1999 ANNUAL REPORT

Salmonid Screening, Habitat Enhancement and Restoration Section (SSHEAR)

Environmental Restoration Division
Habitat Program

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FISH PASSAGE UNIT

INTRODUCTION

Resident and anadromous salmonids are a vital component of the culture and economy of the Pacific Northwest. Each year, millions of dollars in revenues are generated in Washington, Oregon, and California by sport and commercial fisheries targeting salmon and trout. In addition, the presence and abundance of salmonids indicates the health of Pacific Northwest stream ecosystems. Without question, protection and enhancement of salmonids and the habitats that support them directly enhances the distribution and abundance of many other wildlife species as well.

Correction of human-made fish passage barriers such as impassable culverts, dams, floodgates, or degraded fishways is one of the most cost effective methods of salmonid restoration. In many cases, several miles of quality salmon and trout habitat can be retrieved and brought into production by eliminating a single point source fish barrier. To address these problems, the Fish Passage Unit performs several major functions: fishway inspections, fishway operation and maintenance, culvert inventory work, fishway major project development, database management, and training/consultation on fish passage related issues. The unit is composed of specialized fish biologists, engineers, technicians, and equipment operators. Following is a summary of work completed.

FISHWAYS

The Fish Passage Unit is responsible for the inspection and evaluation of 464 fishways statewide. The majority of the fishways are associated with road culverts and small low head dams. Inspections are conducted in the spring, after the threat of major flooding and damage, so that the condition of the fishways can be adequately evaluated. For those fishways requiring maintenance, fishway notification letters are sent out and follow-up calls are made to the owners. Where necessary, staff schedule on site consultation with the fishway owner to resolve problems.

Compliance inspections are conducted in the late summer/early fall to ensure that the maintenance work has been completed. During 1999, 398 fishways received scheduled inspections. Of this number, 107 (27%) required maintenance or reconstruction. Compliance inspections conducted later in the year indicated that the owners of 46 (43%) fishways had completed the work requested. Most of the fishways not in compliance were those requiring major reconstruction. The unit is continually working with those owners to ensure that a time line for reconstruction is developed and implemented. The compliance rate of 43% for 1999 was up from the last nine-year average of 38%. The improvement in compliance reflects SSHEAR's efforts to work with fishway owners to resolve fish passage problems.

FISHWAYS OPERATION AND MAINTENANCE

Currently, the Environmental Restoration Division is responsible for the operations, maintenance and repair and modification of 76 fishways statewide including 24 formal Mitchell Act fishways.

SSHEAR is responsible for maintaining and operating two major fishways in the state. The Granite Falls fishways on the South Fork Stillaquamish River requires about 1.2 man months per year for weekly maintenance during the salmon run. The Sunset Falls fishway on the South Fork Skykomish River also requires maintenance and daily operations in the handling and hauling of fish from July through December. Operation of the trap and haul facility at Sunset Falls requires 10.8 staff months annually.

Built in 1958, the Sunset Falls fishway consists of a series of 33 vertical slots which lead into a trap and haul facility at River Mile 51.5. The facility provides salmon, steelhead, trout and native char access to over 92 miles of spawning and rearing habitat in the upper South Fork Skykomish watershed. The number of each species which were passed upstream at the Sunset Falls fishway during the 1999 season is listed in Table 1.

Table 1. Fish trapped and transported upstream at Sunset Falls during 1999.

Species	Total No. Adults	Total No. Jacks
Coho Salmon	12,839	52
Chum Salmon	45	
Summer Chinook Salmon	72	52
Fall Chinook Salmon	458	140
Pink Salmon	962	
Sockeye Salmon	4	
Steelhead Trout	716	
Sea Run Cutthroat Trout	0	
Native Char	45	

During the 1999 construction season, maintenance, major repairs, and modifications were performed on the following fishways:

Granite Falls Fishway Modifications
Built in 1956, the Granite Falls fishway consists of a series of 51 vertical slots which lead into a 300 foot long tunnel. The fishway provides pink, coho, chinook, steelhead and native char access to 57 miles of spawning and rearing habitat in the upper South Fork Stillaguamish River. Unfortunately, during high flow conditions gravel tends to accumulate in the tunnel and fishway. When the flows dropped, the accumulated gravel dewatered the fishway and stranded fish. During the summer of 1999 an automatic shut off gate was installed. The gate automatically closes during flood flows and shuts off flow through the tunnel and minimizes gravel accumulation in the fishway. Additional modifications will be completed in 2000 and 2001 with the addition of new trash racks and entrance fill.

Little Kalama River Fishway Repair
The Little Kalama River Fishway is one of 24 formal Mitchell Act fishways and provides steelhead and trout access to over four miles of spawning and rearing habitat. In recent years, floods resulted in damage to stop logs in the fishway. The damaged stop logs were replaced in 1999. A large fir tree which had became lodged in the fishway was also removed.

