes | NMFS | Phase 1 | Completed as part of this initiative. |
| 2. Identify recovery thresholds. | Numerical recovery thresholds are to be determined in 2000. | WDFW, Tribes | NMFS | Phase 1 | Scheduled for completion in spring 2000. |
| ***Objective****:* Periodically evaluate summer chum population performance and provide effective management response to evaluation. | | | | | |
| 1. Annually review population performance and provide specified response. | Review entails comparing past year's estimates of run sizes or escapements (for the defined management units and stocks) with identified critical threshold values. If any estimates fall below critical thresholds or flags, the following responses are implemented: 1) identify and if appropriate implement appropriate emergency actions; 2) within 6 months, prepare assessment of causes of population decline and recommend modifications to plan to effect prompt restoration of management unit or stock to non-critical status. All potential factors for decline will be considered in assessment. | WDFW, Tribes | NMFS and other interested parties. | Phase 1 | Annual |
| 2. Review population performance every 5 years. | Five year review will include: 1) performance review of each element of plan relative to its specific existing and any subsequent newly defined standards, 2) cumulative and comprehensive review of annual population performances relative to critical thresholds, 3) refinement of recovery standards if sufficient information is available, and 4) preparation of recommendations pertaining to management objectives, strategies and actions including possible modification or termination of existing measures and addition of new ones. Management actions will be pursued based on recommendations. | WDFW, Tribes | NMFS and other interested parties. | Phase 1 | Every five years beginning 2004. |

# 4.3 Accomplishing Goals of Recovery Plan and Meeting ESA Objectives

The Summer Chum Salmon Conservation Initiative comprehensively addresses all factors affecting the decline of summer chum salmon in Hood Canal and Strait of Juan de Fuca. Specific actions and strategies are identified to protect and restore the populations and, because there is much to learn about summer chum and the effectiveness of management actions taken, adaptation based on knowledge gained is a part of the plan. Over time, learning as we go, the co-managers believe that recovery of the summer chum will be realized.

## 4.3.1 Achieving the Recovery Plan Goal

Recovery activities for Hood Canal and Strait of Juan de Fuca summer chum salmon were begun by the co-managers in 1992. The recovery goal was, and still is, to return summer chum salmon to full health and to allow future harvests. This goal is in some respects more rigorous than the requirements of ESA, since it goes beyond the singular need to secure summer chum populations from the risk of extinction. The plan goal statement is presented below and is discussed in the Foreword (page 2).

**The goal of the Summer Chum Salmon Conservation Initiative is:**

***To protect, restore and enhance the productivity, production and diversity of Hood Canal summer chum salmon and their ecosystems to provide surplus production sufficient to allow future directed and incidental harvests of summer chum salmon.***

The co-managers believe that there is a very high likelihood that this plan will accomplish the recovery of Hood Canal and Strait of Juan de Fuca summer chum stocks. The recovery objectives and actions identified for artificial production, ecological interactions, and harvest management will be immediately implemented by the co-managers (most are already underway). The implementation of strategies for habitat recovery is necessarily an activity that is longer term and will involve participants other than just the co-managers. The following elements of the plan will contribute to its ultimate success.

### 4.3.1.1 Artificial Production

The plan identified 16 individual summer chum stocks, seven of which have recently become extinct (Part One). The co-managers are committed to seeing that no additional extinctions occur. Annual assessments of individual stocks will determine levels of extinction risk, and if any stock is found to be at great risk, hatchery

***"The co-managers are committed to seeing that no additional extinctions occur."***

supplementation using local brood stock will be used to sustain and recover the stock. The hatchery supplementation techniques to be applied under this plan have been proven to be extremely successful for the Big/Little Quilcene and Snow/Salmon summer chum salmon stocks, and if needed can confidently be used in the future. In addition to the supplementation of at risk extant stocks, the plan provides for the staged reintroduction of summer chum salmon to streams where recent extinctions have occurred. Two such projects are currently underway, at Big Beef and Chimacum creeks, and the first three-year old spawners are expected back in 1999. These and future reintroductions will further reduce the overall extinction risk to summer chum salmon by increasing the number of independent populations.

### 4.3.1.2 Ecological Interactions

Two significant sources of negative competition and/or predation were identified in Part Two - Region-wide Factors For Decline, interactions with hatchery salmonids and predation on adult summer chum by marine mammals. The co-managers will institute rigorous criteria for the release of hatchery salmonids into the waters of the Hood Canal and Strait of Juan de Fuca regions. These criteria include time, size and species restrictions that are designed to greatly reduce potential negative impacts on summer chum salmon. The co-managers will monitor and evaluate risk aversion measures being implemented to meet these criteria. The plan recommends that the on-going studies of harbor seal predation on summer chum salmon continue, and recognizes that future remedial measures may be required if seal predation is shown to be affecting recovery.

> ***"The co-managers will institute rigorous criteria for the release of hatchery salmonids into the waters of the Hood Canal and Strait of Juan de Fuca regions."***

### 4.3.1.3 Habitat

Habitat degradation was identified as a major factor for decline (Part Two). Recovery of proper habitat quality and function is a long term effort. The habitat portion of the plan cannot be implemented by the co-managers, but rather is the responsibility of land and water management agencies, major land holders, and private citizens. The summer chum plan has identified watershed and estuarine limiting factors and measures for recovery, however, the identification of specific actions, prioritization, and implementation are a part of an on-going process to be completed by the jurisdictions actually controlling the habitat.

> ***"... the identification of specific actions, prioritization, and implementation are a part of an on-going process to be completed by the jurisdictions actually controlling the habitat".***

### 4.3.1.4 Harvest Management

The harvest of summer chum salmon in various terminal and pre-terminal fisheries was identified as one of the factors contributing to the decline of summer chum stocks. The co-managers will limit the incidental summer chum harvests in Washington terminal and pre-terminal fisheries to levels that will minimize impacts on summer chum stocks. Annual evaluation and adaptive management of the fisheries will assure that the numbers of summer chum salmon that are harvested incidentally to fisheries for other species remain at very low levels.

> ***"The co-managers will limit the incidental summer chum harvests in Washington terminal and pre-terminal fisheries to levels that will minimize impacts on summer chum stocks."***

### 4.3.1.5 Cumulative Effects of Recovery Actions

Taken together, the above described conservation and restoration activities will have a synergistic effect on the recovery of Hood Canal and Strait of Juan de Fuca summer chum stocks. In summary, the following results are expected. No further extinctions will occur. Re-introductions of summer chum to currently unpopulated streams will occur through time. The past negative consequences potentially resulting from hatchery fish interactions will be largely eliminated as a precautionary measure. The impacts of incidental fishery harvests on summer chum stocks will be minimized. Habitat, both freshwater and estuarine, will be gradually returned to a more productive state. Annual monitoring and evaluation and adaptive management will assure that recovery objectives are achieved. Ultimately, the combined effects of these actions will recover summer chum salmon.

## 4.3.2 Meeting ESA Objectives

In 1996, NMFS published a document titled "Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast". The purpose of this guidance was to identify the elements that would constitute a successful salmon recovery plan. NMFS described three major criteria to be met by a conservation plan (NMFS 1996a). One criterion is that the plan must have substance; that is, it includes measures that will effect recovery. Another criterion is that there must be certainty that the measures will be undertaken by the parties with the authority and means to implement recovery actions. The third criterion is for monitoring and assessment that will lead to effective adaptive management and help determine what recovery is and when it occurs. This initiative provides the basis for addressing all three criteria.. However, in order to meet the three criteria and succeed in recovering summer chum, the measures summarized in the following sections must be addressed by the indicated parties. As implementation of the below described strategies actions occur, the participants in recovery can learn from the experience, making adjustments as appropriate. Furthermore as information is gained, the conditions of recovery may be determined and ultimately recovery of the summer chum can be achieved.

The 1996 NMFS guidance document also presented nine critical and desirable elements that should constitute a salmon restoration strategy for an ESA listed Evolutionarily Significant Unit (ESU).

### 4.3.2.1 NMFS - Critical and Desirable Elements

#### Substance of the Plan

1. Identify at appropriate scales the major factors that have contributed to decline of the ESU.
2. Establish priorities for action.
3. Establish explicit objectives and timelines for correcting factors for decline and achieving desired population characteristics.
4. Establish quantifiable criteria and standards by which progress toward each objective will be measured.
5. Adopt measures (actions) needed to achieve the explicit objectives.

#### Implementation Certainty

6. Provide high levels of certainty that the identified measures and actions will be implemented, including necessary authorities, commitments, funding, staffing, and enforcement measures.

#### Monitoring

7. Establish a comprehensive monitoring and reporting program, including methods to measure whether objectives are being met, and to detect subpopulation declines and increases in each ESU.

#### Other

8. As much as possible, integrate Federal state, tribal, local, corporate, and non-governmental activities and projects that are designed to recover salmon populations and the habitats upon which they depend.
9. Utilize an adaptive management approach that actively shapes management actions to generate needed information.

### 4.3.2.2 NMFS Elements and the Summer Chum Plan

Those recovery actions that will be implemented by the co-managers are in the areas of artificial production, ecological interactions, and harvest management. Each of the NMFS recovery plan elements is discussed below in the context of the co-managers' responsibility and their implementation of recovery actions. Habitat recovery actions should also eventually be incorporated under the NMFS recovery plan elements but are not included in the following discussion because they fall primarily outside the co-managers' jurisdiction.

## Substance of the Plan

### Element 1) Identify at appropriate scales the major factors that have contributed to decline of the ESU.

Region-wide factors contributing to the observed summer chum salmon declines in Hood Canal and Strait of Juan de Fuca were identified in Part Two - Region-wide Factors For Decline of this recovery plan. Major factors for decline for Hood Canal stocks were habitat deterioration and terminal area fishery harvest, and moderate impacts resulted from climate effects on stream flow, interactions with hatchery salmonids, and pre-terminal harvests. Strait of Juan de Fuca summer chum stocks experienced major cumulative habitat impacts and climate effects on stream flow, along with moderate impacts from pre-terminal harvest. The recent expansion of harbor seal populations and their predation on summer chum was identified as a recent major factor that may affect recovery.

Limiting factors for summer chum salmon at the stock, watershed, and management unit levels are assessed in Part Three - Evaluation and Mitigation of Factors for Decline, which identifies specific limiting factors and also provides specific strategies and actions for recovery.

### Element 2) Establish priorities for action.

For those management actions that are the responsibility of the co-managers (including artificial production, ecological interactions, and harvest management) , the recovery plan has adopted a single priority: **immediate action**. In fact, substantial co-manager actions in these areas have been underway since 1992, and have resulted in increased summer chum salmon runsizes and escapements in recent years (see discussions in Parts One and Three).

### Element 3) Establish explicit objectives and timelines for correcting factors for decline and achieving desired population characteristics.

Specific objectives are identified in detail in the artificial production, ecological interactions, and harvest management discussions in Part Three, and are summarized above in section 4.2. Each objective has one or more specific actions that address recovery needs. Specific timelines are not identified for the various objectives and actions because immediate implementation is the co-manager intent (see Element 2 above). In some situations, future actions may be instituted based on currently unforeseeable circumstances, e.g. supplementation of a stock that declines to a point of extinction risk, or an opportunity for reintroduction to a former summer chum stream. Adaptive management is also a major feature of the plan (see Element 9 below), however, since, changes in management will be in response to future events and results, no timelines can be established.

### Element 4) Establish quantifiable criteria and standards by which progress toward each objective will be measured.

Very specific and quantifiable criteria and standards for management and implementation of recovery objectives are presented in the individual sections of Part Three, and are summarized below. Some examples of specific criteria include; brood stock collection criteria to avoid loss of genetic variability, time and size at release criteria for hatchery salmon to avoid competition and predation effects on summer chum, and exploitation rate criteria to minimize fishery impacts. In addition, the plan contains three approaches for evaluating the abundance, distribution, and extinction risk for summer chum stocks.

**Element 5) Adopt measures (actions) needed to achieve the explicit objectives.**

Individual action items (relating to specific objectives) are presented in the artificial production, ecological interactions, and harvest management sections of Part Three, and are summarized above (section 4.2). Many of the actions have been previously implemented and will be continued, while others represent new recovery activities.

## Implementation Certainty

**Element 6) Provide high levels of certainty that the identified measures and actions will be implemented, including necessary authorities, commitments, funding, staffing, and enforcement measures.**

The co-managers are the lawfully designated agencies (under US v. Washington and State statutes) with the responsibility for managing summer chum salmon. Co-manager recovery activities have been underway since 1992, and as a result, many of the objectives of this plan have been included in the normal operation of WDFW and the Tribes. Management biologists, hatchery personnel and facilities, and enforcement officers are routinely assigned to the activities affecting summer chum salmon. The co-mangers feel that current dedicated levels of funding and staffing are minimally acceptable to effect summer chum salmon recovery. However, additional activities are identified in the plan, the funding and implementation of which, will improve summer chum salmon management and likely speed recovery. Important new measures include support of supplementation and reintroduction projects, collection of information on productive capacity and recovery levels, and the monitoring and evaluation of recovery actions.

## Monitoring

**Element 7) Establish a comprehensive monitoring and reporting program, including methods to measure whether objectives are being met, and to detect subpopulation declines and increases in each ESU.**

The co-managers have a number of long term monitoring programs in place that are adequate to measure general population responses to recovery efforts. These include spawner escapement monitoring, harvest accounting, run size estimation procedures, and hatchery release accounting. The plan identifies specific ways that these existing programs can be improved. In addition, needed new monitoring and evaluation action items are identified in Part Three (and see above summary in section 4.2.5). Some examples are; collection of comprehensive age data for use in determining production rates for summer chum stocks, genetic stock identification in fisheries to help minimize selective impacts, evaluation of the success of supplementation programs, and monitoring of straying of supplemented stocks. While the existing co-manager monitoring and evaluation programs are sufficient to achieve the long range recovery goals of this plan, the recommended new monitoring efforts will allow more protective and directed recovery approaches and will ultimately speed recovery.

### Other

**Element 8) As much as possible, integrate Federal state, tribal, local, corporate, and non-governmental activities and projects that are designed to recover salmon populations and the habitats upon which they depend.**

This recovery plan is the combined effort of technical staff members representing the co-managers (WDFW and The Point-No-Point Treaty Tribes), and representatives of NMFS and USFWS. Additionally, private citizen salmon enhancement groups were provided opportunities to meet with the co-managers and to offer comments on plan elements affecting their projects. As the plan proceeds, there will be opportunities for general public comment on all parts of the recovery effort.

**Element 9) Utilize an adaptive management approach that actively shapes management actions to generate needed information.**

Adaptive management is a critical element of the recovery plan for summer chum salmon. Annual and longer term evaluations of the abundance, distribution, and extinction risk of summer chum stocks will guide the future application of the recovery activities under this plan. At the same time, monitoring and evaluation programs will evaluate the effectiveness of individual recovery efforts like supplementation and reintroduction, fishery impacts, and seal predation. These evaluation and adaptive management approaches are described in Part One, 1.7 Stock Evaluations, and in Part Three, 3.6 Program Integration and Adaptive Management (see also summary in section 4.2.6 below).

## 4.4 Population-based Recovery Goals

The following sections describe how the overall goal to protect and restore summer chum is to be achieved and summarize measures to be taken to meet that goal. However, specific quantitative, population-based recovery goals are also needed that determine when recovery has been achieved. These goals must account for the condition and dynamics of the summer chum populations and should define recovery in terms of population abundance, productivity and diversity. For a given population, management unit or all of the summer chum to be recovered, goals specified as levels or ranges of summer chum abundance (run size) and escapement must be specified, consistent with the productive capacity of the habitat. Lacking adequate information on the relationship of habitat to productive capacity, historical experience with populations may initially serve to set the abundance and escapement recovery goals.

But in addition to defining abundance and escapement recovery goals, it is critical to determine productivity goals; that is, target production rates or ranges of rates. Productivity can be thought of as a rate of survival; that is, the number of salmon produced for each parent spawner that survive over a given life stage or range of life stages. Productivity may be measured, for example, over the entire life cycle as the number of recruits per spawner. Productivity determines the amount of harvest a given population can support and it determines the resiliency of that population; that is, it's ability to recover and to sustain itself under a range of environmental conditions. For a population to be considered recovered, it should demonstrate adequate productivity for sustainability and harvest, as defined by the productivity recovery goals.

Finally, population-based recovery goals must include diversity. This set of goals should include maintaining the geographic range and variable life histories expressed by the populations of summer chum. To a large extent this consideration is already addressed in this recovery plan with the focus first on protecting and restoring existing populations, but also on restoring summer chum to watersheds where they are now extinct.

The co-managers have defined performance standards upon which to measure the progress of the summer chum salmon populations towards achieving recovery (see section 3.6.4). In addition, the co-managers are developing a comprehensive set of population-based recovery goals, addressing abundance, productivity and diversity as described above. These recovery goals are scheduled for completion in spring 2000 and will be made available in a supplement to this recovery plan (see section 4.6, Plan Supplements).

## 4.5 Plan Implementation

The above summary descriptions of objectives, strategies and actions for summer chum protection and recovery include listings of the participants with the authority or jurisdiction to pursue specific actions or strategies and also listings of other participants who can provide support as partners. The fisheries co-managers, Washington Department of Fish and Wildlife and Point No Point Treaty Tribes, are committed to carrying out the provisions of the plan for which they have the authority (measures addressing harvest management, artificial production and ecological interactions) and to supporting other parties who pursue recommendations of the plan for which they have jurisdiction or authority (e.g., counties in their efforts to address habitat protection and recovery measures). The co-managers have, in fact, since 1992 been implementing many of the actions specified in this initiative. The process of developing the initiative has confirmed and refined many of the co-managers' existing management measures and led to the development and immediate implementation of others. The co-managers intend to file this initiative with the federal court to be adopted as a court order under U.S. v Washington.

The preparers of this plan have attempted to develop a comprehensive document that addresses all the components for protection and recovery of summer chum and provides a scientific basis for recommending actions/strategies. However, particularly with respect to summer chum habitat, this plan is only the first step to a larger planning and implementation effort that must continue if recovery of the summer chum is to succeed. Counties and other agencies, who have not participated in the development of this plan but have provided review comments during its development, are encouraged to address the recommended strategies and actions that fall under their jurisdiction or authority. This will lead to additional planning, that will result in definition and execution of specific protection and recovery actions. The support of landowners, private non-profit organizations, volunteer groups and local citizens is also important if these efforts are to succeed.. The co-managers will offer technical support in how to interpret and apply the recommendations of this plan.

The basic requirements for the harvest management, artificial production and ecological interaction components of the plan are currently being met by resources and funding available to WDFW, the Tribes and USFWS. These include: 1) the annual planning, regulation, monitoring and enforcement of fisheries and also, monitoring of harvests and escapements; 2) the operation, basic assessments and monitoring of supplementation and reintroduction projects; and 3) all of the mitigative measures to prevent or reduce ecological impacts on summer chum from potential hatchery-caused ecological interactions. All of these currently supported actions/strategies are categorized in the tables above as Phase 1, meaning that funding and resources to execute the measures are presently in place. There are, however, several actions under jurisdiction of the fisheries co-managers that are categorized as Phase 2 or a combination of Phases 1 and 2, meaning the actions are not funded or could be improved with additional funding. Development of the needed support of these actions is strongly recommended to speed recovery. Still, given the existing available resources and funding, the co-managers' believe the summer chum conservation requirements under their jurisdiction are being met.

Many of the recommended habitat-related strategies and actions are not currently funded (Phase 2 in Tables 4.4 and 4.5). As previously noted, additional participation in planning is expected to result in the specification of habitat protection and restoration measures for which funding will need to be found. On-going and new funding sources through the county, state and federal governments as well as voluntary participation by citizens, landowners and others can help to meet the requirements for funding and implementation of these measures.

It is expected that the measures identified in this plan and that are subsequently developed based on recommendations of the plan will be incorporated into the ESA permitting process. That process has been in development in the same time frame as this plan. There may be a need to adapt or modify measures within the plan in response to the permitting requirements (i.e., under ESA sections 4 (d), 7 or 10).

## 4.6 Plan Supplements

Two additional reports have been published to provide supporting information for this initiative: Supplemental Report No.1 - Revised Estimates of Escapement of Hood Canal and Strait of Juan de Fuca Natural Spawning Summer Chum Populations (Haymes 2000), and Supplemental Report No.2- Public Review Comments on Draft Habitat Sections of the Summer Chum Salmon Conservation Initiative (PNPTT and WDFW 2000). The first supplement provides a detailed description of results from an intensive review of the escapement data, including revised estimates of annual summer chum salmon escapements and ratings of the quality of the estimates. Supplemental Report No.2 is a compilation of all written comments received from distribution of a draft of the habitat element of the initiative (section 3.4) in March, 1999. Additional supplemental reports to the initiative will prepared in the course of its implementation. A third supplement describing population-based summer chum salmon recovery goals is scheduled for completion in spring 2000. Later this year, another supplement comprising the results of the first annual plan review will also be made available.

# References

Allen, B. 1974. Early marine life history of Big Qualicum River chum salmon, p 137-148. *In* Harding, D.R. (ed.) Proceedings of the 1974 northeast Pacific pink and chum salmon workshop. Dept. of Environment and Fisheries, Vancouver, B.C.

Allendorf, F.W. and N. Ryman. 1987. Genetic management of hatchery stocks, p. 141-159. *In* Population genetics & fishery management. Edited by N. Ryman and F. Utter. Univ. of Wash. Press, Seattle, WA.

Allendorf, F.W., D. Bayles, D.L. Bottom, K.P. Currens, C.A. Frissell, D. Hankin, J.A. Lichatowich, W. Nehlsen, P.C. Trotter, and T.H. Williams. 1997. Prioritizing Pacific salmon stocks for conservation. Conservation Biology 11.1:140-152.

Ames, J. 1983. Salmon stock interactions in Puget Sound: a preliminary look. *In* M.A. Miller (ed.), Southeast Alaska coho salmon research and management review and planning workshop, 18-19 May 1982. Alaska Dept. Fish and Game, Juneau, AK. 109 p.

Ames, J. 1984. Puget Sound chum salmon escapement estimates using spawner curve methodology, p. 135-148. *In* Symons, P.E.K. and M. Waldichuk (eds.), Proc. of the Workshop on Stream Indexing for Salmon Escapement Estimation, West Vancouver, B.C., 2-3 February 1984. Can. Fish. Aquat. Sci. Tech. Rpt. no. 1326.

Ames, J., and H. Beecher. 1995. Recommended spawning flows for Cedar River sockeye salmon: with a review of spawning distribution and flood risk studies - Rpt. to Cedar River In-stream Flow Committee. Wash. Dept. Fish and Wild., Olympia, WA. 108 p.

Ames, J. 1997. Status summary - Hood Canal and Strait of Juan de Fuca summer chum - Report to the Joint Natural Resources Cabinet. October, 1997. Wash. Dept. Fish and Wild., Olympia, WA. 7 p.

Ashcraft, W. 1982. WDFW memorandum October 21, 1982 (subject: Loading rate guidelines for hauling fish). Wash. Dept. Fish and Wild., Olympia, WA. 2 p.

Bakkala, R.G. 1970. Synopsis of biological data on the chum salmon, *Oncorhynchus keta* Walbaum 1792. FAO species synop. No. 41, U.S. Fish. Wild. Serv. circ. 315. 89 p.

Bams, R.A., and C.N.H. Lam. 1983. Influences of deteriorating water quality on growth and development of chum salmon (*Oncorhynchus keta*) larvae in a Japanese style keeper channel. Can. J. Fish. Aquat. Sci. 40:2098-2104.

Bax, N.J., E.O. Salo, B.P. Snyder, C.A. Simenstad, and W.J. Kinney. 1978. Salmonid out-migration studies in Hood Canal (final rpt., phase III, Jan.-July 1977). UW Fish. Res. Inst. rpt. FRI-UW-7819, Univ. of Wash., Seattle, WA. 128 p.

Bax, N.J., E.O. Salo and B.P. Snyder. 1979. Salmonid out-migration studies in Hood Canal (final rpt., phase IV, Jan.-July 1978). UW Fish. Res. Inst. rpt. FRI-UW-7921. 89 p.

Bax, N.J., E.O. Salo, and B.P. Snyder. 1980. Salmonid out-migration studies in Hood Canal (final rpt., phase V, Jan.-July 1979). UW Fish. Res. Inst. rpt. FRI-UW-8010, Univ. of Wash., Seattle, WA. 55 p.

Bax, N.J. and C.J. Whitmus. 1981. Early marine survival and migratory behavior of juvenile chum salmon released from the Enetai Hatchery, Washington in 1980. UW Fish. Res. Inst. rpt. FRI-UW-8109, Univ. of Wash., Seattle, WA. 48 p.

Bax, N.J. 1982. Seasonal and annual variations in the movement of juvenile chum salmon through Hood Canal, Washington, p. 208-218. *In* Brannon, E. L. and E. O. Salo (eds.) Proceedings of the Salmon and Trout Migratory Behavior Symposium. School of Fisheries, Univ. of Wash, Seattle WA.

Bax, N.J. 1983. The early migration of juvenile chum salmon (*Oncorhynchus keta*) through Hood Canal - its variability and consequences. Ph.D. Dissertation, Univ. of Wash, Seattle, WA. 196 p.

Beamer, E.M., and R.G. LaRock. 1998. Fish use and water quality associated with a levee crossing the tidally influenced portion of Browns Slough, Skagit River Estuary, Washington. A report prepared for Skagit County Diking District No. 22. Skagit System Cooperative, La Conner, WA.

Beamish, R.J., and D.R. Bouillon. 1993. Pacific salmon production trends in relation to climate. Can. J. Fish. Aquat. Sci. 50:1002-1016.

Beamish, R.J., C.M. Neville, and A.J. Cass. 1997. Production of Fraser River sockeye salmon (*Oncorhynchus nerka*) in relation to decadal-scale changes in the climate and the ocean. Can. J. Fish. Aquat. Sci. 54:543-554.

Berejikian, B.A. 1995. The effects of hatchery and wild ancestry and experience on the relative ability of steelhead trout fry (*Oncorhynchus mykiss*) to avoid a benthic predator. Can. J. Fish. Aquat. Sci. 52:2476-2482.

Beschta, R.L., R.E. Bilby, G.W. Brown, L.B. Holtby, and T.D. Hofstra. 1987. Stream temperature and aquatic habitat: fisheries and forestry interactions, p. 191-232. *In* Salo, E.O., and T.W. Cundy (eds.) Streamside management: forestry and fishery interactions. College Of Forest Research, Univ. of Wash., Seattle, WA.

Beschta, R.L., J.R. Boyle, C.C. Chambers, W.P. Gibson, S.V. Gregory, J. Grizzel, J.C. Hagar, J.L. Li, W.C. McComb, M.L. Reiter, G.H. Taylor, and J.E. Warila. 1995. Cumulative effects of forest practices in Oregon. Prepared for Oregon Dept of Forestry *by* Ore. State Univ., Corvallis, OR.

Bilby, R.E. 1984. Removal of woody debris may affect stream channel stability. J. of Forestry 82:609-613.

Bilby, R.E., and J.W. Ward, 1989. Changes in characteristics and function of large woody debris with increasing size of streams in western Washington. Trans. Amer. Fish. Soc. 118:368-378.

Bisson, P.A., R.E. Bilby, M.D. Bryant, C.A. Dolloff, G.B. Grette, R.A. House, M.L. Murphy, K.V. Koski, and J.R. Sedell. 1987. Large woody debris in forested streams in the Pacific Northwest: past, present, and future, p. 143-190. *In* Salo, E.O., and T.W. Cundy (eds.). Stream management : forestry and fishery interactions. Contribution no. 57, Institute of Forest Resources, Univ. of Wash., Seattle, WA.

Bjornn, T.C., and D.W. Reiser. 1991. Habitat requirements of salmonids in streams, p. 83-138. *In* Meehan, W.R. (ed.) Influences of forest and rangeland management on salmonid fishes and their habitats. Special Publication 19, Amer. Fish. Soc.

Booth, D.B., and C.J. Jackson. 1997. Urbanization of aquatic systems – degradation thresholds, stormwater detention, and the limits of mitigation. Water Resources Bulletin 33:1077-1090.

Bouchard, R., and D. Kennedy. 1997. A review and evaluation of Twana ethnographic sites on the North Fork Skokomish River. Tacoma Public Utilities, Tacoma, WA.

Brodeur, R.D. 1991. Ontogenetic variations in the type and size of prey consumed by juvenile coho, *Oncorhynchus kisutch*, and chinook, *O. tshawytscha*, salmon. Environ. Biol. Fishes 30:303-315.

Brock, V.E., and R.H. Riffenburgh. 1960. Fish schooling: a possible factor in reducing predation. J. Cons. Int. Explor. Mer. 25:307-217.

Brosofske, K.D., J. Chen, R.J. Naiman, and J.F. Franklin. 1997. Effects of harvest on microclimate from small streams to uplands in western Washington. Ecological Applications 7:1188-1200.

Busack, C.A. and K.P. Currens. 1995. Genetic risks in hatchery operations: fundamental concepts and issues, p 71-80. *In* Schramm, H.L. Jr., and R.G. Piper (eds.) Uses and effects of cultured fishes in aquatic ecosystems, Amer. Fish. Soc. Symp. 15.

Busack, C., B. Watson, T. Pearsons, C. Knudsen, S. Phelps, and M. Johnston. 1997. Yakima fisheries project spring chinook supplementation plan. 185 p.

Cardwell, R.D., and K.L. Fresh. 1979. Predation upon juvenile salmon (draft technical paper, September 13, 1979). Wash. Dept. Fish and Wild., Olympia, WA. 19 p.

Cavalli-Sforza, L. L., and A. W. F. Edwards. 1967. Phylogenetic analysis: Models and estimation procedures. Evolution 21: 550-570.

Cederholm, C.J. 1972. The short-term physical and biological effects of stream channelization at Big Beef Creek, Kitsap County, Washington. M.S. Thesis, Univ. of Wash., Seattle, WA.

Chamberlin, T.W., R.D. Harr, and F.H. Everest, 1991. Timber harvesting, silviculture, and watershed processes, p. 181-205. *In* Meehan, W.R. (ed.) Influences of forest and rangeland management on salmonid fishes and their habitats. Special Publication 19, Amer. Fish. Soc.

Chapman, D.W. 1988. Critical review of variables used to define effects of fines in redds of large salmonids. Trans. A. Fish Soc. 117:1-21.

Cook-Tabor, C.K. 1994. Summer chum salmon in Hood Canal. U.S. Dept. of the Inter., Fish and Wild. Serv., Lacey, WA. 52 p.

Crawford, B.A. 1997. Letter to M. Schiewe, dated April 25, 1997 (subject: Response to partial draft of NMFS review of the status of chum salmon). Wash. Dept. Fish and Wild., Olympia, WA. 62 p. + attachments

Cuenco, M.L., T.W.H. Backman, and P.R. Mundy. 1993. The use of supplementation to aid in natural stock restoration, p. 269-293. *In* J.G. Cloud and G.H. Thorgaard (eds.) Genetic Conservation of Salmonid Fishes. Proceedings of a NATO Advanced Study Institute, Plenum Press, New York, NY.

Cuenco, M.L. 1994. A model of an internally supplemented population. Trans. Amer. Fish. Soc. 123:277-288.

Dawe, G. (No year cited). The classification and description of predator attack marks in juvenile pink salmon (*Oncorhynchus gorbuscha*). Canadian Department of Fisheries and Oceans. Unpublished.

Day, D., W. Palsson, K. Hoeman, and G. Bargmann. 1995. Puget Sound bottomfish status of stocks report (Draft # 1). Wash. Dept. Fish and Wild. Olympia, WA. 171 p.

Desbonnet, A. L., P. Pogue, D. Reis, J. Boyd, J. Wills, M. Imperial. 1995. Development of coastal vegetated buffer programs. Coastal Management 23: 91-109.

Dolloff, C.D. 1986. Effects of stream cleaning on juvenile coho salmon and dolly varden in southeast Alaska. Trans. Amer. Fish. Soc. 115:743-755.

Eames, J. M., T. J. Quinn II, and M. Hino. 1983. 1977 Northern Puget Sound adult coho and chum tagging studies. Wash. Dept. Fish and Wild., Olympia, WA. 239 p.

Ebbesmeyer C.C., C.A. Coomes, G.A. Cannon, and D.E. Bretschneider. 1989. Linkage of ocean and fjord dynamics at decadal period. American Geophys. Union Geophys. Monogr. 55:399-417.

Egan, R. 1978. Salmon spawning ground data report. WDF prog. report No. 51. Wash. State Dept. Fish. and Wild., Olympia, WA. 484 p.

Emlen, J.M. 1995. Population viability of the Snake River chinook salmon. Can. J. Fish. Aquat. Sci. 52:1442-1448.

Emmett, R.L., S.L. Stone, S.A. Hinton, and M.E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in west coast estuaries, Volume II: species life history summaries. ELMR Rep. No. 8, NOAA/NOS Strategic Environ. Assessments Div., Rockville, MD. 329 p.

Emmett, R.L., and M.H. Schiewe. 1997. Estuarine and ocean survival of northeastern Pacific salmon: Proceedings of the workshop. NOAA tech. memo. no. NMFS-NWFSC-29, NMFS NW Sci. Center, U.S. Dept. Commer. Nat. Marine Fish. Serv., Seattle, WA. 313 p.

Evans, W.A., and B. Johnson. 1980. Fish migration and fish passage: a practical guide to solving fish passage problems. USFS rpt. no. EM-7100-2. U.S. Dept. of Ag., Forest Service, Wash. D.C.

FAO-UN (Food and Agriculture Organization of the United Nations). 1981. Conservation of the genetic resources of fish: problems and recommendations. Report of the Expert Consultation on the Genetic Resources of Fish, Rome, Italy, 9-13 June 1980. FAO Fisheries Technical Paper 217. 43 p.

FEMAT (Forest Ecosystem Management Team). 1993. Forest Ecosystem Management: an ecological, economic, and social assessment. Report of the Forest Ecosystem Management Team, U.S. Government Printing Office 1993-783-071. U.S. Government Printing Office for the U.S. Dept. of Agri., Forest Serv.; U.S. Dept. of the Inter., Fish and Wild. Serv., Bureau of Land Mgt., and Nat. Park Serv.; U.S. Dept. of Comm., Nat. Ocean. and Atmospheric Admin. and Nat. Mar. Fish. Serv.; and U.S. Envir. Prot. Ag.

Feller, R.J. 1974. Trophic analysis of juvenile chum and pink salmon from Puget Sound, 1970-72. Pp. 149-160 *in* Harding, D.R. (ed.) Proceedings of the 1974 northeast Pacific pink and chum salmon workshop. Dep. Of Env. Fish, Vancouver, B.C.

FERC (Federal Energy Regulatory Commission). 1996. Final Environmental Impact Statement, Cushman Hydroelectric Project (FERC Project No. 460), Washington. FERC/EIS-0095F, Washington DC.

Fiscus, G. 1969. 1968 Admiralty Inlet chum salmon tagging. Pp. 12-19 *in* 1968 WDF Annual Report, Wash. State Dept. Fish., Olympia, WA.

Francis, R.C. and S.R. Hare. 1997. Regime scale climate forcing of salmon populations in the northeast Pacific - some new thoughts and findings, p. 113-128. *In* Emmett, R. L., and M. H. Schiewe (eds.) Estuarine and ocean survival of northeastern Pacific salmon: Proceedings of the workshop. NOAA tech. memo. no. NMFS-NWFSC-29, NMFS NW Sci. Center, U.S. Dept. Commer. Nat. Marine Fish. Serv., Seattle, WA.

Fresh, K.L., D. Rabin, C.A. Simenstad, E.O. Salo, K. Garrison and L. Matheson. 1979. Fish Ecology studies in the Nisqually Reach area of southern Puget Sound, Washington (final rpt., March 1977-Aug. 1978). Univ. Washington, Fish. Res. Inst. Final Rep. FRI-UW-7904. 229 p.

Fresh, K.L., R.D. Cardwell, B.P. Snyder, and E.O. Salo. 1980. Some hatchery strategies for reducing predation upon juvenile chum salmon (Oncorhynchus keta) in freshwater, p. 79-89. *In* Proceedings of the North Pacific Aquiculture Symposium. Alaska Dept. Fish and Game. Anchorage, Alaska.

Fresh, K.L. (ed.). 1984. Evaluation of potential species interaction effects in the planning and selection of salmonid enhancement projects (unpublished). Species Interaction Workgroup (SWIG) of the Enhancement Planning Team. Wash. Dept. of Fish and Wild., and Northwest Indian Fish. Comm., Olympia, WA.

Fresh, K.L., and S.L. Schroder. 1987. Influence of the abundance, size, and yolk reserves of juvenile chum salmon (*Oncorhynchus keta*) on predation by freshwater fishes in a coastal stream. Can. J. Fish. Aquat. Sci. 44(2): 236-243.

Fresh, K. L. 1997. The role of competition and predation in the decline of Pacific salmon and steelhead, p. 245-275. *In* Stouder, D. J., P. A. Bisson, and R. J. Naiman (eds.) Pacific Salmon and Their Ecosystems: Status and Future Options, Chapman and Hall, New York City, NY.

Furniss, M.J., T.D. Roelofs, and C.S. Yee. 1991. Road construction and maintenance, p. 297-324. *In* Meehan, W.R. (ed.) Influences of forest and rangeland management on salmonid fishes and their habitats. Special Publication 19, Amer. Fish. Soc.

Fuss, H.J. and C.W. Hopley. 1991. Survival, marine distribution, and age at maturity of Hood Canal hatchery chum, p. 9-16. *In* B. White and I. Guthrie (eds.) Proceedings of the 15th Northeast Pacific Pink and Chum Salmon Workshop. Pacific Salmon Comm., and Can. Dept. Fish and Oceans, Vancouver, B.C.

Fuss, H.J. 1997a. Can hatchery-origin salmonids establish naturally reproducing populations? - WDFW technical report. Wash. Dept. Fish and Wild., Olympia, WA. 25 p.

Fuss, H.J. 1997b. Length-weight relationship for juvenile chum salmon (table). Wash. Dept. Fish and Wild., Olympia, WA. 1 p.

Gallagher, A.F. 1979. An analysis of factors affecting brood year returns in the wild stocks of Puget Sound chum (Oncorhynchus keta) and pink salmon (Oncorhynchus gorbuscha). M.S. thesis, Univ. of Wash., Seattle, WA. 152 p.

Gerke, R.J., and V. W. Kaczynski. 1972. Food of juvenile pink and chum salmon in Puget Sound, Washington - WDF tech. rpt. 10. Wash. Dept. Fish and Wild., Olympia, WA. 27 p.

Hager, B. 1980. History of chum salmon rearing in Washington state, p. 108-118. *In* Kingsbury, A.P. (ed.) Proceedings of the 1980 Northeast Pacific Pink and Chum Salmon Workshop. Sitka, Alaska. Alaska Dept. Fish and Game, Juneau, AK.

Hamma Hamma Supplementation Subcommittee. 1997. Hamma Hamma River summer chum salmon supplementation program - HCSEG, LLTK, PNPTC, Skokomish Tribe Dept. Nat. Res., USFWS, and WDFW. Wash. Dept. Fish and Wild. Olympia, WA. 12 p.

Hard, J.J., R.P. Jones, Jr., M.R. Delarm, and R.S. Waples. 1992. Pacific salmon and artificial propagation under the Endangered Species Act. NOAA tech. memo NMFS-NWFSC-2, U.S. Dept. Comm., NOAA, NMFS NW Sci. Center, Seattle, WA. 56 p.

Hargreaves, N.B. and R.J. LaBrasseur. 1985. Species selective predation on juvenile pink (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) by coho salmon (*O. kisutch*). Can. J. Fish. Aquat. Sci. 42:659-668.

Hargreaves, N.B. and R.J. LaBrasseur. 1986. Size selectivity of coho (*Oncorhynchus kisutch*) preying on juvenile chum salmon (*O. keta*). Can. J. Fish. Aquat. Sci. 43:581-586.

Hastein, T. and T. Lindstad. 1991. Diseases in wild and cultured salmon: possible interaction. Aquaculture, 98: 277-288.

Hawkins, S. W. and J. M. Tipping. *In press*. Predation by juvenile hatchery salmonids on wild fall chinook salmon fry in the Lewis River, Washington. California Fish and Game Dept., Sacramento, CA.

Haymes, J. H. 2000. Revised estimates of escapement of Hood Canal and Strait of Juan de Fuca natural spawning summer chum populations. Supplemental Report No. 1 to the Summer Chum Salmon Conservation Initiative. Wash. Dept. Fish and Wild., Olympia, WA.

HCSMP (Hood Canal Salmon Management Plan). 1986. United States v. Washington, No. 9213. Sub-proceeding No. 83-8. 26 p.

Henegar, O.L., and K.W. Harmon. 1971. A review of references to channelization and its environmental impact. Pages 79-83 *in* Stream channelization. Amer. Fish. Soc., Bethesda, MD.

Hillman, T.W. and J.W. Mullan. 1989. Effect of hatchery releases on the abundance of wild juvenile salmonids, p. 265-285. *In* Summer and Winter Ecology of Juvenile Chinook Salmon and Steelhead Trout in the Wenatchee River, Washington - Report to Chelan County PUD. D.W. Chapman Consultants, Inc., Boise, ID.

Hirschi, R., and M. Reed. 1998. Salmon and trout life history study in the Dungeness River. Jamestown S'Klallam Tribe, Blyn, WA.

Hoar, W.S. 1951. The behavior of chum, pink, and coho salmon in relation to their seaward migration. J. Fish Res. Bd. 8:241-263.

Hodges, J.I., J.G. King, B. Conant and H.A. Hanson. 1996. Aerial surveys of waterbirds in Alaska 1957-94: population trends and observer variability. Information and Technology Report 4, U.S. Dept. of Inter., National Biological Service.

Holtby, L.B., T.E. McMahon, and J.C. Scrivener. 1989. Stream temperatures and inter-annual variability in the emigration timing of coho salmon (Oncorhynchus kisutch) smolts and fry and chum salmon (*O. keta*) fry from Carnation Creek, British Columbia. Can. J. Fish. Aquat. Sci. 46:1396-1405.

Holtz, T., T. Liptan, and T. Schueler. 1998. Beyond innovative development: site design techniques to minimize impacts to salmon habitat. Presentations at the Salmon in the City Conference, Mt. Vernon, WA.

Horner, R.R. and C.W. May. 1998. Watershed urbanization and the decline of salmon in Puget Sound Streams. Presentation at the Salmon in the City conference, Mount Vernon, WA.

Hunter, J.G. 1959. Survival and production of pink and chum salmon in a coastal stream. J. Fish. Reserve Bd. Can. 16:835-886.

Iwata, M. 1982. Transition of fry into saltwater, p. 204-207. *In* Brannon, E.L. (ed.) Proceedings of the salmon and trout migratory behavior symposium. School of Fisheries, Univ. of Wash., Seattle, WA.

Jeffries, S.J., J.M. London, and M.L. Wilson. 1999. Estimates of harbor seal predation on selected Hood Canal salmon run for fall 1998 (Annual prog. rpt.). Wash. Dept. Fish and Wild., Olympia, WA. 33 p.

Juanes, F. 1994. What determines prey size selectivity in piscivorous fishes?, p. 79-100. *In* Stouder, D.J, K.L. Fresh, R.J. Feller (eds.) Theory and Application in Fish Feeding Ecology. Univ. of South Carolina Press, Columbia, SC.

Johnson, O.W., W.S. Grant, R.G. Kope, K. Neely, F.W. Waknitz, and R.S. Waples. 1997. Status review of chum salmon from Washington, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-32, NMFS NW Sci. Center, U.S. Dept. Commer. Nat. Marine Fish. Serv., Seattle, WA. 280 p.

Kaeriyama, M. 1989. Aspects of salmon ranching in Japan, Kawanabe, H., F. Yamazaki, and D.L.G. Noakes (eds.). Physiology and Ecology Japan, spec., Vol. 1. Hokkaido Univ., Sapporo, Japan. *In* Proceedings of the International Symposium on Chars and Masu Salmon, Oct. 1988.

Kaczynski, V., and J. Plamisano. 1992. A review of management and environmental factors responsible for the decline and lack of recovery of Oregon's wild anadromous salmonids. Report to Oregon Forest Industries Council, Salem, OR. 292 p.

Kapuscinski, A. R., and L.M. Miller. 1993. Genetic guidelines for the Yakima/Klickitat fisheries project. Co-Aqua consultants, St. Paul, MN. 66 p.

Kendra, W. 1991. Quality of salmonid hatchery effluents during a summer low-flow season. Trans. Amer. Fish. Soc. 120:43-51.

King County. 1989. Bear Creek basin current and future conditions analysis. Dept. of Public Works, Surface Water Management Division, Seattle, WA.

Koski, K.V. 1975. The survival and fitness of two stocks of chum salmon (*Oncorhynchus keta*) from egg deposition to emergence in a controlled stream environment at Big Beef Creek. Ph.D. thesis, Univ. of Wash., Seattle. 212 p.

Koski, K.V. 1981. The survival and quality of two stocks of chum salmon (*Oncorhynchus keta*) from egg deposition to emergence in a controlled stream environment at Big Beef Creek, p. 330-333. *In* Lasker, R., and K. Sherman (eds.) The early life history of fish: recent studies. Rapp. P.-v Reun. Cons. Int. Explor. Mer. 178 p.

Lampsakis, N. 1994. Memorandum (subject: chum entry pattern data) to Tim Tynan, WDFW, and Keith Lutz, NWIFC. Point No Point Treaty Council, Kingston, WA. 25 p.

LeClair, L.L. 1995. Memorandum (subject: 1995 Area 20 chum by-catch) to Tim Tynan, WDFW. Wash. Dept. Fish and Wild., Olympia, WA.

LeClair, L.L. 1996. Memorandum (subject: 1996 Area 20 chum by-catch) to Tim Tynan, WDFW. Wash. Dept. Fish and Wild., Olympia, WA.

Lee, D.C., and B.E. Rieman. 1997. Population viability assessment of salmonids by using probabilistic networks. North Amer J. Fish. Mgt. 17:1144-1157.

Lemberg N.A., M.F. O'Toole, D.E. Pentilla, and K.C. Stick. 1997. 1996 forage fish stock status report. WDFW rpt. no. 98-1. Wash. Dept. Fish and Wild., Olympia, WA. 83 p.

Levings, C.D. 1980. Consequences of training walls and jetties for aquatic habitats at two British Columbia estuaries. Coastal Engineering 4:111-136.

Levy, D.A., and T.G. Northcote. 1981. The distribution and abundance of juvenile salmon in marsh habitats of the Fraser River estuary. Westwater Research Centre tech. rep. 25, Univ. British Columbia. 117 p.

Lister, D.B. and C.E. Walker. 1966. The effect of flow control on freshwater survival of chum, coho and chinook salmon in the Big Qualicum River. Can. Fish Culturist. 37:3-25.

Lisle, T.E. 1986a. Effects of woody debris on anadromous salmonid habitat, Prince of Wales Island, southeast Alaska. North Amer. J. Fish. Mgt. 6:538-550.

Lisle, T.E. 1986b. Stabilization of a gravel channel by large streamside obstructions and bedrock bends, Jacoby Creek, northwestern California. Geo. Soc. Amer. Bull. 97:999-1011.

MacDonald, K., D. Simpson, B. Paulson, J. Cox, and J. Gendron. 1994. Shoreline armoring effects on physical coastal processes in Puget Sound, Washington. Coastal Erosion Management Studies, Vol. 5, Rept. 94-78, Water and Shorelands Restoration Program, Wash. Dept. Ecol., Olympia, WA.

Madej, M.A. 1978. Response of a stream channel to an increase in sediment load. MS Thesis, Univ. of Wash., Seattle, WA.

Major, P.F. 1978. Predator-prey interactions in two schooling fishes, Caranx ignobilis and *Stolephorus pupureus*. Animal Behavior 26:760-777.

Mantua, N. (No year cited). Relationships between the ENSO and PDO and PNW regional temperatures, precipitation, snowpack, and streamflow. 11 p. + graphs.

Mantua, N.J. and S.R. Hare, Y. Zhang, J.M. Wallace, and R.C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Pp. 1069-1079 *in* Bulletin of the Amer. Meteorological Soc. 78.

Mason, J.C. 1969. Hypoxial stress prior to emergence and competition among coho salmon fry. J. Fish. Res. Bd. Can. 26:63-91.

Mason, J.C. 1974. Behavioral ecology of chum salmon fry in a small estuary. J. Fish. Res. Bd. Can. 31:83-92.

May, C.W., E.B. Welch, R.R. Horner, J.R. Karr, and B.W. Mar. 1997. Quality indices for urbanization effects in Puget Sound Lowland streams. Wash. Dept. of Ecol., Water Resources Series Tech. Rpt. 154.

McHenry, M.L., D.C. Morrill, and N. Currance. 1994. Spawning gravel quality, watershed characteristics, and early life history survival of coho salmon and steelhead in five north Olympic Peninsula watersheds. Natural Resources Department, Lower Elwha S'Klallam Tribe, Port Angeles, WA, and Natural Resources Department, Makah Tribe, Neah Bay, WA.

McNeil, W.J., and W.H. Ahnell. 1964. Success of pink salmon spawning relative to size of spawning bed materials. Special scientific report – fisheries 469. US Dept. of the Interior, Fish and Wild. Serv., Washington D.C.

McNeil, W.J. 1964. Redd superimposition and egg capacity of pink salmon spawning beds. J. Fish. Res. Bd. Can. 21:1385-1396.

Mid-Columbia Mainstem Conservation Plan (MCMCP). 1998. Biological Assessment and Management Plan- Mid-Columbia River Hatchery Program. National Marine Fisheries Service, U.S. Fish and Wildlife Service, Washington Department of Fish and Wildlife, Confederated Tribes of the Yakima Indian Nation, Confederated Tribes of the Colville Indian Reservation, and the Confederated Tribes of the Umatilla Indian Reservation. Washington Department Fish and Wildlife, Olympia. 135 p.

Montgomery, D.R., G.E. Grant, and K, Sullivan. 1995. Watershed analysis as a framework for implementing ecosystem management. Water Resources Bulletin 31:369-385.

Montgomery, D.R., J.M. Buffington, N.P. Peterson, D. Schuett-Hames, and T.P. Quinn. 1996. Stream-bed scour, egg burial depths, and the influence of salmonid spawning on bed surface mobility and embryo survival. Can. J. Fish. Aquat. Sci. 53:1061-1070.

Myers, K.W. 1993. New conceptual models of high-seas migrations of pink and chum salmon, p. 83-96. *In* Alaska Sea Grant (ed.) Proceedings of the 16th annual 1993 northeast pacific pink and chum salmon workshop. Alaska Sea Grant college program report 94-02, Univ. of AK, Fairbanks, AK.

Mysak, L.A. 1986. El Nino, interannual variability and fisheries in the northeast Pacific Ocean. Can. J. Fish. Aquat. Sci. 43:464-497.

Natural Resource Consultants. 1994. 1992-93 hooking mortality study final report. Saltenstall-Kennedy grant NA26FD0138-01. Natural Resources Consultants, Seattle, WA.

Nawa, R.K., C.A. Frissell, and W.J. Liss. 1990. Life history and persistence of anadromous salmonid stocks in relation to stream habitats and watershed classification - Annual prog. rpt. Oreg. Dept. Fish and Wild., Portland, OR, and Oreg. State Univ., Corvallis, OR.

Nawa, R.K., and C. A. Frissell. 1993. Measuring scour and fill of gravel streambeds with scour chains and sliding-bead monitors. North Amer. J. Fish. Mgt. 13:634-639.

NMFS (National Marine Fisheries Service). 1996a. Coastal salmon conservation: working guidance for comprehensive salmon restoration initiatives on the Pacific coast. NMFS NW Sci. Center, U.S. Dept. Commer., Nat. Marine Fish. Serv., Seattle, WA. 28 p.

NMFS (National Marine Fisheries Service). 1996b. Review of information on Hood Canal Summer Chum Salmon ESU collected in 1995 and 1996. Unpubl. rpt., NMFS NW Sci. Center, U.S. Dept. Commer., Nat. Marine Fish. Serv., Seattle, WA. 21 p.

NMFS (National Marine Fisheries Service). 1997a. (Draft) Snake River recovery plan. NMFS NW Sci. Center, Seattle, WA. 150 p. (plus appendices).

NMFS (National Marine Fisheries Service). 1997b. Investigation of scientific information on the impacts of California sea lions and Pacific harbor seals on salmonids and on the coastal ecosystems of Washington, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-28, NMFS NW Sci. Center, U.S. Dept. Commer. Nat. Marine Fish. Serv., Seattle, WA. 172 p.

NRC (National Research Council). 1992. Restoration of aquatic ecosystems. National Academy Press, Washington D.C.

NRC (National Research Council). 1996. Upstream: Salmon and Society in the Pacific Northwest. National Academy Press, Washington D.C.

Neave, F. 1955. Notes on the seaward migration of chum and pink fry. J. Fish Res. Bd. Can. 12:369-374.

Neave, F., T. Yonemori, and R.G. Bakkala. 1976. Distribution and origin of chum salmon in offshore waters of the north Pacific Ocean. Inter. N. Pac. Fish Comm. Bull. 35, Vancouver B.C. 79 p.

Nehlsen, W., J.E. Williams, and J.A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16:4-21.

Nelson, W.R. and M. Soule. 1987. Genetic conservation of exploited fishes. Pp. 345-368 *in* Ryman, N. and F. Utter (eds.) Population genetics & fishery management, Univ. of Wash. Press, Seattle, WA.

NWIFC (Northwest Indian Fisheries Commission) and WDFW (Washington Department of Fish and Wildlife). 1998. Salmonid disease control policy of fisheries co-managers of Washington State. Wash. Dept. Fish and Wild., Olympia, WA.

Oregon Natural Resources Council, et al. v. William M. Daley, Secretary of Commerce and Rolland Schmitten, Director, National Marine Fisheries Service (and) State of Oregon. 1998. CV-97-1155-ST Opinion. J.M. Stewart, Magistrate, U.S. District Court for the District of Oregon. Portland. June 1, 1998.

Orsborne, J.F., and S.C. Ralph. 1994. An aquatic resource assessment of the Dungeness River system: Phase II - physical channel analysis, hydrology, and hydraulics, and Phase III - fisheries habitat survey. Jamestown S'Klallam Tribe, Blyn, WA.

PSC (Pacific Salmon Commission). 1997. Incidental fishing mortality of chinook salmon: mortality rates applicable to PSC fisheries. Tech rpt. TCCHINOOK (97-1). Pacific Salmon Commission, Vancouver, BC.

Palmisano, J.F., R.H. Ellis, and V. Kaczynski (eds.). 1993. The impact of environmental and management factors on Washington’s wild anadromous salmon and trout (two volumes). Prepared for Washington Forest Protection Association, Olympia, WA, and Wash. Dept. Nat. Res., Olympia, WA.

Pearcy, W.G. 1992. Ocean ecology of north Pacific salmonids. Univ. of Wash. Press. Seattle, WA. 179 p.

Peterson, N.P., and T.P. Quinn. 1994a. Persistence of egg pocket architecture in chum salmon redds, p. 9-25. *In* Quinn, T.P., and N.P. Peterson (eds.) The effects of forest practices on fish populations. WDNR rpt. no. TFW-F4-94-001. Forest Pract. Div., Wash. Dept. Nat. Res., Olympia, WA.

Peterson, N.P., and T.P. Quinn. 1994b. Variability of dissolved oxygen in natural egg pockets of chum salmon. Pp. 26-41 *in* Quinn, T.P., and N.P. Peterson (eds.) The effects of forest practices on fish populations. WDNR report no. TFW-F4-94-001. Forest Pract. Div., Wash. Dept. Nat. Res., Olympia, WA.

Peterman, R.M. 1977. A simple mechanism that causes collapsing stability region in exploited salmonid populations. J. Fish. Res. Bd. Can. 34:1130-1142.

Phelps, S. 1993. Breeding of Quilcene Hatchery summer-run chum. WDFW memorandum to Tim Tynan, Hatcheries Program. June 11, 1993. Wash. Dept. Fish and Wild., Olympia, WA. 1 p.

Phelps, S., J. Uehara, D. Hendrick, J. Hymer, A. Blakley, and R. Brix. 1995. Genetic diversity units and major ancestral lineages for chum salmon in Washington, p. C1-C55. *In* Busack, C. and J. B. Shaklee, (eds.), Genetic diversity units and major ancestral lineages of salmonid fishes in Washington. WDFW Tech. Rpt. no. RAD 95-2, Wash. Dept. Fish and Wild., Olympia, WA.

PNFHPC (Pacific Northwest Fish Health Protection Committee). 1989. Model comprehensive fish health protection program. 19 p.

Point No Point Treaty Tribes and Washington Department of Fish and Wildlife. 2000. Public Review Comments on Draft Habitat Sections of the Summer Chum Salmon Conservation Initiative. Supplemental Report No. 2 to the Summer Chum Salmon Conservation Initiative. Wash. Dept. Fish and Wild., Olympia, WA.

Pollock, M. M. and P. M. Kennard. 1989. A low-risk strategy for preserving riparian buffers needed to protect and restore salmonid habitat in forested watersheds of Washington State. December 1988. 31 p.

Prinslow, T.E., E.O. Salo, and B.P. Snyder. 1979. Studies of behavioral effects of a lighted and unlighted wharf on out-migrating salmonids (final rpt., March-April 1978). Fish. Res. Inst. rpt. FRI-UW-7920, Univ. of Wash., Seattle, WA. 35 p.

Prinslow, T.E., C.J. Whitmus, J.J. Dawson, N.S. Bax, B.P. Snyder, and E.O. Salo. 1980. Effects of wharf lighting on out-migrating salmonids, 1979 (final rpt., Jan.-Dec. 1979). UW Fish. Res. Inst. rpt. FRI-UW- 8007, Univ. of Wash., Seattle, WA. 137 p.

Pritchard., A.L. 1936. Stomach content analysis of fishes preying upon the young of the Pacific salmon during the fry migration at McClinton Cr., Masset Inlet, B.C. Field-Natur. 50:104-105.

PSSMP (Puget Sound Salmon Management Plan). 1985. U.S. v. Washington, 384 F. supp. 312; sub no. 85-2 (W.D. Wash.), Seattle WA.

Ratner, S., R. Lande, and B.B. Roper. 1997. Population viability of spring chinook salmon in the South Umpqua River, Oregon. Conserv. Biol. 11:879-889.

Reimer, S.D., and R.F. Brown. 1996. Marine mammal (pinniped) food habits in Oregon. ODFW Wildlife Diversity Program tech. rep. 96-6-01, Oregon Dept. Fish and Wild., Portland, OR. 26 p.

Reisenbichler, R.R. and G. Brown. 1995. Is genetic change from hatchery rearing of anadromous fish really a problem?, p. 578-579. *In* Schramm, H.L. Jr., and R.G. Piper (eds.) Uses and effects of cultured fishes in aquatic ecosystems, Amer. Fish. Soc. Symp. 15.

Ricker, W.E. 1972. Hereditary and environmental factors affecting certain salmonid populations, p. 19-160. *In* Simon, R,C. and P.A. Larkin (eds.) The Stock Concept. of Pacific Salmon. MacMillian Lectures in Fisheries, University of British Columbia, Vancouver B.C.

Riggs, L. 1990. Principles for genetic conservation and production quality. Results of a scientific and technical clarification and revision. Northwest Power Planning Council, Portland, OR.

Ruggerone, G.T. 1989. Coho salmon predation on juvenile sockeye in the Chignik lakes, Alaska. Ph.D. Dissertation. School of Fisheries, Univ. of Wash., Seattle, WA.

Ruggerone, G.T. 1992. Threespine stickleback aggregations create a potential predation refuge for sockeye salmon fry. Can J. of Zoology 70:1052-1056.

Ryman, N. and L. Laikre. 1991. Effects of supportive breeding on the genetically effective population size. Conservation Biology 5:325-329.

Salo. E.O., N.J. Bax, T.E. Prinslow, C.J. Whitmus, B.S. Snyder, and C.A. Simenstad. 1980. The effects of construction of naval facilities on the out-migration of juvenile salmonids from Hood Canal, Washington (final rpt., March 1 1975-July 31, 1979). UW Fish. Res. Inst. rep. FRI-UW- 8006, Univ. of Wash., Seattle, WA. 159 p.

Salo, E.O. 1991. Life history of chum salmon, Oncorhynchus keta, p. 231-309. *In* Groot, C., and L. Margolis (eds.), Pacific Salmon Life Histories. Univ. B.C. Press, Vancouver, B. C., Canada.

Saunders, R.L. 1991. Potential interaction between cultured and wild Atlantic salmon. Aquaculture 98:51-61.

Schreiner, J.U. 1977. Salmonid out-migration studies in Hood Canal, Washington. M. S. Thesis. Univ. of Wash. 91 p.

Schreiner, J.U., E.O. Salo, B.P. Snyder and C.A. Simenstad. 1977. Salmonid out-migration studies in Hood Canal (final rpt., phase II). UW Fish Res. Inst. rpt. FRI-UW-7715, Univ. of Wash., Seattle, WA. 64 p.

Schreiner, J.U., and M.J. Brownlee. 1989. Effects of forest harvesting on spawning gravel and incubation survival of chum (*Oncorhynchus keta*), and coho (*O. kisutch*) in Carnation Cr., British Columbia. Can. J. Fish. Aquat. Sci. 46:681-696.

Schroeder, S.L. 1977. Assessment of production of chum salmon fry from the Big Beef Creek spawning channel. Fish. Res. Inst. final rep. no. FRI-UW-7718. Univ. of Wash., Seattle, WA. 77 p.

Schroder, S.L. 1981. The role of sex selection in determining overall mating patterns and mate choice in chum salmon. Ph.D thesis, Univ. of Wash., Seattle, WA.

Schuett-Hames, D., and G. Pess. 1994. A strategy to implement watershed analysis monitoring: assessment of parameters and methods monitoring module outline recommendations. TFW-AM14-94-01. Timber, Fish, and Wildlife, Olympia, WA.

Schuett-Hames, D., N.P. Peterson, and T.P. Quinn. 1994. Patterns and scour and fill in a low gradient alluvial channel, p. 42-55. *In* Quinn, T.P., and N.P. Peterson (eds.) The effects of forest practices on fish populations. WDNR report no. TFW-F4-94-001. Forest Pract. Div., Wash. Dept. Nat. Res., Olympia, WA.

Schwab, R. 1974. Hatchery propagation of chum and pink salmon in Washington, p. 50-53. *In* Harding, D. R. (ed.) Proceedings of the 1974 Northeast Pacific pink and chum salmon workshop. Dept. of the Envir., Fisheries. Vancouver, BC.

Sedell, J.R. and K.J. Luchessa. 1982. Using the historical record as an aid to salmonid habitat enhancement. Pp. 210-223 *in* Armantrout, N.B. (ed.) Proceedings of Acquisition and Utilization of Aquatic Habitat Inventory Information symposium, 23-28 Oct. 1981, Portland, OR. Amer. Fish. Soc., Bethesda, MD.

Sedell, J.R. and J.L. Frogatt. 1984. Importance of streamside forests to large rivers: the isolation of the Willamette R., U.S.A., from its floodplain by snagging and streamside forest removal. International Vereingung fur theoretische und angewandte Limnologie Verhandlungen 22:1828-1834.

Sele, B. 1995. Status of summer chum salmon in the Strait of Juan de Fuca (Draft document). Fisheries Management Department, Jamestown S`Klallam Tribe. Blyn, WA.

Shaffer, J. A. and C. Burge. In press. Ulvoid mats and shellfish of the Strait of Juan de Fuca: a pilot study. Estuarine and Coastal Sciences Association Bulletin, vol. 32.

Simenstad, C.A. and W.J. Kinney. 1978. Trophic relationships of out-migrating chum salmon in Hood Canal, Washington, 1977 (Final rpt., Oct. 1, 1977–March 31, 1978). UW Fish. Res. Inst. rpt. FRI-UW-7810, Univ. of Wash., Seattle, WA. 75 p.

Simenstad, C.A., W.J. Kinney, S.S. Parker, E.O. Salo, J.R. Cordell, and H. Buechner. 1980. Prey community structure and trophic ecology of out-migrating juvenile chum and pink salmon in Hood Canal, Washington: A synthesis of three years' studies, 1977-1979. UW Fish. Res. Inst. rpt. FRI-UW- 8026. Univ. of Wash., Seattle, WA. 113 p.

Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: and unappreciated function, p. 343-364. *In* Kennedy, V.S. (ed.) Estuarine comparisons. Academic Press. Toronto, Ontario, Canada. 709 p.

Sokal, R.R., and F.J. Rohlf. 1981. Biometry, 2nd ed. W.H. Freeman & Co., San Francisco, CA. 859 p.

Smoker W.A., H.M. Jensen, D.R. Johnson, and R. Robison. 1952. The Skokomish River Indian fishery. Wash. Dept. Fish and Wild., Olympia, WA. 17 p.

Spence, B.C., G.A. Lomnicky, R.M. Hughes, and R.P. Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. Man-Tech Environmental Research Services Corp., Corvallis, OR.

Steward, C. R. and T. C. Bjornn. 1990. Supplementation of salmon and steelhead stocks with hatchery fish: a synthesis of published literature. UI tech. rpt. 90-1, Idaho Cooperative Fish and Wildlife Research Unit, Univ. of Id., Moscow, ID. 126 p.

Tallman, R.F. and M.C. Healey. 1994. Homing, straying, and gene flow among seasonally separated populations of chum salmon (*Oncorhynchus keta*). Can. J. Fish. Aquat. Sci., 51:577-588.

Thom, R.M., and D.K. Shreffler. 1994. Shoreline armoring effects on coastal ecology and biological resources in Puget Sound, Washington. Coastal Erosion Mgmt. Studies, Vol. 7, 94-74. Water & Shorelands Restoration Prog., Wash. Dept. Ecol., Olympia WA.

Thorne, R.E., and J.J. Ames. 1987. A note on variability of marine survival of sockeye salmon (*Oncorhynchus nerka*) and effects of flooding on spawning success. Can. J. Fish. Aquat. Sci. 44: 1791-1795.

Thornsteinson, F.V. 1962. Herring predation on pink salmon in a southeastern Alaska estuary. Trans. Amer. Fish. Soc. Vol. 91 No. 3:321-323.

Toews, D.A.A., and M.J. Brownlee. 1981. A handbook for fish habitat protection on forest lands in British Columbia. Canada Dept. of Fisheries and Oceans, Vancouver, BC.

Tripp, D., and V.A. Poulin. 1986. The effects of logging and mass wasting on salmonid spawning habitat in streams on the Queen Charlotte Islands. Land Management Report. No. 50, British Columbia Ministry of Forest and Lands, Vancouver, B.C.

Turner, R. 1995. WDFW's comments to NMFS on "Preliminary Conclusions of the Review of the Status of Chum Salmon (*Oncorhynchus keta*) from Washington, Oregon, and California under the U.S. Endangered Species Act", August 4, 1995. Wash. Dept. Fish and Wild., Olympia, WA. 29 p.

Tynan, T.J. 1992. Hood Canal early chum harvest and escapement assessment: a review of Hood Canal early chum escapements and inside Hood Canal commercial net fishery harvests (1968-91) with recommendations for short and long term management measures to assist stock rebuilding (WDF rpt.). Wash. Dept. of Fish. and Wild., Olympia, WA. 57 p.

Tynan, T.J. 1997. Life history characterization of summer chum salmon populations in the Hood Canal and eastern Strait of Juan de Fuca regions. Tech. Report No. H 97-06. Hatcheries Program, Wash. Dept. Fish and Wild., Olympia. WA. 99 p.

Tynan, T. and J. Ames. 1997. Memorandum to Orlay Johnson, National Marine Fisheries Service (NMFS), April 10, 1997 (subject: Hoodsport hatchery chum timing). Wash. Dept. Fish and Wild., Olympia, WA.

Tynan, T.J. 1998. Characterization of WDFW and tribal cooperative hatchery salmonid production in the Hood Canal and eastern Strait of Juan de Fuca regions. Vol. II - Biological assessment of WDFW hatchery program effects on the status of Hood Canal and Strait of Juan de Fuca region summer chum salmon populations (unpublished). Wash. Dept. Fish. and Wild., Olympia, WA. 104 p.

Uehara, J. 1994. A salmon damage assessment for the December 1993 channelization of the lower Big Quilcene River. Wash. Dept. Fish and Wild., Olympia, WA. 21 p.

USFWS (U.S. Fish and Wildlife Service). 1994. Biological assessments for operation of U.S. Fish and Wildlife Service operated or funded hatcheries in the Columbia River Basin in 1995-1998. Submitted to National Marine Fisheries Service (NMFS) under cover letter, dated August 2, 1994, from William F. Shake, Acting USFWS Regional Director, to Brian Brown, NMFS.

USFS (United States Forest Service) and WDNR (Washington Dept. of Nat. Res.). 1994. Big Quilcene watershed analysis - an ecological report at the watershed level. U.S. Dept. of Agri., Forest Serv., Olympic National Forest, Olympia, WA.

U.S. v. Washington. 1974. 384 F. Supp 312 (W.D. Wash.), aff'd, 500 F.2nd 676 (9th Cr. 1975, cert. denied), 423 U.S. 1086 (1976), Seattle WA.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The river continuum concept. Can J. Fish. Aquat. Sci. 37:130-137.

Varanasi, U., E. Casillas, M.R. Arkoosh, T. Hom, D.A. Misitano, D.W. Brown, S-L. Chan, T.K. collier, B.B. McCain, and J.E. Stein. 1993. Contaminant exposure and associated biological effects in juvenile chinook salmon (*Oncorhynchus tshawytscha*) from urban and nonurban estuaries of Puget Sound. NOAA Technical Memorandum NMFS-NWFSC-8, NMFS NW Sci. Center, U.S. Dept. Commer. Nat. Marine Fish. Serv., Seattle, WA.

Wainwright, T.C., and R. S. Waples. 1998. Prioritizing Pacific salmon stocks for conservation: Response to Allendorf et al. Conservation Biology 12:1144-1147.

Waldichuck, M. 1993. Fish habitat and the impact of human activity with particular reference to Pacific salmon. Pp. 295-337 *in* Parsons, L.S., and W.H. Lear (eds.) Perspectives on Canadian marine fisheries management. Can. J. Fish. Aquat. Sci. pub. 226.

Waples, R.S. 1990. Conservation genetics of Pacific salmon II. Effective population size and the rate of loss of genetic variability. Jour. Heredity 81:267-276

Waples, R.S. 1996. Towards a risk/benefit analysis for salmon supplementation (draft document). NMFS NW Sci. Center, U.S. Dept. Commer. Nat. Marine Fish. Serv., Seattle, WA. 25 p.

Washington Forest Practices Board. 1995. Standard methodology for conducting watershed analysis (Version 3). Wash. Forest Pract. Bd., Olympia, WA.

WDF (Washington Department of Fisheries). 1957. Research relating to fisheries problems that will arise in conjunction with current and projected hydroelectric developments in the Skokomish River (WDF rpt.). Wash. Dept. Fish and Wild., Olympia, WA. 132 p.

WDF (Washington Department of Fisheries), U. S. Fish and Wildlife Service, and Washington Department of Game. 1973. Joint statement regarding the biology, status, management, and harvest of the salmon and steelhead resources of the Puget Sound and Olympic Peninsular drainage areas of western Washington. U. S. v Wash. et al. Civil No. 9213. U.S. District Court, Western District of Wash. Wash. Dept. Fish and Wild., Olympia, WA. 140 p. (plus tables and figures).

WDF (Washington Department of Fisheries). 1974. 1974 status of the salmon resource of the Puget Sound region, Washington. Wash. Dept. Fish and Wild., Olympia, WA. 24 p.

WDF (Washington Department of Fisheries). 1975. 1975 status of the salmon resource of the Puget Sound and Coastal regions, Washington. Wash. Dept. Fish and Wild., Olympia, WA. 48 p.

WDF (Washington Department of Fisheries), Washington Department of Wildlife, and Western Washington Treaty Indian Tribes. 1993. 1992 Washington State Salmon and Steelhead Stock Inventory. Wash. Dept. Fish and Wild., Olympia, WA. 212 p.

WDFW (Washington Department of Fish and Wildlife) and WWTIT (Western Washington Treaty Indian Tribes). 1994. 1992 Washington State salmon and steelhead stock inventory- Appendix One - Puget Sound stocks - Hood Canal and Strait of Juan de Fuca vol. Wash. Dept. Fish and Wild., Olympia, WA. 424 p.

WDFW (Washington Department of Fish and Wildlife). 1996. Fish health manual. Wash. Dept. Fish and Wild., Olympia, WA. 69 p.

WDFW (Washington Department of Fish and Wildlife). 1997a. Lower Columbia steelhead conservation initiative (draft document, June 12, 1997). Wash. Dept. Fish and Wild., Olympia, WA. 115 p.

WDFW (Washington Department of Fish and Wildlife). 1997b. Watershed resource inventory process. Fish supplementation and rearing projects. Wash. Dept. Fish and Wild., Olympia, WA.

WDFW (Washington Department of Fish and Wildlife) and WWTIT (Western Washington Treaty Indian Tribes). 1997. Policy of Washington Department of Fish and Wildlife and Western Washington Treaty Tribes concerning wild salmonids. Wash. Dept. Fish and Wild., Olympia, WA. 46 p.

WDFW (Washington Department of Fish and Wildlife) and WWTIT (Western Washington Treaty Indian Tribes). 1999. Comprehensive Chinook Management Plan (June 1999 draft). Wash. Dept. Fish and Wild., and Northwest Indian Fish., Comm., Olympia, WA.

Whitmus, C. J., and S. Olsen. 1979. The migratory behavior of juvenile chum salmon released in 1977 from the Hood Canal hatchery at Hoodsport, Washington. UW Fish. Res. Inst. rpt. FRI-UW-7916, Univ. of Wash, Seattle, WA. 46 p.

Whitmus, C.J. 1985. The influence of size on the early marine migration and mortality of juvenile chum salmon (*Oncorhynchus keta*). M. S. Thesis. Univ. of Wash. 69 p.

Wiggins, W.D., G.P. Ruppert, R.R. Smith, L.L. Reed, L.E. Hubbard, and M.L. Courts. 1997. Water Resources Data - Washington - Water Year 1996. USGS water data rpt. WA-96-1. U.S. Geo. Surv., Tacoma, WA. 494 p.

Williams, I.V. and D.F. Amend. 1976. A natural epizootic of Infectious Hematopoietic Necrosis in fry of sockeye salmon (*Oncorhynchus nerka*) at Chilko Lake, British Columbia. J. Fish. Res. Bd. Can. 33:1564-1567.

Williams, R.W., R.M. Laramie, and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization, Volume 1, Puget Sound Region. Wash. Dept. Fish and Wild., Olympia, WA. 974 p.

Wilson, U. 1991. Responses of three seabird species to El Nino events and other warm episodes on the Washington coast, 1979-1990. Condor 93:853-858.

Wissmar, R.C. and C.A. Simenstad. 1980. Optimal management of chum salmon based on estuarine and nearshore carrying capacity for out-migrating juveniles in Hood Canal. NSF Research grant proposal. UW Fish. Res. Inst., Univ. of Wash, Seattle, WA. 80 p.

Witty, K., C. Willis, and S. Cramer. 1995. A review of potential impacts of hatchery fish on naturally produced salmonids in the migration corridor of the Snake and Columbia rivers. Comprehensive Environmental Assessment (final rpt.). S.P Cramer and Associates, Gresham, OR. 76 p.

Wolcott, R.S.C., Jr. 1978. The chum salmon run at Wolcott Slough. Special report to the U.S. Department of the Interior, Fish and Wildlife Service, Reno, NV. 41 p.

Wright, L.D., J.R. Coleman, and B.G. Thom. 1973. Processes of channel development in a high tide range environment; Cambridge Gulf-Ord River delta, Western Australia. J. of Geology. 81: 15-41.

Wydoski, R.S. and R.R. Whitney. 1979. Inland Fishes of Washington. University of Washington Press, Seattle, WA.

# Glossary

## Definitions (acronyms and abbreviations follow).

**Acclimatization** - A juvenile fish rearing and release process applied to promote adaptation and imprinting of a fish stock to the environmental and geographic parameters of its home watershed, or desired watershed for adult return.

**Aggradation** - The accumulation of sediment in a river channel resulting from changes in flow, sediment inputs, or changes to the adjacent floodplain.

**Alevin** - Newly hatched salmonids which remain in gravel until their yolk sacs have been resorbed.

**Allele** - One of two or more alternate forms of a gene.

**Alluvial** - Originating from the transport and deposition of sediment by running water.

**Anadromous fish** - Fish that are born in freshwater, migrate to the ocean to grow and mature, and return to freshwater as adults to reproduce.

**Area Under the Curve (AUC)** - An escapement calculation methodology that converts the area under a spawner abundance curve to a total fish estimate.

**Artificial propagation** - Any assistance provided by human technology to animal reproduction. In the context of Pacific salmonids, this assistance includes (but is not necessarily limited to) spawning and/or rearing in hatcheries, captive broodstock projects, or the use of remote site incubators.

**Base Conservation Regime (BCR)** - The management of the harvests of summer chum salmon at population levels that provide incremental increases in escapements and are above critical population thresholds.

**Best Management Practices (BMP)** - State-of-the-art environmental protection measures.

**Biodiversity** - The variety and abundance of species, their genetic composition, and the natural communities, ecosystem, and landscapes in which they occur.

**Boldt Decision** - See *U.S. v. Washington*.

**Broodstock** - Those adult salmonids that are destined to be the parents for a particular stock or smaller group of fish.

**Bulkhead** - A structure or wall constructed in or above the intertidal zone to prevent shoreline erosion from wave action.

**Canadian Department of Fisheries and Oceans (CDFO)** - The national fishery management agency of Canada.

**Carrying Capacity** - The maximum number of individuals or biomass of a given species or complex of species of fishes that a limited and specific aquatic habitat may support during a stated interval of time.

**Cascade** - A series of small steep drops increasing the velocity of the stream.

**Catch** - The act of landing a fish at which point the fisher has the option of release or retention.

**Catch Record Card (CRC) -** A data recording system for recreational salmon fisheries that requires that anglers record all sport caught salmon on a “punch” card, by species, date, and location of harvest.

**Channelized -** A portion of a river channel that has been enlarged or deepened, and often has armored banks.

**Channel processes -** The interaction of elements that form river habitat including riparian vegetation, large woody debris, sediment delivery, and hydrology.

**Channel migration zone -** The area occupied by a stream channel under existing climate conditions, approximated by the 100 year floodplain, side channels and low terraces of a river.

**Co-managers -** The Hood Canal and Strait of Juan de Fuca salmon co-managers are thePoint-No-Point Treaty Tribes including: the Skokomish Tribe, the Port Gamble S’Klallam Tribe, The Jamestown S’Klallam Tribe, and the Lower Elwha Klallam Tribe; and the Washington State Department of Fish and Wildlife**.**

**Composite stock (population) -** A stock sustained by both wild and artificial propagation.

**Conspecific -** Individuals of the same species.

**Convention waters**

**Critical Abundance Threshold (CAT)**

**Critical Escapement Threshold (CET)**

**Critical stock -** A stock of fish experiencing production levels that are so low that permanent damage to the stock is likely or has already occurred.

**Cubic feet per second (cfs) -** A measurement of stream flow.

**Cultured stock -** A stock that depends upon spawning, incubation, hatching, or rearing in a hatchery or other artificial production facility.

**Cumulative effect -** A change to the environment caused by multiple, incremental impacts interacting with natural ecosystem processes. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time.

**Decommission (a road) -** To remove those elements of a road that reroute hillslope drainage and present slope stability hazards.

**Deep-water -** Defined in terms of habitat use by summer chum, deep-water habitat includes those areas greater than 2 meters in depth (6.5 feet, relative to mean lower low-water) used by larger summer chum juveniles for feeding and out-migration and by adults during their return migration.

**Delta -** An alluvial landform, typically triangular in shape, composed of sediment at a river mouth that is shaped by river discharge, sediment load, tidal energy, land subsidence, and sea-level changes.

**Dendrogram -** A graphic summary of the genetic relationships among populations. The horizontal distance at which the stock branches connect indicates the degree of similarity/dissimilarity. The longer the distance at which the branch points connect, the greater the average genetic differences among stocks.

**Depensatory Mortality -** Mortality is depensatory when its rate (i.e., proportion of population affected) increases as the size of the population decreases. This is in contrast to compensatory mortality where the mortality rate decreases as the population size decreases.

**Depressed stock** - A stock of fish whose production is below expected levels based on available habitat and natural variations in survival levels, but above the level where permanent damage to the stock is likely.

**Detritus** - Litter formed from fragments of organic material (leaves, animal wastes, carcasses, etc.).

**Diameter at breast height (dbh)** - The diameter of a tree, measured 4.5 feet above the ground on the uphill side of the tree.

**Dispersal** - The movement of plants and animals from one habitat to another. Juvenile chum disperse from freshwater to subestuaries, then onto nearshore and finally deep-water marine areas.

**Drift cell** - A discrete shoreline segment that, in an unaltered state, allows for the uninterrupted movement of beach materials. A drift cell includes a sediment source (such as a "feeder bluff"), a driftway along which the sediment moves, and a sink or site of deposition.

**Drift gillnet** - A gillnet of single web construction, not anchored, tied, staked, placed, or weighted in such a manner that it cannot drift (WAC 220-16-040).

**Ecological interaction** - The sum total of impacts of one species on another species, or on other members of the same species.

**Ecosystem** - A complex of biological communities and environment that forms a functioning, interrelated unit in nature.

**Eelgrass** - A flowering plant (*Zostera spp.*) that grows underwater in shallow estuarine and marine areas and that has long, grass-like leaves.

**Effective population size ($N_e$)** - The effective number of breeders per year times generation length. This can be calculated for summer chum salmon as; $N_e$ = Average escapement times 0.2 ($N_e/N$, the proportion of the population assumed to effectively breed), times 3.6 (generation length) where 3.6 is the average age of Hood Canal summer chum salmon.

**Electrophoresis** - A process whereby charged molecules (such as DNA and enzymes) are separated in an electric field.

**El Niño-Southern Oscillation (ENSO)** - A climate event that begins as a warming episode in the tropical Pacific zone that can result in large scale intrusions of anomalously warm marine water northward along the PNW coastline.

**Emergence** - When newly-hatched salmonids that have fully absorbed their yolk-sac, they emerge from the gravel and promptly migrate downstream to estuaries.

**Endangered Species Act (ESA)** - A 1973 act of congress that mandated that endangered and threatened species of fish, wildlife, and plants be protected and restored.

**Escapement** - The number of adult fish returning to a stream that escape mortality from harvest and natural attrition, and comprise a spawning population.

**Escapement Distribution Flag (EDF)** - An escapement benchmark for checking the deviation of any one stock's escapement from the overall pattern of escapement within the stock's management unit.

**Escapement goal** - A predetermined biologically derived number of salmonids that are not harvested and will be the parent spawners for a wild or hatchery stock of fish.

**Estuarine landscape** - The mosaic of deepwater, nearshore, and subestuarine delta environments used by summer chum as they feed, rear, and migrate through Hood Canal and the eastern Strait of Juan de Fuca.

**Evolutionarily Significant Unit (ESU)** - NMFS definition of a distinct population segment (the smallest biological unit that will be considered to be a “ species” under the Endangered Species Act). A population will be is considered to be an ESU if 1) it is substantially reproductively isolated from other conspecific population units, and 2) it represents an important component in the evolutionary legacy of the species.

**Exploitation rate** - The proportion of a returning run or total population of salmonids that is taken by fisheries.

**Extinction** - The loss of a stock of fish from its original range, or as a distinct stock elsewhere. Individuals of the same species may be observed in very low numbers, consistent with straying from other stocks.

**Extinct stock** - A stock of fish that is no longer present in its original range, or as a distinct stock elsewhere. Individuals of the same species may be observed in very low numbers, consistent with straying from other stocks.

**Extirpation** - The elimination of a species from a particular area.

**Extreme terminal fishing (management) area** - Marine or freshwater areas where salmonids of a single stock or management unit have separated from fish of other stocks.

**$F_1$** - A genetic term representing first generation individuals reulting from a given cross or breeding.

**$F_2$** - The second generation resulting from the interbreeding of $F_1$ individuals.

**Feeder Bluff** - An eroding shoreline bluff that supplies sediment to beaches via longshore drift.

**Fingerling** - Juvenile salmonids up to nine months of age and generally two to four inches in total length.

**Fishery** - The process of attempting to catch fish, which then may be retained or released.

**Fitness** - The relative ability of an individual (or population) to survive and reproduce in a given environment. The ‘fit’ of an organism to its environment.

**Floodplain** - The part of a river valley composed of unconsolidated river deposits that periodically floods. Sediment is deposited on the floodplain during floods and through the lateral migration of the river channel across the floodplain. The 100-year floodplain refers to that area of a river valley that is inundated during a large-magnitude flood occurring, on average, once every one hundred years.

**Forest Ecosystem Management Assessment Team (FEMAT)** - A team of scientists organized by the federal government in 1993 to develop a management plan for federal lands and rivers within the range of the northern spotted owl.

**Forest Practices Act** - A Washington State statute establishing minimum standards for forest practices and providing for necessary administrative procedures and rules applicable to activities conducted on or pertaining to forests on both state-managed and private lands.

**Fork length (FL)** - A fish length measurement from the tip of the nose to the fork of the tail fin.

**Fragmentation** - The process of reducing the size and connectivity of habitats, especially with reference to their use and accessibility by animal species that must disperse through them.

**Fry** - Young salmonids that have emerged from the gravel and are up to one month of age or any cultured salmonid from hatching through fourteen days after being ponded.

**Gear limits** - Restrictions placed on sport or commercial fishing gear, which are used to control the take of fish.

**Gene** - A specific unit of genetic material (DNA) that encodes the information for a single genetic trait.

**Genetic diversity** - All of the genetic variation within a group. The genetic diversity of a species includes both genetic differences between individuals in a breeding population (=within-stock diversity) and genetic differences among different breeding populations (=among-stock diversity).

**Genetic drift** - Gradual change with time in the genetic composition of a continuing population resulting from the elimination of some genetic features and the appearance of others, and appearing to be unrelated to the environmental benefits or detriments of the genes involved.

**Gene flow** - The rate of entry of non-native genes into a population, measured as the proportion of the alleles at a locus in a generation that originated from outside of the population. Can be thought of as the genetically successful stray rate into a population. See also *stray rate* and *homing rate.*

**Gene pool** - The total variety and proportions of alleles within a population.

**Genetic risk** - The probability of an action or inaction having a negative impact on the genetic character of a population or species.

**Genetic Stock Identification (GSI)** - A method that can be used to characterize populations of organisms based on the genetic profiles of individuals. The GSI process consists of a series of steps: 1) collect selected tissues from a representative sample of individuals from the population(s) under investigation; 2) develop genetic profiles for the individuals in each population by conducting starch-gel electrophoresis and histo-chemical staining using tissue extracts; 3) characterize each population by aggregating the individual genetic profiles and computing allele frequency distributions; and 4) conduct statistical tests using the allele counts characterizing each population to identify significantly different populations.

**Genome** - The total genetic composition of an individual. The complete genetic information possessed by an organism.

**Geographic Information System (GIS)** - A computer mapping program.

**Geomorphic processes** - Landform-modifying processes such as erosion, mass-wasting, and streamflow.

**Glide** - A gently flowing, calm reach of shallow water in a stream.

**Governor's Salmon Recovery Office** - See *Salmon Recovery Office.*

**Gradient** - The amount of vertical drop a stream experiences over a given distance.

**Habitat** - An area that supplies food, water, shelter, and space necessary for a particular animal's existence.

**Habitat complexity** - Variations in stream or tidal flow, velocity, and depth arising from structural features like LWD, floodplain, or estuarine landforms that provide cover from predators, suitable gravel for spawning, sufficient food resources, dispersal corridors, and refuge from harsh physical or chemical conditions.

**Habitat Conservation Plan (HCP)** - A program for the long-term protection and benefit of a species in a defined area; required as part of a Section 10 incidental take permit application under the federal Endangered Species Act.

**Harmonic mean** - The reciprocal of the arithmetic mean of the reciprocals of a finite set of numbers; harmonic mean = $\frac{1}{\frac{1}{n}\sum\frac{1}{x_i}} = \frac{n}{\sum\frac{1}{x_i}}$

**Harvest** - Fish that are caught and retained in a fishery (consumptive harvest).

**Harvest project** - Projects designed for the production of fish that are primarily intended to be caught in fisheries.

**Harvest rate** - The proportion of the available numbers of salmonids that is taken by fisheries in a specific time period.

**Hatchery fish** - A fish that has spent some part of its life-cycle in an artificial environment and whose parents were spawned in an artificial environment.

**Hatchery stock (population)** - A stock that depends on spawning, incubation, hatching or rearing in a hatchery or other artificial propagation facility (synonymous with cultured stock).

**Hatchery production** - The spawning, incubation, hatching, or rearing of fish in a hatchery or other artificial production facility (e.g., spawning channels, egg incubation boxes, or pens).

**Hazard** - Undesirable events that an artificial propagation program is attempting to avoid.

**Headwaters** - The upper reaches of a stream or stream system.

**Healthy stock** - A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock. This does not imply that the habitat itself is necessarily "healthy."

**Heterozygosity** - The proportion of individuals in a population that possess two different forms (alleles) of a single gene (locus).

**Homing rate** - Of all the fish from a population that successfully return to spawn, the homing rate is the proportion that return to spawn in the same population in which their parents spawned. See also *stray rate* and *gene flow*.

**Hood Canal Coordinating Council (HCCC)** - A council of governments formed under Washington State RCW 29.34 consisting of Jefferson, Kitsap and Mason counties, Port Gamble S'Klallam and Skokomish tribes, and with the support of federal and state agencies. Its mission is to coordinate actions that protect and restore the environment and natural resources of the Hood Canal basin. It also provides educational services to local communities.

**Hood Canal Salmon Enhancement Group (HCSEG)** - The HCSEG is one of twelve Regional Fisheries Enhancement Groups established by the Washington State legislature in 1991. Funds for projects and administration are provided through recreational and commercial salmon license sales, and salmon carcass sales from state hatchery facilities. Technical support for the group is provided by the WDFW Volunteer Program. The group is volunteer-based, and is active in salmonid enhancement and habitat improvement projects throughout the Hood Canal region.

**Hood Canal Salmon Management Plan (HCSMP)** - A state/tribal salmon management plan for the Hood Canal region adopted in 1986 as a part of U.S. v. Washington.

**Hybridization** - The interbreeding of fish from two or more different stocks or species.

**Hydraulic Project Approval (HPA)** - A WDFW permit that is required for construction and other work that uses, diverts, obstructs, or changes the natural flow or bed of fresh- or saltwaters of the state.

**Hydraulics code** - The primary authority that the Washington Department of Fish and Wildlife has to meet its goal of protecting fish and wildlife habitat. This code grants WDFW the authority to approve or deny requests by landowners to carry out activities that occur below the ordinary high-water line.

**Hydrologic maturity** - Condition of a forest stand in which hydrologic processes operate as they do in a mature or old-growth forest. In particular, snow accumulation is typically lower in thick, dense forest (at middle and lower elevations) than in openings, due to the melting of snow caught in the canopy between storms.

**Impervious surfaces** - Areas covered by buildings, roads, parking lots, and other hard structures which reduce or prevent infiltration of rain water thereby increasing runoff to streams which results in a greater magnitude and frequency of peak flow events.

**Implementation monitoring** - Monitoring done to determine whether conservation strategies are implemented as planned.

**Imprinting** - A juvenile fish rearing and release process applied in an artificial propagation program to promote recognition, and high fidelity, of returning adult fish to the watershed of release..

**Inbreeding** - The mating of related individuals.

**Incidental harvest** - The capture and retention of species other than those a fishery is primarily opened to target/take. It can also refer to marked fish of the same species.

**Incubation** - A salmon life stage prior to egg hatching during which embryos are developing in the gravel where they were spawned. After hatching young chum salmon remain in the gravel until their yolk-sacs are fully absorbed, then emerge and migrate to estuaries.

**Independent tributary** - A small stream flowing directly into marine waters.

**Instream Flow Incremental Methodology (IFIM)** - An analytical methodology for estimating the stream flows that will provide usable stream area for various salmonid life stages.

**Integrated project** - Project where artificially propagated fish are intended to spawn in the wild and become fully reproductively integrated into a particular natural population.

**Intertidal zone** - The area between the highest and lowest tidal levels.

**Isolated project** - Project where artificially propagated fish are not intended to spawn in the wild or be genetically integrated with any specific natural population.

**Joint Natural Resources Cabinet (JNRC)** - A committee made up of the directors of 13 Washington State natural resource agencies that promotes interagency communication, coordination, and policy direction on environmental and natural resource issues.

**Landscape** - A large regional unit of land or water that is composed of a mosaic of communities or ecosystems, each changing through time and affecting conditions at the larger landscape scale. See “estuarine landscape”.

**Large woody debris (LWD)** - Logs, limbs, or root wads 4 inches or larger in diameter, delivered to river and stream channels from streamside forests (in the riparian or upslope areas) or from upstream areas. LWD provides streambed stability and habitat complexity. LWD recruitment refers to the process whereby streamside forests supply wood to the stream channel to replenish what is lost by decay or downstream transport.

**Life history** - The events that make up the life cycle of an animal including migration, spawning, incubation, and rearing. There is typically a diversity of life history patterns both within and between populations. Life history can refer to one such pattern, or collectively refer to a stylized description of the ‘typical’ life history of a population.

**Locally adapted population** - A population whose members have genetically based characteristics that increase their fitness in their local environment compared individuals that lack these characteristics.

**Long Live The Kings (LLTK)** - An independent, private, professional non-profit organization based in Seattle, Washington dedicated to the perpetuation and recovery of Washington salmonid populations. The group is active in salmon enhancement and habitat improvement projects throughout the Puget Sound region. LLTK is responsible for on-going summer chum supplementation projects on Lilliwaup Creek and the Hamma Hamma River in the Hood Canal region.

**Longshore drift** - The movement of sediment along a shoreline by water currents and waves breaking at an angle to the shore.

**Loss** - Loss refers to the consequences of a hazard occurring. In this risk assessment, losses are measured at the level of individual populations and (to some degree) the entire ESU.

**Management Unit (MU)** - A stock or group of stocks which are aggregated for the purpose of achieving a desired spawning escapement objective.

**Maximum Sustained Yield (MSY)** - The maximum number of fish from a stock or management unit that can be harvested on a sustained basis, measured as the number of fish that would enter freshwater to spawn in the absence of fishing after accounting for natural mortality.

**Mean higher high water (MHHW)** - A tidal elevation obtained by averaging each day's highest tide at a particular location over a period of nineteen years. It is measured from the MLLW = 0.0 tidal elevation.

**Mean lower low water (MLLW)** - A tidal elevation obtained by averaging each day's lowest tide at a particular location over a period of nineteen years. It is the tidal datum for vertical tidal references in saltwater areas.

**Microcomputer Historic Catch and Landing Summary (MHCLS)** - A tribal data base maintained by NWIFC.

**Migrant (or stray)** - An individual that breeds in a population other than that of its parents.

**Migration** - The seasonal movement of an animal from one area to another.

**Migration rate (or stray rate)** - The proportion of a population that consists of migrants.

**Minimum Escapement Flag (MEF)** - An escapement benchmark for checking if any stock's escapement is below a critical abundance threshold.

**Minimum viable population (MVP)** - The size of a population which, with a given probability, will ensure the persistence of the population for a specified period of time.

**Mitigation** - An action intended to reduce the adverse impact of a specific project or development.

**Mixed-origin stock** - A stock whose individuals originated from commingled native and non-native parents; or a previously native stock that has undergone substantial genetic alteration.

**Mixed stock** - A stock whose individuals originated from commingled native and non-native parents, and/or by mating between native and non-native fish (hybridization); or a previously native stock that has undergone substantial genetic alteration.

**Mixed-stock fisheries** - Any fishery that catches fish from more than one stock.

**National Marine Fisheries Service (NMFS)** - A branch of the National Oceanic and Atmospheric Administration, Department of Commerce whose responsibilities include administration of the endangered species act for anadromous and marine fish.

**National Pollution Discharge Elimination System (NPDES)** - A program under the federal Clean Water Act.

**Native population** - See *Native stock*.

**Native species** - A species of fish indigenous to Washington State.

**Native stock** - An indigenous stock of fish that has not been substantially impacted by genetic interactions with non-native stocks or by other factors, and is still present in all or part of its original range. In limited cases, a native population may also exist outside of its original range (e.g. in a captive broodstock program).

**Natural fish** - A fish that has spent essentially all of its life-cycle in the wild and whose parents spawned in the wild. Synonymous with *natural origin recruit (NOR).*

**Natural Origin Recruit (NOR)** - See *Natural fish*.

**Natural population** - See *Natural stock*.

**Natural Return Rate (NRR)** - The number of native, naturally produced fish spawning in on generation divided by the total number of naturally spawning fish (hatchery plus naturally -produced fish) in the previous generation.

**Natural spawners (NS)** - See *Natural fish*.

**Natural stock** - A stock that is sustained by natural spawning and rearing in the natural habitat.

**Nearshore** - Defined in terms of habitat use by summer chum, nearshore habitat includes intertidal and shallow sub-tidal areas (less than 2 meters or 6.5 feet in depth relative to mean lower low-water), and includes beaches, mud- and sandflats, eelgrass, kelp, and macroalgae beds used by smaller summer chum juveniles for feeding and migration.

**Net pen** - A fish-rearing enclosure used in lakes and marine areas.

**Non-native stock (population)** - A stock (population) that has become established outside of its original range.

**Non-target population** - Any natural populations that is not intended to be integrated with a particular artificial propagation program.

**North of Falcon (NOF)** - An annual pre-season salmon management process for fisheries occurring between Cape Falcon (Oregon) and the Canadian border.

**North Olympic Salmon Coalition (NOSC)** - NOSC is based in Hadlock, Washington, and is one of twelve Regional Fisheries Enhancement Groups established by the Washington State legislature in 1991. Funds for projects and administration are provided through sales of recreational and commercial salmon licenses, and salmon carcass sales from state hatchery facilities. Technical support for the group is provided by the WDFW Volunteer Program. NOSC is volunteer-based, and is active in salmonid enhancement and habitat improvement projects throughout the Strait of Juan de Fuca region, including the Salmon Creek summer chum supplementation and Chimacum Creek reintroduction programs, which are operated co-operatively with Wild Olympic Salmon and WDFW.

**Northwest Indian Fisheries Commission (NWIFC)** - Created in 1974 by treaty Indian tribes in western Washington, the commission's role is to assist the tribes in conducting orderly and biologically sound fisheries.

**Nutrients** - Chemical compounds derived from organic and inorganic sources which move through the soil, air, water, and living organisms. Many nutrients, such as carbon dioxide ($CO_2$), are essential for life but can become harmful to organisms in excessive quantities.

**Off-channel area** - Any relatively calm portion of a stream outside of the main flow.

**Ordinary high water mark** - A distinctive change in the character of soil, banks, and vegetation in the area adjoining a stream channel related to typical and yearly high flow events.

**Pacific Decadal Oscillation (PDO)** - A pattern of climate and ocean condition regimes occurring in the north Pacific Ocean (associated with the Aleutian low pressure system) that results in shifts in sea surface temperatures and plankton abundance on a decadal time scale.

**Pacific Salmon Commission (PSC)** - The Pacific Salmon Commission is the bilateral commission with responsibility for administering the PST.

**Pacific Salmon Treaty (PST)** - The Pacific Salmon Treaty, signed between the U.S. and Canada in 1985, governs salmon interceptions by each country.

**Parties (to the recoverey plan**) - The co-managers (the Point-No-Point Treaty tribes and WDFW) alnong with USFWS, and NMFS are "parties" to the recovery plan.

**Peak flows** - Extremely high winter-time flows which can cause excessive streambed scour and damage or destroy salmon eggs incubating in the gravel. Peak flows can become more severe as a result of an increase in impervious surfaces and a reduction of hydrologic maturity, both of which increase the rate of water delivery to stream channels.

**Pieces per meter (pcs/m)** - Refers to large woody debris in streams.

**Pinniped** - Marine mammals of the suborder *Pinnipedia*, including seals, sea lions, and walruses.

**Piscivorous** - Organisms that feed on fishes.

**Point-No-Point Treaty Council (PNPTC)** - An intergovernmental fisheries management agency serving the four Point No Point Treaty Tribes whose usual and accustomed fishing areas include Hood Canal and Strait of Juan de Fuca. See also Point No Point Treaty Tribes.

**Point-No-Point Treaty Tribes (PNPTT)** - Point-No-Point Treaty Tribes; including Jamestown S'Klallam, Lower Elwha Klallam, Port Gamble S'Klallam, and Skokomish.

**Pool** - A relatively deep, still section in a stream.

**Population** - Synonymous with the term *stock*.

**Population Viability Analysis (PVA)** - A statistical analysis that provides an estimate of the probability that a population will become extinct over a specific time frame.

**Pre-terminal fishing (management) area** - Marine waters where specific stocks (or groups of stocks) are mixed with fish returning to other regions. These areas for summer chum salmon include all marine waters of Admiralty Inlet, the Strait of Juan de Fuca, and the Pacific Ocean seaward of Hood Canal and Discovery, Sequim, and Dungeness bays.

**Production type** - The method of spawning and rearing that produced the fish that constitute a stock.

**Productivity** - A measure of a biological system's ability to supply organisms with energy and resources to feed, grow, and survive.

**Puget Sound Salmon Management Plan (PSSMP)** - A state/tribal salmon management plan for the Puget Sound region adopted in 1985 as a part of U.S. v. Washington.

**Quilcene National Fish Hatchery (QNFH)** - A fish culture station operated by the USFWS on the Big Quilcene River.

**Recolonization** - The reestablishment of a salmonid stock in a habitat that the species previously occupied.

**Recovery project** - Artificial production projects primarily designed to aid in the recovery, conservation or reintroduction of particular natural population(s).

**Recruits** - The total numbers of fish of a specific stock available at a particular stage of their life history.

**Redd** - A spawning site for a pair of salmon, where eggs are buried in gravels for incubation and hatching.

**Regional fisheries enhancement group** - One of 12 regional fisheries enhancement (volunteer) groups funded under recreational and commercial salmon license fees, allowed to do habitat enhancement projects plus rear and release salmon into state waters under the direction of WDFW.

**Refugia** - Areas where an animals can go to escape predation or unfavorable environmental conditions.

**Remote Site Incubator (RSI)** - A lightweight, dark colored plastic barrel incubator that employs plastic substrate (hatching medium), and can be sized to accommodate 5,000 to 125,000 eggs per incubator. They are used mainly for incubating chum salmon eggs.

**Resident fish** - A life history type in which all life stages (e.g. spawning, rearing, growth, maturation) occur in small headwater streams, often upstream from impassable physical barriers.

**Resilience** - The potential for recovery if a loss occurs.

**Riffle** - A shallow gravel area of a stream that is characterized by increased velocities and gradients, and is the predominate stream area used by salmon for spawning.

**Riparian** - Referring to the transition area between aquatic and terrestrial ecosystems. The riparian *zone* includes the channel migration zone and the vegetation directly adjacent to the CMZ that influence channel habitat through alteration of microclimate or input of LWD. The riparian *buffer* refers to the strip of vegetation left adjacent to rivers, streams, estuaries, and coastlines following human alterations (harvest or development). Riparian *function* refers to LWD-recruitment and stream-shading functions provided by riparian vegetation, which if removed, result in a change in the physical, chemical, or biological properties to the waterbody.

**Risk assessment** - Evaluating the probability of an action having a negative impact that is not within prescribed limits or acceptable bounds.

**River mile (RM)** - A statute mile measured along the center line of a river. River mile measurements start at the stream mouth (RM 0.0)..

**Riverine** - Referring to the entire river network, including tributaries, side channels, sloughs, intermittent streams, etc.

**Run** - The sum of stocks of a single salmonid species which migrates to a particular region, river, or stream of origin at a particular season.

**Run Reconstruction -** A post season accounting of all salmon harvest and escapement for each individual stock or management unit.

**Salmon and Steelhead Habitat Inventory and Assessment Project (SSHIAP)** - A state/tribal cooperative program to gather, analyze, and inventory data on the amount and condition of salmon and steelhead habitat.

**Salmon and Steelhead Stock Inventory (SASSI) -** A cooperative program by the Washington Department of Fish and Wildlife, and Washington Treaty Indian Tribes to inventory and rate the status of salmon and steelhead stocks on a recurring basis. The 1993 SASSI identified salmonid stocks and their status with information on stock origin and history and provided descriptions of the factors which affect stock status. The inventory process is no longer confined to just salmon and steelhead, and now encompasses several additional salmonid species. Future inventories will be titled Salmonid Stock Inventory (SaSI) to accommodate the inclusion of anadromous trout species.

**Salmonid** - Any member of the taxonomic family Salmonidae, which includes all species of salmon, trout, char, whitefish, and grayling.

**Salmon Recovery Office (SRO) -** Also called the Governor's Salmon Recovery Office, it is a State work group that coordinates statewide efforts dealing with all aspects of salmon recovery.

**Saltmarsh** - A grass-dominated wetland periodically inundated by saltwater.

**Salvage** - The removal of snags, downed logs, windthrow, or dead and dying material.

**Scour chain** - A device that is inserted into a gravel streambed and used to measure scour or streambed instability.

**Selective fishery** - A fishery that allows the release of non-targeted fish stocks/runs, including unmarked fish of the same species.

**Self-sustaining population** - A population of salmonids that exists in sufficient numbers to replace itself through time without supplementation with hatchery fish. It does not necessarily produce surplus fish for harvest.

**Set gillnet** - A gillnet which is anchored, tied, staked, laid in part on shore, or whose lead line is so heavily weighted that it cannot drift (WAC 220-16-095).

**Shoreline Management Act** - A Washington State law which establishes a process for coordinated planning to protect shorelines and public uses of shorelines. The act requires that the Department of Ecology oversee and advise local governments in shoreline planning. Local governments develop shoreline erosion management standards and permit structural and non-structural erosion control measures adjacent to shorelines and large waterbodies.

**Sinuous** - Bending, winding, or curving.

**Site potential tree height (SPTH)** - The average maximum height attained by a tree within a specified time period, given particular site conditions. For the purposes of this plan, this period is 200-300 years, or the time necessary for a riparian forest to reach full maturity.

**Skiff gillnet** - A gillnet of single web construction with floats along the corkline sufficient to float the net. A skiff gillnet may be laid in part on shore, but may not be anchored, tied, or staked, nor have a lead line so heavily weighted that the net cannot drift (WAC 220-16-046).

**Smolt** - A juvenile anadromous salmonid which is undergoing the physiological and behavioral changes required to migrate from fresh water to salt water.

**Stock** - The fish spawning in a particular lake or stream(s) at a particular season, which to a substantial degree do not interbreed with any group spawning in a different place, or in the same place at a different season.

**Stock origin** - The genetic history of a stock.

**Stock status** - The current condition of a stock, which may be based on escapement, run-size, survival, or fitness level.

**Subestuary** - The area at the mouth of a river tributary to Hood Canal and the eastern Strait of Juan de Fuca that includes the delta, tidal channels, mudflats, marshes, and eelgrass meadows. See “estuarine landscape”.

**Substantial risk of extinction guideline** - Judgements regarding the acceptability of risks assumed through measures proposed in this plan may be based on whether the target population is believed to be in substantial danger of extinction within the next 36 years. This duration is derived from an average summer chum life span of 3.6 years applied to a 10 generation risk standard set forth by the Federal Court in judging extinction risk (Oregon Natural Resources Council v. NMFS and the State of Oregon 1998).

**Subtidal zone** - Shallow-water areas below mean low water.

**Summer chum salmon** - The earliest returning chum salmon (*Onchorynchus keta*) stocks in the Hood Canal and Strait of Juan de Fuca region. Summer chum salmon return from the ocean from mid-August through October, and spawn predominately in September and October. These stocks have been shown to be genetically distinct from fall and winter timed chum salmon.

**Supplementation** - The use of artificial propagation to maintain or increase natural production while maintaining the long-term fitness of the target population, and keeping the ecological and genetic impacts to non-target populations within specified biological limits.

**Targeted fishery** - A harvest strategy designed to catch a specific group of fish.

**Terminal fishing (management) area** - Marine waters near the ultimate freshwater destination of specific salmonid stocks (or groups of stocks) where they have separated from fish returning to other regions. These areas for summer chum salmon include all marine waters of Hood Canal, and Discovery, Sequim, and Dungeness bays.

**Thalweg** - A line connecting the deepest channel sections along a stream. In fisheries work "thalweg" commonly is used to identify the deepest portion of the channel along a stream.

**Timber Fish and Wildlife (TFW)** - A coalition of the timber industry, state and local governments, tribes, and recreational and environmental groups that addresses the interactions of timber management activities and fish.

**Total population size (*N*)** - The number of spawners cumulated over a number of years equivalent to one generation. For summer chum salmon, total population size can be calculated; $N$ = Average escapement times 3.6 (generation length).

**Trend** - The directional change in a time-series data set.

**Tribal Fish Ticket data base (TFT)** - Maintained by the NWIFC.

**Tributary** - A stream feeding, joining or flowing into a larger stream, a lake, or saltwater.

**Unknown stock** - A stock for which there is insufficient information to identify stock origin or stock status with confidence.

**U.S. Fish and Wildlife Service (USFWS)** - A branch of the federal Department of Interior whose responsibilities include administration of the endangered species act as it affects non-anadromous fish and steelhead, wildlife and plants.

**U.S. Forest Service (USFS)** - A branch of the Department of Agriculture.

**U.S. v. Washington** - A 1974 Federal Court Decision that affirmed the fishing rights of western Washington Treaty Indians Tribes. Commonly referred to as the "Boldt Decision".

**Viable population** - A population in a state that maintains its vigor and its potential for evolutionary change.

**Washington Catch Record Card Area** - A WDFW sport salmon harvest reporting system that uses standard catch areas (identified by number).

**Washington Commercial Catch Reporting Area** - A WDFW commercial salmon harvest reporting system that uses standard catch areas (identified by number).

**Washington Department of Fish and Wildlife (WDFW)** - Created by the merger of the Washington Department of Fisheries (WDF) and the Washington Department of Wildlife (WDW) in 1994.

**Water resource inventory area (WRIA)** - Watershed-based planning unit, defined by the Washington State Department of Ecology. WRIAs are determined by drainages and common water bodies.

**Watershed** - The region drained by or contributing water to a stream, lake or other body of water, physically separated from other watersheds by a drainage divide..