Wind River Fishway Repair
Work continued on the Wind River Fishway at Shipperd Falls to repair major damage incurred by the flood event of 1996. A new trash plate along with an exit closure gate was installed so concrete repair work could continue on the vertical slot fishway. The fishway provides spring chinook and summer steelhead access to 38 miles of spawning and rearing habitat.

Mitchell Act Stream Clearance and Fishway Operation and Maintenance
This project provides stream clearance and maintenance of fishways constructed under the Mitchell Act in the lower Columbia River drainage. Between January 1 and December 31 , 1999, a total of 10.4 staff months were spent for fishway maintenance and inspections, barrier reconnaissance, design work and development of recommendations for future work.

DEPARTMENT OF TRANSPORTATION CULVERT INVENTORY

In 1991, the Washington State Legislature, working with the Washington State Department of Transportation (WSDOT) and the Washington State Department of Fish and Wildlife (WDFW), organized and implemented a fish passage inventory on Washington State Highways. The purpose of the ongoing inventory is to document fish passage problems at State Route stream crossings and to correct passage problems located by order of highest priority.

During the ongoing WSDOT inventory 3,415 culverts in natural drainages have been inspected; 1999 have been identified as fish bearing, including 774 fish barriers. The second phase of the ongoing project involves conducting habitat surveys, both up and downstream of identified barriers, to establish priorities for correction and quantify the habitat gain. Based on results of surveys completed to date, sufficient habitat gains to justify correction have been identified at 513 barrier culverts. A total of 123 additional culverts are scheduled for further evaluation to determine the need for fish passage repair. The culverts designated for further evaluation are classified as such in part because the recently merged agency, Department of Fish and Wildlife, has recognized the need for maintaining diverse and healthy stocks of resident salmonids through the correction of barrier culverts. Some of the resident species occupy steeper gradient stream sections which may be unsuitable for salmon. Hence, further assessment is underway to determine potential additional corrections based on consideration for resident fish. An estimated 449 barriers remain to be corrected to address all salmonids (513 barriers to fix minus 64 already fixed barriers equals 449).

Since the inventory began, fish passage has been provided by WSDOT and WDFW's Environmental Restoration Division, using dedicated funding, at 36 priority sites.
Twenty four fish passage barriers were reported corrected by WSDOT during safety and mobility projects, one barrier was corrected during WSDOT's routine operational maintenance, and three barriers were corrected using other funding sources.

Barriers corrected during the year 1999 by WSDOT and WDFW were Schoolyard Creek SR 5 Fishway (WRIA 5.0145), Tibbetts Creek SR 900 Fishway (08.0169), Unnamed trib to Pacific Ocean SR 109 Fishway (WRIA 21.0715), Birnie Creek SR 4 Fishway (WRIA 25.0281), and the First Creek bridges (WRIA 47.0096).

DEPARTMENT OF TRANSPORTATION CULVERT REPAIRS

Schoolyard Creek - State Route 530
This is one of three major fish passage correction projects completed on Schoolyard Creek this season. Schoolyard Creek is a tributary on the North Fork Stillaguamish near the town of Trafton which is located 5 miles east of Arlington.

With Washington Department of Transportation (DOT) funding, WDFW designed a project to jack a new culvert under State Route 530 road fill adjacent to the existing pipe. The channel gradient downstream of the new pipe was adjusted with five log weirs to ensure fish passage. Jacking a pipe through the road fill allowed WDFW to complete the project without interfering with heavy traffic and was equally, if not more cost effective.

With WDFW assistance, a contractor first jacked the new six feet diameter pipe through the road fill. Then a number of small baffles were welded to the bottom of the pipe to improve conditions for fish passage. Then the log weirs were set using log cribbing to provide bank stability with out the use of rock rip-rap. Large tree stems with attached roots were made an

integral part of the project for fish benefit. Spawning rock was placed between the weirs and the banks were fully planted with native shrubs and trees. The design was planned to not only provide a visually attractive project but also demonstrate the use of natural materials in fish passage projects. Using natural materials with little or no heavy rock will allow faster vegetative recovery, allow a more natural hydraulic flow and quickly return the site to valuable fish habitat.

The other two projects on School Yard creek were conducted on privately own land and are reported on page 22 and 23.

Tibbetts Creek - State Route 900
Tibbetts Creek is a tributary of Lake Samammish entering the lake just west of the City of Issaquah in King County. The creek supports naturally reproducing populations of cutthroat and steelhead trout and sockeye and coho salmon. Steelhead, sockeye and coho stocks in the Lake Washington watershed were all listed as depressed in the 1992 edition of the Washington State Salmon and Steelhead Stock Inventory.

A 4 foot by 6 foot concrete box culvert located under State Route 900 blocked the upstream passage of fish at mile post 19.5. The 110 foot long culvert has a slope of 2.9 percent. This together with an approximate 3 foot drop at the culvert outfall combined to form a total barrier to the passage of fish.

In 1999, WDFW contracted with WSDOT to modify the culvert to provide fish passage. Seven steel baffles were installed in the culvert to increase water depth and reduce velocities. Twelve double log controls were placed immediately downstream of the culvert to backwater the 3 foot drop at the culvert and partially backwater the lower half of the culvert. Spawning gravel was also placed between the log controls to provide additional spawning habitat. The construction work was completed in October of 1999 and all disturbed areas were re-vegetated in February of 2000.

Periodic surveys in the fall of 1999 indicated only a few coho salmon used the stream for spawning but numerous cutthroat juveniles have been observed in and above the project area.

Unnamed Tributary - Pacific Ocean Fishway
At the recommendation of WDFW, a severe anadromous fish blockage located on State Route 109 at mile post 36.4 was resolved by WSDOT by constructing a small pool and weir fishway during the summer of 1999. The project is unique in that it ladders an independent tributary to the Pacific Ocean. Once the fishway was complete 1,783 M^2 of habitat was made accessible. This project undertaken by the WSDOT Olympic region cost $189,566 to complete**.**

Birnie Creek SR 4 Fishway
Birnie Creek is a tributary to the Columbia River. Prior to construction, the State Route 4 culvert crossing was an complete blockage to all salmonids because of a slope related velocity barrier and depth barrier at low flow. The Birnie Creek SR 4 Fishway was constructed in 1999 and

consisted of a series of four log controls to step the stream up to the culvert apron. In addition, 21 steel angle baffles were attached to the floor of the culvert using a Hilti epoxy glue system. The result was a series of roughness features providing fish passage through this culvert at a wide range of flows. Three other fish passage problems are located in the city of Cathlamet and will need to be repaired on Birnie Creek before complete fish passage is achieved. Those are Birnie Creek FFA, Birnie Creek Una Road, and Birnie Creek Highway 409.

First Creek Bridges

First Creek is a larger tributary to Lake Chelan and is not a stream historically accessed by anadromous fish. It does however receive escapements from adfluvial chinook, cutthroat and rainbow trout, brook trout and kokanee. Two culverts located at mile 8.9 and 9.1 on State Route 971 were determined to be barriers to these species and were placed on list for replacement. WSDOT dedicated $530,000 in fish passage funding to removing the culverts and replace them with bridges. This work resulted in a substantial gain of 42,000 M^2 of habitat available to salmonids in First Creek

SAFETY AND MOBILITY WORK

Given the large number of identified barriers in the Washington Department of Transportation inventory (513), it would take more than a century to provide fish passage at the current rate of correction (average six/biennium). However, it is apparent the benefits to Washington's economy and ecosystems are directly proportional to the number of culverts repaired per year. Because of this, WSDOT and WDFW have agreed on integrating fish passage concerns into ongoing WSDOT road safety and mobility projects. Culvert repairs associated with road projects on state highways can be done more quickly and at lower cost since equipment is already mobilized or in the vicinity of ongoing road construction. Continued fish passage improvements at road crossings and safety and mobility project collaboration will require a substantial long term commitment by the legislature. However by correcting these barriers the recovery of depressed or critical stocks may be accelerated and avoid the need for further listings under the Endangered Species Act. (See Washington Department of Transportation Fish Passage Barrier Removal Program Progress Performance Report for Fish Passage Corrections and WSDOT Safety and Mobility Project Review, December, 2000.)

WILDLIFE AREA INVENTORY

Over the past 58 years, WDFW has purchased approximately 840,000 acres of wildlife area sites, scattered throughout almost every county in the state. Due to previous land utilization practices and the increasing interest of fish passage issues, the Salmon Screening Habitat Enhancement and Restoration Division (SSHEAR) initiated a statewide inventory of fish passage barriers and hydraulic diversions on all state owned or managed lands in October of 1997. The purpose of the inventory is to document and correct all agency owned fish passage problems and hydraulic

diversions. Washington State laws (RCW 77.16.220, RCW 75.20.040, RCW 75.20.061) require all diversions from waters of the state to be screened to protect fish. SSHEAR designs and installs approximately 10 gravity diversion screens and 100 pump diversion screens throughout the state annually.

In cooperation with other Lands and Restorations Services Program staff, SSHEAR designed a sampling protocol, database format, and Wildlife Area Priority Index for the study. To create the priority index of Wildlife Areas, a prioritization questionnaire was distributed to Regional Lands Coordinators, Regional Fish Biologists and Wildlife Area Managers. This enabled SSHEAR staff to take advantage of the many years of experience and data accumulated form local Wildlife Area Managers. The questionnaire was designed to prioritize wildlife areas based on four main factors (e.g. number of known fish passage problems, stock status, stock mobility, and high profile fish passage issues of public interest) to allow the inventory to be completed in order of priority.