**Watershed Administrative Unit (WAU)** - The State of Washington has been divided into approximately 800 watersheds called Watershed Administrative Units, the boundaries of which are described in the Department of Natural Resources Watershed Administrative Unit Map. These are the basic geographic units for the process of watershed analysis administered by the Department of Natural Resources.

**Watershed Analysis** - A systematic procedure for characterizing watershed and ecological processes to provide a basis for resource management planning.

**Western Washington Treaty Indian Tribes (WWTIT)** - Indian tribes located west of the Cascade Crest that have been recognized by the United States government, with usual and accustomed fishing grounds, and whose fishing rights were reserved under a treaty and have been affirmed by a federal court.

**Wetland** - An area that is inundated or saturated by surface or ground water at a frequency and duration sufficient to naturally support distinct soil and vegetation types. Wetlands interact with surface and ground waters and can regulate stream flow, moderating extreme winter peak and summer low flow conditions.

**Wild Olympic Salmon (WOS)** - Based in Chimacum, Washington, WOS is an independent, private organization dedicated to the perpetuation and recovery of Washington salmonid populations. The group is volunteer-based, and is active in salmonid enhancement and habitat improvement projects throughout the Strait of Juan de Fuca region. The group operates the Salmon Creek summer chum supplementation and Chimacum Creek reintroduction programs co-operatively with North Olympic Salmon Coalition and WDFW.

**Wild stock** - A stock that is sustained by natural spawning and rearing in the natural habitat, regardless of parentage (includes native).

**Wild Stock Restoration Initiative (WSRI)** - A cooperative program between the state and western Washington Indian tribes that is intended to maintain and restore healthy salmon ad steelhead stocks and habitats.

**Within-stock diversity** - The overall genetic variability among individuals of a single population or stock.

## Acronyms and Abbreviations

**AUC** - Area Under the Curve.
**BBC** - Big Beef Creek.
**BCR** - Base Conservation Regime.
**BMP** - Best Management Practices.
**CDFO** - Canadian Department of Fisheries and Oceans
**cfs** - Cubic feet per second.
**CMZ** - Coastal Management Zone.
**COE** - U.S. Army Corps of Engineers.
**CRC** - Catch Record Card.
**CREP** - Washington State Conservation Enhancement Program**.**
**CTED** - Washington State Department of Community, Trade and Economic Development.
**CWT** - Coded Wire Tag.
**dbh** - Diameter at breast height.
**DNA** - Deoxyribonucleic acid.
**DNR** - Washington State Department of Natural Resources.
**DO** - Dissolved oxygen.
**DOE** - Washington State Department of Ecology.
**DOT** - Washington State Department of Transportation.
**EDF** - Escapement Distribution Flag.
**EHB** - Engrossed House Bill (Washington State Legislature).

**ELJ** - Engineered logjam.
**ENSO** - El Niño-Southern Oscillation.
**EPA** - U.S. Environmental Protection Agency.
**ESA** - Endangered Species Act.
**ESU** - Evolutionarily Significant Unit.
**FAO/UN** - Food and Agriculture Organization of the United Nations.
**FEMA** - Federal Emergency Management Agency.
**FEMAT** - Forest Ecosystem Management Assessment Team.
**FERC** - Federal Energy Regulatory Commission.
**fpp** - fish per pound.
**fl** - Fork length.
**GIS** - Geographic Information System.
**GSI** - Genetic Stock Identification.
**HB** - House Bill (Washington State Legislature).
**HC** - Hood Canal .
**HCCC** - Hood Canal Coordinating Council.
**HCP** - Habitat Conservation Plan.
**HCPEP** - Hood Canal Production and Evaluation Program.
**HCSEG** - Hood Canal Salmon Enhancement Group.
**HCSMP** - Hood Canal Salmon Management Plan.
**HC-SJF** - Hood Canal and Strait of Juan de Fuca.
**HCWCP** - Hood Canal Wild Coho Salmon Evaluation and Rehabilitation program.
**HPA** - Hydraulic Project Approval.
**IFIM** - Instream Flow Incremental Methodology.
**JCL** - Jimmycomelately Creek.
**JNRC** - Joint Natural Resources Cabinet.
**LLTK** - Long Live The Kings.
**LWD** - Large Woody Debris.
**MEF** - Minimum Escapement Flag.
**MHCLS** - Microcomputer Historic Catch and Landing Summary.
**MHHW** - Mean higher high water.
**MLLW** - Mean lower low water.
**MSY** - Maximum Sustained Yield.
**MU** - Management Unit.
**MVP** - Minimum viable population.
$N$ - Total population size.
**NA** - Not applicable.
$N_e$ - Effective population size.
**NFH** - National Fish Hatchery.
**NMFS** - National Marine Fisheries Service.
**NOF** - North of Falcon.
**NOR** - Natural Origin Recruit.
**NOSC** - North Olympic Salmon Coalition.
**NPDES** - National Pollution Discharge Elimination System.

**NPS** - U.S. National Park Service.
**NRC** - National Research Council.
**NRR** - Natural Return Rate.
**NS** - Natural spawners.
**NWIFC** - Northwest Indian Fisheries Commission.
**pcs/m** - Pieces per meter.
**PDO** - Pacific Decadal Oscillation.
**PFMC** - Pacific Fisheries Management Commission.
**PNPTC** - Point-No-Point Treaty Council.
**PNPTT** - Point-No-Point Treaty Tribes.
**PNW** - Pacific Northwest.
**PSC** - Pacific Salmon Commission.
**PSCRBT** - Puget Sound Cooperative River Basin Team.
**PSMFC** - Pacific Salmon Marine Fisheries Commission.
**PSSFI** - Puget Sound Stream Flow Index.
**PSSMP** - Puget Sound Salmon Management Plan.
**PST** - Pacific Salmon Treaty.
**PSWQAT** - Puget Sound Water Quality Action Team.
**PUD** - Public Utility District.
**PVA** - Population Viability Analysis.
**QNFH** - Quilcene National Fish Hatchery.
**RCW** - Revised Code of Washington.
**RM** - River Mile.
**RSI** - Remote Site Incubator.
**SASSI** - Salmon and Steelhead Stock Inventory.
**SEPA** - State Environmental Policy Act.
**SJF** - Strait of Juan de Fuca.
**SPTH** - Site potential tree height.
**SR** - State Route highway.
**SRO** - Governor’s Salmon recovery Office.
**SSHIAP** - Salmon and Steelhead Habitat Inventory and Assessment Project.
**STC** - Simpson Timber Company.
**TFT** - Tribal Fish Ticket data base.
**TFW** - Timber Fish and Wildlife.
**USFS** - U.S. Forest Service.
**USFWS** - U.S. Fish and Wildlife Service.
**USDA** - U.S. Department of Agriculture.
**USDI** - U.S. Department of Interior.
**USGS** - U.S. Geological Survey.
**UW** - University of Washington.
**WAC** - Washington Administrative Code.
**WAU** - Watershed Administrative Unit.
**WCVI** - West Coast Vancouver Island.
**WDF** - Washington Department of Fisheries.

**WFPB** - Washington Forest Practices Board.
**WDFW** - Washington Department of Fish and Wildlife.
**WDW** - Washington Department of Wildlife.
**WOS** - Wild Olympic Salmon
**WRIA** - Water Resource Inventory Area.
**WSRI** - Wild Stock Restoration Initiative.
**WWTIT** - Western Washington Treaty Indian Tribes.

# Part One
# Appendix

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**Appendix Reports**

# Appendix Figures

**Appendix Figure 1.1.** UPGMA clustering of Cavali-Sforza and Edwards (1967) chord distances among Hood Canal and Strait of Juan de Fuca summer-run chum salmon populations.

**Appendix Figure 1.2.** Three-dimensional scaling of genetic distances among Hood Canal and Strait of Juan de Fuca summer-run chum salmon populations.

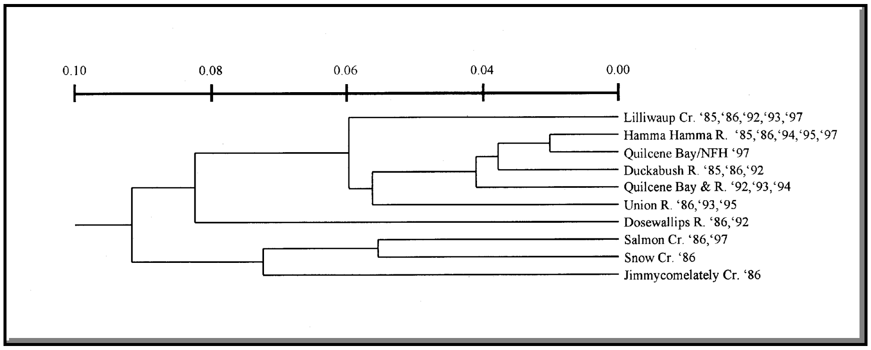

**Figure 1.1.** UPGMA clustering of Cavali-Sforza and Edwards (1967) chord distances among Hood Canal and Strait of Juan de Fuca summer-run chum salmon populations.

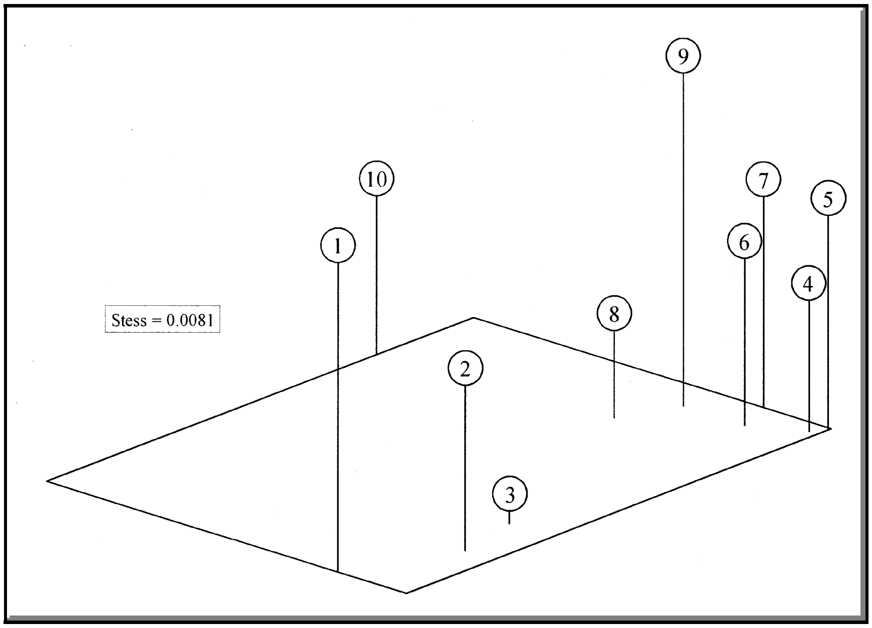

**Figure 1.2.** Three-dimensional scaling of genetic distances among Hood Canal and Strait of Juan de Fuca summer-run chum salmon populations. Collections are as follows: 1 = Snow Creek 1986; 2 = Salmon Creek 1986; 3 = Jimmycomelately Creek 1986; 4 = Duckabush River 1985, 1986, 1992; 5 = Quilcene Bay/National Fish Hatchery 1997; 6 = Hamma Hamma River 1985, 1986, 1994, 1995, 1997; 7 = Quilcene Bay/River 1992, 1993, 1994; 8 = Union River 1986, 1993, 1995; 9 = Lilliwaup Creek 1985, 1986, 1992, 1993, 1997; 10 = Dosewallips river 1986, 1992.

# Appendix Tables

**Appendix Table 1.1.** Summer chum salmon spawning escapement estimates in the Hood Canal and Strait of Juan de Fuca region (1968-1998).

**Appendix Table 1.2.** Big Quilcene summer chum salmon return year age samples collected in Quilcene Bay fisheries and at the QNFH from 1992 to 1998.

**Appendix Table 1.3.** Hood Canal summer chum salmon return year age samples collected in mixed stock fisheries from 1976 to 1996 (ages for years with >100 fish sampled in bold).

**Appendix Table 1.1.** Summer chum salmon spawning escapement estimates in the Hood Canal and Strait of Juan de Fuca region (1968-1998).
*Excluded values = missing estimates; Italicized = estimates based on regression or extrapolation.*

| Return Year | Jimmy Come Lately | Snow | Salmon Natural | Salmon Brdstk | Salmon Total | Big Beef | Anderson | Dewatto | Tahuya | Union | Lilliwaup | Hamma Hamma | Duckabush | Dosewallips | Big Quilcene Natural | Big Quilcene Brdstk | Big Quilcene Total | Little Quilcene |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1968 | | | | | | 100 | | 2,275 | | | | 13,548 | 4,693 | | 5,797 | | 5,797 | 897 |
| 1969 | | | | | | 100 | | 280 | | | | 3,104 | 3,871 | | 1,307 | | 1,307 | |
| 1970 | | | | | | 178 | 65 | 2,666 | | | | 1,390 | 2,301 | | 655 | | 655 | 12 |
| 1971 | | | 249 | | 249 | 159 | 125 | 2,012 | | | 318 | 4,282 | 3,904 | | 1,798 | | 1,798 | 71 |
| 1972 | | 436 | 534 | | 534 | 177 | 225 | 1,403 | 4,487 | | 716 | 5,346 | 13,546 | 1,733 | 2,067 | | 2,067 | 300 |
| 1973 | | | 636 | | 636 | 244 | | 691 | | | | | 5,761 | 623 | 3,107 | | 3,107 | 238 |
| 1974 | ***438*** | 818 | 512 | | 512 | 75 | 0 | 181 | 880 | 68 | 616 | ***2,448*** | 3,581 | ***3,593*** | 795 | | 795 | 44 |
| 1975 | ***348*** | 327 | 755 | | 755 | 1,15 | 195 | 613 | 1,389 | ***84*** | 706 | ***7,341*** | 2,245 | ***2,250*** | 1,405 | | 1,405 | 868 |
| 1976 | ***365*** | 608 | 521 | | 521 | 1,28 | 234 | 741 | 3,200 | 100 | 1,612 | ***7,648*** | 6,095 | 3,271 | 2,445 | | 2,445 | 1,088 |
| 1977 | ***405*** | 538 | 701 | | 701 | 302 | ***26*** | 225 | 726 | 75 | 420 | ***1,675*** | 2,453 | 3,215 | 821 | | 821 | 773 |
| 1978 | ***778*** | 629 | 1,664 | | 1,664 | 680 | 16 | 544 | 266 | 35 | 1,331 | ***8,215*** | 1,898 | ***1,901*** | 2,978 | | 2,978 | 1,816 |
| 1979 | ***170*** | 133 | 458 | | 458 | 191 | 6 | 49 | 117 | ***90*** | 163 | ***3,096*** | 1,190 | ***1,190*** | 345 | | 345 | 110 |
| 1980 | ***1,326*** | 709 | 3,074 | | 3,074 | 123 | 2 | 117 | 178 | 208 | 247 | 329 | 827 | 1,216 | 375 | | 375 | 154 |
| 1981 | ***203*** | 242 | 439 | | 439 | 90 | 1 | 41 | 140 | 41 | 293 | 926 | 557 | 63 | 138 | | 138 | 84 |
| 1982 | 599 | 766 | 1,386 | | 1,386 | 0 | ***0*** | 21 | 86 | ***153*** | 84 | 801 | 690 | 507 | 156 | | 156 | 125 |
| 1983 | 254 | 154 | 731 | | 731 | 0 | 0 | 15 | 86 | 170 | 18 | 190 | 80 | 64 | 64 | | 64 | 176 |
| 1984 | 367 | 384 | 828 | | 828 | 22 | 1 | 44 | 142 | 194 | 187 | ***170*** | 299 | 212 | 60 | | 60 | 83 |
| 1985 | 61 | 20 | 151 | | 151 | 0 | 0 | 19 | 122 | 334 | 92 | ***231*** | 30 | 236 | 44 | | 44 | 1 |
| 1986 | 292 | 213 | 582 | | 582 | 0 | 0 | 20 | 109 | 1,892 | 97 | 173 | 177 | 57 | 15 | | 15 | 12 |
| 1987 | 464 | 465 | 1,062 | | 1,062 | 6 | 0 | 5 | 91 | 497 | 32 | 26 | 12 | 9 | 8 | | 8 | 71 |
| 1988 | 1,052 | 723 | 1,915 | | 1,915 | 0 | 0 | 23 | 145 | 629 | 275 | 440 | 497 | 661 | 120 | | 120 | 177 |
| 1989 | 173 | 21 | 194 | | 194 | 0 | 0 | 2 | 9 | 450 | 43 | 16 | 60 | 16 | 1 | | 1 | 1 |
| 1990 | 63 | 33 | 245 | | 245 | 0 | 0 | 0 | 6 | 275 | 2 | 90 | 42 | 8 | 6 | | 6 | 0 |
| 1991 | 125 | 12 | 172 | | 172 | 0 | 0 | 31 | 5 | 208 | 30 | 68 | 102 | 250 | 49 | | 49 | 1 |
| 1992 | 616 | 21 | 371 | 62 | 433 | 0 | 0 | 0 | 0 | 140 | 90 | 123 | 617 | 655 | 320 | 414 | 734 | 9 |
| 1993 | 110 | 11 | 400 | 52 | 452 | 0 | 0 | 1 | 0 | 251 | 72 | 69 | 105 | 105 | 97 | 50 | 147 | 12 |
| 1994 | 15 | 2 | 137 | 24 | 161 | 0 | 0 | 0 | 0 | 738 | 105 | 370 | 263 | 225 | 349 | 393 | 742 | 0 |
| 1995 | 223 | 25 | 538 | 53 | 591 | 0 | 0 | 0 | 0 | 721 | 79 | 476 | 825 | 2,787 | 4,029 | 498 | 4,527 | 54 |
| 1996 | 30 | 160 | 785 | 109 | 894 | 0 | 0 | 0 | 5 | 494 | 40 | 774 | 2,650 | 6,976 | 8,479 | 882 | 9,361 | 265 |
| 1997 | 61 | 67 | 724 | 110 | 834 | 0 | 0 | 6 | 0 | 410 | 10 | 104 | 475 | 47 | 7,339 | 657 | 7,996 | 29 |
| 1998 | 98 | 28 | 1,013 | 121 | 1,134 | 2 | 0 | 12 | 0 | 223 | 4 | 95 | 226 | 336 | 2,244 | 544 | 2,788 | 265 |

**Appendix Table 1.2.** Big Quilcene stock summer chum salmon return year ages from fish collected in Quilcene Bay fisheries and at the QNFH from 1992 to 1998.

| Return Year | Number sampled | % Age-2 | % Age-3 | % Age-4 | % Age-5 |
|---|---|---|---|---|---|
| 1992 | 210 | 0.0 | 3.3 | 98.6 | 0.0 |
| 1993 | 33 | 6.1 | 6.1 | 18.2 | 69.7 |
| 1994 | 309 | 1.0 | 91.6 | 6.1 | 1.3 |
| 1995 | 407 | 0.0 | 95.8 | 4.2 | 0.0 |
| 1996 | 481 | 1.9 | 4.0 | 94.2 | 0.0 |
| 1997 | 457 | 0.4 | 88.8 | 6.1 | 4.6 |
| 1998 | 396 | 0.3 | 65.7 | 33.6 | 0.5 |

**Appendix Table 1.3.** Hood Canal summer chum salmon return year age samples collected in mixed stock fisheries from 1974 to 1998 (ages for years with >100 fish sampled in bold).

| Return Year | Sample size | % Age-3 | % Age-4 | % Age-5 |
|---|---|---|---|---|
| 1974 | 0 | – | – | – |
| 1975 | 0 | – | – | – |
| 1976 | unknown | 11.2 | 88.8 | 0.4 |
| **1977** | **102** | **41.3** | **52.0** | **6.7** |
| **1978** | **285** | **51.9** | **47.7** | **0.4** |
| **1979** | **167** | **34.7** | **61.1** | **1.8** |
| **1980** | **1,201** | **59.3** | **39.9** | **0.2** |
| **1981** | **691** | **39.4** | **55.1** | **3.9** |
| **1982** | **465** | **35.9** | **61.9** | **1.9** |
| 1983 | 87 | 65.5 | 31.0 | 3.5 |
| 1984 | 72 | 33.3 | 61.1 | 0.0 |
| **1985** | **115** | **74.8** | **24.3** | **0.0** |
| **1986** | **361** | **55.1** | **42.7** | **1.7** |
| **1987** | **180** | **33.9** | **61.7** | **3.3** |
| 1988 | 31 | 16.1 | 67.7 | 16.1 |
| 1989 | 18 | 5.8 | 90.5 | 3.6 |
| 1990 | 11 | 9.1 | 81.8 | 0.0 |
| 1991 | 19 | 26.3 | 68.4 | 5.3 |
| **1992** | **203** | **3.9** | **95.6** | **0.5** |
| 1993 | 58 | 39.1 | 15.9 | 27.5 |
| 1994 | unknown | 91.6 | 6.1 | 1.3 |
| 1995 | 0 | – | – | – |
| 1996 | 0 | – | – | – |
| 1997 | 0 | – | – | – |
| 1998 | 0 | – | – | – |

# Appendix Report 1.1
# Methodology For Summer Chum Salmon Escapement Estimation

## Introduction

In response to the populations trends and pending ESA review processes for summer chums in the Hood Canal and Strait of Juan de Fuca regions the Washington Department of Fish and Wildlife (WDFW), and the member Tribes of the Point No Point Treaty Council (PNPTC) initiated a program in 1997 to develop a recovery plan for the summer chum populations in the region. A co-manager's summer chum restoration committee was assembled for development of the recovery plan, and proceeded to identify several data analysis needs. One of the identified needs was to re-examine the historical escapement estimations for these populations, and develop a new historical escapement database that applied consistent and well documented analytical techniques to the revised estimates.

WDFW and Washington Treaty Indian Tribes cooperatively conduct annual escapement estimation programs for many Washington salmon populations. The field data collection and analysis methods used to derive the escapement estimates are both species, and region and/or stock-specific. It is assumed that escapement estimates derived for most salmon stocks in more recent years have generally higher precision than those for earlier years because field data collection, survey effort, and data analysis methods have become more standardized, and increased knowledge and experience of the biologists conducting the estimates has resulted in more appropriate and consistent analysis of the annual field census data.

In 1997-98 revised estimates of escapement were derived for the 1968 to 1997 return years, utilizing a uniform group of analytical techniques and assumptions. An ordinal rating of the uncertainty in each estimate was also assigned, based on assessment uncertainties associated with each estimate. The same estimation approaches were subsequently applied to the 1998 summer chum escapement estimates for watersheds in the Hood Canal and Strait of Juan de Fuca region (and will continue to be used for future years).

## Review of escapement estimation methodologies used for Washington chum salmon

Puget Sound salmon escapement census methods have historically included fish and/or redd counts, fishway counts, and carcass or live fish tagging and recovery (Ames 1984). Assessment of spawning escapements for management purposes were most commonly done in the time period prior to the mid-1970s by calculation of “fish/mile” estimates derived from the peak survey counts[1] of live and dead fish in selected surveyed stream reaches (WDF 1964). Estimates of total spawning escapements of naturally spawning salmon to individual Washington streams (based on defensible quantitative methods) were rarely generated prior to the 1970s. The exceptions were for the few streams where weir or fishway count data were available, or when mark-and-recapture escapement estimation studies were performed.

In the late 1970s the “Area-Under the-Curve” (AUC) methodology was adopted for estimating escapements of many Washington pink and chum populations. This method was used by itself in smaller stream basins, or in conjunction with expansion values derived from tagging studies to derive basin-side estimates on some of the larger Puget Sound tributaries, such as the Skagit, Stillaguamish, Snohomish, and Nisqually rivers. In 1978 Washington Department of Fisheries (WDF – now WDFW) staff reviewed the historical chum survey data collected to date in the Hood Canal and southern Puget Sound regions, and derived new or revised escapement estimates for most of the major chum bearing stream basins for the time period 1968 to 1977. This process was repeated for the northern Puget Sound region in 1984. AUC has since been used as a primary escapement estimate derivation tool for most Puget Sound chum, pink, sockeye, coho, and chinook populations, where periodic live fish or spawning redd counts are the primary population data available. More detailed discussions of the AUC methodology can be found in several publications, including Ames (1984), English et al. (1992), Haymes (2000), and Lady (1996), Hilborn et al. (1999).

Given there is inter-stream and inter-annual variability in the quality of the census data collected, and that there are elements of subjectivity in application of the AUC escapement estimation method, it was determined by the members of the WDFW/PNPTC summer chum technical committee that a comprehensive review and revision of the summer chum escapement estimates was needed to provide the highest quality and most precise escapement database for the recovery planning process. An ordinal rating system (Zar 1984) for the relative quality of each individual escapement estimate was developed during the revision process, to provide users of the escapement data with an indicator of the relative quality of each estimate (good, fair, poor, etc.).

## Historical monitoring of Hood Canal and Strait of Juan de Fuca summer chum escapements

The first quantitative observations of summer chum spawning abundance recorded in the WDFW spawning survey database were collected in 1943 (J. Haymes, WDFW Olympia WA, pers. comm.). Early observation records (1943-47) were confined to the Dosewallips, Duckabush, and Hamma Hamma rivers. Information in the database for these observations is mostly limited to summaries of the total number of live and dead fish observed in the survey reach, river mile boundaries of the reach surveyed, and the date of observation. There were no Hood Canal or Strait summer chum stream observations recorded for the time period 1948 to 1950. In 1951 an “index reach” survey system was developed by WDF to monitor stream escapements of salmon in each region of

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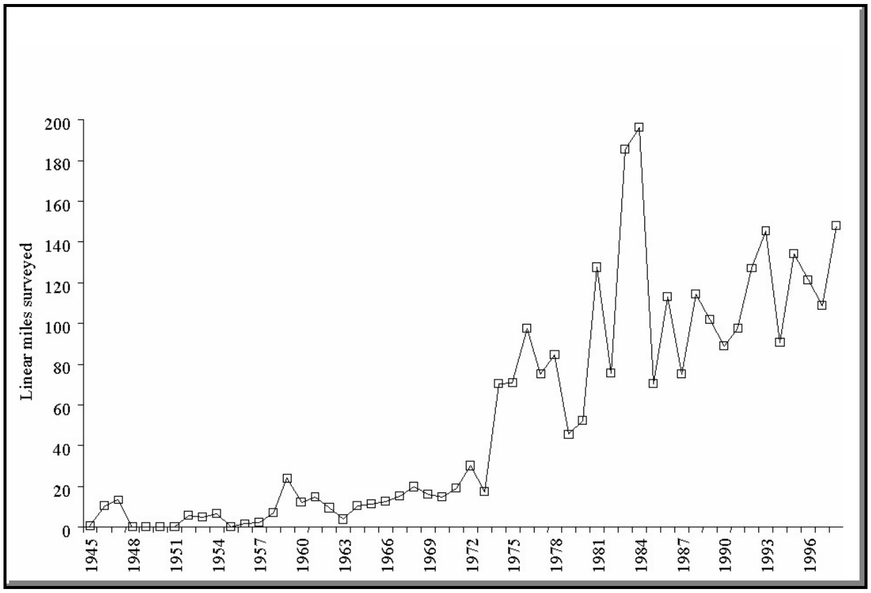
[1] Which may not reflect the actual peak abundance of fish in the index reach, since annual scheduling of the peak survey was based upon professional judgement, and expectations of previous observed run timing patterns.

Washington on an annual basis (Egan 1982), and the scope of survey effort was expanded through the early 1950s time period to meet the objectives of this program. The index reaches encompassed (somewhat) fixed sections of selected streams. One to three surveys were typically conducted annually on each index reach. It is assumed that the selection of streams surveyed, sections surveyed, and timing of the survey(s) were based on review of available information and professional judgment that the survey reaches were representative of the spawning escapements of one or more salmon species to each geographic region of the state.

The Boldt Decision in 1974 prompted WDF and Washington Department of Game (WDG) to revise many of their salmon and steelhead escapement estimation techniques in the mid-1970s, due to the need for more accurate and/or precise estimates of escapements to meet new fishery management objectives and obligations. Consequently, survey effort was greatly increased in this time period. Many Treaty Indian tribes also developed or expanded fishery management programs in this time period and began to participate more extensively in spawning survey efforts.

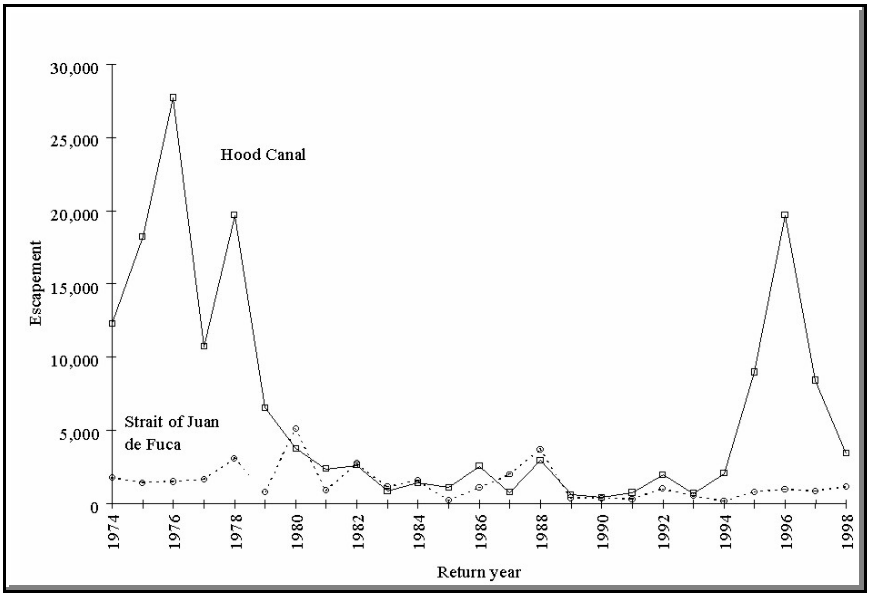
Appendix Figure 1.1.1 summarizes the historical reported annual chum spawning survey effort for summer chum streams in the Hood Canal region that have received dedicated, long-term annual summer chum survey effort for the time period 1945-98. These are Anderson Creek, Dewatto Creek, Tahuya River, Union River, Hamma Hamma River, Duckabush River, Dosewallips River, Big Quilcene River, Little Quilcene River, Snow Creek, Salmon Creek, and JimmyComeLately Creek. Only surveys conducted in the annual time period Aug. 1 to Oct. 31 are included. In general live fish counted after ~ Oct. 20 are very likely to be early returning fall chum salmon, and not used in the summer chum escapement estimates. Survey information for late October is included in the field data summary tables and charts because it is a transitional period in the streams from summer to fall chum stock entry.



**Appendix Figure 1.1.1.** Annual reported distance surveyed on Hood Canal and Strait of Juan de Fuca streams 1945-98.

## Summary of revised escapement estimates for Hood Canal and Strait of Juan de Fuca wild summer chum populations

Appendix Figure 1.1.2 summarizes the annual aggregate natural spawning summer chum escapement estimates for the Hood Canal and Strait of Juan de Fuca regions for 1974-1998 (the 1968-1973 time period is omitted because of the limited number of individual stream escapement estimates available in this time period).

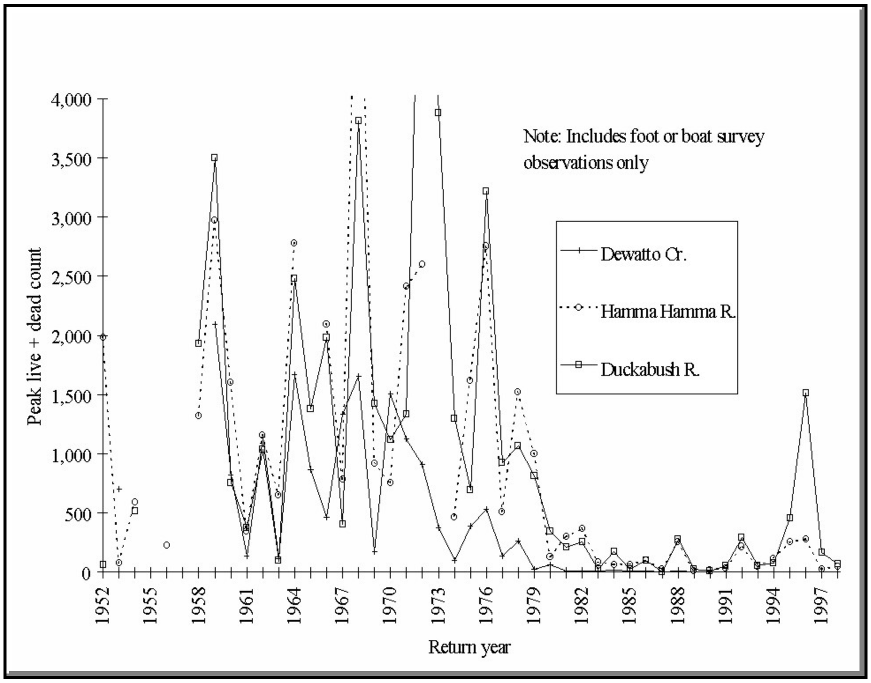


**Appendix Figure 1.1.2.** Hood Canal and Strait of Juan de Fuca summer chum spawning escapements, 1974-98.

In summary, a period of relatively large escapements in the Hood Canal region in the mid - 1970s was followed by a period of very poor escapements in the 1980s, a recent rebound in the 1995-96 period, and then a decline in the 1997-98 period. Unfortunately during the mid-1980s period the populations in several east shore Hood Canal tributaries become extirpated (Anderson Creek, Dewatto River, Big Beef Creek, and Tahuya River). Since this time period the majority of the total escapement for the Hood Canal region has occurred only in the west shore Hood Canal streams, with small to moderate numbers in the Union R. (100-300 fish). The Strait of Juan de Fuca streams have experienced relatively stable escapements overall. However, individual streams in this region, particularly Snow and Jimmy-Come-Lately creeks have periodically experienced extremely low escapements through this time period (< 100 fish).

For a longer term (mid-1900s to present) perspective on escapements to the Hood Canal region, Appendix Figure 1.1.3 summarizes the annual peak summer chum count (mid - September to mid - October period) for three selected Hood Canal streams that had adequate numbers of historical survey observations to facilitate a long term trend analysis (Dewatto, Hamma Hamma, and Duckabush rivers). The peak counts are not directly comparable to each other because each observation may or may not represent the absolute peak abundance for the year. Also, these values should not be rigorously compared to AUC estimates of total abundance for the years 1974 to

present, because the peak counts generally represent less than the total escapement to the stream. However, these observations do provide some indication on the relative abundance of summer chums over a longer time frame than the period formal escapement estimates have been derived.
A detailed summary of the escapement estimates for each summer chum stream in the Hood Canal and SJF region, and discussions of the field data and analysis issues for each estimate are presented



**Appendix Figure 1.1.3.** Peak live + lead counts of summer chum in Dewatto Creek (WRIA 15.0420), Hamma Hamma River (WRIA 16.0251), and Duckabush River (WRIA 16.0351), 1952-1998.

in the report Revised Estimates of Escapement for Hood Canal and Strait of Juan de Fuca Natural Spawning Summer Chum Populations (Haymes 2000), available as Supplemental Report No. 1 to this Summer Chum Salmon Conservation Initiative.

## Summer chum presence in other streams in the Region

Summer chum have been observed in several other streams in the region, generally sporadically and in small numbers. These observations were typically made during surveys targeted at other salmonid species. Most of these observations are likely the result of straying fish from other river systems, as suggested by the sporadic nature to the observations, and the small numbers of fish that were typically observed. However, review of historical records did lead to the addition of three streams to the list of watersheds in the region that appear to have contained substantial summer chum populations historically and/or currently. These are the Dungeness River, Skokomish River, and Finch Creek Insufficient data exists, however to determine historical abundance in these watersheds in detail.

The Dungeness River had sufficient observations of chum in the September/October time period to suggest that a self-sustaining population is present in the river. There are 70 historical survey observations of chum in the Dungeness River in the annual time period Aug. 1 – Oct. 31 in the WDFW survey database (Haymes 2000). The Skokomish River historically had a summer chum run present in some years, as indicated by historical in-river commercial fishery catch data, and spawning ground data. The most significant spawning ground observation was 233 summer chum on Sept. 20, 1976 (Haymes 2000). Given 1) there are only a limited number of survey observations of summer chum in this river basin, and 2) there were a fair number of chinook surveys conducted annually in the watershed during the typical summer chum spawning period that would have noted the presence of summer chums, the runsizes generally were likely typically fairly small in the recent historical time period (1960s-present). Finch Creek historically had returns of up to several hundred summer chum in the 1950s/60s time period, as indicated by summer chum capture data at the Finch Creek (Hoodsport) hatchery rack (Tynan and Ames 1997). Both the Skokomish and Finch creeks stocks are considered currently extirpated. Status of the Dungeness stock is unknown.

There are further discussions of this subject in Haymes (2000), and in the main body of this report.

## Bibliography

Ames, J. 1984. Puget Sound chum escapement estimates using spawner curve methodology. Pp. 133-148 in Symons, P.E.K. and M. Waldichuk (eds.) Proceedings of the Workshop on Stream Indexing for Salmon Escapement Estimation. Can. Tech. Rep. Fish. Aquat. Sci. No. 1326.

Egan, R. 1982. Puget Sound salmon spawning ground report - Water Resource Inventory Area 1-19 for escapement year 1982-83. WDF prog. rpt. no. 194. Wash. Dept. Fish and Wild., Olympia, WA. 574 p.

English, K.K., Bocking, R.C., and Irvine, J.R.. 1992. A robust procedure for estimating salmon escapement based on the area-under-the-curve method. Can. J. Fish. Aquat. Sci. 49:1982-1989.

Haymes, J. H. 2000. Revised estimates of escapement of Hood Canal and Strait of Juan de Fuca natural spawning summer chum populations. Supplemental Report No. 1 to the Summer Chum Salmon Conservation Initiative. Wash. Dept. Fish and Wild., Olympia, WA.

Lady, J. 1996. Release-recapture models for estimating the stream residue time of spawning salmon. Masters Thesis, Univ. of Wash., Seattle WA.

Tynan, T. and J. Ames. 1997. Memorandum to Orlay Johnson, National Marine Fisheries Service (NMFS), April 10, 1997 (subject: Hoodsport hatchery chum timing). Wash. Dept. Fish and Wild., Olympia, WA.

WDF (Washington Department of Fisheries). 1964. Report on the Salmon Escapement to the State of Washington, 1962. Wash. Dept. Fish and Wild., Olympia, WA. 96 p.

Zar, J. H. 1984. Biostatistical Analysis. Prentice Hall Inc., Englewood Cliffs, NJ.

# Appendix Report 1.2
# Methodology For Estimation of Summer Chum Salmon Escapement and Freshwater Entry Timing

## Introduction

Knowledge of run and spawning timing behaviors for migratory fish stocks is an important tool for fisheries management, and as an indicator of adaptive differences or similarities between different populations to their environments. Typically, the migratory behavior of salmonids is tracked through the application and subsequent recovery of internal marks (binary code wire and pit tags), external marks (fin marks, external tags, freeze brands), or genetic stock identification (GSI-used to monitor for the presence of genetic traits unique to particular populations/groups of populations). Pacific salmonids that typically out-migrate at the fry stage (pinks, chums) are generally more difficult to mark with current technologies than the other species, because of their small size during the freshwater residence/out-migration phase; the time at which the mark application phase of most Pacific salmonid marking programs are conducted. Because of the difficulty of marking chum out-migrants by traditional methods, and the small runsizes and limited economic importance of the summer chum populations in the Hood Canal and Strait of Juan de Fuca region, there historically have been no significant marking or GSI analysis programs. Some limited GSI data that identify the presence of these fish in certain commercial fisheries has been collected in recent years, and the Big Quilcene Hatchery has begun to clip adipose fins of summer chum releases being produced for the supplementation program (first return of fin clipped fish to occur in 2000).

In order to develop estimates of spawning timing and migratory timing through the terminal fishery areas for selected major Hood Canal-SJF region summer chum populations, the spawning census data from each population was analyzed to determine average spawning timing, and assumptions were made from these analyses to calculate terminal marine migratory timing. Washington Department of Fish and Wildlife (WDFW) and Point No Point Treaty Council (PNPTC) staffs independently calculated spawning timing and terminal area passage timing statistics, using somewhat different approaches to analyzing the data and deriving the timing statistics. Each method makes some unique assumptions in regards to analysis of the survey data, and are discussed below.

## Methods and discussion

! WDFW analysis (Jeff Haymes, WDFW)

The area-under-the-curve (AUC) escapement estimation approach used for calculating the annual spawning escapements to each stream basin (described in Appendix Report 1.1), provided the data to do a time density analysis of the rate at which the spawning populations recruited to each of the surveyed stream reaches. This data was used in combination with assumptions about average migration time through the terminal area was used to derive estimates of average escapement timing, and run timing through the terminal marine area.

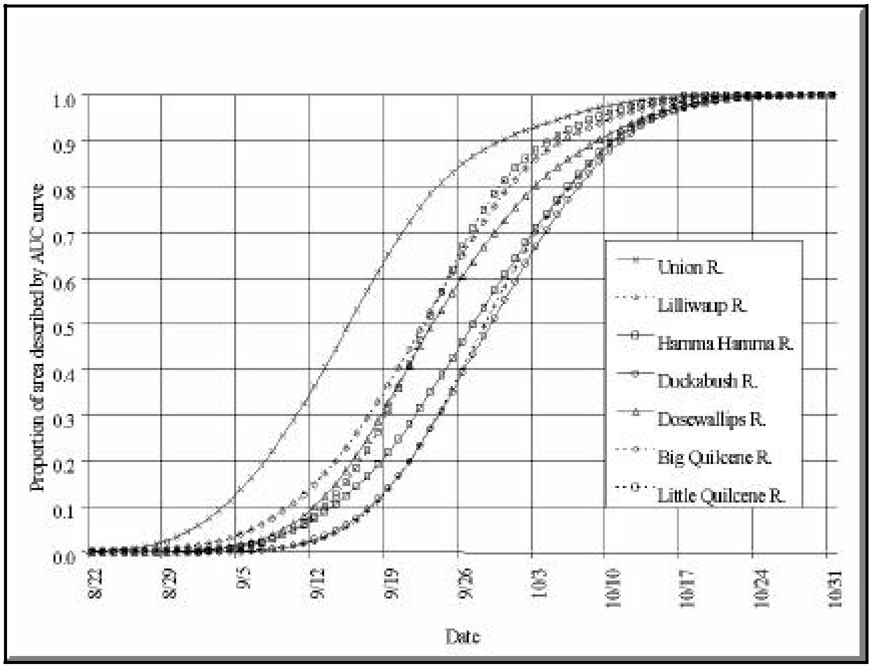
The area defined by each AUC curve can be described as a time density function. The proportion of the season total fish*days accumulated within each of the surveyed stream reaches at any given time point in the spawning run can be used as an indirect measure of the proportion of escapement completed for the season. This value is derived by :

Proportion of total fish*days accumulated for the season at day $i$ = $p_i = \sum f_i / FD_T$

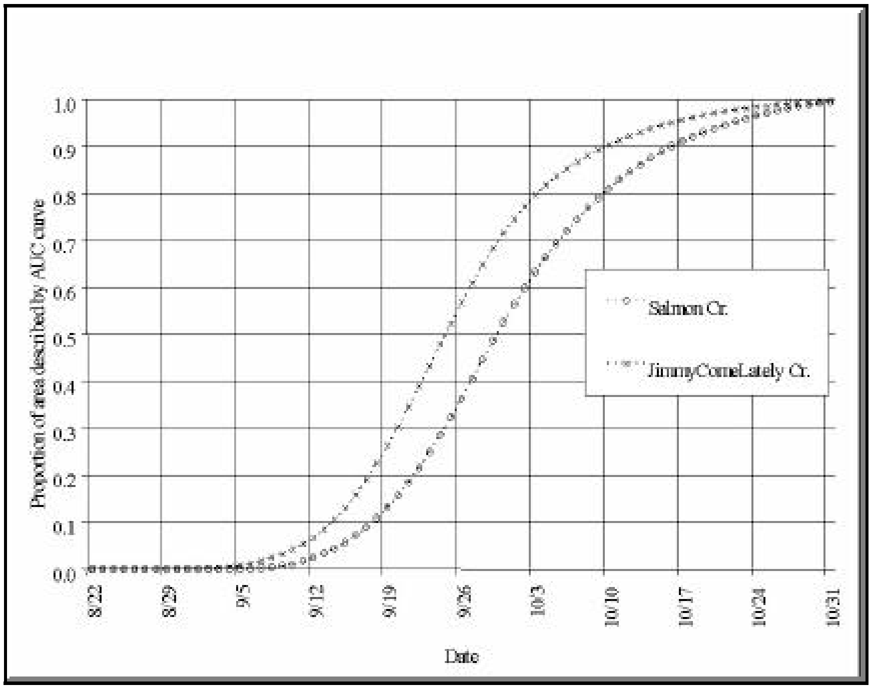
Where:

$f_i$ = Live fish observed or estimated to have been present in the survey reach on the $i^{th}$ day
$FD_T$ = Season total fish*days

For each of the major summer chum spawning populations (still extant) the value $p_i$ was calculated for each calendar day $i$ through the spawning run, for each year that the spawning activity was adequately documented by surveys. These values were averaged for each calendar day $i$ to provide an estimate of the average proportion of total fish*days accumulated at each day $i$ in the in the index reaches (Appendix Figure 1.2.1 – Hood Canal streams, and Appendix Figure 1.2.2 – Strait of Juan de Fuca streams). Appendix Table 1.2.1 summarizes the average WDFW estimates of dates of 10, 50, and 90 % fish*day accumulation (i.e., estimated escapement) in the spawning streams.



**Appendix Figure 1.2.1.** Average proportion of summer chum fish * days accumulated through spawning period in Hood Canal region streams.



**Appendix Figure 1.2.2.** Average proportion of summer chum fish * days accumulated through spawning period in Strait of Juan de Fuca region streams.

**Appendix Table 1.2.1.** Average dates of 10, 50, and 90 % completion of escapement for selected Hood Canal and Strait of Juan de Fuca summer chum populations (WDFW).

| Management Unit | Stock | N | Avg. 10 % comp. | Std. dev. | Range (min. and max.) | Avg. 50 % comp. | Std. dev. | Range (min. and max.) | Avg. 90 % comp. | Std. dev. | Range (min. and max.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sequim Bay | JimmyCL | 15 | 9/14 | +/- 4 d | 9/6-9/23 | 9/24 | +/- 4 d | 9/17-10/2 | 10/10 | +/- 8 d | 9/28-10/25 |
| Discovery Bay | Snow/Salmon | 20 | 9/18 | +/- 5 d | 9/10-10/2 | 9/29 | +/- 6 d | 9/18-10/13 | 10/16 | +/- 8 d | 9/29-10/26 |
| Area 12B | Dosewallips | 13 | 9/12 | +/- 5 d | 9/7-9/25 | 9/23 | +/- 4 d | 9/18-10/3 | 10/9 | +/- 6 d | 9/28-10/18 |
| | Duckabush | 16 | 9/17 | +/- 4 d | 9/11-9/27 | 9/29 | +/- 4 d | 9/21-10/5 | 10/11 | +/- 9 d | 9/15-10/16 |
| | Hamma Hamma | 21 | 9/14 | +/- 6 d | 9/6-9/27 | 9/27 | +/- 5 d | 9/18-10/6 | 10/10 | +/- 4 d | 10/1-10/18 |
| Area 12C | Lilliwaup | 13 | 9/17 | +/- 4 d | 9/10-9/26 | 9/28 | +/- 4 d | 9/21-10/6 | 10/10 | +/- 4 d | 9/30-10/16 |
| Area 12A | Big Quilcene | 17 | 9/10 | +/- 6 d | 8/30-9/22 | 9/22 | +/- 5 d | 9/14-10/1 | 10/5 | +/- 6 d | 9/25-10/18 |
| | Little Quilcene | 12 | 9/13 | +/- 4 d | 9/7-9/19 | 9/23 | +/- 4 d | 9/18-9/30 | 10/4 | +/- 6 d | 9/25-10/14 |
| Area 12D | Union | 16 | 9/3 | +/- 5 d | 8/28-9/14 | 9/15 | +/- 4 d | 9/8-9/25 | 9/30 | +/- 5 d | 9/22-10/7 |

An example of how this information was used for management purposes is illustrated by planning of the 1998 terminal area fishery management periods for summer chum in 1998. WDFW used the Hood Canal Management Plan summer chinook management period start dates in each Hood Canal terminal marine management area (Areas 12-12D) as a conservative starting point for summer chum management concerns, and for the end period the calendar date that the average "$p_i$ = 90 %" values for the streams entering each management unit occurred (Flint 1998). The one exception was for Area 12, where the completion date for the proposed summer chum management period was derived by subtracting 7 days from the 90 % $p_i$ value for Area 12B streams. Appendix Table 1.2.2 summarizes these dates, which are based on the spawning timing information illustrated in Appendix Figures 1.2.1 and 1.2.2.

**Appendix Table 1.2.2.** WDFW proposed 1998 marine and in-river management unit fishery management periods.

| Marine/In-river Management Unit | Date | Comments |
|---|---|---|
| 12 | 7/12-10/9 | Beginning date matches summer/fall chinook management period, and ending date backs out one week from 12B. |
| 12A | 7/12-10/10 | Beginning date matches summer/fall chinook management period, and ending date is average 90% $p_i$ value for Big Quilcene River. |
| Big Quilcene R. | 8/25-10/19 | Encompasses earliest and latest dates summer chum have been projected to have been present in Big Quilcene River. |
| 12B | 7/12-10/16 | Beginning date matches summer/fall chinook management period, and ending date is average of average 90% $p_i$ value for Duckabush, Dosewallips, and Hamma Hamma rivers. |
| 12C | 7/19-10/12 | Beginning data matches summer/fall chinook management period, and ending date is average 90% $p_i$ value for Lilliwaup River. |
| 12D | 7/19-10/7 | Beginning date matches summer/fall chinook management period, and ending date is average 90% $p_i$ value for Union River. |

There are some potential analytical weaknesses in this approach. The first is that the majority of $f_i$ values used to calculate $p_i$ are approximated. Furthermore, the $p_i$ values will not correspond directly to the proportion of total egg deposition that has occurred at time *i* for the season in the survey reach. For the purposes of this exercise we are assuming there is a correspondence, but it has not been experimentally measured. No data is available for the transit times of Hood Canal summer chums through the terminal marine areas to into the surveyed reaches of the spawning streams, so these values are currently only based on professional judgment.

! PNPTC analysis (Nick Lampsakis, PNPTC)

The estimates of run timing of summer chum salmon at various locations were developed using the probability distribution of the migratory time density. This approach is based on methods developed by numerous investigators (Walters and Buckingham, 1975; Mundy, 1979, 1982; Fried and Hilborn, 1988; Starr and Hilborn, 1988; Springborn et al, 1998; etc.) For further details on the rationale of the application of migratory time density, see above citations.

Simply put, the empirical function $f(t_i) = n_i / n$ is the "time density" of T, where T is the migratory timing. The expected value of T is then:

$T = t_i * f(t_i)$,

where:

$i=1$

In the case of spawner-count data, the actual daily live counts were converted to fish per mile, which, when divided by the season's estimated gross escapement (fish entering the river), provided $n_i$ above. Before proceeding further, data from individual years were examined for continuity of sampling, distribution across the overall known time spectrum of entry, and total number of samples with fish/mile > 0. In no cases were values "filled in" or extrapolated, or interpolated through any means.

For the selected years in the record, the expected value of T was then estimated. This value varied between years, and since this variation is normally limited in salmonid populations (see above citations), any unusual deviations from the empirical mean of T were examined for data discrepancies. The results can be shown for the Big Quilcene River spawner counts, which were found to be:

T = 09/22

1974 = T+7
1975 = T+3
1978 = T-5
1979 = T-3
1980 = T+4
1981 = T-1
1982 = T-3
1985 = T+3
1988 = T+2
1991 = T+1
1992 = T-3
1993 = T+3
1994 = T+5
1995 = T-4
1996 = T-7
1997 = T-2

Unfortunately spawning ground counts are hardly continuous (estimates sometimes are nearly a month apart) and therefore these estimates may indicate a level of variability which is actually much lower. Regardless, however the above example indicates a maximum observed variability of 7 days, and no more than +/- 4 days within one standard deviation. It is worth noting, that while T may be estimated quite easily for any given year, using as few as 2-3 observations (if properly placed across the entry spectrum), it is not possible to describe the full entry pattern in a given year, without the use of "filled-in" values which would ultimately depend on subjective judgment. Therefore, in order to generate a complete timing profile, it is necessary to aggregate information from a number of years' observations, and this of course requires standardization of the data (done above) as well as elimination of the effects of inter-annual variability.

The expected entry pattern was estimated by using an average of the above 16 years. The previously estimated inter-annual variability can then be used to predict future variation. The resulting pattern describes the expected distribution through time, of the spawner count observations. Results are summarized by stock in Appendix Table 1.2.3. The timings shown in Appendix Table 1.2.3 are based on observations of spawners in the surveyed stream reaches; they do not describe the timing of spawner entry to the observation locales. If surveys are spaced pretty far apart, it is quite possible that many of the individuals observed entered the spawning grounds as far back as two weeks previous, or more. However, for this initial analysis, we would use the assumption of a constant (across the run entry), average stream life of 10 days and therefore, assuming that some of the observed spawners are recent arrivals, and some are near the end of their stream life, we would back-date the spawner count profile by 5 days, in order to arrive at an estimated entry profile.

**Appendix Table 1.2.3** – Average dates of 10, 50, and 90 % completion of fish escapement for selected Hood Canal and Strait of Juan de Fuca summer chum populations (PNPTC)

| Management Unit | Stock | N | Avg. 10% comp. | Avg. 50% comp. | Std. dev. | Range (min. and max.) | Avg. 90% comp. |
|---|---|---|---|---|---|---|---|
| Sequim Bay | Jimmycomelately | 14 | 9/17 | 9/26 | +/- 4 d | 9/19-10/2 | 10/9 |
| Discovery Bay | Snow/Salmon | 20 | 9/19 | 9/29 | +/- 6 d | 9/17-10/11 | 10/13 |
| Area 12B | Dosewallips | 16 | 9/13 | 9/25 | +/- 4 d | 9/16-10/4 | 10/9 |
|  | Duckabush | 24 | 9/19 | 9/28 | +/- 4 d | 9/20-10/6 | 10/11 |
|  | Hamma Hamma | 23 | 9/17 | 9/27 | +/- 4 d | 9/18-10/4 | 10/8 |
| Area 12C | Lilliwaup | 18 | 9/15 | 9/28 | +/- 4 d | 9/19-10/5 | 10/10 |
| Area 12A | Big & Little Quil. | 16 | 9/12 | 9/22 | +/- 4 d | 9/15-9/29 | 10/1 |
| Area 12D | Union | 18 | 9/6 | 9/16 | +/- 3 d | 9/11-9/22 | 9/29 |

One obvious source of potential error is the assumption concerning a constant stream life, across the entire spectrum of the run. We have no direct method to correct for this, however historical tagging studies of adult salmon seem to indicate that the stream life of early arrivals may be much greater than that of spawners arriving after the middle of the run.

Reliable estimates for marine areas have been developed for north Hood Canal (Area 12) using 10 years of useable data (T = 9/14 (average 50% complete) with maximum variability from 9/8 to 9/18 and no more than 3 days within 1 standard dev.); and for Area 12A (Quilcene/Dabob bays), using 8 years of useable data (T = 9/13 (average 50% complete) with maximum variability from 9/8 to 9/15 and no more than 2 days within one standard dev.). For these marine areas, gillnet catch/landing data were used (this gear is preferred because of its passive sampling nature) instead of spawners/mile. Instead of gross escapement, the estimated annual recruitment to the area was used.

An unique problem in marine area samples involves the separation of summer from fall chum salmon. The end of the summer chum migration appears to slightly overlap the beginning of the fall migration. Since the fall populations are larger, by orders of magnitude, a small error in the selection of the last data point for summer chum, can have an enormous effect on f(t) above; that is, where a very large number of fall chum, relative to the overall summer chum abundance, control the value of $n_i$. In the case of Area 12A, this problem is not as significant because the fall chum are of a later variety. But in Area 12, despite our effort to select a point of consistently low chum abundance, the number of fish at that point may still include a significant number of fall chum. The only way to resolve this would be through GSI sampling of the suspected overlap period, in order to assign relative proportions of summer and fall chum to each time segment. The period of suspected overlap is from 9/20 through 10/10.

In marine areas of Hood Canal where no robust samples exist (Area 12B and 12C) we used the relationship developed between the Quilcene River entry, and the marine Area 12A entry profile, to develop marine area profiles, using the Dosewallips, Duckabush, and Hamma Hamma river entries for Area 12B, and the Union River (with minor additional backing out) for Area 12C.

## Bibliography

Flint, T. 1998. Internal WDFW memo from Tim Flint to Angelika Hagen-Breaux, March 10, 1998 (subject: Hood Canal summer chum spawning timing). Wash. Dept. Fish and Wild., Olympia, WA.

Fried, S.M., and R. Hilborn. 1988. In-season forecasting of Bristol Bay, Alaska sockeye salmon (*Oncorhynchus nerka*) abundance using Bayesian probability theory. Can. J. Fish. Aquat. Sci. 45:850-855.

Mundy, P.R. 1979. A quantitative measure of migratory timing illustrated by application to the management of commercial salmon fisheries. Doctoral dissertation, Univ. of Wash., Seattle, WA.

Mundy, P.R. 1982. Computation of migratory timing statistics for adult chinook salmon in the Yukon River, Alaska, and their relevance to fisheries management. North Amer. J. Fish. Mgt. 2:359-370.

Springborn, R.R., N.D. Lampsakis, and V.F. Gallucci. 1998. A time density model to estimate runsize and entry timing in a salmon fishery. North. Amer. J. Fish Mgt. 18:391-405.

Starr, P. and R. Hilborn. 1988. reconstruction of harvest rates and stock contribution in gauntlet salmon fisheries: application to British Columbia and Washington sockeye (*Oncorhynchus nerka*). Can. J. Fish. Aquat. Sci. 45:2216-2229.

Walters, C.J., and S. Buckingham. 1975. A control system for intra-season salmon management. Proceedings of a workshop on salmon management. International Institute For Applied Systems Analysis, Schloss Laxenburg, 2361 Laxenburg, Austria.

# Appendix Report 1.3
# Methodology For Summer Chum Salmon Run Reconstruction

Run re-construction is a post season accounting procedure used by the Washington Department of Fish and Wildlife and Tribes to assign catches to contributing populations; resulting in total annual run size estimates for individual wild and hatchery populations. Harvests in each management unit are apportioned to each stock by timing and presumed migration route on a proportional basis, and are sequentially added (from the streams and extreme terminal areas outward to terminal and pre-terminal areas) to population escapement estimates to arrive at total run size estimates. For Hood Canal summer chum salmon the previous co-manager's standard run re-construction model mis-allocates substantial numbers of early arriving fall chum salmon to summer chum salmon run size estimates (see discussion in Part One). For the current recovery planning process, a separate run re-construction was developed using earlier cutoff dates for allocating harvests during the summer chum period to reduce the influence of fall chum on summer chum run size estimates. However, some mis-allocation remains. The following is a brief summary of the methods used in this run re-construction.

## Escapements

The escapement estimates used for this run re-construction were from the revised estimates of summer chum salmon escapements prepared during the recovery planning process (see Appendix Report 1.1).

## Harvest Data

Commercial harvest data were obtained from the Northwest Indian Fisheries Commission (NWIFC) databases (TFT and MHCLS ), for all fisheries of concern in U.S. waters. Canadian harvest estimates for Area 20 were obtained from L. HopWo (CDFO - Naniamo). Only one major correction was applied to the data retrieved from these sources; catches by the Skokomish Tribe in 1976 were erroneously coded as "central Hood Canal", and were corrected here to "southern Hood Canal" (Area 12C). The correction was made on the basis of PNPTC data tapes, previously submitted to WDFW for database correction. The run reconstruction has been updated to include all years from 1974 through 1998 (25 years). However, it is somewhat incomplete at the time of preparation because the 1998 catch data from PST test fisheries in Area 20 had not yet been received. There were no commercial catches in Area 20, in 1998, during the period of interest. Also, the 1998 Washington data was at the time still considered preliminary, and may be modified.

Recreational harvest data were provided by WDFW for Puget Sound fisheries from 1974 through 1996 (1997 and 1998) data are unavailable at present) in the Strait of Juan de Fuca, San Juan Islands, Admiralty Inlet, and Hood Canal. Additionally, freshwater recreational harvest data were provided by WDFW for the Big Quilcene and Skokomish rivers for the 1976-1994 period. It was not possible to access data for the remaining years in these systems, however, given the low levels of reported caches in other years, it is not anticipated that there will be a significant effect on run re-construction. No data were used from fisheries west of the Bonilla-Tatoosh line.

Re-construction was accomplished by use of a proportional contribution assumption in all Hood Canal areas, whereby the harvest in each area was attributed proportionally to the stocks with streams of origin located “upstream” from the harvest location. In all cases, random distribution of the available populations was assumed. No Hood Canal summer chum were presumed to have been harvested in Area 10. Summer chum returning to both Hood Canal and the Strait of Juan de Fuca were presumed to be subject to harvest in Area 9. U.S. Convention areas’ harvest was added to each management unit, with no assumption of any separate migratory pathway. Finally, Canadian harvests were added to the entire region, and its management units.

The results of the reconstruction are shown in the attached tables; summarized by individual management unit and include total run size estimates for the Hood Canal and the Strait of Juan de Fuca regions.

Run reconstruction details:

Data - Inconsistent and insufficient data were found for some years preceding 1974. Therefore, because of data limitations, run reconstruction was limited to the 1974-to-the-present period. The data used in the summer chum reconstruction are as follows:

Spawning escapements - as re-assessed in 1998, for each stock where counts existed. For some stocks, as well as reaches within units, where no direct estimates were possible, estimates were “filled in”, using a variety of methods (interpolation, extrapolation, regression statistics, etc.) More details can be found in the description of escapement estimation methods (Appendix Report 1.1). In two cases (Dungeness and Skokomish rivers) no estimates are available for any year. Therefore, the reconstruction is incomplete, and biased to a certain degree.

Catch data - initially include all reported, or estimated, commercial and recreational catches of chum salmon in the following areas and time periods:

Canadian Area 20: July 1 through September 15
Washington Areas 4B, 5, 6, 6A, 6B, 6C, 7: July 1 through September 15
Washington Area 9: July 1 through September 8
Washington Area 10: July 1 through September 1
Washington Areas 12, 9A: July 1 through September 27
Washington Areas 12B, 12C, 12D: July 1 through September 30
Washington Area 12A: July 1 through October 5
Big Quilcene R. and Skokomish R.: July 1 through October 10

Commercial catches were available on a daily basis. Recreational catches are estimated on a monthly basis and we used a straight line proportion, for reconstruction periods of less than a month. The time periods were generally based on reviews of the data series, and establishment of cutoff dates to separate summer from fall chum, in an effort to equalize the number of summer chum after the cutoff date, with the number of fall chum before the cutoff date. This was done to avoid an assessment bias in either direction. No precise information concerning the relative proportions of each segment, on each date and area, is currently available. However, we believe that any remaining bias may be quite small.

Commercial and recreational catches in each area were further apportioned between the summer chum of this region, and other commingled populations, using the following methods:

Canadian Area 20 and Washington Areas 4B, 5, 6, 6A, 6B, 6C: 7-day segments were assigned stock composition proportions, based on Area 20 GSI samples of recent years.

Washington Areas 9, 10: All chum before 9/8 (Area 9) and 9/1 (Area 10) were assumed to be HC-SJF summer chum, and all chum following this date, were assumed to be from other Puget Sound regions (cutoff date method). For instance in Area 10, the higher abundance of South Sound early fall chum was assumed to far outweigh HC-SJF summer chum abundance after 9/1, and the reverse was assumed for earlier periods.

Washington Areas 9A, 12. 12A, 12B, 12C, 12D, 82F, 82G: all chum during the specified period were assumed to be of HC-SJF summer chum.

Methods - The annual reconstruction of runs was accomplished using a series of incremental additive steps, starting from spawning escapements and ending with the addition of near-ocean catches, with the intent to reconstruct the total annual recruitment of each management unit (MU), to all fisheries and escapement.

Assumptions - Major assumptions used in the reconstruction are included the following:

> Catches in each reporting area and fishery were assumed to be a random mix of all stocks and management units passing through the area. For individual stocks, this assumption was only used within the terminal areas of Hood Canal.
>
> All passing populations were assumed to be equally available for harvest in each area, regardless of their entry timing. For instance, SE Hood Canal (Union River) chum were assumed to be equally available at all times, along with other management units, despite their somewhat earlier timing. This assumption probably biased upwards the estimates of the population size and exploitation rates on it. At the same time, it probably biased low the population sized and exploitation rates on commingled populations, in all preceding fisheries. This effect obviously becomes more pronounced in fisheries where lesser numbers of other populations are present, and/or where exploitation (as a proportion of the total) is higher.

A straight-line migratory pathway was assumed in all cases. That is, stocks whose river of origin lies further "out", were assumed to have no contribution to catches further "inshore". If this assumption were incorrect, to a significant degree, it would result in mis-apportionment of catches, to individual MUs and a downward bias in our estimates of abundance of units further "out", with the reverse being true for units returning to streams further "inshore".

The final estimates, are not true "recruitment" estimates because we have not attempted to estimate, or add certain components, including: natural mortality in the year of maturity, non landed mortalities (drop-offs, predation from gear, etc.), catches in Canadian fisheries outside of Area 20, or US fisheries in ocean areas, or Area 7A. Some of these catches may be quite small and nearly insignificant, however if HC-SJF summer chum salmon migrate to US waters through the Canadian "inside passage", mortalities in Canadian Areas 11-13 and 29 could be significant. All of the above were excluded from the present reconstruction because of the complete lack of appropriate data (see following run reconstruction tables for the years 1974-98).

Reconstruction Steps :

1. SE Hood Canal escapements expanded to Area 12D whose catches were apportioned by population strength. The total provided estimated return to Area 12D

2. Area 82G escapements (zero) were added to catches in 82G.

3. Escapements to Area 12C tributaries, including fish taken for supplementation, and any pre-spawning mortalities, and the totals from 1. and 2. above, were used to apportion Area 12C catches to each component, by population strength, and expand these components to obtain the run size entering Area 12C.

4. Escapements to Area 12A streams, including pre-spawning mortalities and fish taken for supplementation, were added to any in-river catches, to obtain in-river run sizes. Catches in Area 12A were apportioned to each stock by population strength and expanded them to obtain run sizes entering Area 12A.

5. Escapements to Area 12B rivers, and the totals from 3. and 4. above, were used to apportion Area 12B catches to each component, by population strength, and expand these components to obtain the run size entering Area 12B.

6. Escapements to Area 12 streams, and the total from 5. above, were used to apportion Area 12 catches (including Hood Canal marine recreational) to each component, by population strength, and expand these components to obtain the run size entering Area 12.

7. Catches in Area 9A were apportioned by population strength and added to the totals from 6. above, to obtain the total terminal area return of each stock and management unit originating in

Hood Canal. Each Hood Canal management unit was further expanded by apportioning to it catches from Area 10.

8. The terminal run sizes of the Sequim and Discovery management units were estimated by adding catches in Sequim and Discovery bays to their escapements and fish taken for supplementation.

9. Commercial and recreational catches in Area 9, Washington Areas 4B, 5, 6, 6A, 6B, 6C, 7, and Canadian Area 20 were apportioned to the management units in 7. and 8. above, by management unit strength, to expand these units, and obtain estimates of MU strength entering Area 9 (Admiralty), Washington waters, and Canadian waters, respectively. The sum total of these, provided an annual estimate of region's recruits to all fisheries and escapements.

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| **Year:** | **1974** | **Harvest** | | 356 | 0 | 0 | 0 | 0 | 12 | 12 | 0 | 0 | 0 | | 0 | 190 | 188 | 1,399 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | Management Unit | | | | |
| | | | Brood | | ********** | | Run Abundance by Location | | | | ********** | | | | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A | | 356 | | 356 | | | 356 | 357 | 357 | | | 357 | 357 | 361 | 366 | 401 |
| 12D | Tahuya | 880 | | | 880 | 880 | | | 881 | 882 | 882 | | | 950 | 950 | 962 | 975 | 1,067 |
| | Union | 68 | | | 68 | 68 | | | 68 | 68 | 68 | | | | | | | |
| 12A | L. Quilcene | 44 | | | | | | 44 | 44 | 44 | 44 | | | 841 | 841 | 852 | 863 | 944 |
| | B. Quilcene | 795 | | | | | 795 | 795 | 796 | 797 | 797 | | | | | | | |
| 12-12B-12C | Big Beef | 75 | | | | | | | 75 | 75 | 75 | | | 10,515 | 10,515 | 10,654 | 10,791 | 11,810 |
| | Anderson | 0 | | | | | | | 0 | 0 | 0 | | | | | | | |
| | Dosewallips | ***3,593*** | | | | | | | 3,596 | 3,600 | 3,600 | | | | | | | |
| | Duckabush | 3,581 | | | | | | | 3,585 | 3,588 | 3,588 | | | | | | | |
| | HammaHamma | ***2,448*** | | | | | | | 2,451 | 2,453 | 2,453 | | | | | | | |
| | Lilliwaup | 616 | | | | 616 | | | 617 | 617 | 617 | | | | | | | |
| | Dewatto | 181 | | | | 181 | | | 181 | 181 | 181 | | | | | | | |
| Discovery | Snow | 818 | | | | | | | | | | 818 | | 1,330 | | 1,348 | 1,365 | 1,494 |
| | Salmon | 512 | | | | | | | | | | 512 | | | | | | |
| Sequim | Jimmycomelatel | ***438*** | | | | | | | | | | | 438 | 438 | | 443 | 449 | 492 |
| **Totals** | | 14,049 | 0 | 356 | 948 | 2,101 | 795 | 839 | 12,650 | 12,662 | 12,662 | 1,330 | 438 | 14,430 | 12,662 | 14,620 | 14,808 | 16,207 |
| | Hood Canal | 12,281 | 0 | | | | | | | | | | | 12,662 | 12,662 | 12,829 | 12,994 | 14,222 |
| | E. Strait Portion | 1,768 | 0 | | | | | | | | | | | 1,768 | | 1,791 | 1,814 | 1,985 |

Note: Values in bold italics were estimated indirectly

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| **Year:** | **1975** | **Harvest** | Brood stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | Seattle (Area | Admiralt (Area 9) | US Conv. | Canadi Area |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1,118 | 54 | 4,010 | 0 | 372 | 3,664 | 78 | 0 | 205 | 0 | | 0 | 54 | 546 | 1,064 |
| | | | Brood | | ********** | | Run Abundance by Location | | | | ********** | | | | Management Unit | | | |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A | | 1,118 | | 2,249 | | | 2,595 | 2,601 | 2,601 | | | 2,601 | 2,601 | 2,605 | 2,654 | 2,749 |
| 12D | Tahuya | 1,389 | | | 1,440 | 2,897 | | | 3,342 | 3,352 | 3,352 | | | 3,555 | 3,555 | 3,561 | 3,628 | 3,757 |
| | Union | ***84*** | | | 87 | 175 | | | 202 | 203 | 203 | | | | | | | |
| 12A | L. Quilcene | 868 | | | | | | 1,010 | 1,166 | 1,169 | 1,169 | | | 3,061 | 3,061 | 3,066 | 3,124 | 3,235 |
| | B. Quilcene | 1,405 | | | | | 1,405 | 1,635 | 1,887 | 1,892 | 1,892 | | | | | | | |
| 12-12B-12C | Big Beef | 1,152 | | | | | | | 1,329 | 1,333 | 1,333 | | | 18,326 | 18,326 | 18,360 | 18,703 | 19,371 |
| | Anderson | 195 | | | | | | | 225 | 226 | 226 | | | | | | | |
| | Dosewallips | ***2,250*** | | | | | | | 2,596 | 2,604 | 2,604 | | | | | | | |
| | Duckabush | 2,245 | | | | | | | 2,591 | 2,598 | 2,598 | | | | | | | |
| | HammaHamma | ***7,341*** | | | | | | | 8,471 | 8,495 | 8,495 | | | | | | | |
| | Lilliwaup | 706 | | | | 1,420 | | | 1,639 | 1,643 | 1,643 | | | | | | | |
| | Dewatto | 613 | | | | 1,233 | | | 1,423 | 1,427 | 1,427 | | | | | | | |
| Discovery | Snow | 327 | | | | | | | | | | 389 | | 1,287 | | 1,289 | 1,313 | 1,360 |
| | Salmon | 755 | | | | | | | | | | 898 | | | | | | |
| Sequim | Jimmycomelatel | ***348*** | | | | | | | | | | | 348 | 348 | | 348 | 355 | 368 |
| **Totals** | | 19,678 | 0 | 1,118 | 1,527 | 7,974 | 1,405 | 2,645 | 27,466 | 27,541 | 27,541 | 1,287 | 348 | 29,176 | 27,541 | 29,230 | 29,776 | 30,840 |
| | Hood Canal | 18,248 | 0 | | | | | | | | | | | 27,541 | 27,541 | 27,592 | 28,108 | 29,112 |
| | E. Strait Portion | 1,430 | 0 | | | | | | | | | | | 1,635 | | 1,638 | 1,668 | 1,728 |

Note: Values in bold italics were estimated indirectly

**Reconstruction of the HC-SJF Summer Chum Salmon Runs**

| **Year:** | **1976** | **Harvest** | | 991 | 618 | 26,150 | 0 | 5,704 | 4,046 | 86 | 0 | 0 | 0 | | 968 | 1,486 | 929 | 5,705 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | Management Unit | | | | |
| | | | Brood | | ********** | | Run Abundance by Location | | | | ********** | | | | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A | | 991 | | 4,560 | | | 4,861 | 4,865 | 4,865 | | | 4,865 | 4,937 | 5,045 | 5,113 | 5,529 |
| 12D | Tahuya | 3,200 | | | 3,799 | 17,480 | | | 18,636 | 18,661 | 18,661 | | | 19,244 | 19,530 | 19,958 | 20,225 | 21,869 |
| | Union | 100 | | | 119 | 546 | | | 582 | 583 | 583 | | | | | | | |
| 12A | L. Quilcene | 1,088 | | | | | | 2,845 | 3,033 | 3,037 | 3,037 | | | 9,861 | 10,007 | 10,227 | 10,364 | 11,206 |
| | B. Quilcene | 2,445 | | | | | 2,445 | 6,392 | 6,815 | 6,824 | 6,824 | | | | | | | |
| 12-12B-12C | Big Beef | 1,281 | | | | | | | 1,366 | 1,368 | 1,368 | | | 31,339 | 31,803 | 32,500 | 32,936 | 35,613 |
| | Anderson | 234 | | | | | | | 249 | 250 | 250 | | | | | | | |
| | Dosewallips | 3,271 | | | | | | | 3,487 | 3,492 | 3,492 | | | | | | | |
| | Duckabush | 6,095 | | | | | | | 6,498 | 6,507 | 6,507 | | | | | | | |
| | HammaHamma | ***7,648*** | | | | | | | 8,154 | 8,165 | 8,165 | | | | | | | |
| | Lilliwaup | 1,612 | | | | 7,417 | | | 7,907 | 7,918 | 7,918 | | | | | | | |
| | Dewatto | 741 | | | | 3,409 | | | 3,635 | 3,640 | 3,640 | | | | | | | |
| Discovery | Snow | 608 | | | | | | | | | | 608 | | 1,129 | | 1,154 | 1,169 | 1,264 |
| | Salmon | 521 | | | | | | | | | | 521 | | | | | | |
| Sequim | Jimmycomelatel | ***365*** | | | | | | | | | | | 365 | 365 | | 373 | 378 | 409 |
| **Totals** | | 29,209 | 0 | 991 | 3,918 | 33,412 | 2,445 | 9,237 | 65,225 | 65,309 | 65,309 | 1,129 | 365 | 66,803 | 66,277 | 69,256 | 70,186 | 75,891 |
| | Hood Canal | 27,715 | 0 | | | | | | | | | | | 65,309 | 66,277 | 67,730 | 68,638 | 74,218 |
| | E. Strait Portion | 1,494 | 0 | | | | | | | | | | | 1,494 | | 1,527 | 1,547 | 1,673 |

Note: Values in bold italics were estimated indirectly

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| **Year:** | **1977** | **Harvest** |  | 320 | 7 | 3,015 | 0 | 24 | 590 | 488 | 0 | 0 | 0 |  | 1 | 73 | 711 | 913 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | Management Unit |  |  |  |  |
| Mgmt Unit | Prod. Unit | Escapement | Brood stock | 82G/J | ********** 12D | 12C | 82F | Run Abundance by Location 12A | 12B | 12 | ********** 9A | Discov | Sequi | Term. | Seattle (Area | Admiralt (Area 9) | US Conv. | Canadi Area |
| Skokomish | Skokomish | N/A |  | 320 |  | 864 |  |  | 900 | 921 | 921 |  |  | 921 | 921 | 925 | 964 | 1,014 |
| 12D | Tahuya | 726 |  |  | 732 | 1,978 |  |  | 2,061 | 2,129 | 2,129 |  |  | 2,349 | 2,349 | 2,359 | 2,459 | 2,587 |
|  | Union | 75 |  |  | 76 | 204 |  |  | 213 | 220 | 220 |  |  |  |  |  |  |  |
| 12A | L. Quilcene | 773 |  |  |  |  |  | 785 | 817 | 845 | 845 |  |  | 1,742 | 1,742 | 1,750 | 1,823 | 1,918 |
|  | B. Quilcene | 821 |  |  |  |  | 821 | 833 | 868 | 897 | 897 |  |  |  |  |  |  |  |
| 12-12B-12C | Big Beef | 302 |  |  |  |  |  |  | 315 | 325 | 325 |  |  | 10,134 | 10,135 | 10,179 | 10,608 | 11,159 |
|  | Anderson | ***26*** |  |  |  |  |  |  | 27 | 28 | 28 |  |  |  |  |  |  |  |
|  | Dosewallips | 3,215 |  |  |  |  |  |  | 3,350 | 3,461 | 3,461 |  |  |  |  |  |  |  |
|  | Duckabush | 2,453 |  |  |  |  |  |  | 2,556 | 2,641 | 2,641 |  |  |  |  |  |  |  |
|  | HammaHamma | ***1,675*** |  |  |  |  |  |  | 1,745 | 1,803 | 1,803 |  |  |  |  |  |  |  |
|  | Lilliwaup | 420 |  |  |  | 1,134 |  |  | 1,182 | 1,221 | 1,221 |  |  |  |  |  |  |  |
|  | Dewatto | 225 |  |  |  | 608 |  |  | 633 | 654 | 654 |  |  |  |  |  |  |  |
| Discovery | Snow | 538 |  |  |  |  |  |  |  |  |  | 538 |  | 1,239 |  | 1,244 | 1,297 | 1,364 |
|  | Salmon | 701 |  |  |  |  |  |  |  |  |  | 701 |  |  |  |  |  |  |
| Sequim | Jimmycomelatel | ***405*** |  |  |  |  |  |  |  |  |  |  | 405 | 405 |  | 406 | 424 | 446 |
| **Totals** |  | 12,355 | 0 | 320 | 808 | 4,788 | 821 | 1,618 | 14,667 | 15,146 | 15,146 | 1,239 | 405 | 16,790 | 15,147 | 16,864 | 17,575 | 18,488 |
|  | Hood Canal | 10,711 | 0 |  |  |  |  |  |  |  |  |  |  | 15,146 | 15,147 | 15,213 | 15,855 | 16,679 |
|  | E. Strait Portion | 1,644 | 0 |  |  |  |  |  |  |  |  |  |  | 1,644 |  | 1,651 | 1,720 | 1,810 |

Note: Values in bold italics were estimated indirectly

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| **Year:** | **1978** | **Harvest** |  | 130 | 0 | 2,036 | 0 | 1 | 386 | 1,817 | 6 | 0 | 0 |  | 0 | 167 | 552 | 701 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | Management Unit |  |  |  |  |
|  |  |  | Brood |  | ********** |  | Run Abundance by Location |  |  |  | ********** |  |  |  | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A |  | 130 |  | 243 |  |  | 248 | 261 | 261 |  |  | 261 | 261 | 262 | 268 | 275 |
| 12D | Tahuya | 266 |  |  | 266 | 498 |  |  | 507 | 548 | 548 |  |  | 680 | 680 | 684 | 698 | 716 |
|  | Union | 64 |  |  | 64 | 120 |  |  | 122 | 132 | 132 |  |  |  |  |  |  |  |
| 12A | L. Quilcene | 1,816 |  |  |  |  |  | 1,816 | 1,848 | 1,999 | 2,000 |  |  | 5,279 | 5,279 | 5,311 | 5,418 | 5,554 |
|  | B. Quilcene | 2,978 |  |  |  |  | 2,978 | 2,979 | 3,031 | 3,279 | 3,279 |  |  |  |  |  |  |  |
| 12-12B-12C | Big Beef | 680 |  |  |  |  |  |  | 692 | 748 | 749 |  |  | 17,858 | 17,858 | 17,968 | 18,331 | 18,791 |
|  | Anderson | 16 |  |  |  |  |  |  | 16 | 18 | 18 |  |  |  |  |  |  |  |
|  | Dosewallips | ***1,901*** |  |  |  |  |  |  | 1,935 | 2,093 | 2,093 |  |  |  |  |  |  |  |
|  | Duckabush | 1,898 |  |  |  |  |  |  | 1,931 | 2,089 | 2,090 |  |  |  |  |  |  |  |
|  | HammaHamma | ***8,215*** |  |  |  |  |  |  | 8,360 | 9,043 | 9,045 |  |  |  |  |  |  |  |
|  | Lilliwaup | 1,331 |  |  |  | 2,492 |  |  | 2,536 | 2,742 | 2,743 |  |  |  |  |  |  |  |
|  | Dewatto | 544 |  |  |  | 1,018 |  |  | 1,036 | 1,121 | 1,121 |  |  |  |  |  |  |  |
| Discovery | Snow | 629 |  |  |  |  |  |  |  |  |  | 629 |  | 2,293 |  | 2,307 | 2,354 | 2,413 |
|  | Salmon | 1,664 |  |  |  |  |  |  |  |  |  | 1,664 |  |  |  |  |  |  |
| Sequim | Jimmycomelatel | ***787*** |  |  |  |  |  |  |  |  |  |  | 787 | 787 |  | 791 | 807 | 828 |
| **Totals** |  | 22,789 | 0 | 130 | 330 | 4,371 | 2,978 | 4,795 | 22,263 | 24,073 | 24,078 | 2,293 | 787 | 27,158 | 24,078 | 27,324 | 27,876 | 28,576 |
|  | Hood Canal | 19,710 | 0 |  |  |  |  |  |  |  |  |  |  | 24,078 | 24,078 | 24,226 | 24,715 | 25,336 |
|  | E. Strait Portion | 3,080 | 0 |  |  |  |  |  |  |  |  |  |  | 3,080 |  | 3,098 | 3,161 | 3,240 |

Note: Values in bold italics were estimated indirectly

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| **Year:** | **1979** | **Harvest** | | 31 | 0 | 950 | 0 | 137 | 218 | 146 | 0 | 0 | 0 | | 2 | 134 | 889 | 591 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | Management Unit | | | |
| | | | Brood | | ********** | | Run Abundance by Location | | | | ********** | | | | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A | | 31 | | 95 | | | 98 | 100 | 100 | | | 100 | 100 | 101 | 111 | 118 |
| 12D | Tahuya | 117 | | | 117 | 360 | | | 370 | 377 | 377 | | | 690 | 690 | 701 | 771 | 817 |
| | Union | ***97*** | | | 97 | 299 | | | 307 | 313 | 313 | | | | | | | |
| 12A | L. Quilcene | 110 | | | | | | 143 | 147 | 150 | 150 | | | 620 | 620 | 630 | 692 | 734 |
| | B. Quilcene | 345 | | | | | 345 | 449 | 462 | 470 | 470 | | | | | | | |
| 12-12B-12C | Big Beef | 191 | | | | | | | 196 | 200 | 200 | | | 6,627 | 6,628 | 6,729 | 7,399 | 7,844 |
| | Anderson | 6 | | | | | | | 6 | 6 | 6 | | | | | | | |
| | Dosewallips | ***1,190*** | | | | | | | 1,224 | 1,246 | 1,246 | | | | | | | |
| | Duckabush | 1,190 | | | | | | | 1,224 | 1,247 | 1,247 | | | | | | | |
| | HammaHamma | ***3,096*** | | | | | | | 3,185 | 3,244 | 3,244 | | | | | | | |
| | Lilliwaup | 163 | | | | 502 | | | 516 | 526 | 526 | | | | | | | |
| | Dewatto | 49 | | | | 151 | | | 155 | 158 | 158 | | | | | | | |
| Discovery | Snow | 133 | | | | | | | | | | 133 | | 591 | | 600 | 660 | 699 |
| | Salmon | 458 | | | | | | | | | | 458 | | | | | | |
| Sequim | Jimmycomelatel | ***170*** | | | | | | | | | | | 170 | 170 | | 173 | 190 | 201 |
| **Totals** | | 7,315 | 0 | 31 | 214 | 1,407 | 345 | 592 | 7,891 | 8,037 | 8,037 | 591 | 170 | 8,798 | 8,039 | 8,934 | 9,823 | 10,413 |
| | Hood Canal | 6,554 | 0 | | | | | | | | | | | 8,037 | 8,039 | 8,161 | 8,973 | 9,513 |
| | E. Strait Portion | 761 | 0 | | | | | | | | | | | 761 | | 773 | 849 | 900 |

Note: Values in bold italics were estimated indirectly

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| **Year:** | **1980** | **Harvest** | | 17 | 0 | 773 | 18 | 156 | 2,912 | 4,280 | 1 | 0 | 0 | | 6 | 97 | 474 | 980 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | Management Unit | | | |
| | | | Brood | | ********** | | Run Abundance by Location | | | ********** | | | | | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A | | 17 | | 34 | | | 55 | 78 | 78 | | | 78 | 78 | 79 | 81 | 85 |
| 12D | Tahuya | 179 | | | 179 | 359 | | | 580 | 904 | 904 | | | 1,955 | 1,956 | 1,967 | 2,021 | 2,134 |
| | Union | 208 | | | 208 | 417 | | | 674 | 1,050 | 1,051 | | | | | | | |
| 12A | L. Quilcene | 154 | | | | | | 198 | 319 | 498 | 498 | | | 1,770 | 1,770 | 1,780 | 1,830 | 1,932 |
| | B. Quilcene | 375 | | | | | 393 | 505 | 815 | 1,271 | 1,271 | | | | | | | |
| 12-12B-12C | Big Beef | 123 | | | | | | | 199 | 310 | 310 | | | 8,124 | 8,128 | 8,174 | 8,400 | 8,868 |
| | Anderson | 2 | | | | | | | 3 | 5 | 5 | | | | | | | |
| | Dosewallips | 1,216 | | | | | | | 1,963 | 3,061 | 3,061 | | | | | | | |
| | Duckabush | 827 | | | | | | | 1,335 | 2,082 | 2,082 | | | | | | | |
| | HammaHamma | 329 | | | | | | | 531 | 828 | 828 | | | | | | | |
| | Lilliwaup | 247 | | | | 496 | | | 800 | 1,247 | 1,248 | | | | | | | |
| | Dewatto | 117 | | | | 235 | | | 379 | 591 | 591 | | | | | | | |
| Discovery | Snow | 709 | | | | | | | | | | 709 | | 3,783 | | 3,804 | 3,910 | 4,127 |
| | Salmon | 3,074 | | | | | | | | | | 3,074 | | | | | | |
| Sequim | Jimmycomelatel | ***1,326*** | | | | | | | | | | | 1,326 | 1,326 | | 1,334 | 1,371 | 1,447 |
| **Totals** | | 8,886 | 0 | 17 | 387 | 1,541 | 393 | 703 | 7,652 | 11,925 | 11,926 | 3,783 | 1,326 | 17,036 | 11,932 | 17,138 | 17,613 | 18,592 |
| | Hood Canal | 3,777 | 0 | | | | | | | | | | | 11,926 | 11,932 | 12,000 | 12,332 | 13,018 |
| | E. Strait Portion | 5,109 | 0 | | | | | | | | | | | 5,109 | | 5,138 | 5,281 | 5,574 |

Note: Values in bold italics were estimated indirectly

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| Year: | 1981 | Harvest |  | 116 | 0 | 158 | 2 | 137 | 466 | 1,294 | 3 | 0 | 0 |  | 6 | 63 | 597 | 915 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | Management Unit |  |  |  |  |
|  |  |  | Brood |  | ********** | Run Abundance by Location |  |  |  |  | ********** |  |  |  | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A |  | 116 |  | 145 |  |  | 169 | 219 | 219 |  |  | 219 | 220 | 222 | 246 | 283 |
| 12D | Tahuya | 140 |  |  | 140 | 175 |  |  | 204 | 286 | 286 |  |  | 369 | 370 | 374 | 415 | 477 |
|  | Union | 41 |  |  | 41 | 51 |  |  | 60 | 84 | 84 |  |  |  |  |  |  |  |
| 12A | L. Quilcene | 84 |  |  |  |  |  | 135 | 158 | 221 | 221 |  |  | 589 | 590 | 597 | 662 | 761 |
|  | B. Quilcene | 138 |  |  |  |  | 140 | 226 | 263 | 368 | 368 |  |  |  |  |  |  |  |
| 12-12B-12C | Big Beef | 90 |  |  |  |  |  |  | 105 | 147 | 147 |  |  | 3,354 | 3,359 | 3,398 | 3,767 | 4,334 |
|  | Anderson | 1 |  |  |  |  |  |  | 1 | 2 | 2 |  |  |  |  |  |  |  |
|  | Dosewallips | 63 |  |  |  |  |  |  | 74 | 103 | 103 |  |  |  |  |  |  |  |
|  | Duckabush | 557 |  |  |  |  |  |  | 650 | 909 | 909 |  |  |  |  |  |  |  |
|  | HammaHamma | 926 |  |  |  |  |  |  | 1,081 | 1,511 | 1,512 |  |  |  |  |  |  |  |
|  | Lilliwaup | 293 |  |  |  | 366 |  |  | 428 | 598 | 598 |  |  |  |  |  |  |  |
|  | Dewatto | 41 |  |  |  | 51 |  |  | 60 | 84 | 84 |  |  |  |  |  |  |  |
| Discovery | Snow | 242 |  |  |  |  |  |  |  |  |  | 242 |  | 681 |  | 689 | 764 | 879 |
|  | Salmon | 439 |  |  |  |  |  |  |  |  |  | 439 |  |  |  |  |  |  |
| Sequim | Jimmycomelatel | ***203*** |  |  |  |  |  |  |  |  |  |  | 203 | 203 |  | 205 | 227 | 261 |
| **Totals** |  | 3,258 | 0 | 116 | 181 | 789 | 140 | 361 | 3,253 | 4,529 | 4,532 | 681 | 203 | 5,416 | 4,538 | 5,485 | 6,081 | 6,997 |
|  | Hood Canal | 2,374 | 0 |  |  |  |  |  |  |  |  |  |  | 4,532 | 4,538 | 4,591 | 5,090 | 5,857 |
|  | E. Strait Portion | 884 | 0 |  |  |  |  |  |  |  |  |  |  | 884 |  | 894 | 991 | 1,140 |

Note: Values in bold italics were estimated indirectly

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| **Year:** | **1982** | **Harvest** |  | 90 | 0 | 245 | 0 | 304 | 726 | 2,485 | 0 | 0 | 0 |  | 0 | 132 | 296 | 2,219 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | Management Unit |  |  |  |
|  |  |  | Brood |  | ********** |  | Run Abundance by Location |  |  |  | ********** |  |  |  | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A |  | 90 |  | 141 |  |  | 172 | 253 | 253 |  |  | 253 | 253 | 257 | 265 | 326 |
| 12D | Tahuya | 86 |  |  | 86 | 135 |  |  | 164 | 267 | 267 |  |  | 743 | 743 | 753 | 777 | 956 |
|  | Union | ***153*** |  |  | 153 | 240 |  |  | 293 | 476 | 476 |  |  |  |  |  |  |  |
| 12A | L. Quilcene | 125 |  |  |  |  |  | 260 | 318 | 516 | 516 |  |  | 1,161 | 1,161 | 1,177 | 1,215 | 1,495 |
|  | B. Quilcene | 156 |  |  |  |  | 156 | 325 | 397 | 644 | 644 |  |  |  |  |  |  |  |
| 12-12B-12C | Big Beef | 0 |  |  |  |  |  |  | 0 | 0 | 0 |  |  | 4,291 | 4,291 | 4,352 | 4,490 | 5,525 |
|  | Anderson | ***0*** |  |  |  |  |  |  | 0 | 0 | 0 |  |  |  |  |  |  |  |
|  | Dosewallips | 507 |  |  |  |  |  |  | 620 | 1,006 | 1,006 |  |  |  |  |  |  |  |
|  | Duckabush | 690 |  |  |  |  |  |  | 844 | 1,369 | 1,369 |  |  |  |  |  |  |  |
|  | HammaHamma | 801 |  |  |  |  |  |  | 979 | 1,589 | 1,589 |  |  |  |  |  |  |  |
|  | Lilliwaup | 84 |  |  |  | 131 |  |  | 161 | 261 | 261 |  |  |  |  |  |  |  |
|  | Dewatto | 21 |  |  |  | 33 |  |  | 40 | 65 | 65 |  |  |  |  |  |  |  |
| Discovery | Snow | 766 |  |  |  |  |  |  |  |  |  | 766 |  | 2,152 |  | 2,183 | 2,252 | 2,771 |
|  | Salmon | 1,386 |  |  |  |  |  |  |  |  |  | 1,386 |  |  |  |  |  |  |
| Sequim | Jimmycomelatel | 599 |  |  |  |  |  |  |  |  |  |  | 599 | 599 |  | 608 | 627 | 771 |
| **Totals** |  | 5,374 | 0 | 90 | 239 | 679 | 156 | 585 | 3,988 | 6,447 | 6,447 | 2,152 | 599 | 9,198 | 6,447 | 9,330 | 9,626 | 11,845 |
|  | Hood Canal | 2,623 | 0 |  |  |  |  |  |  |  |  |  |  | 6,447 | 6,447 | 6,540 | 6,747 | 8,302 |
|  | E. Strait Portion | 2,751 | 0 |  |  |  |  |  |  |  |  |  |  | 2,751 |  | 2,790 | 2,879 | 3,543 |

Note: Values in bold italics were estimated indirectly

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| **Year:** | **1983** | **Harvest** |  | 23 | 0 | 209 | 276 | 1,131 | 105 | 664 | 9 | 0 | 0 |  | 2 | 131 | 146 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | Management Unit |  |  |  |  |
|  |  |  | Brood |  | ********** | Run Abundance by Location |  |  |  |  | ********** |  |  |  | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A |  | 23 |  | 38 |  |  | 40 | 45 | 45 |  |  | 45 | 45 | 47 | 48 | 49 |
| 12D | Tahuya | 86 |  |  | 86 | 144 |  |  | 150 | 188 | 188 |  |  | 560 | 561 | 577 | 596 | 599 |
|  | Union | 170 |  |  | 170 | 284 |  |  | 296 | 371 | 372 |  |  |  |  |  |  |  |
| 12A | L. Quilcene | 176 |  |  |  |  |  | 562 | 585 | 734 | 736 |  |  | 2,157 | 2,158 | 2,222 | 2,293 | 2,307 |
|  | B. Quilcene | 64 |  |  |  |  | 340 | 1,085 | 1,131 | 1,419 | 1,421 |  |  |  |  |  |  |  |
| 12-12B-12C | Big Beef | 0 |  |  |  |  |  |  | 0 | 0 | 0 |  |  | 510 | 510 | 526 | 542 | 546 |
|  | Anderson | 0 |  |  |  |  |  |  | 0 | 0 | 0 |  |  |  |  |  |  |  |
|  | Dosewallips | 64 |  |  |  |  |  |  | 67 | 84 | 84 |  |  |  |  |  |  |  |
|  | Duckabush | 80 |  |  |  |  |  |  | 83 | 105 | 105 |  |  |  |  |  |  |  |
|  | HammaHamma | 190 |  |  |  |  |  |  | 198 | 248 | 249 |  |  |  |  |  |  |  |
|  | Lilliwaup | 18 |  |  |  | 30 |  |  | 31 | 39 | 39 |  |  |  |  |  |  |  |
|  | Dewatto | 15 |  |  |  | 25 |  |  | 26 | 33 | 33 |  |  |  |  |  |  |  |
| Discovery | Snow | 154 |  |  |  |  |  |  |  |  |  | 154 |  | 885 |  | 911 | 941 | 946 |
|  | Salmon | 731 |  |  |  |  |  |  |  |  |  | 731 |  |  |  |  |  |  |
| Sequim | Jimmycomelatel | 254 |  |  |  |  |  |  |  |  |  |  | 254 | 254 |  | 262 | 270 | 272 |
| **Totals** |  | 2,002 | 0 | 23 | 256 | 521 | 340 | 1,647 | 2,607 | 3,266 | 3,272 | 885 | 254 | 4,411 | 3,274 | 4,544 | 4,690 | 4,718 |
|  | Hood Canal | 863 | 0 |  |  |  |  |  |  |  |  |  |  | 3,272 | 3,274 | 3,372 | 3,480 | 3,500 |
|  | E. Strait Portion | 1,139 | 0 |  |  |  |  |  |  |  |  |  |  | 1,139 |  | 1,173 | 1,210 | 1,218 |

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| **Year:** | **1984** | **Harvest** |  | 70 | 0 | 80 | 75 | 902 | 112 | 458 | 2 | 0 | 0 |  | 5 | 3 | 65 | 314 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | Management Unit |  |  |  |  |
|  |  |  | Brood |  | ********** |  | Run Abundance by Location |  |  |  | ********** |  |  |  | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A |  | 70 |  | 79 |  |  | 82 | 91 | 91 |  |  | 91 | 91 | 91 | 92 | 98 |
| 12D | Tahuya | 142 |  |  | 142 | 160 |  |  | 167 | 196 | 196 |  |  | 463 | 464 | 464 | 471 | 502 |
|  | Union | 194 |  |  | 194 | 218 |  |  | 228 | 267 | 268 |  |  |  |  |  |  |  |
| 12A | L. Quilcene | 83 |  |  |  |  |  | 426 | 445 | 522 | 522 |  |  | 1,372 | 1,374 | 1,375 | 1,394 | 1,486 |
|  | B. Quilcene | 60 |  |  |  |  | 135 | 694 | 724 | 849 | 849 |  |  |  |  |  |  |  |
| 12-12B-12C | Big Beef | 22 |  |  |  |  |  |  | 23 | 27 | 27 |  |  | 1,181 | 1,183 | 1,184 | 1,200 | 1,279 |
|  | Anderson | 1 |  |  |  |  |  |  | 1 | 1 | 1 |  |  |  |  |  |  |  |
|  | Dosewallips | 212 |  |  |  |  |  |  | 221 | 260 | 260 |  |  |  |  |  |  |  |
|  | Duckabush | 299 |  |  |  |  |  |  | 312 | 366 | 366 |  |  |  |  |  |  |  |
|  | HammaHamma | ***170*** |  |  |  |  |  |  | 178 | 208 | 208 |  |  |  |  |  |  |  |
|  | Lilliwaup | 187 |  |  |  | 210 |  |  | 220 | 258 | 258 |  |  |  |  |  |  |  |
|  | Dewatto | 44 |  |  |  | 50 |  |  | 52 | 61 | 61 |  |  |  |  |  |  |  |
| Discovery | Snow | 384 |  |  |  |  |  |  |  |  |  | 384 |  | 1,212 |  | 1,213 | 1,230 | 1,311 |
|  | Salmon | 828 |  |  |  |  |  |  |  |  |  | 828 |  |  |  |  |  |  |
| Sequim | Jimmycomelatel | 367 |  |  |  |  |  |  |  |  |  |  | 367 | 367 |  | 367 | 372 | 397 |
| **Totals** |  | 2,993 | 0 | 70 | 336 | 717 | 135 | 1,120 | 2,654 | 3,105 | 3,107 | 1,212 | 367 | 4,686 | 3,112 | 4,694 | 4,759 | 5,073 |
|  | Hood Canal | 1,414 | 0 |  |  |  |  |  |  |  |  |  |  | 3,107 | 3,112 | 3,114 | 3,157 | 3,365 |
|  | E. Strait Portion | 1,579 | 0 |  |  |  |  |  |  |  |  |  |  | 1,579 |  | 1,580 | 1,602 | 1,708 |

Note: Values in bold italics were estimated indirectly

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| **Year:** | **1985** | **Harvest** |  | 70 | 0 | 56 | 40 | 274 | 288 | 648 | 10 | 0 | 0 |  | 2 | 40 | 445 | 1,620 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | Management Unit |  |  |  |  |
|  |  |  | Brood |  | ********** |  | Run Abundance by Location |  |  |  | ********** |  |  |  | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A |  | 70 |  | 76 |  |  | 90 | 111 | 111 |  |  | 111 | 111 | 113 | 131 | 197 |
| 12D | Tahuya | 122 |  |  | 122 | 133 |  |  | 157 | 213 | 214 |  |  | 799 | 800 | 812 | 943 | 1,420 |
|  | Union | 334 |  |  | 334 | 363 |  |  | 431 | 583 | 585 |  |  |  |  |  |  |  |
| 12A | L. Quilcene | 1 |  |  |  |  |  | 4 | 5 | 7 | 7 |  |  | 577 | 578 | 586 | 681 | 1,026 |
|  | B. Quilcene | 44 |  |  |  |  | 84 | 355 | 421 | 569 | 570 |  |  |  |  |  |  |  |
| 12-12B-12C | Big Beef | 0 |  |  |  |  |  |  | 0 | 0 | 0 |  |  | 995 | 996 | 1,011 | 1,174 | 1,768 |
|  | Anderson | 0 |  |  |  |  |  |  | 0 | 0 | 0 |  |  |  |  |  |  |  |
|  | Dosewallips | 236 |  |  |  |  |  |  | 280 | 379 | 380 |  |  |  |  |  |  |  |
|  | Duckabush | 30 |  |  |  |  |  |  | 36 | 48 | 48 |  |  |  |  |  |  |  |
|  | HammaHamma | ***231*** |  |  |  |  |  |  | 274 | 371 | 372 |  |  |  |  |  |  |  |
|  | Lilliwaup | 92 |  |  |  | 100 |  |  | 119 | 161 | 161 |  |  |  |  |  |  |  |
|  | Dewatto | 19 |  |  |  | 21 |  |  | 25 | 33 | 33 |  |  |  |  |  |  |  |
| Discovery | Snow | 20 |  |  |  |  |  |  |  |  |  | 20 |  | 171 |  | 174 | 202 | 304 |
|  | Salmon | 151 |  |  |  |  |  |  |  |  |  | 151 |  |  |  |  |  |  |
| Sequim | Jimmycomelatel | 61 |  |  |  |  |  |  |  |  |  |  | 61 | 61 |  | 62 | 72 | 108 |
| **Totals** |  | 1,341 | 0 | 70 | 456 | 693 | 84 | 359 | 1,837 | 2,473 | 2,483 | 171 | 61 | 2,715 | 2,485 | 2,757 | 3,202 | 4,822 |
|  | Hood Canal | 1,109 | 0 |  |  |  |  |  |  |  |  |  |  | 2,483 | 2,485 | 2,521 | 2,929 | 4,411 |
|  | E. Strait Portion | 232 | 0 |  |  |  |  |  |  |  |  |  |  | 232 |  | 235 | 273 | 412 |

Note: Values in bold italics were estimated indirectly

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| **Year:** | **1986** | **Harvest** | | 35 | 0 | 55 | 22 | 561 | 1,348 | 2,432 | 4 | 0 | 0 | | 0 | 21 | 146 | 796 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | Management Unit | | | |
| | | | Brood | | ********** | | Run Abundance by Location | | | | ********** | | | | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A | | 35 | | 36 | | | 51 | 68 | 68 | | | 68 | 68 | 68 | 69 | 76 |
| 12D | Tahuya | 109 | | | 109 | 112 | | | 159 | 243 | 243 | | | 4,460 | 4,460 | 4,472 | 4,552 | 4,991 |
| | Union | 1,892 | | | 1,892 | 1,940 | | | 2,751 | 4,215 | 4,217 | | | | | | | |
| 12A | L. Quilcene | 12 | | | | | | 149 | 212 | 324 | 325 | | | 1,325 | 1,325 | 1,329 | 1,353 | 1,483 |
| | B. Quilcene | 15 | | | | | 37 | 461 | 653 | 1,000 | 1,001 | | | | | | | |
| 12-12B-12C | Big Beef | 0 | | | | | | | 0 | 0 | 0 | | | 1,145 | 1,145 | 1,148 | 1,169 | 1,282 |
| | Anderson | 0 | | | | | | | 0 | 0 | 0 | | | | | | | |
| | Dosewallips | 57 | | | | | | | 81 | 124 | 124 | | | | | | | |
| | Duckabush | 177 | | | | | | | 251 | 384 | 385 | | | | | | | |
| | HammaHamma | 173 | | | | | | | 245 | 376 | 376 | | | | | | | |
| | Lilliwaup | 97 | | | | 99 | | | 141 | 216 | 216 | | | | | | | |
| | Dewatto | 20 | | | | 21 | | | 29 | 45 | 45 | | | | | | | |
| Discovery | Snow | 213 | | | | | | | | | | 213 | | 795 | | 797 | 811 | 890 |
| | Salmon | 582 | | | | | | | | | | 582 | | | | | | |
| Sequim | Jimmycomelatel | 292 | | | | | | | | | | | 292 | 292 | | 293 | 298 | 327 |
| **Totals** | | 3,639 | 0 | 35 | 2,001 | 2,208 | 37 | 610 | 4,573 | 6,995 | 6,998 | 795 | 292 | 8,085 | 6,998 | 8,106 | 8,253 | 9,049 |
| | Hood Canal | 2,552 | 0 | | | | | | | | | | | 6,998 | 6,998 | 7,017 | 7,143 | 7,832 |
| | E. Strait Portion | 1,087 | 0 | | | | | | | | | | | 1,087 | | 1,090 | 1,109 | 1,217 |

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| **Year:** | **1987** | **Harvest** |  | 43 | 0 | 56 | 3 | 1,603 | 302 | 860 | 4 | 0 | 0 |  | 0 | 0 | 147 | 390 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | Management |  |  |  |
|  |  |  | Broo |  | ********** |  |  | Run Abundance by Location |  |  | ********** |  |  |  | Seattle | Admira | US | Cana |
| Mgmt Unit | Prod. Unit | Escapeme | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Disco | Sequi | Term. | (Area | (Area | Conv. | Area |
| Skokomish | Skokomish | N/A |  | 43 |  | 47 |  |  | 52 | 61 | 61 |  |  | 61 | 61 | 61 | 63 | 67 |
| 12D | Tahuya | 91 |  |  | 91 | 99 |  |  | 111 | 145 | 145 |  |  | 939 | 939 | 939 | 964 | 1,029 |
|  | Union | 497 |  |  | 497 | 539 |  |  | 605 | 793 | 794 |  |  |  |  |  |  |  |
| 12A | L. Quilcene | 71 |  |  |  |  |  | 1,459 | 1,638 | 2,148 | 2,149 |  |  | 2,482 | 2,482 | 2,482 | 2,547 | 2,719 |
|  | B. Quilcene | 8 |  |  |  |  | 11 | 226 | 254 | 333 | 333 |  |  |  |  |  |  |  |
| 12-12B-12 | Big Beef | 6 |  |  |  |  |  |  | 7 | 9 | 9 |  |  | 137 | 137 | 137 | 141 | 150 |
|  | Anderson | 0 |  |  |  |  |  |  | 0 | 0 | 0 |  |  |  |  |  |  |  |
|  | Dosewallips | 9 |  |  |  |  |  |  | 10 | 13 | 13 |  |  |  |  |  |  |  |
|  | Duckabush | 12 |  |  |  |  |  |  | 13 | 18 | 18 |  |  |  |  |  |  |  |
|  | HammaHam | 26 |  |  |  |  |  |  | 29 | 38 | 38 |  |  |  |  |  |  |  |
|  | Lilliwaup | 32 |  |  |  | 35 |  |  | 39 | 51 | 51 |  |  |  |  |  |  |  |
|  | Dewatto | 5 |  |  |  | 5 |  |  | 6 | 8 | 8 |  |  |  |  |  |  |  |
| Discovery | Snow | 465 |  |  |  |  |  |  |  |  |  | 465 |  | 1,527 |  | 1,527 | 1,567 | 1,673 |
|  | Salmon | 1,062 |  |  |  |  |  |  |  |  |  | 1,062 |  |  |  |  |  |  |
| Sequim | Jimmycomelat | 464 |  |  |  |  |  |  |  |  |  |  | 464 | 464 |  | 464 | 476 | 508 |
| **Totals** |  | 2,748 | 0 | 43 | 588 | 724 | 11 | 1,685 | 2,764 | 3,616 | 3,619 | 1,527 | 464 | 5,610 | 3,619 | 5,610 | 5,757 | 6,147 |
|  | Hood Canal | 757 | 0 |  |  |  |  |  |  |  |  |  |  | 3,619 | 3,619 | 3,619 | 3,714 | 3,965 |
|  | E. Strait | 1,991 | 0 |  |  |  |  |  |  |  |  |  |  | 1,991 |  | 1,991 | 2,043 | 2,181 |