After further communications with Regional personnel, some changes were made to the priority index for wildlife areas. Snoqualmie Wildlife Area replaced Scatter Creek Wildlife as the prototype due to ESA listings and high public interest. On the Snoqualmie Wildlife Area a total of 42 features were evaluated at 41 individual sites (37 culverts, two dams, two fishways and one pump diversion). All were on fish bearing streams or lakes. The Methow Wildlife Area ranked the highest priority of the eastern Washington wildlife areas. On the Methow Wildlife Area, a total of 183 features were evaluated. There are 146 culvert crossings, 21 dams, zero fishways, zero lake screens and 16 water diversions. Fifty-two features (26 culverts, 14 dams, 12 diversions) are considered to be in fish bearing streams or lakes. Twenty-five culverts and seven dams were identified as potential fish passage barriers. Four diversions are unscreened. The second wildlife area to be inventoried on the west side of the Cascade range was the Olympic Wildlife Area. On the Olympic Wildlife Area a total of 62 features were evaluated. There are 60 culvert crossings and two gravity diversions. Forty-four culverts and both diversions are considered to be in fish bearing streams. Twenty-five culverts were identified as potential barriers, nine are total barriers and 16 are partial barriers. Both water diversions meet current screening criteria.

Currently, the Cowlitz Wildlife Area is being inventoried, and is expected to be completed by winter of 2001. The Sunnyside Wildlife Area is next on the prioritization list for areas east of the Cascade range and should be completed by Fall 2001.

JEFFERSON COUNTY CULVERT INVENTORY

A culvert and habitat inventory to identify and prioritize fish passage problems at stream crossings in Jefferson County began in 1997 was completed in 1999. A total of 1180 county culverts were evaluated, of which 246 were determined to be in fish bearing streams. Of those, 122 were considered either total or partial barriers to fish passage. Of the 122 barrier culverts,

downstream checks and physical surveys revealed that 31 had insufficient habitat (< 200 lineal meters) to warrant their correction. Seven barriers were fixed during the inventory, leaving 84 county-owned barriers to be corrected.

While conducting the habitat assessments for the prioritization of county-owned barrier culverts, an additional 251 culverts were assessed on state, federal, and private lands. Of these, 131 were found to be barriers to fish passage, 31 had an insignificant habitat gain, and 6 were fixed during the inventory, leaving 94 non-county-owned culverts requiring correction.

FISH PASSAGE / INVENTORY INFORMATION MANAGEMENT

Designated biologists are responsible for the development and maintenance of the statewide Fish Passage, WSDOT Culvert Inventory, and County Culvert Inventory databases. The Fish Passage database is used to track 460 fishways and their condition to ensure protection of fish life. In addition, this database contains a statewide inventory of other unresolved fish passage barriers (710 to date). Maintenance of the fish passage database involves coordinating the collection of fish passage barrier information by agency staff and individuals outside the agency, and responding to intra-agency and interagency requests for database reports. The WSDOT Culvert Inventory database contains 1,719 records of culvert inspections made during the barrier inventory process. This database is used to identify, evaluate, and prioritize the repair of fish passage impediments on state managed highways. The Thurston County Culvert Inventory database contains 668 records of culvert evaluations made during the inventory. The Jefferson County Culvert Inventory database contains 1,228 records of culvert evaluations made during the inventory. The county culvert inventory databases are used in the same fashion as that contained in the WSDOT database.

MAJOR FISH PASSAGE PROJECT DEVELOPMENT

In addition to the cooperative program with the Department of Transportation, the Fish Passage Unit develops fish passage improvement projects on federal, state, county/local, and private lands. The unit works within the framework of the "Team Concept". Professional staff from the Environmental Engineering Services (EES) work with biologists from SSHEAR's and the Construction Unit to develop, design, permit, construct, and evaluate fish passage projects. The major projects undertaken in 1999 are described below.

Unnamed Tributary to Lake Creek

As part of a project guarantee, the 1998 fish passage project on the Lake Cavanaugh Road on the Unnamed Tributary to Lake Creek was revisited in 1999. The scope of work involved geotechnical engineering to address a slope failure over the newly constructed bottomless arch pipe. A mat of geo-grids were installed on the slope along with planting native vegetation. To date, the project is doing as intended in stabilizing the fill. As a follow up to our 1998 project, adult salmon surveys were conducted above the culvert during the Fall of 1999 with over 30 adult coho counted.

Unnamed Tributary to Waddell Creek
This project was designed and developed to restore fish passage and habitat features to an Unnamed Tributary to Waddell Creek. As a cooperative effort between U.S. Fish and Wildlife Service, a private landowner and the Washington State Department of Fish and Wildlife (SSHEAR), two longstanding barrier culverts were replaced by passable culverts and a longstanding dam was retrofitted with a series of log controls and a weir/pool fishway. A series of four fir trees with rootwads attached, were anchored along the bankline of an adjacent pond to provide rearing and refuge habitat to juvenile salmonids.