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year:** | **1988** | **Harvest** | | 43 | 0 | 30 | 17 | 1,897 | 93 | 30 | 12 | 0 | 0 | | 5 | 0 | 305 | 738 |
| | | | | | | | | | | | | | | | Management Unit | | | |
| | | | Brood | | ********** | | | Run Abundance by Location | | | ********** | | | | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A | | 43 | | 44 | | | 45 | 45 | 45 | | | 45 | 45 | 45 | 47 | 51 |
| 12D | Tahuya | 145 | | | 145 | 149 | | | 152 | 153 | 153 | | | 816 | 817 | 817 | 846 | 914 |
| | Union | 629 | | | 629 | 646 | | | 658 | 662 | 664 | | | | | | | |
| 12A | L. Quilcene | 177 | | | | | | 1,246 | 1,270 | 1,277 | 1,279 | | | 2,269 | 2,271 | 2,271 | 2,350 | 2,541 |
| | B. Quilcene | 120 | | | | | 137 | 965 | 983 | 989 | 990 | | | | | | | |
| 12-12B-12C | Big Beef | 0 | | | | | | | 0 | 0 | 0 | | | 1,956 | 1,958 | 1,958 | 2,026 | 2,190 |
| | Anderson | 0 | | | | | | | 0 | 0 | 0 | | | | | | | |
| | Dosewallips | 661 | | | | | | | 673 | 677 | 679 | | | | | | | |
| | Duckabush | 497 | | | | | | | 506 | 509 | 511 | | | | | | | |
| | HammaHamma | 440 | | | | | | | 448 | 451 | 452 | | | | | | | |
| | Lilliwaup | 275 | | | | 282 | | | 288 | 289 | 290 | | | | | | | |
| | Dewatto | 23 | | | | 24 | | | 24 | 24 | 24 | | | | | | | |
| Discovery | Snow | 723 | | | | | | | | | | 723 | | 2,638 | | 2,638 | 2,730 | 2,951 |
| | Salmon | 1,915 | | | | | | | | | | 1,915 | | | | | | |
| Sequim | Jimmycomelatel | 1,052 | | | | | | | | | | | 1,052 | 1,052 | | 1,052 | 1,089 | 1,177 |
| **Totals** | | 6,657 | 0 | 43 | 774 | 1,145 | 137 | 2,211 | 5,047 | 5,077 | 5,086 | 2,638 | 1,052 | 8,776 | 5,091 | 8,781 | 9,086 | 9,825 |
| | Hood Canal | 2,967 | 0 | | | | | | | | | | | 5,086 | 5,091 | 5,091 | 5,268 | 5,696 |
| | E. Strait Portion | 3,690 | 0 | | | | | | | | | | | 3,690 | | 3,690 | 3,818 | 4,128 |

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| **Year:** | **1989** | **Harvest** | | 18 | 0 | 49 | 29 | 339 | 606 | 536 | 11 | 0 | 0 | | 1 | 4 | 421 | 2,273 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | Management Unit | | | |
| | | | Brood | | ********** | | Run Abundance by Location | | | | ********** | | | | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A | | 18 | | 20 | | | 31 | 38 | 38 | | | 38 | 38 | 38 | 44 | 78 |
| 12D | Tahuya | 9 | | | 9 | 10 | | | 16 | 21 | 21 | | | 1,063 | 1,063 | 1,065 | 1,239 | 2,179 |
| | Union | 450 | | | 450 | 492 | | | 781 | 1,036 | 1,042 | | | | | | | |
| 12A | L. Quilcene | 1 | | | | | | 12 | 19 | 25 | 25 | | | 781 | 782 | 783 | 911 | 1,602 |
| | B. Quilcene | 1 | | | | | 30 | 358 | 568 | 754 | 756 | | | | | | | |
| 12-12B-12C | Big Beef | 0 | | | | | | | 0 | 0 | 0 | | | 299 | 299 | 299 | 348 | 613 |
| | Anderson | 0 | | | | | | | 0 | 0 | 0 | | | | | | | |
| | Dosewallips | 16 | | | | | | | 25 | 34 | 34 | | | | | | | |
| | Duckabush | 60 | | | | | | | 95 | 126 | 127 | | | | | | | |
| | HammaHamma | 16 | | | | | | | 25 | 34 | 34 | | | | | | | |
| | Lilliwaup | 43 | | | | 47 | | | 75 | 99 | 100 | | | | | | | |
| | Dewatto | 2 | | | | 2 | | | 3 | 5 | 5 | | | | | | | |
| Discovery | Snow | 21 | | | | | | | | | | 21 | | 215 | | 215 | 251 | 441 |
| | Salmon | 194 | | | | | | | | | | 194 | | | | | | |
| Sequim | Jimmycomelatel | 173 | | | | | | | | | | | 173 | 173 | | 173 | 202 | 355 |
| **Totals** | | 986 | 0 | 18 | 459 | 571 | 30 | 370 | 1,640 | 2,171 | 2,181 | 215 | 173 | 2,569 | 2,182 | 2,574 | 2,994 | 5,267 |
| | Hood Canal | 598 | 0 | | | | | | | | | | | 2,181 | 2,182 | 2,185 | 2,542 | 4,472 |
| | E. Strait Portion | 388 | 0 | | | | | | | | | | | 388 | | 389 | 452 | 795 |

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| **Year:** | **1990** | **Harvest** |  | 58 | 0 | 43 | 29 | 307 | 36 | 48 | 67 | 0 | 0 |  | 0 | 0 | 45 | 696 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | Management Unit |  |  |  |
|  |  |  | Brood |  | ********** | | Run Abundance by Location |  |  |  | ********** |  |  |  | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A |  | 58 |  | 65 |  |  | 68 | 70 | 75 |  |  | 75 | 75 | 75 | 78 | 116 |
| 12D | Tahuya | 6 |  |  | 6 | 7 |  |  | 7 | 7 | 8 |  |  | 372 | 372 | 372 | 384 | 577 |
|  | Union | 275 |  |  | 275 | 310 |  |  | 323 | 340 | 364 |  |  |  |  |  |  |  |
| 12A | L. Quilcene | 0 |  |  |  |  |  | 0 | 0 | 0 | 0 |  |  | 389 | 389 | 389 | 402 | 604 |
|  | B. Quilcene | 6 |  |  |  |  | 35 | 342 | 356 | 375 | 389 |  |  |  |  |  |  |  |
| 12-12B-12C | Big Beef | 0 |  |  |  |  |  |  | 0 | 0 | 0 |  |  | 167 | 167 | 167 | 173 | 259 |
|  | Anderson | 0 |  |  |  |  |  |  | 0 | 0 | 0 |  |  |  |  |  |  |  |
|  | Dosewallips | 8 |  |  |  |  |  |  | 8 | 9 | 9 |  |  |  |  |  |  |  |
|  | Duckabush | 42 |  |  |  |  |  |  | 44 | 46 | 49 |  |  |  |  |  |  |  |
|  | HammaHamma | 90 |  |  |  |  |  |  | 94 | 99 | 106 |  |  |  |  |  |  |  |
|  | Lilliwaup | 2 |  |  |  | 2 |  |  | 2 | 2 | 3 |  |  |  |  |  |  |  |
|  | Dewatto | 0 |  |  |  | 0 |  |  | 0 | 0 | 0 |  |  |  |  |  |  |  |
| Discovery | Snow | 33 |  |  |  |  |  |  |  |  |  | 33 |  | 278 |  | 278 | 287 | 431 |
|  | Salmon | 245 |  |  |  |  |  |  |  |  |  | 245 |  |  |  |  |  |  |
| Sequim | Jimmycomelatel | 63 |  |  |  |  |  |  |  |  |  |  | 63 | 63 |  | 63 | 65 | 98 |
| **Totals** |  | 770 | 0 | 58 | 281 | 384 | 35 | 342 | 902 | 948 | 1,003 | 278 | 63 | 1,344 | 1,003 | 1,344 | 1,389 | 2,085 |
|  | Hood Canal | 429 | 0 |  |  |  |  |  |  |  |  |  |  | 1,003 | 1,003 | 1,003 | 1,037 | 1,556 |
|  | E. Strait Portion | 341 | 0 |  |  |  |  |  |  |  |  |  |  | 341 |  | 341 | 352 | 529 |

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| Year: | 1991 | Harvest |  | 3 | 0 | 13 | 31 | 751 | 0 | 6 | 66 | 0 | 0 |  | 0 | 59 | 171 | 483 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | Management Unit |  |  |  |  |
| Mgmt Unit | Prod. Unit | Escapement | Brood stock | 82G/J | ********** 12D | 12C | Run Abundance by Location 82F | 12A | 12B | 12 | ********** 9A | Discov | Sequi | Term. | Seattle (Area | Admiralt (Area 9) | US Conv. | Canadi Area |
| Skokomish | Skokomish | N/A |  | 3 |  | 3 |  |  | 3 | 3 | 3 |  |  | 3 | 3 | 3 | 4 | 5 |
| 12D | Tahuya | 5 |  |  | 5 | 5 |  |  | 5 | 5 | 5 |  |  | 233 | 233 | 241 | 262 | 321 |
|  | Union | 208 |  |  | 208 | 218 |  |  | 218 | 219 | 228 |  |  |  |  |  |  |  |
| 12A | L. Quilcene | 1 |  |  |  |  |  | 10 | 10 | 10 | 11 |  |  | 853 | 853 | 879 | 956 | 1,172 |
|  | B. Quilcene | 49 |  |  |  |  | 80 | 822 | 822 | 825 | 843 |  |  |  |  |  |  |  |
| 12-12B-12C | Big Beef | 0 |  |  |  |  |  |  | 0 | 0 | 0 |  |  | 507 | 507 | 523 | 569 | 697 |
|  | Anderson | 0 |  |  |  |  |  |  | 0 | 0 | 0 |  |  |  |  |  |  |  |
|  | Dosewallips | 250 |  |  |  |  |  |  | 250 | 251 | 262 |  |  |  |  |  |  |  |
|  | Duckabush | 102 |  |  |  |  |  |  | 102 | 102 | 107 |  |  |  |  |  |  |  |
|  | HammaHamma | 69 |  |  |  |  |  |  | 69 | 69 | 72 |  |  |  |  |  |  |  |
|  | Lilliwaup | 30 |  |  |  | 31 |  |  | 31 | 32 | 33 |  |  |  |  |  |  |  |
|  | Dewatto | 31 |  |  |  | 32 |  |  | 32 | 33 | 34 |  |  |  |  |  |  |  |
| Discovery | Snow | 12 |  |  |  |  |  |  |  |  |  | 12 |  | 184 |  | 190 | 206 | 253 |
|  | Salmon | 172 |  |  |  |  |  |  |  |  |  | 172 |  |  |  |  |  |  |
| Sequim | Jimmycomelatel | 125 |  |  |  |  |  |  |  |  |  |  | 125 | 125 |  | 129 | 140 | 172 |
| **Totals** |  | 1,054 | 0 | 3 | 213 | 290 | 80 | 832 | 1,543 | 1,549 | 1,597 | 184 | 125 | 1,906 | 1,597 | 1,965 | 2,136 | 2,620 |
|  | Hood Canal | 745 | 0 |  |  |  |  |  |  |  |  |  |  | 1,597 | 1,597 | 1,647 | 1,790 | 2,195 |
|  | E. Strait Portion | 309 | 0 |  |  |  |  |  |  |  |  |  |  | 309 |  | 319 | 346 | 425 |

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| **Year:** | **1992** | **Harvest** |  | 7 | 0 | 0 | 9 | 199 | 0 | 0 | 8 | 0 | 0 |  | 1 | 44 | 84 | 980 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | Management Unit |  |  |  |  |
|  |  |  | Brood |  | ********** |  | Run Abundance by Location |  |  |  | ********** |  |  |  | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A |  | 7 |  | 7 |  |  | 7 | 7 | 7 |  |  | 7 | 7 | 7 | 7 | 9 |
| 12D | Tahuya | 0 |  |  | 0 | 0 |  |  | 0 | 0 | 0 |  |  | 140 | 140 | 142 | 145 | 183 |
|  | Union | 140 |  |  | 140 | 140 |  |  | 140 | 140 | 140 |  |  |  |  |  |  |  |
| 12A | L. Quilcene | 9 |  |  |  |  |  | 11 | 11 | 11 | 11 |  |  | 952 | 953 | 964 | 986 | 1,241 |
|  | B. Quilcene | 320 | 414 |  |  |  | 743 | 940 | 940 | 940 | 941 |  |  |  |  |  |  |  |
| 12-12B-12C | Big Beef | 0 |  |  |  |  |  |  | 0 | 0 | 0 |  |  | 1,490 | 1,490 | 1,508 | 1,542 | 1,941 |
|  | Anderson | 0 |  |  |  |  |  |  | 0 | 0 | 0 |  |  |  |  |  |  |  |
|  | Dosewallips | 655 |  |  |  |  |  |  | 655 | 655 | 657 |  |  |  |  |  |  |  |
|  | Duckabush | 617 |  |  |  |  |  |  | 617 | 617 | 619 |  |  |  |  |  |  |  |
|  | HammaHamma | 123 |  |  |  |  |  |  | 123 | 123 | 123 |  |  |  |  |  |  |  |
|  | Lilliwaup | 90 |  |  |  | 90 |  |  | 90 | 90 | 90 |  |  |  |  |  |  |  |
|  | Dewatto | 0 |  |  |  | 0 |  |  | 0 | 0 | 0 |  |  |  |  |  |  |  |
| Discovery | Snow | 21 |  |  |  |  |  |  |  |  |  | 21 |  | 454 |  | 459 | 470 | 591 |
|  | Salmon | 371 | 62 |  |  |  |  |  |  |  |  | 433 |  |  |  |  |  |  |
| Sequim | Jimmycomelatel | 616 |  |  |  |  |  |  |  |  |  |  | 616 | 616 |  | 623 | 637 | 802 |
| **Totals** |  | 2,962 | 476 | 7 | 140 | 237 | 743 | 951 | 2,583 | 2,583 | 2,590 | 454 | 616 | 3,660 | 2,591 | 3,705 | 3,788 | 4,769 |
|  | Hood Canal | 1,954 | 414 |  |  |  |  |  |  |  |  |  |  | 2,590 | 2,591 | 2,622 | 2,681 | 3,375 |
|  | E. Strait Portion | 1,008 | 62 |  |  |  |  |  |  |  |  |  |  | 1,070 |  | 1,083 | 1,107 | 1,394 |

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| **Year:** | **1993** | **Harvest** | | 2 | 0 | 1 | 0 | 15 | 0 | 0 | 2 | 0 | 0 | | 0 | 46 | 53 | 67 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | Management Unit | | | |
| | | | Brood | | | ********** | | Run Abundance by Location | | | ********** | | | | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A | | 2 | | 2 | | | 2 | 2 | 2 | | | 2 | 2 | 2 | 2 | 2 |
| 12D | Tahuya | 0 | | | 0 | 0 | | | 0 | 0 | 0 | | | 252 | 252 | 261 | 271 | 284 |
| | Union | 251 | | | 251 | 252 | | | 252 | 252 | 252 | | | | | | | |
| 12A | L. Quilcene | 12 | | | | | | 13 | 13 | 13 | 13 | | | 163 | 163 | 169 | 175 | 183 |
| | B. Quilcene | 97 | 39 | | | | 136 | 150 | 150 | 150 | 150 | | | | | | | |
| 12-12B-12C | Big Beef | 0 | | | | | | | 0 | 0 | 0 | | | 353 | 353 | 365 | 379 | 397 |
| | Anderson | 0 | | | | | | | 0 | 0 | 0 | | | | | | | |
| | Dosewallips | 105 | | | | | | | 105 | 105 | 105 | | | | | | | |
| | Duckabush | 105 | | | | | | | 105 | 105 | 105 | | | | | | | |
| | HammaHamma | 69 | | | | | | | 69 | 69 | 69 | | | | | | | |
| | Lilliwaup | 72 | | | | 72 | | | 72 | 72 | 72 | | | | | | | |
| | Dewatto | 1 | | | | 1 | | | 1 | 1 | 1 | | | | | | | |
| Discovery | Snow | 11 | | | | | | | | | | 11 | | 463 | | 479 | 497 | 520 |
| | Salmon | 400 | 52 | | | | | | | | | 452 | | | | | | |
| Sequim | Jimmycomelatel | 110 | | | | | | | | | | | 110 | 110 | | 114 | 118 | 124 |
| **Totals** | | 1,233 | 91 | 2 | 251 | 327 | 136 | 163 | 769 | 769 | 771 | 463 | 110 | 1,344 | 771 | 1,389 | 1,442 | 1,509 |
| | Hood Canal | 712 | 39 | | | | | | | | | | | 771 | 771 | 797 | 827 | 866 |
| | E. Strait Portion | 521 | 52 | | | | | | | | | | | 573 | | 592 | 615 | 644 |

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year:** | **1994** | **Harvest** | | 1 | 0 | 0 | 0 | 20 | 0 | 0 | 13 | 0 | 0 | | 0 | 26 | 54 | 451 |
| | | | | | | | | | | | | | | Management Unit | | | | |
| | | | Brood | | ********** | | Run Abundance by Location | | | ********** | | | | | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A | | 1 | | 1 | | | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | 1 |
| 12D | Tahuya | 0 | | | 0 | 0 | | | 0 | 0 | 0 | | | 742 | 742 | 749 | 765 | 892 |
| | Union | 738 | | | 738 | 738 | | | 738 | 738 | 742 | | | | | | | |
| 12A | L. Quilcene | 0 | | | | | | 0 | 0 | 0 | 0 | | | 744 | 744 | 751 | 767 | 894 |
| | B. Quilcene | 349 | 373 | | | | 722 | 742 | 742 | 742 | 744 | | | | | | | |
| 12-12B-12C | Big Beef | 0 | | | | | | | 0 | 0 | 0 | | | 968 | 968 | 978 | 998 | 1,164 |
| | Anderson | 0 | | | | | | | 0 | 0 | 0 | | | | | | | |
| | Dosewallips | 225 | | | | | | | 225 | 225 | 226 | | | | | | | |
| | Duckabush | 263 | | | | | | | 263 | 263 | 264 | | | | | | | |
| | HammaHamma | 370 | | | | | | | 370 | 370 | 372 | | | | | | | |
| | Lilliwaup | 105 | | | | 105 | | | 105 | 105 | 106 | | | | | | | |
| | Dewatto | 0 | | | | 0 | | | 0 | 0 | 0 | | | | | | | |
| Discovery | Snow | 2 | | | | | | | | | | 2 | | 163 | | 165 | 168 | 196 |
| | Salmon | 137 | 24 | | | | | | | | | 161 | | | | | | |
| Sequim | Jimmycomelatel | 15 | | | | | | | | | | | 15 | 15 | | 15 | 15 | 18 |
| **Totals** | | 2,204 | 397 | 1 | 738 | 844 | 722 | 742 | 2,444 | 2,444 | 2,455 | 163 | 15 | 2,633 | 2,455 | 2,660 | 2,714 | 3,165 |
| | Hood Canal | 2,050 | 373 | | | | | | | | | | | 2,455 | 2,455 | 2,480 | 2,530 | 2,951 |
| | E. Strait Portion | 154 | 24 | | | | | | | | | | | 178 | | 180 | 183 | 214 |

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| **Year:** | **1995** | **Harvest** | | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 32 | 0 | 0 | | 0 | 0 | 68 | 458 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | Management Unit | | | | |
| | | | Brood | | ********** | | Run Abundance by Location | | | | ********** | | | | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A | | 0 | | 0 | | | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | 0 |
| 12D | Tahuya | 0 | | | 0 | 0 | | | 0 | 0 | 0 | | | 723 | 723 | 723 | 728 | 760 |
| | Union | 721 | | | 721 | 721 | | | 721 | 721 | 723 | | | | | | | |
| 12A | L. Quilcene | 54 | | | | | | 54 | 54 | 54 | 54 | | | 4,589 | 4,589 | 4,589 | 4,619 | 4,822 |
| | B. Quilcene | 4,029 | 491 | | | | 4,520 | 4,527 | 4,527 | 4,527 | 4,535 | | | | | | | |
| 12-12B-12C | Big Beef | 0 | | | | | | | 0 | 0 | 0 | | | 4,181 | 4,181 | 4,181 | 4,209 | 4,394 |
| | Anderson | 0 | | | | | | | 0 | 0 | 0 | | | | | | | |
| | Dosewallips | 2,787 | | | | | | | 2,787 | 2,787 | 2,796 | | | | | | | |
| | Duckabush | 825 | | | | | | | 825 | 825 | 828 | | | | | | | |
| | HammaHamma | 476 | | | | | | | 476 | 476 | 478 | | | | | | | |
| | Lilliwaup | 79 | | | | 79 | | | 79 | 79 | 79 | | | | | | | |
| | Dewatto | 0 | | | | 0 | | | 0 | 0 | 0 | | | | | | | |
| Discovery | Snow | 25 | | | | | | | | | | 25 | | 616 | | 616 | 620 | 647 |
| | Salmon | 538 | 53 | | | | | | | | | 591 | | | | | | |
| Sequim | Jimmycomelatel | 223 | | | | | | | | | | | 223 | 223 | | 223 | 224 | 234 |
| **Totals** | | 9,757 | 544 | 0 | 721 | 800 | 4,520 | 4,581 | 9,469 | 9,469 | 9,493 | 616 | 223 | 10,332 | 9,493 | 10,332 | 10,400 | 10,858 |
| | Hood Canal | 8,971 | 491 | | | | | | | | | | | 9,493 | 9,493 | 9,493 | 9,556 | 9,977 |
| | E. Strait Portion | 786 | 53 | | | | | | | | | | | 839 | | 839 | 845 | 882 |

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year:** | **1996** | **Harvest** | | 35 | 0 | 0 | 0 | 51 | 24 | 24 | 40 | 0 | 0 | | 0 | 23 | 80 | 338 |
| | | | | | | | | | | | | | | Management Unit | | | | |
| | | | Brood | | ********** | | Run Abundance by Location | | | | ********** | | | | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A | | 35 | | 35 | | | 35 | 35 | 35 | | | 35 | 35 | 35 | 35 | 36 |
| 12D | Tahuya | 5 | | | 5 | 5 | | | 5 | 5 | 5 | | | 501 | 501 | 502 | 503 | 511 |
| | Union | 494 | | | 494 | 494 | | | 495 | 495 | 496 | | | | | | | |
| 12A | L. Quilcene | 265 | | | | | | 266 | 267 | 267 | 267 | | | 9,597 | 9,597 | 9,607 | 9,643 | 9,792 |
| | B. Quilcene | 8,479 | 771 | | | | 9,250 | 9,300 | 9,310 | 9,321 | 9,330 | | | | | | | |
| 12-12B-12C | Big Beef | 0 | | | | | | | 0 | 0 | 0 | | | 10,544 | 10,544 | 10,555 | 10,594 | 10,758 |
| | Anderson | 0 | | | | | | | 0 | 0 | 0 | | | | | | | |
| | Dosewallips | 6,976 | | | | | | | 6,984 | 6,992 | 7,005 | | | | | | | |
| | Duckabush | 2,650 | | | | | | | 2,653 | 2,656 | 2,661 | | | | | | | |
| | HammaHamma | 774 | | | | | | | 775 | 776 | 777 | | | | | | | |
| | Lilliwaup | 40 | 60 | | | 100 | | | 100 | 100 | 100 | | | | | | | |
| | Dewatto | 0 | | | | 0 | | | 0 | 0 | 0 | | | | | | | |
| Discovery | Snow | 160 | | | | | | | | | | 160 | | 1,054 | | 1,055 | 1,059 | 1,075 |
| | Salmon | 785 | 109 | | | | | | | | | 894 | | | | | | |
| Sequim | Jimmycomelatel | 30 | | | | | | | | | | | 30 | 30 | | 30 | 30 | 31 |
| **Totals** | | 20,658 | 940 | 35 | 499 | 634 | 9,250 | 9,566 | 20,624 | 20,647 | 20,678 | 1,054 | 30 | 21,762 | 20,678 | 21,785 | 21,865 | 22,202 |
| | Hood Canal | 19,683 | 831 | | | | | | | | | | | 20,678 | 20,678 | 20,700 | 20,776 | 21,097 |
| | E. Strait Portion | 975 | 109 | | | | | | | | | | | 1,084 | | 1,085 | 1,089 | 1,106 |

| Reconstruction of the HC-SJF Summer Chum Salmon Runs | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year:** | **1997** | **Harvest** | | 0 | 0 | 77 | 0 | 100 | 3 | 0 | 0 | 0 | 0 | | 0 | 0 | 46 | 198 | |
| | | | | | | | | | | | | | | Management | | | | | |
| | | | Broo | | ********** | | Run Abundance by Location | | | | ********** | | | | Seattle | Admiralt | US | Canadi | |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area | |
| Skokomish | Skokomish | N/A | | 0 | | 0 | | | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | 0 | |
| 12D | Tahuya | 0 | | | 0 | 0 | | | 0 | 0 | 0 | | | 482 | 482 | 482 | 484 | 493 | |
| | Union | 410 | | | 410 | 481 | | | 482 | 482 | 482 | | | | | | | | |
| 12A | L. Quilcene | 29 | | | | | | 29 | 29 | 29 | 29 | | | 8,006 | 8,006 | 8,006 | 8,042 | 8,199 | |
| | B. Quilcene | 7,339 | 535 | | | | 7,874 | 7,974 | 7,976 | 7,976 | 7,976 | | | | | | | | |
| 12-12B-12C | Big Beef | 0 | | | | | | | 0 | 0 | 0 | | | 664 | 664 | 664 | 667 | 680 | |
| | Anderson | 0 | | | | | | | 0 | 0 | 0 | | | | | | | | |
| | Dosewallips | 47 | | | | | | | 47 | 47 | 47 | | | | | | | | |
| | Duckabush | 475 | | | | | | | 475 | 475 | 475 | | | | | | | | |
| | HammaHamma | 104 | | | | | | | 104 | 104 | 104 | | | | | | | | |
| | Lilliwaup | 10 | 16 | | | 31 | | | 31 | 31 | 31 | | | | | | | | |
| | Dewatto | 6 | | | | 7 | | | 7 | 7 | 7 | | | | | | | | |
| Discovery | Snow | 67 | | | | | | | | | | 67 | | 901 | | 901 | 905 | 923 | |
| | Salmon | 724 | 110 | | | | | | | | | 834 | | | | | | | |
| Sequim | Jimmycomelatel | 61 | | | | | | | | | | | 61 | 61 | | 61 | 61 | 62 | |
| **Totals** | | 9,272 | 661 | 0 | 410 | 519 | 7,874 | 8,003 | 9,151 | 9,151 | 9,151 | 901 | 61 | 10,113 | 9,151 | 10,113 | 10,159 | 10,357 | |
| | Hood Canal | 8,420 | 551 | | | | | | | | | | | 9,151 | 9,151 | 9,151 | 9,193 | 9,372 | |
| | E. Strait Portion | 852 | 110 | | | | | | | | | | | 962 | | 962 | 966 | 985 | |

## Reconstruction of the HC-SJF Summer Chum Salmon Runs

| **Year:** | **1998** | **Harvest** | | 5 | 21 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 41 | 98 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | Management Unit | | | | |
| | | | Brood | | ********** | | Run Abundance by Location | | | ********** | | | | | Seattle | Admiralt | US | Canadi |
| Mgmt Unit | Prod. Unit | Escapement | stock | 82G/J | 12D | 12C | 82F | 12A | 12B | 12 | 9A | Discov | Sequi | Term. | (Area | (Area 9) | Conv. | Area |
| Skokomish | Skokomish | N/A | | 5 | | 5 | | | 5 | 5 | 5 | | | 5 | 5 | 5 | 5 | 5 |
| 12D | Tahuya | 0 | | | 0 | 0 | | | 0 | 0 | 0 | | | 244 | 244 | 244 | 246 | 250 |
| | Union | 223 | | | 244 | 244 | | | 244 | 244 | 244 | | | | | | | |
| 12A | L. Quilcene | 265 | | | | | | 266 | 266 | 266 | 266 | | | 3,066 | 3,066 | 3,066 | 3,090 | 3,146 |
| | B. Quilcene | 2,244 | 547 | | | | 2,791 | 2,800 | 2,800 | 2,800 | 2,800 | | | | | | | |
| 12-12B-12C | Big Beef | 0 | | | | | | | 0 | 0 | 0 | | | 741 | 741 | 741 | 747 | 760 |
| | Anderson | 0 | | | | | | | 0 | 0 | 0 | | | | | | | |
| | Dosewallips | 336 | | | | | | | 336 | 336 | 336 | | | | | | | |
| | Duckabush | 226 | | | | | | | 226 | 226 | 226 | | | | | | | |
| | HammaHamma | 143 | | | | | | | 143 | 143 | 143 | | | | | | | |
| | Lilliwaup | 4 | 20 | | | 24 | | | 24 | 24 | 24 | | | | | | | |
| | Dewatto | 12 | | | | 12 | | | 12 | 12 | 12 | | | | | | | |
| Discovery | Snow | 28 | | | | | | | | | | 28 | | 1,172 | | 1,172 | 1,181 | 1,203 |
| | Salmon | 1,023 | 121 | | | | | | | | | 1,144 | | | | | | |
| Sequim | Jimmycomelatel | 98 | | | | | | | | | | | 98 | 98 | | 98 | 99 | 101 |
| **Totals** | | 4,602 | 688 | 5 | 244 | 285 | 2,791 | 3,066 | 4,056 | 4,056 | 4,056 | 1,172 | 98 | 5,326 | 4,056 | 5,326 | 5,367 | 5,466 |
| | Hood Canal | 3,453 | 567 | | | | | | | | | | | 4,056 | 4,056 | 4,056 | 4,087 | 4,162 |
| | E. Strait Portion | 1,149 | 121 | | | | | | | | | | | 1,270 | | 1,270 | 1,280 | 1,303 |

# Appendix Report 1.4
# Summary of SASSI Definitions And Criteria

The following material describes the approaches and methods used in the 1992 Washington State Salmon and Steelhead Stock Inventory (SASSI); developed by the Washington Department of Fisheries, Washington Department of Wildlife, and Western Washington Indian Tribes. For a more detailed treatment of the SASSI process see WDF et al. (1993), and additionally, a more complete discussion of the application of genetic stock identification techniques is presented in pages 13-15 of WDFW et al. (1994).

## Stock Definition

The first task in developing salmonid resource inventories is to arrive at a meaningful definition of the units of fish on which to base the assessment. Stocks were chosen as the basis for SASSI for several reasons. They provide the finest resolution of all the units considered and allow assessment of larger units by combination; stocks form the basic building blocks of Northwest salmonid management, and stock units are widely accepted within the scientific community as a basis for evaluating fish populations.

The definition of the term "stock" and its application frequently present difficulties because the distinctions between different groups of organisms are often difficult to measure, and because the term is used for a variety of purposes. For example, as applied in bottomfish management, a stock is a group of fish that exhibits a homogeneous response to fishing effort in an area, and may be made up of several breeding populations, or be part of a population. However, in salmonid management a stock is generally considered a discrete breeding population. Ricker (1972) defined salmon stocks as temporally or spatially separated breeding populations. The Puget Sound Salmon Management Plan refers to the fish of a single species that migrate at a particular season to a specific hatchery or independent river system as a stock. For the purpose of this inventory the authors of SASSI adopted the following definition which is essentially the same as that proposed by Ricker.

> **SASSI STOCK DEFINITION: The fish spawning in a particular lake or stream(s) at a particular season, which fish to a substantial degree do not interbreed with any group spawning in a different place, or in the same place at a different season.**

It should be noted that some differing views likely will surround any specific definition of stock. The inventory did not attempt to resolve these views or their applications. The purpose of the SASSI definition is simply to provide a clear, consistent and meaningful basis for conducting an inventory of the salmonid resources in Washington, and does not imply that this definition should be applied for other uses, that even smaller units of production are unimportant, or that the management of fisheries or fish habitat should be on this basis. Where reproductive isolation was shown or presumed to exist in the inventory, it may or may not indicate genetic uniqueness from other stocks. The terms stock and spawning population are used synonymously in the inventory.

Even with SASSI's basic stock definition, considerable uncertainty often occurs in applying it to any specific spawning group because limited direct data exist to evaluate the degree of reproductive isolation among spawning groups. Fish management entities have inventoried fish populations annually as an integral part of the management process. Data collection programs focus primarily on gathering information necessary to manage various salmonid fisheries. Consequently the detailed information needed to identify and evaluate Washington's wild stocks is often quite limited. This lack of detailed data has imposed some restrictions on the development and use of the inventory. It is impossible to ensure that SASSI accurately defines all wild salmonid stocks in the state. Many stocks listed in this inventory have not been studied in enough detail to be designated as discrete stocks with great certainty. Many others need more refined data to determine whether observed differences in timing or distribution actually represent stock differentiation. The inventory must be viewed as a starting point, and its list of stocks should be expected to evolve with future updates. The stock inventory process will continue to be conducted and, as more information is assembled, stocks will be added or deleted based on additional information.

The SASSI process emphasizes naturally-reproducing stocks of salmonids regardless of origin (native, non-native and mixed parentage). Future reports may include hatchery stocks as well. Only those stocks that spawn within Washington State are included. Past extinctions are not included in the status assessment because it is a current resource inventory, and the historic information on lost stocks is incomplete and often anecdotal. Where reliable information is available, reference may be made to extinctions in general terms in introductory sections only.

## Stock Definition Criteria

The criteria for defining stocks are:

Distinct spawning distribution.

Distinct temporal distribution (including spawning or run-timing).

Distinct biological characteristics (e.g. size, age structure, gene frequency differences, etc.)

Each of these criteria is an attribute that can be used to determine whether a group of fish is displaying substantial reproductive isolation. A population meeting any one of the above criteria is initially classified as a SASSI stock until additional information shows that it should not be considered distinct. The term distinct is not intended to imply complete isolation from other stocks. The SASSI stock definition recognizes that some interchange between populations is a natural part of salmonid biology.

Distinct spawning distribution is the most commonly used criterion for identifying individual stocks in the SASSI process because general information on the geographic location of spawning and spawning habitat is the most readily available. However, spawning distribution often does not show distinct separation and can be difficult to assess. A number of factors must be considered such as: degree of isolation, interchange between spawning groups, and the relationships between spawners in adjacent streams. It is also difficult to measure directly because it requires that spawning distribution of several generations of fish be tracked (i.e., do offspring of each generation return to spawn in the same areas that are substantially separated from areas used by other spawning groups). This criterion must usually be assumed since empirical data are often unavailable and are difficult to collect.

Distinct temporal distribution identifies stock differences based on variations in timing of critical life stages (e.g., spawn timing). Such differences are sometimes very distinct with no overlap between adjacent stocks. Differences are then generally quite obvious and easy to assess from readily-collected information. Many cases occur, however, where timing does overlap, and the difference between within-stock variation and distinct stocks becomes less clear.

Distinct biological characteristics can include any observable distinctions between stocks in size, color, age structure, scale patterns, parasites, or genetic differences. For some stocks, the stock differentiation is based on observable physical attributes. An example would be the distinction between tule and bright fall chinook from the upper Columbia River. These two types of chinook exhibit differences in spawning timing, but can also be characterized by differences in skin and flesh color. In this case, tule and bright fall chinook are designated as separate stocks based on both spawning timing and biological characteristics.

Genetic distinctions are the most common biological characteristic used in the inventory. There are indirect and direct approaches in SASSI for using genetic characterizations to distinguish among stocks. The indirect approach assumes that in some cases the genetic makeup of a group of fish has been substantially changed by past or continuing introductions of non-native stocks. If these introductions represent a major impact on the native gene pool, it is sometimes assumed that the resulting fish are probably hybridized and are a single genetic stock. In some areas, the introduction of hatchery origin fish (in particular chinook and coho salmon) has impacted the genetic character of stocks in a region which includes several streams, and it is assumed that the impact of these releases has resulted in one genetic stock.

The direct approach is based on genetic stock identification (GSI), which is a method that can be used to characterize populations of organisms using the genetic profiles of individuals. The GSI methodology relies on the combined use of biochemical, genetic, and statistical procedures to discriminate among populations. While the GSI characterization of stocks and testing of stock structure provide a direct measure of genetic interrelationships, it is important to be aware of this approach's limitations. Geneticists can investigate only a tiny and restricted fraction of the genetic traits of salmonids by the electrophoretic analysis of proteins. To the extent that characteristics investigated do not represent the entire genome, the view of genetic interrelationships could be incomplete. Also, while statistically significant differences among samples provide evidence for the existence of distinct gene pools (i.e. separate stocks), the absence of significant differences does not constitute proof that only a single stock exists.

## The Stock Identification Process

To arrive at a preliminary list of stocks, biologists identify individual stocks based on the first two criteria; known differences in spatial or temporal distribution. These distinctions are difficult to determine in some cases, particularly in situations where the amount of interchange among adjacent groups of fish was unknown. This preliminary list of stocks is then examined using available information on unique biological characteristics (principally genetic stock identification data). This review can result in a number of changes to the stock list, where additional groups of fish are identified based on observed genetic differences or other biological characteristics. More detailed analysis during future inventories likely will change some stock designations.

## Stock Origin

An understanding of the genetic background of salmonid stocks in Washington State is important for the development of any future efforts to restore and maintain these resources. Regardless of species, the SASSI process recognizes three categories of stock origin: 1) those stocks of fish that are thought to represent native gene pools, 2) those stocks that resulted from the introductions of non-native fish, and 3) those stocks that are a mix of native and non-native fish, or are substantially genetically altered native fish. A great deal of uncertainty often exists about the genetic histories of many salmon and steelhead stocks, and the contributions of hatchery-origin salmonids to native Washington populations have not been rigorously evaluated.

The definitions for stock origin used in SASSI are:

> **Native** -- An indigenous stock of fish that has not been substantially impacted by genetic interactions with non-native stocks, or by other factors, and is still present in all or part of its original range. In limited cases, a native stock may also exist outside of its original habitat (e.g., captive brood stock programs).
>
> **Non-native** -- A stock that has become established outside of its original range.
>
> **Mixed** -- A stock whose individuals originated from commingled native and non-native parents, and/or by mating between native and non-native fish (hybridization); or a previously native stock that has undergone substantial genetic alteration. This may include species cross such as hybrids between cutthroat and steelhead, or rainbow trout.
>
> **Unknown** -- This description is applied to stocks where there is insufficient information to identify stock origin with confidence.

### Production Type

The inventory describes the naturally-reproducing salmonids in the state. The origin of a stock or stock refers only to the genetic background of that specific group of fish. To understand more about the nature of an individual stock, it is also necessary to describe the type of spawning and rearing that produced the fish. For example, a stock of fish may be a genetic mixture of native and non-native fish, but in the absence of continuing hatchery releases, the stock may be self-sustaining as the result of natural spawning and rearing. These fish would be identified as a stock with a mixed origin and a wild production type. A native stock of fish in a rehabilitation program also can be sustained entirely by fish culture techniques. This situation is typified by Baker River sockeye salmon, a stock that is currently being restored by placing most spawners in an artificial spawning beach. This stock would be characterized as a native stock with a cultured production type.

The terms defining production type are:

> **Wild** -- A stock that is sustained by natural spawning and rearing in the natural habitat, regardless of parentage (includes native).
>
> **Cultured** -- A stock that depends upon spawning, incubation, hatching, or rearing in a hatchery or other artificial production facility.
>
> **Composite** -- A stock sustained by both wild and artificial production.

## Stock Status

Once the stocks are identified, the current status of each is assessed based primarily on trends in fish population size or spawner abundance, or survival. Detailed abundance data for individual stocks are sometimes not available.

A two-step process is used to evaluate the status of the state's salmonid stocks. First, five separate criteria (see the Stock Screening section below for a description of these criteria) were developed to describe changes in stock status and fitness, and each stock is screened to identify negative changes in abundance, production or survival. Stocks that met none of the criteria and are judged to be experiencing production levels within natural variations in survival and consistent with their available habitat were rated as "Healthy." Second, any stock that met one or more of the five negative performance criteria is examined further and subsequently rated in Depressed or Critical status categories to identify the probable level of damage suffered by the stock. An "Unknown" category is used for stocks if trend information is unavailable or could not be used to assess stock status.

There are several circumstances that complicate the rating process. When a wild stock experiences an extremely low survival, it is sometimes difficult to know if that survival is within the normal range for the stock, or if it is entering a depressed state caused by human impacts (e.g., habitat destruction or over-fishing). Naturally-produced salmonid stocks exhibit wide variations in survival, caused in part by changes in freshwater stream flows (droughts and flooding), ocean conditions (e.g., El Niño events) and biological interactions such as competition and predation (Cooper and Johnson 1992). It is not uncommon for wild stocks to experience one or two extremely low survival years each decade, resulting in low adult returns. This type of natural variation also provides years of above average production.

Some stocks are experiencing survivals that are so low that they are clearly below the level of natural variation. The survivals of other stocks are intermediate between obviously healthy stocks and clearly depressed stocks and are the most challenging to evaluate because they could be experiencing low survivals within the normal range for the stock. Short-term databases often exacerbate the rating problem because with only a few years of observation it is unlikely that the lowest natural survivals have been documented. The evaluation of stocks with intermediate survivals was based on the collective judgment of technical agency staff members most familiar with each stock.

The possibility of cycling in the survival rates of various stocks also can create difficulty in rating stock status. These cycles may be associated with weather-related impacts on freshwater spawning and rearing success. The apparent existence of cycles in survival and production data complicates the task of identifying depleted stocks, since poor stock performance could be the result of natural cyclic variation. Wherever possible, the existence of survival cycles is considered during the stock evaluation process and stocks with production levels within normal ranges of variation (including cyclic variation) are rated healthy.

## Stock Screening

The best available escapement, population size, and survival data are used to screen each stock for indications of negative production or survival trends. Only stock-specific data are used, which sometimes limits the available data to a short span of recent years. These data are plotted and qualitatively examined for changes in abundance or survival. Often, only a single stock-specific statistic is available to analyze the production trend of a stock. When multiple types of data can be used to examine individual stock status, the available production or survival data sets are examined individually, and each stock's rating is based on the data that best described current status.

Five stock screening criteria were developed and are used in the initial evaluation of each stock for trends in survival, escapement, or production. These criteria do not currently incorporate quantitative formulas because the available stock specific information is often too limited for statistical evaluation. More subjective criteria were applied, and decisions are based on the collective judgment of the technical reviewers most familiar with each stock. While this approach likely can be improved in the future with additional and better information, it facilitates the initial stock status classification process. The status of each stock will be subject to ongoing review and refinement in subsequent inventories.

The five stock screening criteria are:

> **Long-Term Negative Trend** -- This criterion reflects ten years of data showing a consistent drop in a survival or production parameter. The negative trend is the important factor and several high values would not eliminate a stock from being categorized under this criterion. Most

Washington salmon and steelhead escapement and production data bases span periods of ten to twenty-five years.

**Short-Term Severe Decline** -- A short-term drop in escapement or production is often difficult to distinguish from the amount of natural variation displayed by all naturally produced stocks of fish. It is important, however, to attempt to identify declining stocks as early as possible, so that limiting factors can be recognized and, if possible, corrected before serious damage occurs. The most recent five years of production data were examined for evidence of any significant drop in escapement, population size, or survival. If two of the five years display significant production decreases, the stock is included in this category.

**Chronically Low** -- Stocks in this category are sustaining themselves at levels significantly below their potential. The determination that a stock is chronically low may be based on observed past production levels, or on an assessment that stock performance does not meet expected levels based on available habitat. Chronically low stocks may display declining, stable, or even increasing trends. For stocks that have displayed chronically low production for an extended period, it may be necessary to examine any available data for the years before current stock assessment databases were developed.

**Decreases In Fitness** -- The ability of wild salmonid stocks to sustain themselves can be significantly affected by changes in the fitness of the individuals that make up a given stock. These changes can be subtle and include factors like changes in adult size or age structure, inbreeding associated with small numbers of spawners, changes in spawn timing, or other reduction in genetic variability. Any significant changes in fitness may justify the inclusion of a stock in this category. Currently no information is included in the inventory that allows any quantitative assessment of change in fitness.

**Unknown** -- Many salmonid stocks have not been monitored or enumerated over a sufficient period of years to enable determination of status. Stocks in this category will have an Unknown status rating. Evaluation of their status for future inventories will require more intensive stock assessment work.

## Stock Status Rating

The stock-screening process is used to place stocks into five status categories. Stocks with escapement, population size or survival levels within normal ranges are rated as Healthy. Those stocks that currently display low production or survival values are assigned to one of two separate rating categories: Depressed or Critical, depending on the current condition of the stock. Stocks are also rated as Unknown when data limitations did not allow assessment of current status. A rating category for Extinct stocks is also included. Definitions and discussions of each of these rating categories are provided below.

The rating of stock status was done during a technical review process. The amount and quality of stock data vary among regions within the state, which can result in some differences in the application of the rating categories. These ratings represent the collective judgment of the technical staff most familiar with the individual stocks. The iterative nature of the inventory process will allow these ratings to be changed in the future as more detailed information becomes available, or because of changes in stock status.

### Healthy Stocks

> **Healthy** -- A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.
>
> Healthy stocks are those currently experiencing stable escapement, survival, and production trends and not displaying a pattern of chronically low abundance. Because wild salmonid stocks experience large natural fluctuations in survival (caused by environmental variations), it is not unusual for even the most robust stock to experience occasional low abundance or even fail to meet escapement goals. Such fluctuations would not necessarily warrant a change in status unless the stock experiences a consistent declining trend, or a sudden significant drop in production. The Healthy category covers a wide range of stock performance levels, from consistently robust production to those stocks that may be maintaining sustainable levels without providing any surplus production for directed harvests. In other words, the fact that a stock may be classified as Healthy in the inventory process does not necessarily mean that managers have no current concerns about its production status. State and tribal fishery managers believe very strongly that habitat protection and restoration needs exist for many of the stocks classified as Healthy in SASSI as well as for Critical and Depressed stocks. In addition, due to a lack of information on changes in fitness, some stock were classified as Healthy that may have been significantly influenced by interactions with non-native species. Much current resource management activity focuses on resolving problems for productive stocks to ensure they remain healthy and continue to provide harvest opportunity.

Approaches to considering habitat degradation, or loss, in assessing the status of individual stocks presents a particularly difficult problem. It is probable that all wild salmonid stocks in Washington State have been affected by some level of habitat loss. It might be argued that if a stock has suffered any habitat loss, it cannot be judged to be Healthy. Such an argument is unrealistic, but it would still be desirable to identify some level at which the cumulative impacts of habitat loss have taken a stock out of the Healthy category. Unfortunately, it is difficult to accomplish this task, because individual stocks are faced with such a wide range of different habitat impacts. The SASSI report rates the current status of each stock based primarily on trends in survival rates and population size, and does not focus directly on causative factors. Habitat loss, over-fishing, or other factors, may be the reason that a stock is Depressed or Critical, but the rating is based on actual stock performance.

The consideration of available habitat is included in the stock rating definitions for Healthy and Depressed stocks. This approach is an effort to recognize that there have been irreversible losses of habitat and that if stock status were rated against a pristine habitat base, virtually every stock could be rated depressed or worse. Such a result would be of little help in addressing the current need to restore our wild salmonid stocks. To provide a meaningful assessment of current stock status, a flexible definition of "available" habitat is needed. In SASSI, "available" habitat may be habitat that is currently accessible to wild salmonids or in some cases may include all habitat that salmonids could reasonably be expected to utilize, even if currently inaccessible. For example, if a stock lost access to and/or was blocked from utilizing a substantial proportion of the available habitat in a stream, this may have been considered in the rating of stock status.

This definition is not meant to imply that a stock rating will remain healthy in the face of continuing habitat loss, even if the stock remains in balance with declining habitat. Future inventories will identify those Healthy stocks that are in need of attention to help ensure they remain at healthy levels. SASSI will also serve as a baseline against which any future changes in stock performance or habitat availability can be measured.

## Depressed Stocks

> **Depressed** -- A stock of fish whose production is below expected levels based on available habitat and natural variations in survival rates, but above the level where permanent damage to the stock is likely.
>
> The category of Depressed stocks is used to identify those stocks that are experiencing difficulties that contribute to lower than expected abundance. These stocks meet one or more of the negative performance criteria, but are likely above the level where permanent damage has occurred to the stock. These stocks may currently be producing relatively large numbers of fish but have experienced a substantial drop in production or are producing well below their potential. Other stocks may be represented by relatively small numbers of individuals and are chronically depressed; forced to a low production level by some combination of biological, environmental, or human-caused factors. It is not unusual for a stock to stabilize at a low production level by achieving a balance with the particular set of survival pressures controlling its success. While Depressed stocks may not immediately be pushed to Critical status or face extinction, they are vulnerable to any additional negative impacts and can potentially change status very rapidly. Additionally, these stocks often constrain fishery harvest opportunity because of their low abundance.

## Critical Stocks

> **Critical** -- A stock of fish experiencing production levels that are so low that permanent damage to the stock is likely or has already occurred.
>
> The Critical stock category is reserved for those stocks that have declined to a level where the stock is in jeopardy of significant loss of within-stock diversity or, in the worst case, could face extinction. The loss of within-stock diversity includes such factors as a reduction of range (e.g., spawning and/or rearing distribution), shifts in age at maturity, changes in body size, reduction in genetic variability, or lowered disease resistance. Major shifts in these or other attributes can all lead to significant reductions in a stock's ability to respond to changing conditions. The usual result is reduced survival and population size. Such stressed stocks can be caught in a downward spiral of ever-increasing negative impacts that can lead to eventual extinction. In contrast, stocks in this category might reach an equilibrium with those factors controlling their performance and could display consistent population size and escapements for an extended period. While such stocks would appear to be stable, they could be delicately balanced, awaiting just one additional

negative impact to push them into failure. The Critical stocks are in need of immediate restoration efforts to ensure their continued existence and to return them to a productive state.

### Unknown Stocks

**Unknown** -- There is insufficient information to rate stock status.

If sufficient trend information is not available or can not be used to assess status, stocks are rated as Unknown. Stocks rated as Unknown may be rated as Healthy, Depressed, Critical, or Extinct once more information is available. It is not known to what extent the Unknown stocks represent historically small populations. There is an immediate need to collect information on Unknown stocks. Historically small populations or currently small populations could be especially vulnerable to any negative impacts.

### Extinct Stocks

**Extinct** -- A stock of fish that is no longer present in its original range, or as a distinct stock elsewhere. Individuals of the same species may be observed in very low numbers, consistent with straying from other stocks.

The SASSI process identifies extant salmonid stocks and makes no effort to identify and assess past extinctions. The past loss of stocks is an important historical fact that challenges resource management effectiveness. It would be difficult, however, to assemble any kind of comprehensive listing of past extinctions because many of these losses occurred prior to the time that enumeration programs were initiated. Since SASSI is an inventory of the current status of wild salmonid stocks, the inclusion of known past extinctions was not emphasized. The Extinct rating is included here to identify any current and future losses of stocks identified during the inventory process. The Extinct category is applied in the inventory if a stock that is currently being tracked in escapement or fishery management data bases is found to have been extirpated within its native range.

## References

Cooper, R. and T. H. Johnson. 1992. Trends in steelhead abundance in Washington and along the Pacific Coast of North America. Wash. Dept. of Wildlife, Fisheries Management Division. Rept. No. 92-20. 90p.

Ricker, W.E. 1972. Hereditary and environmental factors affecting certain salmonid populations. In Simon, R,C. and P.A. Larkin (eds.) The Stock Concept. of Pacific Salmon. MacMillian Lectures in Fisheries, University of British Columbia, Vancouver B.C. (need page numbers).

WDF (Washington Department of Fisheries), Washington Department of Wildlife, and Western Washington Treaty Indian Tribes. 1993. 1992 Washington State Salmon and Steelhead Stock Inventory. Wash. Dept. Fish and Wild., Olympia, WA. 212 p.

WDFW (Washington Department of Fish and Wildlife) and WWTIT (Western Washington Treaty Indian Tribes). 1994. 1992 Washington State salmon and steelhead stock inventory-Appendix One - Puget Sound stocks - Hood Canal and Strait of Juan de Fuca vol. Wash. Dept. Fish and Wild., Olympia, WA. 424 p.

# Appendix Report 1.5

# Derivation of Critical Status Thresholds for Management Units and Escapement Distribution and Minimum Escapements Flags for Stocks

It is necessary to annually evaluate the abundance (total return) and the escapement of the summer chum salmon of the region to ensure that timely adaptive management will occur if recovery objectives are not met. However, reliable data do not currently exist on the age composition of summer chum stocks and on the distribution of harvest among the stocks of summer chum. Thus, it is not possible to develop stock specific spawner/recruit functions for use in evaluating specific fisheries effects for individual management units or stocks. This limits the fisheries managers' ability to assess incidental harvest impacts on the summer chum of the management units and stocks.

Because of these data limitations, the Base Conservation Regime is designed to be conservative in its approach and is believed to be sufficient to protect summer chum stocks for all immediately foreseeable conditions (see section 3.5.6.1 for a description of the specific conduct of fisheries). However, to ensure the protection and restoration of individual stocks, and also to ensure the health and diversity of Hood Canal and Strait of Juan de Fuca summer chum as a whole, specific criteria have been developed to serve as critical thresholds (or flags) to identify individual management units and stocks that may be performing poorly. In a post-season review, annually estimated abundances (total adult recruitments) and escapements are compared with the critical status[1] thresholds and flags to assess the status of individual management units and stocks. Also, in preparation for the next fishing season, the forecast run sizes and their parental brood run sizes and escapement are reviewed. If the estimated population parameters fall below the thresholds, or flags, then additional management measures beyond those provided in the Base Conservation Regime may be warranted. The application of these thresholds and flags is described in sections 1.7.3, 3.5.7.1 and 3.6.4, and their derivation is described below.

## Critical Thresholds for Management Units

The critical management unit thresholds for abundance and escapement are based on the lowest levels observed in the historical data. A "buffer" is added to the lowest observed values to obtain the thresholds. The "buffers" were determined as follows. First, the annual recruit abundances of each management unit, including all currently existing stocks, were examined for statistical outliers (using Hadi outlier detection procedure of SYSTAT, version 9.0). This procedure was applied to all summer chum salmon management units for return years from 1974 through 1998 (25 years). Exceptions were made for the Discovery Bay

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[1] Note that "critical status" in the context used here has a different definition (as described in section 1.7.3 and in detail within this appendix) than the critical definition for SASSI stocks (shown in section 1.7.2).

and Quilcene/Dabob Bay management units, where the years 1995-1998 were excluded (leaving a total of 21 years) because of substantial adult returns in that time period from summer chum supplementation projects.

The highest two detected abundance outliers of each management unit were removed with two exceptions. In the Discovery Bay Management Unit, only one outlier was found and removed, while in the Mainstem Hood Canal Management Unit (12B), three outliers were removed because there was no significant difference between the second and third detected outliers.

Once the abundance outliers were removed, the "buffer" was calculated for each management unit as 25% of the range between the minimum and maximum abundance values. (The exception is Discovery Bay where 20% of the range was used because of the distribution of the abundance values.) As indicated previously, the calculated "buffer" was added to the lowest abundance value of each management unit to obtain each critical abundance threshold level. The critical escapement threshold levels were then calculated by multiplying each abundance threshold by the estimated escapement rate for each management unit. (The escapement rate was calculated by subtracting the Base Conservation Regime's estimated by-catch rate for each management unit from 1.0.) Data used and results of this procedure are shown in Appendix Table 1.5.1. The results are summarized as follows (values rounded to nearest 10):

| Management Unit | Critical Abundance Threshold | Critical Escapement Threshold |
|---|---|---|
| Sequim Bay | 220 | 200 |
| Discovery Bay | 790 | 720 |
| Mainstem Hood Canal | 2,980 | 2,660 |
| Quilcene/Dabob | 1,260 | 1,110 |
| SE Hood Canal | 340 | 300 |
| Total | 5,590 | 4,990 |

## Escapement Distribution Flags and Minimum Escapement Flags within the Mainstem Hood Canal Management Unit

Each management unit currently corresponds to one summer chum stock with the exception of the Mainstem Hood Canal Management Unit, in which four individual stocks are represented. The Mainstem Hood Canal Management Unit's thresholds (described above), provide criteria for assessing the management unit as a whole but do not address the possibility of poor performance by its individual stocks. For example, in a given year, one or more stocks within the Mainstem Hood Canal Management Unit may have a dangerously low escapement level that is not detectable by the management unit's threshold because other stocks in the unit may have a relatively high escapement level.

To address this problem, specific criteria were developed to detect when significant deviations occur from the expected distribution of escapement among the Mainstem Hood Canal Management Unit's stocks, and to assist in determining when an individual stock's escapements fall below a critical level. These criteria are respectively called escapement distribution flags and minimum escapement flags.

The escapement distribution flags were computed in the following manner. The average proportional contribution of each stock to the Mainstem Hood Canal Management Unit was calculated for the period of 1974 through 1980. Then, for each stock, one standard deviation was subtracted from the average contributed proportion to arrive at the value that would serve as the escapement distribution flag for that stock. The computation of the escapement distribution flag is shown in the following equation.

$$\text{Escapement Distribution Flags} = \frac{\left[\sum_{x=1974}^{1980} \frac{\text{Escapement}_{s}}{\text{Escapement}_{HCMMU}}\right]}{N} - \left[\text{Standard Deviation of Average}\right]$$

where,

*S* = stock within the Hood Canal Mainstem Management Unit
*HCMMU* = Hood Canal Mainstem Management Unit
N = number of years between 1974-1980

The years 1974 through 1980 were used in the above computation because that was a period of relatively high abundance prior to the decline of the 1980s, and there was relatively stable distribution of escapements among the stocks within the Mainstem Management Unit. It was assumed that setting the flag one standard deviation below the average proportion of escapement would provide adequate detection of potentially dangerous deviation from the historical distribution pattern.

The minimum escapement flags were calculated by simply multiplying the above described average escapement proportions for each stock by the critical escapement threshold for the Mainstem Hood Canal Management Unit as shown in the following equation.

$$\text{Minimum Escapement Flag}_{s} = \left[\text{Critical Escapement Threshold}_{HCMMU}\right] \text{x} \left[\text{Average 1974-1980 proportion}_{s}\right]$$

where,

HCMMU = Hood Canal Mainstem Unit
S = individual stock within HCCMU

It was assumed that the minimum escapement flags, based on the Mainstem Hood Canal Management Unit's threshold and the escapement distribution of the individual stocks, would provide adequate detection of dangerously low escapements for each stock.

The immediately following table describes for each Mainstem Hood Canal Management Unit stock, the mean proportion of escapement in the non-critical years of 1974 through 1980, the standard deviation, the escapement distribution flag and the minimum escapement flag.

**Critical Status Flags for Individual Stocks of the Hood Canal Mainstream Unit**

| Stock | Mean Proportion in non-Critical Years | Sample Standard Deviation | EDF | MEF |
|---|---|---|---|---|
| Dosewallips | 0.277 | 0.130 | 0.147 | 736 |
| Duckabush | 0.263 | 0.083 | 0.180 | 700 |
| Hamma Hamma | 0.392 | 0.199 | 0.193 | 1,042 |
| Lilliwaup | 0.069 | 0.026 | 0.043 | 182 |
|  | 1.000 |  |  | 2,660 |

Appendix Table 1.5.2 describes results of applying the flags to estimated stock escapements over the years 1974 through 1998. This table also shows where the Mainstem Hood Canal Management Unit's total escapements were above and below the critical escapement threshold over the same years.

How the Mainstem Management Unit threshold and escapement flags function when they are applied to abundances and escapements of past years is shown in Appendix Table 1.5.2. The results of these applications demonstrate how the critical thresholds and the EDFs work together to ensure that a flag will be raised whenever the Hood Canal Mainstem Management Unit, or the stocks within it, experience severe abundance or escapement problems. They also demonstrate that the method used to derive the EDFs is conservative. EDFs are triggered in some years, but a closer examination reveals escapements to some stocks were, in fact, sufficient. Given the conservativeness of the approach, the triggering of an EDF requires an evaluation of the associated stock(s), but does not mandate that action be taken if it can be shown that the additional actions are not necessary (see section 3.6.1).

**Appendix Table 1.5.1**. Hood Canal and Strait of Juan de Fuca summer chum salmon escapements (1974-98) used to calculate critical thresholds for management unit abundance and escapement.

| Run Year | Discovery | | | Sequim | | | Strait of Juan de Fuca | | | Mainstem HC | | | Quilcene | | | SE HC | | | Hood Canal | | | ESU | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Esc | Harv | Total | Esc | Harv | Total | Esc | Harv | Total | Esc | Harv | Total | Esc | Harv | Total | Esc | Harv | Total | Esc | Harv | Total | Esc | Harv | Total |
| **1974** | 1,330 | 164 | 1,494 | 438 | 54 | 492 | 1,768 | 218 | 1,986 | 10,23 | 1,284 | 11,52 | 839 | 105 | 944 | 68 | 9 | 77 | 11,14 | 1,398 | 12,54 | 12,91 | 1,616 | 14,529 |
| **1975** | 1,082 | 278 | 1,360 | 348 | 20 | 368 | 1,430 | 298 | 1,728 | 8 | 3,673 | 2 | 2,273 | 962 | 3,235 | 84 | 130 | 214 | 5 | 4,765 | 3 | 3 | 5,063 | 21,392 |
| **1976** | 1,129 | 135 | 1,264 | 365 | 44 | 408 | 1,494 | 179 | 1,672 | 12,54 | 11,01 | 16,21 | 3,533 | 7,673 | 11,20 | 100 | 563 | 663 | 14,89 | 19,24 | 19,66 | 16,32 | 19,42 | 43,181 |
| **1977** | 1,239 | 125 | 1,364 | 405 | 41 | 446 | 1,644 | 166 | 1,810 | 2 | 3 | 5 | 1,594 | 324 | 6 | 75 | 167 | 242 | 9 | 9 | 4 | 9 | 8 | 14,020 |
| **1978** | 2,293 | 120 | 2,413 | 787 | 41 | 828 | 3,080 | 161 | 3,240 | 18,62 | 2,287 | 29,63 | 4,794 | 760 | 1,918 | 64 | 75 | 139 | 22,25 | 2,778 | 41,50 | 23,75 | 2,944 | 25,739 |
| **1979** | 591 | 108 | 699 | 170 | 31 | 201 | 761 | 140 | 900 | 6 | 3,460 | 9 | 455 | 279 | 5,554 | 97 | 273 | 370 | 9 | 4,295 | 8 | 3 | 4,455 | 9,417 |
| **1980** | 3,783 | 344 | 4,127 | 1,326 | 121 | 1,447 | 5,109 | 465 | 5,574 | 7,763 | 1,773 | 10,05 | 529 | 1,403 | 734 | 208 | 939 | 1,147 | 9,432 | 2,326 | 12,21 | 11,07 | 2,465 | 16,532 |
| **1981** | 681 | 198 | 879 | 203 | 59 | 261 | 884 | 257 | 1,140 | 13,34 | 5,260 | 0 | 222 | 539 | 1,932 | 41 | 67 | 108 | 18,20 | 7,602 | 0 | 6 | 8,067 | 6,043 |
| **1982** | 2,153 | 619 | 2,771 | 599 | 172 | 771 | 2,751 | 791 | 3,542 | 6 | 2,195 | 16,80 | 281 | 1,214 | 761 | 153 | 459 | 612 | 4 | 2,801 | 22,49 | 21,28 | 3,057 | 11,090 |
| **1983** | 885 | 61 | 946 | 254 | 18 | 272 | 1,139 | 79 | 1,218 | 5,639 | 3,359 | 6 | 240 | 2,067 | 1,495 | 170 | 228 | 398 | 6,191 | 5,032 | 8 | 3 | 5,823 | 4,433 |
| **1984** | 1,212 | 99 | 1,311 | 367 | 30 | 397 | 1,579 | 129 | 1,708 | 2,619 | 159 | 7,412 | 143 | 1,343 | 2,307 | 194 | 96 | 290 | 3,356 | 2,453 | 8,517 | 6,952 | 2,532 | 4,666 |
| **1985** | 171 | 133 | 304 | 61 | 47 | 108 | 232 | 180 | 412 | 1,839 | 315 | 7,879 | 45 | 981 | 1,486 | 334 | 706 | 1,040 | 2,102 | 1,754 | 10,95 | 8,465 | 1,882 | 4,186 |
| **1986** | 795 | 95 | 890 | 292 | 35 | 327 | 1,087 | 130 | 1,217 | 2,082 | 1,120 | 4,034 | 27 | 1,456 | 1,026 | 1,892 | 2,827 | 4,719 | 2,516 | 2,806 | 8 | 2,986 | 2,986 | 8,651 |
| **1987** | 1,527 | 146 | 1,673 | 464 | 44 | 508 | 1,991 | 190 | 2,181 | 352 | 728 | 5,441 | 79 | 2,640 | 1,483 | 497 | 373 | 870 | 762 | 5,012 | 4,903 | 5,267 | 5,141 | 5,902 |
| **1988** | 2,638 | 313 | 2,951 | 1,052 | 125 | 1,177 | 3,690 | 438 | 4,128 | 868 | 53 | 511 | 297 | 2,244 | 2,719 | 629 | 114 | 743 | 1,205 | 3,066 | 7,548 | 1,901 | 3,256 | 9,575 |
| **1989** | 215 | 226 | 441 | 173 | 182 | 355 | 388 | 407 | 795 | 589 | 290 | 1,183 | 2 | 1,600 | 2,541 | 450 | 1,686 | 2,136 | 968 | 2,648 | 3,215 | 2,784 | 3,086 | 5,137 |
| **1990** | 278 | 153 | 431 | 63 | 35 | 98 | 341 | 188 | 529 | 504 | 468 | 1,709 | 6 | 598 | 1,602 | 275 | 289 | 564 | 2,423 | 3,755 | 2,959 | 1,200 | 4,162 | 1,956 |
| **1991** | 184 | 69 | 253 | 125 | 47 | 172 | 309 | 116 | 425 | 79 | 117 | 1,232 | 50 | 1,122 | 604 | 208 | 105 | 313 | 655 | 1,004 | 3,774 | 3,510 | 1,192 | 2,561 |
| **1992** | 454 | 137 | 591 | 616 | 186 | 802 | 1,070 | 324 | 1,394 | 1,873 | 200 | 132 | 743 | 498 | 1,172 | 140 | 43 | 183 | 2,799 | 1,427 | 7,435 | 2,646 | 1,543 | 4,760 |
| **1993** | 463 | 57 | 520 | 110 | 14 | 124 | 573 | 71 | 644 | 135 | 456 | 2,163 | 148 | 35 | 1,241 | 251 | 33 | 284 | 587 | 998 | 3,721 | 6,489 | 1,322 | 1,506 |
| **1994** | 163 | 33 | 196 | 15 | 3 | 18 | 178 | 36 | 214 | 142 | 44 | 603 | 722 | 172 | 183 | 738 | 154 | 892 | 423 | 112 | 5,447 | 975 | 183 | 3,163 |
| **1995** | 616 | 31 | 647 | 223 | 11 | 234 | 839 | 43 | 882 | 451 | 201 | 259 | 4,574 | 248 | 894 | 721 | 39 | 760 | 709 | 526 | 4,342 | 764 | 562 | 10,858 |
| **1996** | 1,054 | 21 | 1,075 | 30 | 1 | 31 | 1,084 | 22 | 1,106 | 1,485 | 227 | 651 | 9,515 | 277 | 4,822 | 494 | 12 | 506 | 2,368 | 515 | 1,427 | 1,018 | 557 | 22,162 |
| **1997** | 901 | 22 | 923 | 61 | 1 | 62 | 962 | 23 | 985 | 351 | 258 | 1,941 | 7,903 | 296 | 9,792 | 410 | 83 | 493 | 750 | 547 | 2,136 | 3,438 | 569 | 10,350 |
| **1998** | 1,172 | 31 | 1,203 | 98 | 3 | 101 | 1,270 | 34 | 1,304 | 963 | 21 | 395 | 3,056 | 90 | 8,199 | 223 | 27 | 250 | 2,423 | 400 | 3,366 | 1,323 | 423 | 5,460 |
| | | | | | | | | | | 4,167 | 31 | 1,164 | | | 3,146 | | | | 9,462 | 148 | 862 | 2,601 | 182 | |
| | | | | | | | | | | 10,50 | | 4,394 | | | | | | | 20,50 | | 2,949 | 10,30 | | |
| | | | | | | | | | | 0 | | 10,75 | | | | | | | 9 | | 9,977 | 1 | | |
| | | | | | | | | | | 652 | | 8 | | | | | | | 8,965 | | 21,05 | 21,59 | | |
| | | | | | | | | | | 729 | | 673 | | | | | | | 4,008 | | 6 | 3 | | |
| | | | | | | | | | | | | 760 | | | | | | | | | 9,365 | 9,927 | | |
| | | | | | | | | | | | | | | | | | | | | | 4,156 | 5,278 | | |
| Avg | | | 1,280 | | | 400 | | | 1,736 | | | 5,501 | | | 2,145 | | | 721 | | | 8,666 | | | 10,402 |
| Max | | | 2,951 | | | 828 | | | | | | 11,52 | | | 3,235 | | | 1,147 | | | | | | |
| Min | | | 253 | | | 18 | | | | | | 2 | | | 604 | | | 77 | | | | | | |
| Max-Min | | | 2,698 | | | 810 | | | | | | 132 | | | 2,631 | | | 1,070 | | | | | | |
| | | | | | | | | | | | | 11,39 | | | | | | | | | | | | |
| | | | | | | | | | | | | 0 | | | | | | | | | | | | |
| Buffer | | | 540 | | | 202 | | | | | | 2,848 | | | 658 | | | 268 | | | | | | |
| Min+Buffer=Crit Abun | | | 793 | | | 220 | | | | | | 2,979 | | | 1,262 | | | 345 | | | | Sum Recr | 5,600 | |
| Crit Esc. Using BCR | | | 723 | | | 201 | | | | | | 2,655 | | | 1,108 | | | 301 | | | | Sum Esc. | 4,990 | |
| Rounded Crit Abund. | | | 790 | | | 220 | | | | | | 2,980 | | | 1,260 | | | 340 | | | | Ttl ER | 0.109 | |
| Rounded Crit Esc. | | | 720 | | | 200 | | | | | | 2,660 | | | 1,110 | | | 300 | | | | | | |

**Appendix Table 1.5.2**. Summer chum salmon escapements of the mainstem Hood Canal stocks and the occurrence of critical status flags for the years 1974-98.

| | Escapements | | | | | Status and Flags | | | | | Proportions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Lilliwaup | Hamma Hamma | Duckabush | Dosewallips | MU Total | MU Status Threshold 2,660 | Lilliwaup | Hamma Hamma | Duckabush | Dosewallips | Lilliwaup | Hamma Hamma | Duckabush | Dosewallips |
| 1974 | 616 | 2,448 | 3,581 | 3,593 | 10,238 | Above | Ok | Ok | Ok | Ok | 0.060 | 0.239 | 0.350 | 0.351 |
| 1975 | 706 | 7,341 | 2,245 | 2,250 | 12,542 | Crit | Ok | Ok | Ok | Ok | 0.056 | 0.585 | 0.179 | 0.179 |
| 1976 | 1,612 | 7,648 | 6,095 | 3,271 | 18,626 | Above | Ok | Ok | Ok | Ok | 0.087 | 0.411 | 0.327 | 0.176 |
| 1977 | 420 | 1,675 | 2,453 | 3,215 | 7,763 | Crit | Ok | Ok | Ok | Ok | 0.054 | 0.216 | 0.316 | 0.414 |
| 1978 | 1,331 | 8,215 | 1,898 | 1,901 | 13,346 | Above | Ok | Ok | Ok | Ok | 0.100 | 0.616 | 0.142 | 0.142 |
| 1979 | 163 | 3,096 | 1,190 | 1,190 | 5,639 | Crit | Check | Ok | Ok | Ok | 0.029 | 0.549 | 0.211 | 0.211 |
| 1980 | 247 | 329 | 827 | 1,216 | 2,619 | Above | Ok | Check | Ok | Ok | 0.094 | 0.126 | 0.316 | 0.464 |
| 1981 | 293 | 926 | 557 | 63 | 1,839 | Crit | Ok | Check | Check | Check | 0.159 | 0.504 | 0.303 | 0.034 |
| 1982 | 84 | 801 | 690 | 507 | 2,082 | Above | Check | Check | Check | Check | 0.040 | 0.385 | 0.331 | 0.244 |
| 1983 | 18 | 190 | 80 | 64 | 352 | Crit | Check | Check | Check | Check | 0.051 | 0.540 | 0.227 | 0.182 |
| 1984 | 187 | 170 | 299 | 212 | 868 | Above | Ok | Check | Check | Check | 0.215 | 0.196 | 0.344 | 0.244 |
| 1985 | 92 | 231 | 30 | 236 | 589 | Crit | Check | Check | Check | Check | 0.156 | 0.392 | 0.051 | 0.401 |
| 1986 | 97 | 173 | 177 | 57 | 504 | Crit | Check | Check | Check | Check | 0.192 | 0.343 | 0.351 | 0.113 |
| 1987 | 32 | 26 | 12 | 9 | 79 | Crit | Check | Check | Check | Check | 0.405 | 0.329 | 0.152 | 0.114 |
| 1988 | 275 | 440 | 497 | 661 | 1,873 | Crit | Ok | Check | Check | Check | 0.147 | 0.235 | 0.265 | 0.353 |
| 1989 | 43 | 16 | 60 | 16 | 135 | Crit | Check | Check | Check | Check | 0.319 | 0.119 | 0.444 | 0.119 |
| 1990 | 2 | 90 | 42 | 8 | 142 | Crit | Check | Check | Check | Check | 0.014 | 0.634 | 0.296 | 0.056 |
| 1991 | 30 | 69 | 102 | 250 | 451 | Crit | Check | Check | Check | Check | 0.067 | 0.153 | 0.226 | 0.554 |
| 1992 | 90 | 123 | 617 | 655 | 1,485 | Crit | Check | Check | Check | Check | 0.061 | 0.083 | 0.415 | 0.441 |
| 1993 | 72 | 69 | 105 | 105 | 351 | Crit | Check | Check | Check | Check | 0.205 | 0.197 | 0.299 | 0.299 |
| 1994 | 105 | 370 | 263 | 225 | 963 | Crit | Check | Check | Check | Check | 0.109 | 0.384 | 0.273 | 0.234 |
| 1995 | 79 | 476 | 825 | 2,787 | 4,167 | Crit | Check | Check | Ok | Ok | 0.019 | 0.114 | 0.198 | 0.669 |
| 1996 | 100 | 774 | 2,650 | 6,976 | 10,500 | Crit | Check | Check | Ok | Ok | 0.010 | 0.074 | 0.252 | 0.664 |
| 1997 | 26 | 104 | 475 | 47 | 652 | Crit | Check | Check | Check | Check | 0.040 | 0.160 | 0.729 | 0.072 |
| 1998 | 24 | 143 | 226 | 336 | 729 | Crit | Check | Check | Check | Check | 0.033 | 0.196 | 0.310 | 0.461 |
| | | | | | | Crit | | | | | | | | |
| | | | | | | Crit | | | | | | | | |
| | | | | | | Above | | | | | | | | |
| | | | | | | Crit | | | | | | | | |
| | | | | | | Above | | | | | | | | |
| | | | | | | Crit | | | | | | | | |
| | | | | | | Crit | | | | | | | | |
| | | | | | | Crit | | | | | | | | |
| | | | | | | | | | | 74-98 Mean | 0.109 | 0.311 | 0.292 | 0.288 |
| | | | | | | | | | | 74-80 Mean | 0.069 | 0.392 | 0.263 | 0.277 |
| | | | | | | | | | | SD | 0.026 | 0.199 | 0.083 | 0.130 |
| | | | | | | | | | | EDF | 0.043 | 0.193 | 0.180 | 0.147 |
| | | | | | | | | | | MEF | 182 | 1,042 | 700 | 736 |

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# Part Two
# Appendix

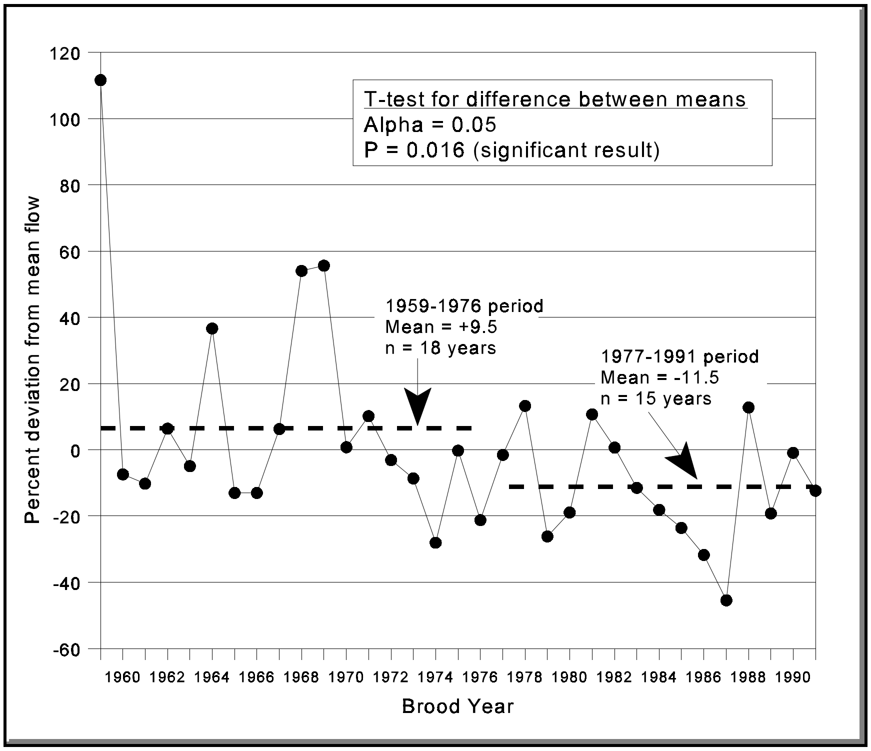
## Contents

# Appendix Figures

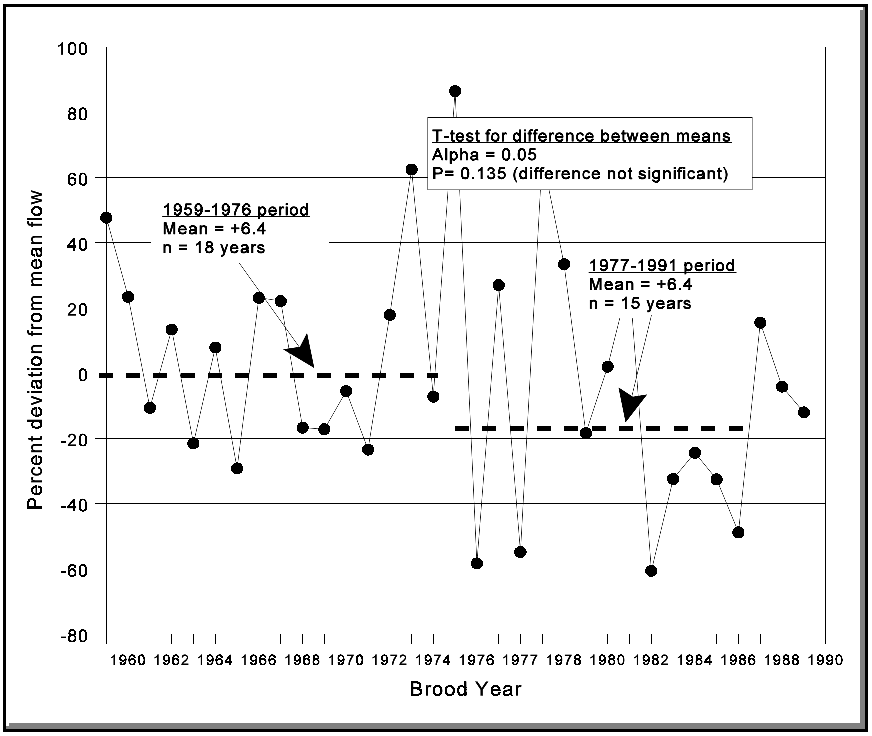
**Appendix Figure 2.13.** Hatchery-origin coho salmon out-plants in the Hood Canal region, 1970-94 (from Tynan 1998).

**Appendix Figure 2.14.** Hatchery-origin coho salmon out-plants in the Hood Canal region, 1952-94 (from Tynan 1998).

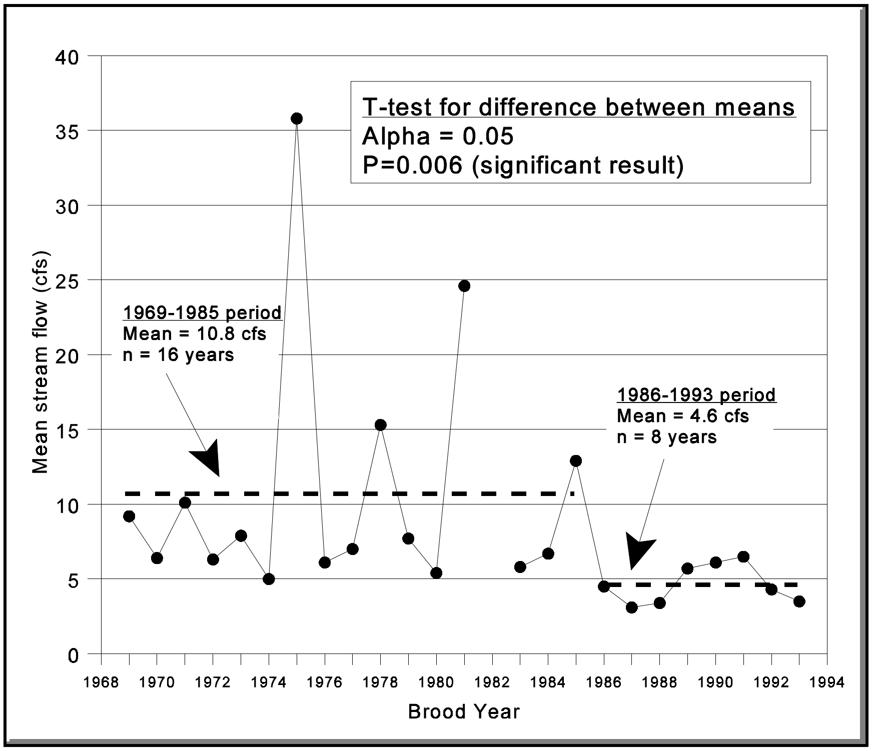
**Appendix Figure 2.15.** Hatchery-origin pink salmon out-plants in the Hood Canal region, 1953-95 (from Tynan 1998).



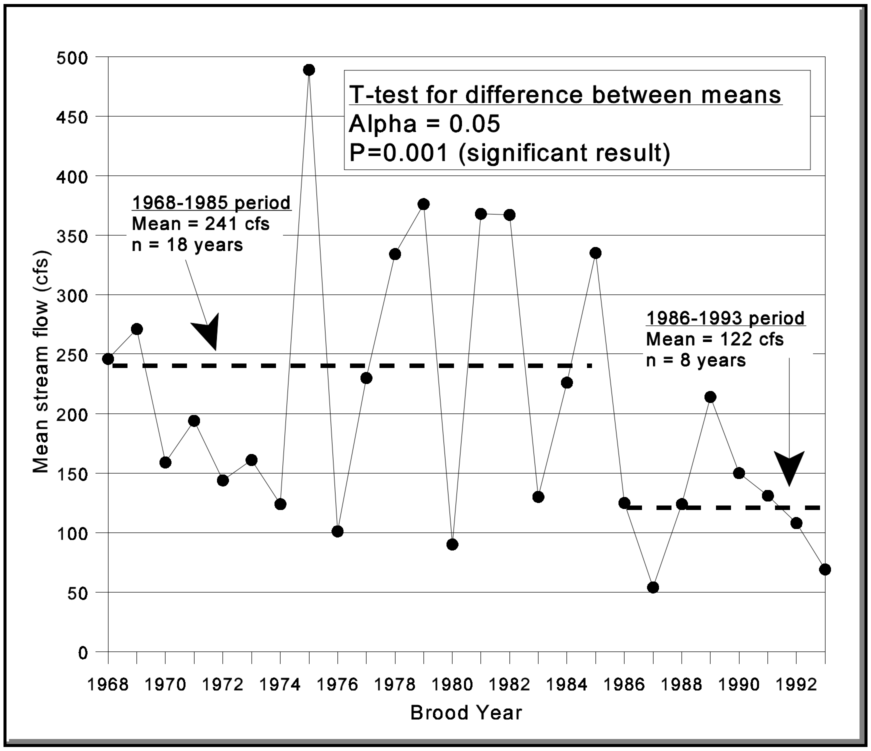
**Appendix Figure 2.1.** PSSFI mean 10 day low flow (Sept. 15-Nov. 14) for the brood year period 1959-91.



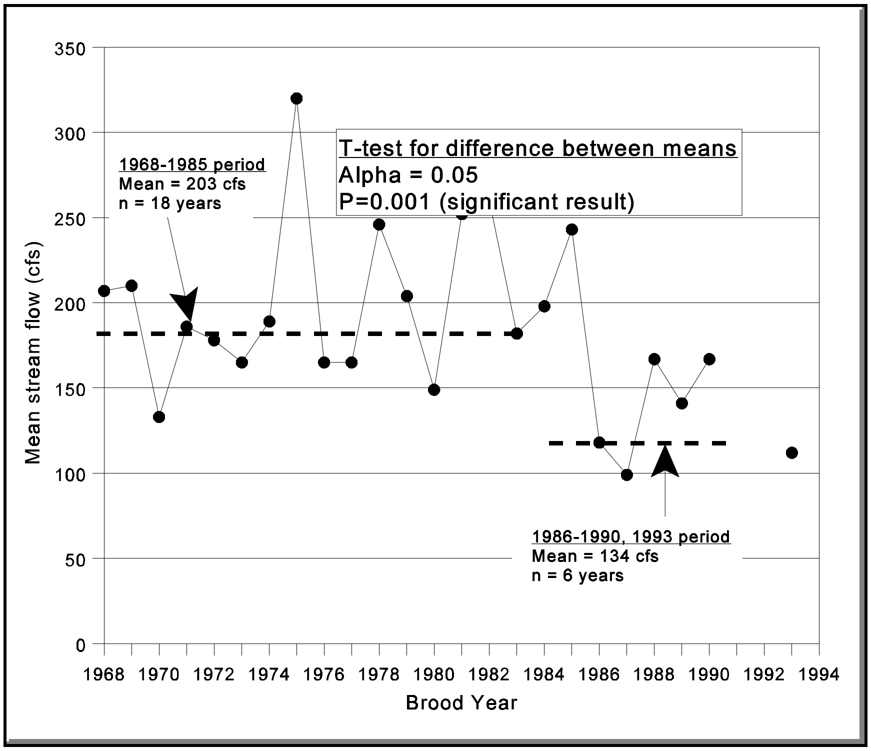
**Appendix Figure 2.2.** PSSFI mean 10 day high flow (Nov. 15 - Feb. 14) for the brood year period 1959-89.



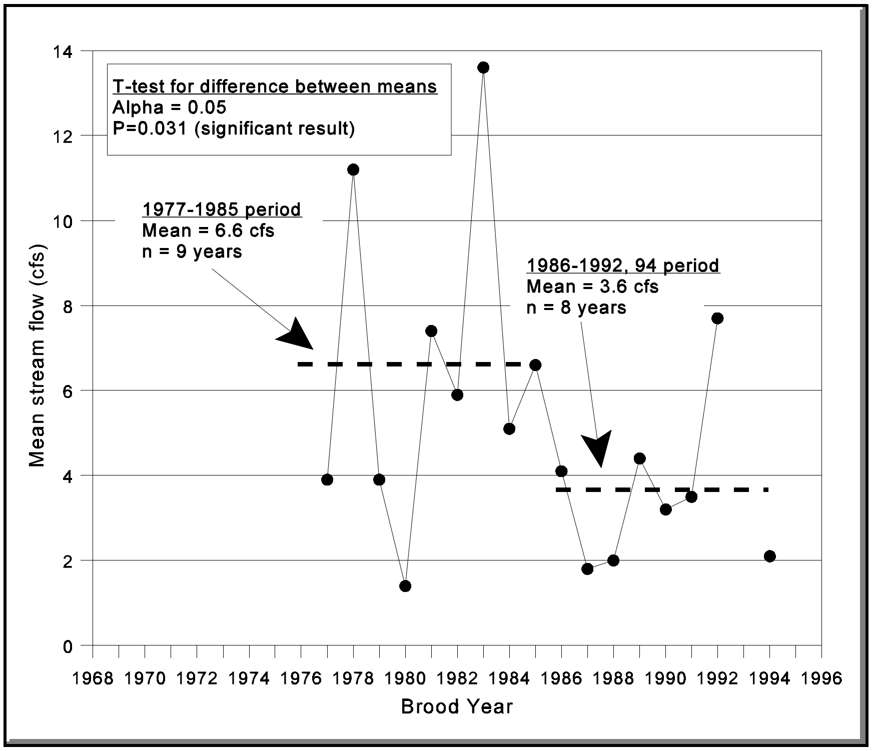
**Appendix Figure 2.3.** Mean September/October stream flow in Big Beef Creek for the brood year period 1969-93.



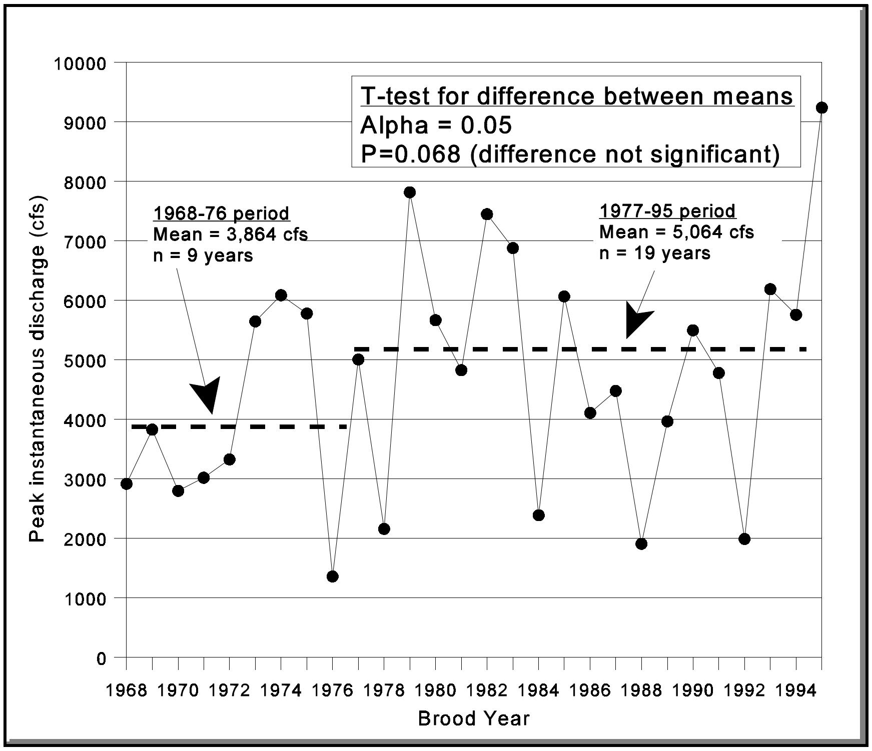
**Appendix Figure 2.4.** Mean September/October stream flow in the Duckabush River for the brood year period 1968-93.



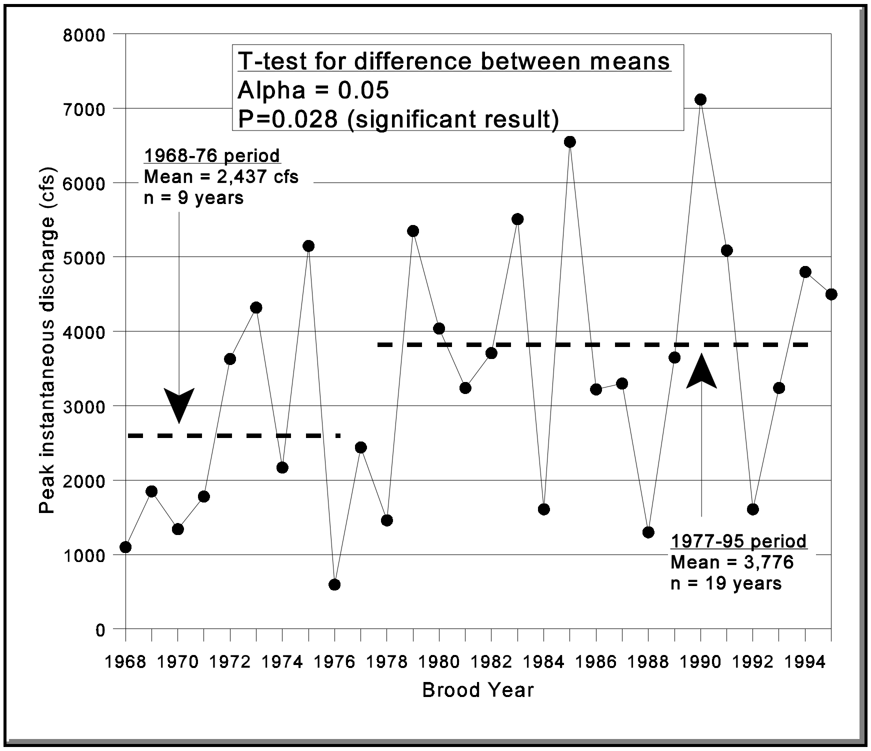
**Appendix Figure 2.5.** Mean September/October stream flow in the Dungeness River for the brood year period 1968-90, 93.



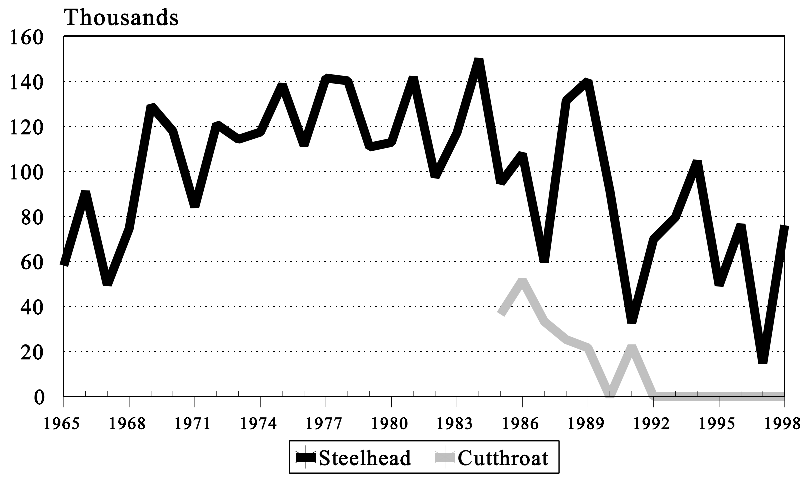
**Appendix Figure 2.6.** Mean September/October stream flow in Snow Creek for the brood year period 1977-92, 1994.



**Appendix Figure 2.7.** Peak instantaneous discharge in the Duckabush River from October - March for the brood year period 1968-1995.

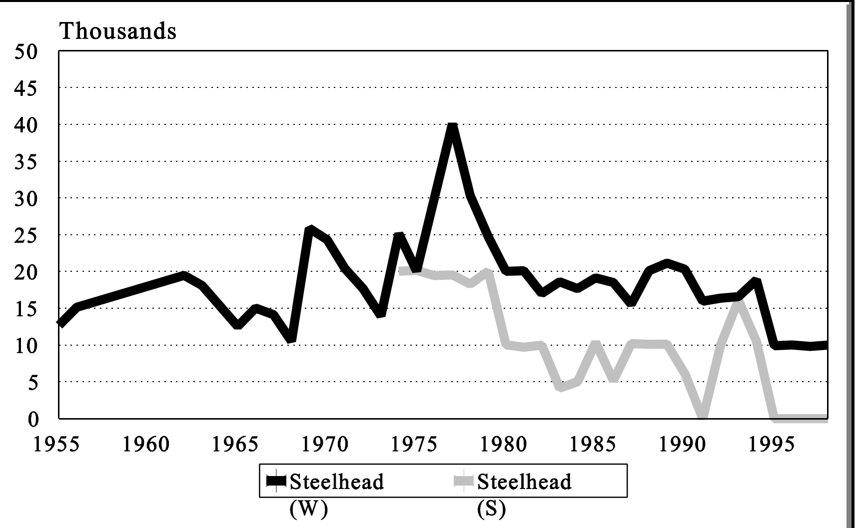


**Appendix Figure 2.8.** Peak instantaneous discharge in the Dungeness River from October - March for brood year period 1968-1995.



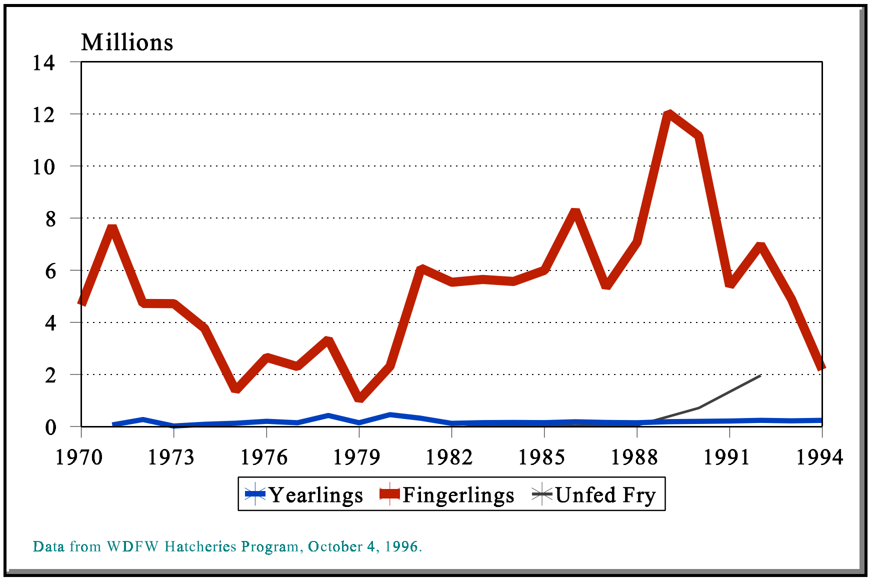
Data from WDFW Hatcheries Program fish planting records - August 28, 1996, and from T. Johnson, WDFW, June 22, 1998.

**Appendix Figure 2.9.** Hatchery -origin steelhead and cutthroat smolt out-plants in the Hood Canal region, 1965-98.



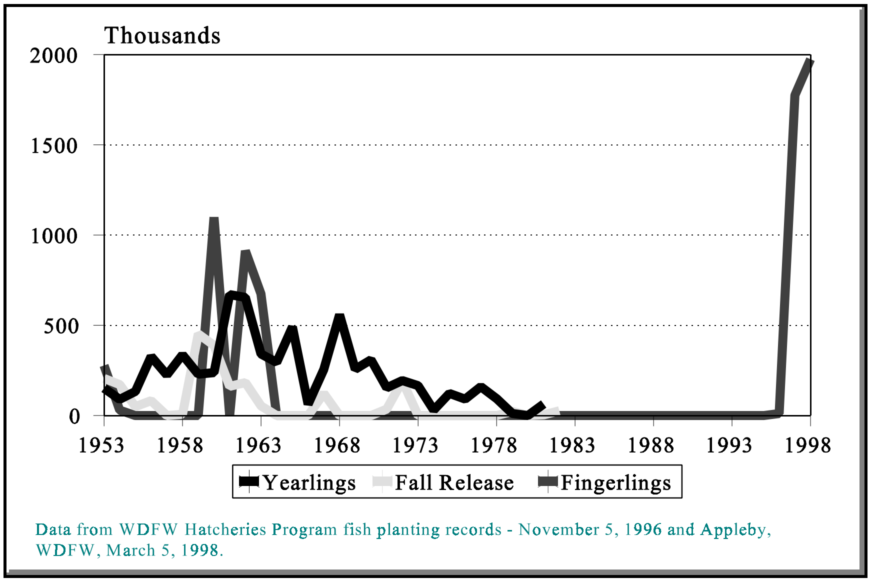
Data from WDFW Hatcheries Program fish planting records (March 3, 1998) and PNPTC, WDFW, and Makah 1995.

**Appendix Figure 2.10.** Hatchery-origin steelhead smolt out-plants in the Strait of Juan de Fuca region, 1955-97.



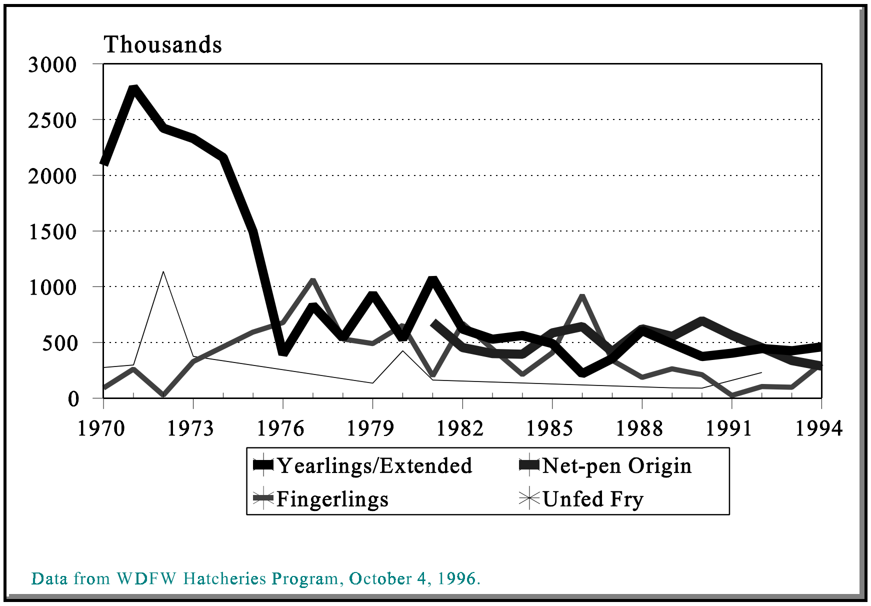
Data from WDFW Hatcheries Program, October 4, 1996.

**Appendix Figure 2.11.** Hatchery-origin chinook salmon out-plants in the Hood Canal region, 1970-94.



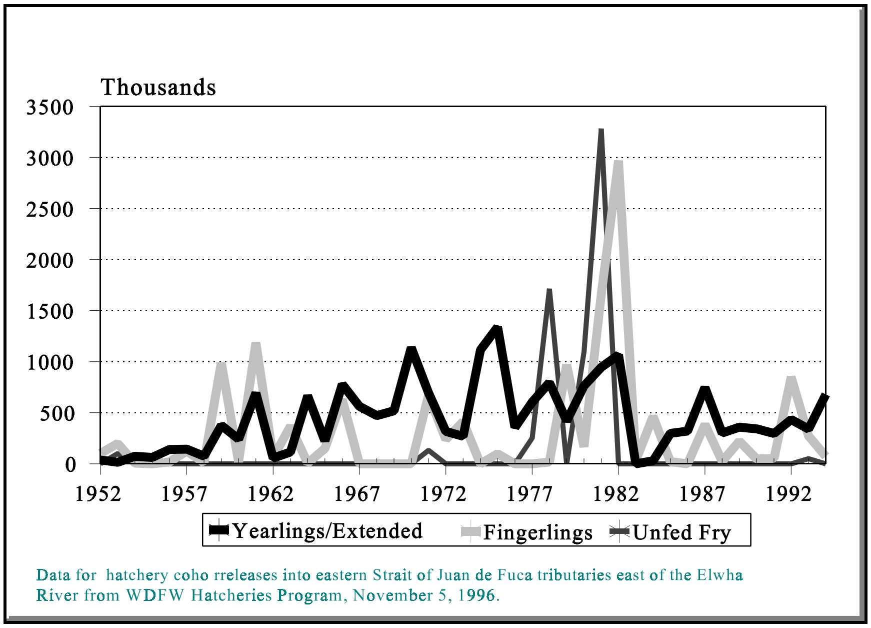
Data from WDFW Hatcheries Program fish planting records - November 5, 1996 and Appleby, WDFW, March 5, 1998.

**Appendix Figure 2.12.** Hatchery-origin chinook out-plants in the Strait of Juan de Fuca region, 1953-98.



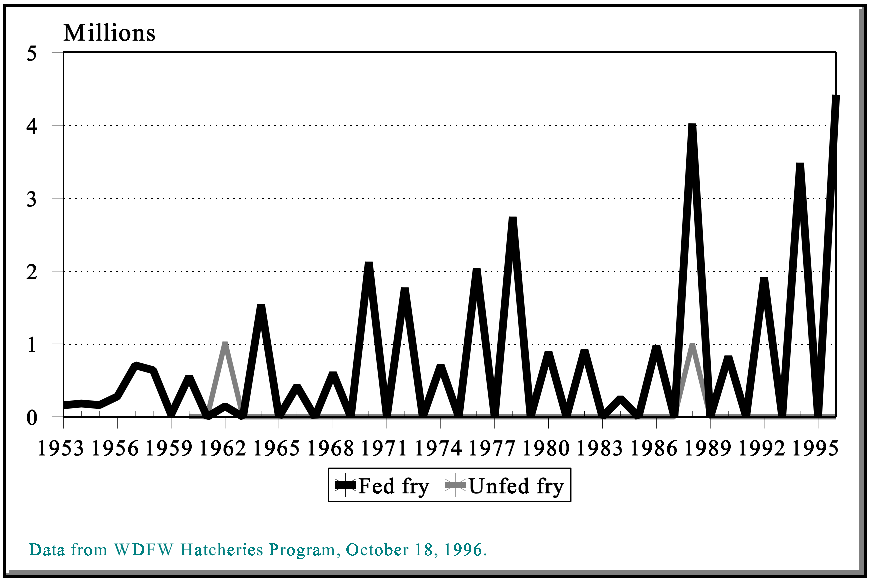
Data from WDFW Hatcheries Program, October 4, 1996.

**Appendix Figure 2.13.** Hatchery -origin coho salmon out-plants in the Hood Canal region, 1970-94.



Data for hatchery coho rreleases into eastern Strait of Juan de Fuca tributaries east of the Elwha River from WDFW Hatcheries Program, November 5, 1996.

**Appendix Figure 2.14.** Hatchery-origin coho salmon out-plants in the Hood Canal region, 1952-94.



Data from WDFW Hatcheries Program, October 18, 1996.

**Appendix Figure 2.15.** Hatchery-origin pink salmon out-plants in the Hood Canal region, 1953-95.

# Appendix Tables

**Appendix Table 2.1.** Puget Sound Stream Flow indexes, mean monthly stream flows for September - October and average peak instantaneous flows in various streams for differing time periods between 1959 and 1995.

**Appendix Table 2.2.** Results of statistical tests of significance for changes in mean flows and peak instantaneous discharges over time for the PSSFI and several streams. One tailed t-tests (alpha=0.05) were used to examine the null hypotheses of equality between mean flows for various time periods (see Part Two, section 2.2.2.3).

**Appendix Table 2.3.** Hood Canal summer chum escapements and fall chum salmon escapements to those streams with summer chum populations (1974-1998).

**Appendix Table 2.4.** Annual liberations of Finch Creek stock fed and unfed fall chum fry from WDFW hatcheries in Hood Canal, Washington, 1969-93.

**Appendix Table 2.1.** Puget Sound Stream Flow indexes, mean monthly stream flows for September - October and average peak instantaneous flows in various streams for differing time periods between 1959 and 1995.

| Brood Year | PSSFI Low 10 | PSSFI High 10 | B. Beef Cr. Mean Flow | Duckabush Mean Flow | Snow Cr. Mean Flow | Dungeness Mean Flow | Duckabush Peak Flow | Dungeness Peak Flow |
|---|---|---|---|---|---|---|---|---|
| 1959 | 111.62 | 47.74 | | | | | | |
| 1960 | -7.36 | 23.39 | | | | | | |
| 1961 | -10.21 | -10.55 | | | | | | |
| 1962 | 6.39 | 13.40 | | | | | | |
| 1963 | -4.87 | -21.50 | | | | | | |
| 1964 | 36.55 | 7.93 | | | | | | |
| 1965 | -12.98 | -29.24 | | | | | | |
| 1966 | -13.02 | 23.12 | | | | | | |
| 1967 | 6.31 | 22.05 | | | | | | |
| 1968 | 54.00 | -16.71 | | 246 | | 207 | 2920 | 1100 |
| 1969 | 55.58 | -17.17 | 9.2 | 271 | | 210 | 3830 | 1850 |
| 1970 | 0.75 | -5.48 | 6.4 | 159 | | 133 | 2800 | 1340 |
| 1971 | 10.16 | -23.41 | 10.1 | 194 | | 186 | 3020 | 1780 |
| 1972 | -3.09 | 17.94 | 6.3 | 144 | | 178 | 3330 | 3630 |
| 1973 | -8.60 | 62.48 | 7.9 | 161 | | 165 | 5650 | 4320 |
| 1974 | -28.03 | -7.19 | 5.0 | 124 | | 189 | 6090 | 2170 |
| 1975 | -0.24 | 86.50 | 35.8 | 489 | | 320 | 5780 | 5150 |
| 1976 | -21.20 | -58.31 | 6.1 | 101 | | 165 | 1360 | 597 |
| 1977 | -1.49 | 27.01 | 7.0 | 230 | 3.9 | 165 | 5010 | 2440 |
| 1978 | 13.29 | -54.84 | 15.3 | 334 | 11.2 | 246 | 2160 | 1460 |
| 1979 | -26.14 | 66.37 | 7.7 | 376 | 3.9 | 204 | 7820 | 5350 |
| 1980 | -18.94 | 33.38 | 5.4 | 90 | 1.4 | 149 | 5670 | 4040 |
| 1981 | 10.73 | -18.40 | 24.6 | 368 | 7.4 | 252 | 4830 | 3240 |
| 1982 | 0.72 | 2.00 | | 367 | 5.9 | 260 | 7450 | 3710 |
| 1983 | -11.47 | 28.73 | 5.8 | 130 | 13.6 | 182 | 6880 | 5510 |
| 1984 | -18.06 | -60.55 | 6.7 | 226 | 5.1 | 198 | 2390 | 1610 |
| 1985 | -23.61 | -32.37 | 12.9 | 335 | 6.6 | 243 | 6070 | 6550 |
| 1986 | -31.73 | -24.42 | 4.5 | 125 | 4.1 | 118 | 4110 | 3220 |
| 1987 | -45.43 | -32.57 | 3.1 | 54 | 1.8 | 99 | 4480 | 3300 |
| 1988 | 12.82 | -48.78 | 3.4 | 124 | 2.0 | 167 | 1910 | 1300 |
| 1989 | -19.23 | 15.53 | 5.7 | 214 | 4.4 | 141 | 3970 | 3650 |
| 1990 | -0.91 | -4.05 | 6.1 | 150 | 3.2 | 167 | 5500 | 7120 |
| 1991 | -12.31 | -12.04 | 6.5 | 131 | 3.5 | | 4780 | 5090 |
| 1992 | | | 4.3 | 108 | 7.7 | | 1990 | 1610 |
| 1993 | | | 3.5 | 69 | | 112 | 6190 | 3240 |
| 1994 | | | | | 2.1 | | 5760 | 4800 |
| 1995 | | | | | | | 9240 | 4500 |

**Appendix Table 2.2.** Results of statistical tests of significance for changes in mean flows and peak instantaneous discharges over time for the PSSFI and several streams. One tailed t-tests (alpha = 0.05)were used to examine the null hypotheses of equality between mean flows for various time periods (see Part Two, section 2.2.2.3).