This project restored over a mile of habitat to coho salmon, steelhead and cutthroat trout. After completion, 20 adult coho were counted above the project site during the Fall of 1999.

Fisher Creek #1
This project was located on the Cedardale Road crossing on Fisher Creek. A Skagit County owned culvert with an outdated fishway impeded the passage of coho, steelhead and cutthroat trout to 9 miles of spawning and rearing habitat. The project involved the placement of steel baffles throughout the 115 foot length of box culvert in addition to the forming and pouring of a new concrete floor. The outlet of the culvert and old fishway were removed and replaced with a pool chute type fishway. Funding for the project was provided by the State of Washington and Skagit County.

Fisher Creek #2
This project was done in concert with Fisher Creek #1 as a cooperative between the State of Washington Department of Fish and Wildlife and Skagit County Public Works on the Starbird Road crossing on Fisher Creek. A sheet flow problem associated with a concrete culvert apron impeded the migration of coho, steelhead and cutthroat trout to 7 miles of spawning and rearing habitat. The culvert apron was back watered by an elevation of two feet by a series of five standard WDFW log controls in order to alleviate the passage impediment.

Tibbetts Creek Private Crossing #1
Two perched culverts under a private driveway (83rd Street) blocked fish passage at River Mile 2.8 on Tibbetts Creek. Environmental Restoration Division staff replaced these culverts with a single, 112 inch by 72 inch corrugated metal culvert. The new pipe was laid at 0.0 percent slope and was counter sunk into the streambed 20 inches. Work at this site was completed in August of 1999 and the area was re-vegetated with native plants in February of 2000.

Tibbetts Creek Private Crossing #2
A dilapidated 30 inch metal pipe under an abandon road blocked fish passage at River Mile 3.3 of Tibbetts Creek. With the permission of the landowners, Environmental Restoration Division construction crews removed this culvert and stabilized the streambanks.

East Fork Tarboo Creek

This project was at milepost 0.42 on Coyle Road near Quilcene on the east side of the Olympic Peninsula. The existing 6' culvert had a 2% slope and one foot outfall drop making it virtually a complete barrier to the upstream migration of salmonids. The project involved removing the existing culvert and installing a 13' 1" by 8' 6" culvert. The new culvert was installed at a 0% slope and 3.5' deeper than the existing culvert to provide a natural stream bottom throughout the culvert. Three rock controls were placed upstream of the culvert to maintain the elevation of the streambed upstream of the new culvert.

This project, along with future projects upstream, restored fish passage to 4.2 miles of spawning and rearing habitat in the stream, a tributary to Dabob Bay. Coho salmon and steelhead and cutthroat trout benefitted from the construction of this project. This project was constructed by the SSHEAR Construction Unit and funded by the WDFW, Jefferson County, and the Interagency Committee for Outdoor Recreation (IAC).

North Branch East Fork Tarboo Creek

This project was at milepost 0.67 on the Coyle Road. The 36" diameter culvert at this site was 30' long, had a 3% slope. Fish passage was blocked to salmonids by a 1.3' outfall drop and high velocities inside the culvert. The project involved the removal of the existing culvert and replacing it with a 3 sided aluminum box culvert measuring 10' 6' wide by 5' 7" high.

This project restored fish passage to 1.2 miles of spawning and rearing habitat. Coho salmon and steelhead and cutthroat trout benefitted from the construction of this project. This project was constructed by the SSHEAR Construction Unit and funded by WDFW, Jefferson County, Port Gamble S'Klallam Tribe, and IAC.

TECHNICAL ASSISTANCE

Nine fish passage barrier inventory grants were funded in 1998 and we continued to provide technical assistance and training to these groups and others in 1999. Sixteen formal training sessions were conducted in 1999 and staff was available for numerous meetings and telephone consultations from individuals and organizations interested in fish passage.

Work commenced on updating the *Fish Passage Barrier Assessment and Prioritization Manual* to improve clarity and add a protocol for the assessment of surface water diversion screens.

WILD STOCK RESTORATION / ENHANCEMENT

INTRODUCTION

The 1987 Washington State Legislature directed WDFW to develop a wild coho habitat enhancement program on North Coast and North Puget Sound rivers. Those rivers included the Hoh, Queets, and Quillayute systems on the North Coast, and the Skagit and Stillaguamish Rivers in North Puget Sound. The purpose was to increase and stabilize coho smolt production by expanding and improving key production habitats. Improved production could ease harvest impacts and strengthen wild stocks. Harvest restrictions necessary to protect low numbers of these wild fish resulted in reduced fishing opportunity and economic loss to citizens of Washington State and Indian Tribes.

Historical watershed reconstruction has shown that key habitat features for coho have been lost. These key habitats consisting of flowing backwater sloughs, channels, and ponds have been termed "off-channel" habitat. Many of these high quality habitats have been degraded or permanently lost by diking, urban development, agricultural activities, logging, road building, and dams. Restoration of these areas can improve survival throughout all freshwater life history stages.