**Puget Sound Stream Flow Index (10-day low flows, Sept. 15 - Nov. 14)**

| | |
|---|---|
| Mean 1959-1976 vs. mean 1977-1991 | significantly different (P=0.016) |

**Puget Sound Stream Flow Index (10-day high flows, Nov. 15 - Feb. 14)**

| | |
|---|---|
| Mean 1959-1976 vs. mean 1977-1991 | not significantly different (P=0.135) |

**Spawning Flows (September/October mean flows)**

***Big Beef Creek***

| | |
|---|---|
| Mean 1968-1976 vs. mean 1977-1993 | not significantly different (P=0.216) |
| Mean 1968-1985 vs. mean 1986-1993 | significantly different (P=0.006) |
| Mean 1968-1976 vs. mean 1977-1985 | not significantly different (P=0.484) |

***Duckabush River***

| | |
|---|---|
| Mean 1968-1976 vs. mean 1977-1993 | not significantly different (P=0.433) |
| Mean 1968-1985 vs. mean 1986-1993 | significantly different (P=0.001) |
| Mean 1968-1976 vs. mean 1977-1985 | not significantly different (P= 0.128) |

***Dungeness River***

| | |
|---|---|
| Mean 1968-1976 vs. mean 1977-1993 | not significantly different (P=0.259) |
| Mean 1968-1985 vs. mean 1986-1993 | significantly different (P=0.001) |
| Mean 1968-1976 vs. mean 1977-1985 | not significantly different (P=0.237) |

***Snow Creek***

| | |
|---|---|
| Mean 1977-1985 vs. mean 1986-1994 | significantly different (P=0.031) |

**Incubation Flows (October/March peak instantaneous flows)**

***Duckabush River***

| | |
|---|---|
| Mean 1968-1976 vs. mean 1977-1995 | not significantly different (P=0.068) |
| Mean 1977-1985 vs. mean 1986-1995 | not significantly different (P = 0.279) |

***Dungeness River***

| | |
|---|---|
| Mean 1968-1976 vs. mean 1977-1995 | significantly different (P= 0.028) |
| Mean 1977-1985 vs. mean 1986-1995 | not significantly different (P=0.493) |

**Appendix Table 2.3.** Hood Canal summer chum escapements and fall chum salmon escapements to those streams with summer chum populations (1974-1998).

| Return Year | Summer Chum Escapements | Fall Chum Escapements |
|---|---|---|
| 1974 | 12,281 | 20,231 |
| 1975 | 18,248 | 8,060 |
| 1976 | 27,715 | 23,319 |
| 1977 | 10,711 | 8,959 |
| 1978 | 19.710 | 39,460 |
| 1979 | 6,554 | 4,955 |
| 1980 | 3,776 | 7,338 |
| 1981 | 2,374 | 6,092 |
| 1982 | 2,623 | 5,133 |
| 1983 | 863 | 2,766 |
| 1984 | 1,414 | 10,479 |
| 1985 | 1,109 | 28,393 |
| 1986 | 2,552 | 14,752 |
| 1987 | 757 | 12,963 |
| 1988 | 2,967 | 18,007 |
| 1989 | 598 | 13,777 |
| 1990 | 429 | 15,339 |
| 1991 | 744 | 21,500 |
| 1992 | 2,368 | 59,221 |
| 1993 | 751 | 39,242 |
| 1994 | 2,423 | 101,160 |
| 1995 | 9,462 | 84,080 |
| 1996 | 20,514 | 168,164 |
| 1997 | 8,971 | 34,700 |
| 1998 | 4,020 | 54,891 |

**Appendix Table 2.4** Annual liberations of Finch Creek stock fed and unfed fall chum fry from WDFW hatcheries in Hood Canal, Washington, 1969-93.

| | **Unfed Fry** | | | **Fed Fry** | | | |
|---|---|---|---|---|---|---|---|
| **Brood Year** | **Total** | **Pre April 1** | **(% Total)** | **Total** | **Pre April 1** | **(% Total)** | **(Avg. FPP)** |
| 1969 | 188,748 | 0 | 0% | 795,040 | 0 | 0% | - |
| 1970 | 0 | 0 | 0% | 1,447,406 | 0 | 0% | - |
| 1971 | 508,000 | 112,000 | 22.0% | 855,110 | 0 | 0% | - |
| 1972 | 64,600 | 64,600 | 100% | 974,568 | 0 | 0% | - |
| 1973 | 323,600 | 0 | 0% | 2,012,198 | 0 | 0% | - |
| 1974 | 0 | 0 | 0% | 9,408,285 | 0 | 0% | - |
| 1975 | 0 | 0 | 0% | 8,465,125 | 0 | 0% | - |
| 1976 | 85,000 | 0 | 0% | 13,594,756 | 507,825 | 3.7% | 650 |
| 1977 | 0 | 0 | 0% | 7,939,467 | 1,324,075 | 16.7% | 547 |
| 1978 | 5,230,000 | 475,000 | 9.1% | 24,376,329 | 13,424,882 | 55.1% | 684 |
| 1979 | 6,068,700 | 3,524,300 | 58.1% | 33,041,394 | 1,781,700 | 5.4% | 900 |
| 1980 | 5,842,192 | 0 | 0% | 30,498,031 | 11,847,861 | 38.8% | 704 |
| 1981 | 0 | 0 | 0% | 16,859,884 | 4,253,000 | 25.2% | 530 |
| 1982 | 7,921,700 | 2,500,000 | 31.6% | 27,983,444 | 5,113,000 | 18.3% | 649 |
| 1983 | 0 | 0 | 0% | 28,325,669 | 5,000,000 | 17.7% | 578 |
| 1984 | 4,374,157 | 1,445,000 | 33.0% | 45,955,845 | 13,978,300 | 30.4% | 869 |
| 1985 | 5,483,300 | 2,684,600 | 49.0% | 31,051,700 | 9,010,100 | 29.0% | 795 |
| 1986 | 6,400,600 | 0 | 0% | 33,999,500 | 13,240,200 | 38.9% | 640 |
| 1987 | 5,763,900 | 3,033,900 | 52.6% | 34,358,600 | 14,189,700 | 41.3% | 680 |
| 1988 | 5,284,500 | 5,284,500 | 100% | 29,932,600 | 5,172,600 | 17.3% | 916 |
| 1989 | 6,106,500 | 3,853,000 | 63.1% | 28,415,000 | 10,410,200 | 36.6% | 697 |
| 1990 | 0 | 0 | 0% | 19,619,100 | 4,000,000 | 20.4% | 733 |
| 1991 | 7,175,500 | 7,175,500 | 100% | 31,463,600 | 12,508,300 | 39.8% | 657 |
| 1992 | 8,744,000 | 8,494,000 | 97.1% | 30,908,200 | 20,073,200 | 64.9% | 494 |
| 1993 | 2,990,600 | 0 | 0% | 30,215,050 | 7,294,000 | 24.1% | 616 |
| Average | 3,142,224 | 1,545,856 | 49.2% | 20,899,836 | 6,125,158 | 29.3% | 686 |

Note: Hatchery production data from WDFW Hatcheries Program, March 21, 1997.

# Part Three
# Appendix

## Contents

Page

### Appendix Reports

# Appendix Report 3.1
# Specific Criteria Guiding Supplementation and Reintroduction Program Operations

Following are specific criteria that should be used for all summer chum supplementation and reintroduction programs under this plan. These criteria refine general criteria for conducting supplementation programs that were previously provided in Part Two of the plan. Application of these specific criteria will help minimize adverse ecological and genetic effects to natural summer chum populations. The criteria also define practical rearing and release procedures that have been demonstrated to be of greatest benefit to healthy chum fry production in the hatchery environment and the survival of released fish to adulthood.

## 1. Donor Stock Selection and Collection Methods

Donor stocks selected for supplementation programs will be derived from the indigenous summer chum population within the targeted watershed. For reintroductions, donor stocks selected will be those that are geographically nearest the targeted stream, and that show the greatest similarity in genetic lineage, life history patterns, and ecology to the extirpated population. Donor stocks selected for reintroduction will only be used at one location.

The acceptable minimum and maximum broodstock collection levels, based on the abundance of the donor population, are indicated in Table 3.2 in Part Two of the preceding plan. As noted in the table, in the case of severely depressed populations and for supplementation programs only, if the entire population is less than 100 fish, all of the population may be taken for use as broodstock in the supplementation program. In this case, a minimum of 25 pairs should be targeted for the supplementation program.

Donor broodstock may be available for use if escapement to the donor stream will: 1) meet an identified spawner escapement objective, 2) provide the egg-take needs of any on-going supplementation program operating in the donor stream; and 3) provide a minimum of 25 pairs required for a reintroduction program.

Summer chum should be collected from donor populations across the breadth of the freshwater return (mid August through October 15 - to preclude egg takes of fall chum), and at weekly levels proportional to average escapement timings for the returning population. Methods used to collect broodstock are as follows:

- fish weirs permitted via Hydraulic Project Approval, Shoreline Act, and SEPA processes positioned at or very near the downstream limit of spawning within the donor/targeted watershed;
- snorkel survey/block seine collection within freshwater fish migration and holding areas; and
- selective fishery (e.g. beach seine) removal in the targeted stream, or in extreme terminal marine areas immediately adjacent to the mouth of the target stream.

Collected fish will be transferred as soon as possible from trap holding boxes, adult holding tubes or net-pens to hatchery holding and spawning facilities. During all capture, holding and handling phases, fish will be netted, handled, and transferred with the utmost care, ensuring that harm to the fish, including the duration that chum are out of water, is maintained to a minimum.

## 2. Spawning/Mating Protocols

The two main goals for the breeding of summer chum broodstock are for every adult to contribute, and for the genetic contribution from each fish to the population to be as equal as possible (Phelps 1993). These goals include the desire to minimize loss of alleles and to maintain the heterozygosity present in the existing wild populations. In meeting these goals, spawning protocols will be applied that ensure that contributing broodstocks are representative of wild stock diversity. Fish spawned will represent the breadth of the summer chum return, in timing and proportion by timing. The entire August through October span of the return will be represented in spawning, to the extent feasible.

Mating schemes used in all summer chum supplementation programs have the objective of incorporating at least 1:1 male-female spawning ratios. Given the preceding goals, and the parameters regarding run timing representation, all matings will be randomized with respect to fish age, size, and phenotypic traits. Intentional selection of any particular trait in the use of spawners, including age, size, and other morphological characters, will be avoided.

For populations scheduled for supplementation that are small (25 pairs or less), the desire to ensure that every adult used in the program will contribute to matings, rather than equalized contribution, will be prioritized. Matings for such populations on any given spawning day will be conducted by dividing each female’s eggs into as many aliquots as there are ripe males. Each aliquot from one female will then be fertilized with a different male. Fertilization would be accomplished by adding sperm from one male, mixing the eggs thoroughly for 30 seconds, and then adding sperm from a different back-up male prior to water hardening the eggs. For these small donor populations, males can be held after spawning for use on more than one spawning day, as long as the number of times each male is used is noted, and that newly captured or ripe males are incorporated. The use of sperm extenders and cryopreservation are also viable options for maintaining sperm for crosses made for small populations. Kapuscinski and Miller (1993) provides further protocols that should be followed in devising mating schemes for depressed populations when either males or females are in short supply.

# 3. Incubation and Rearing Protocols

Incubation and rearing protocols proposed in this plan are designed to produce the most summer chum fry in the shortest amount of time in the hatchery, while producing fish that are as genetically and ecologically similar as possible to the founding natural population. Fish health maintenance, disinfection, and fish disease treatment procedures set forth in the Washington Co-manager's Salmonid Disease Control Policy will be applied throughout the husbandry process to maintain high fish quality and to minimize mortalities. Environmental conditions during incubation and propagation, including water temperature (daily and seasonal regimes), water quality, and photoperiod will be equivalent to, or closely simulate, conditions found in the natural environment for the founding population. To help meet this objective, the location of incubation and rearing will be within the same watershed, and in close proximity to the planned summer chum release site. To the extent feasible, achieving this latter goal will also involve the use of water for incubation and rearing sourced from the founding river for supplementation programs. Husbandry strategies will include use of low incubation and rearing densities, as set forth in the following sections.

The following survival rate objectives for each life stage will be applied to all programs. These rates will be used as criteria for measuring the effectiveness of each program.

| Chum Life Stage | % Survival by Life Stage | Cum. % Survival from Green Egg |
|---|---|---|
| Green egg to eye-up | 90.0 % | 90.0 % |
| Eye-up to Swim-up | 99.5 % | 89.5 % |
| Swim-up to release | 95.0 % | 85.0 % |

## a) Production Levels

Annual summer chum fry production levels for supplementation and reintroduction programs will be determined through estimation of the number of smolts required to meet historical spawning levels upon return as adults. Criteria that will be used to derive the desired annual production levels are provided in section 3.2.2.3 of the preceding plan.

Appendix Table 3.1.1 presents desired, initial planting levels derived from the aforementioned production and survival criteria for summer chum streams that are supplemented, or have the potential to be supplemented or receive fish for reintroductions, in the future. These planting levels are minimums, based on 1974-78 average escapement estimates, and may be adjusted if research shows that survival rates are different than those assumed. It is recognized that there is likely some "critical mass" for a chum fry release that must be achieved for the propagated population to exhibit adult returns at desired survival rates. This concept is based on the premise that small releases (e.g. <15,000) of fish of 1 gram size may be more subject to loss through happenstance or natural mortality than larger release groups (e.g. 100,000). In studies of chum fry predation on Big Beef Creek, Fresh and Schroder (1987) corroborated this premise, finding that the number of fry eaten by predators increased asymptotically with the number of fry released. Chum fry were most vulnerable at low abundance and least vulnerable when abundance was high. The decreased vulnerability at high release levels generally resulted from predator satiation or from time constraints arising from capturing and swallowing prey. The upper end of the release ranges indicated in Appendix Table 3.1.1 are therefore recommended.

**Appendix Table 3.1.1** Recommended initial annual summer chum fry supplementation program production levels needed to produce adult returns equal to historical (1974-78) average run sizes. [1]

| Watershed | 1974-78 Average Run Sizes[2] | Fed Fry Survival Rate[3] | Annual Fry Supplementation Level (1000s)[4] |
|---|---|---|---|
| Big Quilcene R. | 3,152 | 0.81 - 1.63 % | 193 - 389 |
| Little Quilcene R. | 1,418 | 0.81 - 1.63 % | 87 - 175 |
| Dosewallips R. | 3,355 | 0.81 - 1.63 % | 206 - 414 |
| Duckabush R. | 3,855 | 0.81 - 1.63 % | 236 - 476 |
| Hamma Hamma R. | 6,503 | 0.81 - 1.63 % | 399 - 803 |
| Dewatto R. | 1,549 | 0.81 - 1.63 % | 95 - 191 |
| Tahuya R. | 5,732 | 0.81 - 1.63 % | 352 - 708 |
| Lilliwaup R. | 3,132 | 0.81 - 1.63 % | 192 - 387 |
| Anderson Ck. | 700 | 0.81 - 1.63 % | 43 - 86 |
| Big Beef Ck. | 839 | 0.81 - 1.63 % | 51 - 104 |
| Union River | 700 | 0.81 - 1.63 % | 43 - 86 |
| Salmon Ck. | 859 | 0.81 - 1.63 % | 53 - 106 |
| Snow Ck. | 720 | 0.81 - 1.63 % | 44 - 89 |
| Chimacum Ck. | 700 | 0.81 - 1.63 % | 43 - 86 |
| Jimmycomelately Ck. | 700 | 0.81 - 1.63 % | 43 - 86 |

**Notes:**

[1] The number of adult summer chum recruiting to Puget Sound (all age classes) as a result of escapement and spawning by adult fish produced through the supplementation program may be estimated as follows, assuming a 20% fisheries exploitation rate: multiply the expected number of female spawners ((run size*0.8)/2) by 2,500 (average fecundity), then by 10% (estimated wild survival green egg to smolt), and then by 1% (estimated survival of wild smolts to adult return).

[2] Run size estimates over 700 represent the 1974-78 average run size for each stream or stock. For populations averaging less than 700 for the 1974-78 period, the run size level is listed as 700. This 700 fish standard is derived from criteria set forth in Allendorf et al. (1997) which defines the minimum population size needed for a stock to *not* be at moderate risk of extinction (use $N_e$ of 2,500/3.6 years (average chum generational length) = 700 fish). These levels are provisional, and will be changed when the parties to this plan have developed agreed escapement and run size objectives to be applied to recover the populations. The run size figures presented here are used to derive recommended planting levels.

[3] Survival rate range presented is based on the estimated average percent survival rate to Puget Sound for Hoodsport Hatchery fall chum (1.63 % from Fuss and Hopley 1991) and, to be conservative, ½ that average, assuming expected, smaller summer chum release levels and potentially lower productivity for summer chum.

[4] Desired annual production levels were derived by dividing the 1974-78 average run size by each of the potential survival rates. These fry release ranges assume a wild fish contribution of "0". To account for wild production, annual, estimated wild adult returns each year may be subtracted from base year average run sizes to refine the number of hatchery-origin fry needed.

## b) Incubation

Eggs and alevins will be incubated under density, substrate, light, temperature, and oxygen conditions that simulate the natural intragravel environment (Kapuscinski and Miller 1993), or exceed its quality, to the extent feasible. Acceptable incubator types for use in proposed supplementation programs are listed and prioritized as follows: Heath-style trays, incubation baskets in rearing troughs, remote site incubators (RSIs). Incubation trays, baskets, and screens will be loaded at conservative, low densities that produce the highest survivals and quality to the fry stage. Green eggs, eyed eggs, and alevins will be incubated under dark or low-light conditions to minimize stress and decrease energy expenditure, minimizing the incidence of yolk malformation, decreased survival, and smaller fry at swim-up. Artificial substrate will be used during incubation and hatching of eyed eggs to mimic the natural environment. Shocking and removal of dead eggs will be accomplished when the eggs portray a well developed, strongly pigmented eye (after the accumulation of approximately 550 to 600 temperature units).

Heath trays will be loaded at a maximum density of 4,500-5,000 green eggs, and 3,500-4,000 eyed eggs. Flows into Heath stacks will be maintained at 4 gallons per minute to provide the most suitable environment to reduce bacterial loads (T. Kane and D. Zajac, USFWS, pers. comm., Feb. 1998).

Although it is desirable to match incubation water temperatures with ambient stream temperatures to match wild chum emergence timing, water supplies for RSIs shall be spring or well-sourced to minimize the risk of losses due to flooding, or from egg/alevin suffocation caused by excess siltation. Eyed eggs are the preferred life stage for incubation and fifty-five gallon RSIs are the preferred version used for summer chum propagation. RSIs may be operated with up to five or six incubation screens, with each screen loaded with up to 15,000 eggs (K. Dimmitt, WDFW, pers. comm. April, 1998). Loading at these densities will lead to the incubation of up to 90,000 eyed eggs per RSI. Flows into RSIs will be maintained between 9 - 12 gpm during operation. Bio-saddles will be used to harbor incubating alevins. Bio-saddles should be loaded to occupy a minimum depth of 15" of the bottom portion of the RSI to safely hold alevins resulting from the recommended eyed egg loading densities.

## c) Rearing

The objective of all summer chum supplementation programs shall be the production and release of 1 gram average size smolts for release during March (Hood Canal) or April (Strait of Juan de Fuca) each year. It is recognized that summer chum naturally have little tendency to rear in freshwater, out-migrating seaward immediately after swim-up (see Tynan 1997). Therefore, rather than mimicking natural rearing behavior, summer chum fry and fingerlings will be reared in freshwater under density, light, temperature, hydraulic conditions, and oxygen conditions, and with diets and at feeding rates, that promote the production of healthy smolts that will exhibit the highest possible survival rates to return.

1. **Densities** - Hatchery rearing densities will be those that yield the highest number survivals. Given that the actual identification of such densities is not likely, given current available data, the following conservative “standard” and “maximum” pond loading densities will be applied in all proposed supplementation programs to promote the release of healthy, viable fish (S. Evans and T. Tynan, WDFW, pers. comm. Feb. 1998).

| | **Pounds fish/gpm inflow** | | **Pounds fish/ft3 rearing volume** | |
|---|---|---|---|---|
| **Chum size** | Standard | Max. | Standard | Max. |
| Swim-up | <1.0 | 1.5 | 0.5 | 0.75 |
| 1200-600/lb | 1.0 | 2.5 | 1.0 | 2.0 |
| 600-400/lb | 1.5 | 3.0 | 1.0 | 2.0 |

Summer chum reared in marine net-pens should be held at densities no greater than 0.3 pounds of fish per cubic foot of net-pen space, assuming the pens are sited in an area with moderate tidal exchange (see marine net-pen guidelines from Washington Department of Ecology for siting criteria as per NPDES Permit requirements).

Accurate estimates of the biomass of the rearing population are needed to allow for the calculation of pond densities. Weight samples should be taken on a bi-weekly basis to determine average fish size to be applied to inventoried numbers of fish in deriving biomass estimates.

2. **Light conditions** - Light conditions during rearing will be maintained to mimic ambient seasonal photo-periods. Summer chum will be propagated outdoors to the extent feasible to comply with this objective.

3. **Hydraulic conditions** - Velocities and flow patterns in freshwater rearing ponds will be maintained at levels that provide for beneficial exercise of rearing fish, promoting prolonged swimming ability while optimizing feed distribution, removal of fish waste, and water exchange. The occurrence of “dead spots” in rearing ponds should be minimized to help avoid gill problems and to maintain fish health.

4. **Oxygen conditions** - Oxygen levels in rearing ponds will be maintained at levels that are optimal for juvenile salmon growth and survival. Oxygen concentrations at inflow should be at or near saturation (11-13 ppm). Effluent oxygen concentrations should be no less than 9 ppm.

5. **Fish diets and feeding rates** - Diets used in supplementation programs will be high quality, commercial grade, fish meal-based moist or semi-moist feeds currently available to Pacific Northwest salmon hatchery operations. Observed food conversion rates should be <1.3 for the diets used and as achieved through the methods used to apply the feed. Diets selected will have a minimum percentage of fines to minimize the risk of gill irritation and disease. Feed sizes will be matched to fish size as follows:

| **Chum size** | **Feed Size** |
|---|---|
| Swim-up | #1 |
| 1200-600/lb | #1 or #2, 1/32" |
| 600-350/lb | #2 or 1/32" |

Feed will be applied at rates that balance the need to minimize the duration of rearing, the maintenance of acceptable feeding efficiencies, and the desire to achieve targeted release sizes by the March or April release dates, with the need to prevent gill irritation and disease through over-application of feed. At all times, daily feeding rates will be maintained below 0.10 pounds feed per gallon per minute pond inflow per day to minimize gill irritation, and to guard against bacterial gill disease out-breaks. Accurate population size inventories, and average fish size estimates, are needed in order to evaluate whether this maximum feeding rate limitation is being met. Direct human contact with fish during feeding will also be minimized to reduce association of humans with food and to allow for more natural development of predator avoidance behavior in rearing fish. Feed shall not be supplied to fish that will be fin-clipped or tagged beginning one day in advance of the planned handling date.

6. **Fish health maintenance, monitoring, and pre-release evaluation** - Rearing ponds and screens will be maintained in a manner that ensures a hygienic environment for summer chum production. Mortalities should be removed and enumerated at least daily to allow for monitoring of population size and fish health status. Rearing units should be cleaned frequently to remove accumulated fish waste and uneaten feed. Troughs and tanks used for rearing should be cleaned daily, and raceways should be cleaned three times per week in a manner that does not re-suspend wastes into the water column where rearing fish may be adversely affected. The frequency of rearing unit cleaning should be balanced, however, with the need to minimize disturbance to the fish.

   All summer chum will be reared under the guidance of certified fish health personnel and in accordance with the Co-Manager’s Salmonid Disease Control Policy (NWIFC and WDFW 1998). Fish will be monitored daily during rearing for signs of disease, through observations of feeding behavior and monitoring of daily mortality trends. Preferred and maximum pond loading and feeding parameters will be adhered to at all times. Summer chum will be examined by a fish pathologist within three weeks prior to release to determine fish health status.

7. **Differentially mark all hatchery release groups** - To allow for estimation of spawning ground return rates, contribution rates to extreme terminal area fisheries, and (through mass marking) differentiation from natural-origin fish, summer chum produced each year in supplementation programs under this plan will be marked. All, or an appropriate proportion of each hatchery population (as determined by population size and the proportion identified as needed to form valid estimates of survival and contribution), will be marked through thermal banding (otoliths), removal of the adipose fin, application of a coded wire tag, or application of a coded wire tag-adipose clip combination. Marking will occur at the appropriate time during incubation (thermal marking), or at least one week in advance of release (adipose fin removal or CWT application).

## d) Release Strategies

Fish liberation strategies will be designed to release fry of a size and condition, and at a time that will maximize freshwater exodus rates, survival from the river to the estuary, survival during estuarine migration, and survival to adult return.

1. **Life stage and size at release** - WDFW fall chum hatcheries in Hood Canal have achieved high fry to adult survival rates (0.62 - 3.23 % - Fuss and Hopley (1991)) through the release of fed

chum fry of an average size of 1 gram (400- 450/pound), equating to an average length of 50-52 mm. This size at release was set as a target by WDFW beginning in the late 1970s to mimic chum production programs in Japan (Hager 1980), which have demonstrated smolt to adult survival rates for one gram chum fry released from hatcheries in Hokkaido of 2.0 - 3.1 % (1965-1981 brood year data from Kaeriyama 1989). Since 1993, summer chum fry of approximately one gram average size have been consistently released through the supplementation program at Quilcene National Fish Hatchery with similar, high apparent adult return rates.

Further rationale for the release of fed fry is the increased freshwater survival rates accrued through the release of larger chum. Fresh et al. (1980) demonstrated a freshwater survival rate of 46.2 % for unfed fry releases (39.2 mm average fork length) at Big Beef Creek, compared to 84.7 % survival for fed fry releases (55.7 mm average fork length).

Therefore, although wild summer chum migrate to seawater immediately after swim-up, the production of unfed fry will *not* be the preferred method for supplementing regional summer chum populations under this plan. Consistent with the desire to quickly boost the abundance of populations in the region in a minimal number of generations, all summer chum supplementation and reintroduction programs will endeavor to release fed fry of an average size of one gram to maximize survival rates. The minimal duration of intervention into the natural summer chum life cycle attached with producing a fed fry, and the survival rate advantage of fed fry over unfed fry, support the strategy of releasing one gram summer chum. Achievement of a one gram average release size should be attained by the normal out-migration period for wild summer chum fry in Hood Canal (March) and the eastern Strait of Juan de Fuca (April).

2. **Location of release** - Summer chum fry produced through this plan will be released into target drainages only after a significant level of incubation, rearing, and therefore, acclimation, within the target watershed. On-site incubation of eyed eggs, or transfer of unfed fry, for rearing of fry at the site of release to one gram size, are the preferred supplementation strategies. Transfers of chum fry reared at a hatchery facility for direct release into another drainage will not be allowed, due to uncertainty regarding homing ability of transferred fish, and the likely, diminished survivability for chum fry transferred and released in this manner. Acclimation ponds may be used at the desired release location to receive unfed fry incubated and hatched at another facility, if the duration of rearing time at the acclimation site is deemed sufficient to foster imprinting. Exceptions to this limitation may be made for hatchery facilities located on watersheds that share the same discrete estuary with a stream desired for planting (e.g. Big and Little Quilcene rivers; Salmon and Snow creeks). Research has shown that natural stray rates between such geographically proximate streams can be substantial (Tallman and Healey 1994). The co-managers consider streams sharing the same immediate estuary as harboring the same stock under this plan, and straying of supplementation-origin fish between such streams is therefore not a concern.

   Summer chum fry released from freshwater locations should be liberated as close to the estuary as possible to allow for rapid exodus from freshwater, and to minimize the number of fish that may be lost to predation (Fresh et al. 1980). Freshwater survival for Big Beef Creek chum was estimated to be 73.7 % for fry released at river kilometer 2.3 and 48.2 % for fry released at river kilometer 10.0, showing that increased exposure to predators decreases survival (Fresh et al. 1980). The choice of a liberation site in the lower part of the watershed should be balanced against the desire to distribute returning spawners across all available summer chum spawning areas upon return. Given that summer chum in the region generally spawn in the lower mile of each watershed, attempts should be made to liberate chum fry no further upstream than the lowest identified spawning locations. Chum fry liberations made further upstream should be mitigated by releasing the fish at night and when flows are amenable for flushing the fish from the system quickly.

Seawater net-pens used for additional rearing of summer chum should be located within the immediate estuary of the watershed where freshwater rearing occurred. Location of net-pens proximate to the desired return stream will minimize the risk of straying to other areas.

3. **Transport methods** - Methods and equipment used to transport summer chum from freshwater rearing sites to acclimation sites or seawater net-pens shall be designed to minimize harm to the fish. Where feasible, fish should be transferred from ponds to transport trucks using sanctuary nets to retain fish in water. Transport tanks should be supplied with oxygen at prescribed flow rates, providing oxygen concentrations within the tank of at least 10 ppm during transport.. Water in tanks should be equal in temperature to the source rearing pond, and fish should be loaded into the tanks at no greater than 0.285 pounds of fish per gallon of water (Ashcraft 1982). Tank lids should be secured with quick-release latches to firmly secure the lid during transport. Fish should be released from transport tanks into acclimation ponds or net-pens through flex hoses connected to the tanks outlet, avoiding additional dip-netting of fish from tanks.

4. **Timing of release** - Summer chum will be released from freshwater facilities during the seasonal period that coincides with the natural out-migration time for wild summer chum in the regions. The schedule of wild fry emigration can be considered the optimum release period because its evolution is geared to maximizing survival (Cardwell and Fresh 1979; Fresh et al. 1980 quoting Kobayashi 1976). For Hood Canal, summer chum fry are estimated to migrate into the estuary and out of Hood Canal between the first week in February and the third week in April (Tynan 1997). For eastern Strait streams, summer chum should be liberated from freshwater facilities or net-pens between the first week in February and the fourth week in May (Tynan 1997). To take advantage of increases in estuarine productivity promoted by spring-time increases in photoperiod, summer chum releases should be timed to occur towards the mid-point of the periods mentioned.

   Within Hood Canal, it is also desirable to release summer chum prior to the advent of hatchery fall chum releases from the southwest Hood Canal facilities. Releasing summer chum prior to the fall chum liberations will decrease the risk of competitive interactions that have the potential to decrease summer chum survival. This strategy may also provide summer chum with a competitive advantage by providing the populations first opportunity for food resources in the Canal. Beginning in 1998, WDFW has implemented a policy to release fall chum fed fry from all southwest Hood Canal hatcheries after the first week in April. Therefore, summer chum should be released prior to the end of March to minimize interactions with hatchery-origin fall chum.

5. **Methods of release** - Methods for liberating fish from freshwater facilities will be employed that maximize the rate of fish exodus from the stream to seawater, and that minimize the risk of predation on the released population. In all cases, hatchery releases should be made between dusk and midnight, mimicking the natural estuarine arrival period for wild chum fry, reducing the likelihood for significant fish and avian predation, and facilitating time for adaptation of the fish to the new estuarine environment (Fresh et al. 1980; Salo 1991). Fresh et al. (1980) found that chum fry released from Big Beef Creek had freshwater survival rates of 93.7 % when released near mid-night, compared to a survival rate of 71.8 % for chum fry released at mid-day (1100 hours).

   Fish should be released directly into the main stream channel to take advantage of the negative rheotactic response inherent in egressing chum, fostering rapid downstream exodus in the main, deepest water course. Summer chum releases should be made so that the arrival of the fish in the estuary coincides with a high tide, or with a high tide that is just beginning to ebb, to decrease the risk of stranding, and minimize the length of confinement in the freshwater channel during downstream migration.

   Fresh et al. (1980) demonstrated that mortality for newly released chum fry was inversely density-dependent (depensatory). Freshwater survival for Big Beef Creek chum was shown to increase non-linearly with number of fry released, ranging from 40.3 % when 517 fry were released, to 91.5 % when 50,155 were released (Fresh et al. 1980). Chum fry should therefore be released en masse to swamp predators in freshwater and in the immediate estuary, and to promote schooling of the fish when in seawater. Schooling has been shown to reduce predation losses (Cardwell and Fresh 1979, citing Brock and Riffenburg 1960 and Major 1978). This release strategy is chosen over practices that incorporate temporal and spatial variation (similar to wild fry emigration, which can span a one month period) because of the optimized time of release (during the period when natural fish have been successful in the estuary), and the survival advantage that may be imparted by predator swamping. The fact that rearing in freshwater as called for through this supplementation plan is not a natural trait for wild summer chum is also considered. The desire in this instance is to maximize survival for the release group, and not to mimic natural egression characteristics exhibited by unfed, wild fry.

## Bibliography

Ashcraft, W. 1982. WDFW memorandum October 21, 1982 (subject Loading rate guidelines for hauling fish). Wash. Dept. Fish and Wild., Olympia, WA. 2 p.

Cardwell, R.D., and K.L. Fresh. 1979. Predation upon juvenile salmon (draft technical paper, September 13, 1979). Wash. Dept. Fish and Wild., Olympia, WA. 19 p.

Fresh, K.L., R.D. Cardwell, B.P. Snyder, and E.O. Salo. 1980. Some hatchery strategies for reducing predation upon juvenile chum salmon (Oncorhynchus keta) in freshwater, p. 79-89. *In* Melteff, B.R., and R.A. Neve (eds.) Proceedings of the North Pacific Aquiculture Symposium. Alaska Dept. Fish and Game, Juneau, Alaska.

Fuss, H.J. and C.W. Hopley. 1991. Survival, marine distribution, and age at maturity of Hood Canal hatchery chum, p. 9-16. *In* B. White and I. Guthrie (eds.) Proceedings of the 15th Northeast Pacific Pink and Chum Salmon Workshop. Pacific Salmon Comm., and Can. Dept. Fish and Oceans, Vancouver, B.C.

Hager, B. 1980. History of chum salmon rearing in Washington state, p. 108-118. *In* Kingsbury, A.P. (ed.) Proceedings of the 1980 Northeast Pacific Pink and Chum Salmon Workshop. Sitka, Alaska. Alaska Dept. Fish and Game, Juneau, AK.

Kaeriyama, M. 1989. Aspects of salmon ranching in Japan. Proceedings of the International Symposium on Chars and Masu Salmon, Oct. 1988, p. 625-638. *In* Kawanabe, H., F. Yamazaki, and D.L.G. Noakes (eds.) Physiology and Ecology Japan, spec., Vol. 1. Hokkaido Univ., Sapporo, Japan.

Kapuscinski, A. R., and L.M. Miller. 1993. Genetic guidelines for the Yakima/Klickitat fisheries project. Co-Aqua consultants, St. Paul, MN. 66 p.

Kobayashi, T. 1976. Salmon propagation in Japan. *In* Proceedings of FAO Technical Conference on Aquiculture, Kyoto, Japan 26 May – 2 June 1976. Pub. No. FIR:AQ/CONF/76/E.75. 12 p.

Phelps, S. 1993. WDFW memorandum to Tim Tynan June 11, 1993 (subject Breeding of Quilcene Hatchery summer-run chum). Wash. Dept. Fish and Wild., Olympia, WA. 1 p.

Salo, E.O. 1991. Life history of chum salmon, Oncorhynchus keta, p. 231-309. *In* Groot, C., and L. Margolis (eds.), Pacific Salmon Life Histories. Univ. B.C. Press, Vancouver, B. C., Canada.

Tallman, R.F. and M.C. Healey. 1994. Homing, straying, and gene flow among seasonally separated populations of chum salmon (Oncorhynchus keta). Can. J. Fish. Aquat. Sci. 51:577-588.

Tynan, T.J. 1997. Life history characterization of summer chum salmon populations in the Hood Canal and eastern Strait of Juan de Fuca regions. Tech. Report No. H 97-06. Wash. Dept. Fish and Wild., Olympia. WA. 99 p.

WDFW (Washington Department of Fish and Wildlife) and WWTIT (Western Washington Treaty Indian Tribes). 1998. Co-managers of Washington fish health policy. Wash. Dept. Fish and Wild., Olympia, WA.

# Appendix Report 3.2
# Existing Summer Chum Supplementation and Reintroduction Projects

Supplementation has been applied as a strategy to help recover summer chum populations in Hood Canal and the eastern Strait of Juan de Fuca since 1992. Programs initiated that year included Big Quilcene River, Lilliwaup Creek, and Salmon Creek supplementation projects. A supplementation project on Hamma Hamma River began in 1987. Beginning in 1996, the regional population recovery strategy evolved to the point where reintroductions of fish into streams where summer chum populations had been extirpated became feasible. Transfers of progeny from appropriate broodstocks to reintroduce summer chum into Chimacum Creek and Big Beef Creek began with brood year 1996. All of these summer chum recovery programs are on-going.

Descriptions of each existing supplementation and reintroduction program, including program objectives, broodstock collection figures, fry production data, and operating procedures and objectives are presented below. These programs were instituted prior to the full development and completion of this plan. The following descriptions of existing programs may therefore include objectives, methods, and strategies that are not fully consistent with the tenets of the plan. However, the intent is to adjust existing programs to comply with the objectives, risk minimization methods, and strategies presented in the preceding document.

## 1. Hood Canal Region

### a) Big Quilcene River - Quilcene National Fish Hatchery Program

Summer chum salmon were first reared at Quilcene National Fish Hatchery (QNFH) from 1912 to 1937. During this time, eggs were collected from broodstock in various rivers of western Hood Canal - Big and Little Quilcene rivers, Dosewallips River, and Duckabush River. Eggs were hatched and fry raised at QNFH, with fry released into the Big Quilcene River or into the river where the broodstock originated. The QNFH summer chum salmon program was terminated in 1938 when the lower Quilcene River was "modified" and the fish could no longer make it back to the hatchery. By the late 1980s and early 1990s the adult returns to the Big Quilcene River were at very low numbers (less than 50 annually 1989-91), and with on-going habitat threats to the population, there was a possibility that summer chum could go extinct in this system. Thus it became a primary candidate for supplementation.

A supplementation program was started in 1992, to take advantage of the last relatively strong summer chum cycle year return. About half of the 400 returning adults were taken for brood stock purposes and delivered to QNFH. A portion of the 1992 brood year release was tagged to determine the success of supplementation and the timing and distribution of the stock. Since most chum salmon do not migrate as far up the river as the hatchery, the 1992 brood stock were obtained from the Quilcene Bay coho fishery and through collecting in the lower river.

With the first brood stock collection, various objectives and provisions were identified. Through an evolving joint interim agreement of the co-managers, the following guidelines have been developed: 1) the summer chum program would attempt to rebuild the run from the existing low level while preserving its genetic character; 2) the program would continue for a maximum of three generations (12 years); 3) brood stock would be captured in the Big Quilcene River and in Quilcene Bay; 4) at least 50% of adults returning to Quilcene Bay in any given year will be allowed to escape to spawn naturally; 5) egg takes will be representative of the timing and duration of the run, 6) brood stock would be sampled for GSI, scales, other biological characters, and for disease assessment purposes; 7) the release goal would be 400,000 maximum; 8) resulting hatchery fry would be released into the Big Quilcene River at this time; 9) hatchery practices would comply with the co-manager's disease policy; and 10) genetic considerations would be addressed prior to the use of this broodstock for any reintroductions.

Supplementation efforts have continued. Data for each brood year are summarized in Appendix Table 3.2.1. Over 2,500 fish have been spawned at QNFH and 1.98 million fry have been released into the Big Quilcene River since the inception of the program. This program may have been immensely important in 1993 and 1996, when portions of the Big Quilcene River containing summer chum redds were illegally bulldozed. The extent of mortality as a result of this activity in 1993 was estimated to be about 29% of the natural spawner escapement to the Big Quilcene River (Uehara 1994). Given that the adult escapement in 1993 was only 89 chum, the mortality level that year was significant.

**Appendix Table 3.2.1.** Quilcene National Fish Hatchery summer chum supplementation program data - 1992-97[1]

| Brood Year | Broodstock Removals/Swim-ins | | | Natural Spawners | Percent Removed | # Fed Fry Released | Release Size (gms) | Release Date |
|---|---|---|---|---|---|---|---|---|
| | # Males | # Females | Total | | | | | |
| 1992 | 225 | 186 | 411 | 320 | 56.2 | 216,441 | 1.05 | 4/13/93 |
| 1993 | 19 | 17 | 36 | 97 | 27.1 | 24,784 | 1.46 | 3/30/94 |
| 1994 | 169 | 178 | 347 | 349 | 50.1 | 343,550 | 1.06 | 3/27/95 |
| 1995 | 228 | 256 | 484 | 4,029 | 10.7 | 441,167 | 1.06 | 3/27/96 |
| 1996 | 438 | 333 | 771 | 8,479 | 8.3 | 612,598[1] | 1.34 | 4/10/97 |
| 1997 | 274 | 261 | 535 | 7,339 | 6.8 | 340,744 | 1.62 | 4/2, 15/98 |
| 1998 | 315 | 232 | 547 | 2,244 | 19.6 | 343,530 | 1.28 | 3/8, 3/22, 4/2/99 |

[1] Figures do not include 204,000 fish in 1997, ~112,000 fish in 1998, ~200,000 fish in 1999 of QNFH origin produced at Big Beef Creek.

The supplementation program at QNFH appears to have been particularly effective in assisting achievement of stock recovery objectives, significantly increasing spawner abundances in the Big Quilcene River. Observed, large adult return levels in 1995-98 relative to previous years have coincided with the timing of expected returns for supplemented brood years (e.g. three year old chum from the first supplementation brood year of 1992 returned in 1995) The increased Big Quilcene

River returns in recent years are likely due to a combination of factors, including harvest management actions and perhaps a change in ocean conditions that may have increased marine survival. But the escapements appear proportionally much higher than for non-supplemented streams within the same time period. Average returns to the Big Quilcene River over the 1994-98 period increased 4,724 % over the recent period (1988-93) preceding the supplementation program (4,488 fish average for 1994-98 compared with 95 fish average in 1988-93). This high percent change in average escapements observed for the Big Quilcene River compares to 1,002 % and 480 % increases recorded for adjacent non-supplemented stocks in the Dosewallips and Duckabush rivers, respectively, over the same two periods. It is apparent that the Big Quilcene supplementation project has contributed to the increased returns observed for this stock.

### b) Lilliwaup Creek Cooperative Program Long Live The Kings Enhancement Group

In 1992, WDFW initiated a cooperative fish rearing project with the Hood Canal Salmon Enhancement Group (HCSEG) to rebuild the indigenous summer chum salmon population in Lilliwaup Creek, a western Hood Canal tributary, through a hatchery supplementation program. This effort was conceived as part of a multi-agency initiative to increase the abundance of summer chum in response to declines in the population observed in the 1980s, and the designation of west-side Hood Canal summer chum the stock as critically depressed through the 1992 Salmon and Steelhead Stock Inventory (WDF et al. 1993) process. In 1994, Long Live the Kings (LLTK) assumed primary responsibility for this project. The project is now managed by LLTK through a contractual agreement with WDFW, and is partially funded through a contract administered by USFWS. LLTK consults with the HCSEG on the operation of the project.

The goal of the Lilliwaup project is to contribute to the restoration of a healthy, naturally self-sustaining population of Lilliwaup Creek summer chum salmon which maintains the genetic characteristics of the native stock. The identified objective was to implement an effective short-term recovery effort to counteract the current risk of extinction due to the small population size.

Supplementation guidelines for the project dictate that recovery planning for the watershed be consistent with a draft version of the Hood Canal and Strait of Juan de Fuca Summer Chum Conservation Plan (January 17, 1997). The contribution of the Lilliwaup project and its potential expansion would be determined through this comprehensive planning process. Production level goals, broodstock collection methods, and rearing densities would be set in accordance with principles identified in the conservation plan. Appendix Table 3.2.2 summarizes summer chum fry production in Lilliwaup Creek for 1992-97.

Through joint agreement between WDFW, the PNPTC tribes, and LLTK, the following guidelines were initially applied for the operation of the project: 1) the program would attempt to rebuild the run from the existing low level while preserving its genetic character; 2) the program would continue for a maximum of three generations (12 years); 3) all brood stock would be captured in the Lilliwaup River; 4) at least 50% of adults returning to river in any given year will be allowed to spawn naturally; 5) egg take will be represented throughout the timing duration of the run, and the spawning ratio shall be one female to one male; 6) brood stock would be sampled for GSI, scales, other biological characters, and for disease assessment; 7) a maximum of 25 pairs will be used in this project, unless otherwise agreed by the parties; 8) resulting hatchery fry would be released as 1 gram fish into the Lilliwaup River; 9) beginning in 1997, all fry released will be otolith marked; 10) in order to prevent the spread of viral pathogens, sampling of all broodstock will follow appropriate actions mandated by the Co-managers' Salmonid Disease Control Policy, and accepted fish health practices and monitoring will be applied during rearing; and 11) the project will include a monitoring and evaluation program. Due to recent, extremely depressed abundance levels, the co-managers determined in 1998 that all returning fish may be used for the supplementation program as an emergency measure.

**Appendix Table 3.2.2** Lilliwaup Creek summer chum supplementation program data - 1992-97

| Brood Year | Broodstock Removals/Swim-ins<br># Males | <br># Females | <br>Total | Natural Spawners | Percent Removed | # Fed Fry Released | Release Size (gms) | Release Date |
|---|---|---|---|---|---|---|---|---|
| 1992 | - | - | 18 | 90 | 16.7 | 20,000 | 0.4 | March |
| 1993 | - | - | 10 | 72 | 12.2 | 12,000 | fed | March |
| 1994 | - | - | 12 | 105 | 10.3 | 15,000 | fed | March |
| 1995 | - | - | 0 | 79 | 0 | 0 | - | - |
| 1996 | - | - | 12 | 40 | 23.1 | 15,000 | fed | March |
| 1997 | 11 | 7 | 18 | 10 | 64.3 | 14,200 | 1.0 | March 1 |

Through 1997, there have been difficulties in collecting adequate numbers of brood stock. Attempts in this regard have been complicated by the lack of a fish collection weir, low overall summer chum return levels, and the presence of pink salmon in the same stream areas as summer chum. In 1998, WDFW was able to provide limited funding for this project, allowing for the installation of a weir in the lower creek, increased agency assistance during fish spawning, and increased monitoring and evaluation of the supplementation program.

### c) Hamma Hamma River Supplementation Project
### Hood Canal Salmon Enhancement Group, Long Live the Kings, Point No Point Treaty Council, Skokomish Tribe, U.S. Fish and Wildlife Service, WDFW

The Hamma Hamma multispecies salmonid recovery project was developed by the HCSEG and LLTK with support from others. Out of this effort evolved the Hamma Hamma supplementation project on John Creek, a Hamma Hamma River tributary. Review of freshwater habitat conditions, summer chum escapements, potential causes for decline in escapement, and current restoration efforts in Hood Canal by the tribes, WDFW, USFWS, LLTK, and the HCSEG led to the recommendation for a summer chum supplementation program at John Creek due to the following (Hamma Hamma Supplementation Subcommittee 1997):

- The returns to the Hamma Hamma River comprised an estimated 20 to 30% of the summer chum returns to the west Hood Canal streams in the 1960s and 1970s, but compromise less than 6% of the total run in the past two years.

- Recent returns to the Hamma Hamma River (566-840), unlike the total number of returns to Hood Canal, are not within the range of returns seen in the 1960s and 1970s (1,772-12,800).

- The slower improvement in summer chum salmon returns to the Hamma Hamma River than in the nearby, but non-supplemented, Dosewallips and Duckabush rivers.

- Recent improvement in returns to the Hamma Hamma River does not ensure a future improvement, therefore providing a boost to the population through supplementation may be beneficial if risks are minimized.

- A summer chum salmon supplementation program appears to have been successful at the Quilcene National Fish Hatchery on the Big Quilcene River. This program has been in existence since 1992 and returns to this system have increased dramatically since 1994.

- A supplementation program would require very low levels of human intervention for up to 12 years, and therefore domestication is not foreseen as a problem.

The goal of the Hamma Hamma project is to contribute to the restoration of a healthy, naturally self-sustaining population of Hamma Hamma River summer chum salmon which maintains the genetic characteristics of the native stock. The stated project objective is to lessen the current risk of extinction due to small population size by implementing an effective short-term recovery effort. The summer chum supplementation project is managed through a partnership between LLTK, HCSEG, and WDFW. The project is staffed by LLTK and supported by HCSEG volunteers.

Recovery planning for this watershed was to be consistent with the draft version of the Summer Chum Salmon Conservation Initiative. The contribution of the Hamma Hamma project and its potential expansion will be determined through this comprehensive planning process. Due to lack of experience in working with summer chum salmon in the Hamma Hamma River, it was determined that a small supplementation program was warranted for 1997. This limitation allowed for extra protection for testing of new procedures at a new site.

Through joint agreement between the cooperators, the following guidelines were applied for the operation of the project: 1) the program would attempt to rebuild the run from the existing low level while preserving its genetic character; 2) the program would continue for a maximum of three generations (12 years); 3) all brood stock would be captured in the Hamma Hamma River or its tributary, John Creek; 4) at least 50% of the adults returning to the river in any given year will be allowed to spawn naturally; 5) egg take would be represented over the entire spawning period, and spawning one female to one male should take place; 6) brood stock would be sampled for GSI, scales, and other biological characters, 7) 34 pairs were recommended for broodstock in 1997 to ensure a minimum effective population size of 200 fish in the program (i.e. for a minimum $N_e$ of 200 fish, and an assumed chum generational length of 3 years, 67 chum (34 pairs) are needed) ; 8) in order to prevent the spread of viral pathogens, sampling of all broodstocks will follow appropriate actions mandated by the Co-managers' Disease Policy, and accepted fish health practices and monitoring will be applied during rearing; 9) all fry released would be otolith marked; 10) resulting hatchery fry would be released as 1 gram fish into John Creek or until naturally spawned fry are seen moving out of the system; 11) the project will include a monitoring and evaluation program; and 12) genetic considerations would be addressed prior to any reintroductions.

During 1997, there were difficulties collecting adequate numbers of brood stock due to flow conditions and the presence of pink salmon in the same areas as summer chum. A total of 5 female and 9 male summer chum were collected and spawned (T. Johnson, WDFW, pers. comm., September, 1998). An estimated 12,000 brood 1997 fry were subsequently released into John Creek on March 1, 1998 at an average size of 1.0 gram. In 1998, WDFW was able to supply a limited amount of funding for this project, allowing for increased agency assistance during fish spawning and increased monitoring and evaluation of the program.

## d) Big Beef Creek Summer Chum Reintroduction Project

This reintroduction project is operated jointly by WDFW and USFWS as a cooperative with the Hood Canal Salmon Enhancement Group. Big Beef Creek was initially identified at the onset of long term conservation planning for Hood Canal summer chum as an initial candidate for summer chum reintroduction from the QNFH program. This eastside Hood Canal drainage showed no escapement for ten consecutive years and it was apparent that the indigenous population was extirpated. Big Beef Creek was identified as a suitable location for reintroduction of summer chum from the QNFH program for the following reasons:

- It has historically produced summer chum, and therefore is likely to still possess habitat characteristics that support self-sustaining natural production of summer chum;

- The proposed donor stock is indigenous to a drainage geographically much closer to Big Beef Creek (22.05 km between stream mouths) than the only eastside Hood Canal donor population from which donor summer chum brood stock might be available at the present time (Union River, approx. 69 km distance). No summer chum are available from any other eastern Hood Canal streams for introduction into Big Beef Creek due to extremely low population abundances.

- The spawning ground entry timing for the extirpated Big Beef Creek stock was nearly the same as the entry time identified for the Big Quilcene River population;

- The existing WDFW coho research project on Big Beef Creek provides the necessary infrastructure to conduct assessments of the effects/success of summer chum reintroduction, including adult return levels, smolt out-migrant levels/timing, etc;

- Salmon incubation and production facilities present at the current NMFS/UW program on Big Beef Creek provide opportunities for on-site incubation, hatching and feeding, ensuring imprinting of released fish and increasing survival potential;

- It is desirable from a genetic conservation perspective to establish the Big Quilcene River summer chum genome in another drainage to limit the risk of loss of the population due to catastrophic events. Over the last few years there have been two major flood events on the Quilcene. In the areas of chum spawning, these floods have been especially devastating as a result of gravel scouring, gravel deposition and altering the course of the lower river);

- The Big Beef summer chum run is recognized by all parties as extirpated, and the introduction of a suitable Hood Canal summer chum population from another drainage will therefore not displace or affect an indigenous population.

The following procedures and methods were used in introducing summer chum from the Big Quilcene River into Big Beef Creek during the 1996 and 1997 seasons:

- Eyed eggs identified as surplus to those needed to meet the QNFH on-station fed fry production objective will be transferred to BBC for incubation and hatching in existing NMFS/UW facilities.

- Personnel needs for monitoring incubators and rearing fry will be met by WDFW, USFWS, and the Hood Canal Salmon Enhancement Group.

- Existing facilities at Big Beef Creek will be used for incubating, hatching and rearing of 120,000 to 200,000 summer chum fry for release.

- Procedures used to transfer eyed eggs will comply with the Co-managers' Fish Disease Policy.

- Eyed eggs transferred to BBC will be from egg takes spread across the breadth of the Big Quilcene return to ensure that the entire summer chum return timing span from the donor stock is represented.

- Fry resulting from these transfers will be reared to a target size of 1 gram for an en masse release into Big Beef Creek in March.

In 1997, 204,000 brood 1996 summer chum fry produced in RSIs at Big Beef Creek were released between early February and early March after one to four weeks of rearing in a net-pen positioned in a pond downstream of the NMFS hatchery. The approximate average size at release for 1996 brood chum ranged from 700-1000 fpp. In 1998, approximately 112,000 brood 1997 fed fry at a size of 0.91 grams were released on February 9, after three to four weeks of rearing in a 24 foot diameter fiberglass tank located in the NMFS rearing compound. Approximately 210,000 1998 brood one gram summer chum fry will be released during March, 1999 to complete the third year of the reintroduction program.

# 2. Strait of Juan de Fuca Region

## a) Salmon Creek Summer Chum Supplementation Program
## WDFW, North Olympic Salmon Coalition, and Wild Olympic Salmon Cooperative

The Salmon Creek supplementation project is a cooperative effort between the North Olympic Salmon coalition, Wild Olympic Salmon and WDFW that was begun in 1992. The project goal is to contribute to the restoration of a healthy, natural, self-sustaining population of Salmon Creek summer chum that will maintain the genetic characteristic of the native stock. An additional goal of the Salmon Creek program, after attaining stable healthy return levels, is to create a donor stock for the reintroduction of summer chum into Chimacum Creek.

The supplementation program, its goal and guidelines, are identified in a 1995 rearing protocol document (WDFW 1995): 1) recovery planning shall be consistent with other WDFW summer chum recovery plans; 2) recovery actions must fully address impacts to other salmonid stocks and not adversely affect their population status; 3) recovery strategies should put the summer chum stock at no greater risk than if no action was taken; 4) the hatchery program will be part of a long-term recovery effort which will have both stock rehabilitation and habitat restoration components; 5) the supplementation program is intended to support natural production, and the program will be discontinued once natural production has been stabilized at healthy stock levels as defined in 1992 SASSI (WDF et al. 1993); 6) the program is limited to twelve years (three chum generations, commencing in 1992), in compliance with stock genetic integrity objectives; 7) at least 50 % of adults returning to Salmon Creek in any given year must spawn naturally; and 8) for 1995, the brood number is initially limited to 10 % of the total number of chum returning to the watershed, with collections occurring over the entire run-timing of the stock.

Following the successful implementation of all protocols required in 1995, the allowable broodstock collection number was adjusted upward to 20 % of the total number of female summer chum returning to the watershed beginning in 1996. In 1995, there were several modifications made to the facility and to the rearing and release process to minimize mortality of eggs and to reduce potential straying. The current program requires that all eggs be transferred to the Dungeness Hatchery for incubation through the eyed stage of development. The eyed eggs are then returned to the Salmon Creek facility for hatching. After emergence, fish are fed in freshwater for two weeks prior to transfer to saltwater net pens in Discovery Bay. The release will be made when the fish are approximately 300 fish/pound. Appendix Table 3.2.3 summarizes releases of summer chum fry since 1992 through the Salmon Creek program.

**Appendix Table 3.2.3.** Salmon Creek Summer Chum Supplementation program data - 1992-97[1]

| Brood Year | Broodstock Removals/Swim-ins | | | Natural Spawners | Percent Removed | # Fed Fry Released | Release Size (gms) | Release Date |
|---|---|---|---|---|---|---|---|---|
| | # Males | # Females | Total | | | | | |
| 1992 | 35 | 27 | 62 | 371 | 14.3 | 19,200 | 1.1 | 5/08/93 |
| 1993 | 29 | 23 | 52 | 400 | 11.5 | 44,000 | 1.8 | 4/24/94 |
| 1994 | 12 | 12 | 24 | 137 | 14.9 | 2,000 | 1.3 | 4/01/95 |
| 1995 | 35 | 18 | 53 | 538 | 9.0 | 38,808 | 1.3 | 4/24/96 |
| 1996 | 59 | 50 | 109 | 785 | 12.2 | 62,000[2] | 1.3 | 4/8,24/97 |
| 1997 | 60 | 50 | 110 | 724 | 13.2 | 71,821[2] | 1.0-1.3 | 3/31,4/16/98 |

[1] Release number and size data from Seymour 1993; Scalf 1995, 1996, 1997; G. Correa, WDFW, Port Townsend, WA pers. comm.

[2] Release numbers do not include 28,788 and 36,840 fry of Salmon Creek-origin released into Chimacum Creek in 1997 and 1998 respectively.

## b) Chimacum Creek Summer Chum Reintroduction Project

The previously described Salmon Creek program was originally conceived with the objectives to rebuild and stabilize the Salmon Creek population and to allow for the transfer of surplus eggs or fry to Chimacum Creek. Chimacum Creek was reported to historically have an indigenous summer chum return, but the run was apparently extirpated due mainly to freshwater habitat degradation and poaching. Chimacum Creek was identified as a suitable location for reintroduction of summer chum from Salmon Creek for the following reasons:

- Chimacum Creek historically produced summer chum, and may possess habitat characteristics that have a potential to support self-sustaining natural production;

- Volunteer groups have been working to remedy habitat damage in the Chimacum drainage limiting to salmon production, including silt removal and stream bank stabilization;

- The Salmon Creek summer chum stock is viewed as the appropriate stock for transfer to Chimacum, as the Salmon Creek population is the closest summer chum stock in the region, the two streams are close geographically (stream mouths approximately 34 km apart by water), the watersheds are adjacent to each other, and the stream characteristics are similar;

- It is desirable from a genetic conservation perspective to establish the Salmon Creek summer chum genome in another drainage to limit the risk of loss of the population due to catastrophic events. Salmon Creek is a small watershed and vulnerable to changes that could alter natural chum production; and

- The Chimacum summer chum run is extirpated, and the introduction of a suitable eastern Strait of Juan de Fuca summer chum population from another drainage will therefore not displace or affect an indigenous population.

Given these foundations for summer chum reintroduction, the following procedures and methods in introducing summer chum from Salmon Creek into Chimacum Creek during the 1996-97 and 1997-98 seasons were employed:

- Available surplus eyed eggs from Salmon Creek were transferred to Chimacum Creek for incubation and hatching in RSIs at appropriate locations;
- Facilities on Chimacum Creek will be used for incubating, hatching, and rearing in freshwater. Additional rearing may occur in seawater net-pens in Port Townsend Bay, if an adequate net-pen site is made available.
- Personnel needs for monitoring incubators and rearing fry will be met by volunteers from the North Olympic Salmon Coalition and Wild Olympic Salmon, and by WDFW staff.
- Transfers were done in accordance with established notification process, including notation in the Equilibrium Brood Document.
- Procedures used to transfer eyed eggs complied with the Co-manager’s Fish Health Policy.
- Eyed eggs transferred to Chimacum Creek will be from egg takes spread across the breadth of the Salmon Creek return to ensure that the entire summer chum return timing span from the donor stock is represented.
- Fry resulting from this transfer will be reared to a size of 400 fpp for release into lower Chimacum Creek (or from net-pens into Port Townsend Bay) during April.
- Additional transfers in the future will be determined by PNPTC and WDFW.

In 1997, 50,000 eyed eggs were transferred in for the Chimacum program. An estimated 28,788 1996 brood summer chum fry were produced from the egg transfer at the Chimacum High School fish hatchery. These fish were released on March 23 and May 9 at a size ranging from 0.4 to 1.5 grams each from a marine net-pen near the mouth of Chimacum Creek after one to five weeks of additional rearing. In 1998, the transfer of 40,000 eyed eggs from the Salmon Creek program led to the production of 36,840 1997 brood fed fry at an approximate size of 0.7 grams. These fry were transferred in three groups from a rearing site on Naylors Creek, a Chimacum Creek tributary, and released on March 27, April 11, and April 19 into lower Chimacum Creek above the estuary. Initial returns of three year old summer chum from brood year 1996 and 1997 Chimacum Creek releases are anticipated in late summer, 1999 and 2000.

## Bibliography

Hamma Hamma Supplementation Subcommittee. 1997. Hamma Hamma River summer chum salmon supplementation program - HCSEG, LLTK, PNPTC, Skokomish Tribe Dept. Nat. Res., USFWS, and WDFW. Wash. Dept. Fish and Wild. Olympia, WA. 12 pp.

Scalf, C. 1995. 1993-94 and 1994-95 Salmon Cr. summer chum restoration project annual reports. Wild Olympic Salmon, Chimacum, WA.

Scalf, C. 1996. 1995-96 Salmon Cr. summer chum restoration project annual report. Wild Olympic Salmon, Chimacum, WA.

Scalf, C. 1997. 1996-97 Salmon Cr. summer chum restoration project annual report. Wild Olympic Salmon, Chimacum, WA.

Seymour, S. 1993. 1992-93 Salmon Cr. summer chum restoration project annual report. Wash. Dept. Fish and Wild., Olympia, WA.

Uehara, J. 1994. A salmon damage assessment for the December 1993 channelization of the lower Big Quilcene River (unpublished). Wash. Dept. Fish and Wild., Olympia, WA. 21 p.

WDF (Washington Department of Fisheries), Washington Department of Wildlife, and Western Washington Treaty Indian Tribes. 1993. 1992 Washington State Salmon and Steelhead Stock Inventory. Wash. Dept. Fish and Wild., Olympia, WA. 212 p.

# Appendix Report 3.3
# Genetic Hazards Discussion

**(This section generally taken from M. Ford, NMFS and K. Currens, NWIFC, "Puget Sound Comprehensive Chinook (Draft) Artificial Production Plan", September, 1998)**

## Hazard: Reduction in Effective Population Size

### General Discussion

***Background information on effective population size:*** The effective size of a population (Ne) is a key parameter in determining both the amount of variation that can be maintained in the population and the relative importance of genetic drift and natural selection in shaping that variation (Hartl and Clark 1989, Lynch and Walsh 1998, Falconer 1989). A population with a small effective size will lose adaptive variation and gain maladaptive variation at a faster rate than an equivalent population with a larger effective size (Lande and Barrowclough 1987, Lande 1994, 1995). The effective size of a population is also directly related to the level of inbreeding that is occurring in the population; small populations have higher levels of inbreeding than larger populations, and therefore may be more vulnerable to inbreeding depression than are larger populations.

The effective size of a population is defined as the size of an idealized population that produces the same level of inbreeding or genetic drift that is seen in an observed population in which one is interested (see Hartl and Clark 1989 and Caballero 1994 for reviews). Attributes of such an idealized population typically include discrete generations, equal sex ratios, binomial variance of reproductive success, random mating, constant breeding population size, and non-selective gamete-to-adult mortality. Violation of any these attributes usually results in an increase in the rate of inbreeding or drift compared to the idealized case, and therefore a reduction in effective population size. For example, if the number of breeding individuals varies from generation to generation, the long term effective size will be equal to the harmonic mean (defined in plan glossary) of the number of breeders each generation (Caballero 1994). Because almost no natural populations are ideal, a population's effective size is almost always smaller than the observed number of breeding individuals (reviewed by Frankam 1995).

***Minimum viable effective populations sizes:*** There are a number of recommendations in the conservation literature on guidelines for "generic" minimum viable effective populations sizes. All of these recommendations are based on effective population size per generation, and for a number of reasons must only be considered as rough guidelines. Franklin (1980) and Soule (1980) suggested that an effective population size of 500 is necessary for long term population persistence. This value is based on estimates of the rates at which mutations add and drift and selection remove variation from an isolated population. Recently Lande (1995) has pointed out that because ~90% of new mutations are strongly deleterious, a more realistic long term minimum viable effective population size may be closer to 5000 per generation. Based on the probability of losing rare alleles, Waples (1990) has suggested that 100 effective breeders/year is necessary to maintain genetic variation in salmon populations. These general recommendations have some severe limitations that must be acknowledged before they are used to help determine levels of abundance necessary for properly functioning salmon populations. First, they are based on models of single, reproductively isolated populations. As the term is used in this paper, a population is substantially reproductively isolated, but may receive regular migrants from other populations. Migration, like mutation, is a source of genetic variation, so it is likely that populations connected by migration will have somewhat lower genetically minimum viable population sizes than completely isolated populations. Second, the genetic parameters that form the basis for the Franklin (1980) and Lande (1995) recommendations were estimated from limited data, and must therefore be regarded as preliminary. Third, there is some debate about the generality of the genetic model used to obtain these recommendations (e.g. Barton and Turelli 1991). None-the-less, these recommendations may be a reasonable as starting points for determining the abundance necessary for long-term genetic viability, especially in the absence of additional information. Note that other factors, such as habitat capacity and population productivity need to be taken into account when determining appropriate levels of abundance necessary for a population to be considered healthy.

In order to convert these recommendations of effective population size per generation to salmon spawning abundance per year, it is necessary to know the ratio of the effective population size to the census size (Ne/N ratio) and the generation time for the population in question. Ne/N ratios estimated from six populations of Snake River spring chinook and one population of Sacramento River winter chinook range from a low of 0.013 (Bartley et al. 1992) to a high of 0.7 (Waples et al. 1993) and average ~0.4. The large range is most likely due both to large sampling errors in estimating Ne as well as real biological differences among populations. Assuming that an Ne/N ratio of 0.4 is approximately correct for salmon and steelhead in general, the recommended minimum long-term genetically viable population sizes discussed above range from 925/generation (Waples 1990, assuming a 3.6 year generation time) to 12,500/generation (Lande 1995). The minimum spawning population size recommended by WDFW (1997) falls in the middle of this range (3,000/generation). For populations that spawn at multiple age classes, the values of spawners/generation must be divided by the generation length (median age of reproduction) to obtain the corresponding numbers of spawners per year. For Hood Canal summer chum populations, this is estimated to be 3.6 years.

***Mechanisms by which artificial propagation can affect Ne:*** Hatchery management actions can affect Ne in a number of ways. If one considers a hatchery population in isolation, factors under at least some management control such as the broodstock size each year, the variance in productivity among individuals, and the sex ratio all strongly affect Ne. For a given abundance, Ne will be maximized when the sex ratio is equal and the variance in productivity among individuals is minimized. This leads to recommendations such as the use of single pair or factorial mating to maximize Ne (e.g. Tave 1993 Chapter 6, Kapuscinski and Jacobsen 1987). Rearing methods that equalize family size as much as possible can also be used to increase Ne. For example, any culling or transfers to other locations that are done unequally across families will reduce Ne.

The potential effects of artificial propagation on the effective population size of a composite natural/hatchery system are more complicated, and gaining a better understanding of these effects is an active area of research (Ryman and Laikre 1991, Waples and Do 1994, Cuenco 1994). The long term effects of hatchery supplementation on the effective size of the combined wild/hatchery population depend a great deal on factors such as the relative productivities of the two environments, the number of breeders in each environment, whether or not the natural population remains large after supplementation ceases, the age structure of the species, the number of brood years for which broodstock are collected, whether or not returning hatchery fish are avoided for broodstock in the second generation of supplementation, and the environmental and genetic effects on the productivity of hatchery fish that spawn in the wild (Waples and Do 1994, Cuenco 1994). Because of the complicated and contingent nature of these effects, some form of mathematical modeling may be useful to estimate the effects on total effective population size that a particular hatchery program is expected to produce. In the absence of modeling, it is important to keep in mind several key factors explored in other modeling efforts (Ryman and Laikre 1991, Waples and Do 1994, Cuenco 1994) that will influence the likelihood of an increase or decrease in effective population size. These are: 1) Situations where a small number of wild fish are taken into a hatchery and produce a large fraction of natural spawners the following generation can lead to a substantial short term reduction in effective size and increase in inbreeding; 2) If the supplemented population returns to its pre-supplementation size after supplementation ceases, then a decrease in effective size compared to the non-supplemented case is possible, especially if the effective size in the hatchery was small. This suggests that a key component of a supplementation program should be to concurrently address the primary causes that depressed the population in the first place; and 3) If the supplementation program lasts for more than a one generation, marking ~100% of the hatchery fish and avoiding marked fish for use as broodstock can increase effective size. The reader is referred to Ryman and Laikre (1991), Waples and Do (1994) and Cuenco (1994) for a fuller discussion of these issues.

## Severity of a Reduction in Ne That Is Considered to Be a Hazard

A reduction in Ne due to artificial propagation is considered to be a hazard if 1) it substantially reduces a wild population's Ne; or 2) reduces a wild population's Ne below 3000 effective spawners/generation; or 3) for target populations below 3000/generation, is expected to result in a lower long-term wild population Ne than would be the case in the absence of the artificial propagation program.

## Rationale for Specific Criteria Used in the Risk Assessment (See Worksheets for Assessment of Hazards - Appendix Report 3.4)

| Criteria | Rationale |
|---|---|
| Hatchery fish are marked to accurately estimate the proportion hatchery fish spawning naturally in the target population and the proportion of wild fish spawning in the hatchery | Estimating the proportion of hatchery fish on the spawning grounds and wild fish in the hatchery is essential for an accurate estimation of the effective size of the composite population. |
| Natural spawners are regularly monitored to accurately estimate the proportion of hatchery fish spawning in the target population. | Same as above. |
| In the target population, the proportion of natural spawners that are hatchery fish is approximately equal to the proportion of wild fish that were taken into the hatchery the previous generation<br>**OR**<br>In the target population, the proportion of natural spawners that are hatchery fish is larger than the proportion of wild fish that were taken into the hatchery the previous generation **AND** the wild population is increasing in abundance at a rate at least equal to the proportion of naturally spawning hatchery fish<br>**OR**<br>The target wild population is believed to be in substantial danger of extinction within the next 36 years **AND** the effective number of breeders in the hatchery is as large as possible given the available broodstock.<br>**OR**<br>The project is to reintroduce fish to a location removed from the target population with the likelihood of less than 5-15 % return to population. | Meeting this criteria ensures that a small number of hatchery fish cannot contribute a large proportion of natural spawners the next generation and thus substantially reduce Ne.<br>In a supplementation program designed to increase natural abundance, the proportion of natural spawners needs to be larger than the proportion of wild fish taken into the hatchery if the program is to be successful (assuming that the target population is the only source of broodstock). Assuming that the hatchery fish are successful in the natural environment and that the natural population is at least productive enough to be self-sustaining, the supplemented population should increase in abundance at a rate approximately equal to the proportion of the natural spawners that are hatchery fish.<br>If a natural population is not able to sustain itself and is going extinct, then maintaining the population artificially will result in an increase in Ne compared to the case of extinction regardless of the effective population size in the hatchery. In this situation it is important, however, to maintain as much variation as possible to maximize the probability that population may be naturally viable in the future.<br>In the case of reintroduction, the concern is potential project-origin returns to the donor population. A small return if any should not affect the donor population's effective population size. |

# Hazard: Loss of Within Population Diversity

## General Discussion

In principal, six basic parameters are likely to control the degree to which a hatchery program might reduce within population diversity; that is, domesticate a wild population. These are 1) the source of the hatchery broodstock, 2) the degree to which the broodstock sample is representative of the target population (if the target population is itself the broodstock source), 3) the degree of difference between the wild and hatchery environments, 4) the duration of the hatchery program, 5) the level of gene flow between the hatchery and wild environments, and 6) the genetic basis of the traits subject to domestication selection pressure. These factors are discussed in more detail below.

***Broodstock source:*** For the purposes of minimizing the risk of domestication, the best source of broodstock is likely to be the target natural population itself or another, similar, wild population. Hatchery populations that have been in culture for many generations or have ever been deliberately or inadvertently selected for particular traits (e.g. run or spawn timing, age structure, size, etc) are likely to be already at least somewhat domesticated (Reisenbichler 1997). Hatchery populations that have been in culture for some time but have used natural rearing and mating methods and/or had frequent infusions of wild fish into the broodstock may fall somewhere in the middle (Maynard et al. 1995). In at least some instances, evidence for domestication has appeared within two-to-four generations of hatchery rearing (Fleming and Gross 1994, Reisenbichler and McIntyre 1977).

***Broodstock collection:*** A second potential source of domestication is non-representative sampling of wild fish for broodstock. Most natural populations exhibit considerable variation in morphological, behavioral and life-history traits. If fish with certain characteristics are more likely to be sampled for broodstock than their frequency within the population, this may result in selection for those characters in the hatchery population. If the hatchery population is itself reproductively integrated with a wild population, then the distribution of the selected trait may also change in the wild population. In many instances collecting a representative broodstock sample is not likely to be easy. A large random sample will approximate the distribution from which it was drawn, but obtaining a truly random broodstock sample may often be difficult because rarely are all fish in the population available for sampling at the same time. This means that in most cases a sample will have to be stratified over the course of the run in order to obtain a representative sample of the entire population.

***Hatchery environment and duration of the hatchery program:*** The environment that a fish faces in a most hatcheries is different from the wild environment, and morphologies, behaviors and life-history strategies favorable in a hatchery may not be the same as those favorable in the wild. There is evidence to show that many hatchery populations have changed over time at a number of behavioral or morphological traits, and that this divergence can occur over a relatively short time period (e.g. Fleming and Gross 1989, 1992, 1993, 1994, Fleming et al. 1996, McGinnity et al. 1997, Reisenbichler 1997, Berejikian et al. 1997, Swain and Riddell 1990, Berejikian 1995). These changes indicate that the possibility that selection pressures different from those in the wild exist in many hatcheries. In addition, mildly deleterious mutations arise continually in all populations (Kondroshov and Houle 1995) and these may accumulate to higher levels in the relatively protected hatchery environment than they do in the wild (Schultz and Lynch 1997). Hatchery environments that closely resemble wild environments are expected to be less likely to produce substantial domestication pressure than those that are very different from wild environments (Maynard et al.

1995). Likewise, all else being equal, programs of short duration are less likely to cause substantial domestication than programs of long duration.

***Gene flow between hatchery and wild environments:*** The basic concept of populations connected by gene flow that face different selection regimens has been modeled for both the case of traits controlled by a single locus (e.g. Levene 1953, Karlin and McGregor 1972) as well as traits controlled by many loci (e.g. Barton 1983, Phillips 1996, Lythgoe 1997). The results of these models suggest that high levels of gene flow between hatchery and natural environments will ensure that a composite population will not become genetically differentiated into two distinct components. This suggests that the continual infusion of wild fish into hatchery broodstocks should at least slow the domestication process. When gene flow occurs in both directions (wild fish into the hatchery and hatchery fish into the wild), however, these models suggest that the potential exists for a composite population to become adapted to the hatchery, rather than remaining adapted to the wild. At this time, it appears impossible to quantitatively predict the outcome of such composite systems. However, it may be reasonable to assume that a composite population will respond to the average' environment that it experiences, weighted by the proportion of the population in each distinct environment. A reasonable course of action to minimize domestication might therefore be to ensure that the majority of a composite population is naturally propagated. This is an area where theoretical and empirical study would be very useful.

***Genetic basis of traits:*** Most traits that may change as a result of hatchery rearing (e.g. age structure, run timing, size, morphology, etc) are quantitative traits that are likely to be influenced by a large number of genes as well as the environment (Hard 1995). In most cases there is little information on the detailed genetic architecture of these traits, but most animal species, including salmonids, appear to contain some heritable variation at many traits (Lynch and Walsh 1998, Tave 1994). For purposes of risk assessment, it therefore seems reasonable to conclude that most traits subject to domestication selection will have at least some heritable variation upon which selection can act.

Diversity within a population may also be reduced by hatchery induced genetic swamping. This is usually caused by fewer broodstock being collected than planned, combined with the successful culture and release of a large number of fry per adult. Thus, a relatively small proportion of the natural population contributes a disproportionately large number of returning spawners. The success of the original small proportion of the population is artificially improved leading to a genetic swamping effect (see Ryman and Laikre, 1991).

## Severity of Loss of Within Population Diversity That Is Considered to Be a Hazard

For purposes of this risk assessment, loss of within population diversity is considered to be a hazard if it will compromise the ability of a population to sustain itself naturally.

## Rationale of the Criteria Used for Risk Assessment

### Source: Broodstock selection

| Criteria | Rationale |
|---|---|
| Broodstock source is not already substantially domesticated | It appears reasonable to assume that the probability of domestication of a composite population is high if the hatchery component is already domesticated. One exception might be the case where the hatchery population is so different from the wild population that the hatchery population has essentially no reproductive success in the wild. In that case, however, an isolated program may be more feasible or appropriate. |

### Source: Broodstock collection

| Criteria | Rationale |
|---|---|
| Distributions of morphological, behavioral or life-history traits (e.g. run or spawn timing, size, appearance, age structure, etc) are accurately known for target population | In order to determine if the distributions of traits in the hatchery part of the population are similar to those in the wild, it is necessary to have an understanding of the wild distributions. |
| Multi-trait distribution of broodstock sample closely matches the multi-trait distribution of target population (e.g. similar run and spawn timing, size, appearance, age structure, etc) | Differences between the wild and hatchery components of a population are evidence that the potential exists for selective differences to have arisen between the two populations. If multi-trait distributions are similar, then one may be at least somewhat more confident that domestication is not occurring than if differences are observed. The number of traits examined and the statistical power to detect differences should also be considered in making this determination (Hard 1995), however. This is an area where generating more detailed guidelines would be useful. |
| Collection is technically and logistically possible (e.g. site is accessible throughout run, weirs will not be blow out, necessary staff are available to carry out collection, funding is available to measure traits, etc) | Collecting a representative sample of a population may sometimes be logistically difficult (e.g. Bugert 1998). The probability of success depends not only on the collection plan but also on the likelihood that it can be successfully carried out. |
| The effective population size will be maintained by collecting a minimum of 50 pairs except where the total population is less than 100 fish. | This criterion applies in order to minimize reduction of effective population size and prevent extinction. |

## Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments) and duration of hatchery program

| Criteria | Rationale |
|---|---|
| Mating and rearing methods are similar enough to those observed in the wild to avoid substantial domestication selection pressure (see below for suggested values) | Differences in mating and rearing between the wild and hatchery environments may be a significant source of potential domestication. Minimizing these differences may therefore reduce the probability of substantial domestication. |
| OR<br>Hatchery program will be of short duration (3 generations) | The genetic aspects of domestication are a form of evolutionary change, and are not expected to occur instantly. Also, populations that are temporarily perturbed are probably more likely to evolve back to their natural state than populations with a long history of artificial selection. The time period of 3 generations appears to be a reasonable starting point, because summer chum would be subject to any hatchery domestication effects for a relatively short part of their life history (that is, incubation and early fry rearing). This is an area where additional research would be useful. |
| OR<br>The proportion of natural spawners that are hatchery fish in the target population is less than 5-15%. | As was argued above, it seems likely that a composite population responds evolutionarily to the average’ environment that it experiences. It seems likely, therefore, that if only a small portion of the composite population is in an artificial environment substantial domestication will not occur. This is another area where additional research and modeling would be useful. |
| Hatchery progeny will be released at essentially the same sizes and life-history stages as observed in the target population at the time of release | Same as the rationale for mating and release methods that are similar to wild environment. |
| OR<br>Hatchery program will be of short duration (3 generations) | Same as above. |
| OR<br>The proportion of natural spawners that are hatchery fish in the target population is less than 5-15%. | Same as above. |

## Source: Genetic Swamping (Ryman-Laikre effect)

| Criteria | Rationale |
|---|---|
| Hatchery induced genetic swamping by a small proportion of the population will be avoided. | The swamping effect is likely to begin with fewer broodstock being collected than planned. Consequently, the supplementation program improves survival of a small proportion of the natural population and, as a result, the genetic contribution of the small fraction of the population is increased. The potential for shortfalls in broodstock collection should be addressed in program planning. |

# Hazard: Loss of among Population Diversity

## Endpoints: Target and non-target populations of target species, populations of other species (hatchery structures source)

## General Discussion

***Evidence for local adaptation:*** Life history and morphological data (e.g. run timing, size, weight, fecundity, age structure) have been collected from a large number of salmon and steelhead populations (reviewed by Groot and Margolis 1991, Ricker 1972, Taylor 1991, Weitkamp et al. 1995, Busby et al. 1996, Johnson et al. 1997, Gustavson et al. 1997, and Myers et al. 1998), and show that salmon populations vary with respect to these traits. Although the genetic basis of phenotypic variation within and among natural salmon populations has rarely been directly determined, most morphological and life history traits in salmon exhibit genetic variation in captive populations (reviewed by Tave 1992), suggesting that much of the variation among natural salmon populations probably is locally adaptive and due to genetic differences (Ricker 1972 and Taylor 1991). Mark recapture data (e.g. Quinn and Fresh 1984, Quinn et al 1991, Labelle 1992) indicate that straying among salmon populations tends to be variable but generally low, and molecular genetic data (e.g. Parkinson 1984, Gharret et al 1987, Reisenbichler and Phelps 1989, Utter et al 1989, Bartley and Gall 1990, Wood et al 1994, Ford 1998) indicate that genetic differences exist among salmon populations and that many populations are sufficiently reproductively isolated for local adaptations to have evolved (reviewed by Grant 1997). In general it appears that natural salmon populations exist in a dynamic equilibrium between local selection and genetic drift which both promote genetic divergence among populations and straying which promotes genetic homogenization among populations.

***Threats to local adaptation:*** Variation among populations may contribute to the potential for future evolution of the species, and local adaptations among populations probably increase species fitness by allowing populations to become specialized to their local environments. The greatest anthropogenic threats to local adaptation are probably the rapid alteration of the environment to which a local population is adapted, and the introduction of fish of non-local origin that interbreed with local fish. Habitat alteration is discussed in Part Three of the plan, and the remainder of this section deals with the potential effects of non-local introductions and how these might be hazardous to local wild populations. Assuming that a population is indeed locally adapted to its particular environment, this implies that fish from other, non-local, populations carry genotypes that are, on average, less fit in the local environment than those of the local fish. If the rate of migration into a locally adapted population is below some threshold (discussed below), then the non-local genotypes which are deleterious in the local environment will be selected against and the population will come to an equilibrium where deleterious genotypes are removed from the population by selection at the same rate as they enter the population by migration (Barton 1983, Felsenstein 1997). On the other hand, if the rate of migration is greater than some threshold, the rate of selection against deleterious genotypes will be lower than the rate of introduction, and the local adaptations contained by the original population will be lost. The threshold level of migration separating the two scenarios depends on the strength and genetic architecture of local adaptation (i.e. the number of genes involved in local adaptation and how they interact with one another) and the level of interbreeding between local and non-local fish. Strong selection against migrants, local adaptations that involve small numbers of genes, low rates of recombination among genes and strong assortative mating between local and non-local fish all will lead to relatively high threshold migration levels. Weak selection involving many genes, high levels of recombination and random mating among local and non-local fish will lead to relatively lower threshold migration levels (Karlin and McGregor 1972, Barton 1983, Lythgoe 1997). The number of genes and the level of recombination among them are not known for typical local adaptations, and cannot safely be assumed to be small. In fact, most traits likely to be involved in local adaptation are quantitative traits that are probably controlled by many genes (Hard 1995), and because salmon have a large number of chromosomes (Sola et al 1981) it is probably reasonable to assume that levels of recombination among genes contributing to quantitative traits will be high. This suggests that in general selection/migration thresholds for locally adapted salmon populations are likely to be low. In this context, low” means that the threshold migration rate will be much less than the total strength of selection against migrants, and may be of the order of the selection coefficients for the individual genes contributing to local adaptation. As these selection coefficients may be very small (e.g. < 1%, Grant 1997), the threshold level of migration may also be very small.

A complete evaluation of the effect of straying of non-native hatchery fish should evaluate both the likelihood of the loss of local adaptation (discussed above) as well as the consequences of this loss. If the level of migration is above the selection/migration equilibrium threshold, the maximum loss of fitness would equal the difference in fitness between the original local fish and the non-native migrants. In some cases this difference could be very large, while in other cases the difference in fitness between the local and non-local fish could be so small that there would be little loss of the population’s fitness even if all local fish were replaced by migrants.

Although ultimately the loss of among population diversity is considered to be hazard because of its potential effects on the productivity and sustainability of the populations that make up a species or ESU, from an adaptive management perspective it is far easier to monitor and control the effects of artificial propagation on genetic diversity itself rather than on the effects of its loss (Busack and Currens 1995). This is because the mean fitness of a population and the traits that are correlated with it (such as survival between various life stages) varies substantially from year to year due to a large number of environmental and biological factors. Detecting and measuring long term changes in population fitness is difficult to begin with, and positively determining that any one factor, such as loss of among population diversity due to a specific hatchery program, is responsible for the trend is expected to be extremely difficult under most circumstances. Because of this difficulty, if a program relies on monitoring of the potential effects of loss of diversity (changes in population fitness and sustainability) to determine adaptive management actions, it is extremely unlikely that such effects will be detected and appropriate action taken until long after substantial genetic change has already occurred. Based on this argument, Busack and Currens (1995) advocate treating the loss of diversity itself as a hazard and suggest that adaptive management actions be based on monitoring genetic diversity directly, rather than on the consequences of its loss. This argument does not negate the need for continuing research on the ultimate effects of loss of diversity, the results of which will continue to increase understanding of how genetic diversity is related to sustainability and productivity.

## Severity of Loss of among Population Diversity That Is Considered to Be a Hazard

For purposes of this risk assessment, a loss of among population diversity is considered to be a hazard if it has the potential to result in the loss of local adaptation among populations. A reasonable approach to limiting potential losses due to straying by non-local hatchery may be something like the following:

Case I: When non-native strays are from a different ESU or are from the same ESU but exhibit substantial genetic, behavioral, life-history, or morphological differences from local fish, the level of straying should be considerably less than the selection/equilibrium threshold or a reasonable estimate of the natural' level of straying between populations with a similar degree of divergence. Using either criteria, this will generally be a very low level of migration (e.g. < 1% of the receiving population consisting of migrants).

Case II: When non-native strays are from the same ESU, one reasonable approach may be to limit stray rates such that they are similar to natural' stray rates estimated from mark/recapture or genetic data.

The second case is most applicable to Hood Canal summer chum.

## Rationale for Criteria Used in Risk Assessment

### Source of hazard: Broodstock selection

| Criteria | Rationale |
|---|---|
| All the discrete populations within the watershed containing the target population have been correctly identified | One way in which a loss of diversity can occur is if two or more discrete populations are mixed during broodstock collection. In order to avoid this, it is necessary to have a sufficient understanding of the population structure within a watershed to be able to correctly identify a discrete population for broodstock collection. In some cases, it may be appropriate to group two or more populations or spawning aggregates into larger management units, and this also requires knowledge of the population structure within the watershed. |
| Selected broodstock source is substantially genetically similar to target population | This is a logical necessity to avoid a loss of among population diversity. |
| Broodstock used for direct reintroduction is used only for one site. | By limiting donor stocks to no more than one reintroduction project the risk of reducing diversity among the total stocks of the ESU is reduced. |

### Source: Broodstock collection

| Criteria | Rationale |
|---|---|
| It will be possible to collect at a location and time such that only the target population will be collected | The proposed collection protocol must be such that it is possible to collect only the population (or other appropriate management unit) without collecting fish from other populations or units. |

**Source: Straying**

| Criteria | Rationale |
|---|---|
| Hatchery fish will be reared to release size in the watershed targeted for supplementation or reintroduction. | Fish likely will become more strongly imprinted in the watershed targeted for supplementation or reintroduction. |
| Hatchery fish will be marked to provide effective estimation of straying. | An effective marking program must be planned and implemented to allow for estimation of straying. |
| Adjacent spawning populations will be effectively monitored to detect straying. | If natural populations are not monitored, it is not possible to know if they are receiving strays or not. |

# Hazard: Masking of Status

## General Discussion

One hazard of artificial propagation is that if substantial numbers of artificially produced fish stray into natural populations, the health and status of those population can be masked. This can occur if, for instance, the hatchery fish are not marked and counted separately from natural fish. In this case, natural abundance would be overestimated. Even if all hatchery fish are marked and counted separately, however, if first generation hatchery fish make up a substantial proportion of natural spawners, then the status of the natural population can still be obscured. For example, one reasonable criteria for a functional, healthy natural population is that it is capable of sustaining its itself in its natural environment over time. This means that, on average, the number of naturally produced spawners in one generation should equal the number of natural spawners the previous generation. The number of naturally produced spawners in one generation divided by the number of natural spawners the previous generation has been termed the Natural Replacement Rate (NRR, Busby et al. 1996), and its long term geometric mean will be equal to approximately 1.0 for a population that is sustaining itself naturally. If, on the other hand, a substantial proportion of the natural spawners are first generation hatchery fish and the population is not growing at a rate at least equal to the proportion of the spawners that are hatchery fish, then the long term NRR will be less than 1.0, indicating that the population is not sustaining itself naturally. An example of this can been seen with upper-Columbia River steelhead, where the NRR is estimated to be ~0.3 (Brown 1995). This statistic is difficult to interpret however, because a large proportion (65% - 85%) of the natural spawners are hatchery fish. If one assumes that naturally spawning hatchery fish are equally productive as naturally spawning wild fish, then this low natural replacement rate indicates that the natural population is falling far short of replacing itself and the presence of naturally spawning hatchery fish may be slowing its decline or keeping it from going extinct. On the other hand, if the hatchery fish have limited productivity in the wild (which may sometimes be the case; see Reisenbichler 1997), a natural replacement rate of 0.3 combined with 65% naturally spawning hatchery fish would indicate that in fact the natural component of the natural spawners may be replacing itself. As long as a large proportion of the natural spawners are hatchery fish, determining the degree to which a population is naturally self-sustaining is very difficult.

## Severity of Masking That Is Considered to Be a Hazard

For purposes of this risk assessment, masking is considered to be a hazard if it substantially compromises the ability to determine if a population is sustaining itself naturally.

## Justification for Criteria Used in Risk Assessment

| Criteria | Rationale |
|---|---|
| A sufficient proportion of hatchery fish are marked to estimate hatchery/wild ratios on the spawning grounds | In order to determine if masking is a problem, it is necessary to distinguish between hatchery and natural fish. Marking does not need to be readily visible, and may based on scale or otolith patterns so long as hatchery and wild fish can be reliably distinguished. |
| Sufficient wild spawning areas (or other appropriate areas such as across weirs or dams) are surveyed to estimate hatchery/wild ratios accurately | In order to determine if masking is a problem, it is necessary to estimate the proportion of natural spawners that are hatchery fish. |
| Proportion of hatchery fish on spawning grounds is (or will be) less than 5 - 15%<br>OR<br>Hatchery program will be of short duration (three generations)<br>OR<br>Returning hatchery fish will spawn only in habitat currently without any natural spawners of the same species | Severity of masking is directly related to the proportion of hatchery fish on the spawning grounds. The value of 5 - 15% is arbitrary, but seems reasonable. In some cases other values may also be reasonable.<br>Masking is not a substantial concern for programs of short duration, because natural population status will only be obscured for a short period of time.<br>During the initial time period of a reintroduction program if there are no natural spawners present, there is by definition no hazard of masking. |

## Bibliography

Bartley D., M. Bagley, G. Gall, and M. Bentley. 1992. Use of linkage dis-equilibrium data to estimate effective size of hatchery and natural fish populations. Conservation Biology 6:365-375.

Barton, N.H. 1983. Multi-locus Clines. Evolution 37:454-471.

Busack, C.A. and K.P. Currens. 1995. Genetic risks in hatchery operations: fundamental concepts and issues. Pp 71-80 in Schramm, H.L. Jr., and R.G. Piper (eds.) Uses and effects of cultured fishes in aquatic ecosystems, Amer. Fish. Soc. Symp. 15.

Brown, L.G. 1995. Mid-Columbia River summer steelhead stock assessment: A summary of the Priest Rapids steelhead sampling project 1986-1994 cycles. WDFW prog. Rpt. AF95-02. Wash. Dept. Fish and Wild., Olympia, WA.

Berejikian, B.A. 1995. The effects of hatchery and wild ancestry and experience on the relative ability of steelhead trout fry (Oncorhynchus mykiss) to avoid a benthic predator. Can. J. Fish. Aquat. Sci. 52:2476-2482

Berejikan, B.A., E.P. Tezak, S.L. Schroder, C.M. Knudsen, and J.J. Hard. 1997. Reproductive behavioral interactions between wild and captively reared coho salmon (Oncorhynchus kisutch). J. Marine Sci. 54:1040-1050..

Busby, P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of West Coast Steelhead from Washington, Idaho, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-27, NMFS NW Sci. Center, U.S. Dept. Commer. Nat. Marine Fish. Serv., Seattle, WA. 261 p.

Caballero, A. 1994. Developments in the prediction of effective population size. Heredity 73:657-679.

Cuenco, M.L. 1994. A model of an internally supplemented population. Trans. of the Amer. Fish. Soc. 123:277-288.

Falconer, D.S. 1989. Introduction to Quantitative Genetics, Third Edition. John Wiley and Sons, New York, NY.

Felsenstein., J. 1997. Population differentiation and evolutionary processes. Pp. (?) in Genetic effects of straying of non-native hatchery fish into natural populations: proceedings of the workshop June 1-2, 1995, Seattle WA. NOAA Tech. Memo. NMFS-NWFSC-30, NMFS NW Sci. Center, U.S. Dept. Commer. Nat. Marine Fish. Serv., Seattle, WA.

Fleming, I.A., and M.R. Gross. 1989. Evolution of adult female life history and morphology in a pacific salmon (coho: Oncorhynchus kisutch). Evolution 43:141-157.

Fleming, I.A., and M.R. Gross. 1992. Reproductive behavior of hatchery and wild coho salmon (Oncorhynchus kisutch) : does it differ? Aquaculture 103:101-121.

Fleming, I.A., and M.R. Gross. 1993. Breeding success of hatchery and wild coho salmon (Oncorhynchus kisutch) in competition. Ecological Applications 3:230-245.

Fleming, I.A., and M.R. Gross. 1994. Breeding competition in a Pacific salmon (coho: Oncorhynchus kisutch): Measures of natural and Sexual selection. Evolution 48: 637-657.

Fleming, I.A., B. Jonsson, M.R. gross, and A. Lamberg. 1996. An experimental study of the reproductive behavior and success of farmed and wild Atlantic salmon. J. Applied Ecology 33: 893-905.

Ford, M.J. 1998. Testing models of migration and isolation among populations of chinook salmon (Oncorhynchus tshawytscha). Evolution 52:539-557.

Frankham, R. 1995. Effective population size/adult population size ratios in wildlife: a review. Genet. Res. 66:95-107.

Franklin, I.R. 1980. Evolutionary change in small populations. Pp. 135-149 in Soule, M.E. and B.A. Wilcox (eds.) Conservation Biology, An Evolutionary-Ecological Perspective. Sinauer Associates, Sunderland, MA.

Grant, W.S. (ed.). 1997. Genetic effects of straying of non-native hatchery fish into natural populations: proceedings of the workshop June 1-2, 1995, Seattle WA. NOAA Tech. Memo. NMFS-NWFSC-30, NMFS NW Sci. Center, U.S. Dept. Commer. Nat. Marine Fish. Serv., Seattle, WA..

Gharret, A.J., S.M. Shirley, and G.R. Tromble. 1987. Genetic relationships among populations of Alaskan chinook salmon (Oncorhynchus tshawytscha). Can. J. Fish. Aquat. Sci. 44:765-774.

Groot, C., and L. Margolis (eds.). 1991. Pacific Salmon Life Histories. Univ. B.C. Press, Vancouver, BC, Canada.

Gustafson, R.G., T.C. Wainwright, G.A. Winans, F.W. Waknitz, L. T. Parker, and R.S. Waples. 1997. Status Review of Sockeye Salmon from Washington and Oregon. NOAA Tech. Memo. NMFS-NWFSC-33, NMFS NW Sci. Center, U.S. Dept. Commer. Nat. Marine Fish. Serv., Seattle, WA. 282 p.

Hard, J.J. 1995. Genetic monitoring of life history characters in salmon supplementation. Pp. 212-225 in Schramm, H.L., and. and R.G. Piper (eds.) Uses of and effects of Cultured Fishes in Aquatic Ecosystems. Am. Fish. Soc. Symp. 15.

Hartl, D.L. and A.G. Clark. 1989. Principles of Population Genetics, Second Edition. Sinear Associates, Sunderland, MA.

Johnson, O.W., W.S. Grant, R.G. Kope, K. Neely, F.W. Waknitz, and R.S. Waples. 1997. Status review of chum salmon from Washington, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-32, NMFS NW Sci. Center, U.S. Dept. Commer. Nat. Marine Fish. Serv., Seattle, WA. 280 p.

Karlin, S., and J. McGregor. 1972. Application of method of small parameters to multi-niche population genetic models. Theor. Pop. Biol. 3:186-209.

Kondrashov, A.S. and D. Houle. 1995. Genotype-environment interaction and the estimation of the genomic mutation rate in Drosophila melanogaster. Proceedings of the Royal Society of London, Series B Biological Sciences 258:221-227.

Labelle, M. 1992. Straying patterns of coho salmon (Oncorhynchus kisutch) stocks from southeast Vancouver Island, B.C. Can. J. Fish. Aquat. Sci. 49:1843-1855.

Lande, R. 1994. Risk of population extinction from fixation of new deleterious mutations. Evolution 48:1460-1469.

Lande R. and G.F. Barrowclough. 1987. Effective population size, genetic variation, and their use in population management. Pp 89-123 in Soule, M.E. (ed.) Viable Populations for Conservation. Cambridge Univ. Press, New York, NY.

Lande, R. 1995. Mutation and Conservation. Conservation Biology 9:782-791

Levene, H. 1953. Genetic equilibrium when more than one ecological niche is available. Amer. Nat. 87: 811-813.

Lynch, M. and B. Walsh. 1998. Genetics and Analysis of Quantitative Traits. Sinauer Associates. Sunderland, MA.

Lythgoe, K.A. 1997. Consequences of gene flow in a spatially structured populations. Genet. Res. 69:49-60.

Maynard, D.J., T.A. Flagg, and C.W. Mahnken. 1995. A review of semi-natural culture strategies for enhancing the post-release survival of anadromous salmonids. Pp. 307-316 in Schramm, H.L., and. and R.G. Piper (eds.) Uses of and effects of Cultured Fishes in Aquatic Ecosystems. Amer. Fish. Soc. Symp. 15.

McGinnity, P., C. Stone, J.B. Taggart, D. Cooke, D. Cotter, R. Hynes, C. McCamley, T. Cross, and A. Ferguson. 1997. Genetic impact of escaped farmed Atlantic salmon Salmo salar L. on native populations: use of DNA profiling to assess freshwater performance of wild, farmed, and hybrid progeny in a natural river environment. J. Marine Sci. 54:in press.

Meyers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S Waples. 1998. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-35, NMFS NW Sci. Center, U.S. Dept. Commer. Nat. Marine Fish. Serv., Seattle, WA. 443 p.

Parkinson, E.A. 1984. Genetic variation in populations of steelhead trout (Salmo gairdneri) in British Columbia. C. Can. J. Fish. Aquat. Sci. 41:1412-1420.

Phillips, P.C. 1996. Maintenance of polygenic variation via a migration-selection balance under uniform selection. Evolution 59:1334-1339.

Quinn, T.P., and K. Fresh. 1984. Homing and straying in chinook salmon (Oncorhynchus tshawytscha) from the Cowlitz R. hatchery, WA. Can. J. Fish. Aquat. Sci. 41:1078-1082.

Quinn, T.P., R.S. Nemeth, and D.O. McIsaac. 1991. Homing and straying patterns of fall chinook salmon in the lower Columbia River. Trans. Am. Fish Soc. 120:150-156.

Reisenbichler, R.R., and J.D. McIntyre. 1977. Genetic differences in growth and survival of juvenile hatchery and wild steelhead trout (Salmo gairdneri). J. Fish. Res. Board Can. 34:123-128.

Reisenbichler, R.R. and S.R. Phelps. 1989. Genetic variation in steelhead (Salmo gairdneri) from the North Coast of Washington. Can. J. Fish. Aquat. Sci. 46:66-73.

Reisenbichler, R.R. 1997. Genetic factors contributing to declines of anadromous salmonids in the Pacific Northwest. Pp. 223-244 in Sounder, D.J., P.A. Bisson, and R.J. Nainman (eds.) Pacific Salmon & Their Ecosystems: Status and Future Options. Chapman & Hall, New York, NY.

Ricker, W.E. 1972. Hereditary and environmental factors affecting certain salmonid populations. In Simon, R,C. and P.A. Larkin (eds.) The Stock Concept. of Pacific Salmon. MacMillian Lectures in Fisheries, University of British Columbia, Vancouver B.C.

Ryman, N. and L. Laikre. 1991. Effects of supportive breeding on the genetically effective population size. Conservation Biology 5:325-329.

Schultz, S.T., and M. Lynch. 1997. Mutation and extinction: The role of variable mutational effects, synergistic epistasis, beneficial mutations, and degree of out-crossing. Evolution 51:1363-1371.

Sola, L.S., S. Cataudella, and E. Capanna. 1981. New developments in vertebrate cytotaxonomy III. Karyology of bony fishes: a review. Genetica 54:285-328.

Soule, M.E. 1980. Thresholds for survival: Maintaining fitness and evolutionary potential. Pp. 151-169 in Soule M.E., and B.A. Wilcox (eds.) Conservation Biology, An Evolutionary-Ecological Perspective. Sinauer Associates, Sunderland, MA.

Swain, D.P., and B.E. Riddell. 1990. Variation in agnostic behavior between newly emerged juveniles from hatchery and wild populations of coho salmon (Oncorhynchus kisutch). Can. J. Fish. Aquat. Sci. 47:566-571.

Tave, D. 1993. Genetics for fish hatchery managers, second edition. AVI, New York, NY.

Taylor, E.B. 1991. A review of local adaptation in Salmonidae, with particular reference to Pacific and Atlantic salmon. Aquaculture 98:185-207.

Utter, F., G. Milner, G. Stahl, and D. Teel. 1989. Genetic population structure of chinook salmon (Oncorhynchus tshawytscha) in the Pacific Northwest. Fish. Bull. 87:239-264.

Waples, R.S. 1990a. Conservation genetics of Pacific salmon II. Effective population size and rate of loss of genetic variability. J. Heredity 81:267-276.

Waples, R.S., O.W. Johnson, P.B. Aebersold, C.K. Shiflett, D.M. VanDoornick, D.J. Teel, and A.E. Cook. 1993. A genetic monitoring and evaluation program for supplemental populations of salmon and steelhead in the Snake R. Basin. Annual Report of Research to the Division of Fish and Wildlife, Bonneville Power Administration, Department of Energy, Project 89-096.

Waples R.S. and C. Do. 1994. Genetic risk associated with supplementation of Pacific salmonids: captive broodstock programs. Can. J. Fish. Aquat. Sci. 51 (suppl. 1):310-329.

Weitcamp, L.A., T.C. Wainwright, G.J. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples, 1995. Status Review of Coho Salmon from Washington, Oregon, and California. 1995. NOAA Tech. Memo. NMFS-NWFSC-24, NMFS NW Sci. Center, U.S. Dept. Commer. Nat. Marine Fish. Serv., Seattle, WA. 258 p.

WDFW (Washington Department of Fish and Wildlife). 1997. Watershed resource inventory process. Fish supplementation and rearing projects. Wash. Dept. Fish and Wild., Olympia, WA.

# Appendix Report 3.4
# Worksheets for Assessment of Supplementation Hazards

A set of worksheets is used to help assess the risk of hazards from undertaking a supplementation or reintroduction project. The worksheets include 1) a list of the hazards being evaluated (e.g., loss of within population diversity), 2) the specific sources of each hazard (e.g., broodstock collection), 3) criteria to minimize risk of each hazard (e.g., collecting broodstock in a manner that maintains traits of the target population), 4) a rating of the likelihood that each criterion will be achieved (e.g., H = High, M = Moderate and L = Low), and 5) notes or explanation of the rationale behind each criterion rating. Background information of the hazards is provided in the discussion paper contained in Appendix Report 3.3.

A set of worksheets has been completed for each of the potential supplementation and reintroduction projects that are subject to risk assessment in Part Three of the conservation plan and is included in this appendix. The potential projects are:

Supplementation

- Union
- Lilliwaup
- Hamma Hamma
- Duckabush
- Dosewallips
- Big Quilcene
- Salmon
- Jimmycomelately
- Dungeness

Reintroduction

- Big Beef
- Chimacum
- Tahuya
- Dewatto
- Skokomish
- Anderson
- Finch

The rating for each criterion of the worksheets generally is determined as follows. A specific criterion is given a high likelihood or probability rating where the project, or the procedure required by the criterion, is well understood and there is certainty that the resources are available to meet the criterion. A moderate likelihood or probability is given where there is less certainty that the resources or knowledge is or will be available. Finally, when there is a high level of uncertainty, a low probability is given.