Work began immediately to identify project options and implement construction. A comprehensive inventory of previously undocumented off-channel habitats on each of the river systems was also initiated. The purpose of the inventory was to carefully describe habitat areas that were not included in the Washington Department of Fisheries Stream Catalog (Williams et al., 1975) and other major surveys. Once identified and compiled into an easily accessible database, these areas could be better managed for protection by various watershed managers and to complement the WDFW Hydraulic Project Approval permit process.

Since 1987, there has been increased recognition that many wild salmonid species use the "off channel" habitat targeted by this program. This understanding has led SSHEAR to implement a variety of similar habitat enhancement projects throughout Washington, such as spawning channels for depressed chum salmon stocks in the lower Columbia River. However, most habitat enhancement work is still focused on coho and other wild salmonids in the North Coast and North Puget Sound, with smaller efforts in central and south Puget Sound and the lower Columbia River. Benefits from these projects accrue to total ecosystem health. Habitat work is an important component to the recovery of wild salmonid stocks. These efforts supplement the fish passage and screening work of SSHEAR.

Wild salmonid recovery efforts received further attention in 1992 in North Puget Sound watersheds when coho salmon were listed as "depressed" in the 1992 SASSI report (WDF et al., 1993). The listing further supported enhancement of high quality habitats to aid in stock recovery.

The high value of small stream and off-channel areas to coho was recognized as early as 1948 through 1958 in work on the Wilson River in northern Oregon (Skeesick, 1970). Additional work on the north coast of Washington by Cederholm and Scarlett (1981) and Peterson and Reid (1984) further demonstrated the value of off-channel winter refuge habitats in the Clearwater River. They demonstrated that 20% to 35% of the total coho smolt production came from these areas.

Additional investigations in Canada by Tschaplinski and Hartman (1983), Foy (1985), and Brown and McMahon (1987) further confirmed these habitat preferences by juvenile coho and the value of off-channel project types to increasing production. Nickelson et al., (1992) have also concluded that off-channel habitat development has the highest potential for increasing wild coho salmon production in Oregon coastal streams. High quality off-channel habitats have not only been found to improve juvenile freshwater survival but lead to faster growth rates and larger size, increasing marine survival (Bilton et al., 1982).

The performance of projects constructed by SSHEAR has been evaluated at selected sites by monitoring summer juvenile use, smolt production, spawner use, and observation of overall project function. Evaluation results are described below for each respective area. Construction methods are also continuously monitored to learn where techniques can be improved. Identifying, designing and permitting these projects entirely within Lands and Restoration Services using a team approach of biologists, engineers, and construction staff greatly increases efficiency and reduces costs.

Recovery of these depressed stocks and all stocks in general will lead to greater watershed health and productivity. Increased escapements will require modifications of land use activities that improve water quality, runoff rates and preserve habitat. Recent work by Bilby et al., (1996) has further shown the carcasses of returning coho spawners can contribute significantly to the nutrient supply and composition of riparian vegetation and rearing juvenile salmon. This finding demonstrates the role these fish play in nutrient cycling and ecosystem function.

NORTH SOUND

ABSTRACT

Major project work completed during 1999 included replacement of two and permanent removal of a third culvert on Schoolyard Creek on the North Fork Stillaguamish River, a culvert replacement on Lornezan Creek on the Skagit River and fishway construction at the outlet of Lake Bosworth, a WDFW owned access site. We also added additional gravel to the Harrison Pond project increasing the spawning habitat enhanced in prior years. All these sites were SSHEAR projects.

We continued spawner surveys and smolt trapping to monitor production at projects completed in previous years. Mean annual smolt production for all projects combined has been 0.44 smolts per square meter at Stillaguamish and 0.36 smolts per square meter at Skagit sites. Although the difference in smolt production between the basins is not statistically significant, Skagit rates may be less because several projects with large pond complexes (i.e., Barnaby/Harrison) have not yet fully cycled up in production (and may never achieve the production rate of smaller sites since not all of the open water area is likely used by juvenile fish). Mean coho spawner densities per

square meter of available spawning area has been higher on the Skagit projects but also not at a level that is statistically significant. Higher Skagit spawner densities may reflect the greater area of specifically designed spawning habitat we have built in this watershed.

Based on mean smolt production from selected sites trapped since 1988 it is estimated that the 21 Skagit projects completed in this program may currently be producing 175,207 smolts annually. This represents about 18% of the estimated wild Skagit coho production averaged over the years 1990-1998 (D. Seiler, Washington Department of Fish and Wildlife, Fish Management Program, unpublished data). Similar evaluation at Stillaguamish sites indicates all 18 projects in this basin are capable of producing 142,448 smolts or 38% of that watershed's estimated production each year based on mean production estimates 1979-1981 (D. Seiler, Washington Department of Fish and Wildlife, Fish Management Program, unpublished data).