# Union Project

## Hazard I: Hatchery Failure

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery personnel live on-site to allow rapid response to water source or power failures. | M | Site and personnel undetermined. |
| Low pressure/low water alarms functioning for water supplies serving summer chum incubation and rearing areas. | M | Specific project design not yet determined. |
| All hatchery personnel responsible for rearing fish trained in standard fish propagation and fish health methods. | H | Expect experienced volunteers and trained WDFW staff support. |
| Incubation and rearing facilities are sited in areas that are not prone to flooding. | M | Expect to site project with low risk of flooding. |

## Hazard II: Ecological Effects

| Criteria | Probability | Notes |
|---|---|---|
| Propagated summer chum are released at a life stage (1 gram fed fry) and time (March-April) that will reduce the risk of predation and competition effects on wild fish. | H | Will be key design element. |
| Summer chum are reared to release size on ground or surface water within the watershed targeted for supplementation or reintroduction. | H | Water source would be within watershed. |
| Fish health practices developed by the co-managers are applied in all hatchery activities to minimize the risk of fish disease occurrence, transmittal, and catastrophic loss. | H | Expected WDFW staff support would ensure proper procedures and treatment. |

## Hazard III: Reduction in Effective Population Size

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish are marked to accurately estimate proportion of hatchery fish spawning naturally in target population and proportion of wild fish spawning in hatchery. | H | Expected to be key element to plan for operations. |
| Natural spawning is regularly monitored to accurately estimate the proportion of hatchery fish spawning in target population. | M | Expected to be key element to plan for operations. |
| **In the target population, the proportion of natural spawners that are hatchery fish is approximately equal to the proportion of wild fish that were taken into the hatchery the previous generation**.<br>**OR**<br>In the target population, the proportion of natural spawners that are hatchery-origin fish is | L | Uncertain. But experience indicates that this factor may be difficult to control. |

## Hazard III: Reduction in Effective Population Size (cont.)

| Criteria | Probability | Notes |
|---|---|---|
| larger than the proportion of wild fish that were taken into the hatchery the previous generation **AND** the wild population is increasing in abundance at a rate at least equal to the proportion of naturally spawning hatchery-origin fish<br>**OR**<br>The target wild population is believed to be in substantial danger of extinction within the next 35 years AND the effective number of breeders in the hatchery is as large as possible given the available broodstock.<br>**OR**<br>The project is to reintroduce fish to a location removed from the target population with likelihood of less than 5-15% return to target population. | | |

## Hazard IV: Loss of Within Population Diversity

| **Source: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Broodstock source is not already substantially domesticated. | H | Broodstock has not previously been propagated. |

| **Source: Broodstock collection** | | |
|---|---|---|
| Distributions of morphological, behavioral or life-history traits (e.g. run or spawn timing, size, appearance, age structure, etc) will be collected for target population. | H | Trained staff will record pertinent biological data. |
| Multi-trait distribution of broodstock sample closely matches the multi-trait distribution of target population (e.g. similar run and spawn timing, size, appearance, age structure, etc). | M | Broodstock collection parameters unknown but key element will be to obtain close match to target population. |
| Collection is technically and logistically possible (e.g. site is accessible throughout run, weirs have reasonable chance of continuous operation throughout season, necessary staff are available to carry out collection, funding is available to measure traits, etc). | M | Unknown but will be key element of project. |
| The effective population size will be maintained by collecting a minimum of 50 pairs except where the total population is less than 100 fish. | M | Criterion will be incorporated in plan. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration)** | | |
|---|---|---|
| The minimum standard for matings will be one male per female. | H | One to one or factorial matings will be a project objective. |
| Mating and rearing methods are similar enough to those observed in the wild to avoid substantial domestication selection pressure<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Project will be of short duration - not to exceed 12 years. |
| Hatchery progeny will be released at essentially the same sizes and life-history stages as observed in the target population at the time of release<br>**OR**<br>Hatchery program will be of short duration (3 generations)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Hatchery progeny to reared to 1 gram size before release; however, program will be of short duration. |

| **Source: Hatchery-induced genetic swamping (Ryman-Laikre effect)** | | |
|---|---|---|
| Broodstocking does not collect a small fraction of the spawner population and, through use of hatchery operation, generate a subsequent large proportion of the natural spawning population. | M | Broodstocking limitations are unknown but avoiding this effect will be a key element of project. |

## Hazard V: Loss of Among Population Diversity

| **Source of hazard: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| All the discrete populations within the watershed containing the target population have been correctly identified. | H | Total accessible area within watershed surveyed since 1982. |
| Selected broodstock source is substantially genetically similar to target population. | H | Broodstock source is target population. |
| Broodstock used for direct reintroduction is used only for one site. | N.A. | |

| **Source: Broodstock collection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| It will be possible to collect at a location and time such that only the target population will be collected. | H | Only target population exists in watershed. |

| **Source: Straying** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Hatchery fish will be reared to release size in the watershed targeted for supplementation or reintroduction. | H | Location of facilities in watershed will be key element of project. |
| Hatchery fish will be marked to provide effective estimation of straying. | H | Fish will be marked to differentiate hatchery-origin and natural-origin spawners within watershed. |
| Adjacent spawning populations will be effectively monitored to detect straying. | L | Undetermined at this time. |

## Hazard VI: Masking of Population Status

| Criteria | Probability | Notes |
|---|---|---|
| A sufficient proportion of hatchery fish are marked to estimate hatchery/wild ratios on the spawning grounds. | H | Expect to provide for adequate marking. |
| Sufficient wild spawning areas are surveyed to estimate hatchery/wild ratios accurately. | M | Expect would be key element to plan for operations. |
| Proportion of hatchery fish on spawning grounds is (or will be) less than 5-15%<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>Returning hatchery fish will spawn primarily in habitat currently underutilized by natural spawners of the same species. | H | Expect returning hatchery-origin fish will spawn in habitat currently under-utilized and project is of short duration. |

# Lilliwaup Project

## Hazard I: Hatchery Failure

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery personnel live on-site to allow rapid response to water source or power failures. | H | One person lives on-station. Hatchery Manager is on 24 hour stand by. |
| Low pressure/low water alarms functioning for water supplies serving summer chum incubation and rearing areas. | H | Alarm system is in place. |
| All hatchery personnel responsible for rearing fish trained in standard fish propagation and fish health methods. | H | Experienced hatchery manager. Trained WDFW staff support. |
| Incubation and rearing facilities are sited in areas that are not prone to flooding. | H | Facilities are located in areas of low flooding risk. |

## Hazard II: Ecological Effects

| Criteria | Probability | Notes |
|---|---|---|
| Propagated summer chum are released at a life stage (1 gram fed fry) and time (March-April) that will reduce the risk of predation and competition effects on wild fish. | H | Capability has been demonstrated at site. |
| Summer chum are reared to release size on ground or surface water within the watershed targeted for supplementation or reintroduction. | H | Surface water source within watershed. |
| Fish health practices developed by the co-managers are applied in all hatchery activities to minimize the risk of fish disease occurrence, transmittal, and catastrophic loss. | H | WDFW staff support ensures proper procedures and treatment. |

## Hazard III: Reduction in Effective Population Size

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish are marked to accurately estimate proportion of hatchery fish spawning naturally in target population and proportion of wild fish spawning in hatchery. | H | Funding, equipment and staff are available to otolith mark all releases. |
| Natural spawning is regularly monitored to accurately estimate the proportion of hatchery fish spawning in target population. | M | Intent is to sample, read and analyze otoliths of spawning population, but funding and resources have not yet been secured. |
| In the target population, the proportion of natural spawners that are hatchery fish is approximately equal to the proportion of wild fish that were taken into the hatchery the previous generation<br>**OR**<br>In the target population, the proportion of natural spawners that are hatchery-origin fish is larger than the proportion of wild fish that were taken into the hatchery the previous generation **AND** the wild population is increasing in abundance at a rate at least | H | The target population is at high risk of extinction with average of 61 spawners over past five years (1993-97) compared to five year average of 937 spawners from 1974 through 1978. Broodstock is to be collected consistent with guidelines |

## Hazard III: Reduction in Effective Population Size (cont.)

| | | |
|---|---|---|
| equal to the proportion of naturally spawning hatchery-origin fish<br>**OR**<br>**The target wild population is believed to be in substantial danger of extinction within the next 35 years AND the effective number of breeders in the hatchery is as large as possible given the available broodstock.**<br>**OR**<br>The project is to reintroduce fish to a location removed from the target population with likelihood of less than 5-15% return to target population. | | (i.e., 50 pairs unless total spawning population is less than 100 fish). |

## Hazard IV: Loss of Within Population Diversity

| **Source: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Broodstock source is not already substantially domesticated. | H | Project begun with brood year 1992. |

| **Source: Broodstock collection** | | |
|---|---|---|
| Distributions of morphological, behavioral or life-history traits (e.g. run or spawn timing, size, appearance, age structure, etc) will be collected for target population. | H | Trained staff records pertinent biological data. |
| Multi-trait distribution of broodstock sample closely matches the multi-trait distribution of target population (e.g. similar run and spawn timing, size, appearance, age structure, etc). | M | Location, timing and protocol of collection intended to achieve matching. |
| Collection is technically and logistically possible (e.g. site is accessible throughout run, weirs have reasonable chance of continuous operation throughout season, necessary staff are available to carry out collection, funding is available to measure traits, etc). | M | New plan and staff in place were successful in first year. |
| The effective population size will be maintained by collecting a minimum of 50 pairs except where the total population is less than 100 fish. | M | New plan and staff in place were successful in first year. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration)** | | |
|---|---|---|
| The minimum standard for matings will be one male per female. | H | One to one or factorial matings to be used. |
| Mating and rearing methods are similar enough to those observed in the wild to avoid substantial domestication selection pressure<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Project to be of short duration - not to exceed 12 years. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration) (cont.)** | | |
|---|---|---|
| Hatchery progeny will be released at essentially the same sizes and life-history stages as observed in the target population at the time of release<br>**OR**<br>Hatchery program will be of short duration (3 generations)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Hatchery progeny to reared to 1 gram size before release; however, program will be of short duration. |

| **Source: Hatchery-induced genetic swamping (Ryman-Laikre effect)** | | |
|---|---|---|
| Broodstocking does not collect a small fraction of the spawner population and, through use of hatchery operation, generate a subsequent large proportion of the natural spawning population. | M | New broodstocking site and weir being tested. |

## Hazard V: Loss of Among Population Diversity

| **Source of hazard: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| All the discrete populations within the watershed containing the target population have been correctly identified. | H | Total accessible area within watershed surveyed since mid-70s. |
| Selected broodstock source is substantially genetically similar to target population. | H | Broodstock source is target population. |
| Broodstock used for direct reintroduction is used only for one site. | N.A. | |

| **Source: Broodstock collection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| It will be possible to collect at a location and time such that only the target population will be collected. | H | Only target population exists in watershed. |

**Source: Straying**

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish will be reared to release size in the watershed targeted for supplementation or reintroduction. | H | Incubation and rearing facilities located in watershed. |
| Hatchery fish will be marked to provide effective estimation of straying. | H | Staff, equipment and funding exist to otolith mark all releases. |
| Adjacent spawning populations will be effectively monitored to detect straying. | L | Funding and resources have not been secured for otolith sampling, reading and analysis. |

## Hazard VI:  Masking of Population Status

| Criteria | Probability | Notes |
|---|---|---|
| A sufficient proportion of hatchery fish are marked to estimate hatchery/wild ratios on the spawning grounds. | H | All releases will be otolith marked. |
| Sufficient wild spawning areas are surveyed to estimate hatchery/wild ratios accurately. | M | Intent is to sample, read and analyze otoliths of spawning population but funding and resources have not yet been secured. |
| Proportion of hatchery fish on spawning grounds is (or will be) less than 5-15%<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>Returning hatchery fish will spawn primarily in habitat currently underutilized by natural spawners of the same species. | H | Returning hatchery fish will spawn in habitat currently underutilized by target population and project is of short duration. |

# Hamma Hamma Project

## Hazard I: Hatchery Failure

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery personnel live on-site to allow rapid response to water source or power failures. | M | Hatchery personnel do not live on-site but no major risk to water supply has been demonstrated. |
| Low pressure/low water alarms functioning for water supplies serving summer chum incubation and rearing areas. | M | No alarm system presently exists but no major risk. |
| All hatchery personnel responsible for rearing fish trained in standard fish propagation and fish health methods. | H | Experienced volunteers. Trained WDFW staff support. |
| Incubation and rearing facilities are sited in areas that are not prone to flooding. | M | Rearing pond may be susceptible at high flows. |

## Hazard II: Ecological Effects

| Criteria | Probability | Notes |
|---|---|---|
| Propagated summer chum are released at a life stage (1 gram fed fry) and time (March-April) that will reduce the risk of predation and competition effects on wild fish. | H | Capability has been demonstrated at site. |
| Summer chum are reared to release size on ground or surface water within the watershed targeted for supplementation or reintroduction. | H | Ground water source within watershed. |
| Fish health practices developed by the co-managers are applied in all hatchery activities to minimize the risk of fish disease occurrence, transmittal, and catastrophic loss. | H | WDFW staff support ensures proper procedures and treatment. |

## Hazard III: Reduction in Effective Population Size

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish are marked to accurately estimate proportion of hatchery fish spawning naturally in target population and proportion of wild fish spawning in hatchery. | H | Funding, equipment and staff are available to otolith mark all releases. |
| Natural spawning are regularly monitored to accurately estimate the proportion of hatchery fish spawning in target population. | M | Intent is to sample, read and analyze otoliths of spawning population, but funding and resources have not yet been secured. |
| **In the target population, the proportion of natural spawners that are hatchery fish is approximately equal to the proportion of wild fish that were taken into the hatchery the previous generation**<br>**OR**<br>In the target population, the proportion of natural spawners that are hatchery-origin fish is larger than the proportion of wild fish that were taken into the hatchery the previous generation **AND** the wild population is increasing in abundance at a rate at least | L | Uncertain. But experience indicates that this factor may be difficult to control. |

## Hazard III: Reduction in Effective Population Size (cont.)

| | | |
|---|---|---|
| equal to the proportion of naturally spawning hatchery-origin fish<br>**OR**<br>The target wild population is believed to be in substantial danger of extinction within the next 35 years AND the effective number of breeders in the hatchery is as large as possible given the available broodstock.<br>**OR**<br>The project is to reintroduce fish to a location removed from the target population with likelihood of less than 5-15% return to target population. | | |

## Hazard IV: Loss of Within Population Diversity

| **Source: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Broodstock source is not already substantially domesticated. | H | Project begun with brood year 1997. |

| **Source: Broodstock collection** | | |
|---|---|---|
| Distributions of morphological, behavioral or life-history traits (e.g. run or spawn timing, size, appearance, age structure, etc) will be collected for target population. | L | Effective broodstocking and sampling does not yet exist. |
| Multi-trait distribution of broodstock sample closely matches the multi-trait distribution of target population (e.g. similar run and spawn timing, size, appearance, age structure, etc). | M | Location, timing and protocol of collection intended to achieve matching. |
| Collection is technically and logistically possible (e.g. site is accessible throughout run, weirs have reasonable chance of continuous operation throughout season, necessary staff are available to carry out collection, funding is available to measure traits, etc). | L | Effective approach to broodstock collection not yet developed. |
| The effective population size will be maintained by collecting a minimum of 50 pairs except where the total population is less than 100 fish. | L | Effective collection still lacking. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration)** | | |
|---|---|---|
| The minimum standard for matings will be one male per female. | H | One to one or factorial matings will be used. |
| Mating and rearing methods are similar enough to those observed in the wild to avoid substantial domestication selection pressure<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Project to be of short duration - not to exceed 12 years. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration)** | | |
|---|---|---|
| Hatchery progeny will be released at essentially the same sizes and life-history stages as observed in the target population at the time of release<br>**OR**<br>Hatchery program will be of short duration (3 generations)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Hatchery progeny to reared to 1 gram size before release; however, program will be of short duration. |

| **Source: Hatchery-induced genetic swamping (Ryman-Laikre effect)** | | |
|---|---|---|
| Broodstocking does not collect a small fraction of the spawner population and, through use of hatchery operation, generate a subsequent large proportion of the natural spawning population. | M | New broodstock collection plan but untested. |

## Hazard V: Loss of Among Population Diversity

| **Source of hazard: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| All the discrete populations within the watershed containing the target population have been correctly identified. | H | Total accessible area within watershed surveyed since mid-70s |
| Selected broodstock source is substantially genetically similar to target population. | H | Broodstock source is target population. |
| Broodstock used for direct reintroduction is used only for one site. | N.A. | |

| **Source: Broodstock collection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| It will be possible to collect at a location and time such that only the target population will be collected. | H | Only target population exists in watershed. |

| **Source: Straying** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Hatchery fish will be reared to release size in the watershed targeted for supplementation or reintroduction. | H | Incubation and rearing facilities located in watershed. |
| Hatchery fish will be marked to provide effective estimation of straying. | H | Staff, equipment and funding exist to otolith mark all releases. |
| Adjacent spawning populations will be effectively monitored to detect straying. | L | Funding and resources have not been secured for otolith sampling, reading and analysis. |

## Hazard VI: Masking of Population Status

| Criteria | Probability | Notes |
|---|---|---|
| A sufficient proportion of hatchery fish are marked to estimate hatchery/wild ratios on the spawning grounds. | H | All releases will be otolith marked. |
| Sufficient wild spawning areas are surveyed to estimate hatchery/wild ratios accurately. | M | Funding and resources have not been secured for otolith sampling, reading and analysis. |
| Proportion of hatchery fish on spawning grounds is (or will be) less than 5-15%<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>Returning hatchery fish will spawn primarily in habitat currently underutilized by natural spawners of the same species. | H | Returning hatchery fish will spawn in habitat currently underutilized by target population and project is of short duration. |

# Duckabush Project

## Hazard I: Hatchery Failure

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery personnel live on-site to allow rapid response to water source or power failures. | M | Site and personnel undetermined. |
| Low pressure/low water alarms functioning for water supplies serving summer chum incubation and rearing areas. | M | Specific project design not yet determined. |
| All hatchery personnel responsible for rearing fish trained in standard fish propagation and fish health methods. | H | Expect experienced volunteers and trained WDFW staff support. |
| Incubation and rearing facilities are sited in areas that are not prone to flooding. | M | Undetermined but expect to site project with low risk of flooding. |

## Hazard II: Ecological Effects

| Criteria | Probability | Notes |
|---|---|---|
| Propagated summer chum are released at a life stage (1 gram fed fry) and time (March-April) that will reduce the risk of predation and competition effects on wild fish. | H | Will be key design element. |
| Summer chum are reared to release size on ground or surface water within the watershed targeted for supplementation or reintroduction. | H | Water source would be within watershed. |
| Fish health practices developed by the co-managers are applied in all hatchery activities to minimize the risk of fish disease occurrence, transmittal, and catastrophic loss. | H | Expected WDFW staff support would ensure proper procedures and treatment. |

## Hazard III: Reduction in Effective Population Size

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish are marked to accurately estimate proportion of hatchery fish spawning naturally in target population and proportion of wild fish spawning in hatchery. | H | Expected to be key element to plan for operations. |
| Natural spawning is regularly monitored to accurately estimate the proportion of hatchery fish spawning in target population. | M | Expected to be key element to plan for operations. |
| **In the target population, the proportion of natural spawners that are hatchery fish is approximately equal to the proportion of wild fish that were taken into the hatchery the previous generation**<br>**OR**<br>In the target population, the proportion of natural spawners that are hatchery-origin fish is larger than the proportion of wild fish that were taken into the hatchery the previous generation **AND** the wild population is increasing in abundance at a rate at least equal to the proportion of naturally spawning hatchery-origin fish | L | Uncertain. But experience indicates that this factor may be difficult to control. |

## Hazard III: Reduction in Effective Population Size

| | | |
|---|---|---|
| **OR**<br>The target wild population is believed to be in substantial danger of extinction within the next 35 years AND the effective number of breeders in the hatchery is as large as possible given the available broodstock.<br>**OR**<br>The project is to reintroduce fish to a location removed from the target population with likelihood of less than 5-15% return to target population. | | |

## Hazard IV: Loss of Within Population Diversity

**Source: Broodstock selection**

| Criteria | Probability | Notes |
|---|---|---|
| Broodstock source is not already substantially domesticated. | H | Broodstock has not previously been propagated. |

**Source: Broodstock collection**

| | | |
|---|---|---|
| Distributions of morphological, behavioral or life-history traits (e.g. run or spawn timing, size, appearance, age structure, etc) will be collected for target population. | H | Trained staff will record pertinent biological data. |
| Multi-trait distribution of broodstock sample closely matches the multi-trait distribution of target population (e.g. similar run and spawn timing, size, appearance, age structure, etc). | M | Broodstock collection parameters unknown but key element will be to obtain close match to target population. |
| Collection is technically and logistically possible (e.g. site is accessible throughout run, weirs have reasonable chance of continuous operation throughout season, necessary staff are available to carry out collection, funding is available to measure traits, etc). | M | Unknown but will be key element of project. |
| The effective population size will be maintained by collecting a minimum of 50 pairs except where the total population is less than 100 fish. | M | Criterion will be incorporated in plan. |

**Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration)**

| | | |
|---|---|---|
| The minimum standard for matings will be one male per female. | H | One to one or factorial matings will be a project objective. |

| | | |
|---|---|---|
| Mating and rearing methods are similar enough to those observed in the wild to avoid substantial domestication selection pressure<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Project will be of short duration - not to exceed 12 years. |
| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration) (cont.)** | | |
| Hatchery progeny will be released at essentially the same sizes and life-history stages as observed in the target population at the time of release<br>**OR**<br>Hatchery program will be of short duration (3 generations)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Hatchery progeny to reared to 1 gram size before release; however, program will be of short duration. |

| | | |
|---|---|---|
| **Source: Hatchery-Induced Genetic Swamping (Ryman-Laikre effect)** | | |
| Broodstocking does not collect a small fraction of the spawner population and, through use of hatchery operation, generate a subsequent large proportion of the natural spawning population. | M | Broodstocking limitations are unknown but project will be operated to avoid this effect. |

## Hazard V: Loss of Among Population Diversity

| | | |
|---|---|---|
| **Source of hazard: Broodstock selection** | | |
| Criteria | Probability | Notes |
| All the discrete populations within the watershed containing the target population have been correctly identified. | H | Total accessible area within watershed surveyed since 1982. |
| Selected broodstock source is substantially genetically similar to target population. | H | Broodstock source is target population. |
| Broodstock used for direct reintroduction is used only for one site. | N.A. | |

| **Source: Broodstock collection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| It will be possible to collect at a location and time such that only the target population will be collected. | H | Only target population exists in watershed. |

| **Source: Straying** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Hatchery fish will be reared to release size in the watershed targeted for supplementation or reintroduction. | H | Location of facilities in watershed will be key element of project. |
| Hatchery fish will be marked to provide effective estimation of straying. | H | Fish will be marked to differentiate hatchery-origin and natural-origin spawners within watershed. |
| Adjacent spawning populations will be effectively monitored to detect straying. | L | Undetermined at this time. |

## Hazard VI: Masking of Population Status

| Criteria | Probability | Notes |
|---|---|---|
| A sufficient proportion of hatchery fish are marked to estimate hatchery/wild ratios on the spawning grounds. | H | Expect to provide for adequate marking. |
| Sufficient wild spawning areas are surveyed to estimate hatchery/wild ratios accurately. | M | Would be key element to plan for operations. |
| Proportion of hatchery fish on spawning grounds is (or will be) less than 5-15%<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>Returning hatchery fish will spawn primarily in habitat currently underutilized by natural spawners of the same species. | H | Returning hatchery-origin fish will spawn in habitat currently under-utilized and project is of short duration. |

# Dosewallips Project

## Hazard I:  Hatchery Failure

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery personnel live on-site to allow rapid response to water source or power failures. | M | Site and personnel undetermined. |
| Low pressure/low water alarms functioning for water supplies serving summer chum incubation and rearing areas. | M | Specific project design not yet determined. |
| All hatchery personnel responsible for rearing fish trained in standard fish propagation and fish health methods. | H | Expect experienced volunteers and trained WDFW staff support. |
| Incubation and rearing facilities are sited in areas that are not prone to flooding. | M | Undetermined but expect to site project with low risk of flooding. |

## Hazard II: Ecological Effects

| Criteria | Probability | Notes |
|---|---|---|
| Propagated summer chum are released at a life stage (1 gram fed fry) and time (March-April) that will reduce the risk of predation and competition effects on wild fish. | H | Will be key design element.. |
| Summer chum are reared to release size on ground or surface water within the watershed targeted for supplementation or reintroduction. | H | Water source would be within watershed. |
| Fish health practices developed by the co-managers are applied in all hatchery activities to minimize the risk of fish disease occurrence, transmittal, and catastrophic loss. | H | Expected WDFW staff support would ensure proper procedures and treatment. |

## Hazard III:  Reduction in Effective Population Size

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish are marked to accurately estimate proportion of hatchery fish spawning naturally in target population and proportion of wild fish spawning in hatchery. | H | Expected to be key element to plan for operations. |
| Natural spawning is regularly monitored to accurately estimate the proportion of hatchery fish spawning in target population. | M | Expected to be key element to plan for operations. |
| **In the target population, the proportion of natural spawners that are hatchery fish is approximately equal to the proportion of wild fish that were taken into the hatchery the previous generation**<br>**OR**<br>In the target population, the proportion of natural spawners that are hatchery-origin fish is larger than the proportion of wild fish that were taken into the hatchery the previous generation **AND** the wild population is increasing in abundance at a rate at least equal to the proportion of naturally spawning hatchery-origin fish | L | Uncertain.  But experience indicates that this factor may be difficult to control. |

## Hazard III: Reduction in Effective Population Size (cont.)

| | | |
|---|---|---|
| **OR**<br>The target wild population is believed to be in substantial danger of extinction within the next 35 years AND the effective number of breeders in the hatchery is as large as possible given the available broodstock.<br>**OR**<br>The project is to reintroduce fish to a location removed from the target population with likelihood of less than 5-15% return to target population. | | |

## Hazard IV: Loss of Within Population Diversity

| **Source: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Broodstock source is not already substantially domesticated. | H | Broodstock has not previously been propagated. |

| **Source: Broodstock collection** | | |
|---|---|---|
| Distributions of morphological, behavioral or life-history traits (e.g. run or spawn timing, size, appearance, age structure, etc) will be collected for target population. | H | Trained staff will record pertinent biological data. |
| Multi-trait distribution of broodstock sample closely matches the multi-trait distribution of target population (e.g. similar run and spawn timing, size, appearance, age structure, etc). | M | Broodstock collection parameters unknown but key element will be to obtain close match to target population. |
| Collection is technically and logistically possible (e.g. site is accessible throughout run, weirs have reasonable chance of continuous operation throughout season, necessary staff are available to carry out collection, funding is available to measure traits, etc). | M | Unknown but will be key element of project. |
| The effective population size will be maintained by collecting a minimum of 50 pairs except where the total population is less than 100 fish. | M | Criterion will be incorporated in plan. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration)** | | |
|---|---|---|
| The minimum standard for matings will be one male per female. | H | One to one or factorial matings will be a project objective. |
| Mating and rearing methods are similar enough to those observed in the wild to avoid substantial domestication selection pressure<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Project will be of short duration - not to exceed 12 years. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration) (cont.)** | | |
|---|---|---|
| Hatchery progeny will be released at essentially the same sizes and life-history stages as observed in the target population at the time of release<br>**OR**<br>Hatchery program will be of short duration (3 generations)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Hatchery progeny to reared to 1 gram size before release; however, program will be of short duration. |

| **Source: Hatchery-Induced Genetic Swamping (Ryman-Laikre effect)** | | |
|---|---|---|
| Broodstocking does not collect a small fraction of the spawner population and, through use of hatchery operation, generate a subsequent large proportion of the natural spawning population. | M | Broodstocking limitations are unknown but project will be operated to avoid this effect. |

## Hazard V: Loss of Among Population Diversity

| **Source of hazard: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| All the discrete populations within the watershed containing the target population have been correctly identified. | H | Total accessible area within watershed surveyed since 1982. |
| Selected broodstock source is substantially genetically similar to target population. | H | Broodstock source is target population. |
| Broodstock used for direct reintroduction is used only for one site. | N.A. | |

| **Source: Broodstock collection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| It will be possible to collect at a location and time such that only the target population will be collected. | H | Only target population exists in watershed. |

| **Source: Straying** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Hatchery fish will be reared to release size in the watershed targeted for supplementation or reintroduction. | H | Location of facilities in watershed will be key element of project. |
| Hatchery fish will be marked to provide effective estimation of straying. | H | Fish will be marked to differentiate hatchery-origin and natural-origin spawners within watershed. |
| Adjacent spawning populations will be effectively monitored to detect straying. | L | Undetermined at this time. |

## Hazard VI:  Masking of Population Status

| Criteria | Probability | Notes |
|---|---|---|
| A sufficient proportion of hatchery fish are marked to estimate hatchery/wild ratios on the spawning grounds. | H | Expect to provide for adequate marking. |
| Sufficient wild spawning areas are surveyed to estimate hatchery/wild ratios accurately. | M | Would be key element to plan for operations. |
| Proportion of hatchery fish on spawning grounds is (or will be) less than 5-15%<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>Returning hatchery fish will spawn primarily in habitat currently underutilized by natural spawners of the same species. | H | Returning hatchery-origin fish will spawn in habitat currently under-utilized and project is of short duration. |

# Big Quilcene Project

## Hazard I: Hatchery Failure

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery personnel live on-site to allow rapid response to water source or power failures. | H | Three occupied residences on-site. |
| Low pressure/low water alarms functioning for water supplies serving summer chum incubation and rearing areas. | H | Alarm system is in place. |
| All hatchery personnel responsible for rearing fish trained in standard fish propagation and fish health methods. | H | Trained and experienced USFWS staff work on station or are otherwise available. |
| Incubation and rearing facilities are sited in areas not prone to flooding. | H | Facilities are in hatchery facility at low risk of flooding. |

## Hazard II: Ecological Effects

| Criteria | Probability | Notes |
|---|---|---|
| Propagated summer chum are released at a life stage (1 gram fed fry) and time (March-April) that will reduce the risk of predation and competition effects on wild fish. | H | Capability has been demonstrated at site. |
| Summer chum are reared to release size on ground or surface water within the watershed targeted for supplementation or reintroduction. | H | Surface water sources within watershed. |
| Fish health practices developed by the co-managers are applied in all hatchery activities to minimize the risk of fish disease occurrence, transmittal, and catastrophic loss. | H | USFWS pathologists ensure compliance with agreed fish health practices. |

## Hazard III: Reduction in Effective Population Size

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish are marked to accurately estimate proportion of hatchery fish spawning naturally in target population and proportion of wild fish spawning in hatchery. | H | Staff and equipment exist to mark all releases with adipose fin clip. USFWS will fund marking for duration of program. |
| Natural spawning is regularly monitored to accurately estimate the proportion of hatchery fish spawning in target population. | H | WDFW index survey stream. USFWS staff also perform surveys. |
| **In the target population, the proportion of natural spawners that are hatchery fish is approximately equal to the proportion of wild fish that were taken into the hatchery the previous generation**<br>**OR**<br>In the target population, the proportion of natural spawners that are hatchery-origin fish is larger than the proportion of wild fish that were taken into the hatchery the previous generation **AND** the wild population is increasing in abundance at a rate at least equal to the proportion of naturally spawning hatchery-origin fish | L | There has not yet been an effective estimate of the proportion of hatchery fish in the target population. However, all released fish are now marked beginning with brood year 1997 and future estimates will be available.<br>The high escapements since hatchery-origin returns were first expected (as 3 year olds) suggest that the proportion of natural spawners that are hatchery-origin fish is greater |

## Hazard III: Reduction in Effective Population Size (cont.)

| | | |
|---|---|---|
| **OR**<br>The target wild population is believed to be in substantial danger of extinction within the next 35 years **AND** the effective number of breeders in the hatchery is as large as possible given the available broodstock.<br>**OR**<br>The project is to reintroduce fish to a location removed from the target population with likelihood of less than 5-15% return to target population. | | than the proportion of wild fish that were taken into the hatchery the previous generation. |

## Hazard IV: Loss of Within Population Diversity

| **Source: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Broodstock source is not already substantially domesticated. | H | Project begun with brood year 1992. |

| **Source: Broodstock collection** | | |
|---|---|---|
| Distributions of morphological, behavioral or life-history traits (e.g. run or spawn timing, size, appearance, age structure, etc) will be collected for target population. | M | Trained staff records pertinent biological data but required collection procedure limits trait assessment. |
| Multi-trait distribution of broodstock sample closely matches the multi-trait distribution of target population (e.g. similar run and spawn timing, size, appearance, age structure, etc). | M | Collection procedure limits trait assessment. |
| Collection is technically and logistically possible (e.g. site is accessible throughout run, weirs have reasonable chance of continuous operation throughout season, necessary staff are available to carry out collection, funding is available to measure traits, etc). | H | Demonstrated technical and logistical collection capability |
| The effective population size will be maintained by collecting a minimum of 50 pairs except where the total population is less than 100 fish. | H | Past experience shows high probability of meeting criterion. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration)** | | |
|---|---|---|
| The minimum standard for matings will be one male per female. | H | One to one matings are used. |
| Mating and rearing methods are similar enough to those observed in the wild to avoid substantial domestication selection pressure<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Project to be of short duration - not to exceed 12 years. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration)** | | |
|---|---|---|
| Hatchery progeny will be released at essentially the same sizes and life-history stages as observed in the target population at the time of release<br>**OR**<br>Hatchery program will be of short duration (3 generations)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Hatchery progeny are reared to 1 gram size before release; however, program will be of short duration. |

| **Source: Hatchery-Induced Genetic Swamping (Ryman-Laikre effect)** | | |
|---|---|---|
| Broodstocking does not collect a small fraction of the spawner population and, through use of hatchery operation, generate a subsequent large proportion of the natural spawning population. | H | Past experience shows high probability of meeting criterion. |

## Hazard V: Loss of Among Population Diversity

| **Source of hazard: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| All the discrete populations within the watershed containing the target population have been correctly identified. | H | Total accessible area of stock surveyed since mid-70s. |
| Selected broodstock source is substantially genetically similar to target population. | H | Broodstock source is target population. |
| Broodstock used for direct reintroduction is used only for one site. | H | Only one direct reintroduction site, separate from Quilcene stock is being used; i.e, Big Beef. |

| **Source: Broodstock collection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| It will be possible to collect at a location and time such that only the target population will be collected. | H | Broodstock collection within the bay most likely to be from target stock (i.e., fish in the two streams of Quilcene Bay are assumed to be same stock). |

| **Source: Straying** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Hatchery fish will be reared to release size in the watershed targeted for supplementation or reintroduction. | H | Incubation and rearing facilities located in watershed. |
| Hatchery fish will be marked to provide effective estimation of straying. | H | Staff and equipment exist to mark all releases with adipose fin clip. USFWS will fund marking for duration of project. |
| Adjacent spawning populations will be effectively monitored to detect straying. | H | Adjacent spawning populations are monitored on regular basis. |

## Hazard VI:  Masking of Population Status

| Criteria | Probability | Notes |
|---|---|---|
| A sufficient proportion of hatchery fish are marked to estimate hatchery/wild ratios on the spawning grounds. | H | The intent is to mark all released fish with adipose fin clip. |
| Sufficient wild spawning areas are surveyed to estimate hatchery/wild ratios accurately. | H | Adjacent spawning areas are regularly surveyed index streams. |
| Proportion of hatchery fish on spawning grounds is (or will be) less than 5-15%<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>Returning hatchery fish will spawn primarily in habitat currently underutilized by natural spawners of the same species. | H | Project is of short duration. |

# Salmon Creek Project

## Hazard I: Hatchery Failure

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery personnel live on-site to allow rapid response to water source or power failures. | M | Eggs are incubated at Dungeness Hatchery with on-station 24 hour personnel. Water source at rearing facility in Salmon Creek watershed is reasonably secure. |
| Low pressure/low water alarms functioning for water supplies serving summer chum incubation and rearing areas. | H | Alarm system is in place at Dungeness Hatchery and at Salmon Creek facility. |
| All hatchery personnel responsible for rearing fish trained in standard fish propagation and fish health methods. | H | Experienced volunteers supervised by trained WDFW staff. |
| Incubation and rearing facilities are sited in areas that are not prone to flooding. | H | Facilities are located in areas of low flooding risk. |

## Hazard II: Ecological Effects

| Criteria | Probability | Notes |
|---|---|---|
| Propagated summer chum are released at a life stage (1 gram fed fry) and time (March-April) that will reduce the risk of predation and competition effects on wild fish. | H | Capability has been demonstrated at site. |
| Summer chum are reared to release size on ground or surface water within the watershed targeted for supplementation or reintroduction. | H | Surface water source within watershed for rearing lifestage. |
| Fish health practices developed by the co-managers are applied in all hatchery activities to minimize the risk of fish disease occurrence, transmittal, and catastrophic loss. | H | WDFW staff support ensures proper procedures and treatment. |

## Hazard III: Reduction in Effective Population Size

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish are marked to accurately estimate proportion of hatchery fish spawning naturally in target population and proportion of wild fish spawning in hatchery. | H | Funding, equipment and staff are available to otolith mark all releases. |
| Natural spawning is regularly monitored to accurately estimate the proportion of hatchery fish spawning in target population. | H | Funding, equipment and staff are available to sample, read and analyze otoliths of spawning population. |
| **In the target population, the proportion of natural spawners that are hatchery fish is approximately equal to the proportion of wild fish that were taken into the hatchery the previous generation**<br>**OR**<br>In the target population, the proportion of natural spawners that are hatchery-origin fish is larger than the proportion of wild fish that were taken into the hatchery the previous generation **AND** the wild | M | The proportion of natural spawners that are hatchery-origin fish is unknown at this time. Spawners are being sampled and an estimate of the proportion should be forthcoming. There is some risk that the hatchery-origin proportion exceeds the proportion of spawners taken for hatchery production in the previous |

## Hazard III: Reduction in Effective Population Size (cont.)

| | | |
|---|---|---|
| population is increasing in abundance at a rate at least equal to the proportion of naturally spawning hatchery-origin fish<br>**OR**<br>The target wild population is believed to be in substantial danger of extinction within the next 35 years **AND** the effective number of breeders in the hatchery is as large as possible given the available broodstock.<br>**OR**<br>The project is to reintroduce fish to a location removed from the target population with likelihood of less than 5-15% return to target population. | | generation. |

## Hazard IV: Loss of Within Population Diversity

| **Source: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Broodstock source is not already substantially domesticated. | H | Project begun with brood year 1992. |

| **Source: Broodstock collection** | | |
|---|---|---|
| Distributions of morphological, behavioral or life-history traits (e.g. run or spawn timing, size, appearance, age structure, etc) will be collected for target population. | H | Trained staff and supervised volunteers will record pertinent biological data. |
| Multi-trait distribution of broodstock sample closely matches the multi-trait distribution of target population (e.g. similar run and spawn timing, size, appearance, age structure, etc). | H | Location, timing and protocol of collection indicates matching. |
| Collection is technically and logistically possible (e.g. site is accessible throughout run, weirs have reasonable chance of continuous operation throughout season, necessary staff are available to carry out collection, funding is available to measure traits, etc). | H | Demonstrated successful collection at permanent weir. |
| The effective population size will be maintained by collecting a minimum of 50 pairs except where the total population is less than 100 fish. | H | Yes. Meeting criterion is ensured by collection at weir. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration)** | | |
|---|---|---|
| The minimum standard for matings will be one male per female. | H | One to one matings are used. |
| Mating and rearing methods are similar enough to those observed in the wild to avoid substantial domestication selection pressure<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years) | H | Project to be of short duration - not to exceed 12 years. |

**Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration) (cont.)**

| | | |
|---|---|---|
| **OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | | |
| Hatchery progeny will be released at essentially the same sizes and life-history stages as observed in the target population at the time of release<br>**OR**<br>Hatchery program will be of short duration (3 generations)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Hatchery progeny to reared to 1 gram size before release; however, program will be of short duration. |

**Source: Hatchery-induced genetic swamping (Ryman-Laikre effect)**

| | | |
|---|---|---|
| Broodstocking does not collect a small fraction of the spawner population and, through use of hatchery operation, generate a subsequent large proportion of the natural spawning population. | H | Meeting criterion is ensured by collection at weir. |

## Hazard V: Loss of Among Population Diversity

**Source of hazard: Broodstock selection**

| Criteria | Probability | Notes |
|---|---|---|
| All the discrete populations within the watershed containing the target population have been correctly identified. | H | Total accessible area within watershed surveyed since mid-70s. |
| Selected broodstock source is substantially genetically similar to target population. | H | Broodstock source is target population. |
| Broodstock used for direct reintroduction is used only for one site. | H | Only one direct reintroduction site, separate from Snow/Salmon stock, is being used - Chimacum. |

**Source: Broodstock collection**

| Criteria | Probability | Notes |
|---|---|---|
| It will be possible to collect at a location and time such that only the target population will be collected. | H | Only target population exists in watershed. |

**Source: Straying**

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish will be reared to release size in the watershed targeted for supplementation or reintroduction. | H | Rearing facilities located in watershed. |
| Hatchery fish will be marked to provide effective estimation of straying. | H | Staff, equipment and funding exist to otolith mark all released fish. |
| Adjacent spawning populations will be effectively monitored to detect straying. | M | Funding and resources have not been secured for otolith sampling, reading and analysis of other watersheds. |

## Hazard VI:  Masking of Population Status

| Criteria | Probability | Notes |
|---|---|---|
| A sufficient proportion of hatchery fish are marked to estimate hatchery/wild ratios on the spawning grounds. | H | All released fish will be otolith marked. |
| Sufficient wild spawning areas are surveyed to estimate hatchery/wild ratios accurately. | H | Funding, equipment and staff are available to sample, read and analyze otoliths of spawning population. |
| Proportion of hatchery fish on spawning grounds is (or will be) less than 5-15%<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>Returning hatchery fish will spawn primarily in habitat currently underutilized by natural spawners of the same species. | H | Project is of short duration. |

# Jimmycomelately Project

## Hazard I:  Hatchery Failure

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery personnel live on-site to allow rapid response to water source or power failures. | M | Site and personnel undetermined. |
| Low pressure/low water alarms functioning for water supplies serving summer chum incubation and rearing areas. | M | Specific project design not yet determined. |
| All hatchery personnel responsible for rearing fish trained in standard fish propagation and fish health methods. | H | Expect experienced volunteers and trained WDFW staff support. |
| Incubation and rearing facilities are sited in areas that are not prone to flooding. | M | Expect to site project with low risk of flooding. |

## Hazard II: Ecological Effects

| Criteria | Probability | Notes |
|---|---|---|
| Propagated summer chum are released at a life stage (1 gram fed fry) and time (March-April) that will reduce the risk of predation and competition effects on wild fish. | H | Will be key design element.. |
| Summer chum are reared to release size on ground or surface water within the watershed targeted for supplementation or reintroduction. | H | Water source would be within watershed. |
| Fish health practices developed by the co-managers are applied in all hatchery activities to minimize the risk of fish disease occurrence, transmittal, and catastrophic loss. | H | Expected WDFW staff support would ensure proper procedures and treatment. |

## Hazard III:  Reduction in Effective Population Size

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish are marked to accurately estimate proportion of hatchery fish spawning naturally in target population and proportion of wild fish spawning in hatchery. | H | Expected to be key element to plan for operations. |
| Natural spawning is regularly monitored to accurately estimate the proportion of hatchery fish spawning in target population. | M | Expected to be key element to plan for operations. |
| In the target population, the proportion of natural spawners that are hatchery fish is approximately equal to the proportion of wild fish that were taken into the hatchery the previous generation<br>**OR**<br>In the target population, the proportion of natural spawners that are hatchery-origin fish is larger than the proportion of wild fish that were taken into the hatchery the previous generation **AND** the wild population is increasing in abundance at a rate at least equal to the proportion of naturally spawning | M | Broodstock is believed to be at high risk of extinction.  Expect to collect as many breeders as possible given the available broodstock. |

## Hazard III: Reduction in Effective Population Size (cont.)

| | | |
|---|---|---|
| hatchery-origin fish<br>**OR**<br>**The target wild population is believed to be in substantial danger of extinction within the next 35 years AND the effective number of breeders in the hatchery is as large as possible given the available broodstock.**<br>**OR**<br>The project is to reintroduce fish to a location removed from the target population with likelihood of less than 5-15% return to target population. | | |

## Hazard IV: Loss of Within Population Diversity

**Source: Broodstock selection**

| Criteria | Probability | Notes |
|---|---|---|
| Broodstock source is not already substantially domesticated. | H | Broodstock has not previously been propagated. |

**Source: Broodstock collection**

| | | |
|---|---|---|
| Distributions of morphological, behavioral or life-history traits (e.g. run or spawn timing, size, appearance, age structure, etc) will be collected for target population. | H | Trained staff will record pertinent biological data. |
| Multi-trait distribution of broodstock sample closely matches the multi-trait distribution of target population (e.g. similar run and spawn timing, size, appearance, age structure, etc). | M | Broodstock collection parameters unknown but key element will be to obtain close match to target population. |
| Collection is technically and logistically possible (e.g. site is accessible throughout run, weirs have reasonable chance of continuous operation throughout season, necessary staff are available to carry out collection, funding is available to measure traits, etc). | M | Unknown but will be key element of project. |
| The effective population size will be maintained by collecting a minimum of 50 pairs except where the total population is less than 100 fish. | M | Criterion will be incorporated in plan. |

**Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration)**

| | | |
|---|---|---|
| The minimum standard for matings will be one male per female. | H | One to one or factorial matings will be a project objective. |
| Mating and rearing methods are similar enough to those observed in the wild to avoid substantial domestication selection pressure<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Project will be of short duration - not to exceed 12 years. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration) (cont.)** | | |
|---|---|---|
| Hatchery progeny will be released at essentially the same sizes and life-history stages as observed in the target population at the time of release<br>**OR**<br>Hatchery program will be of short duration (3 generations)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Hatchery progeny to reared to 1 gram size before release; however, program will be of short duration. |

| **Source: Hatchery-induced genetic swamping (Ryman-Laikre effect)** | | |
|---|---|---|
| Broodstocking does not collect a small fraction of the spawner population and, through use of hatchery operation, generate a subsequent large proportion of the natural spawning population. | M | Broodstocking limitations are unknown but avoiding this effect will be a key element of project. |

## Hazard V: Loss of Among Population Diversity

| **Source of hazard: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| All the discrete populations within the watershed containing the target population have been correctly identified. | H | Total accessible area within watershed surveyed since 1982. |
| Selected broodstock source is substantially genetically similar to target population. | H | Broodstock source is target population. |
| Broodstock used for direct reintroduction is used only for one site. | N.A. | |

| **Source: Broodstock collection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| It will be possible to collect at a location and time such that only the target population will be collected. | H | Only target population exists in watershed. |

| **Source: Straying** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Hatchery fish will be reared to release size in the watershed targeted for supplementation or reintroduction. | H | Location of facilities in watershed will be key element of project. |
| Hatchery fish will be marked to provide effective estimation of straying. | H | Fish will be marked to differentiate hatchery-origin and natural-origin spawners within watershed. |
| Adjacent spawning populations will be effectively monitored to detect straying. | L | Undetermined at this time. |

## Hazard VI:  Masking of Population Status

| Criteria | Probability | Notes |
|---|---|---|
| A sufficient proportion of hatchery fish are marked to estimate hatchery/wild ratios on the spawning grounds. | H | Expect to provide for adequate marking. |
| Sufficient wild spawning areas are surveyed to estimate hatchery/wild ratios accurately. | M | Expect would be key element to plan for operations. |
| Proportion of hatchery fish on spawning grounds is (or will be) less than 5-15%.<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>Returning hatchery fish will spawn primarily in habitat currently underutilized by natural spawners of the same species. | H | Returning hatchery-origin fish will spawn in habitat currently under-utilized and project is of short duration. |

# Dungeness Project

## Hazard I: Hatchery Failure

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery personnel live on-site to allow rapid response to water source or power failures. | M | On-site living is possibility if existing hatchery facilities used. |
| Low pressure/low water alarms functioning for water supplies serving summer chum incubation and rearing areas. | M | Alarm system exists if existing hatchery facilities are used. |
| All hatchery personnel responsible for rearing fish trained in standard fish propagation and fish health methods. | H | Expect experienced volunteers and trained WDFW staff support. |
| Incubation and rearing facilities are sited in areas that are not prone to flooding. | M | Undetermined but expect to site project with low risk of flooding. |

## Hazard II: Ecological Effects

| Criteria | Probability | Notes |
|---|---|---|
| Propagated summer chum are released at a life stage (1 gram fed fry) and time (March-April) that will reduce the risk of predation and competition effects on wild fish. | H | Would be key design element. |
| Summer chum are reared to release size on ground or surface water within the watershed targeted for supplementation or reintroduction. | H | Water source would be within watershed. |
| Fish health practices developed by the co-managers are applied in all hatchery activities to minimize the risk of fish disease occurrence, transmittal, and catastrophic loss. | H | Expected WDFW staff support would ensure proper procedures and treatment. |

## Hazard III: Reduction in Effective Population Size

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish are marked to accurately estimate proportion of hatchery fish spawning naturally in target population and proportion of wild fish spawning in hatchery. | H | Expect would be key element to plan for operations. |
| Natural spawning is regularly monitored to accurately estimate the proportion of hatchery fish spawning in target population. | M | Expect would be key element to plan for operations. |
| In the target population, the proportion of natural spawners that are hatchery fish is approximately equal to the proportion of wild fish that were taken into the hatchery the previous generation<br>**OR**<br>In the target population, the proportion of natural spawners that are hatchery-origin fish is larger than the proportion of wild fish that were taken into the hatchery the previous generation **AND** the wild population is increasing in abundance at a rate at least equal to the proportion of naturally spawning hatchery-origin fish | L | The population status is unknown. |

## Hazard III: Reduction in Effective Population Size (cont.)

| | | |
|---|---|---|
| **OR**<br>The target wild population is believed to be in substantial danger of extinction within the next 35 years **AND** the effective number of breeders in the hatchery is as large as possible given the available broodstock.<br>**OR**<br>The project is to reintroduce fish to a location removed from the target population with likelihood of less than 5-15% return to target population. | | |

## Hazard IV: Loss of Within Population Diversity

| **Source: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Broodstock source is not already substantially domesticated. | H | Dungeness stock has never been propagated. |

| **Source: Broodstock collection** | | |
|---|---|---|
| Distributions of morphological, behavioral or life-history traits (e.g. run or spawn timing, size, appearance, age structure, etc) will be collected for target population. | H | Trained staff would record pertinent biological data. |
| Multi-trait distribution of broodstock sample closely matches the multi-trait distribution of target population (e.g. similar run and spawn timing, size, appearance, age structure, etc). | M | Broodstock collection parameters unknown but key element would be to obtain close match to target population. |
| Collection is technically and logistically possible (e.g. site is accessible throughout run, weirs have reasonable chance of continuous operation throughout season, necessary staff are available to carry out collection, funding is available to measure traits, etc). | M | Unknown but would be key element of project. |
| The effective population size will be maintained by collecting a minimum of 50 pairs except where the total population is less than 100 fish. | M | Criterion would be incorporated in plan. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration)** | | |
|---|---|---|
| The minimum standard for matings will be one male per female. | H | One to one or factorial matings would be project objective. |
| Mating and rearing methods are similar enough to those observed in the wild to avoid substantial domestication selection pressure<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Project will be of short duration - not to exceed 12 years. |

**Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration) (cont.)**

| | | |
|---|---|---|
| Hatchery progeny will be released at essentially the same sizes and life-history stages as observed in the target population at the time of release<br>**OR**<br>Hatchery program will be of short duration (3 generations)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Hatchery progeny to be reared to 1 gram size before release; however, program will be of short duration. |

**Source: Hatchery-induced genetic swamping (Ryman-Laikre effect)**

| | | |
|---|---|---|
| Broodstocking does not collect a small fraction of the spawner population and, through use of hatchery operation, generate a subsequent large proportion of the natural spawning population. | M | Broodstocking limitations are unknown but avoiding this effect will be a key element of project. |

## Hazard V: Loss of Among Population Diversity

**Source of hazard: Broodstock selection**

| Criteria | Probability | Notes |
|---|---|---|
| All the discrete populations within the watershed containing the target population have been correctly identified. | L | Population status is unknown. |
| Selected broodstock source is substantially genetically similar to target population. | M | Lack knowledge about stock but likely to be true. |
| Broodstock used for direct reintroduction is used only for one site. | M | Uncertain. Broodstock source depends on undetermined stock status. |

**Source: Broodstock collection**

| Criteria | Probability | Notes |
|---|---|---|
| It will be possible to collect at a location and time such that only the target population will be collected. | M | Undetermined since population status and broodstock source are unknown. |

**Source: Straying**

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish will be reared to release size in the watershed targeted for supplementation or reintroduction. | H | Locating facilities in watershed would be key element of project. |
| Hatchery fish will be marked to provide effective estimation of straying. | H | Fish would be marked to differentiate hatchery-origin and natural-origin spawners within watershed. |
| Adjacent spawning populations will be effectively monitored to detect straying. | L | Undetermined at this time. |

## Hazard VI:  Masking of Population Status

| Criteria | Probability | Notes |
|---|---|---|
| A sufficient proportion of hatchery fish are marked to estimate hatchery/wild ratios on the spawning grounds. | H | Expect to provide for adequate marking. |
| Sufficient wild spawning areas are surveyed to estimate hatchery/wild ratios accurately. | M | Expect would be key element to plan for operations. |
| Proportion of hatchery fish on spawning grounds is (or will be) less than 5-15%<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>Returning hatchery fish will spawn primarily in habitat currently underutilized by natural spawners of the same species. | H | Returning hatchery fish will spawn in habitat currently underutilized by target population and project will be of short duration. |

# Big Beef Project

## Hazard I:  Hatchery Failure

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery personnel live on-site to allow rapid response to water source or power failures. | H | Hatchery personnel live on-site. |
| Low pressure/low water alarms functioning for water supplies serving summer chum incubation and rearing areas. | H | Functioning alarm system in place. |
| All hatchery personnel responsible for rearing fish trained in standard fish propagation and fish health methods. | H | Experienced volunteers.  Trained WDFW staff support. |
| Incubation and rearing facilities are sited in areas that are not prone to flooding. | M | Facilities location is currently at moderate risk of flooding. |

## Hazard II: Ecological Effects

| Criteria | Probability | Notes |
|---|---|---|
| Propagated summer chum are released at a life stage (1 gram fed fry) and time (March-April) that will reduce the risk of predation and competition effects on wild fish. | H | Capability has been demonstrated at site. |
| Summer chum are reared to release size on ground or surface water within the watershed targeted for supplementation or reintroduction. | H | Ground water source within watershed. |
| Fish health practices developed by the co-managers are applied in all hatchery activities to minimize the risk of fish disease occurrence, transmittal, and catastrophic loss. | H | WDFW staff support ensures proper procedures and treatment. |

## Hazard III:  Reduction in Effective Population Size

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish are marked to accurately estimate proportion of hatchery fish spawning naturally in target population and proportion of wild fish spawning in hatchery. | H | Funding, equipment and staff are available to otolith mark all releases. |
| Natural spawning are regularly monitored to accurately estimate the proportion of hatchery fish spawning in target population. | H | Funding, equipment and staff are available to sample, read and evaluate results of otolith samples from spawning population. |
| In the target population, the proportion of natural spawners that are hatchery fish is approximately equal to the proportion of wild fish that were taken into the hatchery the previous generation<br>**OR**<br>In the target population, the proportion of natural spawners that are hatchery-origin fish is larger than the proportion of wild fish that were taken into the hatchery the previous generation **AND** the wild population is increasing in abundance at a rate at least equal to the proportion of naturally spawning | H | The project is to reintroduce summer chum to Big Beef Creek using broodstock from the Big Quilcene / Little Quilcene stock.  Big Beef Creek is sufficiently removed from the Big and Little Quilcene rivers that the likelihood of returns to the donor stock watersheds from releases at Big Beef Creek is small. |

## Hazard III: Reduction in Effective Population Size (cont.)

| | | |
|---|---|---|
| hatchery-origin fish<br>**OR**<br>The target wild population is believed to be in substantial danger of extinction within the next 35 years **AND** the effective number of breeders in the hatchery is as large as possible given the available broodstock<br>**OR**<br>**The project is to reintroduce fish to a location removed from the target population with likelihood of less than 5-15% return to target population.** | | |

## Hazard IV: Loss of Within Population Diversity

**Source: Broodstock selection**

| Criteria | Probability | Notes |
|---|---|---|
| Broodstock source is not already substantially domesticated. | H | Quilcene in-river broodstocking began 1992. |

**Source: Broodstock collection**

| | | |
|---|---|---|
| Distributions of morphological, behavioral or life-history traits (e.g. run or spawn timing, size, appearance, age structure, etc) will be collected for target population. | M | Trained staff records pertinent biological data but required collection procedure (in Quilcene Bay) limits trait assessment. |
| Multi-trait distribution of broodstock sample closely matches the multi-trait distribution of target population (e.g. similar run and spawn timing, size, appearance, age structure, etc). | M | Collection procedure limits trait assessment. |
| Collection is technically and logistically possible (e.g. site is accessible throughout run, weirs have reasonable chance of continuous operation throughout season, necessary staff are available to carry out collection, funding is available to measure traits, etc). | H | Demonstrated success with broodstock source at Quilcene. |
| The effective population size will be maintained by collecting a minimum of 50 pairs except where the total population is less than 100 fish. | H | Again, demonstrated success. |

**Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration)**

| | | |
|---|---|---|
| The minimum standard for matings will be one male per female. | H | Successfully implemented with Quilcene Project. |
| Mating and rearing methods are similar enough to those observed in the wild to avoid substantial domestication selection pressure<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR** | H | Project to be of short duration - not to exceed 12 years. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration) (cont.)** | | |
|---|---|---|
| The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | | |
| Hatchery progeny will be released at essentially the same sizes and life-history stages as observed in the target population at the time of release<br>**OR**<br>Hatchery program will be of short duration (3 generations)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Hatchery progeny to reared to 1 gram size before release; however, program will be of short duration. |

| **Source: Hatchery-induced genetic swamping (Ryman-Laikre effect)** | | |
|---|---|---|
| Broodstocking does not collect a small fraction of the spawner population and, through use of hatchery operation, generate a subsequent large proportion of the natural spawning population. | H | Demonstrated success with broodstock source at Quilcene. |

## Hazard V: Loss of Among Population Diversity

**Source of hazard: Broodstock selection**

| Criteria | Probability | Notes |
|---|---|---|
| All the discrete populations within the watershed containing the target population have been correctly identified. | H | Total accessible area within watershed surveyed since mid-70s. |
| Selected broodstock source is substantially genetically similar to target population. | H | Broodstock source is target population. |
| Broodstock used for direct reintroduction is used only for one site. | H | Big Beef is only reintroduction project using Quilcene broodstock. |

**Source: Broodstock collection**

| Criteria | Probability | Notes |
|---|---|---|
| It will be possible to collect at a location and time such that only the target population will be collected. | H | Only target population exists in watershed. |

**Source: Straying**

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish will be reared to release size in the watershed targeted for supplementation or reintroduction. | H | Rearing facilities located in watershed. |
| Hatchery fish will be marked to provide effective estimation of straying. | H | Staff, equipment and funding exist to otolith mark all releases. |
| Adjacent spawning populations will be effectively monitored to detect straying. | L | Undetermined at this time. |

## Hazard VI:  Masking of Population Status

| Criteria | Probability | Notes |
|---|---|---|
| A sufficient proportion of hatchery fish are marked to estimate hatchery/wild ratios on the spawning grounds. | H | All releases will be otolith marked. |
| Sufficient wild spawning areas are surveyed to estimate hatchery/wild ratios accurately. | H | Funding, equipment and staff are available to sample, read and evaluate results of otolith samples from spawning population. |
| Proportion of hatchery fish on spawning grounds is (or will be) less than 5-15%<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>Returning hatchery fish will spawn primarily in habitat currently underutilized by natural spawners of the same species. | H | Returning hatchery fish will spawn in habitat currently not being utilized and project is of short duration. |

# Chimacum Project

## Hazard I: Hatchery Failure

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery personnel live on-site to allow rapid response to water source or power failures. | M | Eggs are incubated at Dungeness Hatchery with on-station 24 hour personnel. Water source at rearing facility in Chimacum Creek watershed is reasonably secure. |
| Low pressure/low water alarms functioning for water supplies serving summer chum incubation and rearing areas. | H | Alarm system is in place at Dungeness Hatchery and at Chimacum Creek facility. |
| All hatchery personnel responsible for rearing fish trained in standard fish propagation and fish health methods. | H | Experienced volunteers supervised by trained WDFW staff. |
| Incubation and rearing facilities are sited in areas that are not prone to flooding. | H | Facilities are located in area of low flooding risk. |

## Hazard II: Ecological Effects

| Criteria | Probability | Notes |
|---|---|---|
| Propagated summer chum are released at a life stage (1 gram fed fry) and time (March-April) that will reduce the risk of predation and competition effects on wild fish. | H | Capability has been demonstrated at site. |
| Summer chum are reared to release size on ground or surface water within the watershed targeted for supplementation or reintroduction. | H | Surface water source within watershed for rearing lifestage. |
| Fish health practices developed by the co-managers are applied in all hatchery activities to minimize the risk of fish disease occurrence, transmittal, and catastrophic loss. | H | WDFW staff support ensures proper procedures and treatment. |

## Hazard III: Reduction in Effective Population Size

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish are marked to accurately estimate proportion of hatchery fish spawning naturally in target population and proportion of wild fish spawning in hatchery. | H | Funding, equipment and staff are available to otolith mark all releases. |
| Natural spawning is regularly monitored to accurately estimate the proportion of hatchery fish spawning in target population. | M | Intent is to sample, read and analyze otoliths of spawning population, but funding and resources have not yet been secured. |
| In the target population, the proportion of natural spawners that are hatchery fish is approximately equal to the proportion of wild fish that were taken into the hatchery the previous generation<br>**OR**<br>In the target population, the proportion of natural spawners that are hatchery-origin fish is larger than the proportion of wild fish that were taken into the | H | The project is to reintroduce summer chum to Chimacum Creek using broodstock from Salmon Creek. Chimacum Creek is sufficiently removed from Salmon Creek that few or no adult returns to Salmon Creek are expected. |

## Hazard III: Reduction in Effective Population Size (cont.)

| | | |
|---|---|---|
| hatchery the previous generation **AND** the wild population is increasing in abundance at a rate at least equal to the proportion of naturally spawning hatchery-origin fish<br>**OR**<br>The target wild population is believed to be in substantial danger of extinction within the next 35 years **AND** the effective number of breeders in the hatchery is as large as possible given the available broodstock.<br>**OR**<br>**The project is to reintroduce fish to a location removed from the target population with likelihood of less than 5-15% return to target population**. | | |

## Hazard IV: Loss of Within Population Diversity

| **Source: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Broodstock source is not already substantially domesticated. | H | Salmon Creek broodstocking began 1992. |

| **Source: Broodstock collection** | | |
|---|---|---|
| Distributions of morphological, behavioral or life-history traits (e.g. run or spawn timing, size, appearance, age structure, etc) will be collected for target population. | H | Trained staff and supervised volunteers record pertinent biological data. |
| Multi-trait distribution of broodstock sample closely matches the multi-trait distribution of target population (e.g. similar run and spawn timing, size, appearance, age structure, etc). | H | Location, timing and protocol of collection indicates matching. |
| Collection is technically and logistically possible (e.g. site is accessible throughout run, weirs have reasonable chance of continuous operation throughout season, necessary staff are available to carry out collection, funding is available to measure traits, etc). | H | Demonstrated success with broodstock source at Salmon Creek. |
| The effective population size will be maintained by collecting a minimum of 50 pairs except where the total population is less than 100 fish. | H | Again, demonstrated success. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration)** | | |
|---|---|---|
| The minimum standard for matings will be one male per female. | H | Successfully implemented with Salmon Creek Project. |
| Mating and rearing methods are similar enough to those observed in the wild to avoid substantial domestication selection pressure<br>**OR** | H | Project to be of short duration - not to exceed 12 years. |

**Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration) (cont.)**

| | | |
|---|---|---|
| Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | | |
| Hatchery progeny will be released at essentially the same sizes and life-history stages as observed in the target population at the time of release<br>**OR**<br>Hatchery program will be of short duration (3 generations)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Hatchery progeny to reared to 1 gram size before release; however, program will be of short duration. |

**Source: Hatchery-induced genetic swamping (Ryman-Laikre effect)**

| | | |
|---|---|---|
| Broodstocking does not collect a small fraction of the spawner population and, through use of hatchery operation, generate a subsequent large proportion of the natural spawning population. | H | Demonstrated success with broodstock source at Salmon Creek. |

## Hazard V: Loss of Among Population Diversity

**Source of hazard: Broodstock selection**

| Criteria | Probability | Notes |
|---|---|---|
| All the discrete populations within the watershed containing the target population have been correctly identified. | H | Total accessible area within watershed surveyed since mid-70s. |
| Selected broodstock source is substantially genetically similar to target population. | H | Broodstock source is target population. |
| Broodstock used for direct reintroduction is used only for one site. | H | Chimacum is only reintroduction project using Salmon/Snow broodstock. |

**Source: Broodstock collection**

| Criteria | Probability | Notes |
|---|---|---|
| It will be possible to collect at a location and time such that only the target population will be collected. | H | Only target population exists in donor population’s (Salmon Creek) watershed. |

**Source: Straying**

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish will be reared to release size in the watershed targeted for supplementation or reintroduction. | H | Rearing facilities located in watershed. |

| **Source: Straying (cont.)** | | |
|---|---|---|
| Hatchery fish will be marked to provide effective estimation of straying. | H | Staff, equipment and funding exist to otolith mark all released fish. |
| Adjacent spawning populations will be effectively monitored to detect straying. | L | Funding and resources have not been secured for otolith sampling, reading and analysis. |

## Hazard VI:  Masking of Population Status

| Criteria | Probability | Notes |
|---|---|---|
| A sufficient proportion of hatchery fish are marked to estimate hatchery/wild ratios on the spawning grounds. | H | All released fish will be otolith marked. |
| Sufficient wild spawning areas are surveyed to estimate hatchery/wild ratios accurately. | M | Funding and resources have not yet been secured for otolith sampling, reading and analysis. |
| Proportion of hatchery fish on spawning grounds is (or will be) less than 5-15%<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>Returning hatchery fish will spawn primarily in habitat currently underutilized by natural spawners of the same species. | H | Project is of short duration. |

# Tahuya Project

## Hazard I:  Hatchery Failure

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery personnel live on-site to allow rapid response to water source or power failures. | M | Site and personnel undetermined. |
| Low pressure/low water alarms functioning for water supplies serving summer chum incubation and rearing areas. | M | Specific project design not yet determined. |
| All hatchery personnel responsible for rearing fish trained in standard fish propagation and fish health methods. | H | Expect experienced volunteers and trained WDFW staff support. |
| Incubation and rearing facilities are sited in areas that are not prone to flooding. | M | Expect to site project at site with low risk of flooding. |

## Hazard II: Ecological Effects

| Criteria | Probability | Notes |
|---|---|---|
| Propagated summer chum are released at a life stage (1 gram fed fry) and time (March-April) that will reduce the risk of predation and competition effects on wild fish. | H | Will be key design element. |
| Summer chum are reared to release size on ground or surface water within the watershed targeted for supplementation or reintroduction. | H | Water source would be within watershed. |
| Fish health practices developed by the co-managers are applied in all hatchery activities to minimize the risk of fish disease occurrence, transmittal, and catastrophic loss. | H | Expected WDFW staff support would ensure proper procedures and treatment. |

## Hazard III:  Reduction in Effective Population Size

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish are marked to accurately estimate proportion of hatchery fish spawning naturally in target population and proportion of wild fish spawning in hatchery. | H | Expect to be key element to plan for operations. |
| Natural spawning is regularly monitored to accurately estimate the proportion of hatchery fish spawning in target population. | M | Expect to be key element to plan for operations. |
| In the target population, the proportion of natural spawners that are hatchery fish is approximately equal to the proportion of wild fish that were taken into the hatchery the previous generation<br>**OR**<br>In the target population, the proportion of natural spawners that are hatchery-origin fish is larger than the proportion of wild fish that were taken into the hatchery the previous generation **AND** the wild population is increasing in abundance at a rate at least equal to the proportion of naturally spawning hatchery-origin fish | M | Broodstock undetermined but key project design element will be to find appropriate broodstock. Alternatives to be considered would be sufficiently removed from Tahuya River that expected adult returns from project to donor population would be few or none. |

## Hazard III: Reduction in Effective Population Size (cont.)

| | | |
|---|---|---|
| **OR**<br>The target wild population is believed to be in substantial danger of extinction within the next 35 years **AND** the effective number of breeders in the hatchery is as large as possible given the available broodstock.<br>**OR**<br>**The project is to reintroduce fish to a location removed from the target population with likelihood of less than 5-15% return to target population.** | | |

## Hazard IV: Loss of Within Population Diversity

| **Source: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Broodstock source is not already substantially domesticated. | H | Broodstock undetermined but unlikely to be domesticated. |

| **Source: Broodstock collection** | | |
|---|---|---|
| Distributions of morphological, behavioral or life-history traits (e.g. run or spawn timing, size, appearance, age structure, etc) will be collected for target population. | M | Expect trained staff will record pertinent biological data. |
| Multi-trait distribution of broodstock sample closely matches the multi-trait distribution of target population (e.g. similar run and spawn timing, size, appearance, age structure, etc). | M | Broodstock collection parameters unknown but key element will be to obtain close match to target population. |
| Collection is technically and logistically possible (e.g. site is accessible throughout run, weirs have reasonable chance of continuous operation throughout season, necessary staff are available to carry out collection, funding is available to measure traits, etc). | M | Unknown but will be key element of project. |
| The effective population size will be maintained by collecting a minimum of 50 pairs except where the total population is less than 100 fish. | M | Criterion will be incorporated in plan. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration)** | | |
|---|---|---|
| The minimum standard for matings will be one male per female. | M | One to one or factorial matings will be a project objective. |
| Mating and rearing methods are similar enough to those observed in the wild to avoid substantial domestication selection pressure<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Project will be of short duration - not to exceed 12 years. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration) (cont.)** | | |
|---|---|---|
| Hatchery progeny will be released at essentially the same sizes and life-history stages as observed in the target population at the time of release<br>**OR**<br>Hatchery program will be of short duration (3 generations)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Hatchery progeny to reared to 1 gram size before release; however, program will be of short duration. |

| **Source: Hatchery-induced genetic swamping (Ryman-Laikre effect)** | | |
|---|---|---|
| Broodstocking does not collect a small fraction of the spawner population and, through use of hatchery operation, generate a subsequent large proportion of the natural spawning population. | M | Broodstocking limitations undetermined but key element of project will be to avoid this effect. |

## Hazard V: Loss of Among Population Diversity

| **Source of hazard: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| All the discrete populations within the watershed containing the target population have been correctly identified. | H | Unknown broodstock source but expect to meet criterion. |
| Selected broodstock source is substantially genetically similar to target population. | H | Broodstock source will be target population. |
| Broodstock used for direct reintroduction is used only for one site. | H | General requirement for all projects. |

| **Source: Broodstock collection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| It will be possible to collect at a location and time such that only the target population will be collected. | H | Broodstock undetermined at this time but expect to meet criterion. |

| **Source: Straying** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Hatchery fish will be reared to release size in the watershed targeted for supplementation or reintroduction. | H | Location of facilities in watershed will be key element of project. |
| Hatchery fish will be marked to provide effective estimation of straying. | H | Fish will be marked to differentiate hatchery-origin and natural-origin spawners within watershed. |
| Adjacent spawning populations will be effectively monitored to detect straying. | L | Undetermined at this time. |

## Hazard VI:  Masking of Population Status

| Criteria | Probability | Notes |
|---|---|---|
| A sufficient proportion of hatchery fish are marked to estimate hatchery/wild ratios on the spawning grounds. | H | Expect to provide for adequate marking. |
| Sufficient wild spawning areas are surveyed to estimate hatchery/wild ratios accurately. | M | Expect would be key element to plan for operations. |
| Proportion of hatchery fish on spawning grounds is (or will be) less than 5-15%<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>Returning hatchery fish will spawn primarily in habitat currently underutilized by natural spawners of the same species. | H | Returning hatchery-origin fish will spawn in habitat currently not utilized and project would be of short duration. |

# Dewatto Project

## Hazard I:  Hatchery Failure

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery personnel live on-site to allow rapid response to water source or power failures. | M | Site and personnel undetermined. |
| Low pressure/low water alarms functioning for water supplies serving summer chum incubation and rearing areas. | M | Specific project design not yet determined. |
| All hatchery personnel responsible for rearing fish trained in standard fish propagation and fish health methods. | H | Expect experienced volunteers and trained WDFW staff support. |
| Incubation and rearing facilities are sited in areas that are not prone to flooding. | M | Expect to site project at site with low risk of flooding. |

## Hazard II: Ecological Effects

| Criteria | Probability | Notes |
|---|---|---|
| Propagated summer chum are released at a life stage (1 gram fed fry) and time (March-April) that will reduce the risk of predation and competition effects on wild fish. | H | Will be key design element.. |
| Summer chum are reared to release size on ground or surface water within the watershed targeted for supplementation or reintroduction. | H | Water source would be within watershed. |
| Fish health practices developed by the co-managers are applied in all hatchery activities to minimize the risk of fish disease occurrence, transmittal, and catastrophic loss. | H | Expected WDFW staff support would ensure proper procedures and treatment. |

## Hazard III:  Reduction in Effective Population Size

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish are marked to accurately estimate proportion of hatchery fish spawning naturally in target population and proportion of wild fish spawning in hatchery. | H | Expected to be key element to plan for operations. |
| Natural spawning is regularly monitored to accurately estimate the proportion of hatchery fish spawning in target population. | M | Expected to be key element to plan for operations. |
| In the target population, the proportion of natural spawners that are hatchery fish is approximately equal to the proportion of wild fish that were taken into the hatchery the previous generation<br>**OR**<br>In the target population, the proportion of natural spawners that are hatchery-origin fish is larger than the proportion of wild fish that were taken into the hatchery the previous generation **AND** the wild population is increasing in abundance at a rate at least equal to the proportion of naturally spawning hatchery-origin fish | M | Broodstock undetermined but key project design element will be to find appropriate broodstock. Alternatives to be considered would likely be sufficiently removed from Dewatto River that any adults returning from project to donor population would be few or none. |

## Hazard III: Reduction in Effective Population Size (cont.)

| | | |
|---|---|---|
| **OR**<br>The target wild population is believed to be in substantial danger of extinction within the next 35 years **AND** the effective number of breeders in the hatchery is as large as possible given the available broodstock.<br>**OR**<br>**The project is to reintroduce fish to a location removed from the target population with likelihood of less than 5-15% return to target population**. | | |

## Hazard IV: Loss of Within Population Diversity

**Source: Broodstock selection**

| Criteria | Probability | Notes |
|---|---|---|
| Broodstock source is not already substantially domesticated. | H | Broodstock undetermined but unlikely to be domesticated. |

**Source: Broodstock collection**

| | | |
|---|---|---|
| Distributions of morphological, behavioral or life-history traits (e.g. run or spawn timing, size, appearance, age structure, etc) will be collected for target population. | H | Expect trained staff will record pertinent biological data. |
| Multi-trait distribution of broodstock sample closely matches the multi-trait distribution of target population (e.g. similar run and spawn timing, size, appearance, age structure, etc). | M | Broodstock collection parameters unknown but key element will be to obtain close match to target population. |
| Collection is technically and logistically possible (e.g. site is accessible throughout run, weirs have reasonable chance of continuous operation throughout season, necessary staff are available to carry out collection, funding is available to measure traits, etc). | M | Unknown but will be key element of project. |
| The effective population size will be maintained by collecting a minimum of 50 pairs except where the total population is less than 100 fish. | M | Criterion will be incorporated in plan. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration)** | | |
|---|---|---|
| The minimum standard for matings will be one male per female. | M | One to one or factorial matings will be a project objective. |
| Mating and rearing methods are similar enough to those observed in the wild to avoid substantial domestication selection pressure<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Project will be of short duration - not to exceed 12 years. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration) (cont.)** | | |
|---|---|---|
| Hatchery progeny will be released at essentially the same sizes and life-history stages as observed in the target population at the time of release<br>**OR**<br>Hatchery program will be of short duration (3 generations)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Hatchery progeny to reared to 1 gram size before release; however, program will be of short duration. |

| **Source: Hatchery-induced genetic swamping (Ryman-Laikre effect)** | | |
|---|---|---|
| Broodstocking does not collect a small fraction of the spawner population and, through use of hatchery operation, generate a subsequent large proportion of the natural spawning population. | M | Broodstocking limitations undetermined but key element of project will be to avoid this effect. |

## Hazard V: Loss of Among Population Diversity

| **Source of hazard: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| All the discrete populations within the watershed containing the target population have been correctly identified. | H | Unknown broodstock source but expect to meet criterion. |
| Selected broodstock source is substantially genetically similar to target population. | H | Broodstock source will be target population. |
| Broodstock used for direct reintroduction is used only for one site. | H | General requirement for all projects. |

| **Source: Broodstock collection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| It will be possible to collect at a location and time such that only the target population will be collected. | H | Broodstock undetermined at this time but expect to meet criterion. |

**Source: Straying**

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish will be reared to release size in the watershed targeted for supplementation or reintroduction. | H | Location of facilities in watershed will be key element of project. |
| Hatchery fish will be marked to provide effective estimation of straying. | H | Fish will be marked to differentiate hatchery-origin and natural-origin spawners within watershed. |
| Adjacent spawning populations will be effectively monitored to detect straying. | L | Undetermined at this time. |

## Hazard VI:  Masking of Population Status

| Criteria | Probability | Notes |
|---|---|---|
| A sufficient proportion of hatchery fish are marked to estimate hatchery/wild ratios on the spawning grounds. | H | Expect to provide for adequate marking. |
| Sufficient wild spawning areas are surveyed to estimate hatchery/wild ratios accurately. | M | Expect would be key element to plan for operations. |
| Proportion of hatchery fish on spawning grounds is (or will be) less than 5-15%<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>Returning hatchery fish will spawn primarily in habitat currently underutilized by natural spawners of the same species. | H | Returning hatchery-origin fish will spawn in habitat currently not utilized and project is of short duration. |

# Skokomish Project

## Hazard I:  Hatchery Failure

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery personnel live on-site to allow rapid response to water source or power failures. | M | On-site living is possibility if existing hatchery facilities are used. |
| Low pressure/low water alarms functioning for water supplies serving summer chum incubation and rearing areas. | M | Alarm system exists if hatchery facilities in watershed are used. |
| All hatchery personnel responsible for rearing fish trained in standard fish propagation and fish health methods. | H | Expect experienced volunteers and trained WDFW staff support. |
| Incubation and rearing facilities are sited in areas that are not prone to flooding. | M | Undetermined but expect to site project with low risk of flooding. |

## Hazard II: Ecological Effects

| Criteria | Probability | Notes |
|---|---|---|
| Propagated summer chum are released at a life stage (1 gram fed fry) and time (March-April) that will reduce the risk of predation and competition effects on wild fish. | H | Would be key design element. |
| Summer chum are reared to release size on ground or surface water within the watershed targeted for supplementation or reintroduction. | H | Water source would be within watershed. |
| Fish health practices developed by the co-managers are applied in all hatchery activities to minimize the risk of fish disease occurrence, transmittal, and catastrophic loss. | H | Expected WDFW staff support would ensure proper procedures and treatment. |

## Hazard III:  Reduction in Effective Population Size

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish are marked to accurately estimate proportion of hatchery fish spawning naturally in target population and proportion of wild fish spawning in hatchery. | H | Expected to be key element of plan for operations. |
| Natural spawning is regularly monitored to accurately estimate the proportion of hatchery fish spawning in target population. | M | Expected to be key element of project operations. |
| In the target population, the proportion of natural spawners that are hatchery fish is approximately equal to the proportion of wild fish that were taken into the hatchery the previous generation<br>**OR**<br>In the target population, the proportion of natural spawners that are hatchery-origin fish is larger than the proportion of wild fish that were taken into the hatchery the previous generation **AND** the wild population is increasing in abundance at a rate at least equal to the proportion of naturally spawning hatchery-origin fish | M | Broodstock undetermined but key project design element will be to find appropriate broodstock. Alternatives to be considered would be sufficiently removed from Skokomish River that adult returns from project to donor population would be few to none. |

## Hazard III:  Reduction in Effective Population Size

| | | |
|---|---|---|
| **OR**<br>The target wild population is believed to be in substantial danger of extinction within the next 35 years **AND** the effective number of breeders in the hatchery is as large as possible given the available broodstock.<br>**OR**<br>**The project is to reintroduce fish to a location removed from the target population with likelihood of less than 5-15% return to target population.** | | |

## Hazard IV: Loss of Within Population Diversity

| **Source: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Broodstock source is not already substantially domesticated. | H | Broodstock undetermined but expect to meet criterion. |

| **Source:  Broodstock collection** | | |
|---|---|---|
| Distributions of morphological, behavioral or life-history traits (e.g. run or spawn timing, size, appearance, age structure, etc) will be collected for target population. | H | Expect trained staff will record pertinent biological data. |
| Multi-trait distribution of broodstock sample closely matches the multi-trait distribution of target population (e.g. similar run and spawn timing, size, appearance, age structure, etc). | M | Broodstock collection parameters unknown but key element will be to obtain close match to target population. |
| Collection is technically and logistically possible (e.g. site is accessible throughout run, weirs have reasonable chance of continuous operation throughout season, necessary staff are available to carry out collection, funding is available to measure traits, etc). | M | Unknown but will be key element of project. |
| The effective population size will be maintained by collecting a minimum of 50 pairs except where the total population is less than 100 fish. | M | Criterion will be incorporated in plan. |

| **Source:  Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration)** | | |
|---|---|---|
| The minimum standard for matings will be one male per female. | M | One to one or factorial matings will be project objective. |
| Mating and rearing methods are similar enough  to those observed in the wild to avoid substantial domestication selection pressure<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Project will be of short duration  - not to exceed 12 years. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration) (cont.)** | | |
|---|---|---|
| Hatchery progeny will be released at essentially the same sizes and life-history stages as observed in the target population at the time of release<br>**OR**<br>Hatchery program will be of short duration (3 generations)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Hatchery progeny to be reared to 1 gram size before release; however, program will be of short duration. |

| **Source: Hatchery-induced genetic swamping (Ryman-Laikre effect)** | | |
|---|---|---|
| Broodstocking does not collect a small fraction of the spawner population and, through use of hatchery operation, generate a subsequent large proportion of the natural spawning population. | M | Broodstocking limitations undetermined but key element of project will be to avoid this effect. |

## Hazard V: Loss of Among Population Diversity

| **Source of hazard: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| All the discrete populations within the watershed containing the target population have been correctly identified. | H | Unknown broodstock source but expect to meet criterion. |
| Selected broodstock source is substantially genetically similar to target population. | H | Broodstock source will be target population. |
| Broodstock used for direct reintroduction is used only for one site. | H | General requirement for all projects. |

| **Source: Broodstock collection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| It will be possible to collect at a location and time such that only the target population will be collected. | H | Broodstock undetermined at this time but expect to meet criterion. |

| **Source: Straying** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Hatchery fish will be reared to release size in the watershed targeted for supplementation or reintroduction. | H | Locating facilities in watershed will be key element of project. |
| Hatchery fish will be marked to provide effective estimation of straying. | H | Fish will be marked to differentiate hatchery-origin and natural-origin spawners within watershed. |
| Adjacent spawning populations will be effectively monitored to detect straying. | L | Undetermined at this time. |

## Hazard VI: Masking of Population Status

| Criteria | Probability | Notes |
|---|---|---|
| A sufficient proportion of hatchery fish are marked to estimate hatchery/wild ratios on the spawning grounds. | H | Expect to provide for adequate marking. |
| Sufficient wild spawning areas are surveyed to estimate hatchery/wild ratios accurately. | M | Expect would be key element to plan for operations. |
| Proportion of hatchery fish on spawning grounds is (or will be) less than 5-15%<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>Returning hatchery fish will spawn primarily in habitat currently underutilized by natural spawners of the same species. | H | Returning hatchery fish will spawn in habitat currently underutilized and project will be of short duration. |

# Anderson Project

## Hazard I: Hatchery Failure

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery personnel live on-site to allow rapid response to water source or power failures. | M | Site and personnel undetermined. |
| Low pressure/low water alarms functioning for water supplies serving summer chum incubation and rearing areas. | M | Specific project design not yet determined. |
| All hatchery personnel responsible for rearing fish trained in standard fish propagation and fish health methods. | H | Expect experienced volunteers and trained WDFW staff support. |
| Incubation and rearing facilities are sited in areas that are not prone to flooding. | M | Expect to site project at site with low risk of flooding. |

## Hazard II: Ecological Effects

| Criteria | Probability | Notes |
|---|---|---|
| Propagated summer chum are released at a life stage (1 gram fed fry) and time (March-April) that will reduce the risk of predation and competition effects on wild fish. | H | Will be key design element. |
| Summer chum are reared to release size on ground or surface water within the watershed targeted for supplementation or reintroduction. | H | Water source would be within watershed. |
| Fish health practices developed by the co-managers are applied in all hatchery activities to minimize the risk of fish disease occurrence, transmittal, and catastrophic loss. | H | Expected WDFW staff support would ensure proper procedures and treatment. |

## Hazard III: Reduction in Effective Population Size

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish are marked to accurately estimate proportion of hatchery fish spawning naturally in target population and proportion of wild fish spawning in hatchery. | H | Expect to be key element to plan for operations. |
| Natural spawning is regularly monitored to accurately estimate the proportion of hatchery fish spawning in target population. | M | Expect to be key element to plan for operations. |
| In the target population, the proportion of natural spawners that are hatchery fish is approximately equal to the proportion of wild fish that were taken into the hatchery the previous generation<br>**OR**<br>In the target population, the proportion of natural spawners that are hatchery-origin fish is larger than the proportion of wild fish that were taken into the hatchery the previous generation **AND** the wild population is increasing in abundance at a rate at least equal to the proportion of naturally spawning hatchery-origin fish | M | Broodstock undetermined but key project design element will be to find appropriate broodstock. Alternatives to be considered would be sufficiently removed from Anderson Creek that expected adult returns from project to donor population would be few or none. |

## Hazard III: Reduction in Effective Population Size

| | | |
|---|---|---|
| **OR**<br>The target wild population is believed to be in substantial danger of extinction within the next 35 years **AND** the effective number of breeders in the hatchery is as large as possible given the available broodstock.<br>**OR**<br>**The project is to reintroduce fish to a location removed from the target population with likelihood of less than 5-15% return to target population.** | | |

## Hazard IV: Loss of Within Population Diversity

| **Source: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Broodstock source is not already substantially domesticated. | H | Broodstock undetermined but unlikely to be domesticated. |

| **Source: Broodstock collection** | | |
|---|---|---|
| Distributions of morphological, behavioral or life-history traits (e.g. run or spawn timing, size, appearance, age structure, etc) will be collected for target population. | H | Expect trained staff will record pertinent biological data. |
| Multi-trait distribution of broodstock sample closely matches the multi-trait distribution of target population (e.g. similar run and spawn timing, size, appearance, age structure, etc). | M | Broodstock collection parameters unknown but key element will be to obtain close match to target population. |
| Collection is technically and logistically possible (e.g. site is accessible throughout run, weirs have reasonable chance of continuous operation throughout season, necessary staff are available to carry out collection, funding is available to measure traits, etc). | M | Unknown but will be key element of project. |
| The effective population size will be maintained by collecting a minimum of 50 pairs except where the total population is less than 100 fish. | M | Criterion will be incorporated in plan. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration)** | | |
|---|---|---|
| The minimum standard for matings will be one male per female. | M | One to one or factorial matings will be a project objective. |
| Mating and rearing methods are similar enough to those observed in the wild to avoid substantial domestication selection pressure<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Project will be of short duration - not to exceed 12 years. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration) (cont.)** | | |
|---|---|---|
| Hatchery progeny will be released at essentially the same sizes and life-history stages as observed in the target population at the time of release<br>**OR**<br>Hatchery program will be of short duration (3 generations)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Hatchery progeny to reared to 1 gram size before release; however, program will be of short duration. |

| **Source: Hatchery-induced genetic swamping (Ryman-Laikre effect)** | | |
|---|---|---|
| Broodstocking does not collect a small fraction of the spawner population and, through use of hatchery operation, generate a subsequent large proportion of the natural spawning population. | M | Broodstocking limitations undetermined but key element of project will be to avoid this effect. |

## Hazard V: Loss of Among Population Diversity

| **Source of hazard: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| All the discrete populations within the watershed containing the target population have been correctly identified. | H | Unknown broodstock source but expect to meet criterion. |
| Selected broodstock source is substantially genetically similar to target. | H | Broodstock source will be target population. |
| Broodstock used for direct reintroduction is used only for one site. | H | General requirement for all projects. |

| **Source: Broodstock collection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| It will be possible to collect at a location and time such that only the target population will be collected. | H | Broodstock undetermined at this time but expect to meet criterion. |

| **Source: Straying** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Hatchery fish will be reared to release size in the watershed targeted for supplementation or reintroduction. | H | Location of facilities in watershed will be key element of project. |
| Hatchery fish will be marked to provide effective estimation of straying. | H | Fish will be marked to differentiate hatchery-origin and natural-origin spawners within watershed. |
| Adjacent spawning populations will be effectively monitored to detect straying. | L | Undetermined at this time. |

## Hazard VI:  Masking of Population Status

| Criteria | Probability | Notes |
|---|---|---|
| A sufficient proportion of hatchery fish are marked to estimate hatchery/wild ratios on the spawning grounds. | H | Expect to provide for adequate marking. |
| Sufficient wild spawning areas are surveyed to estimate hatchery/wild ratios accurately. | M | Expect would be key element to plan for operations. |
| Proportion of hatchery fish on spawning grounds is (or will be) less than 5-15%<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>Returning hatchery fish will spawn primarily in habitat currently underutilized by natural spawners of the same species. | H | Returning hatchery-origin fish will spawn in habitat currently not utilized and project would be of short duration. |

# Finch Project

## Hazard I:  Hatchery Failure

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery personnel live on-site to allow rapid response to water source or power failures. | M | On-site living is possibility if existing hatchery facilities are used. |
| Low pressure/low water alarms functioning for water supplies serving summer chum incubation and rearing areas. | M | Alarm system exists if hatchery facilities in watershed are used. |
| All hatchery personnel responsible for rearing fish trained in standard fish propagation and fish health methods. | H | Expect experienced volunteers and trained WDFW staff support. |
| Incubation and rearing facilities are sited in areas that are not prone to flooding. | M | Expect to site project at site with low risk of flooding. |

## Hazard II: Ecological Effects

| Criteria | Probability | Notes |
|---|---|---|
| Propagated summer chum are released at a life stage (1 gram fed fry) and time (March-April) that will reduce the risk of predation and competition effects on wild fish. | H | Will be key design element. |
| Summer chum are reared to release size on ground or surface water within the watershed targeted for supplementation or reintroduction. | H | Water source would be within watershed. |
| Fish health practices developed by the co-managers are applied in all hatchery activities to minimize the risk of fish disease occurrence, transmittal, and catastrophic loss. | H | Expected WDFW staff support would ensure proper procedures and treatment. |

## Hazard III:  Reduction in Effective Population Size

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish are marked to accurately estimate proportion of hatchery fish spawning naturally in target population and proportion of wild fish spawning in hatchery. | H | Expect to be key element to plan for operations. |
| Natural spawning is regularly monitored to accurately estimate the proportion of hatchery fish spawning in target population. | H | Presence of hatchery rack facilitates monitoring. |
| In the target population, the proportion of natural spawners that are hatchery fish is approximately equal to the proportion of wild fish that were taken into the hatchery the previous generation,<br>**OR**<br>In the target population, the proportion of natural spawners that are hatchery-origin fish is larger than the proportion of wild fish that were taken into the hatchery the previous generation **AND** the wild population is increasing in abundance at a rate at least equal to the proportion of naturally spawning hatchery-origin fish, | M | Broodstock undetermined but key project design element will be to find appropriate broodstock. Alternatives to be considered would be sufficiently removed from Finch Creek that expected adult returns from project to donor population would be few or none. |

## Hazard III: Reduction in Effective Population Size

| | | |
|---|---|---|
| **OR**<br>The target wild population is believed to be in substantial danger of extinction within the next 35 years **AND** the effective number of breeders in the hatchery is as large as possible given the available broodstock,<br>**OR**<br>**The project is to reintroduce fish to a location removed from the target population with likelihood of less than 5-15% return to target population.** | | |

## Hazard IV: Loss of Within Population Diversity

| **Source: Broodstock selection** | | |
|---|---|---|
| Criteria | Probability | Notes |
| Broodstock source is not already substantially domesticated. | H | Broodstock undetermined but unlikely to be domesticated. |

| **Source: Broodstock collection** | | |
|---|---|---|
| Distributions of morphological, behavioral or life-history traits (e.g. run or spawn timing, size, appearance, age structure, etc) will be collected for target population. | H | Expect trained staff will record pertinent biological data. |
| Multi-trait distribution of broodstock sample closely matches the multi-trait distribution of target population (e.g. similar run and spawn timing, size, appearance, age structure, etc). | M | Broodstock collection parameters unknown but key element will be to obtain close match to target population. |
| Collection is technically and logistically possible (e.g. site is accessible throughout run, weirs have reasonable chance of continuous operation throughout season, necessary staff are available to carry out collection, funding is available to measure traits, etc). | M | Unknown but will be key element of project. |
| The effective population size will be maintained by collecting a minimum of 50 pairs except where the total population is less than 100 fish. | M | Criterion will be incorporated in plan. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration)** | | |
|---|---|---|
| The minimum standard for matings will be one male per female. | M | One to one or factorial matings will be a project objective. |
| Mating and rearing methods are similar enough to those observed in the wild to avoid substantial domestication selection pressure<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Project will be of short duration - not to exceed 12 years. |

| **Source: Mating, rearing and release methods (degree of difference between wild and hatchery environments and duration) (cont.)** | | |
|---|---|---|
| Hatchery progeny will be released at essentially the same sizes and life-history stages as observed in the target population at the time of release<br>**OR**<br>Hatchery program will be of short duration (3 generations)<br>**OR**<br>The proportion of natural spawners that are hatchery-origin fish in the target population is less than 5-15%. | H | Hatchery progeny to reared to 1 gram size before release; however, program will be of short duration. |

| **Source: Hatchery-induced genetic swamping (Ryman-Laikre effect)** | | |
|---|---|---|
| Broodstocking does not collect a small fraction of the spawner population and, through use of hatchery operation, generate a subsequent large proportion of the natural spawning population. | M | Broodstocking limitations undetermined but key element of project will be to avoid this effect. |

## Hazard V: Loss of Among Population Diversity

**Source of hazard: Broodstock selection**

| Criteria | Probability | Notes |
|---|---|---|
| All the discrete populations within the watershed containing the target population have been correctly identified. | H | Unknown broodstock source but expect to meet criterion. |
| Selected broodstock source is substantially genetically similar to target. | H | Broodstock source will be target population. |
| Broodstock used for direct reintroduction is used only for one site. | H | General requirement for all projects. |

**Source: Broodstock collection**

| Criteria | Probability | Notes |
|---|---|---|
| It will be possible to collect at a location and time such that only the target population will be collected. | H | Broodstock undetermined at this time but expect to meet criterion. |

**Source: Straying**

| Criteria | Probability | Notes |
|---|---|---|
| Hatchery fish will be reared to release size in the watershed targeted for supplementation or reintroduction. | H | Location of facilities in watershed will be key element of project. |
| Hatchery fish will be marked to provide effective estimation of straying. | H | Fish will be marked to differentiate hatchery-origin and natural-origin spawners within watershed. |
| Adjacent spawning populations will be effectively monitored to detect straying. | L | Undetermined at this time. |

## Hazard VI: Masking of Population Status

| Criteria | Probability | Notes |
|---|---|---|
| A sufficient proportion of hatchery fish are marked to estimate hatchery/wild ratios on the spawning grounds. | H | Expect to provide for adequate marking. |
| Sufficient wild spawning areas are surveyed to estimate hatchery/wild ratios accurately. | H | Presence of hatchery rack facilitates monitoring. |
| Proportion of hatchery fish on spawning grounds is (or will be) less than 5-15%<br>**OR**<br>Hatchery program will be of short duration (3 generations equal to 12 years)<br>**OR**<br>Returning hatchery fish will spawn primarily in habitat currently underutilized by natural spawners of the same species. | H | Returning hatchery-origin fish will spawn in habitat currently not utilized and project would be of short duration. |

# Appendix Report 3.5
# Estuarine Landscape Impacts on Hood Canal and Strait of Juan de Fuca Summer Chum Salmon and Recommended Actions

by
Charles A. Simenstad[1]

## Introduction

Summer chum salmon rely on natural features and processes of estuarine and nearshore habitats during their juvenile rearing in subestuary[2] deltas and migration through Hood Canal and the eastern Strait of Juan de Fuca (Appendix Figure 3.5.1). Watershed and summer chum population factors that influence timing and condition of fry emigration to deltas are often disconnected from carrying capacity conditions affecting productivity and carrying capacity within the deltas. These within-delta factors are in turn often independent of factors over the broader migratory route of summer chum during their vulnerable transition to the North Pacific Ocean. However, research on the estuarine ecology of juvenile salmon has typically focused on subestuarine delta, and particularly emergent wetland, habitats but much less on salmonid use of nearshore marine habitats that interconnect deltas in estuarine inland sea systems such as Hood Canal, Puget Sound and the Strait of Juan de Fuca. By bridging the widely dispersed deltas, natural nearshore "landscape linkages" of natural beaches, eelgrass beds and unimpacted drift cells provide productive, protected migratory corridors for summer chum to span delta rearing areas and effectively transition to open-water migration (Appendix Figure 3.5.2). Cumulative impacts on the integrity of these nearshore corridors threaten not only the function of the corridors but also the opportunity to exploit the intervening delta habitats. This report addresses the need for a broader, landscape perspective and assessment of the role of these nearshore corridors in the early estuarine-marine life history of summer chum. In justifying this argument, I describe: 1) the regional and watershed setting, 2) pertinent genetic and life history characteristics of summer chum, 3) estuarine landscape structure and how anthropogenic changes have altered its function, 4) a conceptual model of summer chum rearing and migration, 5) important aspects of the response by summer chum to landscape structure and these changes, and 6) research and management gaps required to incorporate estuarine landscape structure into recovery efforts for summer chum.

As with almost all other fisheries science approaches to anadromous fishes, accounting for factors that have likely led to the decline of summer chum salmon, as well as considerations of recovery

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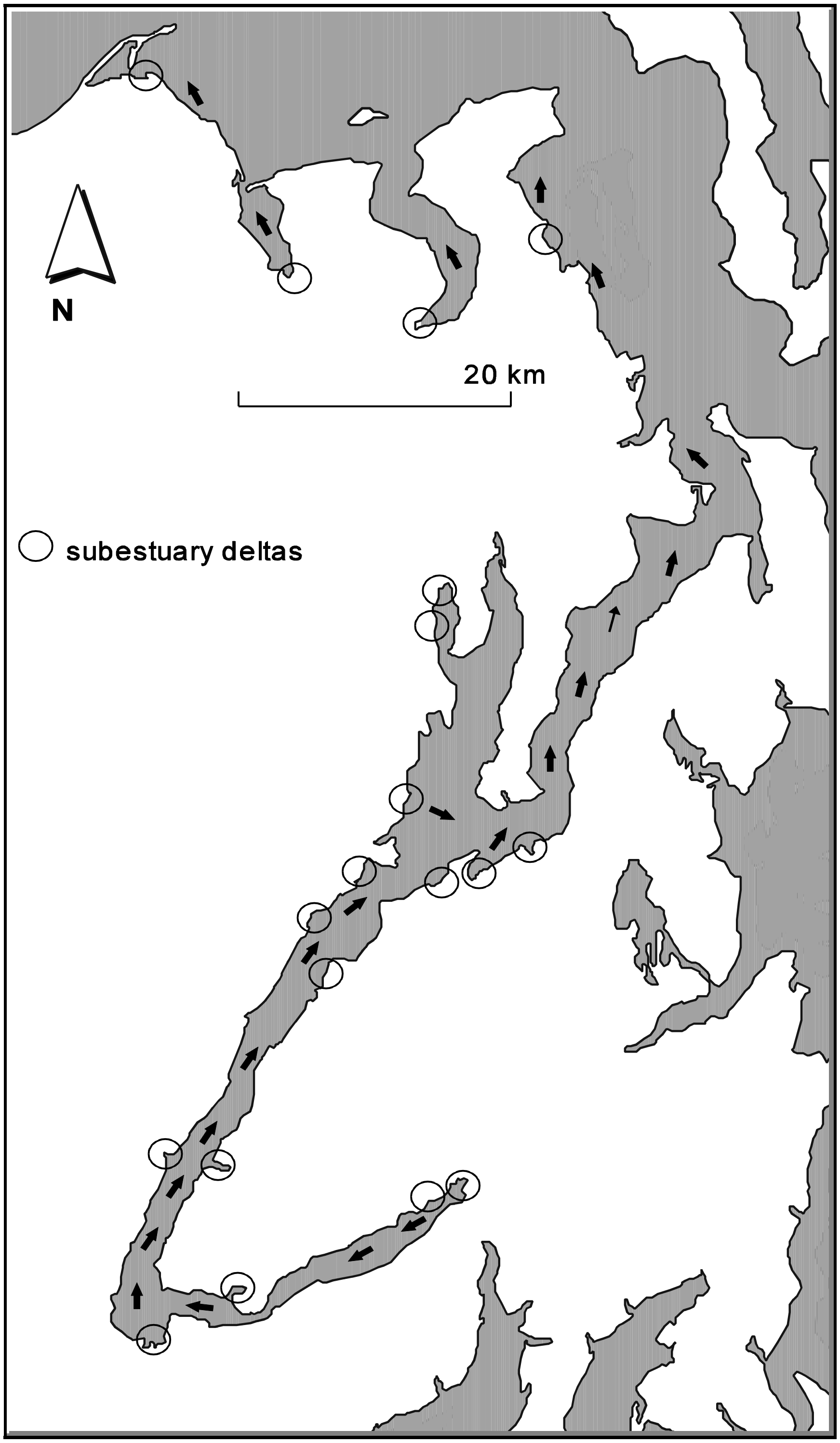
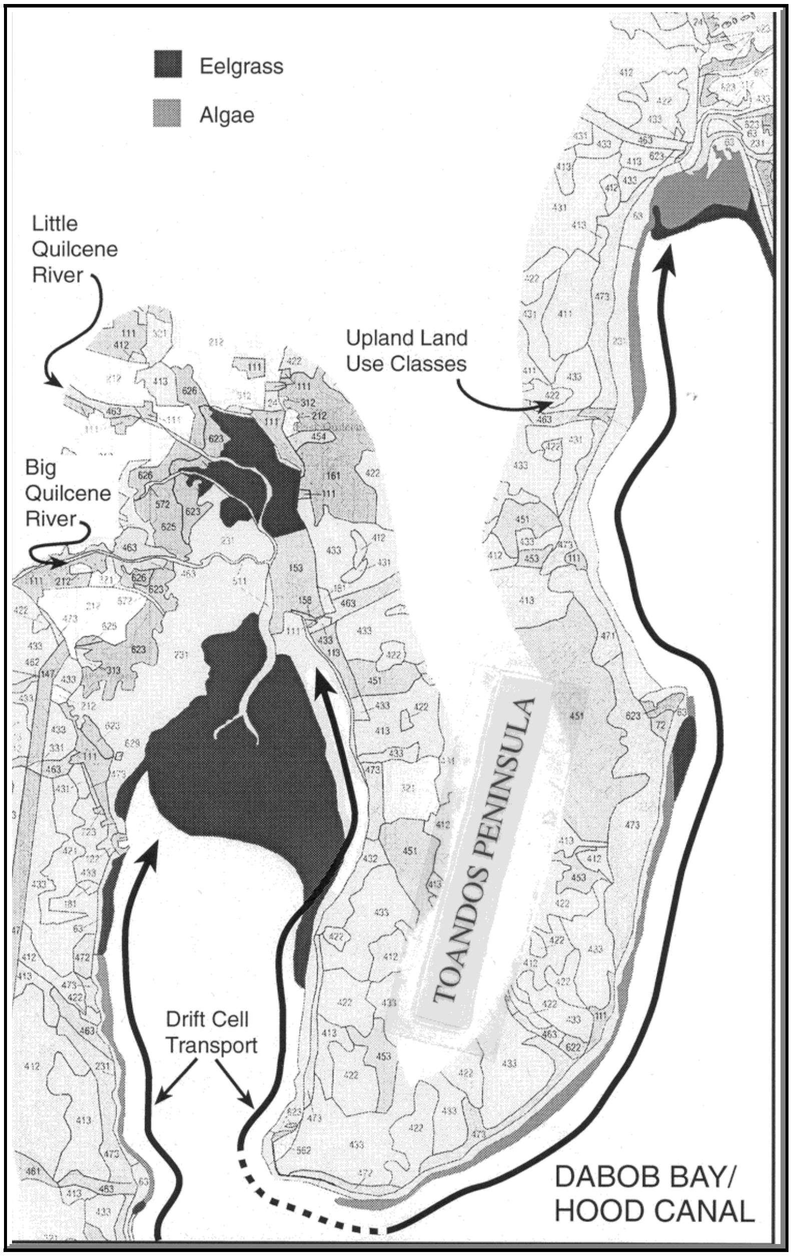
[1] Coordinator of the Wetland Ecosystem Team - School of Fisheries, University of Washington. Report prepared for the Point No Point Treaty Council (January 1998).

[2] The term *subestuary* is herein used to define estuarine deltas at the termini of watersheds, while the receiving body of water, perhaps more appropriately termed an *inland sea*, is still technically an estuary because, although it encloses a number of subestuaries, freshwater is measurably diluted by seawater.

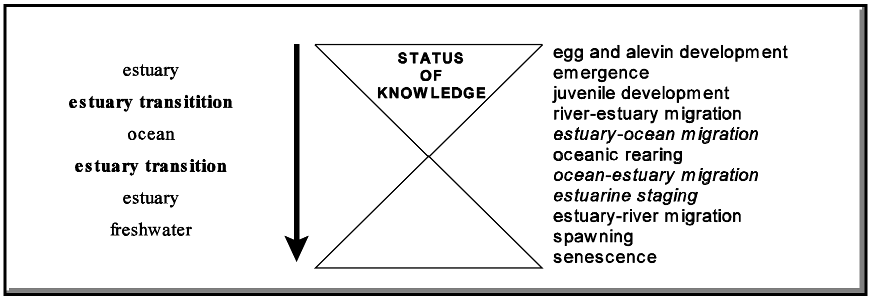


**Appendix Figure 3.5.1.** Nearshore movement (black arrows) of juvenile summer chum among subestuary deltas (circles) in Hood Canal and eastern Strait of Juan de Fuca that are important estuarine rearing habitats and migratory corridors. Primary corridors for fry early after their entry into Hood Canal are focused tightly along the shoreline, but as the fish grow larger they appear more frequently in open water and will cross the Canal (as indicated by some arrows in the middle of the Canal).



**Appendix Figure 3.5.2.** Segment of Jefferson County (upper Dabob Bay) of Washington Coastal Zone Atlas showing delta and shoreline migratory habitats of juvenile summer chum; Big and Little Quilcene rivers delta occupy left center of image, while portion of Tarboo Creek estuary is in upper right. This original Atlas map has been enhanced to illustrate eelgrass (dark gray-black) and algae (stippled light gray) habitats and direction of along-shore drift (arrows). Note contrast between broad expanses of eelgrass and algae habitats on estuarine deltas with the narrow, confined migratory corridors along shorelines that are often interrupted. Indicated nearshore drift is from Johannessen (1992).

initiatives, has traditionally conformed to an "hourglass" distribution relative to their life history (Appendix Figure 3.5.3). That is, the basis of knowledge and attribution of importance to the survival and resilience of summer chum has predominantly centered on freshwater phases of their life history and diminished with transition to and from their oceanic phase. This is particularly the case for the "estuary transition" phases where juvenile chum salmon are still confined to shallow water habitats but for a variety of behavioral and ecological mandates are migrating beyond the subestuary directly associated with their watershed of origin. Next to chinook salmon, juvenile chum salmon have been described as the species most dependent on estuaries (Healey 1982; Levy and Northcote 1982; Simenstad et al. 1982; Salo 1991). This "dependence" is inferred from extended residence time (average individual residence time ~25 days; Simenstad et al. 1982) that is assumed to result in rapid growth and larger size at emigration from the estuary in an environment of comparatively lower predation rate.



**Appendix Figure 3.5.3** Status of knowledge about salmon ecology as a function of life history stanzas.

A multitude of factors, including size and physiological condition upon entry, available prey, surface outflow, shoreline habitat structure, refugia from predators, can potentially influence residence time in an estuary like Hood Canal because the rate of migration is influenced heavily by the carrying capacity of the estuarine environment and the ecophysiological state of the fish. Most research that provides insight into these factors originates from distinct subestuaries at the termini of major rivers and watersheds that have large chum salmon populations. Other than the earlier investigations of juvenile chum salmon distribution in the Strait of Georgia (e.g., Robinson 1969) and Hood Canal (e.g., Salo et al. 1980, Wissmar and Simentad 1988), there has been very little research on the larger scale of juvenile chum salmon ecology, as they migrate among subestuaries along the "estuarine landscape" before entering the North Pacific Ocean.

## Regional Watershed and Estuarine Structure

As for many anadromous fishes, salmon have developed diffuse population and life history traits that indicate strong natural selection in response to variation in aquatic, estuarine and ocean environments. Life history traits can reflect both watershed-subestuary variation as well as whole-system variability. Summer chum of the Hood Canal and eastern Strait of Juan de Fuca region have evolved in a complex landscape and estuarine setting, with strong regional variation in land form, riverine inflow, and estuarine circulation and habitat structure. Furthermore, human modifications to these regional characteristics have introduced both cumulative and far-reaching impacts to the estuary. To effectively assess the decline of summer chum salmon populations, as well as their recovery, the larger estuarine landscape scale as well as the watershed-estuary scale must be considered.

Hood Canal straddles a sharp break in landform, between the Olympic Mountains to the west and the Willamette-Puget Lowland to the east, with it's watersheds positioned on quaternary and Tertiary volcanic rocks or Upper and Lower Tertiary sedimentary rocks, and strongly divided between ultisol (haplohumult) soils on the west and inceticol (haplumbrept, with some cryumbrept) soils on the east (Jackson and Kimerling 1993). The Olympic Mountains produce a strong influence on seasonal precipitation and riverflow on the western region, with up to 2.5 m mean annual runoff within the watersheds draining into the western side of Hood Canal, 1.5-2.0 m on the southern edge of the Olympics, ~1 m on the lowlands draining into the eastern side, and <0.5 m in the "rain shadow" of some regions of the eastern Strait of Juan de Fuca. As a result, rivers draining into Hood Canal from the eastern Olympics have average flows of between 10 (e.g., Hamma Hamma) and 43 $m^3s^{-1}$ (e.g., Elwha), but with peak flows as high as 250 (Duckabush) to 760 $m^3s^{-1}$ (Skokomish). In contrast, streams on the eastern side draining the Kitsap Peninsula have very low flows (e.g., $< 0.01\ m^3s^{-1}$) especially in late summer and early fall. Land use in the watershed is heavily oriented toward forest harvest, with some pasture and very little cropland.

Hood Canal is a fjord type of estuary: long (100 km), narrow (0.8-6.4 km; avg. 2.4 km) and deep (avg. >150 m) with glacial sills that restrict circulation. Because of this structure, except under strong wind forcing, the water column of the Canal is usually highly stratified, with a shallow lens of fresh to brackish water at the surface overlaying waters of near-ocean salinity. Due to the sills, water exchange and turnover are limited and residence time long, especially in the southern reaches of the Canal and Dabob Bay, and cold, nutrient-rich upwelling water from the North Pacific intrudes only in late summer (Friebertshauser et al. 1971; Yoshinaka and Ellifrit 1974; Strickland 1983).

The Strait of Juan de Fuca (shared to a lesser degree with the Strait of Georgia) is the primary point of exchange between oceanic and Puget Sound waters and the migration route of most juvenile summer chum from Hood Canal to the North Pacific Ocean. The deep, fjord structure of the eastern Strait was excavated by the advancement and retreat of the Strait of Juan de Fuca lobe of the Cordilleran Ice Sheet (Burns 1985). It's gently sloping U-shaped cross-channel profile is 18 km wide at it's narrowest point (Race Rocks-Angeles Pt.) and its depth is >150 m except over the shallow (55 m) glacial sill that spans the eastern end south from Victoria, B.C. (Thomson 1981). Unlike the strong salinity stratification in Hood Canal, salinity distribution in the Strait is more of an estuarine "salt wedge" but salinities are still >31 ppt except in the spring when freshwater outflow from Puget Sound and the Fraser River drop surface waters to 28-30 ppt. Due to the stronger wind, wave and current regimes in the eastern Strait (Downing 1983), shoreline habitats are much more dynamic and dominated by steeper, coarser sediments than in Hood Canal. However, Discovery, Sequim and Dungeness bays that are the termini of watersheds supporting summer chum tend to be more protected and are characterized by beach environments similar to Hood Canal.

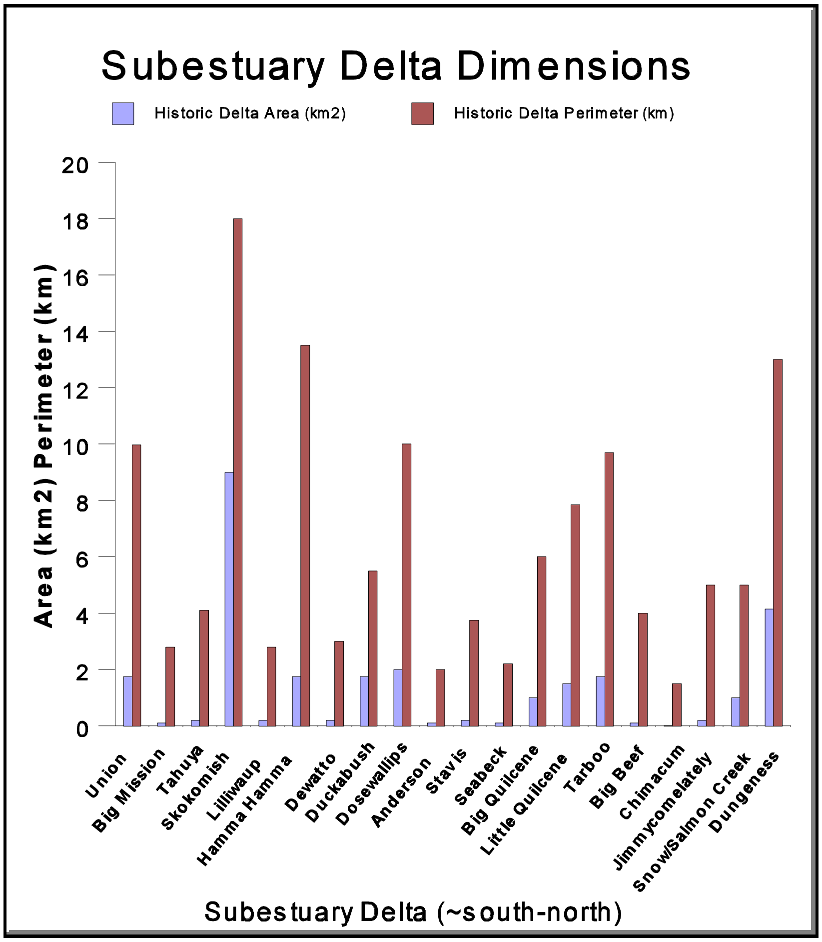
## Genetic and Life History Characteristics of Summer Chum Populations

Summer chum have evolved into discrete metapopulations that reflect their estuarine rearing, as well as their watershed spawning and incubating, setting within each watershed. Likely reflecting the regional physiography over which they reproduce and rear, summer chum salmon from Hood Canal and the eastern Strait of Juan de Fuca are genetically isolated from other chum salmon populations in the region (Johnson et al. 1997). In fact, the genetic structure (based on 34 loci) of the nine summer chum stocks analyzed by Johnson et al. (1997) were entirely displaced from other chum stocks (including four southern Puget Sound summer chum) on the basis of multidimensional scaling in two dimensions of chord genetic differences. Within the Hood Canal-eastern Strait of Juan de Fuca region, visible separation (based on graphical interpretation) was also evident for populations of 1) the five eastern Olympic Mountains watersheds from those of 2) a southern Canal (Union) river, and 3) three eastern Strait of Juan de Fuca rivers. Internal variation was apparently high even within these groupings, as indicated by the separation among the three eastern Strait of Juan de Fuca rivers. Earlier (Wright 1978, cited in WDFW and WWTIT 1994) classification of Hood Canal summer chum stocks based on genetic distance indicated strongest affinities among the Union River and other Hood Canal stocks but more distinct separation from the Jimmycomelately Creek (Sequim Bay) and Salmon and Snow creeks (Discovery Bay) stocks.

While there is little comprehensive documentation of life history characteristics among Hood Canal and eastern Strait of Juan de Fuca summer chum populations, comparison of river entry and spawning timing for several rivers groupings also indicates comparable variation that may correspond to regional physiography and genetic distinction. The window of river entry for the Union River (early August past mid-September) is earlier than at other Hood Canal and eastern Strait of Juan de Fuca (Discovery Bay) streams (early September past mid-October) (Johnson et al. 1997). Spawning may be even more distinct: late August to early October in the Union River (greater delay between river entry and spawning); early September past mid-October in the eastern Strait of Juan de Fuca (short to no delay); and, mid-September to late October in other Hood Canal rivers (shorter delay than Union River). This suggests that, if the Union River is representative, juveniles from the southern Hood Canal populations will be entering the Canal earlier than the central and northern Hood Canal fish, particularly if river temperatures in the Olympic Mountains watersheds are significantly lower than the Puget Lowland rivers, promoting more rapid egg and alevin development. Thus, there are genetic traits to physiographically separated populations that have significant implications to estuarine utilization by summer chum.

## Estuarine Landscape Structure

The fjord estuary structure of Hood Canal, Puget Sound and the Strait of Juan de Fuca is particularly important to the linkage of watersheds and subestuary deltas supporting summer chum as they emigrate from freshwater and migrate seaward. Because juvenile salmon tend to migrate in surface waters, and in particularly shallow water as fry early in their estuarine life history, they are somewhat confined to migratory corridors between these subestuary patches that are distributed along the shoreline adjacent to the deeper, open waters of the Canal, Admiralty Inlet and the eastern Strait of Juan de Fuca (see Conceptual Model section, below). Thus, while the broad expanses of intertidal delta habitats (emergent marsh, mudflat, eelgrass, dendritic channels) at the subestuary termini of the major watersheds comprise expansive rearing habitats (Appendix Figure 3.5.2; but see individual subestuary accounts that describe proportional and qualitative loss of habitat), these deltas are relatively dispersed "patches" along the deep channel "matrix" of the fjord axis (Appendix Figure 3.5.1). Eleven of the twenty deltas (55%) are less than 1 km$^2$ in area, and only two are >2 km$^2$. The largest deltas (Skokomish, Dosewallips, Dabob Bay deltas, Dungeness) are widely separated along the >150 km distribution of summer chum systems. Thus, the estuarine rearing capacity for summer chum fry early in their seaward migration is a function of the interlinked *system* of subestuary deltas and shallow nearshore corridors.



**Appendix Figure 3.5.4.** Estimated historic dimensions of subestuary deltas within documented summer chum distribution; see earlier subestuary descriptions for methodology in estimating historic delta areas.

The resulting summer chum salmon migratory corridors between subestuary deltas tend to be composed of a relatively higher energy, narrow intertidal-shallow subtidal beaches of moderate gradient and usually comprised of mixed cobble, gravel and coarse sand (Appendix Figure 3.5.4). Natural beach erosion and shoreline drift maintain these beach processes that continuously supply, transport and deposit sediments along discrete beach "drift cells" or "drift sectors."[3] Important zones within drift cells are the areas of sediment origin or 'source zones,' the 'transport zone' of prominent longshore drift, and the termini or 'sink zones' where drift cells end by either sediment accretion or by transport into deeper water (Canning and Shipman 1994).

Perhaps one of the most important habitats for summer chums salmon within this zone is a typically dense band of the native eelgrass, *Zostera marina*. Eelgrass provides a vast array of direct (i.e., "habitat") functions in support of estuarine biota but may be equally as important as one of the, if not *the*, major sources of organic matter to intertidal/shallow subtidal food webs in Hood Canal (Simenstad and Wissmar 1985). Eelgrass is somewhat constrained to a longitudinal patch concentrated in tidal elevations between +1 m (in areas of low elevation gradient) to -2 m (but may occur as deep as -6.6 m in extremely clear waters; Phillips 1984) relative to MLLW. This eelgrass corridor is often (in the absence of shoreline development) contiguous within a drift cell but also occurs in fragmented patches between drift cells, depending upon the nature of the shoreline at convergence of drift cells.

Thus, the steeper the beach gradient and more turbid the waters, the narrower the eelgrass corridor. Eelgrass recruits to and persists optimally in mud or muddy-sand to sandy-gravel substrates (Phillips 1984) and can be inhibited by shifts to coarser substrates (e.g., gravel, cobble) and by shading, including by overwater structures such as docks (see Simenstad et al. 1998). Other prominent habitats that are integrated with the eelgrass corridor are macroalgae and kelps and mud- and sandflats. From a variety of ecological standpoints, the functions of this beach landscape for migrating juvenile summer chum should be viewed as the *net* effect of the arrangement of habitat patches, rather than the independent effect of any one habitat.

There are two other scales of this landscape that should also be considered beyond drift cell segments. The next step in the hierarchy of scale is the "nearshore reach" between subestuary deltas that are often composed of multiple drift cell segments. The number of segments would often dictate the extent of eelgrass corridor connectivity between subestuary delta rearing areas for summer chum. The other scale of importance involves the larger physiographic areas of embayments and 'clusters' of deltas (Appendix Figure 3.5.1). In this respect, the location and position of the southern "Big Bend," Dabob Bay, Discovery and Sequim bays will also play a role in terms of summer chum interaction with the estuarine landscape, depending upon the origin of migrating fry.

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[3] Drift cells have been mapped for the Hood Canal region, covering Kitsap and Jefferson counties, by Schwartz et al. (1991) and Johannessen (1992). It is beyond the scope of this report to describe drift cell structure and processes in detail.

## Human Alterations of Estuarine Landscape Structure Likely Impacting Juvenile Summer Chum

Human alterations of the subestuary deltas have been described earlier. While some of the same human alterations to these deltas (e.g., filling, excavation, and jetties) also occur along the nearshore corridors, a number of modifications impose particular impacts to these beach habitats. Acute impacts, involving relatively permanent loss of habitat by filling or excavation that are common in some of the Hood Canal subestuary deltas are not necessarily as prevalent in the intervening shorelines between these deltas. However, shoreline development has caused some direct and considerable indirect impacts in these reaches. Among those documented to cause impacts are intertidal fills, installation of bulkheads and docks and destruction of shoreline vegetation. Bulkheads that intrude into the intertidal zone increase the rate of beach erosion by intensifying the wave energy regime, causing the coarsening of sediments (Macdonald et al. 1994; Canning and Shipman 1995). Bulkheads and other beach armoring or "hardening" also inhibit or eliminate sources of beach sediment material in the source regions of drift cells. Both of these factors decrease the amount and maintenance of fine-sediment structure to shorelines, which can ultimately alter habitat structure from eelgrass and other mixed-fine substrate communities to more coarse substrate communities with less habitat value for migrating salmon fry (Thom and Shreffler 1994). The consequence is either fragmentation or loss of eelgrass as a viable migratory corridor and degradation of habitat for prey and salmon foraging. Low (intertidal) elevation bulkheads, other types of fills, and docks can force fry from shallow water into deeper water, where risk to predation may be significantly higher. Shading and the physical structure from docks also eliminates eelgrass and/or prevents its recruitment. Removal of shoreline vegetation reduces shade and import of large woody debris (LWD), which impacts the supply of terrestrial insects (that salmon also feed on), epibenthic prey resources, and the spawning habitat of baitfish which are prey resources of larger juvenile and resident salmon.

Other potential impacts that are suspected but have not been thoroughly evaluated include boat activity, leakage of septic tanks, and some aquaculture and shellfish harvesting methods. Associated boat activity can result in propeller scouring of benthic communities and potentially remove whole segments of eelgrass patches. Leaking septic tanks could enter beach habitats and cause nutrient enrichment along beach groundwater seepage zones, and concordant response by macroalgae if excessive could cause localized areas of intense organic decomposition and sediment anoxia. Some shellfish aquaculture practices, such as diking and mechanical harvesting can be deleterious to eelgrass under some conditions, but the scale (size, intensity or frequency) of disturbance must be of significant threshold to cause impact. For instance, the impact of beach graveling and predator exclusion netting for clam enhancement on juvenile salmon prey resources depends upon the scale of application (Simenstad and Fresh 1995). Harvesting of natural shellfish populations may also impose some isolated, small-scale impacts, as in hydraulic harvesting of geoduck (*Panope generosa*) clams in intertidal and shallow subtidal habitats, including eelgrass beds despite the fact that that practice is against WDFW/DNR and tribal policy and regulations.

While the imprint of any one of these impacts is small compared to the 10s to 100s of acres of diked emergent marshes in subestuary deltas, the cumulative effect can be exceedingly destructive of summer chum habitat along the fry's migratory corridor. Fragmentation of eelgrass may be one of the more insidious impacts because of the multifunctional role of eelgrass in providing a migratory corridor with both abundant prey resources and a continuous "strip" patch that offers refuge from predation. Although this has not been examined scientifically, loss and disruption of the eelgrass corridor infers reduced prey resources, diminished carrying capacity under some circumstances, migration delays and increased predation risk.

## Conceptual Model of Estuarine Rearing and Migration of Juvenile Chum Salmon

The relationship of summer chum salmon to the structure of Hood Canal and eastern Strait of Juan de Fuca can best be defined within the context of a simple conceptual model that describes our current level of understanding, albeit limited, about the factors affecting their response to estuarine conditions. This remains a conceptual model, rather than a more deterministic or predictive model, because most of the functional relationships between juvenile salmon response to estuarine factors remain unquantified.

In addition to the body of literature that presently encapsulates our understanding of the estuarine life history and ecology of juvenile salmon in Pacific Northwest estuaries (e.g., Healey 1982; Levy and Northcote 1982; Simenstad et al. 1982; Salo 1991; see also Johnson et al. 1997 for a discussion of the role of estuaries relative to the status of chum salmon populations), there is a considerable body of both published and unpublished information on chum salmon ecology in Hood Canal from University of Washington research from the 1960s through the mid-1980s. This research originated in studies of chum salmon population structure, behavior and ecology in Big Beef Creek (University of Washington field research station). Although this research did not specifically address the estuarine phase of chum salmon life history, it considerably expanded our understanding of the factors influencing the timing, behavior and condition of chum salmon fry emigrating from freshwater to Hood Canal (Koski 1975). In the 1970s, comprehensive studies of the potential impact of the U.S. Navy submarine base expansion at Bangor on chum salmon (among other nearshore fishes) contributed considerable fundamental information on the migratory demographics and ecology of chum salmon moving through the shoreline construction (e.g., turbidity plumes) and installations (e.g., Bax et al. 1980; Salo et al. 1980). Earlier results from components of the Bangor studies focused on chum salmon feeding ecology and prey resource assessments (Simenstad 1977; Simenstad and Kinney 1979; Salo et al. 1980; Simenstad et al. 1980; Simenstad and Salo 1982) led to more directed experimental and laboratory research on the carrying capacity limitations of chum salmon prey resources in Hood Canal supported by the National Science Foundation in the early 1980s (Simenstad et al. 1982; Simenstad and Wissmar 1984; Volk et al. 1984; Wissmar and Simenstad 1988). At the same time, Washington Sea Grant supported research on nearshore food webs also provided further insight to the food web pathways supporting juvenile salmon and their prey resources (Wissmar and Simenstad 1984; Simenstad and Wissmar 1985). While some of this research specifically included summer chum, much of it was directed toward or utilized fall chum, and often included both. It is generally assumed here that, apart from timing differences, both runs have similar life history and ecological responses to limiting factors. The following, abbreviated conceptual model of the estuarine ecology of juvenile chum salmon in Hood Canal is synthesized from this body of research.

There are several caveats that should be acknowledged to limit our interpretations from this conceptual model:

1. Much of fundamental data originates from hatchery-propagated fish, whose estuarine demography, behavior and even ecology may not be entirely applicable to wild chum, and in particular summer chum because most hatchery stocks are from normal, fall-run populations.

2. Data is more limited for early (e.g., February-early March) migrating fry, such as summer chum, than for 'normal' and late stocks, which are predominantly hatchery fish; any summer chum from late in their outmigration overlapped early 'normal' and late stock outmigrants and, if different, would have simply shown up as "noise" in the data.

3. There is little or no individual fish-based data, because chum fry had to be mass marked rather than individually tagged because of their small size.

4. There is little corroborative data on physicochemical conditions in Hood Canal at the time of most of these studies, that would provide any insight to how estuarine forcing factors (e.g., circulation, water temperature, etc.) influenced fish migration, feeding, etc.

## Demography of freshwater emigration

The relationship of different summer chum life history characteristics to their response to conditions in the Hood Canal-eastern Strait of Juan de Fuca landscape is influenced by factors that affect the timing of entry into the nearshore landscape and their movement and growth through it. For this reason, even freshwater factors have some influence on the function of the estuarine landscape, and anthropogenic changes in the watershed that alter juvenile migration timing influence subsequent responses by summer chum to both natural and altered nearshore conditions in the estuary. Because chum fry gradually “grow out” of reliance on nearshore habitats and transcend to more open-water habitats over their first few weeks, factors that affect both their growth rate and the timing of this “epibenthic-neritic” (see below) transition tend to operate on the landscape scale, not necessarily within a single subestuary.

The demography (abundance of fish over time) of juvenile summer chum fry emigration to the estuary is a particularly important variable in the early life history of summer chum because variation in winter-early spring estuarine conditions can impose constraints on the eventual fish size and timing of the fishes’ migration to the North Pacific. Fish size and timing of summer chum entering North Pacific coastal waters are assumed to play a large role in determining ocean mortality. Both genetic and environmental factors affect emergence and emigration to estuary, much of which is a function of the metapopulation characteristics of spawning adults the prior fall. For instance, emigration timing is influenced by time of spawning (genetic) and late fall-winter water temperatures (environmental). A number of researchers (e.g., Koski 1975) have suggested that timing of emigration to the estuary is an adaptation to maximize survival. An alternative hypothesis that I adhere to is that diversity in emigration timing may be the actual adaptive advantage given that estuarine conditions are highly stochastic.

Adult summer chum spawn from early September to mid-October over a period of anywhere between ~45-65 days, but according to historical accounts summer chum may have entered Hood Canal streams even as early as August. Age structure may be somewhat different than 'normal' fall and latter run stocks, with slightly higher proportion of 3-ocean aged fish and somewhat smaller female spawners. Historically, summer chum were considerably much more abundant than today, from whence these data are derived, and summer chum spawner densities are now much lower compared to normal and late-run stocks. Because fecundity and egg size may indicate evolutionary mechanisms to compensate for mortality factors later in their life history, it is interesting to note that summer chum fecundity is generally higher (100 $kg^{-1}$) for earlier spawning fish than equivalent female size of later spawning fish. Egg size (0.2-0.5 mm dia.) would also appear to be somewhat larger for summer chum.

Despite some evidence of insignificant differences in survival rate to emergence among early, normal and late-spawning stocks, overall survival through this stage in their early life history may be slightly higher for summer chum than normal or late-run stocks due to late-winter spring freshwater flow impacts. Summer chum fry emerge form spawning redds mid-winter, between January and April. For instance, 50% of the now-extinct (since mid-1980s) early-run stock at Big Beef Creek emerges by mid-March (can even be earlier, e.g., in 1977 it was mid-February) and 90% by early April, compared to late April-mid-May, or ~35 days earlier than 'normal' and late spawning stocks (Koski 1975). Stocks on the west side of Hood Canal may be ~15 days later than the east side if Big Beef Creek was representative of the latter (Koski 1975). The duration of emergence averages ~20 days (90% emerge between 12-53 days at Big Beef Creek) and depends upon time of spawning, gravel composition, temperature, and dissolved oxygen. Temperature appears to be a critical factor, wherein early stocks require considerably more temperature units than 'normal' and late stocks by 12-13 days (11%-17%). Emergence occurs primarily during the initial hours of darkness.

The size and developmental state of summer chum fry at emergence may also differ from normal fall- or late-run chum, where fry of early spawning fish have lower length-weight condition, but lower rate of premature fry. Size increases if there is any residence in the stream. But, stream residence appears to be minimal for summer run as well as normal fall- or late-run stocks and emigration to estuary is typically immediately after emergence.

Thus, natural emigration of summer chum from one watershed to the estuary is spread out over days, if not weeks (This is in stark contrast to hatchery releases of fall chum that may be on the order of 1.8 to 4.7 x $10^6$ fry released over a number hours). Instream feeding during migration is insignificant except in very large rivers. Summer chum fry school but the schools are not compact, with lots of dispersion at night. Schooling lessens as the fish approach the estuary. There is some evidence that chum fry avoid pink fry during migration.

### Physiological adaptation of fry to estuarine waters

Transition from freshwater to brackish and saline waters of the estuary is relatively brief, e.g., on the order of <12 hr. Although relatively brief, the time required to adapt appears to vary with fish size (longer transition with increasing size/freshwater residence), riverflow, and the configuration of the estuary (e.g., extent of mixing zone). There have been observations that chum fry preferentially seek out the brackish (10-15‰) layer of water. This suggests that in small estuaries this adaptation zone may be a vertically-mixed, horizontal gradient within the delta, while in larger, stratified estuaries this brackish layer ("lens") may be a vertical feature that chum fry can follow for extensive distances.

### Dispersion in estuary

Water circulation can play a large role in dispersion of chum fry, especially along the mainstem axis of Hood Canal and the Strait of Juan de Fuca. Under strong freshwater outflow, fish likely are pushed out with the freshwater plume unless there are extensive emergent wetlands and dendritic channels in the delta where the fry can escape high water velocities. Nearshore water movement along beaches may also influence dispersion away from the primary ("subestuary") delta, especially if the fish are pushed out into the freshwater plume. Rheotactic response may be positive or negative, depending upon magnitude of flow, because of the swimming speed limitations of fry. Initial directional behavior (dispersion vs. cross-canal) also appears to depend on size. Fry <50 mm FL have been shown to stay within or disperse to deltas, where they may reside for >5 days, while fry/fingerlings >50-55 mm FL move more into open "neritic" waters and may initially cross the Canal. Thus, an important landscape feature is the proximity to rearing habitats, where large delta habitats may serve as "attractors;" e.g., Bax (1983) experimental release of Enetai fish showing >25% remaining on Skokomish River delta after 4 days.

### Directed migration through estuary

Once chum fry have initiated their migration after some (unknown, but likely <1 week on larger deltas) estuarine delta residence, migration rates along the length of Hood Canal average between 4 and 14 km $d^{-1}$, and generally decrease as the juvenile migration season progresses. But, given the early period of summer chum migration, migration rate may be generally high although there is not much data that is specifically applicable to summer chum fry.

There are two *modes* of migration that reflect the fish's habitat, behavior and ecology and which are directly correlated with size stanzas. Initially, "epibenthic" fry <50-55 mm FL stay very close to shore, in shallow water ~2 m deep (they are often seen swimming within 15 cm depth), when they migrate as relatively dense schools during daylight, but break up/disperse during darkness. I've termed them "epibenthic" (bottom associated) because they are closely associated with shallow water and feed primarily on epibenthic organisms. In this mode, summer chum fry migrate very close, but not necessarily in, native eelgrass (*Zostera marina*) habitat. Maximum average densities of epibenthic summer chum fry are ~1 fish $m^{-2}$.

In the second, subsequent mode, "neritic" fry >50-55 mm FL begin to venture into open neritic (open surface) water, especially at night. By the time they are ~60 mm FL most chum fry appear to freely migrate and feed in neritic waters.

Three factors influence the migration rate of summer chum through the Canal, the transition between epibenthic and neritic mode, and thus total estuarine residence time:

1. Foraging success, where the frequency of encounter (relative abundance) of preferred prey species for epibenthic fry may dictate their migration rate; don't know if same applies for neritic fish (see below);

2. Surface water circulation in Canal, which is generally S6N, is likely to transport neritic fry that are away from the shoreline, thus affecting the migration rate of fry >50 mm FL; and,

3. The availability of shallow water (<2 m) habitat may also influence the movement of epibenthic fry, with eelgrass serving as an important migratory corridor.

## Feeding

These differences between migratory habitats and behavior of migrating chum fry in epibenthic and neritic modes are reflected in, or perhaps even caused by, their feeding ecology. Although terrestrial "drift" insects are often prominent in the diets of chum fry in the inner portion of subestuary deltas or along the margin of large deltas, epibenthic chum fry within nearshore environments feed primarily on small crustaceans such as harpacticoid copepods and other epibenthic invertebrates (e.g., small gammarid amphipods). Their diet is surprisingly specific. Typically, only two or three species of harpacticoid copepods (*Harpacticus uniremis* and *Tisbe* sp., and sometimes *Zaus* sp.) feature prominently in their diet, in contrast to several dozen harpacticoid species seemingly available to them. There is even some indication of preference for ovigerous female harpacticoids (C. Simenstad and J. Cordell, Univ. Wash.; unpubl.), which may be related to either visual prominence (*H. uniremis* egg sacks are actually brightly colored) or bioenergetic value (high nutritional value, perhaps slower escape responses by ovigerous female copepods). As chum fry grow and transcend to neritic migration, they begin to feed principally on planktonic prey such as large calanoid copepods, euphausiids, amphipods, larvaceans. Certain species (e.g., *Calanus* spp.) appear to be preferred in contrast to the overall availability of similar plankton taxa.

The relative temporal and spatial availability of some of these prey organisms may explain some of the apparent selectivity. Some are available throughout the migration period, others not; for instance, *H. uniremis*, which is univoltine, appears and declines early in the outmigration (February-April), replaced by *Tisbe* sp., which is multivoltine (April-June). Preferred species also are distributed in dense patches, perhaps enabling fish to localize on patches? Epibenthic prey are typically associated with algae, either epiphytes on eelgrass or diatom mats or other algae typical of intertidal habitats, and extremely high densities often occur in eelgrass; neritic prey tend to be diel vertical migrators (e.g., deep in the water column during day, but migrating up into shallower water at night) or very patchily distributed on water surface (e.g., "neuston" on or just beneath the surface tension film).

### Estuarine growth, nearshore-offshore transition and emigration

The relatively sharp size transition between epibenthic and neritic chum fry implies that growth (as surrogate for development of burst swimming speed, cognitive capability to adapt capture, or feeding organs such as mouth gape?) is correlated to estuarine residence time. Growth of early migrating chum fry, including some summer chum, ranges between 1% and 4% body weight per day (BW $d^{-1}$) but can be >6% BW $d^{-1}$ for mid- to late stock migrants.

Residence time within Hood Canal has been found to range between 4 and 32 days; the average residence time is approximately 24 days. Their success in effectively foraging for optimum prey is likely linked to the timing and ability of chum fry to effectively make the epibenthic-neritic transition and emigrate to the North Pacific. However, it is relatively unknown whether neritic prey populations respond to the same environmental controlling factors as epibenthic prey populations. It is conceivable that neritic prey resources of summer chum may under some circumstances be on different production schedules than epibenthic prey resources, thus potential growth of the fish may differ between the two modes. As a result, foraging success may strongly affect residence time because fish that do not make the transition because of limiting prey resources and slow growth in the nearshore may not be able to tap abundant neritic prey resources by the time they migrate out of the Canal

### Marine survival

Obviously, overall marine survival of summer chum is influenced by many more factors than those influencing their estuarine life history. There is some suggestion that marine survival is significantly lower (0.5%-0.8%) for early (including summer chum) migrants in Hood Canal as compared to late chum stocks (1.1%-2.6%) even though late stocks had higher proportions of 5-yr fish (Koski 1975; assuming 0.5 estimated average fishing exploitation rate). While this could be attributable to estuarine conditions, these stocks don't necessarily share the same ocean conditions. Oceanic migration routes and rearing areas of summer chum could be significantly different than normal fall- and late chum stocks due to shifts in ocean circulation between early and later entry to the nearshore ocean, e.g., dependent on shifts in California current, Aleutian low, etc. Koski's (1975) assumption of equal fishing mortality at the time may also not be valid. Statistical concordance among early/late, wild/hatchery chum recruit:spawner ratios and age class structure suggests all are influenced by same oceanic conditions, but this question is relatively unexplored.

## Response of Juvenile Summer Chum to Estuarine Landscape Structure

As inferred from this conceptual model (above), responses of juvenile summer chum to the structure of the estuarine landscape depends upon the size and status (physiological, behavioral) of the fish. Fry that have not yet achieved the neritic phase are constrained to migrate along shallow-water habitats where their rate of migration, bioenergetic status and vulnerability to predation is likely dependent upon the state of shoreline habitats. As habitat for juvenile summer chum salmon (see below) eelgrass is likely the primary migratory corridor linking the subestuary deltas in Hood Canal and the eastern Strait of Juan de Fuca. Its multi-functionality in providing both prey resources and refuge from predation suggests that it may be an important feature connecting subestuary deltas and may provide bridges between these larger rearing areas. Information from regions other than Hood Canal suggest that disruptions of contiguous natural habitats by shoreline structures (e.g., dock, piers) may modify juvenile salmon behavior, causing apparent confusion during migration and altering the intensity of schooling behavior (Simenstad et al., in prep.).

The concept and reality of limited estuarine carrying capacity for juvenile salmon is still debated (Simenstad and Wissmar 1984; Simenstad 1997b). There is some evidence that summer chum encounter limited prey resources early in their estuarine migration period, and the response is more rapid migration rates and lower growth. Whether this is driven by exogenous physical forcing, such as surface water transport, or an ecological response to availability of preferred prey (Wissmar and Simenstad 1988) remains to be determined. The potential of the latter, however, implies that both habitat loss and artificially increased densities (from earlier hatchery releases) could increase such carrying capacity responses.

## Recommendations for Further Research, Protection and Restoration/ Mitigation of Estuarine Landscape Impacts

There are four major information needs required to resolve the influence of estuarine landscapes on summer chum and the potential contribution that estuarine habitat restoration and management could make to summer chum recovery:

1. Validation of critical assumptions relating estuarine habitats to summer chum;
2. Testing for mechanisms of impact on summer chum at the estuarine landscape scale;
3. Relating delta and shoreline modifications to impacts on migrating and rearing summer chum; and,
4. Assessment of restoration measures that would enhance estuarine summer chum habitat at both the subestuary delta and estuarine landscape scales.

Much of the conceptual model's description of summer chum dependence upon landscape structure, as well as the subsequent assessment of factors contributing to summer chum population declines, are inferential and not necessarily derived for summer chum. The scientific concepts of landscape ecology and the development of testable hypotheses and analytical approaches are a phenomenon of only the last few decades of ecological research. Furthermore, landscape ecology principles have been applied to estuarine habitat "landscapes" in only a few instances and only preliminarily in the Pacific Northwest. A number of critical information gaps need to be addressed to validate many of the critical assumptions that influence the interpretation of impact mechanisms and the scale of impact. For instance, the assumption that shoreline transitions between subestuary deltas are critical links among estuarine rearing habitats for summer chum needs to be examined within the context of salmon behavior between deltas as well as the importance of shoreline habitats to the fry's successful epibenthic-neritic transition. The relationship between chum salmon and their subestuary delta and nearshore prey resources is based largely upon research on normal and late chum stocks. Thus, the assumptions that summer chum migration behavior (e.g., migration rate) is contingent upon prey availability, and that eelgrass and other mixed-fine substrate beach habitats are essential sources of preferred summer chum prey organisms, both require further validation specific to summer chum fry. Interactions and strength of the preferred prey relationship and other (e.g., physical forcing) factors influencing estuarine migration rate and residence time also need further exploration.

While mechanisms of impact at the subestuary delta scale are based on empirical evidence (albeit somewhat limited), impacts at the landscape scale are considerably less substantiated. Perhaps one of the most important issues is whether disruption of eelgrass patches inhibits the migration and survival of summer chum. The effect of eelgrass and other littoral habitat fragmentation on summer chum migration behavior needs to be evaluated and quantified if possible. In order to capture the importance of landscape structure, any investigation of habitat fragmentation should take into account within- and between-drift cell responses to habitat change by migrating summer chum. Drift cell convergences and divergences can both be areas of change in natural habitat structure, and it would provide insight to understand how juvenile salmon relate to these features.

Changes in the estuarine nearshore environment, such as habitat fragmentation, are often caused by human modification of the shoreline or underlying processes (e.g., water flow, sediment inputs) but can also occur as a result of natural processes. Thus, monitoring and assessment of sources of impact on Hood Canal and eastern Strait of Juan de Fuca shorelines and summer chum salmon must consider human stressors within the context of natural variability in estuarine landscape structure. Human stressors such as the extent and type of shoreline bulkheading and armoring, or the number and dimensions of overwater docks, must be evaluated and quantified within the context of natural variability in habitat elements (e.g., eelgrass corridors and patches) that they are known or suspected to impact. As with the evaluation of impacts on summer chum, this assessment of stressors should be organized around natural shoreline processes and geomorphic regimes such as drift cells.

Protection of existing shoreline habitat through land use regulation can be improved and would be facilitated by more specific information and understanding of current effects of shoreline development on the habitat and summer chum. Identification of shoreline areas where eelgrass beds have been impacted (and of the kinds and magnitude of shoreline developments), as well as areas where beds are not yet impacted but may be susceptible, would provide a basis for local governments to develop effective land use management actions.

Restoration and mitigation of degraded nearshore habitat should be equally important to recovery of sustainable summer chum populations as any recovery actions in freshwater or estuarine deltas. In conjunction with subestuary delta habitat restoration or mitigation, the integrity of nearshore corridors needs to be enhanced or restored through removal or modification of major man-made structures that disrupt the maintenance of natural nearshore attributes. This would involve not only removal or modification of shoreline structure that impedes fish migration, but should also promote restoration of natural nearshore processes. Restoration/mitigation actions that will directly contribute to recovery of summer chum habitat in the nearshore include:

1. Removal of intertidal fill that has changed nearshore habitat structure, beach gradient or circulation; and,

2. Removal or modifications of docks that by shading or other disruption increase habitat fragmentation and decrease patch connectivity.

However, steps to restore fundamental nearshore processes are equally important to the long-term redevelopment and maintenance of summer chum migratory corridors. These restoration actions should include:

1. Removal of bulkheads that similarly intrude into intertidal or block sediment supply to drift cells;

2. Restoration of impacted supply and transport of beach sediments;

3. Transplanting (using adjacent source material) of eelgrass to bridge unvegetated gaps in eelgrass habitat that has been impacted by human structural or process changes; and,

4. Modification of aquaculture and other management practices that impose unnatural disturbance of nearshore habitats.

If there is one guiding concept to the ideas expressed in this document, it is that estuarine nearshore summer chum habitat is an essential segment in a continuum that bridges their natal freshwater with open ocean rearing ecosystems. Ignoring causes for decline and actions for recovery within the estuarine landscape will likely neutralize any significant recovery actions in individual watersheds or subestuary deltas. Much work remains to validate our hypotheses related to the importance of the estuarine landscape to summer chum; nonetheless, even our present-day knowledge base is sufficient to indicate that failure to act on estuarine landscape-scale recovery will postpone or prevent recovery of summer chum in Hood Canal and the eastern Strait of Juan de Fuca. Immediate actions needed to prevent further degradation of nearshore estuarine habitat include:

1. Protection of existing, unaltered shorelines – As development has spread along the Hood Canal and eastern Strait of Juan de Fuca shoreline, remaining unaltered natural shoreline segments have been diminished in number and extent. From a landscape perspective, these remnant habitat patches are likely critical to the overall integrity of summer chum rearing and migration habitat, and are thus worthy of immediate protection. New bulkhead, pier, and dock construction along the Hood Canal and eastern Strait of Juan de Fuca shoreline threatens to further fragment summer chum nearshore rearing and migration habitat. These activities should be prohibited until individual project evaluations determine that activities will not appreciably degrade or diminish nearshore habitats. Individual

projects should be evaluated in the context of overall nearshore habitat condition within the adjoining drift cell.

2. Establishment of adequate shoreline buffers – Unstable and eroding bluffs pose safety threats to homes that are constructed without adequate setbacks. Moreover, eroding "feeder bluffs" constitute an important source of sediment and organic debris for nearshore habitats. Setback distances should be conservative, designed to provide for natural erosion of feeder bluffs over time and to protect natural vegetation and homes. Again, individual cases should be evaluated within the context of overall habitat conditions within the adjoining drift cell.

## References Cited

Bax, N.J., E.O. Salo, and B.P. Snyder. 1980. Salmonid out-migration studies in Hood Canal: A summary of 1977. Pp. 171-201 in McNeil, W.J., and D.C. Himsworth (eds.) Salmonid Ecosystems of the North Pacific. Univ. of Oregon Press. Sea Grant College Program, Univ. of Oreg., Corvallis, OR. 331 p.

Burns, R. 1985. The shape and form of Puget Sound. Wash. Sea Grant Prog., Univ. of Wash., Seattle, WA. 100 p.

Canning, D.J., and H. Shipman. 1995. Coastal erosion management studies in Puget Sound, Washington: Executive summary, Coastal Erosion Mgmt. Studies, Vol. 1. Rpt. no. 94-74, Water & Shorelands Restoration Prog., Wash. Dept. Ecol., Olympia WA. 100 p.

Downing, J. 1983. The coast of Puget Sound: its processes and development. Wash. Sea Grant Prog., Univ. of Wash., Seattle, WA. 126 p.

Friebertshauser, M. et al. 1971. Puget Sound and approaches; seasonal variations of oceanographic parameters in its near surface waters. Rep. Contract RD-NE4, 5 vols., Wash. Sea Grant Prog., Univ. of Wash., Seattle, WA.

Healey, M.C. 1982. Juvenile Pacific salmon in estuaries: the life support system. Pp. 315-341 in V.S. Kennedy (ed.) Estuarine Comparisons. Academic press, New York, NY. 709 p.

Jackson, P.L., and A.J. Kimerling. 1993. Atlas of the Pacific Northwest, 8th ed. OSU Press, Corvallis, OR. 152 p.

Johannessen, J. 1992. Net shore-drift of San Juan, and parts of Jefferson, Island, and Snohomish counties, Washington. Shorelands and Coastal Zone Management Program, Wash. Dept. Ecol., Olympia WA. 58 p. + maps.

Johnson, O.W., W.S. Grant, R.G. Kope, K. Neely, F.W. Waknitz, and R.S. Waples. 1997. Status review of chum salmon from Washington, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-32, NMFS NW Sci. Center, U.S. Dept. Commer. Nat. Marine Fish. Serv., Seattle, WA. 280 p.

Koski, K.V. 1975. The survival and fitness of two stocks of chum salmon (Oncorhynchus keta) from egg deposition to emergence in a controlled stream environment at Big Beef Creek. Ph.D. thesis, Univ. of Wash., Seattle. 212 p.

Levy, D.A., and T. G. Northcote. 1982. Juvenile salmon residency in a marsh area of the Fraser R. estuary. Can. J. Fish. Aquat. Sci. 39:270-276.

MacDonald, K., D. Simpson, B. Paulson, J. Cox, and J. Gendron. 1994. Shoreline armoring effects on physical coastal processes in Puget Sound, Washington. Coastal Erosion Mgt. Studies, Water & Shorelands Restoration Prog., Wash. Dept. Ecol., Olympia WA.

Orsborn, J. F. and S. C. Ralph. 1994. An aquatic resource assessment of the Dungeness River system: phase II – physical channel analysis, hydrology and hydraulics, and phase III – fisheries habitat survey. Prepared for Jamestown S'Klallam Tribe, Sequim, WA.

Phillips, R.C. 1994. The ecology of eelgrass meadows in the Pacific Northwest: A community profile. USFWS tech. rep. FWS/OBS-84/24. U.S. Dept. of the Inter., Fish and Wild. Serv. 85 p.

Robinson, D.G. 1969. Data record : Number, size composition, weight, and food of larval and juvenile fishes caught with a two-boat surface trawl in the Strait of Georgia July 4-6, 1976. Manuscript rep. series 1012, Fish. Res. Bd. Can. Biol. Stat., Nanaimo, BC, Canada. 71 p.

Salo. E.O., N.J. Bax, T.E. Prinslow, C.J. Whitmus, B.S. Snyder, and C.A. Simenstad. 1980. The effects of the construction of naval facilities on the out-migration of juvenile salmonids from Hood Canal, Washington (final rpt., Jan.-Dec. 1979). UW Fish. Res. Inst. rpt. FRI-UW- 8006, Univ. of Wash., Seattle, WA. 159 p.

Salo, E.O. 1991. Life history of chum salmon, Oncorhynchus keta. Pp. 231-309 in Groot, C., and L. Margolis (eds.) Pacific Salmon Life Histories. Univ. B.C. Press, Vancouver, BC, Canada.

Schwartz, M.L. et al. 1991. Net shore-drift in Washington state: Vol. 4. Shorelands and Coastal Zone Management Program, Wash. Dept. Ecol., Olympia WA. 51 p.

Simenstad, C.A. 1977. Prey organisms and prey community composition of juvenile salmonids in Hood Canal, Washington. Pp. 163-176 in Simenstad, C.A., and S. Lipovsky (eds.) Proc. First Pac. NW Tech. Workshop Fish Food Habits Studies, Oct. 13-15, 1976, Astoria, OR. Wash. Sea Grant Publ. WSG-WO-77-2, Univ. of Wash., Seattle, WA. 193 p.

Simenstad, C.A. and W.J. Kinney. 1979. Selection of epibenthic plankton by outmigrating chum, salmon in Hood Canal Washington. Pp. 243-289 in Mason, J. (ed.) Proc. 1978 Pink and Chum Salmon Workshop, March 1978, Parksville, B.C. Canada. Pac. Biol. Sta., Nanaimo, BC. 448 p.

Simenstad, C.A., W.J. Kinney, S.S. Parker, E.O. Salo, J.R. Cordell, and H. Buechner. 1980. Prey community structure and trophic ecology of out-migrating juvenile chum and pink salmon in Hood Canal, Washington: A synthesis of three years' studies, 1977-1979. UW Fish. Res. Inst. no. FRI-UW- 8026. Univ. of Wash., Seattle, WA. 111 p.

Simenstad, C.A., D.M. Eggers, R.C. Wissmar, and E.C. Volk. 1982. Beyond GUTS: The powers and pitfalls of experimentally documenting functional aspects of fish foraging behavior. Pp. 33-46 in Calliet, G.M., and C.A. Simenstad (eds.) GUTSHOP '81, Proc. Third Pacific Workshop, Fish Food Habits Studies, 6-9 Dec. 1981, Pacific Grove, California. Wash. Sea Grant WSG-WO-82-2, Univ. of Wash., Seattle, WA. 312 p.

Simenstad, C.A. and E.O. Salo. 1982. Foraging success as a determinant of estuarine and Nearshore carrying capacity of juvenile chum salmon (Oncorhynchus keta) in Hood Canal, Washington. Pp. 21-37 in Melteff, B.R., and R.A. Neve (eds.) Proc. North. Pacific Aquaculture Symp., 18-27 August 1980, Anchorage AK and Newport, OR. OSU Sea Grant College Prog. ORESU-W-83-001. 327 p.

Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: An unappreciated function. Pp. 343-364 in Kennedy, V.S (ed.) Estuarine Comparisons. Academic Press, New York, NY. 709 p.

Simenstad, C.A., and R.C. Wissmar. 1984. Variability in estuarine food webs and production may limit our ability to enhance pacific salmon (Oncorhynchus spp.) Pp. 273-286 in Pearcy, W.G. (ed.) The influence of ocean conditions on the production of salmonids in the North Pacific. Proc. salmonid oceanography workshop, 8-10 Nov. 1983, OSU Marine Science Center, Newport, OR. OSU Sea Grant College Prog. ORESU-W-83-001. 327 p.

Simenstad, C.A., and R.C. Wissmar. 1985. d13C evidence of the origins and fates of organic carbon in estuarine and nearshore marine food webs. Mar. Ecol. Prog. Ser. 22:141-152.

Simenstad, C.A. and K.L. Fresh. 1995. Influence of Intertidal aquaculture on benthic communities in Pacific Northwest estuaries: scales of disturbance. Estuaries 18: 43-70.

Simenstad, C.A. 1997. The relationship of estuarine primary and secondary productivity to salmonid productivity: bottleneck or window of opportunity? Pp. 133-145 in Emmett, R. and M. Schiewe (eds.) Proc. Estuarine and Ocean Survival of Northeastern Pacific salmon workshop March 20-

22, 1996, Newport, OR. NOAA Tech. Memo. NMFS-NWFSC-29, NMFS NW Sci. Center, Seattle, WA. 313 p.

Simenstad, C.A., T.M. Thom, and A.M. Olsen (eds.). 1998. Mitigating potential impacts of ferry terminal siting and design on eelgrass impact. Wash. Sea Grant WSG 98-05. Univ. of Wash., Seattle, WA.

Simenstad, C.A., T.M. Thom, D.A. Shreffler, B. Nightengale, A.M. Olson, and J.R. Cordell. In prep. Effects of overwater structures on the behavior and habitat of migrating juvenile salmon. An assessment of the scientific and technical literature. Report to Wash. Dept. Transportation. School of Fisheries, Univ. Of Wash., Seattle, WA.

Strickland, R.M. 1983. The fertile fjord; plankton in Puget Sound. Wash Sea Grant Prog., Univ. of Wash., Seattle, WA. 145 p.

Thom, R.M., and D.K. Shreffler. 1994. Shoreline armoring effects on coastal ecology and biological resources in Puget Sound, Washington. Coastal Erosion Mgmt. Studies, Vol. 7, 94-74. Water & Shorelands Restoration Prog., Wash. Dept. Ecol., Olympia WA.

Thomson, R.E. 1981. Oceanography of the British Columbia coast. Can. Spec. Publ. Fish. Aquat. Sci. 56. 291 p.

Volk, E.C., R.C. Wissmar, C.A. Simenstad, and D.M. Eggars. 1984. The relationship between otolith microstructure and the growth of juvenile chum salmon under different prey conditions. Can. J. Fish. Aquat. Sci. 41:126-133.

WDFW (Washington Department of Fish and Wildlife) and WWTIT (Western Washington Treaty Indian Tribes). 1994. 1992 Washington State salmon and steelhead stock inventory-Appendix One - Puget Sound stocks - Hood Canal and Strait of Juan de Fuca vol. Wash. Dept. Fish and Wild., Olympia, WA. 424 p.

Wissmar, R.C. and C.A. Simenstad. 1984. Surface foam chemistry and productivity in the Duckabush R. estuary. Pp. 331-348 in Kennedy, V. (ed.) The Estuary as a Filter. Academic Press, Orlando, FL. 511 p.

Wissmar, R.C. and C.A. Simenstad. 1988. Energetic constraints of juvenile chum salmon migrating in estuaries. Can. J. Fish. Aquat. Sci. 45:1555-1560.

Yoshinaka, M.S., and N.J. Ellifrit. 1974. Hood Canal - priorities for tomorrow; An initial report on fish and wildlife, developmental aspects, and planning considerations for Hood Canal. U.S. Dept. Inter., Fish Wild. Serv., Portland OR. 97 pp + 17 fig.

# Appendix Report 3.6
# Summer Chum Salmon Watershed Narratives

## Contents

# Dungeness Watershed Narrative
# WRIA 18.0018

## Watershed Description

The Dungeness watershed is located in the northeastern corner of the Olympic Peninsula. The western portion of the City of Sequim is the only incorporated area in the watershed. The watershed drains 270 square miles beginning about 6,400 feet. It flows thirty-two miles before entering the Strait of Juan de Fuca at sea-level.

The Dungeness watershed contains a diverse array of land uses and cover types. Thirty percent of the upper watershed (80 square miles) is in the Olympic National Park. Also in the upper portion of the watershed are public and private forestlands totaling 117 square miles (43% of the watershed). This includes public lands that are mandated for uses (wilderness protection, endangered species, wild and scenic rivers, etc.) other than timber production.

In the middle and lower watershed are rural and agricultural lands occupying 56 square miles or 21% of the watershed. Of this land 16 square miles are agricultural and used for crop, hay and pastureland. Seventy to eighty percent of the agricultural land is irrigated from water diverted from the Dungeness River and area streams through an extensive network of irrigation ditches. An agricultural survey identified 604 small farms (non-commercial) and 34 commercial farms. This number is changing as farms convert to residential developments. Private woodlots, which are not intensively managed for timber production, make up another 13 square miles, (five percent of the watershed). Land under conversion, predominately from forest or agricultural to residential use covered nearly 4 square miles in 1990.

Urban areas cover 410 acres in the watershed including portions of the City of Sequim and the Sunland development, a golf course and retirement complex.

## Summer Chum Distribution

Good information on spawning distributions and escapement estimates do not exist as of yet, but ripe adults have been recovered at the Dungeness Hatchery (River Mile 10.8, D. Rogers, WDFW Dungeness Hatchery, Sequim, WA pers. comm.).

## Population Status

Summer chum spawning surveys were conducted in 1996 and a limited number of summer chum were observed. Peak summer chum counted was 199 fish in 1976. Since 1987, one to 60 summer chum have been observed annually during pink salmon surveys. Indications are a small self-sustaining population is present, but its status is uncertain.

## Factors for Decline

The lower 10.8 miles of the Dungeness River is the primary focus of habitat restoration planning because of its high habitat value and sensitivity to disturbances originating in other parts of the watershed. The lower river is judged to be the reach most altered by and most susceptible to human alteration. Virtually all of the bank hardening (rip rap), diking, water withdrawals, gravel mining, channel alignment, bed aggradation from upriver input sources, floodplain development, riparian clearing and woody debris removal has occurred in this terminal section of river. Dikes have reduced or eliminated the floodplain, concentrating all of the energy and sediment of floods into the main channel. By inhibiting normal meander development, important stable side channel habitat has been eliminated, as well as the opportunity for the creation of new side channel habitat. Historically, removal of large woody debris (LWD) and log jams was a prominent element of flood control activities on the Dungeness River. Stable log jams are now scarce throughout this lower section of river.

The habitat above RM 10.9 has been altered by bridge crossings, sediment input associated with timber harvesting, chronic landslides and road failures. But overall the effect has been far less persistent than that occurring in the lower river.

In order for restoration efforts to succeed, sediment inputs must be in balance with the sediment transport and storage capacity of the river channel, floodplain and estuary. Increased sediment recruitment, aggradation and the loss of floodplain have been well recognized; changes at the river mouth and estuary have received less attention. Since 1855, the river mouth has moved to a location approximately 2,000 feet northeast of its earlier location, and approximately 75 acres of river delta have been formed. The river that once ran through an intertidal salt marsh estuary at its mouth, and now bisects the delta cone that has developed since diking began along the bay. The tidal prism (an important sediment transporting feature) in the vicinity of the river mouth appears to have decreased in size by over 100 acres during this time period. The implications of these changes warrant further study to assess the type of estuary-related restoration actions needed.

For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18. Limiting factors that have contributed to the decline of summer chum include:

- *Channel complexity (LWD, Channel condition, loss of side channel, and channel instability)*-Spawning, incubation and adult life stage, rated high impact. Depletion of stable log jams, loss of historical floodplain and the concentration of flows by diking and man-made constrictions have reduced channel complexity. This has resulted in an absence of stable mainstem spawning habitat and good quality pool habitat as well as a lack of high flow refugia and stream energy dissipation. Frequent channel shifting, deep scour and deposition occur after even moderate high flow events. This has been validated by post-flood salmon redd sampling data, scour chain data, aerial photo analysis, and field observations of channel location over time.

- *Riparian condition* - Spawning and incubation life stage, rated high impact. For the purposes of analysis and restoration, the lower 10.8 miles of the Dungeness River was divided into four reaches. Reach one

(RM 0.0 - 4.0) contains 45% of the riparian zone (a 200 ft wide strip) in forested buffer. Where riparian buffers are lacking, land uses include 40% in dikes, 10 % in agriculture and 5% in residential. Fifty-six percent of the forested buffer is less than 66 feet in width. Reach two (RM 4.0 - 6.6) contains 74% in forested buffer. Eighty-four percent of this buffer is in small size classes (<20 in. dbh). Twenty-three percent of the riparian buffer is less than 66 feet in width. Reach three (RM 6.6 - 8.8) contains fifty-six percent of its buffer length in forested buffer. In areas lacking in forest buffer, land uses include 26% in dikes and 18% in residential. Sixty-three percent of the forested buffer is less than 66 feet in width. Reach four (RM 8.8 - 10.8) contains 56% of its length in forested buffer. Additional land uses in areas lacking in forested buffer contains 35% in dikes and 9% in residential uses. Sixty-two percent of the forested buffer is less than 66 feet in width. Sixty-nine percent of the entire forested buffer is in small size classes (< 20 in dbh).

- *Estuarine habitat loss and degradation (diking, filling, ditches and remnant dikes, road causeways*) - Juvenile rearing and migration life stage, rated high impact. The Dungeness River delta, which is estimated to have originally covered 3.93 $km^2$ (970.2 ac, 2.7 mi. perimeter), is second only to the Skokomish River delta in terms of historical summer chum estuarine rearing habitat area. However, this delta has been extensively diked for agriculture, urban and commercial needs. At least 12 diked areas, totaling 0.55 $km^2$ (136.7 ac), now prevent tidal inundation of over at least 14% of the original delta. Diking, in conjunction with road routing, has significantly marginalized juvenile summer chum salmon migration corridors across the delta, and their access to adjacent rearing habitats.

  Two obvious intertidal fills have impacted 0.08 $km^2$ (18.7 ac; 1.9% of historic delta) of the delta, but it is likely that this is a gross underestimate. Three ditches or remnant dikes still impact summer chum habitat along 0.63 km (0.4 mi), constraining tidal circulation and fish movement within and across the delta. Side tributaries and tidal channels have also been extensively channelized and rerouted, as evidenced on both the eastern and the western margins of the delta. Six roads and/or causeways intrude upon or bisect the delta over a combined length of 2.27 km (1.4 mi). As with ditches and remnant dikes, modification of tidal inundation patterns likely alters fish movement and rearing potential even among the remaining emergent marshes and intertidal flats. Between 1987 and 1993, eelgrass declined by 31% in Dungeness Bay, in large measure due to the impact of ulvoid algae mats (Wilson 1993). *Ulva sp.* is commonly found to respond positively to increased nitrogen loading in marine waters. Furthermore, ulvoids within Dungeness Bay have been theorized to have forced ecosystem shifts by changing both water flow and substrate composition (Shaffer and Burge, in press).

- *Low Flow*-Spawning and adult migration life stage, rated moderate impact. Limitations in the quantity of spawning habitat and impediments to adult salmonid migration, results from a combination of irrigation withdrawals and an aggraded riverbed. Negotiations with the irrigation community have led to a series of agreements that should allow for more water to be left in the river during critical low flow period. The effects of this on habitat will be monitored.

## Factors for Recovery

Restoring Dungeness River salmonid habitat will be based on reversing or reducing human impacts responsible for degradation throughout the lower 10.8 miles. Some projects will need to be applied throughout the lower river in order to restore in-channel and floodplain functions, i.e. riparian planting, large woody debris (LWD) placement or side channel creation/stabilization. Other projects will be more river-reach specific due to the location of the problem area, i.e. dikes. For a general discussion of protection and restoration strategies by habitat parameter, refer to Part Three - section 3.4.4.2, toolkit.

Restoring salmonid habitat in the Dungeness River will require the following seven elements:

- Reestablish functional floodplain in the lower 2.6 miles through dike management and constriction abatement.
- Abate man-made constrictions upstream of the COE dike (everything above RM 2.6).
- Create numerous stable long-term log jams.
- Manage sediment to stabilize the channel and reduce the risk of flooding.
- Construct and/or protect side channels.
- Restore suitable riparian vegetation and riparian-adjacent upland vegetation.
- Conserve instream flows.

In addition, initial strategies for restoring rearing and migration habitat within the estuarine delta include the following:

- Removal of remnant dikes and filling of borrow and other created ditches.
- Removal of unnecessary (e.g., recreational) roads and fills
- Reconnection of blocked and diverted channels
- Removal of tidegates and enlarging of culverts

### Strength of Evaluation and Information Needs

The Dungeness Watershed has been the focus of numerous planning processes (Dungeness River Area Watershed Management Plan, Dungeness-Quilcene Water Resources Management Plan, Dungeness Watershed Analysis) and studies (Orsborn and Ralph 1992, 1994; Lichatowich, 1993). In addition, a Watershed Council (Dungeness River Management Team) and a technical work group (Dungeness River Restoration Work Group) have been working for several years to put together a restoration plan to guide efforts to restore salmonids at risk. The plan was approved by the Team in June 1998. Confidence in the assessment of habitat factors is high based on the extensive work that has been done in the watershed. Information that is still needed includes:

1. An understanding of the physical processes that affect the river's sediment supply from the upstream watershed and processes that affect the transport and deposition of sediment on the alluvial fan and estuary are crucial to the assessment of current and future conditions. The Bureau of Reclamation (BOR) has proposed to establish a sediment budget for the Dungeness River that would quantify the sediment supply from the upstream watershed and quantify aggradation rates on the alluvial fan and

estuary. Coupled with a geomorphological investigation and the application of numerical models, BOR proposes to improve our understanding of the following:

- Prediction of flooding impacts from alternative management actions.
- Prediction of scour and fill, channel meandering, and bank erosion from alternative management actions.
- Determine the existing effects of bridges on the river channel and the effects of possible bridge modifications.
- Predict the impacts on flooding from the introduction or removal of large woody debris.
- Determine the sensitivity of the river channel to sediment supply and riverflow
- Explanation of the historical channel changes.

2. A recent life history study of juvenile salmonids rearing in the Dungeness River has revealed that rearing conditions in the mainstem of the river are limited by the lack of optimum habitat. During the winter many of the juveniles move into side channels to rear and seek refuge from the high flows. Assessments should continue of juvenile use of side channels with available methodolgies of trapping and netting as well as an evaluation of the number and condition of side channels available.

3. Elevated fecal coliform bacteria counts have occurred in Dungeness Bay in recent months. The counts have been over threshold standards allowable for safe shellfish harvest set by the Federal Drug Administration and administered by the Washington Department of Health - Shellfish Program. A Dungeness Bay Shellfish Closure Prevention Response Strategy has been developed by local and State Agencies that will provide extensive monitoring to identify bacterial sources and increase enforcement through the years 1999-2000. This water quality issue has not been identified as a factor that would affect summer chum at the present time. It is suggested that as monitoring is developed that criteria be developed that would identify any problems that could affect summer chum during any part of their life history strategy e.g. adult migration and spawning, incubation, juvenile emergence and emigration, and rearing.

4. The tidal prism or area of the intertidal delta in the vicinity of the river mouth appears to have decreased in size by over 100 acres since the earliest recorded survey in 1855. The implications of these changes to sediment transport processes and summer chum rearing conditions in the estuary need to be assessed.

## References

Dungeness Area Watershed Analysis Cooperative team. 1995. Dungeness Watershed Analysis. Dungeness Area Watershed Analysis Cooperative team for U.S. Department of Agriculture, Forest Service, Olympic National Forest, Olympia, WA.

Hirschi, R. and M. Reed. 1998. Salmon and trout life history study in the Dungeness River. Jamestown S'Klallam Tribe, Blyn, WA.

Jamestown S'Klallam Tribe (coordinating entity). 1994. The Dungeness-Quilcene Water Resources Management Plan. Jamestown S'Klallam Tribe, Blyn, WA.

Lichatowich, J. 1993. Dungeness River pink and chinook salmon historical abundance, current status, and restoration. Jamestown S'Klallam Tribe, Blyn, WA.

Orsborne, J.F., and S.C. Ralph. 1994. An aquatic resource assessment of the Dungeness River system: Phase II - physical channel analysis, hydrology, and hydraulics, and Phase III - fisheries habitat survey. Jamestown S'Klallam Tribe, Blyn, WA.

Puget Sound Cooperative River Basin Team. 1991. Dungeness River watershed report. Jamestown S'Klallam Tribe, Blyn, WA.

Shaffer, J. A. and C. Burge. In press. Ulvoid mats and shellfish of the Strait of Juan de Fuca: a pilot study. Estuarine and Coastal Sciences Association Bulletin, vol. 32.

Wash. Dept. Fish and Wild., Clallam County, U.S. Fish Wild. Serv., U.S. Forest. Serv., Jamestown S'Klallam Tribe et al. 1997. Recommended restoration projects for the Dungeness River. Dungeness River Restoration Work Group, Jamestown S'Klallam Tribe, Blyn, WA.

# Jimmycomelately Watershed Narrative
# WRIA 17.0286

## Watershed Description

The Jimmycomelately Creek (JCL) watershed enters Sequim Bay in the eastern region of the Strait of Juan de Fuca on the northeastern corner of the Olympic Peninsula. The JCL watershed headwaters at an elevation of about 3,800 ft., encompasses a watershed area of 19 square miles, and has a stream length of approximately 20 miles. With the exception of the lower two miles, the watershed is primarily managed by the Forest Service. Below river mile (RM) 1.0, land use is mostly rural residential and hobby farms.

## Summer Chum Distribution

The current upper extent of summer chum salmon is believed to be about RM 1.5. However, summer chum may have historically occurred as far upstream as RM 1.9 at the point of an impassable falls.

## Population Status

Escapement ranged from several hundred to over 1,000 in the 1980s, with one year below 100. In the 1990s escapement dropped, with 61 spawners or less in three of the past five years (Appendix Table 1.1).

## Factors for Decline

A Watershed Analysis is being planned for the JCL watershed, but as of this date little information exists on the impacts from timber harvest and roadbuilding in the upper and middle watershed. Nonetheless, some information exists from a USFS habitat survey (Donald 1990). Observations regarding riparian buffer conditions throughout the JCL indicate that logging-related and road failures have continued to contribute sediment to the creek. Severe aggradation in the lower half mile of the creek has caused problems not only for fish but landowners as well. Landowner attempts to control flooding with retaining walls, anchored logs and other means have resulted in concentrated flood flows which have increased the susceptibility of redds to scour.

One of the dominant causes for the severe problems in the lower JCL is that in the early part of this century it was moved into an artificial channel. This channel was constructed too narrow, dredge spoils were placed as de facto dikes, and no provision was made to ensure that the creek was functionally tied to the estuary. The JCL has become effectively isolated from the marine environment. Vegetation non-native to salt marshes (willow, alder, cottonwood, canary grass, black berry, scotch broom) have colonized and stabilized the de facto dikes and other associated fill, eventually causing further constriction of the over-narrow stream channel. A cycle of bed aggradation, flooding and dredging has resulted. In 1997 the lowest reaches of JCL were perched spectacularly above the former estuary creating an effective barrier to spawning summer chum. Limiting factors for chum salmon in JCL include increased scour of redds and deposition of fines in the spawning gravel as well as adult migration barriers to the spawning beds. For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18.

- *Channel complexity (LWD, channel condition, loss of side channel, channel instability)*-Spawning and incubation life stage, rated high impact. In the lower reaches riparian buffers have been reduced or eliminated, stable log jams are scarce and side channels and associated wetlands have been eliminated or cutoff from the main channel. A USFS survey completed in 1990 found 0.09 pieces of LWD per meter, a level that was considered a high impact. Pool habitat is also scare (30% by surface area, pool frequency of 9.0, Appendix Report 3.8). Confinement of the channel by bank hardening in one form or another in addition to the loss of LWD has reduced inchannel complexity resulting in aggradation, increased peak flows and increased bed scour. Scour of redds is perhaps the dominant limiting factor for summer chum in the lower reaches of the Jimmycomelately Creek. This altered hydrologic capacity of the stream has affected low flows as well, but it is not known to what extent.

- *Sediment (aggradation)*-Spawning, incubation and adult migration life stage, rated high impact. Re-routing of the channel, loss of instream channel complexity and a decrease in tidal energy have decreased the channel's ability to route sediment through the system. Increased aggradation levels have resulted in increased scour of redds. Adult summer chum have been inhibited in their migration to spawning beds due to barriers created by the aggraded bed.

- *Riparian condition* - spawning and incubation life stage, rated high impact. Within the lower 1.5 mile of summer chum spawning, the riparian buffer consists of 34% in forest, 12% in agriculture, 9% in roads and dikes, and 7% in residential land uses (Appendix Report 3.7). One hundred percent of the forested riparian buffer is in diameter classes less than 20 in. dbh. Sixty-nine percent of the forested buffer is less than 66 feet in width and 31 percent between 66 and 132 feet in width. Bank armoring in the lower half mile has also reduced the full functions of the riparian forest buffer.

- *Subestuarine habitat loss and degradation (diking, filling, log storage and associated features, road causeways*) - Juvenile rearing and migration life stage, rated high impact. The delta of Jimmycomelately Creek was estimated to originally cover 0.56 km$^2$ (139.4 ac; 4.3 km [2.7 mi] perimeter). Two diked areas, totaling 0.02 km$^2$ (3.9 ac), have impacted 2.8% of the original delta. In addition to the small diked areas, three intertidal fills have impacted 0.01 km$^2$ (3.1 ac; 2.2% of historic delta) of the delta. Most of these fills are associated with residential and commercial development along the Highway 101 corridor and the railroad grade.

Log storage and other associated features in two areas appear to impact a total of 0.01 km$^2$ (1.7 ac; 1.2% of original delta) of delta habitat. These activities are also associated with portions of the road and causeways impacts. Although dependent entirely on log storage and handling practices, there is likely low to moderate impact to benthic communities beneath and near these areas. Heavy disturbance of the benthos, and long-term input of bark and wood fragments, is likely to degrade juvenile summer chum foraging habitat. The fish may also be disrupted in their migration across the delta if they are behaviorally compromised by the floating log booms.

Three roads and/or causeways intrude upon the delta over a combined length of 0.56 km (0.4 mi). Highway 101, associated roads and the railroad grade cut off the non-tidal floodplain from the tidal delta as well as constrain circulation and fish movement among the emergent marshes and flats of the outer delta.

## Factors for Recovery

A critical step for restoring stability in the Jimmycomelately will require re-establishing a functional estuary/freshwater linkage. Estuaries have long been recognized as one of the most productive aquatic environments due to their abundant food supply and wide salinity gradients. In addition to their productivity and importance to fish, estuaries provide a critical linkage for routing stream sediment into the marine environment and thereby contribute significantly to both horizontal and vertical bed stability in the lower reaches of creeks and rivers, as well as maintaining the integrity of emergent marshes on the outer deltas.

In highly functional estuaries, tidal energy is manifested and harnessed for sediment routing through a network of tidal surge plains and channels, collectively referred to as tidal basins, that serve as tributaries to the fresh stream channel. Tidal energy is effective at moving sediment where stream gradient becomes approximately zero at the marine interface. As elevations and gradient drop, stream energy declines and in this transition zone tidal surge energy increases.

Thus, sediment is transported and distributed widely into far-lower tidal elevations than channel gradient and stream energy alone would appear to allow. Linking of fresh water and tidal basins is the mechanism responsible for creating stable, slowly-evolving, complex and productive estuaries.

Perhaps no other aquatic environment on the east and north slopes of the Olympic Peninsula have been so altered by human impacts as estuaries. Diking, road and railroad grade building, and land filling have truncated significant portions of most of the region's estuaries. To date there has been no estuary restoration measure taken to specifically restore these critical functions of estuaries. Specific actions appropriate for Jimmycomelately Creek include:

- Reconnection and expansion of connections between the freshwater reaches of the floodplain and the tidal delta;
- Removal of secondary roads and railroad grade that are significant deterrents to tidal circulation and fish movement;
- Filling of remnant ditches; and
- Mitigation or elimination of the log storage and handling impacts.

Restoration in the Jimmycomelately Creek will require a complex strategy of long and short term restoration actions. A Jimmycomelately Creek Estuary Technical Working Group has been established to identify the scope of work/activities for the restoration project, as well as potential funding sources and time line. Members of the Working Group consist of the Jamestown S'Klallam Tribe, Clallam County, WDFW, Clallam Conservation District, WSU Cooperative Extension, Washington Department of Transportation and landowners in the watershed. Planning efforts include;

- Relocation of the Jimmycomelately Creek channel and reconnection to the estuary,
- Restoration of inchannel habitat and sinuousity,
- Restoration of the estuary,
- Reconnection of the floodplain to the channel
- Negotiations with Department of Transportation over an improved Highway 101 crossing over the Creek,
- Negotiations with Clallam County for a solution to the flooding and maintenance at the County Bridge site over Jimmycomelately Creek,
- Negotiations with owners of the log dump for culvert and private road realignment over a portion of the estuary, and
- Negotiations with landowners for possible land acquisition.

In addition, it has been recognized that a comprehensive solution to flooding and fisheries habitat degradation in the lower basin requires reconnection of another creek (Dean Creek) to its historic estuary, restoration of Dean Creek fish habitat east of Highway 101, and reduction of flooding hazard to Highway 101 at the Dean Creek crossing. For a general discussion of protection and restoration strategies by habitat parameter, refer to Part Three, section 3.4.4.2, toolkit.

## Strength of Evaluation and Information Needs

Confidence in the assessment of habitat factors for decline is high. Information needs include:

1. An assessment of low and peak flow events (hydrologic model) in Jimmycomelately Creek.
2. An assessment of the estuary's rearing habitat conditions.
3. A comprehensive hydrologic and hydraulic analysis of drainage patterns and channel conditions throughout the lower basin.

## References

Donald, M.A. 1990. Jimmycomelately stream survey. U.S. Dept. of Agri., Forest Serv., Olympic Nat. Forest, Olympia, WA.

# Salmon Watershed Narrative
# WRIA 17.0245

## Watershed Description

Salmon Creek originates on the northern slopes of Mount Zion at an elevation of 3,400 feet, has a watershed area of 19 square miles, and flows 9 miles into Discovery Bay, which is located in the eastern portion of the Strait of Juan de Fuca.

Salmon Creek merges with Snow Creek to form a common delta, although both have distinct distributary channels through to the outer delta. The historical manipulation of Salmon and Snow creeks is found in the Snow Creek narrative. The upper and mid-delta of both systems is heavily impacted by transportation, commercial and some residential development associated with the Highway 101 corridor that passes around the southern end of Discovery Bay. A railroad grade also parallels the highway in transecting the delta.

Salmon Creek is one of three major perennial creeks that drain approximately 49% of the greater Discovery Bay Watershed (Snow Creek and Contractors Creek are the other creeks). The Salmon Creek Watershed contains a diverse array of land uses but is dominated by forest cover. Land use includes both public and private forest, hay and pasture lands and residential areas. Much of the commercial forestland is in public ownership and private industrial. The largest acreage of agricultural lands occur in the lower Snow Creek Valley, through which both Salmon and Snow creeks flow.

## Summer Chum Distribution

The highest density of spawners is below Uncas Road (approx. R.M. 0.7), however spawning extends up to River Mile (RM) 2.0.

## Population Status

Escapements have generally been estimated to be in the hundreds, ranging up to approximately 3,000 in one year. In 1992, a supplementation program was started as a strategy to increase or stabilize the abundance to allow transfer of eggs to Chimacum Creek without adversely affecting the spawning population (Appendix Table 1.1).

## Factors for Decline

The most significant issues believed to be affecting fish habitat in Salmon Creek center around changes in peak flow and low flow regimes, sediment accumulation and poor water quality in the lower reaches. Summer chum life history stages most impacted by these factors in the fresh water environment include spawning and incubation. For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18.

- *Channel complexity (LWD, channel condition, loss of side channel, channel instability*) -Spawning and incubation life stage, rated high impact. Timber and agricultural land uses in the watershed have combined to reduce or eliminate riparian buffers, large woody debris (LWD), side channels and associated wetlands. LWD levels were 0.06 individual pieces per meter, or 0.15 pieces if log jams are included, and rated as a high impact (Appendix Report 3.8). Pool habitat is limited (39% by surface area, pool frequency of 4.8) and also rated a high impact. Reductions in the type and amount of LWD have reduced habitat in the form of pools and provide for channel stability.

- *Peak flow* – Incubation life stage, rated high impact. Reduction of LWD has also reduced instream roughness that can dissipate the erosive force of floods. Excessive scour and deposition is one form of channel instability that occurs during peak flow events, leading to redd scour and egg mortality. Attempts to "fix" the channel in place by bank hardening, in one form or another, has ensured the loss of potential side channel development. Confinement of the channel by cutting off meanders and eliminating side channels and associated wetlands has altered the hydrologic capacity of the stream ensuring that peak flow events are much more severe than they were historically.

- *Riparian condition* - Spawning and incubation life stage, rated high impact. Thirty-two percent of the lower 1.5 miles of summer chum spawning distribution is in forested buffer. The dominant land use excluding forested buffers includes 43% in agriculture. Seventy percent of the forested buffer is less than 66 feet in width (Appendix Report 3.7). A habitat survey conducted by the Point No Point Treaty Council under the Centennial Clear Water Act Fund found the number of pools in relation to surface area of the creek to be very low (39% - Appendix Report 3.8). Pools are dependent on the amount of large woody debris which are in turn dependent on the extent, age, and species composition of the riparian buffer. The poor condition of the riparian buffer is a strong determinant of the poor condition of instream habitat.

- *Subestuarine habitat loss and degradation (diking and road causeways)* - Juvenile rearing and migration life stage, rated high impact. The common delta of Salmon Creek and Snow Creek was estimated to have covered 0.28 km$^2$ (70.4 ac; 4.5 km [2.8 mi] perimeter). Three diked areas, totaling 0.02 km$^2$ (5.3 ac), now prevent tidal inundation in approximately 25.3% of the original delta. Ten roads or causeways cross or encompass the delta, the most deleterious of which is Highway 101, but the railroad grade poses almost equivalent impacts because it is located in the center of emergent marsh rearing habitat. The railroad grade is likely a major contributor to muted tidal circulation across the delta, especially in emergent wetland habitat between the railroad grade and Highway 101. The total length of these various segments is ~2 km (1.2 mi).

- *Sediment (fines, aggradation*) -Spawning and incubation life stage, rated moderate impact. Very little information exists regarding the sources of sediment accumulation in the lower reaches. Land uses that confine the channel in the lower reaches increase the potential for sediment accumulation, redd scour and egg mortality. The degree to which this occurs needs to be verified. Fine sediment sampling completed in 1994 indicated 15% fines by volume less than 0.85 mm in size, rated as a moderate impact to the spawning life stage.

## Factors for Recovery

A general discussion of habitat factors for decline and recovery is found in Section IV, toolkit. Knowledge of the historic conditions in Salmon Creek is limited. The historic channel probably had a more sinuous shape than we see today including connecting side channels and associated wetlands. We know that Snow Creek was a tributary to Salmon Creek in the lower reaches. Large woody debris was more abundant throughout the watershed.

- *Channel complexity and sediment –*The historic removal of large woody debris (LWD) and log jams was a prominent element of flood control activities throughout the Northwest. Stable log jams are now scarce throughout the lower reaches of Salmon Creek. Restoration of the lower channel will include restoring a sinuous channel pattern upstream of the WDFW weir, replacement of riprap entirely or with bioengineered solutions, controlling sediment inputs that are in excess of the channel's capacity to store and transport, and creating stable log jams.

- *Riparian forests* – Only 32% of the summer chum reach is cover by a riparian forest, agriculture (43%) is the primary landuse in the riparian zone. Restoration of riparian forests should follow recommendations outlined in the Riparian forest toolkit (Part Three - section 3.4.4.2). This will include replanting appropriate species, and fencing livestock out of the riparian zone (if necessary).

- *Subestuary habitat loss and degradation*- Restoration of the diked delta areas will be problematic because of the integration of the diked areas with the Highway 101 transportation corridor. Removal of the railroad grade, however, poses one of the more direct strategies to remove a significant blockage to riverine-tidal circulation and fish movement across the delta.

## Strength of Evaluation and Information Needs

There has been a Federal Watershed Analysis (USFS 1996), a report produced by the Puget Sound Cooperative River Basin Team (PSCRBT 1992), and a community based watershed management plan produced in Discovery Bay (Discovery Bay Watershed Management Committee 1994). Information needs include:

1. An in-stream summer chum flow assessment.
2. An assessment of the channel's ability to accommodate peak flood flows.
3. An assessment of the extent of scour and deposition within the spawning range of summer chum.
4. An inventory of landslides, road related and other sources of sediment.
5. An assessment of the estuary's rearing habitat condition.

## References

Discovery Bay Watershed Management Committee. 1994. Discovery Bay watershed management plan: A community based resource management plan. Jefferson County, Port Townsend, WA.

PSCRBT (Puget Sound Cooperative River Basin Team). 1992. Discovery Bay Watershed; Jefferson and Clallam County. Jefferson County, Port Townsend, WA.

USFS (United States Forest Service). 1996. Snow and Salmon Cr. Watershed Analysis. U.S. Dept. of Agri., Forest Service, Olympic National Forest, Olympia, WA.

# Snow Watershed Narrative
# WRIA 17.0219

## Watershed Description

The headwaters of Snow Creek originate at approximately 3,600 ft elevation on the northeast and east slopes of Mount Zion. The stream flows east through a confined valley and then turns north into a wide valley before entering Discovery Bay. The stream is about 10 miles long and its major tributaries are Andrews Creek (inclusive of Crocker Lake) and Trapper Creek.

Since European settlement a number of changes have been made to the lower channel. At one time Snow Creek was a tributary to Salmon Creek, and emptied into Salmon Creek just upstream of Discovery Bay. The lower 0.6 miles of Snow creek was moved to the eastern edge of the valley and a new channel dredged to Discovery Bay. During flood events, Snow Creek has been known to overflow into its original channel.

The upper tributary to Snow Creek, Andrews Creek, was also diverted. Once a tributary to Lake Leland within the Little Quilcene River drainage, it was diverted into Crocker Lake. Crocker Lake had no natural outlet prior to diversion of Andrews Creek. After exiting Crocker Lake, Andrews Creek flows a short distance before entering Snow Creek at river mile (RM) 3.5.

The Snow Creek Watershed contains a diverse array of land uses but is dominated by forest cover. Land use includes both public and private forest, hay and pasture lands and residential areas. Much of the commercial forestland is in public ownership and private industrial forestland. The largest area of agricultural lands occurs in the lower Snow Creek Valley, through which both Snow and Salmon creeks flow. Sixty-four percent of the riparian zone below RM 3.0 is forested. Twenty-six percent of the riparian zone is devoted to agriculture, 4% to roads or dikes, and 2% as rural residences (Appendix Report 3.8).

At the entrance to Discovery Bay, Salmon Creek and Snow Creek form a common intertidal delta; the discussion of factors for decline and recovery below will treat this as one ecosystem component.

## Summer Chum Distribution

The majority of summer chum spawn below Uncas Road (approximately RM 1.5), however there are reports that summer chum salmon spawned upstream to RM 3.0 in past years.

## Population Status

Escapement until the late 1980s was estimated to be in the hundreds, varying from to over 800 spawners to three years having below 200. In the late 1980s and early 1990s, escapement dropped to very low levels, with a maximum of 33 spawners between 1989 and 1995 (Appendix Table 1.1). Strays from the Salmon Creek supplementation project may have accounted for escapements of 160 in 1996 and 67 in 1997 (fry are released from a net pen in Discovery Bay).

## Factors for Decline

Channel instability and problems with peak and low flows, loss of LWD, and deposition of fines in spawning gravels are attributed as the principal habitat limiting factors. These changes have likely resulted in an increase in redd scour and a reduction of quality spawning habitat. For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18. Factors for decline in Snow Creek include:

- *Channel complexity (LWD, channel condition, loss of side channel, channel instability)*-Spawning and incubation life stage, rated high impact. In the lower reaches of Snow Creek; riparian buffers have been reduced or eliminated; stable log jams are scarce and side channels and associated wetlands have been largely eliminated. TFW ambient monitoring completed by PNPTC in 1993 found 0.07 pieces of LWD per meter, rated as a high impact (Appendix Report 3.8). The relative scarcity of pool habitat (47% by surface area, pool frequency of 5.7) was considered a moderate to high impact. Confinement of the channel by bank hardening in one form or another, in addition to the loss of LWD, has reduced in-channel complexity resulting in aggradation and an unstable channel. These factors have lead to increased channel instability with a likely increase in redd scour and egg mortality during peak flow events.

- *Sediment (fines, aggradation)*-Spawning and incubation life stage, rated high impact. Re-routing of the channel and loss of instream channel complexity have decreased the channel's ability to route sediment through the system. Increased aggradation levels have resulted in increased scour of redds. It is not known to what degree adult summer chum are inhibited in their migration to spawning beds due to barriers created by lower than normal low flow conditions as a result of the aggradation. Sediment sampling of spawning gravel, completed by PNPTC in 1994, indicated 18% fines by volume less than 0.85 mm, rated as a high impact to the spawning life stage.

- *Flow, peak and summer low*- Spawning and incubation, rated high impact. In recent years higher than normal sediment aggradation has been observed in the lower reaches. The extensive re-routing and channelization in the lower reaches of Snow Creek has lowered the channel capacity to route sediment into the bay. The increase in aggradation in the lower reaches combined with the reduced channel capacity has altered the hydrologic regime causing increased winter peak flows and lower summer flows. It is unknown how the re-routing of Andrews Creek into Snow Creek has impacted the hydrologic conditions in Snow Creek.

- *Riparian condition (species composition, age, and extent)*-Spawning and incubation life stage, rated high impact. Historic timber and agricultural land uses along with re-routing and confinement of the channel has reduced or eliminated riparian buffers along lower Snow Creek. Sixty-four percent of the riparian zone below RM 3.0 is forested. Seventy-six percent of the forested buffer is <66 ft in width. Fifty-six percent of the forested buffer is either absent or <20 in dbh (Appendix Report 3.7). The riparian forest is in poor condition

- *Estuarine habitat loss and degradation (diking and road causeways)* - Juvenile rearing and migration life stage, rated high impact. The common delta of Salmon Creek and Snow Creek was estimated to have covered 0.28 km$^2$ (70.4 ac; 4.5 km [2.8 mi] perimeter). Three diked areas, totaling 0.02 km$^2$ (5.3 ac), now prevent tidal inundation in approximately 25.3% of the original delta. Downstream of Highway 101, both sides of the bank are diked, with the estuary filled behind the right bank dike. Two roads or causeways cross or encompass the delta, the most deleterious of which is Highway 101, but the railroad grade poses almost equivalent impacts because it is located in the center of emergent marsh rearing habitat. The railroad grade is likely a major contributor to muted tidal circulation across the delta, especially in emergent wetland habitat between the railroad grade and Highway 101. The total length of these various segments is ~2 km (1.2 mi).

## Factors for Recovery

In order for restoration efforts to succeed, sediment inputs must be in balance with capacity of the channel to transport and store sediment in the river channel, floodplain and estuary. This will require reducing excessive sediment input, abating constrictions to the channel and re-establishment of a functional floodplain. A general discussion of limiting factors and protection/restoration strategies is found in Part Three - section 3.4.4.2, toolkit.

Historically, removal of large woody debris (LWD) and log jams was a prominent element of flood control activities throughout the Northwest. Stable log jams are now scarce throughout the lower reaches of Snow Creek. In concert with sediment control, the creation of numerous stable, long-term log jams will increase the following functions: dissipation of stream energy to enhance channel and bank stability, creation of stable pools and riffles, reduction of bank erosion, development of physical habitat and cover for fish, and the creation of stable spawning sites. This restoration strategy can be implemented in the short term. The reintroduction of a functional riparian buffer for future recruitment of LWD will require both a protection strategy and recognition that this is an important long-term effort due to the current conditions of the riparian buffer.

In addition, a critical step for restoring stability in lower Snow Creek will require re-establishing a functional estuary/freshwater linkage. Once associated with a significant estuary, Snow Creek was relocated into an artificial channel located on the margin of its estuary. Estuaries have long been recognized as one of the most productive aquatic environments due to their abundant food supply and wide salinity gradients. In addition to their productivity and importance to fish, estuaries provide a critical linkage for routing stream sediment into the marine environment and thereby contribute significantly to both horizontal and vertical bed stability in the lower reaches of creeks and rivers.

In highly functional estuaries, tidal energy is manifested and harnessed for sediment routing through a network of tidal surge plains and channels, collectively referred to as tidal basins, that serve as tributaries to the fresh stream channel. Tidal energy is effective at moving sediment where stream gradient becomes approximately zero at the marine interface. As elevations and gradient drop, stream energy declines and in this transition zone tidal surge energy increases.

Thus, sediment is transported and distributed widely into far-lower tidal elevations than channel gradient and stream energy alone would appear to allow. Linking of fresh water and tidal basins is the mechanism responsible for creating stable, slowly evolving, complex and productive estuaries.

Perhaps no other aquatic environment on the east and north slopes of the Olympic Peninsula have been so altered by human impacts as estuaries. Diking, road and railroad grade building, and land filling have truncated significant portions of most of the region’s estuaries. To date there has been no estuary restoration measure taken to specifically restore these critical functions of estuaries.

In 1995 and 1996, two phases of an early Snow Creek restoration project were implemented. These consisted of constriction abatement/floodplain creation in the lowest reaches north of Highway 101 and west of State Road 20, pool re-establishment, streambed lowering, and large woody debris (LWD) inputs. No specific estuary restoration measures were incorporated, although approximately 150 feet of old de facto dike were removed from the high salt marsh. The actions created a modest in-channel tidal surge reservoir, which in December 1996 was seen to harbor adult salmon and white sturgeon. Evidence of bedload accumulation in recent years indicates that the most important step to restoring Snow Creek is to re-establish the freshwater/estuary link.

Restoration of much of the diked areas of the delta will be problematic because of the integration of the diked areas with the Highway 101 transportation corridor. Removal of the railroad grade, however, poses one of the more direct strategies to remove a significant blockage to riverine-tidal circulation and fish movement across the delta.

Recommended restoration actions include:

- Reconnect Snow Creek to Salmon Creek within its historic channel. This would require the cooperation of state and federal agencies, Jefferson County, Jamestown Tribe, and the local landowners. If this is not possible, then establish a functional floodplain in lower reaches of Snow Creek through abatement of man-made constrictions to the channel.
- Restore sinuosity below Uncas Road (RM 1.5) through to the river mouth.
- Control sediment inputs that are in excess of the channel's capacity to store and transport material.
- Create numerous stable, long-term log jams.
- Re-introduce a functional riparian buffer for future recruitment of large woody debris.
- Remove the railroad grade in the estuary to remove a significant blockage to riverine-tidal circulation and fish movement across the delta.
- Re-integrate estuary with Snow Creek through salt marsh and mud flat restoration.
- Remove dikes on both sides of the estuarine channel and remove fill located behind the right bank dike.

## Strength of Evaluation and Information Needs

There has been a Federal Watershed Analysis (USFS 1996), a report produced by the Puget Sound Cooperative River Basin Team (PSCRBT 1992), and a community based watershed management plan produced in Discovery Bay (Discovery Bay Watershed Management Committee 1994). Information needs include:

1. An assessment of the minimum summer low flows necessary to support the desired summer chum escapement.
2. An assessment of the channel's ability to accommodate flood flows.
3. An assessment of the estuary's rearing habitat conditions.

## References

Discovery Bay Watershed Management Committee. 1994. Discovery Bay watershed management plan: A community based resource management plan. Jefferson County, Port Townsend, WA.

PSCRBT (Puget Sound Cooperative River Basin Team). 1992. Discovery Bay Watershed; Jefferson and Clallam County. Jefferson County, Port Townsend, WA.

USFS (United States Forest Service). 1996. Snow and Salmon Cr. Watershed Analysis. U.S. Dept. of Agri., Forest Service, Olympic National Forest, Olympia, WA.

# Chimacum Watershed Narrative
## WRIA 17.0203

### Watershed Description

Chimacum Creek is located in east Jefferson County, on the northeast side of the Olympic Peninsula. The mouth of the stream enters Admiralty inlet approximately five miles south of the city of Port Townsend. The Chimacum watershed is approximately 37 square miles in area, with a combined stream length of about 30 miles. In the rain shadow of the Olympic Mountains, the watershed generally receives from 35 inches of rain in its headwaters to less than 22 inches at the mouth.

Chimacum Creek originates in a number of spring fed tributaries and lakes in the forested hills, and then flows into two glacially carved lowland valleys dominated by pastureland with peat and muck soils. The surrounding hills are used for rural residences and logging of second and third growth timber, and the lowland valleys are dominated by agricultural use, primarily pastureland. Near the confluence of the east and west forks of Chimacum Creek at RM 2.9, are the towns of Chimacum, Port Hadlock, and Irondale with rapidly growing residential and commercial development. The mainstem enters a moderately confined and forested ravine below RM 1.3. At RM 0.2, the stream continues through a comparatively unimpacted estuarine lagoon, salt marsh and relatively deep inlet to the open saltwater of Admiralty Inlet. The Creek empties into a short, partially forested tidal floodplain but has no distinct tidal delta, and drains into a comparatively deep inlet that adjoins Admiralty Inlet.

Fifty one percent of the riparian zone below RM 3.0 is covered by riparian forests, most of which is in the forested ravine located below RM 1.3 (Appendix Report 3.7). Between RM 1.3 and 3.0, are minimal riparian forests and extensive landuse. Here, 49% of the riparian zone is comprised of agriculture (16%), rural residences (17%), and urban or commercial development (16%).

### Summer Chum Distribution

Summer chum were documented spawning below RM 1.3, between the river mouth and Irondale road crossing, by Ray Lowrie and his Chimacum High School class from 1971 to 1976; WDFW documented summer chum in the same reach in six surveys between 1974 and 1983. Art Giles, a long time landowner on a headwater tributary of Chimacum Creek (WRIA 17.0213, Barnhouse Creek), recalls seeing chum spawning in abundance in this headwater stream decades ago (pers. comm., 1998). Because Chimacum Creek maintains a low gradient, the historic distribution may well have extended more than eight miles upstream in both valleys to the hillside tributaries (Bahls and Rubin 1996). However, for this analysis, we are basing the assessment on the more likely potential distribution below RM 3.0.

### Population Status

No summer chum salmon were observed during spawning surveys conducted by the Port Gamble S'Klallam Tribe during the past five years, indicating that the population is extinct.

Spawning surveys conducted by Ray Lowrie and his Chimacum high school students between 1971 and 1976 show counts of over 100 fish for some years, however no escapement estimates were made. A reintroduction program was begun in 1996 using Salmon Creek stock.

## Factors for Decline

The riparian zone and estuarine lagoon below RM 1.3 of Chimacum Creek remains in good condition with large second growth conifer and no development within the ravine. Above the ravine, 95% of the wide, low gradient, glacial valley was ditched for pasture and cropland beginning in the 1920s (Bahls and Rubin 1996). These upstream changes in land use have impacted the habitat in a number of ways. For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18.

- *Fine sediment* - incubation life stage, rated high impact. In-stream habitat has been severely degraded by a combination of upstream impacts. Siltation from de-forested and channelized segments has degraded spawning gravel conditions. In addition, the collapse of the Irondale road crossing (RM 1.3) and its fill in 1983 caused downstream sedimentation and "cementing" of the stream gravel making redd construction difficult for salmon (Ray Lowrie, pers. comm., 1996). These conditions have improved in recent years, but percentage of fine sediment in the spawning gravel remains high (M. Kennedy, stream restoration volunteer, private comm.).

- *Peak flow, freshwater wetland loss, and channel instability* - incubation life stage, rated moderate impact. The historic conversion of the Chimacum lowland valleys from beaver pond wetlands and forested bogs to pasturelands may increase the duration and magnitude of winter flood flows. The valley still serves as a flood reservoir however it is suspected the valley may release floodwater more rapidly than the previous beaver-pond dominated valley. Areas around Chimacum, Port Hadlock, and Irondale are rapidly urbanizing, with an expected increase to the severity of winter floods from impervious surfaces.

- *Low flow* - spawning life stage, rated moderate-low impact. Water withdrawal for irrigation and loss of wetlands in the Chimacum valley may impact summer chum survival, with a more severe impact in years when the summer dry season overlaps the Summer Chum spawning season (mid August to mid October). DOE has an administrative closure to further surface water diversion (DOE 1998).

- *Water quality* - spawning and incubation life stage, rated moderate-low impact. The good condition of this riparian zone helps reduce high summer stream temperatures coming from the agricultural valleys upstream. Temperature monitoring (1998) at the mouth indicates that while state AA standards were exceeded in July, by the end of August temperatures averaged 14°C and declined to below 12°C by the end of September. Chum prefer spawning temperature of 12-14°C, this is considered a moderate to low impact. Dissolved oxygen at the river mouth averaged between 9.3 and above 10 mg/L, with the state AA standard of 9.5 mg/L. In 1998, fecal coliform at RM 1.1 averaged just below the state AA standard of 50 FC/ml (Al Latham, JCCD). However, in dry years when the summer dry season overlaps the fall spawning season, stream temperatures may be a significant impact.

- *Riparian forest* - spawning and incubation life stage, rated low impact. The riparian forests range from absent or severely degraded, to those in advanced stages of recovery. Most of the degraded riparian forests occur between RM 1.3-3.0. Above RM 1.3, riparian forests are small diameter (<12 in), deciduous or grass dominated and narrow in extent (<66 ft). Below RM 1.3, the forested strip is wide (>200 ft), mixed conifer/deciduous, and with a medium average diameter (12-20 in). Since summer chum is primarily found below RM 1.3, it is these forest conditions that reduced the overall riparian impact from moderate/high to low.

- *Subestuary habitat loss and degradation* - Juvenile rearing and migration life stage, rated moderate impact. Out of all the 20 sub-estuaries, this was the only one that did not have a road directly across or shortly upstream of the subestuary. However, south of the river mouth approximately 30 ac of tidal marshland was filled, probably in the late 1800s. A road now crosses most of the fill, but ends at the river mouth. There are no other roads, jetties or dikes, dredged, ditched or excavated areas evident in this comparatively small, 0.02 km$^2$ (5.2 ac, 1 km [0.6 mi] perimeter) delta. Historically, the bay at the mouth of the creek was used for log storage.

## Factors for Recovery

The following recommendations are provided to allow recovery of Summer Chum habitat in the lower river. Jefferson County should realize that designating Chimacum, Port Hadlock, and Irondale as Urban Growth Areas under the Growth Management Act should consider the impact to the lower Chimacum Creek and subestuary. A general discussion of protection and restorations strategies for each habitat factor is found in Part Three - section 3.4.4.2, toolkit.

- *Fine sediment and water quality* - Investigate replacement of the fill and culvert at the Irondale Road crossing with a bridge to remove the possibility of future culvert failure. The costs and benefits of this project should be weighed against other Chimacum Creek projects. Within the valley, re-establish forested riparian zones along the east and west forks of Chimacum Creek to reduce high summer water temperatures and input of fine sediment.

- *Peak flow and summer low flow* - Restore wetlands where possible to increase flows in the summer and to help reduce the impacts from peak flows in the winter. There are several areas where wetland and beaver pond restoration could be accomplished without impacting existing farmers. Conduct an extensive assessment of surface and groundwater withdrawals to determine the extent of impact on summer low flow and to identify potential remedies. Locate and monitor potential runoff sources from impervious surfaces. Monitor the potential impacts from peak flows to the channel bed with scour chains.

- *Riparian forest and LWD* - Protect the riparian and wetland habitat in the entire lower 1.3 miles (below Irondale Road) and upstream areas that are still forested and in good condition. The Jefferson Land Trust and WDFW are currently working to acquire conservation easements to protect key salmon refugia throughout the watershed.

- *Protect tidal floodplain and estuary* - The subestuarine fill site has been highlighted by conservation groups for aquisition and restoration. Upstream of the mouth, the subestuary narrows and enters a canyon where it is relatively unimpacted by development. The subestuary in the canyon is contiguous with the undeveloped lower 1.3 miles of riparian forest. This entire stretch should be protected with easements or outright purchase.

## Strength of Evaluation and Information Needs

The Chimacum Watershed Coho Salmon Restoration Assessment (Bahls and Rubin 1996) provides a fairly thorough base of information upon which to evaluate the status of habitat for summer chum salmon. However, because most of the impacts on summer chum habitat are an indirect result of upstream habitat changes, confidence in the assessment is moderate.

The following are research and monitoring needs:

1. Determine the impact (if any) on surface and groundwater withdrawals on summer low flow.
2. Conduct scour monitoring to determine the magnitude of peak flow on redd scour.
3. Annual monitoring of fine sediment both above and below Irondale Road.
4. Continuous temperature monitoring at regular intervals below RM 3.0.

## References

Bahls, P. and J. Rubin. 1996. Chimacum watershed coho salmon habitat restoration assessment. Port Gamble Tribe Fish Management, Kingston, WA.

WDOE (Wash. Dept. of Ecology). 1998. Needs assessment for the Eastern Olympic Water Quality Management Area. Wash. Dept. Ecol., Olympia, WA.

# Little Quilcene Watershed Narrative
# WRIA 17.0076

## Watershed Description

The Little Quilcene watershed drains to Quilcene Bay. It is bounded by Snow Creek to the North, Donovan and Tarboo Creek to the east, Big Quilcene to the south, and Dosewallips to the west. The Little Quilcene has a watershed area of 30 square miles, total mainstem length of 12.2 miles and combined tributary length of 81.2 miles. The upper 1/3 of the watershed lies within the basalt-rich Crescent formation, and is primarily Forest Service land. Watersheds of this rock type are steeply dissected with limited anadromous habitat (e.g. similar to most of west Hood Canal from the Big Quilcene south). Port Townsend diverts water (9.6 cfs water right, with a 6 cfs mimimum instream flow requirement at diversion) at RM 7.1 to Lords Lake Reservoir on Howe Creek, which is removed from the watershed (USFS and WDNR 1994). This water right is junior to a total of 5 cfs water rights held by landowners in Quilcene. Lords Lake (generally filled during April and May) is used to supplement Port Townsend water diverted from the Big Quilcene when flows decline below the Big Quilcene minimum instream flow level, or when the Big Quilcene contains excessive suspended sediment during floods (USFS and WDNR 1994, S. Cupp, US Forest Service, pers. comm. 1994). WDOE has an administrative closure to further surface water diversion (WDOE 1998).

From approximately RM 7.0 to the mouth, the watershed is composed of unconsolidated glacial sediment layers interbedded with siltstone and sandstone, and alluvium deposited by the river (Grimstad and Carson 1981). This portion of the watershed contains extensive low-gradient anadromous habitat and associated development for agriculture, homes, and the town of Quilcene. The Little Quilcene reaches the town of Quilcene at about RM 1.0.

Sixty percent of the riparian zone below RM 3.0 is developed (major landuse are 33%-Agriculture, 11% roads or dikes, 8% rural residences and 6% forestry, Appendix Report 3.7), which is considered a high impact. The lower 0.8 miles contains dikes and bank armoring for floodplain residences. Dikes, roads, and ditches impact the tidal delta.

## Summer Chum Distribution

Summer chum spawn in the mainstem up to RM 3.0, however most spawning occurs below RM 1.8. It is unlikely summer chum use tributaries such as Leland Creek due to low summer flows.

## Population Status

Escapement declined in the 1980s from the several hundreds with occasional escapements of over one thousand to less than two hundred spawners. From 1989 through 1994 escapement was 12 spawners or less, with four years of 0 or 1. An improvement in escapement to 265 was seen in 1996. In 1997 escapement dropped to 29, but was again 265 in 1998 (Appendix Table 1.1). The recent increases may be affected by the summer chum supplementation project in the immediately adjacent Big Quilcene River.

## Factors for Decline

The Little Quilcene is similar to the Big Quilcene in terms of factors for decline. The habitat is in poor condition, especially below RM 0.8. Factors for decline are: water withdrawal, low channel complexity, estuarine diking, channel aggradation, and young or absent riparian vegetation. These factors are not separate, but interact to increase pressure across all life stages. For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18.

- *Low flow*-Spawning life stage, rated high impact. Mean annual flow for the Little Quilcene is 54 cfs, with low flows of 5 to 13 cfs (Jamestown S'Klallam 1994). The Little Quilcene is overallocated during low flow periods. The City of Port Townsend and local landowners combined hold a total of 14.6 cfs in water rights. The 5 cfs of senior irrigation water rights held by local landowners in the lower river is downstream of the 6 cfs the City of Port Townsed is required to maintain in the river. The City of Port Townsend (and Port Townsend Paper) "divert very little if any water from the first part of September until the first major rains in the fall" (Stan Cupp, Port Townsend Paper, pers. comm.). The impact of water withdrawal on fish habitat needs further investigation. For eastern Jefferson County, water consumption is expected to increase 78% (over 1990 levels) by the year 2020 (Jamestown S'Klallam 1994). Developing water resources in the glacial deposits of the Little Quilcene, where continuity may exist between surface water and groundwater, may further reduce already low summer flows. An aquifier study for the Big Quilcene was inconclusive on the connectivity between the Big Quilcene and the glacial deposits between the Big and Little Quilcene (Schwartzman 1998). This relationship needs further study for both rivers.

- *Channel complexity*-Spawning and incubation life stages, rated high impact. From habitat surveys, the Little Quilcene has (within the summer chum range) 32% pool, 0.1 pieces of LWD/m., and an average of 5.3 channel widths between pools. Together these numbers translate into highly degraded channel habitat. A 1932 survey of the Little Quilcene noted many logjams and six areas of beaver activity in the lower 10 miles (Amato 1996). Most of these logjams are gone. Six hydraulic permits for LWD removal were issued from 1989 to 1995 alone (WDFW HPA database). The stream catalog reported ditching of the Little Quilcene below RM 0.8 (Williams et al. 1975). Portions of the south riverbank currently are hardened with riprap (B. Rot, pers. comm.).

- *Subestuary habitat loss and degradation*-Juvenile rearing and migration life stage, rated high impact. Undiked river mouths are connected to multiple slough channels, which are heavily utilized by summer chum for spawning and rearing. Dikes along the river and paralleling the coast south of the river mouth have physically isolated the river channel from slough habitat. Through aerial photo analysis, we estimate that 25% of the historic delta area of approximately 230 ac. is diked along the western margin of the delta. These diked areas appear to be controlled by at least two tidegates. Four road or causeway segments totaling 0.45 mi. in lineal extent, may constrict or prevent natural tidal inundation of adjoining wetlands. Ditches, filling and dredging were not detected in the delta. No docks, log storage, jetties or other structures are evident.

- *Riparian forest*-Spawning and incubation life stage, rated high impact. Seventy percent of the forested buffer contains small trees (<12 in dbh), 51% is deciduous dominated or has no riparian forest, and 60% is <66ft in width and/or sparsely vegetated (Appendix Report 3.7). The riparian forest was first harvested in the early 1900s by the Otto Beck Logging Company to supply the Green Shingle Mill located in Quilcene (Amato 1996). At the time, the floodplain between and surrounding the Big and Little Quilcene rivers was mostly old growth cedar swamp and forest. The mill was closed in 1915 when the accessible cedar had been harvested. In addition to historical effects, bank armoring, home building, and agriculture in the 100-year floodplain has reduced the extent of functional riparian forest.

- *Sediment*-Spawning and incubation life stage, rated moderate impact. The channelized and diked lower river near the mouth has resulted in channel aggradation and avulsions at least three times in the past six years below RM 0.3, leaving the main channel dry for at least several weeks (R. Johnson, WDFW, Port Angeles, WA, pers. comm.). The channel avulsed both north and south of the diked mainstem. While very little information exists regarding potential sediment sources within the watershed, failing Forest Service roads, diking of the estuary and lower channel, and increasing percentage of impervious surfaces are suspected primary factors.

## Factors for Recovery

A general discussion of protection and restoration strategy for each factor is found in Part Three - section 3.4.4.2, toolkit.

- *Low flow*- the extent of water usage or draw-down by Port Townsend during August and September and its potential impact to summer chum spawning is unknown. While DOE has the river on administrative closure, the IFIM study currently in progress is expected to provide information needed regarding relative impacts of surface water withdrawal on fish. Further study is needed on whether there is a relationship between well use and instream flows.

- *Property buyout and floodplain easements*-protect the few remaining spawning areas in the lower three miles with intact riparian forest and good instream habitat. Identification of these areas could be done with the assistance of the Hood Canal Salmon Sanctuary group.

- *Construction permits*-below RM 0.7, the 100-year floodplain has extensive development to the south of the river. Except for a road, the north side is relatively undeveloped, although at least one lot is for sale. A recent springtime flood crossed this property. In areas of high channel migration, bank hardening follows floodplain development. The county should restrict future development to areas outside of the 100-year floodplain throughout the summer chum zone.

- *Riparian forest and LWD*-educate local landowners on the importance of LWD to channel complexity and connected forested floodplains. Encourage farmers and residential landowners to plant conifer where the forest is absent or dominated by deciduous species, and discourage removal of LWD (see Riparian Forests toolkit, Part Three - section 3.4.4.2).

- *Channel aggradation*-conduct an assessment using the methodology in the Watershed Analysis mass wasting module to determine the source of channel aggradation.
- *Restoration of estuarine diked areas* — Purchase or obtain an easement of estuarine property, remove dikes (both paralleling the channel and the coast south of the channel) and restore connection to the lower floodplain and subestary. In addition, restore channel sinuosity through this reach. This represents a potential recovery of over 25% of the historic juvenile summer chum rearing and migration habitat in this estuary (see Subestuarine toolkit, Part Three - section 3.4.4.2). Conversion of fill road causeways to pile causeways may also recover additional estuarine habitat.

## Strength of Evaluation and Information Needs

Confidence in the assessment is high given the channel habitat surveys, riparian forest and landuse data for the Little Quilcene, coupled with the large amount of data for the nearby Big Quilcene River.

Information needs include:

1. An understanding of the range of annual summer low flows (given withdrawal) and whether these are adequate to support recruitment goals. If not, what flow is necessary and what density will the existing range of flows support.
2. A study to look at well development and instream flows.
3. A sediment source assessment for the watershed.
4. A study evaluating the relative effect of road fill causeways on the creation and maintenance of tidal slough channels, and the feasibility of dike removal in the lower channel and estuary.

## References

Amato, C. 1996. Historical changes affecting freshwater habitat of coho salmon in the Hood Canal basin, pre-1850 to the present. Point No Point Treaty Council, Kingston, WA.

Grimstad and Carson. 1981. Geology and ground-water resources of eastern Jefferson County, Washington. Wash. Dept. Ecol., Olympia, WA. 125 p.

Jamestown S'Klallam Tribe. 1994. The Dungeness-Quilcene water resources management plan. Jamestown S'Klallam Tribe, Sequim, WA.

Schwartzman, P. 1998. Study of residential well connectivity between Quilcene and Big Quilcene R. Jefferson County Dept. Pub. Works, Port Townsend, WA.

USFS (United States Forest Service) and WDNR (Washington Department of Natural Resources). 1994. Big Quilcene watershed analysis - an ecological report at the watershed level. U.S. Dept. of Agri., Forest Serv., Olympic National Forest, Olympia, WA.

WDOE (Wash. Dept. of Ecology). 1998. Needs assessment for the Eastern Olympic Water Quality Management Area. Wash. Dept. Ecol., Olympia, WA.

Williams, R.W., R.M. Laramie, and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization, Volume 1, Puget Sound Region. Wash. Dept. Fish and Wild., Olympia, WA. 974 p.

# Big Quilcene Watershed Narrative
# WRIA 17.0012

## Watershed Description

The Big Quilcene watershed drains to Quilcene Bay in west Hood Canal, and is bounded by the Little Quilcene to the north, the Dungeness to the west, and the Dosewallips to the south. The Big Quilcene has a watershed area of 68 square miles, total mainstem length of 19 miles, and combined tributary length of 80 miles. Thirty percent of the Big Quilcene watershed (headwater) is contained in the Buckhorn wilderness. Below the Buckhorn, the Forest Service, State, and private forestland owners manage most of the remaining watershed for timber production. This portion of the watershed is steep, with relatively weak, easily eroded rock. The Big Quilcene is a tier II Key Watershed under the President's Forest Plan (FEMAT 1993). The primary water source for the City of Port Townsend (30 cfs water right) is diverted at RM (river mile) 9.4. This is a consumptive use and is diverted out of the basin. The majority of water supports the operation of a paper mill.

Below RM 4.8, the channel gradient moderates and flows through an increasingly wide floodplain. This area of small private land blocks occupies about 5% of the watershed. The Quilcene National Fish Hatchery (QNFH) is located at RM 2.8, and utilizes water from both the Big Quilcene and nearby Penny Creek. On the Big Quilcene, they have a 15 cfs water right with an additional 25 cfs when flows in the mainstem at the hatchery exceed 50 cfs from July 1 to February 28, and 83 cfs from March 1 to June 30 (Jamestown S'Klallam 1994). This water is removed from the Big Quilcene for about 1/2 mile between the hatchery intake and outlet. Penny Creek is a 25 cfs water right (Jamestown S'Klallam 1994).

Thirty eight percent of the riparian zone to RM 4.8 is occupied by landuse, primarily roads or dikes (21%) and agriculture (10%, Appendix Report 3.7). The channel below RM 0.8 is diked, and portions of the channel between RM 0.8 and 4.8 has been dredged, diked, or the bank armored. The Big Quilcene flows through the town of Quilcene at approximately RM 0.8.

## Summer Chum Distribution

Summer chum spawn in the mainstem up to RM 2.8 where the hatchery weir prevents further passage, however most spawning occurs below RM 1.0. Since historical summer chum distribution may have extended up to RM 5.0 on the mainstem (USFS 1994), we examined habitat conditions up to RM 5.0. It is unlikely that summer chum historically spawned in tributaries such as Penny Creek due to low summer flows.

## Population Status

Escapement dropped substantially from estimated in the thousands prior to 1978 to estimates below on hundred from 1983 to 1991, excepting 1998 with 120 spawners in 1988 (Appendix Table 1.1). In 1992, the Tribes, WDFW, and U.S. Fish and Wildlife Service initiated a 12-year brood stocking program (USFWS

1994). The run was to be restarted from chronically low levels while chum habitat was enhanced to support a wild run.

### Factors for Decline

The Big Quilcene watershed has historically been managed for timber, water, and hatchery fish production. The habitat is in poor condition, especially below RM 1.0 where the primary summer chum spawning grounds are located. The habitat is degraded due to: water withdrawal, low channel complexity, sub-estuarine modifications; sediment accumulation, and a young deciduous dominated (or absent) riparian forest. The decline in summer chum cannot be attributed to any one factor. These factors are not mutually exclusive, but interact to increase pressure across all life stages. For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18.

- *Low flow*-Spawning life stage, rated high impact. Discharge (below the diversion dam from August 15 to October 15, for the years 1994-1996) ranged between 23 to 82 cfs, with an average of 30 cfs. Summer chum return to the Big Quilcene in late August and spawn from September to mid-October. In 1994, Port Townsend agreed to reduce or halt water withdrawal during low flow to maintain a minimum of 25 cfs in the channel for fish. Prior to that, an informal arrangement between the dam operators and the hatchery ensured enough water was maintained in the river to satisfy QNFH needs. Another issue is whether residential or municipal wells have the potential for drawing down the Big Quilcene R. (e.g. whether hydrologic continuity exists between the two). A recent study was not conclusive (Schwartzman 1998).

- *Channel complexity and floodplain loss*-Spawning and incubation life stage, rated high impact. In the late 1950s, the lower Big Quilcene between RM 1.0 and 3.8 was a narrow, meandering, single thread channel, with reported good levels of LWD, pools, and an intact riparian forest. A structurally complex channel reduces the amount of stream energy available to scour summer chum redds. The channel is now wide, braided and in poor condition. The river has few, widely spaced pools (31% spaced at 5.1 channels widths between each pool) and relatively few pieces of LWD (0.16/m, PNPTC 1992, Appendix Report 3.8). While simplification of the channel has occurred throughout the past 150 years, substantial LWD has been removed since the 1960s by the WDF stream improvement division and also by local landowners. More recently, dredging (RM 2.5 to 2.2, and below RM 1.0), bank armoring, and dike construction/enhancement (RM 2.5 to 2.2, and below RM 1.0) have increased the continuing channel instability. During floods, a diked reach will have more energy to scour redds to a greater depth than an undiked reach at the same location. In 1995, Jefferson County removed a portion of the northern dike below RM 0.5 as a first step to reduce flooding hazard and improve fish habitat (Williams et al.1995). Channel cross sections surveyed annually by the Jefferson County Conservation District since 1993 indicate a period of channel stability during that time. Further dike removal is needed (Jefferson County 1998).

- *Subestuary habitat loss and degradation*-Juvenile rearing and migration life stage, rated high impact. Undiked river mouths are connected to estuarine slough channels, which are utilized by summer chum for spawning and rearing. Dikes along the river and paralleling the coast south of the river mouth have physically isolated the river channel from slough habitat. Summer chum juveniles are unable to access estuarine rearing habitat without first moving into Quilcene Bay. Predation impacts resulting from this are unknown. In the past 100 years, the river mouth has extended 1,700 ft out into the bay due to dredging and diking (Jefferson County 1998). Dikes obstruct about 21% of the estimated historic delta area of 125 ac (3.5 mi. perimeter). About 3% of the historic delta is filled for commercial and residential use in four areas primarily located in the southeastern corner of the delta. About 2% of the historic delta area was excavated for one large pond (for use by waterfowl). No dredging in the intertidal zone, or road causeways in the delta has been observed. One piledike 0.45 mi. in length apparently runs along the outer edge of the southern delta. The influence of this piledike on estuarine circulation cannot be determined. No other log storage, docks, or other structures were observed in the delta.