The total area enhanced in North Sound now totals about 855,808 square meters. These are stable high quality habitat areas largely exempt from detrimental environmental fluctuations normal to most streams. They will serve to increase and stabilize coho and other salmonid production in these river basins.

Field surveys to record previously undocumented habitat and identify possible enhancement project sites have been about 95% completed in the Skagit River and 10% on the Stillaguamish River. A number of potentially valuable projects have been identified that have been scheduled into a five-year planning cycle.

HABITAT INVENTORY

One of the major products SSHEAR's North Sound program will be a thorough inventory of the previously undocumented off-channel habitat in the Stillaguamish and Skagit river basins. In the past off-channel habitat inventory information has not generally been included in the WDFW Stream Catalog (Williams et al., 1975) or work of other survey studies such as Johnson (1986). The new information collected is being entered into a database developed within the SSHEAR Division and will be available for all resource managers on request. This database is constructed to accommodate entry of earlier information collected in this program in a different format with minimum effort. The new storage and retrieval system will allow this habitat information to be easily accessed and incorporated into land use decisions, plans and practices so these areas can receive the highest level of protection possible. Additionally, inventory information will continue to be used to identify potential habitat enhancement projects.

The inventory effort began in 1989 and has continued through 1999. Techniques used are similar to those developed by the North Coast program. U.S. Geological Survey topographic maps are used to split each river system into convenient reaches for surveys with break points at principal river meanders and other topographic breaks . Each reach is numbered starting at the mouth and moving upstream. Within each reach, each site inventoried is coded as to river, reach, bank (L or

R), and its sequential number examined in that reach. Therefore, a typical code might be "SK-7-LB3" denoting site number 3 (the third site examined) in reach number 7 on the left bank of the Skagit River..

Documented habitat areas such as the Stream Catalog are used to identifying associated or nearby undocumented areas. Aerial photos and topographic maps are then used to identify prospective sites not previously described. In the field, the prospective areas are examined for habitat type and value and the immediate area searched for habitat not visible on aerials and maps. All undocumented area providing habitat for coho and other salmonids is then surveyed and mapped. Variables measured are shown on the sample field form in Attachment 1. The completed field form, site specific drawn maps, and associated copies of topographic maps and aerials are then retained in hard copy files. Currently, only the field form is entered into the database. In the future, the other file information may be scanned and stored in a digital format.

We estimate that about 90% of the previously undocumented habitat in the Skagit system has now been covered by the inventory and about 10% of the Stillaguamish. We expect to complete the Skagit by early 2001.

ENHANCEMENT PROJECT IDENTIFICATION

Our intensive habitat inventory work identifies a number of enhancement project sites. We also find possible projects from general review of aerial photos and foot surveys in likely locations. Aerial flights have also been helpful in locating opportunities, especially where access may be limited. Both fixed-wing and helicopters are used. References from other professional biologists in the field have been helpful as well in locating potential opportunities. Special experience is often required to identify more elusive project opportunities such as ground water channel sites. Listings of habitat enhancement options are then annually ranked by potential habitat gain and fish production, level of design difficulty and construction, landowner considerations, expected project life, cost and related factors. Listings are dynamic with new possibilities continually being added and others dropped. Many sites require several years of review and field checking to determine feasibility.

The highest priority sites are usually studied for at least a year to verify limiting production factors and to gather site specific data required for design and construction considerations. Only projects with high long term production potential are actually built. Each project constructed requires considerable planning time, surveying, flow monitoring, data gathering and evaluation and design development. We have recently moved into a five- year project construction planning cycle to provide needed time for these activities. All project development aspects have evolved to require more lead time.

METHODOLOGY

Enhancement Project Evaluation

Fish production evaluation efforts are designed to determine pre and post project conditions. Pre project evaluation work is conducted to determine existing conditions and learn if habitat enhancement work can be effective in improving productivity. Post project work is conducted to verify that an enhancement project functions as designed.

We use adult coho spawner surveys in addition to juvenile coho immigrant and smolt emigrant trapping at some proposed and completed project sites to evaluate performance. These efforts measure project use at key life history stages and ultimately record project effectiveness.

Evaluation work has required considerable effort during fall and spring each year since program inception. The accumulated data have become useful in identifying key habitat features and functions which are required to make a project most successful.

We conduct spawner surveys about every 10 days at key project sites to accurately measure total fish days use. Fish days use is the best way to summarize a season of spawning activity. Fish days use for coho can be converted to total spawners by dividing days use by 14, the average life of a coho spawner on spawning areas (Baranski, Washington Department of Fish and Wildlife, Fish Program, personal communication). Similar use can be calculated for other species such as chum salmon. Less frequent spot surveys at prospective sites are usually made to determine whether there is any spawner use or access. Spot surveys are also used to confirm an older project continues to function without problems. All spawner survey data are on file with this program as well as included in the WDFW Fish Program database.