- *Sediment aggradation*-Spawning and incubation life stages, rated high impact. Forest Service logging roads built between the 1940s and 1960s were poorly located and constructed, and form a dense network in the middle and upper watershed. Road failure in these areas, with sediment accumulation in the lower watershed has been a chronic problem since the late 1960s. The simplified, braided channel (below RM 4.0) with its lower capacity to transport sediment (see channel complexity) has increased local channel movement and bank erosion which has introduced even more sediment into the system. Recovery begins with stabilization or removal of roads and properly sized culverts on Forest Service land as outlined in the Watershed Analysis (USFS 1994). This is needed to permanently reduce the amount of sediment moving through the Big Quilcene watershed.

- *Riparian forest*-Spawning and incubation life stage, rated moderate impact. A mature conifer dominated riparian forest will provide stable LWD to create structurally complex channels. Forty four percent of the lower Big Quilcene is <12 in dbh, 49% is deciduous dominated or has no riparian forest, and 45% of the forested portion of the riparian zone is < 66 ft in width (Appendix Report 3.7). Recruitment of stable LWD in the future is poor to moderate due to the composition of the surrounding riparian forest. If the primary chum spawning reaches below RM 2.8 were only considered, the riparian forests would rate a high impact. Diking, agriculture, harvest and erosion in the lower Big Quilcene have reduced the extent of functional riparian forest.

## Factors for Recovery

A general discussion of the protection and restoration strategies for each habitat factor is presented in Part Three - section 3.4.4.2, toolkit.

- *Low flow* – Starting in 1998, there was a cooperative effort to monitor stream flows for spawning availability between the City of Port Townsend, QNFH, Port Townsend Paper Co., USFWS, Jefferson County Conservation District, and Tribes. An IFIM study recently conducted by WDFW in part leaves unanswered whether the given low flow of 25 cfs is sufficient to provide good spawning habitat for summer chum. The IFIM flow recommendations were well in excess of late-summer flows in the absence of withdrawal, and likely are better applied to fall chum. Data developed by the cooperative effort will be needed to assess the impacts of stream flow on spawning habitat.

- *Dike removal and property buyout in lower mile* – This relates to the low channel complexity and sediment aggradation habitat factors. The 1998 Big Quilcene Flood Management Plan (Jefferson County 1998, and

Williams et al. 1995) calls for dike removal and property buyout from willing landowners on the north side of the river below RM 1.0. Floodplains are dynamic through time; to maintain residences on them has high social, economic, and ecological costs. The dike north of the channel would be set back to the outer extent of the 100 year floodplain. Additionally, the Linger Longer bridge would be extended as a causeway to allow floodwaters to flow underneath it and across the floodplain. Finally, a sinuous channel pattern found in lowest portion of the channel should be restored. These projects may have several benefits, 1) sediment aggradation will be reduced in the mainstem below RM 1.0, with the capacity to store sediment on the floodplain. In turn, flooding hazard to the houses to the south of the main channel should be lowered. 2) The level of energy or stream power for a given flood level will decline with the dissipation of floodwaters across the floodplain, thereby reducing the erosive energy available to scour summer chum redds.

- *Subestuary habitat loss and degradation* – Removal and dike setback could restore up to about 21% of the currently obstructed historic area of the delta to juvenile and adult summer chum use. Filling the excavated pond would restore an additional 3% of the historic area. Restoration of a sinuous channel pattern through the estuary would increase the amount of habitat for chum. Where feasible, intertidal fills could also be removed. Combined, these actions could reconnect the mainstem to tidal estuarine channels, heavily utilized by chum.

- *Floodplain easement purchase (RM 1.0-2.8)* – The channel is active and dynamic between RM 1.3 and the Hwy 101 bridge at RM 2.5. Bank armoring or riprap is utilized in this reach to stabilize streambanks, although the Jefferson County Conservation District has tried more recently other techniques more favorable to habitat. Allowing or creating a sinuous channel pattern will over time decrease stream power, increase available habitat, and reduce aggradation downstream. A potential mechanism to achieve channel migration is outright property buyout or purchase of floodplain easements from willing property owners. Riverbank within each easement area could be stabilized with LWD and the easement area planted with conifers to serve as a future source of LWD to the channel. Several areas of relatively intact riparian forests exist between RM 1.0 and 2.5. Protection of these forests would provide a base to develop a riparian forest protection plan.

- *Sediment aggradation* – The 1994 Big Quilcene watershed analysis identified mass wasting from Forest Service roads as a causal factor for downstream channel aggradation. Removal of LWD, diking, and channel manipulations, especially below the QNFH, is also considered important (Jefferson County 1998). The City of Port Townsend has entered an agreement with the Forest Service to pursue road obliteration in the portion of the watershed upstream of the diversion dam. The Forest Service has successfully obliterated roads in several sub-basins, however with budget cuts, district office closures, and staff cutbacks it is unclear whether they will be able to complete all the mass wasting prescriptions outlined in the watershed analysis. This needs to be monitored. In addition the severity of the scour problem (due to unstable sediment) in the lower river has not been quantified. The USFWS has the equipment and personnel to study this problem, it is hoped that funding will continue to be available.

## Strength of Evaluation and Information Needs

The Big Quilcene is one of the most intensively studied watersheds in Hood Canal. Confidence in the assessment of habitat factors for decline is high. Further research and monitoring is needed on the following:

1. Determine whether new wells located in Quilcene between the Big and Little Quilcene will impact streamflow.
2. Continue to develop an understanding of the relationship of actual streamflow to the availability of summer chum spawning habitat.
3. Study the depth of bed scour throughout the summer chum zone concentrating on the diked areas below RM 0.8.
4. Update mass wasting data on Forest Service land from the 1994 watershed analysis and determine the extent that presciptions have been followed and whether the prescriptions have met resource objectives.

## References

FEMAT (Forest Ecosystem Management Team). 1993. Forest Ecosystem Management: an ecological, economic, and social assessment. Report of the Forest Ecosystem Management Team, U.S. Government Printing Office 1993-783-071. U.S. Government Printing Office for the U.S. Dept. of Agri., Forest Serv.; U.S. Dept. of the Inter., Fish and Wild. Serv., Bureau of Land Mgt., and Nat. Park Serv.; U.S. Dept. of Comm., Nat. Ocean. and Atmospheric Admin. and Nat. Mar. Fish. Serv.; and U.S. Envir. Prot. Ag.

Jamestown S'Klallam Tribe. 1994. The Dungeness-Quilcene water resources management plan. Jamestown S'Klallam Tribe, Sequim, WA.

Jefferson County. 1998. Lower Big Quilcene R. comprehensive flood hazard management plan. Jefferson County Dept. Pub. Works, Port Townsend, WA. 38 p. + fig.

Schwartzman, P. 1998. Study of residential well connectivity between Quilcene and Big Quilcene R. Jefferson County Dept. Pub. Works, Port Townsend, WA.

USFS (United States Forest Service) and WDNR (Washington Department of Natural Resources). 1994. Big Quilcene watershed analysis - an ecological report at the watershed level. U.S. Dept. of Agri., Forest Serv., Olympic National Forest, Olympia, WA.

USFWS (Unites States Fish and Wildlife Service). 1994. Quilcene National Fish Hatchery – annual report. USFWS Western Wash. Fish. Res. Off., U.S. Dept. of the Inter., Fish and Wild. Serv. Olympia, WA.

Williams, P.B., L. Fishbain, K.G. Coulton, and B. Collins. 1995. A restoration feasibility study for the Big. Quilcene River. Phillip Williams and Assoc., Ltd. San Francisco, CA.

# Dosewallips Watershed Narrative
# WRIA 16.0442

## Watershed Description

The Dosewallips River is located in east Jefferson County on the west side of Hood Canal. The Dosewallips is one of the largest watersheds contributing to Hood Canal, draining 122 square miles and containing 28 miles of mainstem and 140 miles of tributary habitat (Williams et al. 1975). It is bounded on the north by Big Quilcene and Dungeness watersheds, and on the south by the Duckabush watershed. The Dosewallips originates within the Olympic Mountains, flows east through steep terrain, and enters Hood Canal near the town of Brinnon. The middle portion of the watershed lies within the basalt-rich Crescent formation, while various sandstone, siltstone, and slate bedrock formations predominate at the headwaters. Relatively limited glacial and alluvial deposits occur along the lower 13 miles of the river. Average annual discharge is 446 cfs (range 67-13,200 for the years 1931-1958) at RM 7.1. There are two annual runoff peaks, one occurring November-February associated with winter rain, the other occurring in May-June associated with spring snowmelt (USFS 1999).

The lower 2.5 miles of river is fringed by a large floodplain that has been developed for agricultural and rural residential use. Of all Hood Canal tributary deltas, the Dosewallips is second only to the Skokomish in size, historically occupying 444.6 acres (~1.8 $km^2$) with a perimeter of 6.2 miles (9.9 km). North of the river mouth numerous blind tidal sloughs (e.g. Walcott Slough) drain a large estuarine marsh.

The upper 60% of the Dosewallips watershed is undeveloped and protected within Olympic National Park, while the middle 30% of the basin is in Olympic National Forest. As with other west Hood Canal watersheds, private land is concentrated along sensitive lower reaches of the river where use is dominated by pastureland, residential development, and clearcut logging. Dosewallips State Park occupies land on the south side of the river near the mouth, and the town of Brinnon is located to the north within the floodplain-delta area. Brinnon has no municipal water system; area residents derive domestic water supplies from individual wells, stream diversions, or shared community water sources. Since 1956, the City of Port Townsend has maintained a permitted water right to continuously divert 50 cfs of water from the Dosewallips for municipal use, but this application has never been acted upon (USFS 1999). Currently, DOE has an administrative closure on further surface water diversion for the July-October period. Minimum flow criteria have been developed for the Dosewallips River but have not been formally adopted (Rushton 1985). The river is classified as a AA surface flow waterbody by the state and is not listed on EPA’s 303(d) list of impaired and threatened waterbodies, though available ambient water quality data is limited (USFS 1999).

Historically, intensive timber harvest and fires have impacted the slopes of the middle and lower watershed. Logging in the watershed began in 1859 using ox teams, and progressed to the use of railroads and splash dams near the turn of the century, which were replaced by trucks after 1920. A splash dam built by the Sims Logging Company at the head of the Dosewallips canyon (RM 3.2) in 1917 was in operation for 9-10 years. When water was released, most logs that had been accumulated behind the dam were flushed all the way to Hood Canal suggesting the erosive power of these releases was likely catastrophic for salmon and their habitat in the lower river. Railroad logging of the watershed was extensive; the longest railroad line was built on the south side of the river from Brinnon upstream to approximately RM 10.2. Most logging and road building on Forest Service land has occurred in the Rocky Brook subwatershed; between 1920 and 1990, 65% of this subwatershed was clearcut. A landslide inventory based on historic and current aerial photos identified 128 slope failures that have occurred in the watershed since 1939. Forty-five (35%) were road- or harvest-related with 42 (93%) of these occurring within Rocky Brook subwatershed (USFS 1999).

While only 14% of the entire Dosewallips watershed has ever been harvested for timber, 80% of the lower river area (upstream to the confluence with Rocky Brook) has experienced forest harvest (which encompasses the range of summer chum; USFS 1999). Beginning in the late 1800s, the lower river valley (below RM 3.0) was converted from a forested floodplain, rich in LWD jams, side channels and active floodplain wetlands to a channelized river with adjacent pastureland (Amato 1996). The subsequent construction of Highway 101 and development of Brinnon resulted in further wetland loss and degradation, severed the connection of numerous tidal channels to the river and/or Hood Canal, and reduced tidal circulation in the estuary. Nearly 20% of the present-day riparian zone (by area) below RM 4.3 has been negatively impacted by recent land use (7% rural residences, 6% urban/commercial, 3% agriculture, and 3% forestry - Appendix Report 3.7).

### Summer Chum Distribution

Natural barriers and high stream gradients limit summer chum to the lower 4.3 miles of the Dosewallips and most spawning occurs below RM 2.5.

### Population Status

Summer chum population data only extends back to 1972 for the Dosewallips River. During the 1970s, most escapements were over 1,000 spawners, extending up to over 3,000. Escapement decreased during the 1980s to less than 100 spawners in some years and several hundred in other years. In 1995 and 1996 escapement rose to almost 3,000 and 7,000, respectively, then declined again to 47 and 336 spawners in 1997 and 1998, respectively (Appendix Table 1.1).

### Factors for Decline

Low channel complexity, estuarine habitat loss and degradation, riparian degradation, and freshwater wetland loss appear to be the principal factors associated with the decline of summer chum in the Dosewallips watershed. For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18.

- *Low channel complexity* - Spawning and incubation life stages, rated moderate-to-high impact. Much of the lower river below RM 3.0 has been simplified since the late 1800s by the placement of riprap, dike construction, large woody debris removal, the scouring action of splash dam operation, and conversion of floodplain to pastureland and residential development. As a result, the river has become isolated from its floodplain, reducing habitat diversity and complexity and likely reducing the availability of stable spawning gravels. Recovery has been hampered by the loss of riparian forests, which supply LWD to the channel, and the continuing removal of LWD from the channel by area residents (Frissell 1998, T. Labbe, pers. comm.). Although there are no habitat surveys for the lower mainstem, 1990 US Forest Service surveys of Rocky Brook Creek identified 23% of the habitat area in pools and 0.02 LWD pieces/m in the lower half mile of stream which indicate degraded habitat conditions (P. DeCillis, USFS, pers. comm.). Additional surveyed reaches upstream also had poor habitat conditions (29% of habitat area in pools and 0.08 LWD pieces/m) While summer chum are not known to utilize Rocky Brook Creek, it is the largest tributary to the lower Dosewallips mainstem (entering at RM 3.6) and its degraded condition has important consequences for the supply of LWD and sediment to the lower river.

- *Estuarine habitat loss and degradation* - Juvenile rearing/migration life stage, rated moderate-to-high impact. At least six diked areas, totaling 68.5 ac, now occupy 15.4% of the original summer chum rearing and migration habitat in the Dosewallips estuary. Four tidegates appear to regulate or prevent tidal inundation in these diked areas, and one ditch or remnant dike 0.4 mi long attests to past attempts to further eliminate tidal inundation along the delta face. Ten road causeways totaling 1.2 mi bisect or fringe the delta, the most deleterious of which is the cross-delta routing of Highway 101. Construction of the highway, and the subsequent development that derived from it, essentially cut off most of the secondary tidal channel connectivity across the delta, in particular two major distributary channels that appear to have historically linked with the river higher in the delta. Five identifiable fill areas associated with residential or agricultural development occupy 2.5 ac (0.6% of historical delta area). One aquaculture or similar modification to the delta surface covers 2.9 ac (0.6%), but it is not evident whether this poses a significant loss of estuarine habitat function, which depends to a large degree on the scale and frequency of disturbance to important habitat areas such as eelgrass.

- *Riparian degradation* - Spawning and incubation life stages, rated moderate impact. Logging of old-growth floodplain forests, river channelization, and the expansion of pasture and residential areas along the lower 3.0 miles of the river has reduced both the original extent of riparian forests and the potential for LWD recruitment to the channel. Fifty-one percent of the forested buffer below RM 4.3 is dominated by small trees (<12 in dbh) and 41% is deciduous dominated, but 52% is mixed conifer and deciduous forest and 58% of the forested buffer is greater than 132 ft wide (all percentages by length). An analysis of riparian LWD recruitment potential completed by the Olympic National Forest, (Quilcene Ranger District) as part of the Dosewallips Watershed Analysis also identified fair (28%, by stream length) to poor (40%) riparian conditions predominating along the entire length of the river mainstem. In addition, the analysis found poor (91%, by stream length) riparian LWD recruitment potential along Rocky Brook Creek, indicating that LWD volumes in stream channels both in and above the zone of summer chum use will remain limited in the foreseeable future, unless mitigation occurs (USFS 1999). For additional information about riparian data refer to Appendix Report 3.7.

- *Floodplain loss* - Spawning and incubation life stages, rated moderate impact. As discussed above, the loss of floodplain forests, most of which were probably forested wetlands, likely reduced the amount and diversity of habitats and increased the impact of flood flows on mainstem channel habitat due to lost floodwater storage capacity.

## Factors for Recovery

Like other west Hood Canal watersheds, the Dosewallips is remote from the development pressures, such as exist on the Kitsap peninsula, and much of its headwaters are managed by public agencies with mandates for the conservation of indigenous species. However, development pressures are highly concentrated in and around the lower 3.0 miles of river, where most summer chum use occurs. Nonetheless, compared to other Hood Canal and eastern Strait of Juan de Fuca watersheds, prospects for the recovery of summer chum are good. A general discussion of protection and restoration strategies for each habitat factor is found in Part Three - section 3.4.4.2, toolkit.

Recovery of summer chum in the Dosewallips watershed requires:

- Protection and restoration of the lower 3.0 miles of river mainstem and associated riparian floodplain habitats. Properties in the lower floodplain should be targeted for acquisition or conservation easements from willing landowners, and conifers replanted in the riparian zone. This sensitive lower river area should also be examined for potential placement of engineered logjams to enhance channel complexity and stabilize spawning gravels for summer chum. The proximity and number of private residences in this lower river area also creates a potential for harassment and poaching, which needs further investigation (Frissell 1998).

- Restoration of full tidal action to the various extant and failed diked wetlands across the delta. Numerous tidal channels north of the river mouth could be reconnected to the river and/or Hood Canal, which would restore valuable summer chum rearing habitat.

## Strength of Evaluation and Information Needs

Very little habitat research or survey data exists for the Dosewallips River, although it represents one of the larger, more pristine watersheds in Washington with high salmon production potential. A U.S. Forest Service watershed analysis has been completed for the Dosewallips. Most of the conclusions presented here are based on observations of current habitat conditions in the watershed and knowledge gained from historical research and habitat studies conducted in other similar watersheds, such as the Big Quilcene watershed. The strength of the evaluation is thus rated moderate to low due to the lack of site-specific field studies. Information needs include:

1. Habitat surveys of the lower river.
2. An assessment of channel stability as it relates to spawning and incubation life stages.
3. A study of impacts to estuarine rearing potential from road causeway constrictions (necessarily involving multiple estuaries under various degrees of impact).

## References

Amato, C. 1996. Historical changes affecting freshwater habitat of coho salmon in the Hood Canal basin, pre-1850 to the present. Point No Point Treaty Council, Kingston, WA.

Frissell, C.A. 1998. Landscape refugia for conservation of Pacific salmon in selected river basins of the Olympic Peninsula and Hood Canal, Washington. Open File Report # 147-98. Flathead Lake Biological Station, Univ. of Montana, Billings, MT.

Rushton, C.D. 1985. Skokomish-Dosewallips WRIA 16 technical document supplement, office report 74-B, background data and Information. Water resources planning and management section, Wash. Dept. Ecol., Olympia, WA.

USFS (United States Forest Service) 1999. Dosewallips River Watershed Analysis. U.S. Dept. of Agri., Forest Service, Olympic National Forest, Olympia, WA.

Williams, R.W., R.M. Laramie, and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization, Volume 1, Puget Sound Region. Wash. Dept. Fish and Wild., Olympia, WA. 974 p.

# Duckabush Watershed Narrative
# WRIA 16.0351

## Watershed Description

The Duckabush River is located in east Jefferson County on the west side of Hood Canal. The Duckabush watershed is over 75 square miles in area and contains 25 miles of mainstem and 91 miles of tributary habitat (Williams et al. 1975). It is bounded on the north by the Dosewallips and on the south by the Hamma Hamma watersheds. The river originates in the Olympic mountains, flows east through rugged terrain, and enters Hood Canal approximately four miles south of the town of Brinnon. As in the Dosewallips watershed, various sandstone, siltstone, and slate bedrock formations predominate at the headwaters while the lower two-thirds of the watershed lies within the basalt-rich Crescent formation. Limited alluvial deposits are found along the lower 6 miles of river. Average annual discharge is 411 cfs (range 46-9,240 for the years 1939-1996) at RM 4.9. There are two annual runoff peaks, one occurring in November-February associated with winter rain, the other occurring in May-June associated with spring snowmelt (USFS 1997). The Duckabush enters Hood Canal over a broad 291.6-acre (1.2 $km^2$) estuarine delta with minimal development impacts excepting those associated with Highway 101.

The upper 80% of the watershed is protected in Olympic National Park and the Brothers Wilderness (Olympic National Forest). Timber extraction is the dominant land use in the lower watershed, on both National Forest and private lands. Timber harvest on lands now under National Forest ownership began in the 1900s. Webb Logging Company of Brinnon, Washington built a logging railroad up the Duckabush and logged most of lower and middle portions of the watershed in the early 1900s. Before the construction of the logging railroad, timber was harvested as far upstream as Collins Campground (RM 5.5) and floated downstream to Hood Canal. There is limited evidence that early loggers may have employed splash damming in the Duckabush (USFS 1997). The WDF Stream Improvement Division removed logjams and dynamited falls in the river between 1955 and 1970 with the goal of improving fish passage (Amato 1996). More recently, dense recreational homesite development has occurred along the lower 1.5 miles of the floodplain.

The Washington Department of Ecology maintains an administrative closure on issuance of further surface water rights for the July-October period, and minimum flow criteria have been developed for the Duckabush River but have not been formally adopted (Rushton 1985). The loss of LWD and development on the floodplain has confined the river to a single channel and reduced channel complexity. Overall road density in the watershed is low (0.6 $mi/mi^2$), but moderately high road densities in the lower Duckabush (2.2 $mi/mi^2$) subwatershed (which encompasses the range of summer chum) has contributed to mass wasting (USFS 1997). A landslide inventory based on historic and current aerial photos identified 191 slope failures that have occurred in the watershed since 1939, 133 (70%) of which were located within the lower half of the watershed. At least 65 (34%) were road- or harvest-related and 148 (78%) were estimated to have delivered sediment to stream channels (USFS 1997). As in other Hood Canal watersheds, road causeways impact the Duckabush estuary, disrupting tidal circulation, and impeding fish access to productive marsh and slough habitats. Nearly 25% of the riparian zone (by area) below RM 3.0 is now developed (12% urban/commercial, 9% rural residences, and 3% roads/dikes).

### Summer Chum Distribution

A series of cascades between RM 3.5 and 4.5 confine summer chum to the lower river. Most summer chum spawning occurs in the lower 2.2 miles.

### Population Status

Escapement estimates shows the Duckabush falling from levels in the thousands in the 1970s to less than 100 spawners in several years of the 1980s. In the 1990s, escapement estimates increased to the hundreds, except for 2,650 spawners in 1996, overall still substantially less than the 1970s (Appendix Table 1.1).

### Factors for Decline

Low channel complexity, estuarine habitat loss and degradation, riparian degradation, and freshwater wetland loss appear to be the principal factors associated with the decline of summer chum in the Duckabush watershed. For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18.

- *Low channel complexity* - Spawning and incubation life stages, rated moderate-to-high impact. The channel in the lower river appears to have been greatly simplified since the late 1800s by the scouring action of splash damming, large woody debris removal, and conversion of floodplain to pastureland and residential development. As a result, habitat diversity and complexity has been reduced (e.g. side channels, deep holding pools, and stable spawning gravels). A 1992 U.S. Fish and Wildlife Service survey from RM 0.2-2.3 found 31% of habitat area in pools and sparse woody debris, which indicates degraded habitat conditions (Tabor et al. 1993).

- *Subestuarine habitat loss and degradation* - Juvenile rearing/migration life stage, rated moderate impact. Two diked areas totaling 3.9 acres occupy 2.8% of the original 291.6 acres of estuarine delta habitat; these diked areas are located at the northern edge of the delta in association with residential development adjacent to a small distributary channel. An estimated 0.2 acres (0.1%) of the historic delta area has been filled and two ditches or remnant dikes with a total length of 0.3 mi are evident in the delta. Five roads traverse the delta at various locations, the most obvious of which is Highway 101. The total length of these road segments is 0.4 mi but, as in the Hamma Hamma and other Hood Canal estuaries, these relatively short road causeways represent a major disruption to tidal circulation and fish movement across emergent wetlands in the mid-reaches of the delta.

- *Riparian degradation* - Spawning and incubation life stages, rated moderate impact. Logging of old growth floodplain forest and conversion to pasture and residential areas has greatly reduced the potential for LWD recruitment to the channel. The forested buffer below RM 3.0 is dominated by medium-sized (12-20 in dbh) trees (66%) and, to a lesser degree, small (<12 in dbh) trees (32%). As in the Dosewallips, mixed conifer and deciduous forests predominate (57%) in the riparian zone, and 59% of the forested buffer is >132 ft in width (all percentages by length). By comparison, another analysis of riparian LWD recruitment potential along both the mainstem river and tributaries in the lower Duckabush watershed identified approximately 36% of riparian forests in poor condition, 11% in fair condition, and 53% in good condition (USFS 1997). These data suggest that riparian forests are currently degraded, and that near-term LWD volumes in stream channels both in and above the zone of summer chum use will remain limited in the foreseeable future, unless mitigation occurs.

- *Floodplain loss* - Spawning and incubation life stages, rated moderate impact. As discussed above, the loss of floodplain forests, most of which were probably forested wetlands, likely reduced the amount and diversity of habitats available to summer chum during freshwater life stages.

## Factors for Recovery

Like other west Hood Canal watersheds, the Duckabush is remote from development pressures such as exist on the Kitsap peninsula, and much of its headwaters are managed by public agencies with mandates for the conservation of indigenous species. As a result, prospects for the recovery of summer chum are good.

Recovery of summer chum in the Duckabush watershed requires:

- Protection and restoration of riparian floodplain habitat along the lower 2.5 river miles. Properties in the lower floodplain should be targeted for acquisition or conservation easements from willing landowners, and conifers replanted in the riparian zone. This sensitive lower river area should also be examined for potential placement of engineered logjams to enhance channel complexity and stabilize spawning gravels for summer chum.

- Restoration of a natural tidal distributary channel system across the waist of the estuarine delta through reduction of the impact from the Highway 101 road causeway. Rerouting or refitting of the Highway 101 road causeway across the delta would be required to significantly restore natural tidal circulation and juvenile salmon movement across or residence in the delta. One of the diked areas in the northern delta represents a viable opportunity for restoration of juvenile summer chum foraging habitat through the dike removal and recovery of full tidal inundation.

## Strength of Evaluation and Information Needs

Very little research has been conducted on fish habitats of the Duckabush watershed, although it represents one of the larger, more pristine watersheds in Washington with a high salmon production potential. Only recently, a U.S. Forest Service watershed analysis was completed. Only cursory habitat survey data exist for the lower Duckabush River (Tabor et al. 1993). Information needs include: 1) more detailed habitat surveys of the lower river, 2) an assessment of channel stability as it relates to spawning and incubation life stages, and 3) a study of impacts to estuarine rearing potential from road causeway constrictions (necessarily involving multiple estuaries under various degrees of impact). Most of the conclusions presented here are based on observations of current habitat conditions in the watershed and knowledge gained from historical research and habitat studies conducted in other similar watersheds, such as the Big Quilcene watershed. The strength of the evaluation is thus rated moderate to low due to the lack of site-specific field studies.

## References

Amato, C. 1996. Historical changes affecting freshwater habitat of coho salmon in the Hood Canal basin, pre-1850 to the present. Point No Point Treaty Council, Kingston, WA.

Rushton, C.D. 1985. Skokomish-Dosewallips WRIA 16 technical document supplement, office report 74-B, background data and Information. Water resources planning and management section, Wash. Dept. Ecol., Olympia, WA.

Tabor, R. et al. 1993. Ambient monitoring data. Unpublished. U.S. Dept. of the Inter., Fish and Wild. Serv., Lacey, WA.

USFS (United States Forest Service). 1998. Hamma Hamma R. and Hood Canal Tributaries Watershed Analysis. U.S. Dept. of Agri., Forest Serv., Olympic National Forest, Olympia, WA.

Williams, R.W., R.M. Laramie, and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization, Volume 1, Puget Sound Region. Wash. Dept. Fish and Wild., Olympia, WA. 974 p.

# Hamma Hamma Watershed Narrative
# WRIA 16.0251

## Watershed Description

The Hamma Hamma River is located in northern Mason and southern Jefferson counties on the west side of Hood Canal. It is bounded on north by the Duckabush, on the west by the Skokomish, and on the south by the Lilliwaup and Jorsted creeks watersheds. The Hamma Hamma watershed is about 85 square miles in area and contains 18 miles of mainstem and 93 miles of tributary habitat (Williams et al. 1975). Average annual discharge is 559 cfs (range 39-6,010 for the years 1951-1979). There are two annual runoff peaks, one occurring in November-February associated with winter rains, the other occurring in May-June associated with spring snowmelt (USFS 1997). The Hamma Hamma originates on the rugged, eastern flank of the Olympic mountains and flows east through steep, forested terrain and drains to Hood Canal at the town of Eldon. Except for limited sandstone, siltstone, and slate bedrock formations at the headwaters, most of the watershed is underlain by the basalt-rich Crescent formation with glacial and alluvial deposits along the river mainstem. Below RM 1.5 the stream gradient moderates and the river is flanked by a large floodplain. A major tributary, John Creek, enters at RM 1.4. The lower 0.6 miles of the Hamma Hamma is tidally influenced, and at high tide at least one small secondary channel connects the mainstem with a large tidal marsh, just north of the main channel.

Nearly 95% of the watershed is under public ownership; 60% is managed public forestland and 34% is protected in National Park or designated wilderness. Private lands (5%) are concentrated in the productive, low-elevation areas near the river mouth, and are managed primarily for timber extraction (Heller et al. 1995). By the 1930s most of the Hamma Hamma watershed had been logged. Removal of LWD from streams began as early as 1953 when John Creek was cleared or diverted around 12 log jams. In 1958 the Hamma Hamma Logging Company constructed a dike, placed riprap, and dredged the mouth of the river to facilitate log booming (Amato 1996). A 1930s-era Hamma Hamma Logging Company timber cruise map reveals a 0.3-mile-long side channel at RM 0.8 that is no longer in existence.

Manipulation of and timber salvage from the main channel has continued to the present, and some of this activity has been illegal (T. Labbe personal observation, Cook-Tabor 1996). Recent, intensive clearcut logging has likely contributed to severe landslides along John Creek and in the mainstem gorge area (~RM 2.0; USFS 1997). Overall road density in the watershed is low (1.4 mi/mi$^2$), but in the lower Hamma Hamma subwatershed (inclusive of John Creek) road densities are high (2.4 mi/mi$^2$), approaching a level where significant channel degradation can be expected to occur (USFS 1997).

Most of the floodplain area along the lower 1.5 miles of the Hamma Hamma has been appropriated for agricultural and residential uses. Cattle have unlimited access to most of this lower river area. Thirty-five percent of the riparian zone (by area) below RM 3.3 has been impacted by recent intensive landuse (23% forestry, 10% agriculture, 2% rural residences). The Washington Department of Ecology maintains an administrative closure on issuance of further surface water rights for the July-October period, and minimum flow criteria have been developed for the Hamma Hamma River but have not been formally adopted

(Rushton 1985). An application by Mason County Public Utility District for hydroelectric development on the Hamma Hamma is currently pending before the Federal Energy Regulatory Commission.

### Summer Chum Distribution

Natural barriers and high stream gradients in the middle and upper watershed limit anadromous fish use to the lower 2.0 miles of the Hamma Hamma River and to the lower 1.8 miles of John Creek. Most summer chum spawning occurs below RM 1.8 in the Hamma Hamma and below RM 0.3 in Johns Creek.

### Population Status

Through the 1970s, escapement for the Hamma Hamma River and John Creek combined numbered in the thousands. After 1979, spawner density declined to hundreds per year. In the 1990s, estimated spawner density fluctuated from below 100 to several hundred (Appendix Table 1.1).

### Factors for Decline

Low channel complexity, estuarine habitat loss, altered sediment dynamics, and riparian degradation appear to be the principal habitat factors associated with the decline of summer chum in the Hamma Hamma watershed. These factors are interrelated and the most severe impacts have occurred in the extreme lower reaches of the river, where summer chum spawning is concentrated. For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18.

- *Low channel complexity* - Spawning and incubation life stages, rated moderate-to-high impact. Dredging and bank hardening of the lower mainstem, and removal of LWD from streams have reduced overall channel complexity in the Hamma Hamma watershed. A 1996 U.S. Fish and Wildlife Service habitat survey in the Hamma Hamma River from approximately RM 0.5-1.8 found 50% of the habitat area in pools, which is considered fair, and a LWD loading of 0.13 pieces/m which is considered poor (Appendix Report 3.8). In the lower 1.8 miles of John Creek, pools composed 51% of the total habitat area (rated fair) but LWD loading was extremely poor (0.06 LWD pieces/m). Most notably, large-sized, “key” LWD pieces, which are important habitat-forming and stabilizing features of larger rivers, were completely absent from the Hamma Hamma mainstem suggesting streambed instability that may result in redd scour during peak flow events is a potential threat to summer chum in this watershed (Cook-Tabor, 1996).

- *Subestuarine habitat loss and degradation* – Juvenile rearing/migration life stage, rated moderate-to-high impact. Over 13% of the estimated 368.5-acre historic delta is diked in three areas, accounting for a loss of 48 acres of summer chum rearing habitat. One filled area in the outer, southern corner of the delta accounts for a loss of 3.2 acres (1% of historic delta habitat). An estimated 2.4 acres (0.6% of historic delta area) of the mainstem distributary channel where it crosses the outer intertidal area has been dredged, and at least seven areas of aquaculture or other modifications of the delta surface are apparent from contemporary aerial photographs which total 2.2 acres (0.6% of historic delta area). Three jetties or piledikes, totaling 0.4 mi in length, are evident in the delta. In addition, eight road and causeway segments, totaling 1 mile in length, transect the delta, the largest of which is the Highway 101 causeway that has caused a direct loss of habitat and constrained tidal action and fish movement across the delta. The apparent isolation of the north bank estuarine marsh from the main river by dredging and dike/road causeway construction at the river mouth has eliminated the connectivity of the river with a critical chum rearing habitat. As a result, outmigrant chum fry are routed directly into deepwater habitat and must reenter the marsh from the east (via Hood Canal). The impacts of such a severe transition on summer chum outmigrants are unknown but they are suspected to be severe given the relative vulnerability of this life stage to physiological stress, predation, etc.

- *Altered sediment dynamics* - Spawning and incubation life stages, rated moderate impact. Sediment aggradation in the lower reaches of John Creek has resulted in a series of high gradient cascades near the mouth where, in some years, subsurface flow occurs during late summer when summer chum adults return to spawn. In addition to impeding/delaying the spawning migration of summer chum into John Creek, there is potential for the dewatering of redds. Logging-induced landslides in upper John Creek have likely resulted in elevated sediment delivery rates to the channel.

- *Riparian degradation* - Spawning and incubation life stages, rated moderate impact. Reduction in riparian forest extent has eliminated recruitment sources for LWD. Moreover, a shift from conifer-dominated to alder-dominated riparian communities (along lower John Creek, in particular) has diminished the longevity and stability of LWD in the channel because alder logs are typically smaller than conifers and do not persist as long in streams. As a result, sediment is not retained in John Creek but routed downstream to accumulate near the mouth (see above). Forty-eight percent of the forested buffer below RM 3.3 is composed of small (<12 in dbh) trees, and 45% is dominated by medium-sized (12-20 in dbh) trees. Conifer- (48%) and deciduous-dominated (26%) buffers prevail along the lower river, and while 58% of the forested buffer is >132 ft wide, the remaining 42% is sparse and/or <66 ft. In combination, these conditions represent moderate impact.

## Factors for Recovery

Like other west Hood Canal watersheds, the Hamma Hamma is remote from the development pressures such as exist on the Kitsap peninsula, and much of its headwaters are managed by public agencies with mandates for the conservation of indigenous species. One family owns most of the land in the lower reaches of the river where summer chum spawn, simplifying potential public-private conservation efforts. Although summer chum habitat in the Hamma Hamma is presently degraded, conditions are not beyond recovery and past escapement estimates indicate the watershed has strong summer chum production potential. A general discussion of protection and restoration strategies by habitat factor is found in Part Three - section 3.4.4.2, toolkit.

Recovery of summer chum in the Hamma Hamma watershed requires:

- Protection and restoration of riparian forests to guarantee long-term LWD recruitment sources. Illegal logging and timber salvage from riparian forests should be stopped and sites evaluated for the placement of engineered log jams to enhance channel complexity. In particular, logging of steep erosive areas in John Creek and the mainstem along the gorge (beneath the powerlines) should be curtailed as both these areas have high landslide risk.

- Reconnection of the river with the north bank estuarine marsh and reclamation of floodplain habitats for fish. Elimination of both inhibitors to migration and restoration of rearing habitat will be essential to provide significantly greater access to natural delta habitats. This would require removal of training dikes and cessation of dredging in the lower tidal distributary channel. Ultimately, however, rerouting or refitting the Highway 101 road causeway across the delta may be required to completely restore tidal circulation, and juvenile salmon rearing habitat in the Hamma Hamma delta.

- Reduction of upstream impacts of sedimentation (particularly in John Creek) by preventing logging on potentially unstable slopes and removing and repairing roads with surface erosion or landslide hazard problems.

### Strength of Evaluation and Information Needs

Confidence in this assessment of habitat factors is moderate to high. To date, a U.S. Forest Service watershed analysis and a Puget Sound Cooperative River Basin Team report have been completed. The U.S. Fish and Wildlife Service surveyed the anadromous extent of both the Hamma Hamma and John Creek in 1996. Information needs include: 1) an assessment of the north bank estuarine marsh and its potential for reconnection with the main river, 2) an analysis of the sediment budget in John Creek, 3) an assessment of channel stability as it relates to spawning and incubation life stages, and 4) a study of impacts to estuarine rearing potential from road causeway constrictions (necessarily involving multiple estuaries under various degrees of impact).

### References

Amato, C. 1996. Historical changes affecting freshwater habitat of coho salmon in the Hood Canal basin, pre-1850 to the present. Point No Point Treaty Council, Kingston, WA.

Cook-Tabor, C. 1996. Hamma Hamma watershed habitat surveys (unpublished). USFWS Lacey Field Office, U.S. Dept. of the Int., Fish and Wild. Serv., Lacey, WA.

Heller, J., J. Smith, M. Floover, A. Trombley, T. Granger, B. McIntosh, and M. Hepp. 1995. West shore Hood Canal watersheds. Puget Sound Cooperative River Basin Team (PSCRBT) for Mason County, Shelton, WA.

Rushton, C.D. 1985. Skokomish-Dosewallips WRIA 16 technical document supplement, office report 74-B, background data and Information. Water resources planning and management section, Wash. Dept. Ecol., Olympia, WA.

USFS (United States Forest Service). 1998. Hamma Hamma R. and Hood Canal Tributaries Watershed Analysis. U.S. Dept. of Agri., Forest Serv., Olympic National Forest, Olympia, WA.

Williams, R.W., R.M. Laramie, and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization, Volume 1, Puget Sound Region. Wash. Dept. Fish and Wild., Olympia, WA. 974 p.

# Lilliwaup Watershed Narrative
# WRIA 16.0230

## Watershed Description

The Lilliwaup Creek watershed is located in northern Mason county on the west side of Hood Canal. It is bounded on the north by Eagle, Jorsted, and Hamma Hamma watersheds, on the west by the Skokomish, and on the south by the Sund Creek watershed. The Lilliwaup watershed is underlain by the basalt-rich Crescent formation, is 17.9 square miles in area, and contains 6.9 miles of mainstem and 10.8 miles of tributary habitat (WDF 1975). Lilliwaup Creek is fed by extensive wetlands associated with Price Lake and upper Lilliwaup valley, totaling over 910 acres (Heller et al. 1995). The remaining upper and middle watershed stream habitats are generally high gradient. Below a large falls at RM 0.7 the stream flows through a large well-developed floodplain before draining to Hood Canal at the town of Lilliwaup.

Managed public forestland accounts for 89% of the watershed area. Private managed forestland (7%) and residential lands (2%) are concentrated to the east, along Hood Canal (Heller et al. 1995). Little historical information on the watershed exists, but it is known that by the early 1930s, the entire Lilliwaup watershed had been logged (Amato 1996). Much of the lower floodplain/estuarine area has been developed for transportation and residential use. At some point during the 1960s or 1970s, a section of stream immediately above Highway 101 was straightened and dredged to route floodwaters away from homes on the east side of Lilliwaup Creek (R. Endicott, personal communication). A hatchery operates on lower Lilliwaup Creek and rears summer chum for release into the creek (summer chum salmon are the only species released into the stream). There are 7.75 cfs of issued surface water rights in the watershed (Heller et al. 1995). A private landowner operates a small hydroelectric power facility immediately below Lilliwaup Falls (RM 0.7). Road density in the Lilliwaup Creek watershed is 2.9 mi/mi$^2$, significantly above the level where channel degradation can be expected to occur (USFS 1997). Forty-eight percent of the riparian zone (by area) below RM 0.7 is developed (28% roads, 20% agriculture).

## Summer Chum Distribution

Lilliwaup Falls at RM 0.7 blocks anadromous passage upstream. Spawning surveys indicate summer chum utilize the full extent of the anadromous zone in Lilliwaup Creek.

## Population Status

Annual escapement from 1971-1978 ranged from several hundred to over one thousand spawners. Since that time escapement has never exceeded 300, and generally is below 100 spawners (Appendix Table 1.1).

## Factors for Decline

Riparian degradation, estuarine habitat loss, and low channel complexity appear to be the principal habitat factors associated with the decline of summer chum in the Lilliwaup Creek watershed. All of the factors discussed below cover immediate impacts to the area accessible to summer chum but upstream cumulative impacts such as altered stream flow characteristics or sediment/LWD delivery rates may also be important. For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18.

- *Riparian degradation* - Spawning and incubation life stages, rated moderate impact. Agricultural and residential development along the lower reaches of Lilliwaup Creek has reduced the extent and altered the age and species composition of the riparian forest. Elimination of riparian forests has decreased LWD recruitment sources for both the creek and estuary. Seventy-nine percent of the forested buffer below RM 0.7 is dominated by medium-sized (12-20 in dbh) trees of mixed conifer and deciduous composition, and 21% lacks a buffer altogether. Fifty-two percent of the buffer is >132 ft in width, while 48% is <66 ft wide and/or sparse.

- *Subestuarine habitat loss and degradation* - Juvenile rearing/migration life stage, rated moderate impact. Of the estimated 48.2 acres of historic delta, one diked area associated with a fish hatchery accounts for a loss of 1.5 acres (3.1% of historic delta area). Fill for residential development on the south side of Lilliwaup estuary accounts for a loss of 1.2 acres (2.6%), and a human-excavated pond at a fish hatchery represents a loss of 0.5 acres (1%). In addition, the 0.12 mi long Highway 101 causeway that bisects the delta has constrained the estuarine distributary channels of Lilliwaup Creek, eliminated habitat area, and likely altered overall estuarine function by altering tidal circulation. Although a relatively small percentage of the historic delta area has been impacted, the location of these habitat alterations has likely contributed to their disproportionately large effect on the overall functional value of Lilliwaup estuary as juvenile rearing and transition habitat for summer chum.

- *Low channel complexity* - Spawning and incubation life stages, rated moderate impact. No habitat survey data exist for Lilliwaup Creek. Based on aerial photo interpretation and communication with local residents, approximately 600 feet of Lilliwaup Creek at RM 0.2 was straightened and dredged. The lack of LWD in both the creek and estuary also contributes to reduced channel complexity, and raises the potential for channel instability and redd scour during peak flow events.

## Factors for Recovery

Limited spawning habitat likely restricted the summer chum population in Lilliwaup Creek under natural conditions. Human occupation and use of the Lilliwaup Creek floodplain and estuary has probably further diminished summer chum production potential. On a positive note, the large wetlands of upper Lilliwaup valley that appear to guarantee sufficient stream flow for returning summer chum remain intact and functional (Heller et al. 1995).

Recovery of summer chum in the Lilliwaup Creek watershed requires:

- Restriction of human activity in the lower floodplain to allow for the reestablishment of riparian forests and natural recruitment of LWD to the main channel.

- Restoration of a natural tidal distributary channel system across the waist of the estuarine delta through reduction of the impact from the Highway 101 road causeway.
- Protection of the Washington DNR-owned wetlands in upper Lilliwaup valley, which sustain summer flows in Lilliwaup Creek.

## Strength of Evaluation and Information Needs

Confidence in this assessment of habitat factors is moderate. To date, a U.S. Forest Service watershed analysis and a Puget Sound Cooperative River Basin Team report have been completed but little additional information exists. Information needs include:

1. An assessment of the condition and role of upstream wetlands in sustaining summer low flows suspected to be critical to summer chum.
2. A survey of lower Lilliwaup Creek to collect baseline habitat information.
3. An assessment of channel stability as it relates to spawning and incubation life stages.
4. A study of impacts to subestuarine rearing potential from road causeway constrictions (necessarily involving multiple subestuaries under various degrees of impact).

## References

Amato, C. 1996. Historical changes affecting freshwater habitat of coho salmon in the Hood Canal basin, pre-1850 to the present. Point No Point Treaty Council, Kingston, WA.

Heller, J., J. Smith, M. Floover, A. Trombley, T. Granger, B. McIntosh, and M. Hepp. 1995. West shore Hood Canal watersheds. Puget Sound Cooperative River Basin Team (PSCRBT) for Mason County, Shelton, WA.

USFS (United States Forest Service). 1998. Hamma Hamma R. and Hood Canal Tributaries Watershed Analysis. U.S. Dept. of Agri., Forest Serv., Olympic National Forest, Olympia, WA.

Williams, R.W., R.M. Laramie, and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization, Volume 1, Puget Sound Region. Wash. Dept. Fish and Wild., Olympia, WA. 974 p.

# Skokomish Watershed Narrative
# WRIA 16

Skokomish and North Fork Skokomish River 16.0001, Purdy Creek 16.0005, Weaver Creek 16.0006, Hunter Creek 16.0007, South Fork Skokomish River 16.0011, Richert Springs 16.0010, Vance Creek 16.0013

## Watershed Description

The Skokomish River is the largest river system in the Hood Canal Basin of Puget Sound with a watershed area of approximately 240 square miles comprised of 80 miles of mainstem and over 260 miles of tributaries. The Skokomish watershed drains the southeast corner of the Olympic Mountains and enters the southwest end of Hood Canal known as the Great Bend between the towns of Union and Potlatch creating the largest subestuary and intertidal delta in the Hood Canal Basin. Historically the Skokomish River system produced the Hood Canal region's largest runs of salmon and steelhead, most of which were produced in the North Fork Skokomish River.

The Skokomish watershed consists of three major drainages, the North Fork (33.3 miles) and South Fork Skokomish rivers (27.5 miles) and Vance Creek (11 miles). The North Fork Skokomish River originates in high mountainous areas of the Olympic National Park. Beginning in 1930, the construction of two dams as part of the Cushman hydroelectric project blocked all fish passage to the upper North Fork. The reservoirs behind the dams inundated a naturally formed lake and about 11.5 miles of the North Fork River channel and associated floodplain.

The Cushman project's lower dam diverts flow out of the watershed to a power plant on the west shore of Hood Canal. The project has reduced average annual North Fork flows below the lower dam by over 96% (Stetson Engineers 1996). This out-of-basin diversion substantially dewaters eight miles of the lower North Fork and reduces by about 40 percent, the flow of the mainstem Skokomish River. An interim instream flow of 30 cfs has been set for the North Fork Skokomish River to be released at the lower dam (WDOE, Vicki Cline, pers. comm.).

The South Fork Skokomish River originates in the Olympic National Park and flows through U.S. Forest Service (USFS) timberland and land owned by the Simpson Timber Company, before joining the North Fork to form the mainstem Skokomish River. The Skokomish mainstem then flows for about 9 miles through a wide valley to its mouth and intertidal delta on Hood Canal. Upper Vance Creek flows through USFS lands and in its middle portions through timberland owned by Simpson Timber Company. The lower 3 miles of Vance Creek is bordered by several small farms and single family homes and enters the South Fork Skokomish River at river mile 0.8. Richert Springs is a spring fed system of channels coalescing into a single channel, which enters the mainstem Skokomish at river mile 7.9. Hunter and Weaver creeks are predominately spring fed tributaries that flow through agricultural lands in the southern portion of the Skokomish floodplain and join the mainstem Skokomish River at river mile 6.2 and 4.1 respectively. Purdy Creek begins in wetlands located above the alluvial floodplain and is fed by numerous springs before joining the mainstem Skokomish River just below Weaver Creek at river mile 3.6. Fish hatcheries operated by the

Washington Department of Fish and Wildlife are located on Hunter, Weaver, and Purdy creeks where there is access to high quality spring water.

The upper portions of the South Fork and North Fork Skokomish rivers and Vance Creek are located in the Crescent Uplands, which consist of submarine basalt flows, and tuffs. Continental glaciation from British Columbia overran the lower basin and deposited hundreds of feet of sediment in the southern portion of the watershed. Soil depths are variable and generally less than 3 feet except in valley bottoms where soils are deep due to glacial deposition. River downcutting has formed steep gorges and valley walls and a broad flat alluvial valley in the lower basin, and has formed smaller gorges in the upper basin. The lower 11 miles of the watershed flow through an alluvial valley about 3/4 to 1 ½ miles wide consisting of large and small farms and numerous single family homes. The lower 5.9 miles of the river including a substantial portion of the subestuary are located on the Skokomish Indian Reservation.

The Skokomish watershed is designated as a Tier 1 Key Watershed under the President's Forest Plan (FEMAT, 1993). Industrial forestry is the dominant land use above the valley floodplain. Agriculture and residential development dominate the alluvial valley. Portions of the lower river are diked and remnants of a system of dikes and tidegates remain in the subestuary and intertidal area.

## Summer Chum Distribution

Summer chum are considered extinct in the Skokomish River system and there is little population data upon which to assess potential historical distribution. However, based on observations made in a 1954-1955 study (WDF 1957) and similarities in habitat attributes between streams, it is assumed that summer chum are likely to have been distributed in the mainstem, North Fork, Vance Creek, Richert Springs, and in Hunter, Weaver, and Purdy creeks. Several thousand summer chum spawners were observed in the mainstem on October 1, 1954 (WDF 1957). Because there was no appreciable flow in the North Fork that year, owing to the Cushman hydroelectric flow diversion, no summer chum access was assumed to occur and there were no North Fork spawner surveys. Nevertheless, the habitat attributes of the North Fork suggest that summer chum may have historically ascended to the lower falls at river mile 15.6. Summer chum were observed in Purdy Creek in 1954, and while no surveys were performed in Richert Springs, Weaver Creek, or Hunter Creek, the latter streams possess habitat attributes similar to Purdy Creek and it is assumed summer chum salmon existed in them as well. Vance Creek is also assumed to have supported summer chum salmon production, due to its location, habitat characteristics and the observed early run timing of juvenile chum salmon emigrants (consistent with expected summer chum emigration timing) observed in 1955 (WDF 1957).

## Population Status

Few to no summer chum salmon have been observed in spawner surveys of the Skokomish River in recent years. The stock is thought to be extirpated. A spawning ground survey in Purdy Creek conducted on September 23, 1954 documented 9 adults and 8 redds 200 yards above U.S. 101 (site of George Adams Salmon Hatchery). On October 1 of the same year an aerial survey of the Skokomish River documented over 3,000 live and dead chum from the mouth to the Hwy 101 bridge and 1,000 live and dead chum from the bridge to the forks (WDF 1957). Observations of early returning chum have been encountered during in-river fisheries for chinook and coho and incidentally during spawning ground surveys targeting chinook since that time period, although the numbers are extremely small. In addition, a document discussing the Skokomish Indian fishery in the river presented data from 1936 through the early 1950s on catches of salmon. September counts of chum salmon were as high as 986 in 1940. Smaller catches were made during October throughout that period which may represent summer chums and early fall chums (Smoker 1952).

### Factors for Decline

The Skokomish watershed has been managed primarily for timber, power production and agriculture. The habitat conditions overall are poor due primarily to water withdrawal, estuarine modifications, low channel complexity, extensive diking, sediment accumulation, peak flows, poor riparian conditions and water quality degradation. Impacts on summer chum habitat are not universal throughout the basin (different streams and stream segments are affected by varied factors for decline). For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18.

- *Low flow* - Adult migration, spawning, incubation and juvenile rearing life stages, rated high impact. From 1930 through 1988, the Cushman Project diverted all flows out of the North Fork Skokomish River at the lowermost dam, causing much of the North Fork between the lower dam and the confluence to be dry or nearly so during dry periods. This eliminated summer chum from the North Fork and severely degrading fish habitat conditions in the North Fork, mainstem Skokomish River, subestuary and intertidal delta. Since 1988, the Department of Ecology has required a minimum flow of 30 cfs [4% of average annual flow] to be released to the North Fork from the lowermost Cushman dam, pending federal licensing (WDOE 1987) . Presently with the 30cfs release, the North Fork does not meet state water quality standards due to insufficient flows for habitat and high temperatures (WDOE 1994). According to the U.S. Environmental Protection Agency, North Fork flow releases of about 228 cfs [28% of average annual flow] proposed by the Federal Energy Regulatory Commission would be inadequate for recovery of fish resources and inadequate to prevent continued impairment of fish habitat and degradation of the subestuary (EPA, 1998). The U.S. Environmental Protection Agency, U.S. Department of Commerce's National Marine Fisheries Service, and U.S. Department of Interior agree that substantial restoration of North Fork flow (target of 84% natural) is the minimum protection required for aquatic resources of the North Fork and mainstem Skokomish River and subestuary/delta (USDI, 1997; EPA, 1998; NMFS, 1998).

- *Subestuarine delta impacts* - Juvenile rearing and migration life stage, rated high impact. Probably the largest long-term impact to this delta for juvenile salmon rearing, in addition to many other ecological functions, has been the steepening of the delta and loss of approximately 17% of the delta's eelgrass habitat along the face of the delta (Jay and Simenstad, 1996). This dramatic change is primarily attributed to the loss of sediment transport through the delta due to water withdrawals by the Cushman project. Diversion of the North Fork has severely degraded estuarine habitat conditions for summer chum by disrupting sediment transport abilities and natural salinity and nutrient regimes in the subestuary and intertidal delta, and by reducing extent of tidal influence in the Skokomish River.

- *Subestuarine alterations* - Juvenile rearing and migration life stage, rated high impact. Of the original 2,175 acre delta (11.2 miles perimeter), 14.4% (313 acres) was diked for agriculture. A recent dike breach in the largest contiguous diked farm area in the delta (Nalley Farm, ~215 acres), has allowed tidal inundation of this area. Nine diked areas persist, totaling 99 acres (4.6% of original delta). Restoration of the Nalley Farm will contribute to increased juvenile summer chum rearing habitat although access is limited with the only dike breach located on the northern perimeter of the dike. Chum fry will have to migrate along existing dikes to the central portion of the delta before accessing the restoring wetland, and then predominantly at high tide. Dikes and several tidegates continue to keep wetlands isolated from the subestuary thereby cutting off the primary production in these once saltwater marshes. Two identifiable fill areas occupy approximately 5 acres (0.2% of historical delta area) of the delta and are thought to have a low impact.

- *Subestuarine road causeways* -. Thirteen roads or causeways cross or encompass the delta, the total length of which is 4.7 miles. Almost all of these roads are associated with dikes surrounding the original agricultural lands or service roads to electric line transmission towers. Even in the restoring Nalley Farm site, the dike roadways inhibit cross-delta movement of juvenile summer chum. Transmission tower service roads impact a long segment of the upper intertidal habitat, affecting tidal movement and fish foraging activity in the western portion of the delta.

- *Miscellaneous subestuarine impacts* - A debris dam and dilapidated concrete abutments are located at the junction of a major distributary channel in the delta that divides the Nalley Farm properties. The distributary once was a more prominent channel that provided access of migrating juvenile salmon to the central delta. Flow was intentionally reduced to this channel to reduce flooding potential, although some tidal flow persists (B. Martino, Skokomish Tribe Nat. Res. Dept., Potlatch, WA, pers. comm. 1998).

- *Channel complexity* - Spawning and incubation life stage, rated high impact. Historically, the Skokomish valley floodplain contained numerous sloughs, side channels and forested cedar wetlands. In the late 1800s and early 1900s woody debris and logjams were removed from the South Fork and mainstem Skokomish rivers in an attempt to prevent flooding and to facilitate log transport to saltwater via river drives. One report documented a jam 3 miles thick formed over 50 years that took 18 months to remove using dynamite, horse teams and steam donkeys (Richert, 1964). Continual channel manipulations for flood control and wood salvage have continued to the present. During the 1960s and 1970s, the WDF Stream Improvement Division removed log jams and beaver dams in Vance Creek, Purdy Creek and the North Fork Skokomish River. Despite the intense history of studies in the Skokomish basin, there is scarce instream habitat data available for the suspected summer chum reaches, although current wood loading has been characterized as poor in most channel segments (USFS 1995; Simpson Timber Co. and WDNR 1997, Skokomish DNR and PNPTC 1994). Habitat surveys conducted in 1994 in the lower 3 miles of Vance Creek found 39% pools and a range of 1.5 to 2.6 channel widths between each pool. LWD counts ranged from 0.02 to 0.15 pieces of LWD/m with much of the wood perched above the wetted perimeter, stranded on exposed gravel terraces (Skokomish DNR and PNPTC 1994). The pool data is also misleading because much of the reach was dry during the survey, skewing the number of pool habitat units due to numerous small isolated pools

(K. Dublanica, Skokomish Tribe Dept. Nat. Res., pers. comm. 1998). Observations made during a July 1998 float trip from the lower end of the South Fork Skokomish River canyon (approximately R.M. 3.0) downstream to river mile 4 on the mainstem Skokomish River (total distance of nine miles) revealed a lack of pools, long glides and riffles and a scarcity of wood, particularly large wood and jams . Ambient Monitoring has not been conducted in the North Fork Skokomish River, but observations by local biologists suggests wood loading is poor with much of it being alder and small conifer (K. Dublanica, Skokomish Tribe, personal communication 1998) The majority of the mainstem Skokomish and portions of the South Fork Skokomish River and Vance Creek have been diked and /or channelized, reducing channel complexity and sinuosity, eliminating important side channels, simplifying the remaining habitat and creating a disconnect between these streams and existing floodplain sloughs and side channels. The Highway 101 and 106 bridges over the mainstem Skokomish restrict channel migration, as do two Mason County bridges across Vance Creek. Riparian corridors in all summer chum habitat zones including the floodplain tributaries are sparse and do not provide the large woody debris necessary to maintain structurally diverse channels. Woody debris continues to be removed from the channel and riparian areas to prevent flooding and as a source of firewood and lumber. The summer chum zone is highly modified with dikes, roads and armored banks prevalent throughout the valley. Highly modified channels promote channel instability which impact summer chum by inhibiting redd construction and increasing redd scour.

- *Sediment*- Spawning and incubation life stage, rated high impact. Past timber management practices in the basin have increased sediment aggradation in Vance Creek, the South Fork and mainstem Skokomish rivers through mass wasting and road failures (USFS 1995; STC 1997). Aggradation increases flooding, scouring of redds and bed materials, bank erosion and has led to more anthropogenic channel manipulations (e.g., diking) in the valley in response to greater flooding. Bed aggradation and channel braiding in the valley is well documented and is attributable to 1) increased sediment from road and slope failures due to logging, 2) reductions in sediment transport abilities with loss of flows from the North Fork Skokomish, 3) dikes limiting transport of bed materials out of the channel and onto floodplain areas and cutting off side channels and sloughs and 4) loss of stable bars and banks throughout the basin due to reductions in instream woody debris and riparian forests. Aggradation has reduced the conveyance capacity of the mainstem from the pre-Cushman level of 18,000 cfs to roughly 5,000 cfs (Stetson, 1996). Aggradation has been estimated by numerous entities to range from 3.0 to 4.5 feet (USDI 1997). Aggraded channels tend to be unstable with severe scour and fill episodes following storm events which destroy redds and hinder redd construction.

- *Peak flows* - Incubation life stage, rated high impact. Timber management has increased fall/winter storm flows by broadening the hydrograph and increasing the duration of high flows by up to 18%. These changes could translate to increases in sediment transport and channel disturbance (Simpson Timber Co. and WDNR 1997), scouring the redd environment. Road densities in some sub-basins in the South Fork Skokomish and Vance Creek drainages are over 6 miles/mile sq. and may contribute to peak flows by extending the stream network. Rain on snow peak flow events, combined with an aggrading channel, affects the incubation environment by bed scour and movement. Dikes contribute to bed scour by retaining water within the channel forcing the energy down onto the substrate rather than laterally across the floodplain. Typically depth of scour is greater in diked reaches than undiked reaches. Dikes and removal and filling of important side channel habitats eliminated these areas from floodwater retention.

- *Riparian condition* - Spawning and incubation life stage, rated high impact. Riparian and floodplain habitat was removed in the late 1800s and early 1900s as the thick old growth stands in the lower valley were cleared for farming, timber extraction and perceived flood protection (Richert, 1964). A large portion of the valley is maintained in agricultural fields. Sixty two percent of the mainstem Skokomish River, 81% of Hunter Creek, and 57% of Weaver Creek are either agricultural fields, sparsely vegetated, and/or have a forested riparian buffer <66 feet in width. The South Fork and Vance Creek riparian forests are in slightly better condition overall with 20% and 32% respectively as sparsely vegetated or <66 feet in width. The North Fork Skokomish and Richert Springs are the least disturbed with less than 20% of the riparian forest sparsely vegetated or with widths <66 feet in width (PNPTC, 1998). The majority of Purdy Creek flows through a large intact wetland system, except for the hatchery area above Hwy 101 which is the location of summer chum observations in 1954. Degraded or non-existent riparian forests affect potential recruitment of LWD to stream channels. Lack of instream and potential sources of woody debris leads to reduced pool habitat, increased bank erosion, unstable bars and stream channels thereby affecting the spawning and incubation environment.

- *Water quality (temperature, nutrients)* - Adult migration, spawning and rearing life stages, rated low impact. Elevated summer temperatures have been observed in the SF Skokomish River partially attributable to channel widening and aggradation which can inhibit upstream movement and migration of summer chum and induce premature emigration of fry from the redd environment (K. Dublanica, personal communication, 1998). Elevated temperatures may occur in the mainstem as well where water withdrawal along with aggradation and channel widening could influence peak temperatures. Nutrients from livestock and septic systems may impact water quality in the river and subestuary causing shifts in primary and secondary production of marine organisms. Failing septic systems and livestock are thought to be responsible for high levels of fecal coliform noted in several tributaries including Purdy,Weaver, Hunter creeks and parts of the mainstem (J. Park, Skokomish DNR, pers. comm. 1998).

## Factors for Recovery

In general, to assist in restoring summer chum habitat in the Skokomish watershed it is necessary to restrict development in critical reaches of the Skokomish Valley. Additionally, the following actions should be taken: 1) protect and restore the existing riparian and wetland habitats in the basin to enhance instream woody debris inputs, moderate temperatures and promote aquatic habitat diversity; 2) encourage the maximum amount of the watershed to be maintained as forestland; 3) restore floodplain connections of wetlands, sloughs and side channels with the main river channel; 4) reduce sediment inputs by road stabilization or abandonment, avoid timber harvests on unstable slopes; 5) restore riparian forests; 6) return flows to the North Fork to reduce bed aggradation in the mainstem Skokomish and return sediment transport to the delta, including reversal of eelgrass habitat loss in outer delta (additionally, it will restore mainstem channel depth and conveyance capacity as mandated by the Department of the Interior and recommended by the National Marine Fisheries Service, Skokomish Tribe, Pacific Fisheries Management Council, Hood

Canal Coordinating Council, Mason County and others (USDI 1997)); and 7) restore and enhance subestuary habitat through modification of dikes and tidegates. The following are more detailed descriptions of factors needed for recovery.

- *Water withdrawal* - The Department of the Interior's mandatory conditions for future operation of the Cushman Project, which include managed restoration of North Fork flow and restoration of mainstem channel conveyance capacity, represent the minimum requirements for protection and restoration of anadromous fish in the Skokomish River system and subestuary, and are broadly supported by federal, regional and local resource agencies and comprehensive watershed planning led by the Skokomish Tribe. Substantial restoration of North Fork flow from the Cushman Project is essential to reduce or eliminate aggradation of the mainstem channel, enhance instream habitat conditions and reverse continuing degradation of critical estuarine habitat. In addition, restored flows during the summer low flow months would improve upstream migration of all salmonids including summer chum and promote the recovery of the North Fork Skokomish River channel. The DOI/NMFS/EPA agreement on Interior 4(e) flow restoration conditions, are the minimum necessary to protect aquatic resources.

- *Subestuarine alterations* - Restore subestuary migration and rearing habitat by eliminating dikes, tide gates and roadways, converting agricultural lands back to estuarine wetlands and natural distributary and dendritic channels. Restoration of flows from the Cushman project is essential for subestuary recovery (Jay and Simenstad 1996). Several reports have been commissioned by the Skokomish Tribe to examine the structure of the delta and the potential for restoration, including environmental impacts and cost estimates for dike breaching (USCOE 1995).

- *Channel complexity/ aggradation* - There have been several areas identified by the Mason County Department of Public Works where the potential for catastrophic channel avulsions may occur due to sediment aggradation and confinement by dikes. These reaches as well as others are extremely dynamic. Removal of dikes and property buy-outs and/or purchase of floodplain easements from willing landowners would allow the river to migrate and interact with its floodplain. Allowing the channel to migrate in these dynamic reaches will over time decrease stream power by increasing channel sinuosity, increase available habitat and reduce bed aggradation. Reconnection of isolated sloughs and side channels will increase habitat diversity and promote habitat development. In addition, in conjunction with restoration of North Fork flows from the Cushman project, there may be a need for mechanical removal of sediments in selected reaches of the river. However, on it's own, mechanical removal of sediment would not be cost effective or achieve the desired outcome of restoring channel capacity and natural stream function. Instream habitat may be protected and enhanced by experimenting with and monitoring the use of engineered logjams (ELJ's) to stabilize bars and reduce erosion potential.

- *Peak flows* - At a landscape level it is necessary to restore ecosystem processes and lessen peak flow impacts by reducing road densities through obliteration and decommissioning, and improving the remaining road drainage network by installing larger and more frequent cross drains and water bars. The forest must be allowed to mature to improve hydrologic maturity and to reduce rain on snow impacts. The forest stand age can be increased throughout the watershed by staggering harvest units and reducing even age (clear-cut) harvests.

- *Riparian condition* - The riparian corridors in all summer chum habitats in the Skokomish Valley need to be enhanced through revegetation efforts. Dike decommissioning and subsequent revegetation efforts along the mainstem streams will allow the river to migrate, connecting the river with its floodplain and incorporate riparian vegetation into the stream channels. Much of the adjacent agricultural lands (especially Hunter and Weaver creeks) need to be enhanced by revegetation and fencing with livestock exclusion fencing. Riparian corridors need to be significantly wider and allow for the natural movement of the alluvial river segments in their floodplain. Water quality will be enhanced as well with the addition of wider riparian areas and fencing which will assist in moderating temperature impacts and preventing livestock access to the streams. A riparian forest protection/restoration plan may assist in developing these riparian corridors and would be greatly enhanced by support from local citizens. Riparian corridors above the summer chum zone in Vance Creek, South and North Fork Skokomish rivers provide LWD to downstream reaches and need protection as well. Simpson Timber Company has proposed a 50 year timber management plan for their lands in the Skokomish basin (Simpson Timber Company 1998), but the adequacy of protections have not been evaluated completely.

### Strength of Evaluation and Information Needs

Numerous studies, reports and documents have been drafted discussing various issues in the Skokomish watershed. The major plans include a DNR/Simpson Timber Co. watershed analysis on the South Fork Skokomish River (Simpson Timber Co. and WDNR 1997) to direct watershed protection and identify sensitive habitats, a Draft Habitat Conservation Plan/Landscape Plan proposed by Simpson Timber Company, the Presidents Forest Plan (1994) and a federal watershed analysis of the South Fork Skokomish River (USFS 1995) to guide USFS land management and restoration efforts, a KCM Consultants (1997) to reduce the impact of flooding on people and property and finally the Skokomish Tribe’s Watershed/Ecosystem Improvement Action Plan (in press). Numerous other documents are available as well including historical information on Skokomish valley settlement and activities (Richert, 1964). Impacts to the aquatic system are well documented and the confidence in the habitat factors for decline is high but the confidence in the escapement and distribution of summer chum in the watershed is low to moderate.

More information is needed to determine current summer chum use and to assess the relative impacts of land use on summer chum habitat. Information needs include:

1. Monitoring of bed scour in selected channel reaches correlated to flows from existing USGS gauges or other means of measuring flows.
2. Monitoring habitat components in the subestuary as agricultural lands are converted back to subestuary habitats.
3. Dike reconnaissance throughout the basin to identify dikes structural integrity and dikes that have major negative influences on channel geometry.

4. Increase survey effort throughout the Skokomish and tributaries to document any current summer chum utilization in the basin.
5. Investigate modification of the log jam at the top of Nalley slough to facilitate the movement of juvenile and adult salmon as well as sediment and flow.

## References

Amato, C. 1996. Historical changes affecting freshwater habitat of coho salmon in the Hood Canal basin, pre-1850 to the present. Point No Point Treaty Council, Kingston, WA.

Chinook Northwest Consultants. In press. Skokomish Water/Ecosystem Improvement Action Plan. Chinook Northwest Consultants for Skokomish Tribe Dept. Nat. Res., Potlatch, WA.

EPA (U.S. Environmental Protection Agency). 1998. Letter from Chuck Clarke, regional EPA administrator to Lois D. Cashell, FERC (Federal Energy Regulatory Commission), January 30, 1998 (subject EPA's request for rehearing, Cushman Hydroelectric Project). U.S. Environmental Protection Agency (EPA), Washington, D.C.

FEMAT (Forest Ecosystem Management Team). 1993. Forest Ecosystem Management: an ecological, economic, and social assessment. Report of the Forest Ecosystem Management Team, U.S. Government Printing Office 1993-783-071. U.S. Government Printing Office for the U.S. Dept. of Agri., Forest Serv.; U.S. Dept. of the Inter., Fish and Wild. Serv., Bureau of Land Mgt., and Nat. Park Serv.; U.S. Dept. of Comm., Nat. Ocean. and Atmospheric Admin. and Nat. Mar. Fish. Serv.; and U.S. Envir. Prot. Ag.

Jay, D.A., and J.C. Simenstad. 1996. Downstream effects of water withdraw in a small, West Coast river basin. Estuaries 19:501-517.

KCM Consultants. 1997. Skokomish R. CFHMP. KCM Consultants Project # 2540037 for Mason County Dept. of Comm. Dev., Shelton, WA under DOE grant # G9400224 (Wash. Dept. Ecol., Olympia, WA).

NMFS (National Marine Fisheries Service). 1998. Letters from Susan B. Fruchter, Dept. of Commerce Office of Under Secretary for Oceans and Atmosphere. Feb. 18, 1998; William Stelle Jr., Regional Administrator NMFS, July 28, 1998 to David P. Boergers, Federal Energy Regulatory Comm. (subject NMFS request for rehearing on Cushman Hydroelectric Project, FERC No. 460, August 29, 1998).

PNPTC (Point No Point treaty Council). 1998. Riparian area assessment data (unpublished). Point No Point Treaty Council, Kingston, WA.

Richert, E. 1964. A Long Time Ago in the Skokomish Valley. Publisher unknown. 84 p.

R2 Resource Consultants. 1996. Fisheries resources and sediment aggradation in the Skokomish River Valley, Washington. R2 Resource consultants for Northwest Economic Associates for U.S. Dept. of the Inter., Bureau of Indian Affairs.

Simpson Timber Co. and WDNR (Washington Department of Natural Resources). 1997. South Fork Skokomish Watershed Analysis. Simpson Timber Co., Northwest Operations, Shelton, WA., and Wash. Dept. Nat. Res., Olympia, WA.

Simpson Timber Co. 1998. Draft Habitat Operation Plan (July 1998). Northwest operations, Simpson Timber Company, Shelton, WA.

Skokomish DNR (Skokomish Tribe Department of Natural Resources) and PNPTC (Point No Point Treaty Council). 1994. Ambient Monitoring Project data (unpublished). Skokomish Tribe Dept. Nat. Res., Potlach, WA.

Skokomish DNR (Skokomish Tribe Department of Natural Resources). 1998. Water quality assessments (Unpublished). Skokomish Tribe Dept. Nat. Res., Potlach, WA.

Smoker, W. 1952. The Skokomish R. Indian Fishery. Wash. Dept. Fish. and Wild., Olympia, WA.

Stetson Engineers. 1996. Technical report support recommended Section 4(e) conditions pertaining to hydrologic impacts on the Skokomish Indian Reservation, Washington.

USFS (United States Forest Service). 1995. South Fork Skokomish Watershed Analysis. U.S. Dept. of Agri., Forest Service, Olympic National Forest, Olympia, WA.

USCOE (United States Corps of Engineers). 1996. Restoration of tidal inundation to the Skokomish R. estuary. Dept. of the Army, U.S. Geo. Surv., Seattle District, Seattle, WA. 15 p.

USFS (United States Forest Service) and BLM (Bureau of Land Management). 1994. Record of decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl. 74 p. + attachments.

USDI (United States Department of the Interior). 1997. Section 4(e) conditions for adequate protection and utilization of Skokomish Indian Reservation. U.S. Dept. of the Interior, Washington D.C.

WDF (Washington Department of Fisheries). 1957. Research relating to fisheries problems that will arise in conjunction with current and projected hydroelectric developments in the Skokomish R. Wash. Dept. Fish. and Wild., Olympia, WA.

WDOE (Washington Department of Ecology). 1987. Letter from Clark Haberman, WDOE to E.E. Coates, Tacoma Dept. Pub. Util., Dec. 30, 1987. Wash, Dept. Ecol., Olympia, WA.

WDOE (Washington Department of Ecology). 1994. Letter from Gary E. Hanson, WDOE to Lois Cashell, FERC, Oct. 27, 1994. Wash, Dept. Ecol., Olympia, WA.

# Union Watershed Narrative
# WRIA 15.0503

## Watershed Description

The Union River enters Lynch Cove in the eastern arm of Hood Canal**.** The watershed area is approximately 24 square miles with 10 miles of mainstem and 30 miles of tributary streams. The headwaters are in the Blue Hills near 1,500 ft. elevation and flow through an undeveloped watershed before entering the Union River Reservoir constructed in 1955-57 as a municipal and industrial water supply. It provides up to 5 million gallons/day for the City of Bremerton and the Puget Sound Naval Shipyard (Williams et al. 1975). The upper watershed contains moderate to steep side-slopes with a relatively low gradient stream channel downstream to McKenna Falls located at river mile (RM) 6.7 immediately below the water supply dam (Cascade Dam) and reservoir. Below the falls, the gradient is also low with the lower 5 miles being quite flat and flowing through a broad shrub-scrub floodplain. The Union River enters a subestuarine delta that has been heavily constrained by diking and filling, mainly for agriculture, flood control, and to protect residences located in the subestuary. The Washington Department of Ecology has closed the Union River and its tributaries from the mouth upstream to McKenna Falls to surface water appropriations (WDOE, 1998).

The dominant landuse in the upper portions of the Union River and its tributaries is industrial forestry and water storage/diversion. The middle and lower reaches have moderately heavy residential development as well as numerous small hobby farms and minor forestry operations (Williams et al. 1975; PSCRBT, 1991). The City of Belfair is located directly east of the river mouth and subestuary. Three county owned bridge crossings and several privately owned bridges (some of poor design) (J. Lenzi, WDFW, Olympia, WA pers. comm.) exist which prevent the river from migrating throughout its floodplain.

## Summer Chum Distribution

Current summer chum distribution is primarily limited to the lower 2.5 miles, but extends upstream as well. Historical distribution is assumed to have extended to the base of McKenna Falls (RM 6.7) under historical flow conditions. Several small tributaries exist within this reach, including Courtney, Bear and Hazel creeks and the East Fork Union River, however historical use by summer chum salmon is unknown.

## Population Status

Escapement estimates show 100 or less spawners during the 1970s. Since then, escapement has risen to several hundred most years with a high of almost 1,900 spawners in 1986. This population contrasts with the rest of the Hood Canal/Strait of Juan de Fuca summer chum populations in that the abundance of the stock has increased since 1978 (Appendix Table 1.1). Although the stock has experienced a general increase over the last 15 years, it is still thought to be less than the historical run size.

## Factors for Decline

The Union River watershed is dominated by residential development, small farms, and industrial forestry. The freshwater habitat overall is in fair condition with the majority of the impacts occurring from encroachment by homes and farms in the floodplain and dikes and agricultural activities and modifications in the subestuary and intertidal areas. The Union River is the only basin on the Kitsap Peninsula to possess a viable population of summer chum salmon. The potential for further habitat degradation remains high due to the trends in growth, urban landuse designations and inadequate stream, riparian and shoreline protections. For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18.

- *Subestuarine habitat loss and degradation* - Juvenile rearing and migration life stage, rated high impact. For it's comparatively small size of 344.6 acres (6.1 miles perimeter), the estuarine delta of the Union River has been extensively diked and the tidal floodplain constrained as a result. Seven diked areas occupy 78.6 acres or 22.8% of the original summer chum rearing and migration habitat area. Some of these diked areas may be breached and now inundated by the tide but the extent of restoration to tidal circulation and the state of recovery cannot be verified without ground truthing. Several tidegates have been identified but their condition and impact on summer chum estuarine habitat is unknown (M. Schirato, WDFW, Olympia, WA pers. comm., Oct. 1995). Juvenile summer chum rearing opportunities are presently limited compared to the historic state of the subestuary. In particular, habitat extent and quality in the mesohaline reaches of the subestuary, which chum fry may volitionally occupy for up to 1-2 weeks, are very limited due to the diking. Much of the breaching of marshes appears to be in an early state of restoration. Fills for commercial or residential use include two areas totaling 3.6 acres, approximately 8.9% of the historical delta area. At least one of these fills is located on the outer edge of the historic subestuary, thus imposing an intertidal barrier to migrating summer chum fry. One small (0.9 acres) pond or other excavation is evident within the delta but its impact is thought to be minor.

- *Subestuarine ditches and remnant dikes* - Juvenile rearing and migration life stage, rated high impact. Although much of the historically diked delta habitat in the Union River subestuary is now exposed to renewed tidal inundation, the associated ditching that accompanied diking and agricultural activities have heavily modified emergent marsh and other intertidal habitats. While these ditches and remnant dikes may not impose a direct impact, they likely inhibit restoration of natural drainage channel systems and delay long-term recovery of estuarine rearing habitat for summer chum. At least 19 ditch and remnant dikes are present, and extend over approximately 2 miles of delta habitat. Many of these are concentrated in a large dike-breach marsh in the lower extent of the delta, where chum fry would be expected to "stage" for migration into the Canal. Such ditching typically prevents or delays the formation of natural dendritic tidal channel systems, which in turn impacts foraging opportunities for juvenile salmon in the marshes. In addition, prey resources of the emergent marshes, which can be important to chum fry early in the estuarine migration, are likely progressing at a slower recovery rate than natural because of the ditching.

- *Riparian condition* - Spawning and incubation life stages, rated high impact. Most of the basin was completely logged of the original forests by the 1930s (Amato 1996). Numerous farms, residential developments and associated bank armoring exist in the riparian corridor affecting the functional status of the riparian forest. Currently fifty two percent of the riparian area is forested of which 96% is dominated by deciduous trees. Sixty two percent of the total riparian length is sparsely vegetated or less than 66 feet wide (Appendix Report 3.7). Rural residential development, agriculture, and roads cover 46% of the riparian area. A more mature and diverse riparian forest is likely to provide stable LWD to create structurally diverse channel conditions and improve stream habitat overall.

- *Channel complexity* - Spawning and incubation life stages, rated moderate impact. The Union River still possesses a structurally diverse channel network with 63% pools. However pool frequency is poor at 5.9 channel widths between each pool. The stream contains low levels of large size LWD due to past stream clean-outs, riparian forest harvesting and natural transport downstream. Habitat surveys in 1993 found the Union River averaged 0.22 pieces of LWD/m from the mouth to McKenna Falls with nearly 42% of the wood being in the small size class [10-20 cm diameter] (PNPTC, 1995, Appendix Report 3.8). The low levels of large size instream LWD may result in redd scour and channel instability. Much of the current instream LWD is western red cedar, which has long instream residency times due to its slow rate of decay. Stream clean-outs of LWD, particularly log jams and channelizations have been recorded back to the late 1800s but were more extensive during the late 1960s. For instance in 1967 the WDF stream improvement division noted that five log jams were removed from the Union River and it was channelized for 5 miles. In a three year period in the late 1960s, numerous log jams were removed from the Union River and 2 of the larger tributaries, Courtney Creek and Bear Creek. In addition, rip rap was placed along 2 miles of Courtney Creek in 2 consecutive years in 1967 and 1968 and the lower two miles of Courtney Creek appears to have been moved sometime in the distant past (Amato, 1996). The previous channel alignment still exists on maps in existence today including the 7.5 minute U.S.G.S. Belfair Quadrangle map printed in 1994.

- *Low flow* - Adult migration and spawning life stage, rated low impact. The impact of water withdrawal by the City of Bremerton is thought to have a low impact on Union River summer chum salmon, but the actual impacts are unknown. Based on 1998 flow data, outflow from the Union Reservoir exceeded inflow to the reservoir during the critical migration and spawning period of mid-August to mid-October 73% of the time (43 of 59 days) (City of Bremerton 1998). Preceding years have not been assessed at this time. Out of basin diversion may reduce the amount of water available for summer chum migration and spawning from historical conditions and may reduce the amount of spawning area available to adults at the site and reach scale, including adequate access to upstream reaches and tributary streams. Mean annual flow for the Union River for the period of 1947 - 1959 was 54.7 cfs with a mean annual minimum flow of 42.7 and a 1 day low flow of 14 cfs. The Bremerton Water Utility maintains a continuous flow gaging station downstream of the dam which has operated from 1958 to the present, however no summary of flow data was available for this station (PSCRBT 1991). An administrative low flow has been set at 3 cfs for the Union River below McKenna Falls and 10 cfs at the river mouth (Cline 1998).

- *Water quality (toxics, nutrients, temperature)* - Adult migration, spawning and rearing life stages, rated low impact. Toxic chemicals (mercury, selenium, cadmium, arsenic, boron) have been found in sediment and water samples near the vicinity of the Olympic View Sanitary Landfill located near the East Fork Union River confluence. Although the impact on summer chum is thought to be low, there has not been any analysis of the impacts. Additionally, the Lynch Cove subestuary at the mouth of the Union River had the highest levels of cadmium and arsenic found in Puget Sound and the third highest levels of chromium and copper (documented by the Puget Sound Ambient Monitoring Program in a letter to DOE from the Mason County Commissioners 1994). Sediment laden, petroleum smelling effluent at approximately RM 6 has been noted near a commercial paving company, but like the toxics mentioned above, the impacts are unknown. Livestock have direct access to the stream in several locations and may inhibit redd formation by creating unstable conditions in the immediate area. Nutrients from livestock and septic systems may impact water quality in the river and subestuary, causing shifts in primary and secondary production. Past water sampling has revealed high bacterial counts in the lower section of the river apparently attributable to septic systems and stormwater (PSCRBT 1991). Summer temperatures may be elevated due to water withdrawals and the lack of riparian shading which can inhibit the upstream movement and migration of summer chum and induce premature immigration of fry from the redd environment increasing mortality

## Factors for Recovery

A general discussion of restoration and protection options for these habitat factors is found in Part Three - section 3.4.4.2, toolkit.

- *Subestuarine habitat* - Currently, Belfair and much of the watershed is designated as an urban growth area in the Mason County Comprehensive Plan and the Union River and most of the nearshore marine areas in Hood Canal adjacent to the Union River have an urban designation under the Mason County Shoreline Master Program. There is a need to strengthen the protection strategies for buffers, building setbacks and bulkhead constructions. The county and other entities should consider acquiring undeveloped estuarine and marine shorelines for permanent protection or acquiring conservation easements from willing landowners. Both existing diked and breached-dike estuarine wetlands are likely limiting the potential for maximal rearing of summer chum within the estuarine delta. Restoration action in the form of dike breaching, with setback dikes to protect public and private property from flood damage if necessary, and ditch in-filling should be considered as the most proactive approaches to recovering critical summer chum habitat in this subestuary. There is a need to evaluate the effectiveness of dikes and the relative impacts on the tidal/freshwater environments and, if appropriate, negotiate restoration opportunities with the landowners.

- *Riparian condition and LWD* - Enhance existing riparian forests through underplanting of shade tolerant conifer and encourage riparian planting throughout the riparian corridor. Consider acquisition of sensitive properties or conservation easements from willing property owners. Modify local government (county and state) riparian protection strategies to protect stream and riparian areas from further residential development.

- *Channel complexity* - Allow natural LWD input processes to occur and LWD to remain in the channel, and consider developing restoration projects to deliver additional wood to the channel. Enhance and restore degraded riparian areas through local partnerships.

- *Water quality* - Elevate best management practices (BMPs) utilized by industrial landowners, small farms and residential homeowners to reduce impacts on instream habitat and water quality. Increase riparian protections through local and state ordinances and laws. Enact effective stormwater protections to reduce the impact of future projected growth on basin hydrology and water quality.

- *Increase awareness and education* - Work with local groups (Union River Basin Protection Association, Hood Canal Salmon Enhancement Group, Theler Wetland Project Center) and stakeholders to increase environmental awareness and educate the public about the importance of functional habitats to preserve and protect all salmon stocks.

## Strength of Evaluation and Information Needs

Confidence in this assessment is rated as moderate due to the amount of information available for analysis, including TFW instream ambient monitoring data, escapement/survey data, historical research conducted by PNPTC and knowledge of experienced habitat biologists in the area.

More information is needed to assess the relative impacts in the summer chum habitat zone.
Information needs include:

1. Assess and quantify the impacts from dikes located in the subestuary on summer chum salmon populations and potential for restoration.
2. Evaluate the recovery of vegetation communities and critical prey resources in the subestuary and intertidal areas.
3. Identify impacts from current water withdrawals by the City of Bremerton and possible measures to improve conditions if warranted.
4. Water quality monitoring (toxics, nutrients, temperature) at industrial sites and throughout the summer chum habitat zone.
5. Continued stream channel habitat monitoring to determine habitat trends.
6. Monitoring of bed scour in selected reaches associated with instream flow measurements.
7. Increased survey effort to document summer chum utilization above the current index area at river mile 2.1 and in the various lower tributaries.

## References

Amato, C. 1996. Historical changes affecting freshwater habitat of coho salmon in the Hood Canal basin, pre-1850 to the present. Point No Point Treaty Council, Kingston, WA.

City of Bremerton. 1998. Unpublished water flow and withdraw data. Water Resources Division of the Public Works Utility, Bremerton, WA.

Cline, V. 1998. Facsimile from Vicki Cline, WDOE to Carol Bernthal, PNPTC dated Dec. 28, 1998. Wash. Dept. Ecol., Olympia, WA.

Mason County. 1994. Letter from Mason County Commissioners to WDOE regarding Puget Sound Ambient Monitoring Program sampling results for Lynch Cove. Mason County, Shelton, WA.

PNPTC (Point No Point Treaty Council). 1995. 1993-95 Ambient Monitoring data (unpublished). Point No Point Treaty Council, Kingston, WA.

PSCRBT (Puget Sound Cooperative River Basin Team). 1991. Lower Hood Canal Watershed, Mason and Kitsap Counties report. Skokomish Tribe Dept. Nat. Res., Potlatch, WA.

WDFW. 1998. Summer chum spawning ground utilization data (Unpublished). Wash. Dept. Fish and Wild., Olympia, WA.

WDOE (Washington Department of Ecology). 1998. In-stream Resources Protection program – Kitsap Water Resources Inventory Area (WRIA) 16. Wash, Dept. Ecol., Olympia, WA.

Williams, R.W., R.M. Laramie, and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization, Volume 1, Puget Sound Region. Wash. Dept. Fish and Wild., Olympia, WA. 974 p.

# Big Mission Watershed Narrative
# WRIA 15.0495

## Watershed Description

The Big Mission Creek watershed enters the eastern arm of Hood Canal and Lynch Cove at Plum Point approximately 2 miles west of the Union River and 3 miles west of the city of Belfair. It contains nearly 10 miles of mainstem and 10 miles of tributary streams. The mean annual flow for Big Mission Creek measured at river mile 4.8 from 1946 to 1953 was 12.4 cfs, with a mean annual minimum flow of 8.5 cfs and a peak flow of 403 cfs (PSCRBT, 1991). The Washington Department of Ecology has closed Big Mission Creek, Mission Lake and their tributaries to further surface water appropriations (WDOE, 1998).

The headwaters begin in a forested area above Mission Lake and in wetlands northwest of Mission Lake, which coalesce into a single stream immediately downstream of Mission Lake outlet. Channel gradients are typically less than five percent the entire length of the creek and flow through glacial advance and recessional outwash sediments consisting of unconsolidated silt, and gravel, which is highly erodible (PSCRBT, 1991). The upper and middle portions of the watershed are forested and dominated by industrial forests managed by the Washington Department of Natural Resources and other industrial forestland owners. The lower 2 miles has several county road crossings and a nearly continuous corridor of single family residences located in the riparian zone. The lower 1/10th mile flows through Belfair State Park and into Hood Canal via a heavily modified and constricted estuarine delta. Analysis of a 1944 aerial photo indicates the subestuarine delta (which is now part of Belfair State Park) was diked and used as a farm at that time. Diking and other modifications have caused a significant loss in estuarine rearing and physiological transition habitat for chum salmon.

## Summer Chum Distribution

Spawning ground surveys since 1974 show only a fall chum population in this watershed. This watershed is included in this plan based on the historical potential for summer chum utilization given available suitable habitat, stable late summer flows, and proximity to the Union River, which supports summer chum. Based on the presence of suitable habitat, summer chum could range up to RM 1.5.

## Population Status

Spawning survey data indicate that a summer chum population does not exist at this time (WDFW 1998). However habitat and flow conditions appear conducive to summer chum and it is possible that prior to spawning surveys (1974), summer chum did exist in this watershed.

## Factors for Decline

The potential summer chum habitat zone in the lower 2 miles of the watershed is in poor condition when compared with the upstream forested areas, primarily due to residential development, road crossings, stream modifications and timber harvesting. For summary results of the limiting factor analysis, refer to Part Three - section 3.4, Tables 3.17 and 3.18.

- *Subestuarine habitat loss*- Juvenile rearing and adult migration/spawning stages, rated high impact. The historical area of this small delta is estimated to be 30.3 acres. Two diked areas comprise 10.3 acres or 34% of the original intertidal habitat potentially available for chum salmon. One large diked area also contains a man-made pond. This extensive diking has likely caused the expansion of the delta into the Canal, although the extent of this has not been estimated to our knowledge. The mesohaline reach of the subestuary is heavily constrained by dikes with minimal emergent or other wetland vegetation. The dikes have resulted in a significant direct loss of habitat and have altered the natural process of tidal mixing in the tidal/freshwater zone which is an important zone for feeding success and transition area from freshwater to saltwater life stages. Two remnant ditches and dikes extend 0.14 miles within the delta, but their impact is unknown and thought to be relatively small.

- *Riparian landuse*- Spawning and incubation life stages, rated high impact. Seventy percent of the riparian area in the potential summer chum reach is forested with 36% being <12 inches dbh (diameter breast height) and 98% dominated by deciduous trees. Forty five percent of the linear buffer length is sparsely vegetated or is less than 66 feet wide. Residential/commercial development and roads cover 30% of the total buffer area, which has reduced the extent of a functional riparian forest (PNPTC 1998, Appendix Report 3.7). The current riparian forest is unable to provide LWD (large woody debris) needed for the creation of stable instream habitat, which impacts the spawning success of chum salmon.

- *Channel complexity*-Spawning and incubation life stages, rated high impact. Habitat surveys conducted in Big Mission Creek revealed 33% pools, 0.07 pieces of LWD/m., and an average of 6.5 channel widths between each pool within the potential summer chum reach (Appendix Report 3.7). This compares to 43% pools and slightly higher wood frequencies and lower pool spacing in the forested area upstream (PNPTC 1995). Bank armoring, removal of standing trees recruitable as LWD and removal of instream large woody debris all continue in association with existing residential development adjacent to the stream channel. A stream channel lacking diverse structure leads to increased redd scour and poorly sorted spawning gravels, which may inhibit redd formation. In the mid to late 1960s WDF stream cleaning crews removed log jams from 12 miles of the watershed and channelized the stream for 4 miles over a four year period in an attempt to improve upstream migration of fish (Amato, 1996). This work presumably included portions of the summer chum zone. In addition, the channel entering the delta may have been channelized to some extent as well. The impacts of low channel complexity are believed to exert a high impact.

## Factors for Recovery

A full discussion of protection options and restoration stategies by habitat factor is found in Part Three - section 3.4.4.2, toolkit.

- *Subestuarine habitat* - Summer chum essentially have little or no brackish to mesohaline rearing habitat in the Big Mission subestuary due to diking and other development of the historic delta. Removal and setback of dikes could contribute significantly to the recovery of a natural distributary tidal channel system and estuarine wetland communities that would significantly enhance rearing prior to migration into the adjacent Canal. Removal of unnecessary fills and bulkheads will allow natural shoreline processes to occur. Property buy outs or conservation easements may be appropriate for some critical areas. Consider negotiating with Belfair State Park and the Washington Parks Department to reconfigure lower stream channel if it is thought that the results would be favorable to summer chum salmon. Strengthen local governments' protection strategies for riparian protections, building setbacks, storm-water runoff and shoreline armoring.

- *Riparian condition and LWD* - Enhance existing riparian corridors through underplanting of shade tolerant conifer. Consider acquisition of sensitive properties or conservation easements of developed properties that can be enhanced. Modify local governments' riparian protection strategies to protect the stream and riparian areas from further residential development by requiring functional riparian buffers. In the middle portion of the watershed the Washington Department of Natural Resources has developed a long term Habitat Conservation Plan for industrial forest activities on state land which will provide increased riparian protections during timber harvesting, but the adequacy of protections have not been evaluated completely. Nevertheless, it will be desirable to link the DNR riparian forests with the riparian corridors in the lower summer chum zone.

- *Channel complexity* - Allow natural woody debris input processes to occur and consider developing restoration projects to deliver additional wood to the channel. Remove unnecessary rip rap and restore sites with appropriate bioengineered techniques. Evaluate the effectiveness of culverts/bridges to allow the free movement of wood, water and sediment to downstream reaches.

- *Increase awareness and education* - Work with local groups and stakeholders to increase environmental awareness and importance of functional habitat to preserve all salmon stocks. Develop local watershed groups to assist in monitoring environmental conditions.

## Strength of Evaluation and Information needs

Confidence for fish distribution is rated low, and based upon professional judgement of where summer chum would likely spawn. Confidence in the habitat assessment is high due to the TFW ambient monitoring data, historical overview, PNPTC riparian assessment and the field knowledge of several local biologists.

More information is needed to assess the relative impacts of land use on summer chum habitat. Information needs include:

1. Water quality monitoring throughout the summer chum habitat zone.
2. Monitoring of bed scour in selected reaches associated with stream flow data and channel cross sections.
3. Increase in survey effort during the summer chum entry period in an attempt to document any current use by summer chum salmon beyond the current survey reach.
4. Analysis of the impact on freshwater and estuarine habitat created by the Belfair State Park and potential for restoration of this critical zone.

## References

Amato, C. 1996. Historical changes affecting freshwater habitat of coho salmon in the Hood Canal basin, pre-1850 to the present. Point No Point Treaty Council, Kingston, WA.

PNPTC (Point No Point Treaty Council). 1993. 1993-95 Ambient Monitoring data (Unpublished). Point No Point Treaty Council, Kingston, WA.

PNPTC (Point No Point Treaty Council). 1998. Riparian area assessment data (Unpublished). Point No Point Treaty Council, Kingston, WA.

PSCRBT (Puget Sound Cooperative River Basin Team). 1991. Lower Hood Canal Watershed, Mason and Kitsap Counties report. Skokomish Tribe Dept. Nat. Res., Potlatch, WA.

WDFW. 1998. Summer chum spawning ground utilization data (Unpublished). Wash. Dept. Fish and Wild., Olympia, WA.

WDOE (Washington Department of Ecology). 1998. In-stream Resources Protection program – Kitsap Water Resources Inventory Area (WRIA) 16. Wash, Dept. Ecol., Olympia, WA.

# Tahuya Watershed Narrative
## WRIA 15.0446

### Watershed Description

The Tahuya River is the largest stream draining Kitsap Peninsula at 45.1 sq. miles, and is located east of Rendsland Creek and the Dewatto River, south of Big Beef Creek, and west of Big Mission Creek and the Union River. It headwaters in the Green Mountain on the plateau of the Kitsap peninsula and flows southwesterly entering the east side of Hood Canal at the community of Tahuya. The Tahuya River has a total mainstem length of 21 miles and a combined tributary length of approximately 64.9 miles.

Below Lake Tahuya, the Tahuya River flows through gently rolling hills with a low to moderate stream gradient. Below RM 14, the river flows through a broad alluvial valley. A distinctive feature of the Tahuya River and most of the streams draining southwest Kitsap Peninsula is the large wetland sections directly associated with the mainstem and numerous tributary wetlands within the drainage. The geology of this watershed is dominated by glacial till. The moderate terrain and low elevation of the Tahuya River watershed results in a rain dominated hydrologic pattern where many of the smaller tributaries go dry early in the summer season, or during winter dry periods. The numerous wetlands within the watershed are critical in moderating peak winter flow and augmenting summer low flow. To provide instream flows during the summer low flow period, the Department of Ecology has closed the Tahuya River to additional consumptive appropriations during the time period June 15 to October 15, per WAC 173-515-040(2).

The primary historical land use in this watershed was timber harvest. A large portion of the watershed is still managed for timber in the Washington Department of Natural Resources, Tahuya State Forest, and on the lands of private timber companies. Seventy one percent of the riparian zone is fully forested, with another 6% clearcut. Agricultural accounts for 8% of the riparian zone, mainly in the form of Christmas tree and small farms. Residential neighborhoods within the 100-year floodplain account for another 12% of the riparian zone. The immediate shoreline of Hood Canal is intensely developed. Many of the natural lakes, reservoirs, and wetlands in the Tahuya drainage are also intensely developed.

### Summer Chum Distribution

Past spawning surveys found summer chum below RM (river mile) 3.0. However, given present flow and gradient patterns, summer chum could extend up to RM 8.0.

### Population Status

During the early 1970s estimated escapement ranged from the high hundreds to thousands. By the 1980s, it was reduced to less than 200. Summer chum have been detected at very low numbers since the early 1990s (Appendix Table 1.1), and a viable population no longer exists.

## Factors for Decline

Aerial photo analysis shows that the lower river channel from RM 0.0 to 3.0, where historically most of the summer chum spawned, has approximately 50 percent of the channel length impacted (on at least one riverbank) by roads, agriculture, and residential development. The adjacent nearshore and estuary habitat has been intensely developed. The habitat is degraded due to (in order of importance): nearshore habitat loss, loss of LWD, the loss of species diversity within the riparian forest, elevated water temperatures late in the summer season, and channel instability. As pressure to develop shoreline and floodplain increases, there is increasing conflict between natural shoreline and channel processes that maintain habitat and bank armoring, flood protection, and LWD removal. For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18.

- *Nearshore habitat loss*- Early rearing life stage, rated high impact. Nearshore development including, bulkheads, filling of near shore areas, erosion onto beaches, installation of docks, and loss of shoreline vegetation, has reduced and eliminated nearshore habitat. Bulkheads increase the rate of beach erosion, modifying and eliminating suitable habitat. Bulkheads and docks force fish into deeper water where they are subjected to increased predation by birds and other fish species. Installation of bulkheads reduces available habitat for chum prey. Bulkheads and filling of nearshore habitat eliminates eelgrass beds and salt marsh, important rearing and feeding habitats. Removal of shoreline vegetation reduces shade, shoreline LWD, and increases erosion onto beaches, all important factors in the survival of summer chum and their prey. Shoreline vegetation is also an important source of terrestrial chum prey. Dock installation through filling, shading, and physical disturbance of the beach eliminates eelgrass beds, micro and macro algae, disrupts salmon migration, increases predation by forcing salmon into deep water, displaces prey species, and disrupts beach spawning of prey species.

- *Water quality, temperature*-Adult spawning life history stage, rated high impact. High water temperatures into late September can negatively affect summer chum by preventing the entry of adults into the river, exposing them to predation. Temperature data shows that on some years water temperatures are 12 degrees Celsius or higher through the first half of September (PNPTC 1994, 1995, 1996, 1997). Reductions in the extent of riparian forests, and the size of trees within the riparian forest increase stream temperatures through a loss of shade and transpiration. Within the lower 9 miles of the Tahuya River 29% of the riparian forest is less than 66 feet in width or sparsely vegetated (Appendix Report 3.7).

- *Riparian forest condition*-Spawning and incubation life history stages, rated moderate impact. By 1930 most of the old growth in the Tahuya River watershed had been harvested (Amato 1996). Historical riparian forests were dominated by a mixture of old growth western red cedar, Douglas-fir, western hemlock, and areas of younger alder. Stumps remaining in the riparian forest adjacent to the stream channel network show that in most areas all the large conifer trees available for recruitment into the stream channel were removed with timber harvest. Presently, 7% of the riparian zone (by stream length) has no buffer, 24% averages <12 in. dbh and, 69% is 12 to 20 inches dbh (12-20 in dbh). Species composition of riparian forest is 52% deciduous dominated, and 37% mixed conifer and deciduous. Forty four percent of the riparian forest is greater than 132 feet in width, 27% 66 to 132 feet in width, and 29% less than 66 feet in width and/or sparsely vegetated. Riparian land use within the riparian buffer is 71% forested, 12% rural residential and 8% agriculture (Appendix Report 3.7). Although 44% of the riparian forest greater than 132 feet in width and 71% of the riparian buffer forested, the small size of most of the trees and lack of conifer in the riparian forest combine for a moderate impact. The habitat is in recovery, however development of this watershed is expected to rapidly increase over the coming decades. Habitat surveys (between RM 4.0 and 9.0) of the Tahuya mainstem shows low numbers of LWD at 0.15 pcs/m of channel length (Appendix Report 3.8). Levels of LWD will continue to decline for the next 25 to 50 years until the existing riparian forest to matures and contributes large diameter LWD to the stream channel.

- *Channel complexity*-Spawning and incubation life history stages, rated moderate impact. Road building, diking, channelization, floodplain agriculture and residences, and bank armoring have constricted the floodplain and limited channel movement and the creation of new habitat. Agriculture landuse found on the floodplain at RM 0.5 to 0.8 and RM 1.1 to 1.3 has eliminated or limited riparian forest development. From RM 1.6 to 2.0, a farm is located on a floodplain island bounded by the mainstem and a side-channel of the river. A roughly 800 foot long dike protects this site. Residential development at RM 2.5 to 2.7 is located in the floodplain on the west side of the river. Residential development at RM 4.5 to 6.0 is located in the floodplain on the north side of the river. Agriculture and residential developments also occur from RM 6.0 to 6.2. From RM 6.3 to 6.9 homes are placed directly on the river bank, and agricultural developments is cutting off old river meanders. Fill is used to protect residential development at RM 7.3 to 7.6. The residential and agricultural development in the floodplain and riparian forest of the river has resulted in the removal of riparian vegetation and bank armoring from river mile 7.5 downstream.

  From 1955 to 1970, the Washington Department of Fisheries Stream Improvement Division removed what was considered at that time as blockages to upstream salmon migration. Logjams, debris, and beaver dams were removed and many miles of mainstem and tributaries were channelized (Amato 1996). The result was a loss of channel complexity and bed stability. From habitat survey data, the Tahuya River has 72% pools, 0.15 pieces of LWD/meter, and an average of 2.4 channel widths between each pool (Appendix Report 3.8). This is a low impact for percent pool, a high impact for LWD and a moderate impact for pool spacing. The low density of LWD has not translated into a low percent pools, since LWD is not the only pool forming factor in low gradient, wetland dominated, channels such as the Tahuya. The combined ratings for channel complexity are rated as moderate, however conditions may decline for the next 50 to 100 years until the existing riparian forest matures and contributes increased LWD to the stream channel.

- *High flow*-Incubation life history stage, rated unknown impact**.** Continuous Tahuya River discharge data exists from 1945-1956 (PSCRBT 1991). The Salmon and Steelhead Stock Inventory (SASSI) (WDF et al. 1993) identified past logging and road building as contributing to increased peak winter flow events. It is impossible to quantify the extent of this problem without new stream gauge data. However, we know from studies of other watersheds that an increase of impervious surfaces translates into higher peak flows. Since winter flows are rain dominated, the numerous wetlands within the watershed moderate peak winter flow. Development adjacent to lakes and wetlands increases the level of impervious surface translating into a reduction in available storage capacity at peak flow.

- *Subestuary habitat loss and degradation* — Juvenile rearing and migration life stage, rated low to moderate impact. Two areas of the delta, totaling >0.01 $km^2$ (~1 ac; 1.4% of historical delta area), appear to have been filled, primarily for residential development. Three areas of roads or causeways have impacted the delta over 0.27 km (0.17 mi) and, in addition to the habitat directly lost in the footprint of the causeways, the effect of this has been to constrict estuarine exchange in the middle of the delta. For example, a bridge at RM 0.0 with a fill causeway, constricts the migration, development, and flushing of estuarine sloughs. The extent of change in tidal flooding circulation and the effect on migrating and rearing salmon is unknown.

## Factors for Recovery

A full discussion of protection options and restoration strategies by habitat factor is found in Part Three - section 3.4.4.2, toolkit.

- *Nearshore habitat loss*- Limit near shore development including, bulkheads, filling of near shore areas, erosion onto beaches, installation of docks, and loss of shoreline vegetation. Prohibit development that impacts or eliminates eelgrass beds, salt marsh and shoreline vegetation.

- *Riparian condition, species composition*-With adequate regulation and protection, the recruitment of LWD to the stream channels within the watershed should be expected to improve over the next 50 to 100 years as riparian forests mature. Only riparian forests of adequate width, age, and species composition will be capable of providing a full range of riparian functions. All forests within the channel migration zone (or 100 year floodplain) plus a riparian buffer of 250 feet should be protected.

- *Water quality, temperature*- Development of fully functional riparian forest will buffer stream temperatures.

- *Channel complexity*-The stream channel should be allowed to migrate naturally within the 100-year floodplain. This requires the elimination of bank hardening, stream channelization or other interruptions of channel and floodplain processes.

- *Peak flow*- Manage all activities within the watershed (logging and road construction, development, clearing, pavement, home construction, road building, placement of fill in and adjacent to lakes and wetlands) to eliminate increases in peak flow (see Peak Flow toolkit, Part Three - section 3.4.4.2). Implement storm water planning for existing and future development, including forest practice road construction. Size all drainage structures within the basin to allow for 100-year or larger storm events.

- *Subestuary habitat restoration* — The long-term refitting of the highway bridge across the subestuary would likely contribute to restoration of more natural tidal circulation and distributary channel structure in the middle of the delta. Education of the problems with dense hardening of the shoreline may be necessary. Shoreline landowners can be offered incentives to retrofit bulkheads and rip-rap with "softer" technologies that are more habitat friendly.

### Strength of Evaluation and Information Needs

Our understanding of the habitat conditions and sources of impact within the Tahuya River are based on instream habitat surveys, assessment of the riparian zone, and on the field knowledge of habitat by fisheries resource biologists. We are moderately confident that the above evaluation depicts the sources of impact and the likely effects on summer chum.

1. Presently the Tahuya River is not gauged. There is no available information for the extent that peak winter flows may be affecting chum survival on the Tahuya River.
2. The present data for stream temperature does not extend late enough into September to determine how long into fall elevated stream temperature effect adult migration and spawning.
3. A gravel scour monitoring program is needed. No information specific to the Tahuya River exists for bed stability and depth of gravel scour. In conjunction with gravel stability and scour, information on the level of fine sediment <0.85mm should be collected. The 1994 (Point No Point 1994) level of 10.5% is at the threshold where negative impacts to egg survival are expected.
4. Public education of the problems with bank hardening (bulkheads, riprap) of shorelines and the floodplain are needed, along with the importance of maintaining these edge habitats in forest.

### References

Amato, C. 1996. Historical changes affecting freshwater habitat of coho salmon in the Hood Canal basin, pre-1850 to the present. Point No Point Treaty Council, Kingston, WA.

PNPTC (Point No Point Treaty Council). 1994, 95, 96, 97. 1994-97 Ambient monitoring data (Unpublished). Point No Point Treaty Council, Kingston, WA.

PSCRBT (Puget Sound Cooperative River Basin Team). 1991. Lower Hood Canal Watershed, Mason and Kitsap Counties report. Skokomish Tribe Dept. Nat. Res., Potlatch, WA.

WDF (Washington Department of Fisheries), Washington Department of Wildlife, and Western Washington Treaty Indian Tribes. 1993. 1992 Washington State Salmon and Steelhead Stock Inventory. Wash. Dept. Fish and Wild., Olympia, WA. 212 p.

# Dewatto Watershed Narrative
# WRIA 15.0420

## Watershed Description

The Dewatto River is located in the southwestern portion of Kitsap Peninsula, approximately 5.5 miles north of the Great Bend of Hood Canal, west of the Tahuya River, and south of Stavis and Big Beef creeks. Originating on the plateau of the Kitsap peninsula, the Dewatto follows a glacial outwash channel as it flows southwesterly and parallel to Hood Canal for approximately 8 miles to saltwater. The headwaters originate in till and outwash sands and gravels. The till is moderately erodible and the outwash is highly erodible. The narrowest portion of the valley is near the river mouth, but the confinement is not extreme. The watershed area is approximately 23 square miles and there are approximately 30 miles of tributary streams.

The Dewatto River gradient is low to moderate throughout its length flowing between gently rolling hills. The Dewatto enters Hood Canal through a mostly undisturbed estuary. Several large wetlands are directly associated with the mainstem, with numerous other tributary wetlands to the mainstem. The moderate terrain and low elevation of the watershed results in a rain dominated system where many small tributaries go dry early in the summer, or during winter dry periods. The numerous wetlands within the watershed are critical in moderating peak winter flow, and augmenting summer low flow. To provide instream flows during the summer low flow period, the Department of Ecology has closed the Dewatto River to additional consumptive appropriations during the time period June 15 to October 15, per WAC 173-515-040(2).

Historically, the prevailing land use in this sparsely developed watershed has been timber harvest, with a large portion of the watershed still managed for timber. Several Christmas tree farms are the only agricultural developments. Rural residences are scattered throughout the drainage. The riparian zone is 87% forested, the highest percentage of all 20 watersheds (Appendix Report 3.7). Rural homes account for 4% and agriculture 2% of riparian landuse

## Summer Chum Distribution

The majority of summer chum spawn in the lower 2 miles of the Dewatto River. Stream flow and gradient characteristics would allow access to summer chum to approximately river mile (RM) 4.0.

## Population Status

The summer chum population in the Dewatto River has been detected only in very low numbers since 1988, and is assumed to no longer be a self-sustaining population. A severe decline in the number of spawners has been recorded since the 1970s. In the 1970s escapement ranged between the hundreds and thousands, in the 1980s it was generally well below 100, and in the 1990s was zero or very few fish (Appendix Table 1.1).

## Factors for Decline

Overall habitat quality in the Dewatto River was rated fairly high and in a state of recovery from historic logging practices, especially in comparison with adjoining watersheds. The estuary is an example of a high quality system that provides abundant transitional areas for adults and rearing habitat for juveniles. The lower river channel, where historically most of the summer chum spawned, remains today relatively undeveloped. Two factors of concern within the lower river are the elevated levels of fine sediment, and stream temperatures. Between 1915 and 1930 all the old growth timber in the Dewatto River watershed was harvested. Logging and road building has had direct and indirect impacts on the stream channel by decreasing volumes of in-channel large woody debris (LWD), and species diversity within the riparian forest. In the 1960s, the Washington Department of Fisheries Stream Improvement Division removed what was considered at that time as blockages to upstream salmon migration (Amato 1996). In the lower Dewatto River the summer chum habitat is degraded due to (in order of importance): elevated stream temperature, fine sediment within the spawning gravel, reduced channel complexity, loss of LWD, and the loss of species diversity within the riparian forest. For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18.

- *Water quality, temperature*-Adult spawning life history stage, rated high impact. Elevated water temperatures into late September can negatively affect summer chum by preventing the entry of adults into the river exposing them to predation. Water temperatures at or above 12 degrees Celsius extend through the first half of September for several years (PNPTC 1994, 1995, 1996, 1997). Reductions in the size of trees within the riparian forest will increase stream temperatures through a loss of shade and transpiration

- *Fine sediment* -Spawning and incubation life history stages, rated moderate impact. Spawning gravel composition sampling below RM 4.0 shows the percent of fines <0.85mm to be above the level where there are impacts to survival of incubating eggs. Levels were 15.1% in 1994 and 20.5% in 1995 (PNPTC 1995). Logging and road building may be the major factors contributing to elevated levels of fine sediment, however in-channel wetlands may also contribute. Elevated levels of fine sediment result in a loss of inter gravel flow and entombment of alevins and fry.

- *Channel complexity, large woody debris*-Spawning and incubation life history stages, rated low to moderate impact. From RM 3.0-3.5, there are 37% pools (high impact), 4.1 pool frequency (high impact) and 0.28 pcs/m of LWD (moderate impact). The survey is limited, and sandwiched between two large in-channel wetlands, which would increase percent pools and pool frequency. In the late 1960s, the Washington Department of Fisheries Stream Improvement Division removed logjams, debris, beaver dams and the channelized several miles of the Dewatto River. This effort degraded channel complexity and stability (Amato 1996).

- *Riparian condition, species composition*-Spawning and incubation life history stages, rated low to moderate impact By 1930 most of the old growth in the watershed had been harvested (Amato 1996). Historical riparian forests were dominated by a mixture of old growth cedar, western hemlock, Douglas-fir and areas of younger red alder, which now contain mixed stands of deciduous and coniferous species.

Stumps remaining in the riparian forest adjacent to the stream channel network show that in most areas all the large conifer trees available for recruitment into the stream channel were removed with timber harvest. Presently 32% of the riparian forest is less than 12 inches diameter breast height (<12 in dbh) and 68% is 12 to 20 inches dbh. Species composition of riparian forest is 96% mixed conifer and deciduous. Sixty nine percent of the riparian zone is greater than 132 feet in width, 16% 66 to 132 feet in width, and 15% less than 66 feet in width and/or sparsely vegetated. The riparian forest is in a state of recovery, and will continue to recover if not harvested in the future. Levels of LWD may decline for the next 25-50 years until the existing riparian forest matures and contributes increased LWD to the stream channel.

## Factors for Recovery

A full discussion of protection options and restoration strategies by habitat factor is found in Part Three - section 3.4.4.2, toolkit.

- *Sediment fines*-Upgrade roads to route drainage away from stream channels. Re-vegetate or stabilize road sidecast, re-vegetate or armor ditch lines, and harden road surfaces to reduce the creation of fine sediment. Upgrade all stream crossing to pass 100 year events. Decommission roads, remove culverts, de-compact roads, outslope and waterbar road surfaces, and remove unstable fill and sidecast.

- *Channel complexity*-The stream channel should be allowed to function naturally within the 100-year floodplain. Natural function of the stream channel requires the elimination of bank hardening, stream channelization or other interruptions of channel and floodplain processes.

- *Riparian condition, species composition*-With adequate regulation and protection, the recruitment of LWD to the stream channels within the watershed should be expected to start to improve over the next 25-50 years as the present riparian forests mature . Only riparian forests of adequate width, age, and species composition will be capable of providing a full range of riparian functions. Stream segments with poor riparian condition and the inability of the channel to transport LWD of the size required from upstream areas, will require the riparian forest to be improved. The extent of the riparian forest must include the channel migration zone of the river to be capable of providing a full range of riparian functions.

- *Water quality, temperature* - As the riparian forests matures, stream temperatures will moderate.

- *Subestuary protection* – The subestuary is one of the remaining relatively undisturbed systems in Hood Canal and should be specifically sought for dedicated preservation or regulatory protection.

## Strength of Evaluation and Information Needs

Our understanding of the habitat conditions and sources of impact within the Dewatto River are based on instream habitat surveys (channel, temperature, and fine sediment), analysis of riparian condition, and the field knowledge of habitat by fisheries resource biologists. We are moderately confident that the above evaluation depicts the sources of impact and the likely effects on summer chum.

1. Presently the Dewatto River is not gauged. There is no available information on the relative magnitude and duration of peak flows.
2. The stream temperature data does not extend late enough into September to determine how long elevated stream temperature impacts adult migration.
3. A gravel scour monitoring program is needed. No information specific to the Dewatto River exists for bed stability and depth of gravel scour. In conjunction with gravel stability and scour, information on the level of fine sediment <0.85mm should be collected. Previous monitoring has shown fine sediment to be above levels considered safe for incubating eggs. This factor should be closely monitored.

## References

Amato, C. 1996. Historical changes affecting freshwater habitat of coho salmon in the Hood Canal basin, pre-1850 to the present. Point No Point Treaty Council, Kingston, WA.

PNPTC (Point No Point Treaty Council). 1993, 94, 95, 96, 97. 1993-97 Ambient monitoring data (Unpublished). Point No Point Treaty Council, Kingston, WA.

# Big Anderson Watershed Narrative
## WRIA 15.0412

### Watershed Description

Big Anderson Creek is located in southwestern Kitsap County. The stream enters Hood Canal approximately one-half mile north of the small community of Holly. The Big Anderson Creek watershed is approximately 5 square miles in area, with 4 miles of mainstem and 13 miles of tributaries (verified stream types 1-4). Similar to other streams in the West Kitsap WAU, Big Anderson Creek originates in headwater wetlands and flows through a confined ravine before opening into a broad floodplain in the lower one-half mile. The small estuary includes a large intertidal delta.

Land-use in the watershed is primarily industrial forestry operations conducted by several large landowners and the Department of Natural Resources. Logging in the Big Anderson most likely began in 1920s, with the establishment of Camp Union logging camp. Between the 1920s and 1944, the headwaters were entirely denuded with erosion observed in steep tributaries; and most of the remaining basin logged (MacLeod 1995). As the habitat recovered in the following decades, logging was again observed in 1984 aerial photos and continues to the present. Three private residences and a small farm are located in the lower mile of stream. A road bisects the floodplain near the mouth, and another road is adjacent to the river, and within the 100-year floodplain, from RM 0.5 to the mouth. Forty-five percent of the riparian zone is occupied by landuse, with 36% as roads and 9% agriculture (Appendix Report 3.8).

### Summer Chum Distribution

Summer chum were recorded to spawn between river mile 0.0 and 1.1. Potential habitat is estimated to extend to at least river mile 1.8, which includes the lowest gradient reaches of the system.

### Population Status

No summer chum salmon have been observed in standard surveys conducted by Washington Department of Fish and Wildlife since 1982 (one was observed in 1984). The population is assumed to be extinct. WDFW escapement estimates show the population ranging up to 234 in 1976 (Appendix Table 1.1).

### Factors for Decline

Spawning and incubation habitat is moderately to highly degraded in the lower river from past logging and associated road building throughout the watershed. The habitat factors for decline, in order of priority, are: 1) increased sediment deposition in the lower mile from roads and landslides in the upper watershed, 2) increased magnitude and frequency of peak flows from road runoff, 3) loss of large woody debris (LWD) due to past logging of riparian zones and channel clearing activities, and 4) a county road built across the estuary and mouth of the stream that constrains the floodplain and may reduce sediment removal by tidal action. For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18.

- *Sediment* - spawning and incubation life stage, rated high impact. Summer chum habitat is highly aggraded from logging roads, bank erosion and landslides. Effects are redd burial and suffocation, and channel instability. The spawning gravel includes a high percentage of fine sediment that can reduce survival during the incubation stage. Some of the high levels of fine sediment are attributed to extensive beaver pond construction in the lower half mile.

- *Riparian condition* - spawning and incubation life stage, rated high impact. Seventy seven percent of the riparian zone is deciduous dominated and 44% of it contains small diameter trees. Fifty nine percent of the riparian zone contains forested buffers <66 ft in width (Appendix Report 3.7). Future LWD recruitment potential is limited due to narrow forested buffers with low levels of conifer.

- *Channel complexity* - spawning and incubation life stage, rated moderate impact. Below RM 1.8, the channel contains 0.3 LWD pieces/m (moderate impact), 51% of the habitat area is in pools (moderate impact), and a pool frequency of 1.7 per channel width (low impact-Tabor 1994) (Appendix Report 3.8). Beaver activity has increased the percentage of pools. Eighty seven percent of LWD pieces are smaller than 20 in. diameter (Appendix Report 3.7). Minimum "key piece" diameter for LWD is 22 in for a channel of this size (Washington Forest Practices Board 1995). Compared to historical levels, the channel is degraded, but is in comparatively better condition than many other watersheds we examined. However, the channel is also unstable and braided, with high sediment loading and peak flow problems. It is expected that channel condition will deteriorate for at least the next several decades due to the poor riparian condition and mass wasting in the upper watershed.

- *Peak flow* - incubation life stage, rated moderate impact. Increased frequency, magnitude and duration of peak winter flows caused by extensive road building is thought to contribute to the bank erosion, channel aggradation and channel instability observed in the lower reaches of the stream. High flows coupled with an unstable channel will increase the depth of scour and redd mortality.

- *Sub-estuary habitat loss and degradation* — Juvenile rearing and migration life stage, rated moderate impact. One road crosses the delta, and another road follows the northern subestuary margin, totaling 0.24 km (0.15 mi) in length. The roads were identified as one of two primary factors for degradation of the sub-estuary, however the amount of change in tidal flooding circulation due to the roads is unknown. The second factor is old railroad fill, which is downstream of the two roads described above and located directly within the subestuary. While all of the estimated historic delta area of approximately 0.12 km$^2$ (28.9 ac; 1.78 km [1.1 mi] perimeter) appears to be inundated by tidal flow, the old roadbed in the subestuary constricts tidal circulation to the main channel. An oyster farm covers about 0.01 km$^2$ (0.8 ac; 2.74% of original delta area) in the outer edge of the delta. This feature does not appear to impact summer chum rearing or migration. Dredging, excavation, docks, and log storage are not evident in the subestuary.

## Factors for Recovery

The following recommendations are provided to allow recovery of Summer Chum habitat in the lower river. A full discussion of protection options and restoration strategies is found in Part Three - section 3.4.4.2, toolkit.

- *Riparian forests/channel complexity* – Protect and restore the riparian floodplain forests along the entire 1.8 river miles of documented summer chum habitat. Below RM 1.0, plant conifers throughout the floodplain. Recruitable LWD of sufficient diameter will be available from newly planted seedlings in 50 to 100 years. In the interim, the amount and size of LWD will decline. Increase riparian buffer protection throughout the watershed. The WDNR (1995) prescriptions may not provide for adequate long-term recruitment of LWD to the stream system.

- *Floodplain*- Relocate roads outside of the floodplain, or replace road fill with causeways that allow channel movement and passage of floodwater (includes two roads described in the sub-estuary section plus another road located on the south side of the floodplain). Modification (e.g., setback, rerouting) of roadways would enhance summer chum migration, spawning, and incubation habitat. The floodplain is mostly owned by one timber company. The Hood Canal Salmon Sanctuary continues to work with the landowner on obtaining riparian easements or purchase of this property.

- *Sedimentation*-Prevent logging on potentially unstable slopes, and remove or repair roads with surface erosion or landslide hazard problems. The WDNR (1995) prescriptions provide some protection from unstable slopes problems, but this level of protection may need to be re-evaluated.

- *Peak flow*-Decommission roads, increase the number of water bars and cross drains on forest roads, identify and re-direct road ditches that contribute rainwater directly to stream channels, and limit new road construction in the watershed.

- *Sub-estuary*-Remove the abandoned railroad fill to improve tidal circulation. This will enhance summer chum rearing and migration habitat.

## Strength of Evaluation and Information Needs

The Department of Natural Resources sponsored the WDNR (1995) that provides an in-depth assessment of habitat conditions in Big Anderson Creek and other streams. This coupled with the riparian and landuse assessment provides sufficient data to assess the factors for decline. However, the relative importance of LWD, sediment, or peak flows in causing channel degradation is not well understood. Further research in these areas is needed. Confidence in the assessment is high.

1. Gauge the stream. It is impossible to monitor the effects of peak flow on incubating eggs without gauge information.
2. Scour chain surveys to monitor bed instability throughout the summer chum reach.

3. McNeil sediment surveys to determine the level of fine sediments throughout the summer chum reach.

## References

Amato, C. 1996. Historical changes affecting freshwater habitat of coho salmon in the Hood Canal basin, pre-1850 to the present. Point No Point Treaty Council, Kingston, WA.

MacLeod, A. 1995. Land use history: West Kitsap County watershed, from 1850. Point No Point Treaty Council, Kingston, WA.

Tabor, R. 1994. Ambient monitoring data. Unpublished. USFWS Lacey Field Office, U.S. Dept. of the Inter., Lacey, WA.

Washington Forest Practices Board. 1995. Standard methodology for conducting watershed analysis (Version 3). Wash. Forest Pract. Bd., Olympia, WA.

WDNR (Washington Department of Natural Resources). 1995. West Kitsap Watershed Analysis. Wash. Dept. Nat. Res., South Puget Sound region office, Enumclaw, WA.

# Stavis Watershed Narrative
## WRIA 15.0404

### Watershed Description

The Stavis Creek watershed is located in the northeastern portion of the Hood Canal on the Kitsap Peninsula, 3 miles southwest of the town of Seabeck. The watershed area is about 7 square miles, with 5 miles of mainstem, and 11 miles of tributary habitat.

The Stavis Creek watershed is typical of stream systems on the Kitsap Peninsula (see description under Seabeck Creek). Stavis Creek originates in a series of beaver ponds, forested and emergent wetlands located on a flat glacial till plain. Several watershed reports have listed Morgan Marsh as the headwaters of Stavis, Big Beef, and Tahuya River. Field investigations have shown Stavis Creek is not directly connected with Morgan Marsh although groundwater interchange is likely. The mainstem then flows in a northeasterly direction in steep, tightly confined ravines for approximately 3.5 miles. Below the junction with tributary 15-0405 the channel gradient moderates and is unconfined, eventually emerging into a relatively broad floodplain, high quality estuary and Stavis Bay. The estuary and delta are not impacted to any substantial degree, and represents one of the better undisturbed examples of estuarine lagoon and spit features in Hood Canal.

The majority of base flow to area streams is provided through hydrologic continuity with a shallow perched aquifer with a smaller contribution via indirect hydrologic continuity with a deeper aquifer known as the Seabeck Aquifer (Becker, 1998). The Seabeck Aquifer contributes baseflow near the mouth of several streams including Little Anderson, Seabeck, and Big Beef creeks. The western boundary of the Seabeck Aquifer is indistinct, but given similarities in landform and geology, is assumed to include Stavis Creek. Stream flow data specific to Stavis Creek is not consistently available, although instaneous readings include minimum flows of 1 cfs (May et al. 1995).

Historically, land use in this area was dominated by timber extraction activities with two major cycles of timber harvest (see history under Seabeck Creek). The area of Stavis Creek headwaters, similar to Seabeck Creek, was connected to a network of timber railroads by 1927, but appeared to be spared the heavy logging seen in other watersheds. Aerial photographs in 1944 show large areas of large trees, and intact marshland in the lower basin (MacLeod, 1995).

Current land use in the watershed is a mixture of rural residential scattered along the shorelines, lower half mile of the stream and upper basin. Forestry is a major land use, with Department of Natural Resources managing a large block of land for timber production, the Kitsap Forest Natural Area Preserve, and limited private forest lands. Conservation easements to protect the primary summer chum range are currently being negotiated by the Washington Department of Fish and Wildlife through the Hood Canal Salmon Sanctuary. The watershed has undergone less development that adjoining Seabeck Creek, but has been actively managed for timber production in the last 30 years. Shoreline development and associated impacts (bankhardening, bulkhead construction, and loss of shoreline vegetation) is focused primarily on the shoreline to the east of Stavis Creek, but at lower concentration than the shoreline near Seabeck.

### Summer Chum Distribution

Stavis Creek is included in this plan based on the potential for historical summer chum utilization given available suitable habitat, stable late summer flows, and similarities to nearby Big Beef Creek that is known to support summer chum. Based on habitat features, distribution is assumed to have occurred from RM 0.0 to RM 0.6.

### Population Status

Summer chum salmon have not consistently been surveyed or reported in spawning surveys conducted by WDFW or the Tribes. The tribes reported 6 live and 3 dead summer chum in three September surveys conducted in 1983, and one summer chum was found in a 1981 survey. A survey by a University of Washington scientist found no chum in one survey in 1968, and 75 chum in an October survey in 1972.

### Factors for Decline

Overall, habitat quality within Stavis Creek was rated fairly high and in a state of recovery from historic logging practices, especially in comparison with adjoining watersheds in the Hood Canal sub-region. This can be attributed to the relatively low density of residences, roads and other intrusive landuses. The total impervious surface area for the basin is 1.5%, with the majority of those surface not connected to the stream network (May et al 1997). The estuary is an example of a high quality system that provides abundant transitional areas for adults and rearing habitat for juveniles. The lower 0.6 miles provides high quality spawning and rearing habitats, with only minor impacts from several residences and one bridge crossing of the stream near the mouth of the creek. No fish passage problems were noted. For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18.

Habitat factors rated as contributing to the decline of summer chum (in order of importance) include:

- *Sediment (aggradation and degradation)*-Spawning and incubation life stages, rated moderate impact. Limited scour chain monitoring in the lower reaches indicate areas of moderate scour and fill associated with peak winter flows with potential impacts to egg incubation (May et al, 1997). Sources include logging that has contributed to mass wasting events and historic removal of LWD.

- *Riparian forest (species composition)*-Spawning and incubation life stage, rated moderate impact. Riparian zones which were historically dominated by a mixture of old growth cedar, douglas fir, and areas of younger alder are now more dominated by mixed stands of deciduous and coniferous species (58%) and deciduous dominated (42%), generally 50 to 70 years old (WDNR, 1995, Appendix Report 3.7). While these stands are on a trajectory of recovery, it will take approximately 50 to 100 years more to achieve old growth conditions that provided the most stable and complex habitat. Riparian forest composition has an impact on the quality of wood recruited to the channel, which in turn effects the stability of the channel during the egg incubation stage. Eighty-three percent of the total riparian area evaluated in Stavis Creek is forested, indicating a fairly sizable and intact riparian forest within the presumed distribution of summer chum.

- *Flow (winter peak flow)*-Incubation life stage, rated potential but unknown impact. Historic and current logging practices and associated roads are responsible for altering hydrologic patterns and increasing the rate of mass wasting events, although the relative magnitude of changes in the hydrologic regime is unknown.

### Factors for Recovery

Protect existing high quality habitat
- Continue and expand the acquisitions efforts underway by the Hood Canal Salmon Sanctuary. Priority areas should include estuary, adjoining shoreline areas, lower mainstem and floodplain, and upstream wetland hydrologic source areas. The estuary and associated bordering uplands should be explicitly protected or regulated to prevent any further development.

Protect and restore riparian forest quality
- For properties acquired in lower watershed that are lacking riparian forest, reforest riparian areas with appropriate native species and abandon any associated roads.
- Provide upstream recruitment sources by reforesting narrow riparian zones on upstream DNR lands.
- Consider limited silvilcultural treatments on alder dominated zones to encourage conifer regeneration within summer chum range on WDFW properties.
- Work with Kitsap County to establish appropriate riparian zone widths for upstream areas to provide long term LWD recruitment sources.
- Evaluate the effectiveness of West Kitsap Watershed Analysis prescriptions for logging operations to reduce mass wasting events and modify prescriptions if necessary.

Establish hydrologic maturity targets for basin
- Establish rate of harvest targets for forestry activities to ensure hydrologic maturity.
- Work with Kitsap County to maintain low densities within basin.
- Develop mitigation standards for development activities that create impervious surface greater than 10% of lot size.

Monitoring/reference site
- Utilize the Stavis Creek estuary as a critical habitat template for eastern Hood Canal, establish long-term monitoring programs to track estuarine quality including macroinvertebrate populations, water quality, channel structure and complexity.

### Strength of Evaluation and Information Needs

Confidence for fish distribution is rated low based on the extremely limited spawning data for Stavis Creek. Considerably more data is available on habitat conditions, including temperature, limited instream flow, scour chain, TFW ambient monitoring and an assessment of channel, riparian, and instream habitat conditions conducted through the West Kitsap Watershed Analysis. Confidence for habitat data is rated as high. Overall confidence for the assessment is moderate.

Additional information needed to better quantify the relationship between current conditions and summer chum distribution includes:

1. Instream flow monitoring of both summer flow periods and peak winter flows;
2. Channel assessments to determine the relationship between peak flows and channel forming events.

## References

Becker, J. 1998. Aquifer modeling and mitigation options for the Seabeck aquifer system. Pub. Util. Dist. 1, Kitsap County, Bremerton, WA.

MacLeod, A. 1995. Land use history: West Kitsap County watershed, from 1850. Point No Point Treaty Council, Kingston, WA.

May, C.W., E.B. Welch, R.R. Horner, J.R. Karr, and B.W. Mar. 1997. Quality indices for urbanization effects in Puget Sound lowland streams. WDOE water resources tech. rep. 154. Wash. Dept. Ecol., Olympia, WA.

WDNR (Washington Department of Natural Resources). 1995. West Kitsap Watershed Analysis. Wash. Dept. Nat. Res., South Puget Sound region office, Enumclaw, WA.

# Seabeck Watershed Narrative
# WRIA 15.0400

## Watershed Description

The Seabeck Creek watershed is located in the northeastern portion of the Hood Canal on the Kitsap Peninsula near the town of Seabeck. The watershed area is about 6 square miles, with 5 miles of mainstem, and 16 miles of tributary habitat.

The Seabeck Creek watershed is typical of streams on the Kitsap Peninsula. These systems are rain-dominated watersheds with low elevation flat and rolling terrain dissected by deeply incised stream ravines, small to moderate sized estuaries, and extensive nearshore habitat. The geology of the area is dominated by glacial materials, which are prone to erosion and moderate to high sediment production rates within the confined stream ravine reaches.

The majority of base flow to area streams is provided through hydrologic continuity with a shallow perched aquifer with a smaller contribution via indirect hydrologic continuity with a deeper aquifer known as the Seabeck Aquifer (Becker 1998). The Seabeck Aquifer contributes baseflow near the mouth of several streams including Little Anderson, Seabeck, and Big Beef creeks. The western boundary of the Seabeck Aquifer is indistinct, but given similarities in landform and geology, is assumed to include Seabeck Creek. The stream is currently closed to further surface water appropriations.

Seabeck Creek originates in headwater wetlands located on a flat glacial till plain. The mainstem then flows in a northerly direction in steep tightly confined ravines for approximately two miles. Below the junction with tributary 15-0401 the channel gradient moderates and is unconfined, eventually emerging into a relatively broad floodplain, small estuary and Seabeck Bay. A small tributary to the east of the mainstem also feeds into the estuary. The estuary has a comparatively narrow delta that is heavily encroached upon by residential development on the east side.

Historically, land use in this area was dominated by timber extraction activities. Seabeck was the site of a major timber mill that began operations in 1857 and continued until the mill burned in 1886. The Seabeck mill concentrated on harvesting old growth timber along easily assessable waterways such as shorelines and streams. Another major period of timber extraction continued from 1920 to 1936 with the establishment of Camp Union in the upper Big Beef watershed. At the peak of operations, over 1.5 million board feet of timber per day was cut in the watersheds surrounding Camp Union, and railroad spurs were constructed in the valley bottom of Seabeck Creek to facilitate transport of timber. By 1944, most of the Seabeck Creek watershed (except for the headwaters near Hite Center) had been completely harvested (MacLeod 1995)

Current land use in the watershed is a mixture of rural residential, forest lands, small scale hobby farms, limited aquaculture, the nearby town of Seabeck, and a marina. The watershed has undergone a dramatic increase in rural development over the last ten years as evidenced by increases in application for land use and hydraulic permits. In particular, applications to convert forest land to rural development have accelerated since the late 1970s. Shoreline development and associated impacts (bank hardening, bulkhead construction, and loss of shoreline vegetation) is especially heavy on the shoreline to the east of Seabeck Creek.

### Summer Chum Distribution

Summer chum salmon have not been reported in spawning surveys conducted by WDFW or the Tribes. Surveys conducted in late September and October for 1981 and 1983 found no summer chum in the watershed. Seabeck Creek is included in this plan based on the historical potential for summer chum utilization given available suitable habitat, stable late summer flows, and proximity to adjacent watersheds (Big Beef Creek) which have supported summer chum. Based on the presence of suitable habitat, we expect summer chum could have occurred up to RM 0.9 on the mainstem, RM 0.5 on Tributary 15-0401, and to RM 0.3 on an unnamed tributary flowing from the east to the mainstem.

### Population Status

Limited survey data for summer chum indicate that a summer chum population does not exist at this time. However, habitat and flow conditions appear conducive to summer chum and it is possible that prior to spawning surveys summer chum did historically occupy the watershed.

### Factors for Decline

Impacts to habitat quality include: 1) Coarse sediment aggradation and high levels of fine sediment in spawning gravel; 2) loss of channel complexity; 3) altered hydrologic patterns; 4) degraded riparian conditions and 5) floodplain connectivity. Sources of impacts are historic and current logging and rural development patterns in the Seabeck Creek watershed. For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18. More details are provided below:

- *Sediment (aggradation, degradation, and fine sediments)*-Spawning, incubation, migration life stages, rated high and moderate impact. The lower two miles of Seabeck Creek show evidence of increased sediment bedload, to the extent that the some sections of the stream go subsurface in early summer in many years (WDNR 1995). Sediment aggradation has also caused a decrease in channel complexity with the end result of increased flooding frequency with relatively minor precipitation events. While the glacial geology of the area is prone to high sediment production rates, the effects of historic logging practices coupled with minimal protection of riparian areas in rural development and current logging has accelerated the rate and magnitude of slope failures and overwhelmed the capacity of stream channels to process these sediments. Areas of localized scour were also noted during the West Kitsap Watershed Analysis, especially in the reach just above the lower bridge crossing on Stavis Creek Road. The end result of channel aggradation and instability on summer chum includes: 1) upstream passage of adults is hindered due to insufficient stream flow and lack of deep holding pools; 2) reduction in egg survival due to scour of egg pockets during increased winter peak flows; 3) downstream migrating juveniles are subjected to increased predation due to loss of stream depth and cover.

TFW Ambient Monitoring data (1989) indicates high rates of embeddedness in spawning gravels related to increased levels of fine sediment. Increased fines are primarily linked to surface water runoff from roads in the watershed, many of which are private and have minimal maintenance and inadequate surfacing. Fine sediment is also linked to improper logging, and runoff from impervious surfaces associated with rural development. Inadequate treatment of runoff from recent rural development such as Seabeck Heights, especially when construction occurs during wet weather conditions, have contributed significant amounts of fine sediment episodically to the channel. Seabeck is located within a rapidly growing rural area, with a total effective impervious rate of 2.7% (May et al 1997) which is expected to increase over time. Diminished chum populations in the watersheds of the eastern Hood Canal may also impact gravel quality. The effectiveness of chum salmon in cleaning gravels associated with redd building activities has been noted by several researchers (Montgomery et al. 1996; Peterson and Quinn 1994b).

- *Channel complexity (LWD, channel condition, loss of side channel habitat, and channel instability)*-Spawning, incubation, and migration life history stages, moderate and high impact. The amount of LWD in Seabeck Creek has been diminished from historic levels through actions such as stream cleanout, logging without leaving streamside buffers, and rural development. Channel complexity is closely linked with large woody debris as log jams form hard points, deflecting flow and causing the formation of side channel habitat, a limited habitat type within the Seabeck Creek watershed. Reduced channel capacity has also altered the hydrologic regime of the channel, causing lower summer flows and increased winter peak flows.

- *Flow (winter peak and summer low flows)*-Spawning and incubation life stages, rated moderate impact. Related to increased sediment load and modifications in channel capacity, winter peak flows have increased and summer flows frequently are substantially diminished within the upper portion of the historic summer chum range, although the relative magnitude of the problem is unknown due to a lack of stream flow data specific to Seabeck Creek. The end result has been displacement of incubating eggs and suboptimal conditions for spawning adults.

- *Floodplain connectivity*-Rearing and migration life history stages, rated high impact. Rural development, channel alteration, and altered flow patterns due to the bridge crossing have affected the quality of the Seabeck floodplain. Illegal clearing of streamside areas and attempts to fix the channel in place are common problems within the lower 0.5 miles of the stream.

- *Riparian condition (species composition, age, and width)* - Spawning and incubation life stage, rated moderate to high impact. Riparian zones which were historically dominated by a mixture of old growth cedar, douglas fir, and areas of younger alder are now more dominated by mixed stands of small- (<12 inch dbh) to medium-sized (12-20 inch dbh) trees within the distribution of summer chum. Mixed deciduous and coniferous stands comprise (59%) and deciduous dominated stands (41%) of the riparian forest. Below RM 0.9, the riparian forest is significantly impaired, 100% of the area having a sparse buffer less than 66 feet, due to residential development, roads and dikes (Appendix Report 3.7). The generally degraded condition of riparian forest suggests that critical functions such as LWD recruitment, will remain limited for the foreseeable future, unless active restoration steps are taken.

- *Estuarine habitat loss and degradation* — Juvenile rearing and migration life stage, rated moderate to high impact. Fills for recreational, and some commercial use including shoreline-dependent marina activities, include two areas totaling 0.01 km$^2$ (3.6 ac; ~8.9% of historical delta area). The residential development appears to have extracted a significant portion of the mid- to lower delta summer chum rearing area. Associated bulkheads and armoring have also impacted shoreline migration. Although the Seabeck marina is located on the outer margins of the delta, the associated docks do not appear to directly impact the delta because of their position over deeper water, receiving a low impact rating.

## Factors for Recovery

A discussion of protection options and restoration strategies in terms of these habitat factors is found in Part Three - section 3.4.4.2, toolkit.

Control coarse and fine sediment sources
- Evaluate the effectiveness of existing slope stability standards (West Kitsap Watershed Analysis, Kitsap County Critical Areas Ordinance) and modify if necessary.
- Improve road maintenance and surfacing on existing private roads, paying particular attention to the routing of stormwater runoff onto vegetative surfaces prior to entering the stream system.
- Enact timing restrictions for clearing and grading activities in areas adjacent to Seabeck Creek.

Restore channel complexity
- Evaluate the feasibility of restoring large woody debris jams in the lower river.

Protect low flow conditions and prevent increases in peak discharge
- Prohibit additional withdrawals of surface water or ground water in hydraulic continuity with Seabeck Creek until an instream flow has been established.
- Establish impervious surface target rates for basin and condition landuse permit consistent with this standard.
- Retrofit existing developments to control stormwater runoff.
- Maintain 60% of the watershed in forest cover through low densities and site design to maximize retention of native plant cover.

Protect and restore riparian forests
- Acquire remaining high quality riparian forest habitat and replant riparian buffers using native species.
- Review and adjust the Kitsap Critical Area Ordinance standards consistent with the recommendations given for functional riparian buffers.

Protect remaining estuarine features
- Given the extent of development already imposed on the delta, further modifications to the estuary should be prevented by land acquisition or regulation.

## Strength of Evaluation and Information Needs

Confidence for fish distribution is rated low, and based upon professional judgement of where summer chum would likely spawn. A considerable amount of data is available on habitat conditions, including temperature data, limited instream flow, and an assessment of channel, riparian, and instream habitat conditions conducted through the West Kitsap Watershed Analysis and confidence is rated as moderate.

Information needs for Seabeck Creek include continuous monitoring of instream flows, sediment source surveys, and an assessment of channel capacity.

## References

Becker, J. 1998. Aquifer modeling and mitigation options for the Seabeck aquifer system. Pub. Util. Dist. 1, Kitsap County, Bremerton, WA.

MacLeod, A. 1995. Land use history: West Kitsap County watershed, from 1850. Point No Point Treaty Council, Kingston, WA.

May, C.W., E.B. Welch, R.R. Horner, J.R. Karr, and B.W. Mar. 1997. Quality indices for urbanization effects in Puget Sound lowland streams. WDOE water resources tech. rep. 154. Wash. Dept. Ecol., Olympia, WA.

Montgomery, D.R., J.M. Buffington, N.P. Peterson, D. Schuett-Hames, and T.P. Quinn. 1996. Stream-bed scour, egg burial depths, and the influence of salmonid spawning on bed surface mobility and embryo survival. Can. J. Fish. Aquat. Sci. 53:1061-1070.

Peterson, N.P., and T.P. Quinn. 1994. Persistence of egg pocket architecture in chum salmon redds. Pp. 9-25 in Quinn, T.P., and N.P. Peterson (eds.) The effects of forest practices on fish populations. WDNR report no. TFW-F4-94-001. Forest Pract. Div., Wash. Dept. Nat. Res., Olympia, WA.

WDNR (Washington Department of Natural Resources). 1995. West Kitsap Watershed Analysis. Wash. Dept. Nat. Res., South Puget Sound region office, Enumclaw, WA.

# Big Beef Watershed Narrative
# WRIA 15.0389

## Watershed Description

Big Beef Creek is located in the northeast portion of Hood Canal on the Kitsap Peninsula, 2 miles northeast of the town of Seabeck. The watershed area is about 14 square miles, with 11 miles of mainstem, and 24 miles of tributary habitat (source: SSHIAP database, PNPTC 1988).

The geomorphology of Big Beef Creek watershed is typical of stream systems on the Kitsap Peninsula where glacial action deposited loose, unsorted coarse gravel and sand (see more detailed description under Seabeck Creek). Big Beef Creek has the largest drainage area and most extensive stream network for watersheds supporting summer chum in northeastern Hood Canal. Upper Big Beef Creek consists of low gradient reaches originating from a series of wetlands, including Morgan Marsh on tributary 15.0398. An artificial lake (Lake Symington) at RM 5.3 was constructed in the 1964 to accommodate lakeshore residential development. Lower Big Beef Creek (RM 2.0 to 5.3) is contained within a steep, moderately confined ravine. The valley walls widen below RM 2.0 and channel gradient moderates to less than 1%. In this area the river includes a fairly well developed floodplain and complex side channel habitat. The Big Beef estuary is 47.7 acres in a semi-enclosed lagoon.

The majority of base flow in Big Beef Creek is provided through hydrologic continuity with a shallow perched aquifer with indirect hydrologic continuity from a deeper aquifer known as the Seabeck Aquifer (Becker 1998). The Seabeck Aquifer contributes baseflow predominantly at the mouth of Big Beef Creek. Minimum streamflow averages 3.1 cfs and maximum flows average around 200 cfs, with a maximum discharge of 1,500 cfs recorded in 1967 (Lestelle et al. 1992, Cederholm 1972).

In the past, the prevailing land use in the upper watershed has been timber harvest; some lands are still managed for harvest of timber resources including several large blocks of land managed by the Department of Natural Resources. Historic logging activities began in earnest with the establishment of Camp Union in 1920, with the entire watershed above RM 5.0 to the headwaters logged by 1950 (Amato 1996). Agricultural developments exist at several locations along the upper stream reaches. Since 1970, residential development has proliferated, especially concentrated around and just downstream of Lake Symington. Lake Symington has had a primary impact on the lower system; lake levels and downstream flows were for many years managed to meet the needs of the lakeshore residents, with little regard for effects on downstream flows. WDFW has recently incorporated provisions in the lake's rules of operation to protect downstream flow requirements of fisheries resources. Below Lake Symington, there is limited residential development along the stream with the majority occurring on the flat till plain above the river. The University of Washington's 320-acre fisheries research facility is located between RM 0.0 to 0.8. Washington Department of Fish and Wildlife operates a weir at RM 0.1 to count upstream and downstream coho salmon migrants. The Hood Canal Salmon Sanctuary program has actively been purchasing key riparian habitat upstream of the U.W. research facility.

## Summer Chum Distribution

Before the disappearance of summer chum from Big Beef Creek, the majority of the spawning population is believed to have occurred in the lower reaches of Big Beef Creek up to RM 2.0. However, summer chum may have historically occurred as far upstream as RM 6.0 (inlet of Lake Symington) or perhaps even further upstream. A significant portion of summer chum spawning may have also occurred intertidally in the protected subestuary.

## Population Status

Escapement estimates for 1975 and 1976 exceed 1,000 spawners, although most surrounding years are in the low hundreds. No summer chum have been reported since 1982, with the exception of 22 in 1984. The population is assumed to be extinct. In 1996, an experimental program to reintroduce summer chum to Big Beef Creek was begun by the co-managers at the U.W. research facility.

## Factors for Decline

A general discussion of protection and restoration strategies for each habitat factor is found in Section IV, toolkit. Impacts to habitat quality (in order of priority) include: 1) Coarse sediment aggradation and high levels of fine sediment in spawning gravels; 2) loss of channel complexity; 3) alteration of estuarine habitats; 4) altered hydrologic patterns; 5) degraded riparian conditions; and 6) potential elevated temperatures. Sources of impacts are historic and current logging, rural development patterns, and construction and operation of scientific research facilities in the Big Beef watershed. For a comparison of the limiting factors in this watershed to other watersheds, refer to Part Three - section 3.4, Tables 3.17 and 3.18. More details are provided below:

- *Sediment (aggradation, fines)*-Spawning, egg incubation, and migration life history stages, rated high impact. The lower river channel, where historically most of the summer chum production occurred, has been severely impacted by upstream landuse practices, with concurrent reductions in survival in all life history stages. Past logging and road building on steep unstable slopes in the lower Big Beef watershed have caused mass wasting, channel widening and bank instability, causing a 800% increase in sediment bedload over natural, undisturbed conditions (Madej 1978, 1982). The majority of this coarse sediment has been deposited within the lower stream reaches, reducing available pool habitat and causing the channel to widen and become more shallow (WDNR, 1995). Channelization, along with the construction of the WDFW fish weir, has also increased aggradation by constricting the channel and forcing the bedload to be deposited upstream from the weir. The bridge causeway on the Seabeck Road has also restricted the freshwater-saltwater interface and reduced the potential flushing action of sediment associated with tidal action.

  During summer low flow periods, the aggraded and widened channel has been reported to impede upstream passage and reduce spawning success for adult summer chum due to increased predation associated with loss of stream cover (Cederholm, 1972). In 1969 and 1971, the entire summer chum run was moved into the UW Research Station spawning channel because of unstable conditions in the main channel and in anticipation of channelization activities (see description below). Cederholm (1972) documented a 58% loss of summer chum redds due to scour, fill, and channel displacement, with an average survival to emergence rate of 9.4%. In the same study, he noted 16.3% fine sediment (less than 0.8 mm in diameter) in spawning gravel, a rate at which permeability and intergravel survival would be substantially diminished.

- *Channel complexity (LWD, channel condition, loss of side channel, channel instability, floodplain connectivity)*-Spawning, egg incubation, rearing, and migration life history stage, rated high to moderate impact. Channel alterations, in combination with sediment aggradation described above, have reduced channel complexity in lower Big Beef Creek, affecting all major life history stages. Monitoring data collected in 1993 and 1994 indicated 0.17 pieces of LWD per meter, rated as a high impact (Appendix Report 3.8). Pool habitat is rated as moderate impact (46% percent pools, pool spacing of 2.4) with the majority of pools being formed by the roots of standing trees or old growth stumps, and log jams anchored by remnant old growth LWD (PNPTC 1993,1994). In a recent field review of Big Beef Creek, Cederholm noted the loss of stable, deep pools present in the 1960s associated with the loss of LWD and sediment deposition in the lower river.

  Reduced LWD levels have been attributed to illegal cedar salvage, stream cleanout of log jams, channelization activities (S. Neuhaueser, pers. comm.; Amato 1996). At least three separate incidents of channel dredging, dike construction, wood removal, and channel relocation by private landowners have been documented in the lower river from the 1950s (Amato 1996). In response to extreme channel aggradation and braiding in the lower river, and concerns for stranding and reduced survival of summer chum, the University of Washington channelized 1,968 feet of the lower river in 1969 (Cederholm 1972). At the same time, the U.W. constructed dikes consisting of excavated gravel on the southwest side of the river, further constricting the floodplain and creating a new sediment source for downstream areas. Channelization attempts were largely unsuccessful in dealing with sediment aggradation and channel instability in lower Big Beef Creek.

  Routine spot dredging upstream of the weir has occurred since the 1970s, with deposition of dredge spoils along the bridge causeway and a floodplain service road. Diking, construction of a road within the floodplain to service an artesian well for the Big Beef rearing facility operated by NMFS, and filling and alteration of side channel habitat associated with the construction and operation of the Big Beef Research Station, have also contributed to reduced channel complexity in the lower 2 miles of the river.

- *Subestuarine habitat loss and degradation* - Juvenile rearing and migration life stages, rated high impact. The research facility, road, bridge construction and sediment aggradation near the mouth of the stream have decreased the quality and amount of the subestuarine habitat that is most immediately available to emigrating summer chum fry. Three areas, totaling 0.64 ac or 1.4% of historic delta area have been filled; this filling, as with evacuation of one pond covering <0.72 acres or 1.5% of the historic delta area, is associated with the fish research and culture facilities of the Big Beef Research Station. A fish counting weir operated by WDFW, tends to act as a channel constriction and sediment trap, affecting upstream channel conditions and sediment transport processes into the estuary. Historically, timber from logging operations in the area was dumped from trucks into Big Beef Harbor upstream from the sandspit at the harbor's mouth where they were rafted to adjacent mills (Amato 1996).

The Seabeck Road bridge and its associated causeway crosses 0.03 mile of the middle reach of the delta, essentially narrowing the opening previously associated with a sandspit originating on the east side of the estuary. Aerial photographs from 1947, 1961, and 1997 show that extension and reinforcement of the bridge causeway has significantly constrained tidal interaction with the estuary, causing the estuary to infill with sediment, and reducing channel complexity. This observation is reinforced by historic accounts that at one time, small boats were able to navigate into the estuary and lower channel (S. Neuhaueser, personal communication). Adult intertidal spawning may also have also been impacted by these changes.

- *Flow (summer low flow and peak winter)*-Spawning, egg incubation, and migration life history stages, rated moderate and high impact respectively. Summer low flows that occur during late August through the end of September, especially during natural drought cycles, have impacted adult migration and spawning success. Reports of adult stranding were recorded in the late 1960s and 1970s, mostly as a result of channel aggradation (Cedarholm 1972). Future withdrawals of water for domestic water supply, both from the shallow perched and deeper aquifer, have the potential to further compound the problem. The contribution from the Seabeck Aquifer to baseflows at the mouth of Big Beef Creek, is considered important, since the zone of influence overlap almost perfectly with the area of summer chum distribution.

  Winter flood flows have increased as a result of upstream urbanization effects, logging, road building and manipulation of flows at Lake Symington. As of 1993, 3.1% of the watershed was covered by impervious surfaces, approaching a rate at which changes to habitat quality are first noted (May et al. 1977). Changes in the duration and magnitude of peak flows with relatively minor precipitation have been observed since the late 1980s (WDNR 1995). This causes channel instability, including greater scouring and filling of sediments in the channel. May et al. (1997) noted several incidences of scour in excess of 22 cm, the typical depth for egg deposition.

- *Riparian forest (species composition, age)*-Spawning and incubation life stages, rated moderate impact. Riparian zones which were historically a mixed forest of old growth cedar with limited areas of deciduous species associated with disturbance regimes (primarily windthrow and channel migration) are now predominantly composed of mixed conifer and deciduous (47%), deciduous species (48%) and 36% less than 12 inches in diameter (Appendix Report 3.7, WDNR 1995). In comparison to adjoining watersheds, the riparian forest of lower Big Beef Creek is relatively intact (76% of the total riparian length having a buffer greater than 132 feet, low impact rating), with only minor areas of narrow riparian zone related to logging and limited residential developments (at RM 3.5 and below Lake Symington). Other land use impacts to the buffer include roads, dikes, and the UW Research facility in the lower river.

- *Water quality (temperature)*-Migration and spawning life stages, rated moderate impact. Temperature monitoring conducted in 1996 and 1997 indicated temperatures above the optimal target of 7-12 degrees

Celcius in the lower basin, with increasing temperatures at sites within 2 miles of Lake Symington. Lake Symington is a shallow artificial lake prone to heating. Other factors compounding the effects of Lake Symington include channel widening and associated loss of riparian cover, and potential impacts from groundwater extraction. The extent of impairment on migration and spawning is unknown.

**Factors for Recovery**

Reduce sources of sediment aggradation

- Reduce the rate and magnitude of mass wasting within the lower five miles by prohibiting logging and development on steep, unstable slopes.
- Monitor the effectiveness of current prescriptions adopted for logging (West Kitsap Watershed Analysis) and rural development (Kitsap County Critical Areas Ordinance).
- Address sediment contribution from existing abandoned or active roads, and correct known problems. Of special concern, is the Kidhaven Road at RM 3.2.
- Prohibit construction of new roads on steep ravine slopes below Lake Symington.

Increase channel complexity

- Remove the service road located within the floodplain (RM 0.5) and evaluate the feasibility of restoring several side channels and wetlands adjoining the U.W. research facility.
- Evaluate the role of the WDFW fish weir in changing sediment routing patterns and investigate options for reducing its impact.
- Evaluate the need for placing LWD jams in the lower river through a feasibility study.

Reduce road and causeway constriction of estuarine delta

- Long-term planning for replacement or retrofitting of roadway should consider expanding the bridge span and reducing the foodprint of the roadway on the historic delta in order to maximize the opportunity for full creek-tidal water exchange and circulation.

Reduce the impact of peak flows and ensure adequate summer low flows

- To reduce the deleterious impact of peak flows, institute impervious surface thresholds for the basin, retain 60% of the basin in forest cover, and encourage the use of innovative designs for permitted residential developments.
- Ensure road drainage is not routed into the stream network.
- Use the established minimum instream flow recommendation to condition future water applications. Prohibit additional surface water withdrawal or groundwater withdrawals that will diminish the recommended flow level.
- Institute water conservation programs, and investigate opportunities for reducing the number of shallow wells within the watershed.
- Require onsite infiltration of runoff from impervious surfaces where soils are appropriate.

Protect and restore riparian forests

- Continue acquisition efforts underway throughout the watershed through the efforts of the Hood Canal Salmon Sanctuary.
- Replant degraded riparian zones with appropriate native species.

- Review and adjust the Kitsap Critical Area Ordinance consistent with recommendations for riparian buffers.

## Strength of Evaluation and Information Needs

Confidence in the evaluation is rated as high based on the extensive amount of habitat monitoring conducted by PNPTC, research at the UW, and long term escapement returns collected for the Big Beef watershed.

Additional information needed to better quantify the relationship between current conditions and summer chum distribution includes:

1. Instream flow monitoring of both summer flow periods and peak winter flows.
2. Channel assessments to determine the relationship between peak flows and channel forming events. It would be helpful to establish permanent channel cross sections and resurvey Madej's original cross sections.
3. Temperature monitoring extended into mid October to determine if elevated temperatures are a concern.
4. Completion of a sediment budget, including identification of the amount of sediment being actively contributed by destabilized banks and failing roads.

## References

Amato, C. 1996. Historical changes affecting freshwater habitat of coho salmon in the Hood Canal basin, pre-1850 to the present. Point No Point Treaty Council, Kingston, WA.

Becker, J. 1998. Aquifer modeling and mitigation options for the Seabeck aquifer system. Pub. Util. Dist. 1, Kitsap County, Bremerton, WA.

Cederholm, C.J. 1972. The short term physical and biological effects of stream channelization at Big Beef Cr., Kitsap County, WA. MS Thesis, Univ. of Wash., Seattle, WA.

Lestelle, L.C., M.L. Rowse, and C. Weller. 1992. Evaluation of natural stock improvement measures for Hood Canal coho salmon. PNPTC tech. rep. TR93-1. Point No Point Treaty Council, Kingston, WA.

Madej, M.A. 1978. Response of a stream channel to an increase in sediment load. MS Thesis, Univ. of Wash., Seattle, WA.

Madej, M.A. 1982. Sediment transport and channel changes in an aggrading stream in the Puget Lowland, Washington. Pages?) in Swanson, F.J., R.J. Landa, T. Dunne, and D.N. Swanston (eds.) Forest Serv. general tech. Rpt. PNW-141. USFS Pacific Northwest Research Station, U.S. Dept. of Agri., Forest Serv., Portland, OR.

May, C.W., E.B. Welch, R.R. Horner, J.R. Karr, and B.W. Mar. 1997. Quality indices for urbanization effects in Puget Sound lowland streams. WDOE water resources tech. rep. 154. Wash. Dept. Ecol., Olympia, WA.

PNPTC (Point No Point Treaty Council) 1998. Salmon and Steelhead Habitat Inventory and Assessment Project (SSHIAP) database. Point No Point Treaty Council, Kingston, WA.

PNPTC (Point No Point Treaty Council) 1993, 94. 1994-95 Ambient monitoring data (Unpublished). Point No Point Treaty Council, Kingston, WA.

WDNR (Washington Department of Natural Resources). 1995. West Kitsap Watershed Analysis. Wash. Dept. Nat. Res., South Puget Sound region office, Enumclaw, WA.

# Appendix Report 3.7
# Riparian Assessment Methodology and Summary of Results

As part of the analysis of habitat limiting factors, aerial photo interpretation was employed to evaluate the condition of riparian forests along summer chum streams in Hood Canal and the eastern Strait of Juan de Fuca. Using 1997 Washington State Department of Natural Resources 1:12,000-scale aerial photos viewed in stereo, two trained analysts assessed the impacts to riparian zones in relation to adjacent land use. On the Dungeness River 1998, 1:6,000-scale photos were used. Segments with relatively homogenous riparian conditions and land use were delineated on each side of all stream channels within the current or known historic range of summer chum. For each segment the forested riparian buffer width, average stand diameter, species composition, and stand density were noted and the dominant, stream-adjacent land use recorded. We modified the methodology outlined under the Washington State Watershed Analysis Riparian Module to consider both riparian conditions and dominant land use within 200 feet of stream channels. Due to time constraints, the data was not field verified, and we did not assess stream channels upstream of the range of summer chum though downstream transport of large woody debris (LWD) is known to be an important recruitment source for in-channel LWD.

Each riparian segment was categorized according to forested buffer width, species composition, average stand diameter, and stand density. We resolved six buffer width categories: none, <33 ft, 33-66 ft, 66-99 ft, 99-132 ft, and 132-200 ft. Species composition categories included: conifer-dominated (>70% canopy coverage), deciduous-dominated (>70%), mixed conifer/deciduous (both <70%), and none. Tree canopy size and structure was used as a surrogate for average stand diameter: <12 in diameter at breast height (dbh), 12-20 dbh, and >20 dbh. Stand density was categorized as dense (<33% ground exposure), sparse (33-80% ground exposure), and extensively cleared (>80% ground exposure). It is important to note that our assessment of buffer width, species composition, average stand diameter, and stand density applied to only the stream-adjacent, forested portion of the 200 ft. riparian zone. We also categorized dominant land use outside this forested buffer (if any) and within the 200 ft. riparian zone. Land use categories included: forestry, agriculture, rural residential, urban/industrial, road/dike, and no land use (wetlands, protected areas). The road/dike land use class was used where stream-adjacent parallel roads or dikes were present because, though they were rarely dominant land uses within a segment on a per area basis, their impact on riparian forests was interpreted to supersede in importance other land uses within the segment. The forestry category included clearcut and recently replanted areas without canopy closure. Older managed forest stands often could not be readily distinguished from adjacent forested buffers and were included in the calculation of forested buffer. As a result, our estimates of permanent forested buffer areas are likely high and the estimated area under active forestry use likely low.

Thresholds were used to determine generalized summer chum habitat impact ratings (low=1, moderate=2, and high=3) from riparian forest condition for each variable (width, average stand diameter, species composition, stand density; Appendix Table 3.7.1) by segment. Since no riparian forests within the range of summer chum exhibited old-growth or undisturbed conditions, we did not utilize a no impact rating. These thresholds were determined after considering the relative ability of riparian forests to provide critical shade and LWD-supply functions for stream channels used by summer chum. For example, the ability of a buffer to supply LWD over time is partly dependent upon buffer width. It has been calculated that a 50 ft no cut buffer will supply 32% of LWD at age 200, a 135 ft buffer 77% of LWD, and a 210 ft buffer 100% of LWD (T. Beechie, personal communication). Thus, buffers greater than 132 ft in width were considered low impact, 66-132 ft a moderate impact, and <66 ft in width high impact. The riparian forest buffer extent rating was computed as a composite of the scores for stand density and width; stand density scores were added to the buffer width scores, and if either or both scored as a high impact the riparian extent rating defaulted to high impact. Average stand diameter was used as a surrogate to rate riparian age in our overall matrix of habitat factors (see section 3.4.3.2, Table 3.17). Overall watershed-level riparian assessment ratings were then computed for riparian species composition, ageaverage stand diameter), and extent (Appendix Table 3.7.3) using all the riparian segments for a given stream weighted by their total *length*.

**Table 3.7.1.** Summary of riparian assessment impact categories. Low impact was rated a 1, moderate impact was rated 2, and high impact rated 3. The one exception was riparian buffer density, rated 0 for low impact, 1 for moderate impact, and 2 for high impact. Riparian buffer density was added to riparian buffer extent to calculate that rating.

| Riparian assessment category | Low Impact | Moderate Impact | High Impact |
|---|---|---|---|
| Species composition | Conifer dominated (>70% of the canopy) | Mixed conifer/deciduous (both < 70%) | Deciduous dominated (>70% of the canopy) or no tree cover |
| Average stand diameter | >20 in dbh[1] | 12-20 in dbh | <12 in dbh |
| Density | <33% ground exposure | 33-80% ground exposure | >80% ground exposure |
| Width | >132 ft wide forested buffer | 66-132 ft wide forested buffer | <66 ft wide forested buffer |

[1] dbh, diameter at breast height

An example serves to illustrate how these impact ratings were calculated. In Snow Creek (Appendix Table 3.7.2) there is 4,400 ft. of mixed conifer and deciduous stands, no conifer-dominated stands, and 28,000 ft. of shrub/grass or deciduous-dominated forest. The weighted mean calculation for riparian species composition is thus: (4,400/32,400)*2+(28,000/32,400)*3 = 2.86.

**Table 3.7.2**. Calculation of weighted average rating. For Snow Creek, the weighted mean calculation was (4,400/32,400)*2+(28,000/32,400)*3 = 2.86.

*Riparian species composition*

| Stream | Total Riparian Length | Mixed conifer and decid | Conifer dom (<70%) | Decid dom (>70%) | Shrub or grass | No riparian vegetation | Weighted mean rating |
|---|---|---|---|---|---|---|---|
| Snow | 32,400 | 4,400 | 0 | 26,000 | 2,000 | 0 | 2.86 |

While the analysis of riparian buffer extent, age, and species composition was based on stream *length*, the analysis of riparian land use sought to quantify the *area* of the riparian zone occupied by various land uses. The “riparian zone” was defined as the area within 200 ft. of streams harboring summer chum, from the mouth to the upper extent of their spawning distribution. We calculated the area under each land use and report percentages of the total riparian zone under each land use (Appendix Table 3.7.3-D).

**Table A3.7.3**. Summary of results for the riparian forest assessment. For the riparian buffer condition analysis, a rating of 2.5 to 3.0 was considered a high impact, 2.0-2.49 a moderate impact, <2.0 a low impact.

***A. Riparian Forest Average Stand Diameter (Percent by Length)***

| Stream | Total Riparian Length (ft) | Small (<12 in dbh) | Medium (12-20 in dbh) | Large (>20 in dbh) | No buffer present | Weighted mean rating |
|---|---|---|---|---|---|---|
| Big Anderson | 16,000 | 48% | 52% | 0% | 0% | 2.5 |
| Big Beef | 60,200 | 36% | 64% | 0% | 0% | 2.4 |
| Big Mission | 20,400 | 36% | 64% | 0% | 0% | 2.4 |
| Big Quilcene | 49,600 | 44% | 48% | 0% | 8% | 2.5 |
| Chimacum | 29,600 | 42% | 42% | 0% | 16% | 2.6 |
| Dewatto | 40,800 | 32% | 68% | 0% | 0% | 2.3 |
| Dosewallips | 45,800 | 51% | 45% | 0% | 4% | 2.6 |
| Duckabush | 32,200 | 32% | 66% | 0% | 2% | 2.4 |
| Dungeness | 104,200 | 44% | 52% | 0% | 4% | 2.5 |
| Hamma Hamma | 35,000 | 48% | 45% | 3% | 4% | 2.5 |
| Jimmycomelately | 18,800 | 34% | 66% | 0% | 0% | 2.3 |
| Lilliwaup | 5,800 | 0% | 79% | 0% | 21% | 2.2 |
| Little Quilcene | 29,800 | 70% | 27% | 0% | 3% | 2.7 |
| Salmon | 21,600 | 15% | 63% | 0% | 22% | 2.4 |
| Seabeck | 11,600 | 41% | 59% | 0% | 0% | 2.4 |
| Skokomish | 323,200 | 33% | 48% | 4% | 16% | 2.4 |
| Snow | 32,400 | 50% | 44% | 0% | 6% | 2.6 |
| Stavis | 4,800 | 0% | 100% | 0% | 0% | 2.0 |
| Tahuya | 96,800 | 24% | 69% | 0% | 7% | 2.3 |
| Union | 53,800 | 67% | 33% | 0% | 0% | 2.7 |

***B. Riparian Forest Buffer Species Composition (Percent by Length)***

| **Stream** | **Total Riparian Length (ft)** | **Mixed** | **Conifer** | **Decid** | **Shrub /grass** | **No riparian veg** | **Weighted mean rating** |
|---|---|---|---|---|---|---|---|
| Big Anderson | 16,000 | 23% | 0% | 77% | 0% | 0% | 2.8 |
| Big Beef | 60,200 | 47% | 5% | 48% | 0% | 0% | 2.4 |
| Big Mission | 20,400 | 2% | 0% | 98% | 0% | 0% | 3.0 |
| Big Quilcene | 49,600 | 11% | 40% | 41% | 5% | 3% | 2.1 |
| Chimacum | 29,600 | 57% | 0% | 27% | 16% | 0% | 2.4 |
| Dewatto | 40,800 | 96% | 0% | 4% | 0% | 0% | 2.0 |
| Dosewallips | 45,800 | 52% | 3% | 41% | 4% | 0% | 2.4 |
| Duckabush | 32,200 | 57% | 18% | 23% | 0% | 2% | 2.1 |
| Dungeness | 104,200 | 66% | 5% | 25% | 4% | 0% | 2.2 |
| Hamma Hamma | 35,000 | 22% | 48% | 26% | 4% | 0% | 1.8 |
| Jimmycomelately | 18,800 | 15% | 43% | 42% | 0% | 0% | 2.0 |
| Lilliwaup | 5,800 | 79% | 0% | 0% | 21% | 0% | 2.2 |
| Little Quilcene | 29,800 | 42% | 7% | 48% | 0% | 3% | 2.5 |
| Salmon | 21,600 | 63% | 0% | 15% | 22% | 0% | 2.4 |
| Seabeck | 11,600 | 59% | 0% | 41% | 0% | 0% | 2.4 |
| Skokomish | 323,200 | 25% | 26% | 33% | 15% | 2% | 2.2 |
| Snow | 32,400 | 14% | 0% | 80% | 6% | 0% | 2.9 |
| Stavis | 4,800 | 58% | 0% | 42% | 0% | 0% | 2.4 |
| Tahuya | 96,800 | 37% | 4% | 52% | 7% | 0% | 2.6 |
| Union | 53,800 | 4% | 0% | 96% | 0% | 0% | 3.0 |

### *C. Riparian Forest Buffer Extent (Percent by Length)*

| Stream | Total Riparian Length (ft) | Low Impact (buffer >132 ft wide) | Medium Impact (buffer 66-132 ft wide) | High Impact (buffer sparse and/or <66 ft wide) | Weighted Mean Rating |
|---|---:|---:|---:|---:|---:|
| Big Anderson | 16,000 | 41% | 0% | 59% | 2.2 |
| Big Beef | 60,200 | 76% | 6% | 18% | 1.4 |
| Big Mission | 20,400 | 31% | 24% | 45% | 2.1 |
| Big Quilcene | 49,600 | 53% | 2% | 45% | 1.9 |
| Chimacum | 29,600 | 33% | 26% | 41% | 2.1 |
| Dewatto | 40,800 | 69% | 16% | 15% | 1.5 |
| Dosewallips | 45,800 | 58% | 21% | 21% | 1.6 |
| Duckabush | 32,200 | 59% | 25% | 16% | 1.6 |
| Dungeness | 104,200 | 32% | 18% | 50% | 2.2 |
| Hamma Hamma | 35,000 | 58% | 0% | 42% | 1.8 |
| Jimmycomelately | 18,800 | 0% | 31% | 69% | 2.7 |
| Lilliwaup | 5,800 | 52% | 0% | 48% | 2.0 |
| Little Quilcene | 29,800 | 3% | 38% | 60% | 2.6 |
| Salmon | 21,600 | 8% | 22% | 70% | 2.6 |
| Seabeck | 11,600 | 0% | 0% | 100% | 3.0 |
| Skokomish | 323,200 | 45% | 25% | 35% | 1.9 |
| Snow | 32,400 | 17% | 7% | 76% | 2.6 |
| Stavis | 4,800 | 79% | 0% | 21% | 1.4 |
| Tahuya | 96,800 | 44% | 27% | 29% | 1.9 |
| Union | 53,800 | 27% | 11% | 62% | 2.4 |

### *D. Riparian Land Use (Percent by Area)*

| Stream | Total Riparian Area ($ft^2$) | Forested buffer | No land use | Forestry | Agric | Rur resid | Urb/ Com | Road / |
|---|---:|---:|---:|---:|---:|---:|---:|---:|
| Big Anderson | 3,200,000 | 55% | 0% | 0% | 9% | 0% | 0% | 36% |
| Big Beef | 12,040,000 | 85% | 0% | 0% | 0% | 4% | 4% | 7% |
| Big Mission | 4,080,000 | 70% | 0% | 0% | 0% | 17% | 8% | 5% |
| Big Quilcene | 9,920,000 | 62% | 0% | 1% | 10% | 3% | 3% | 21% |
| Chimacum | 5,920,000 | 51% | 0% | 0% | 16% | 17% | 16% | 0% |
| Dewatto | 8,160,000 | 87% | 0% | 5% | 2% | 4% | 0% | 2% |
| Dosewallips | 9,160,000 | 79% | 2% | 3% | 3% | 7% | 6% | 0% |
| Duckabush | 6,440,000 | 74% | 2% | 0% | 0% | 9% | 12% | 3% |
| Dungeness | 20,840,000 | 58% | 0% | 0% | 9% | 13% | 0% | 20% |
| Hamma Hamma | 7,000,000 | 65% | 0% | 23% | 10% | 2% | 0% | 0% |
| Jimmycomelately | 3,760,000 | 34% | 0% | 38% | 12% | 7% | 0% | 9% |
| Lilliwaup | 1,160,000 | 52% | 0% | 0% | 20% | 0% | 0% | 28% |
| Little Quilcene | 5,960,000 | 40% | 2% | 6% | 33% | 8% | 0% | 11% |
| Salmon | 4,320,000 | 32% | 0% | 25% | 43% | 0% | 0% | 0% |
| Seabeck | 2,320,000 | 33% | 0% | 0% | 23% | 21% | 0% | 23% |
| Skokomish | 64,640,000 | 64% | 1% | 1% | 26% | 2% | 2% | 4% |
| Snow | 6,480,000 | 42% | 0% | 7% | 35% | 5% | 0% | 11% |
| Stavis | 960000 | 83% | 0% | 0% | 17% | 0% | 0% | 0% |
| Tahuya | 19360000 | 71% | 1% | 6% | 8% | 12% | 0% | 2% |
| Union | 10760000 | 52% | 0% | 2% | 13% | 30% | 0% | 3% |

# Appendix Report 3.8
# Freshwater Habitat Data Summary and Analysis Criteria

Freshwater habitat data can be found for a number of streams in Hood Canal and the Straits of Juan de Fuca. Below is a summary of the available habitat data (Appendix Table 3.8.1), targets used to analyze the data (Appendix Table 3.8.2), and the channel condition data (Appendix Table 3.8.3). Temperature data was only used if it was a continuous thermograph (i.e. no spot sampling). Temperature graph data was visually examined during the workshops to determine if it exceeded 12EC. Fine sediment data was only considered if it was gathered with a McNeil core sampler; visual estimates of surface sediment are not accurate and were not considered.

**Appendix Table 3.8.1.** Watersheds with habitat data used in the assessment.

| Watershed | Channel condition data | Temperature | Fine Sediment |
|---|---|---|---|
| Jimmycomelately | X | | |
| Salmon | X | | X |
| Snow | X | | X |
| Little Quilcene | X | | |
| Big Quilcene | X | | |
| Duckabush | X | | |
| Hamma Hamma | X | | |
| Skokomish | x[1] | X | |
| Union | X | | |
| Big Mission | X | | |
| Tahuya | X | X | X |
| Dewatto | X | X | X |
| Big Anderson | X | | |
| Stavis | X | X | |
| Big Beef | X | X | |

[1] Skokomish watershed channel condition data is for Vance Creek only.

**Appendix Table 3.8.2.** Stream habitat targets for channel condition habitat factors. Large woody debris (LWD) is number of pieces/m of channel length[1], percent pools is the surface area occupied by pools [2,3], pool frequency is the number of channel widths per pool [2], and fine sediment is the percentage of fine sediment with a diameter <0.85mm [2].

| **Habitat factor targets** | **Channel width and gradient** | **No-Low impact** | **Mod. impact** | **High impact** |
|---|---|---|---|---|
| *LWD* [1] | <15 m | >0.4 | 0.2-0.4 | <0.2 |
| *Percent pools* [2] | <15 m; 2% | >55% | 40-55% | <40% |
| *Percent pools* [3] | >15 m | >50% | 35-50% | <35% |
| *Pool frequency*[2] | <15 m; 2% | <2 | 2-4 | > 4 |
| *Temperature* [4] | all | <12 °C | -- | >12°C |
| *Fine sediment* [2] | all | <12% | 12-17% | >17% |

[1] Montgomery et al. 1995

[2] WFPB1995

[3] Pess et al. 1998

[4] Bjorn and Reiser 1991

**Appendix Table 3.8.3.** Channel condition habitat data summary. USFS (US Forest Service) was collected using Hankin and Reeves survey methodology. PNPTC (Point No Point Treaty Council) and USFWS (US Fish and Wildlife Service) were collected using TFW ambient monitoring methodology. Pool frequency is the number of channel widths per pool.

| **Stream** | **Data source** | **Survey year** | **RM (rivermile)[1]** | **LWD pieces/m** | **Pool freq.** | **Percent pools** |
|---|---|---|---|---|---|---|
| Jimmycomelately | USFS | 1990 | 0-1.9 | 0.09 | 9.0 | 30% |
| Salmon | PNPTC | 1992 | 0-1.3 | 0.06, 0.15 [2] | 4.8 | 39 |
| Snow | PNPTC | 1993 | 0-3.6 | 0.07 [3] | 5.7 | 47 |
| Little Quilcene | PNPTC | 1992 | 0-3.8 | 0.03, 0.1 [2] | 5.3 | 32 |
| Big Quilcene | PNPTC | 1993 | 0.8-3.8 | 0.01, 0.16 [2] | 5.1 | 31 |
| Big Quilcene | USFS | 1992 | 0-4.0 | 0.06 | -[4] | 20 |
| Duckabush | USFWS | 1992 | 0.2-2.3 | sparse | -[5] | 31 |
| Hamma Hamma | USFWS | 1996 | 0.5-1.8 | 0.13 | -[5] | 50 |
| Johns Creek | USFWS | 1996 | 0-1.8 | 0.06 | -[5] | -[5] |
| Union | PNPTC | 1993 | 0-6.7 | 0.22 | 5.9 | 63 |
| Big Mission | PNPTC | 1993 | 0-1.5 | 0.07 | 6.5 | 33 |
| Tahuya | PNPTC | 1994 | 4.0-9.0 | 0.04, 0.15 [2] | 2.4 | 72 |
| Dewatto | PNPTC | 1994 | 3.0-3.5 | 0.09, 0.28 [2] | 4.1 | 37 |
| Big Anderson | USFWS | 1993/4 | 0-1.8 | 0.30 | 1.7 | 51 |
| Stavis | USFWS | 1993/4 | 0-0.6 | 0.26 | 1.8 | 53 |
| Big Beef | PNPTC | 1993/4 | 0-6.3 | 0.17 | 2.4 | 46 |

[1] This is the surveyed portion of the channel that overlapped the summer chum range.

[2] For PNPTC data, LWD volumes are calculated using only single piece data and calculated using single pieces plus pieces in jams. For LWD jams, only the overall volume was measured and not the individual piece count. To convert volume to pieces, jam volume was divided by average single piece volume for each survey. Thus the incomplete packing of wood within jams was not accounted for and total LWD numbers are likely overestimated. It is presented as both single pieces, and the total of single pieces plus those in LWD jams.

[3] This number does not include pieces in LWD jams and should be considered a low estimate. Individual piece volumes were not available to calculate pieces per jam. However given field observations, had total LWD pieces been counted, the channel would still fall within the highly degraded category.

[4] Could not be calculated from the data. Channel width was measured as summer low flow width.

[5] Partial survey, did not collect this information.

## References

Bjornn, T.C., and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. American Fisheries Society Special Publication 19:83-138.

Montgomery, D.R., G.E. Grant, and K, Sullivan. 1995. Watershed analysis as a framework for implementing ecosystem management. Water Resources Bulletin 31:369-385.

Pess, G.R., B.D. Collins, M. Pollock, T.J. Beechie, S. Grigsby, and A. Haas. 1998. Historic and current factors that limit coho salmon (Oncorhynchus kisutch) in the Stillaguamish river basin, Washington state: implications for salmonid habitat protection and restoration. A report prepared for Snohomish County Department of Public Works – Surface Water Management Division and the Stillaguamish Tribe, Everett, WA. 40 p.

WFPB (Washington Forest Practices Board). 1995. Standard methodology for conducting watershed analysis (Version 3). Wash. Forest Pract. Bd., Olympia, WA.

# Appendix Report 3.9
# General Fishing Patterns, and Regulation Summary by Year, Fishery, and Fleet

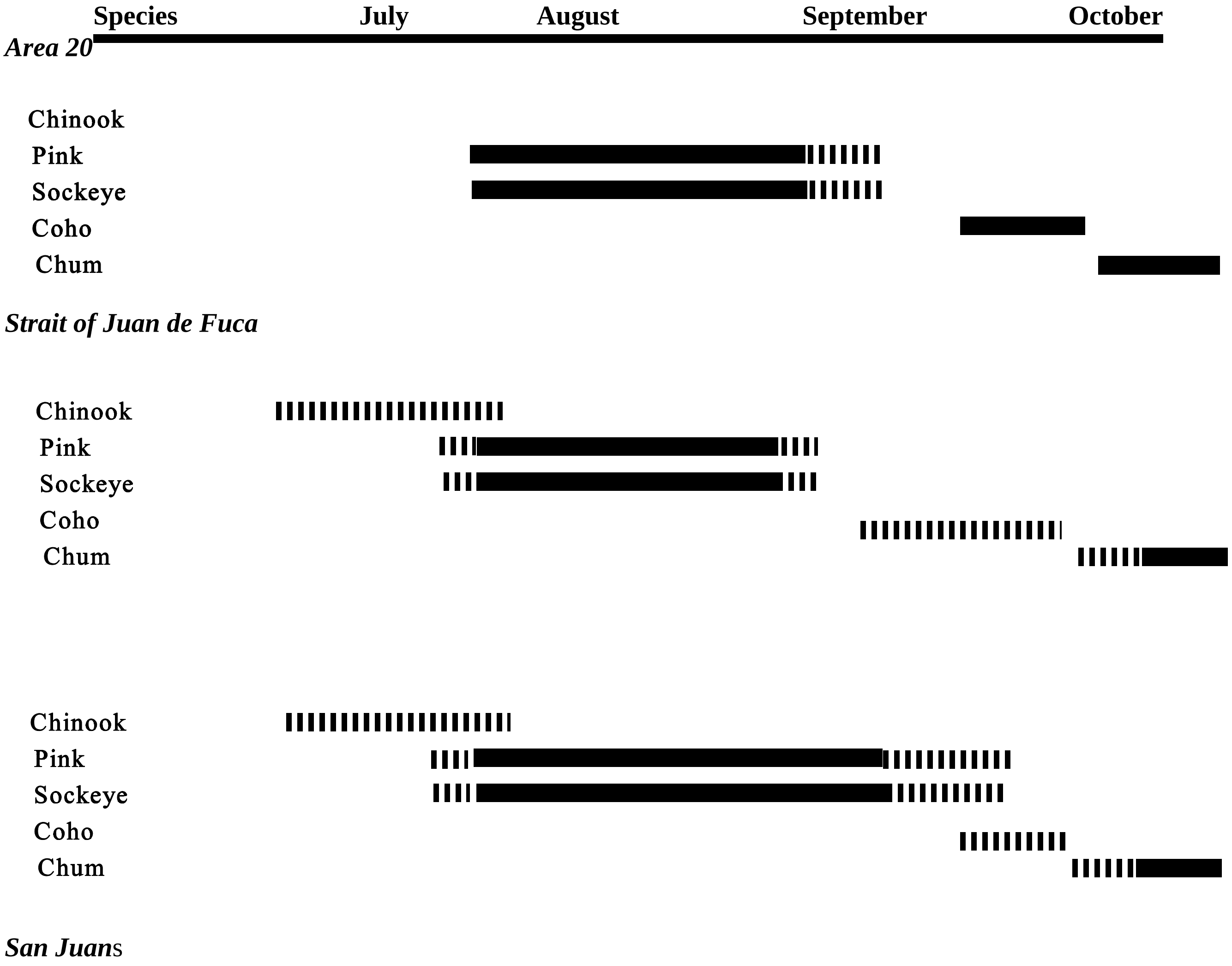
## Introduction

The Harvest Management section (3.5) of the Summer Chum Salmon Conservation Initiative provides a narrative description of all fisheries that potentially can have some impact on Hood Canal and Strait of Juan de Fuca (HC-SJF) summer chum (see Part Three, section 3.5.3). This appendix report provides additional information specifically on commercial fishing patterns and regulations.

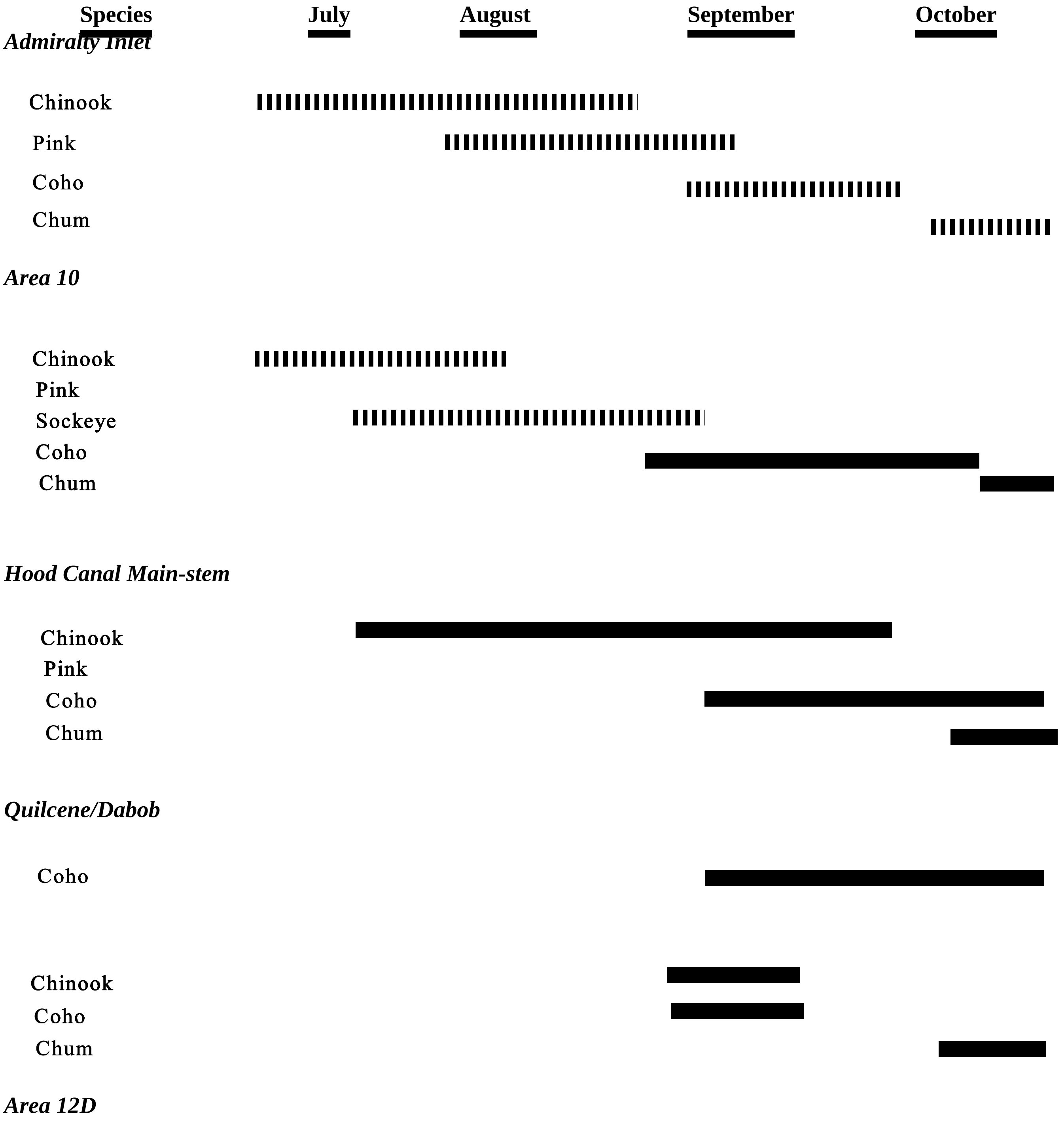
Appendix Figure 3.9.1 is a simple graphical depiction of the general pattern of commercial fishing in the major fishing areas impacting HC-SJF summer chum. The solid bars indicate some consistency in fishing pattern from year to year, and the dotted bars indicate a fishery that has been severely curtailed or eliminated in recent years or one that occurs very sporadically and with low effort or impact. For example, sockeye and pink salmon fisheries in the Strait of Juan de Fuca occur consistently every year (solid bar) and it is only the extremes of the timing of the fishery that changes much from year to year (dotted bar). The coho fishery in the Strait of Juan de Fuca used to occur with significant effort and catch, but has been severely constrained or eliminated in recent years (dotted bar). Commercial net fisheries for chinook in the Strait of Juan de Fuca used to be much more extensive, involving drift gill net gear. Now this fishery is very constrained, restricted to set gill net gear in near shore areas with very little effort and catch (dotted bar).

Detailed summaries of July through October net fishery openings in Hood Canal management units are provided in Appendix Tables 3.9.1 and 3.9.2 for treaty and non-treaty fishermen, respectively. These tables summarize regulations for the period from 1980 to 1997 and provide weekly summaries of the specific areas, gear types and number of days open.

**Appendix Figure 3.9.1.** General commercial fishing pattern by area, fleet and gear since the late 1970s (see text for explanation of dotted lines).



**Appendix Figure 3.9.1** (continued)



**Appendix Table 3.9.1.** 1980-97 non-treaty openings for Hood Canal Mainstem Management Area (July through October). Gear Types: PS=purse seine, BS=beach seine, and GN=gillnet.

| Year | Date(s) | Days | Marine Area | Gear Type |
|---|---|---|---|---|
| 1980 | 10/21 - 10/28 | 2 | 12 | PS, GN |
| 1981 | 10/19 -10/19 | 1 | 12 | PS, GN |
| 1981 | 10/25 -10/25 | 1 | 12 | GN |
| 1981 | 10/26 -10/26 | 1 | 12 | PS |
| 1982 | 09/15 -09/15 | 1 | 12 | GN |
| 1982 | 09/16 -09/16 | 1 | 12 | PS |
| 1982 | 10/11 -10/11 | 1 | 12 | GN |
| 1982 | 10/12 -10/12 | 1 | 12 | PS |
| 1982 | 10/18 -10/18 | 1 | 12 | PS, GN |
| 1982 | 10/25 -10/26 | 1 | 12 | GN |
| 1982 | 10/26 -10/26 | 1 | 12 | PS |
| 1983 | 07/26 -07/26 | 1 | 12 | GN |
| 1983 | 08/01 -08/01 | 1 | 12 | GN |
| 1983 | 08/09 -08/09 | 1 | 12 | GN |
| 1983 | 08/15 -08/17 | 3 | 12 | GN |
| 1983 | 08/22 -08/24 | 3 | 12,12B | GN |
| 1983 | 08/28 -09/01 | S | 12, 12B | GN |
| 1983 | 09/11 -09/11 | 1 | 12 | GN |
| 1983 | 09/12 -09/12 | 1 | 12 | PS |
| 1983 | 09/19 -09/20 | 2 | 12 | PS, GN |
| 1983 | 09/25 -09/29 | 5 | 12 | GN |
| 1983 | 09/26 -09/30 | 5 | 12 | PS |
| 1983 | 10/03 -10/06 | 4 | 12,12A,12B | PS, GN |
| 1983 | 10/09 -10/11 | 3 | 12,12A,12B | GN |
| 1983 | 10/10 -10/12 | 3 | 12,12A,12B | PS |
| 1983 | 10/17 -10/17 | 1 | 12 | PS, GN |
| 1983 | 10/23 -10/23 | 1 | 12 | GN |
| 1983 | 10/24 -10/24 | 1 | 12 | PS |
| 1983 | 10/31 -10/31 | 1 | 12 | PS, GN |
| 1984 | 07/30 -07/30 | 1 | 12,12B | GN |
| 1984 | 07/31 -07/31 | 1 | 12,12B | PS |
| 1984 | 08/07 -08/09 | 3 | 12,12B | PS, GN |

**Appendix Table 3.9.1** (continued). 1980-97 non-treaty openings for Hood Canal Mainstem Management Area (July through October). Gear Types: PS=purse seine, BS=beach seine, and GN=gillnet.

| Year | Date(s) | Days | Marine Area | Gear Type |
|---|---|---|---|---|
| 1984 | 08/13 -08/15 | 3 | 12,12B | PS, GN |
| 1984 | 08/20 -08/22 | 3 | 12,12B | GN |
| 1984 | 09/21 -08/23 | 3 | 12,12B | PS |
| 1984 | 08/27 -08/29 | 3 | 12,12B,12C | PS, GN |
| 1984 | 09/10 -09/11 | 2 | 12,12A | GN |
| 1984 | 09/11 -09/12 | 2 | 12,12A | PS |
| 1984 | 09/17 -09/19 | 3 | 12,12A,12B | PS, GN |
| 1984 | 09/24 -09/24 | 1 | 12A | GN |
| 1984 | 09/25 -09/25 | 1 | 12A | PS |
| 1984 | 10/01 -10/01 | 1 | 12A | PS, GN |
| 1984 | 10/08 -10/08 | 1 | 12A | GN |
| 1984 | 10/09 -10/09 | 1 | 12A | PS |
| 1984 | 10/15 -10/15 | 1 | 12,12A,12B | PS, GN |
| 1984 | 10/15 -10/17 | 3 | 12A | PS, GN |
| 1984 | 10/21 -10/21 | 1 | 12,12B | GN |
| 1984 | 10/22 -10/22 | 1 | 12,12B | PS |
| 1985 | 07/30 -07/30 | 1 | 12C | GN |
| 1985 | 07/31 -07/31 | 1 | 12C | PS |
| 1985 | 08/05 -08/07 | 3 | 12C | PS, GN |
| 1985 | 08/13 -08/16 | 4 | 12C | PS |
| 1985 | 08/18 -08/22 | S | 12B,L2C | GN |
| 1985 | 08/19 -08/23 | S | 12C | PS |
| 1985 | 08/25 -08/29 | S | 12B,L2C | GN |
| 1985 | 08/26 -08/30 | S | 12C | PS |
| 1985 | 09/02 -09/05 | 4 | 12B,12C | GN |
| 1985 | 09/03 -09/06 | 4 | 12B,12C | PS |
| 1985 | 09/09 -09/09 | 1 | 12,12A | GN |
| 1985 | 09/10 -09/10 | 1 | 12,12A | PS |
| 1995 | 09/16 -09/17 | 2 | 12,12A | PS, GN |
| 1985 | 09/23 -09/25 | 3 | 12,12A | GN |
| 1985 | 09/24 -09/26 | 3 | 12,12A | PS |
| 1985 | 09/30 -10/03 | 4 | 12,12A | PS, GN |

**Appendix Table 3.9.1** (continued). 1980-97 non-treaty openings for Hood Canal Mainstem Management Area (July through October). Gear Types: PS=purse seine, BS=beach seine, and GN=gillnet.

| Year | Date(s) | Days | Marine Area | Gear Type |
|---|---|---|---|---|
| 1985 | 10/06 -10/10 | 5 | 12,12A,12B,12C | GN |
| 1985 | 10/07 -10/11 | S | 12,12A,12B,12C | PS |
| 1985 | 10/14-10/16 | 3 | 12,12A,12B,12C | PS, GN |
| 1985 | 10/21 -10/21 | 1 | 12 | GN |
| 1985 | 10/22 -10/22 | 1 | 12 | PS |
| 1985 | 10/21 -10/23 | 3 | 12C | GN |
| 1985 | 10/22 -10/24 | 3 | 12C | PS |
| 1985 | 10/28 -10/28 | 1 | 12 | PS, GN |
| 1986 | 07/28 -07/31 | 4 | 12B,12C | PS, GN |
| 1986 | 08/04 -08/07 | 4 | 12B,12C | GN |
| 1986 | 08/05 -08/08 | 4 | 12B,12C | PS |
| 1986 | 08/11-08/14 | 4 | 12B,12C | PS, GN |
| 1986 | 08/18 -08/19 | 2 | 12B,12C | GN |
| 1986 | 08/19 -08/20 | 2 | 12B,12C | PS |
| 1986 | 08/25 -08/26 | 2 | 12,12B | PS, GN |
| 1986 | 09/01 -09/03 | 3 | 12,12B | GN |
| 1986 | 09/02 -09/04 | 3 | 12,12B | PS |
| 1986 | 09/08 -09/09 | 2 | 12,12A,12B | PS, GN |
| 1986 | 09/15 -09/16 | 2 | 12,12A,12B | GN |
| 1986 | 09/16 -09/17 | 2 | 12,12A,12B | PS |
| 1986 | 09/22 -09/24 | 3 | 12,12A,12B | PS, GN |
| 1986 | 09/28 -09/30 | 3 | 12,12A,12B | GN |
| 1986 | 09/29 -10/01 | 3 | 12,12A,12B | PS |
| 1986 | 10/20 -10/20 | 1 | 12 | GN |
| 1986 | 10/21 -10/21 | 1 | 12 | PS |
| 1986 | 10/27 -10/27 | 1 | 12 | PS, GN |
| 1987 | 07/27 -07/30 | 4 | 12B,12C | GN |
| 1987 | 07/28 -07/31 | 4 | 12C | PS |
| 1987 | 08/03 -08/06 | 4 | 12B,12C | GN |
| 1987 | 08/03 -08/06 | 4 | 12C | PS |
| 1987 | 08/10 -08/13 | 4 | 12B,12C | GN |
| 1987 | 08/11 -08/14 | 4 | 12C | PS |

**Appendix Table 3.9.1** (continued). 1980-97 non-treaty openings for Hood Canal Mainstem Management Area (July through October). Gear Types: PS=purse seine, BS=beach seine, and GN=gillnet.

| Year | Date(s) | Days | Marine Area | Gear Type |
|---|---|---|---|---|
| 1987 | 08/16 -08/19 | 4 | 12B,12C | GN |
| 1987 | 08/17 -08/20 | 4 | 12C | PS |
| 1987 | 09/14 -09/15 | 2 | 12,12A | PS, GN |
| 1987 | 09/20 -09/22 | 3 | 12C | GN |
| 1987 | 09/21 -09/23 | 3 | 12C | PS |
| 1987 | 09/21 -09/22 | 2 | 12,12A | GN |
| 1987 | 09/22 -09/23 | 2 | 12,12A | PS |
| 1987 | 09/28 -09/29 | 2 | 12,12A,12C | PS, GN |
| 1987 | 10/04 -10/04 | 1 | 12,1 2A,12B,12C | GN |
| 1987 | 10/06 -10/05 | 1 | 12,12A,12B,12C | PS |
| 1987 | 10/12 -10/13 | 2 | 12,12A,12B,12C | PS, GN |
| 1987 | 10/19 -10/19 | 1 | 12,12B | GN |
| 1987 | 10/20 -10/20 | 1 | 12,12B | PS |
| 1987 | 10/19 -10/22 | 4 | 12A | GN |
| 1987 | 10/20 -10/23 | 4 | 12A | PS |
| 1987 | 10/26 -10/26 | 1 | 12,12B | PS, GN |
| 1988 | 08/15 -08/16 | 2 | 12B,12C | PS, GN |
| 1988 | 08/22 -08/23 | 2 | 12B,12C | GN |
| 1988 | 08/23 -08/24 | 2 | 12B,12C | PS |
| 1988 | 09/06 -09/07 | 2 | 12A | PS, GN |
| 1988 | 09/12 -09/14 | 3 | 12A | GN |
| 1988 | 09/13 -09/15 | 3 | 12A | PS |
| 1988 | 09/19 -09/21 | 3 | 12A | PS, GN |
| 1988 | 09/26 -09/27 | 2 | 12A | GN |
| 1988 | 09/27 -09/28 | 2 | 12A | PS |
| 1988 | 10/24 -10/25 | 2 | 12,12B | PS, GN |
| 1988 | 10/31 -11/01 | 2 | 12,12B | GN |
| 1989 | 07/24 -07/27 | 4 | 12B,12C | PS, GN |
| 1989 | 07/31 -08/03 | 4 | 12B,12C | GN |
| 1989 | 08/01 -08/04 | 4 | 12B,12C | PS |
| 1989 | 08/07 -08/10 | 4 | 12B,12C | PS, GN |
| 1989 | 08/14 -08/17 | 4 | 12B,12C | GN |

**Appendix Table 3.9.1** (continued). 1980-97 non-treaty openings for Hood Canal Mainstem Management Area (July through October). Gear Types: PS=purse seine, BS=beach seine, and GN=gillnet.

| Year | Date(s) | Days | Marine Area | Gear Type |
|---|---|---|---|---|
| 1989 | 08/15 -08/18 | 4 | 12B,12C | PS |
| 1989 | 08/21 -08/24 | 4 | 12B,12C | PS, GN |
| 1989 | 08/28 -08/31 | 4 | 12B,12C | GN |
| 1989 | 08/29 -09/01 | 4 | 12B,12C | PS |
| 1989 | 09/05 -09/08 | 4 | 12A,12B,12C | PS, GN |
| 1989 | 09/11 -09/11 | 1 | 12,12B | GN |
| 1989 | 09/11 -09/14 | 4 | 12A | GN |
| 1989 | 09/12 -09/12 | 1 | 12,12B | PS |
| 1989 | 09/12 -09/15 | 4 | 12A | PS |
| 1989 | 09/18 -09/18 | 1 | 12,12B | PS, GN |
| 1989 | 09/25 -09/26 | 2 | 12,12B | GN |
| 1989 | 09/26 -09/27 | 2 | 12,12B | PS |
| 1989 | 10/02 -10/03 | 2 | 12,12B | PS, GN |
| 1989 | 10/09 -10/10 | 2 | 12,12B | GN |
| 1989 | 10/10- 10/11 | 2 | 12,12B | PS |
| 1989 | 10/16- 10/16 | 1 | 12,12B | GN |
| 1989 | 10/17- 10/17 | 1 | 12,12B | PS |
| 1989 | 10/23- 10/23 | 1 | 12,12B | PS, GN |
| 1989 | 10/29- 10/30 | 2 | 12,12B | GN |
| 1989 | 10/30- 10/31 | 2 | 12,12B | PS |
| 1990 | 07/30- 08/02 | 4 | 12B,12C | PS, GN |
| 1990 | 08/06- 08/09 | 4 | 12B,12C | GN |
| 1990 | 08/07- 08/10 | 4 | 12B,12C | PS |
| 1990 | 08/13- 08/16 | 4 | 12B,12C | PS, GN |
| 1990 | 08/20- 08/23 | 4 | 12B,12C | GN |
| 1990 | 08/21- 08/24 | 4 | 12B,12C | PS |
| 1990 | 08/27- 08/30 | 4 | 12B,12C | PS, GN |
| 1990 | 09/03- 09/06 | 4 | 12A,12B,12C | GN |
| 1990 | 09/04- 09/07 | 4 | 12A,12B,12C | PS |
| 1990 | 09/10- 09/10 | 1 | 12,12B | PS, GN |
| 1990 | 09/10- 09/13 | 4 | 12A | PS, GN |
| 1990 | 09/16- 09/21 | 5 | 12A | PS, GN |

**Appendix Table 3.9.1** (continued). 1980-97 non-treaty openings for Hood Canal Mainstem Management Area (July through October). Gear Types: PS=purse seine, BS=beach seine, and GN=gillnet.

| Year | Date(s) | Days | Marine Area | Gear Type |
|---|---|---|---|---|
| 1990 | 09/17- 09/18 | 2 | 12,12B | GN |
| 1990 | 09/18- 09/19 | 2 | 12,12B | PS |
| 1990 | 09/24- 09/25 | 2 | 12,12B | PS, GN |
| 1990 | 10/01- 10/03 | 3 | 12,12B | GN |
| 1990 | 10/02- 10/02 | 3 | 12,12B | PS |
| 1990 | 10/08- 10/09 | 2 | 12,12A,12B | PS, GN |
| 1990 | 10/15- 10/15 | 1 | 12,12A,12B | PS, GN |
| 1990 | 10/22- 10/23 | 2 | 12,12B | GN |
| 1990 | 10/23- 10/24 | 2 | 12,12B | PS |
| 1990 | 10/29- 10/30 | 2 | 12,12B | PS, GN |
| 1991 | 09/03- 09/06 | 4 | 12A | PS, GN |
| 1991 | 09/09- 09/13 | 5 | 12A | PS, GN |
| 1991 | 09/18- 09/20 | S | 12A | PS, GN |
| 1991 | 09/23- 09/27 | 5 | 12A | PS, GN |
| 1991 | 09/30- 10/04 | 5 | 12A | PS, GN |
| 1991 | 10/16- 10/18 | 3 | 12A | PS, GN |
| 1993 | 09/08- 09/10 | 3 | 12A | GN |
| 1993 | 09/13- 09/16 | 4 | 12A | GN |
| 1993 | 10/18- 10/19 | 2 | 12,12B | PS, GN |
| 1993 | 10/25- 10/26 | 2 | 12,12B | PS, GN |
| 1993 | 10/26- 10/27 | 2 | 12,12B | PS, GN |
| 1994 | 10/31- 10/31 | 1 | 12B | GN |
| 1995 | 10/30- 10/30 | 1 | 12,12B | PS, GN |
| 1995 | 10/31- 10/31 | 1 | 12,12B | PS, GN |
| 1998 | 09/23- 09/27 | 5 | 12A | BS |
| 1996 | 09/30- 10/04 | 5 | 12A | BS |
| 1996 | 10/07- 10/11 | 5 | 12A | BS |
| 1997 | 09/03- 09/06 | 4 | 12A | BS |
| 1997 | 09/08- 09/12 | 5 | 12A | BS |
| 1997 | 09/15- 09/19 | 5 | 12A | BS |
| 1997 | 09/22- 09/26 | 5 | 12A | BS |
| 1997 | 09/29- 10/03 | 6 | 12A | BS |

**Appendix Table 3.9.1** (continued). 1980-97 non-treaty openings for Hood Canal Mainstem Management Area (July through October). Gear Types: PS=purse seine, BS=beach seine, and GN=gillnet.

| Year | Date(s) | Days | Marine Area | Gear Type |
|---|---|---|---|---|
| 1997 | 10/06- 10/10 | 5 | 12A | BS |
| 1997 | 10/13- 10/17 | 5 | 12A | BS |
| 1997 | 10/20- 10/21 | 2 | 12,12B | PS, GN |
| 1997 | 10/27- 10/28 | 2 | 12,12B | PS, GN |

**Appendix Table 3.9.2.** 1980-96 Treaty openings for Hood Canal Mainstem Management Area (July through October). Gear types: GN=gillnet, SN=set net, BS=beach seine, and HL=hook and line.

| Year | Date (s) | Days | Area | Gear |
|---|---|---|---|---|
| 1980 | 08/03 - 08/06 | 3 | 12 | HL, SN, GN |
| 1980 | 08/10 - 08/13 | 3 | 12 | HL, SN, GN |
| 1980 | 08/17 - 08/21 | 4 | 12 | HL, SN, GN |
| 1980 | 09/01 - 09/03 | 2 | 12 | HL, SN, GN |
| 1980 | 09/07 - 09/10 | 3 | 12,12B | SN, GN |
| 1980 | 09/14 - 09/19 | 5 | 12,12C | SN, GN |
| 1980 | 09/21 - 09/24 | 3 | 12,12B | SN, GN |
| 1980 | 09/28 - 09/30 | 2 | 12,12C | SN, GN |
| 1981 | 08/02 - 08/04 | 2 | 12,12C | HL, SN, GN |
| 1981 | 08/09 - 08/12 | 3 | 12,12C | HL, SN, GN |
| 1981 | 08/16 - 08/19 | 3 | 12,12C | HL, SN, GN |
| 1981 | 08/23 - 08/25 | 2 | 12,12C | HL, SN, GN |
| 1981 | 09/13 - 09/15 | 2 | 12 | HL, SN, GN |
| 1981 | 09/15 - 09/17 | 2 | 12,12B | HL, SN, GN |
| 1981 | 09/20 - 09/22 | 2 | 12,12B | HL, SN, GN |
| 1981 | 09/22 - 09/24 | 2 | 12,12C | HL, SN, GN |
| 1981 | 09/27 - 09/30 | 3 | 12,12C | HL, SN, GN |
| 1982 | 08/02 - 08/04 | 2 | 12 | HL, SN, GN |
| 1982 | 08/15 - 08/17 | 2 | 12 | HL, SN, GN |
| 1982 | 08/22 - 08/25 | 3 | 12 | HL, SN, GN |
| 1982 | 08/29 - 09/03 | 5 | 12 | HL, SN, GN |
| 1982 | 09/05 - 09/10 | 5 | 12 | HL, SN, GN |
| 1982 | 09/12 - 09/17 | 5 | 12,12C | HL, SN, GN |
| 1982 | 09/18 - 09/23 | 5 | 12,12C | HL, SN, GN |
| 1982 | 09/24 - 09/30 | 6 | 12,12C | HL, SN, GN |
| 1983 | 08/01 - 08/03 | 2 | 12 | HL, SN, GN |
| 1983 | 08/07 - 08/10 | 3 | 12 | HL, SN, GN |
| 1983 | 08/14 - 08/18 | 4 | 12,12C | HL, SN, GN |
| 1983 | 08/21 - 09/03 | 13 | 12,12C | HL, SN, GN |
| 1983 | 09/03 - 09/08 | 5 | 12C | HL, SN, GN |
| 1983 | 09/11 - 09/14 | 3 | 12,12B | HL, SN, GN |
| 1983 | 09/16 - 09/18 | 2 | 12,12B | HL, SN, GN |

**Appendix Table 3.9.2** (continued). 1980-96 Treaty openings for Hood Canal Mainstem Management Area (July through October). Gear types: GN=gillnet, SN=set net, BS=beach seine, and HL=hook and line.

| Year | Date (s) | Days | Area | Gear |
|---|---|---|---|---|
| 1983 | 09/18 - 09/23 | 5 | 12,12C | HL, SN, GN |
| 1983 | 09/25 - 09/30 | 5 | 12,12C | HL, SN, GN |
| 1984 | 08/01 - 08/03 | 2 | 12,12C | HL, SN, GN |
| 1984 | 08/05 - 08/10 | 5 | 12,12B | HL, SN, GN |
| 1984 | 08/04 - 08/10 | 6 | 12C | HL, SN, GN |
| 1984 | 08/12 - 08/17 | 5 | 12,12C | HL, SN, GN |
| 1984 | 08/19 - 08/22 | 3 | 12,12C | HL, SN, GN |
| 1984 | 09/03 - 09/05 | 2 | 12 | HL, SN, GN |
| 1984 | 09/09 - 09/14 | 5 | 12 | HL, SN, GN |
| 1984 | 09/16 - 09/21 | 5 | 12 | HL, SN, GN |
| 1984 | 09/17 - 09/20 | 3 | 12B | HL, SN, GN |
| 1984 | 09/21 - 09/26 | 5 | 12 | HL, SN, GN |
| 1985 | 08/01 - 08/02 | 1 | 12,12B | HL, SN, GN |
| 1985 | 08/04 - 08/09 | 5 | 12,12C | HL, SN, GN |
| 1985 | 08/11 - 08/16 | 5 | 12,12C | HL, SN, GN |
| 1985 | 08/18 - 08/21 | 3 | 12,12C | HL, SN, GN |
| 1985 | 08/25 - 08/28 | 3 | 12,12C | HL, SN, GN |
| 1985 | 09/02 - 09/04 | 2 | 12,12C | HL, SN, GN |
| 1985 | 09/08 - 09/11 | 3 | 12,12B | HL, SN, GN |
| 1985 | 09/15 - 09/28 | 13 | 12,12B | HL, SN, GN |
| 1985 | 09/21 - 09/24 | 3 | 12C | HL, SN, GN |
| 1985 | 09/29 - 09/30 | 1 | 12C | HL, SN, GN |
| 1986 | 08/01 - 08/01 | 1 | 12,12C | HL, SN, GN |
| 1986 | 08/04 - 08/08 | 4 | 12,12C | HL, SN, GN |
| 1986 | 08/10 - 08/15 | 5 | 12,12C | HL, SN, GN |
| 1986 | 08/17 - 08/20 | 3 | 12,12C | HL, SN, GN |
| 1986 | 08/24 - 08/26 | 2 | 12,12B | HL, SN, GN |
| 1986 | 09/07 - 09/11 | 4 | 12,12B | HL, SN, GN |
| 1986 | 09/14 - 09/19 | 5 | 12,12B | HL, SN, GN |
| 1986 | 09/21 - 09/26 | 5 | 12,12C | HL, SN, GN |
| 1986 | 09/26 - 09/30 | 4 | 12,12C | HL, SN, GN |
| 1987 | 08/02 - 08/07 | 5 | 12,12C | HL, SN, GN |

**Appendix Table 3.9.2** (continued). 1980-96 Treaty openings for Hood Canal Mainstem Management Area (July through October). Gear types: GN=gillnet, SN=set net, BS=beach seine, and HL=hook and line.

| Year | Date (s) | Days | Area | Gear |
|---|---|---|---|---|
| 1987 | 08/09 - 08/14 | 5 | 12,12C | BS, HL, SN, GN |
| 1987 | 08/12 - 08/14 | 2 | 12C | HL, SN, GN |
| 1987 | 08/16 - 08/21 | 5 | 12,12C | BS |
| 1987 | 08/19 - 08/21 | 1 | 12C | HL, SN, GN |
| 1987 | 08/20 - 09/05 | 16 | 12,12C | BS |
| 1987 | 08/21 - 08/21 | 1 | 12C | HL, SN, GN |
| 1987 | 09/06 - 09/11 | 5 | 12 | BS, HL, SN, GN |
| 1987 | 09/13 - 09/18 | 5 | 12,12B | BS, HL, SN, GN |
| 1987 | 09/20 - 09/25 | 5 | 12,12C | HL, SN, GN |
| 1987 | 09/27 - 09/30 | 3 | 12,12C | HL, SN, GN |
| 1988 | 08/01 - 08/05 | 4 | 12,12C | HL, SN, GN |
| 1988 | 08/07 - 08/13 | 6 | 12,12C | HL, SN, GN |
| 1988 | 08/14 - 08/19 | 5 | 12,12C | HL, SN, GN |
| 1988 | 09/25 - 09/28 | 3 | 12 | HL, SN, GN |
| 1989 | 08/01 - 08/04 | 3 | 12,12C | HL, SN, GN |
| 1989 | 08/06 - 08/11 | 5 | 12,12C | HL, SN, GN |
| 1989 | 08/13 - 08/18 | 5 | 12,12C | HL, SN, GN |
| 1989 | 08/20 - 08/25 | 5 | 12,12C | HL, SN, GN |
| 1989 | 08/27 - 09/01 | 5 | 12,12C | HL, SN, GN |
| 1989 | 09/03 - 09/09 | 6 | 12,12C | HL, SN, GN |
| 1989 | 09/10 - 09/13 | 3 | 12,12C | HL, SN, GN |
| 1989 | 09/14 - 09/17 | 3 | 12C | HL, SN, GN |
| 1989 | 09/17 - 09/21 | 4 | 12,12B | BS, HL, SN, GN |
| 1989 | 09/17 - 09/21 | 4 | 12C | HL, SN, GN |
| 1989 | 09/24 - 09/29 | 5 | 12,12C | HL, SN, GN |
| 1990 | 08/01 - 08/04 | 3 | 12,12C | HL, SN, GN |
| 1990 | 08/05 - 08/11 | 6 | 12,12C | HL, SN, GN |
| 1990 | 08/12 - 08/18 | 6 | 12,12C | HL, SN, GN |
| 1990 | 08/19 - 08/25 | 6 | 12,12C | HL, SN, GN |
| 1990 | 08/26 - 09/01 | 6 | 12,12C | HL, SN, GN |
| 1990 | 09/02 - 09/08 | 6 | 12,12C | HL, SN, GN |
| 1990 | 09/10 - 09/14 | 4 | 12,12C | HL, SN, GN |

**Appendix Table 3.9.2** (continued). 1980-96 Treaty openings for Hood Canal Mainstem Management Area (July through October). Gear types: GN=gillnet, SN=set net, BS=beach seine, and HL=hook and line.

| Year | Date (s) | Days | Area | Gear |
|---|---|---|---|---|
| 1990 | 09/16 - 09/21 | 5 | 12,12C | HL, SN, GN |
| 1990 | 09/23 - 09/28 | 5 | 12,12C | HL, SN, GN |
| 1990 | 09/30 - 09/30 | 1 | 12,12C | HL, SN, GN |
| 1991 | 08/01 - 08/03 | 2 | 12,12C | HL, SN, GN |
| 1991 | 08/04 - 08/10 | 6 | 12,12C | HL, SN, GN |
| 1991 | 08/11 - 08/17 | 6 | 12,12C | HL, SN, GN |
| 1991 | 08/18 - 08/24 | 6 | 12,12C | HL, SN, GN |
| 1991 | 08/25 - 08/31 | 6 | 12,12D | HL, SN, GN |
| 1991 | 09/01 - 09/07 | 6 | 12,12D | HL, SN, GN |
| 1992 | 08/01 - 08/01 | 1 | 12,12C | HL, SN, GN |
| 1992 | 08/02 - 08/08 | 6 | 12,12C | HL, SN, GN |
| 1992 | 08/09 - 08/15 | 6 | 12,12C | HL, SN, GN |
| 1992 | 08/15 - 08/23 | 8 | 12,12C | HL, SN, GN |
| 1992 | 08/23 - 08/30 | 7 | 12,12C | HL, SN, GN |
| 1992 | 08/30 - 09/05 | 6 | 12,12C | HL, SN, GN |
| 1993 | 08/01 - 08/08 | 7 | 12,12C | HL, SN, GN |
| 1993 | 08/08 - 08/15 | 7 | 12,12C | HL, SN, GN |
| 1993 | 08/15 - 08/22 | 7 | 12,12C | HL, SN, GN |
| 1993 | 08/22 - 08/29 | 7 | 12,12C | HL, SN, GN |
| 1993 | 08/29 - 09/05 | 7 | 12C | HL, SN, GN |
| 1994 | 08/07 - 08/11 | 4 | 12,12C | HL, SN, GN |
| 1994 | 08/14 - 08/18 | 4 | 12,12C | HL, SN, GN |
| 1994 | 08/21 - 08/25 | 4 | 12C | HL, SN, GN |
| 1995 | 08/01 - 08/03 | 2 | 12C | BS, HL |