Trapping methods and materials are similar to those used on the North Coast program. Both one and two-way traps are used (enabling enumeration of both up and downstream migrants) depending on the level of desired evaluation. One-way traps are installed with large mesh screens to capture emigrating smolts only. The large screen mesh allows both emigrant and immigrant 0 age fish to pass through reducing workload of the trap check team and severe predation problems at some sites. Two way traps are fitted with a division board to separately capture, count and separate differentially moving fish.

Trapped fish are anesthetized briefly for handling, measured and/or marked, allowed to fully recover and passed in the direction of their migration. A systematic sampling scheme is used to reduce number of fish handled and to speed the process, avoiding unnecessary handling stress. Adult traps are sometimes installed in conjunction with juvenile traps to accurately determine extent of on-site spawner use (especially where spawner surveys would be time consuming or difficult) or to coordinate with hatchery management programs where broodstock needs to be captured.

Minnow trapping is another method used to evaluate juvenile coho use at prospective project sites. Minnow trapping provides an easier and more economical method than migrant trapping, especially when only qualitative information is needed. Traps are typically baited with salmon eggs and allowed to fish for a few hours up to several days depending on initial catches and expectations of population size. Fish are unharmed by this sampling method.

We evaluate every project at some level to verify its function and performance. Extensive evaluation, however, must be restricted to a few key sites where funding is available and practical. Some sites, for example, cannot be trapped in spring or fall because they are frequently back-watered by high river stages in those seasons. Access to other sites for complete spawner surveys and spring trapping can also be limited by snow. Project evaluation, however, is an essential part of our enhancement effort and will continue throughout the life of this program.

RESULTS

North Sound project sites are shown on the map in Figure 1. A list of North Sound projects completed from 1991 through 1999 is found in Table 3.

Fish Production

Smolt production and spawner use has been summarized in Table 4. Site specific smolt and juvenile trap data are shown in Table 5. Some of the trap information precedes the current program. Since Table 5 does not show when and where habitat modifications were made at some sites, production rates in later years does not reflect earlier conditions at these locations. Please contact the Division before using any of this data and for specific questions or needs. Site specific spawner use data are extensive and not included in this report.

Smolt production among all projects measured has varied widely from 0.01 to 2.09 fish per square meter of habitat. Spawner use has also varied greatly among sites, ranging from 0.007 to 0.343 spawners per square meter of available spawning area. Several sites have no “inside” spawning capability and have served as rearing areas only.

Mean smolt production for the Stillaguamish projects in their current condition has been 0.44 smolts per square meter, about 22% greater than the Skagit projects at 0.36 smolts per square meter. Although the difference is not statistically significant, higher production rates on the Stillaguamish may reflect the smaller sized projects in that basin. Smaller sites tend to cycle up in production more quickly and are more likely to be adequately seeded every year. Except for the upper South Fork, the Stillaguamish is also more likely better escaped with spawners than the Skagit, providing more fish to use enhanced habitat areas. Several of the Skagit projects are very large and will require more time to be fully productive.

The high variability in smolt production both within and between project sites (Table 5) over the period of record reflects wide ranges of escapements during this period coupled with many other variables we do not fully understand and are difficult to measure. Severe floods in some years, for instance, have had an effect on spawner and consequently juvenile fish distribution in the watershed. Inter-species behavior between coho and chum spawners may also alter coho distribution patterns in some places at times. Homing is imprecise and juveniles imprinted to a project site may return as adults to adjacent areas rather than the project. Minor homing differences could be exacerbated by small annual variations in flows, temperatures or other water quality factors that may attract or discourage spawners from specific enhancement sites. Projects located high in the watershed may not as reliably recruit juveniles if on-site or upriver spawning is low. Unintentional selective fisheries, especially in depressed stocks, could also impact the return to segments of the river that may include a project site.

Comparing smolt production of sites with large pond areas to those with small or no such area (i.e. groundwater channels) may be inaccurate because we do not believe all of a large pond is used by rearing juveniles. It is unlikely much of the central open water area is contributing to production yet it is entered into the production "per square meter". However, we do not yet have a documented method of knowing the "effective" habitat area to compare sites equally.

Several spawning cycles may be needed for some of these high quality enhancement sites to demonstrate the stability in production levels they can provide. The Hazel site on the Stillaguamish, however, seems to already be demonstrating this value. Figure 2 shows that when there was a significant drop in basin escapement the site was able to keep producing smolts at near its maximum rate. Gold Basin, by contrast, has shown the more typical pattern of tracking escapement closely (Figure 3) in spite of its demonstrated ability to produce fish at a high rate (Table 5).

Figure 4 demonstrates the progressive cycling up of a large project (Newhalem) on the Skagit. It also shows how a single large project can make a significant contribution to basin production. In five years of project life, it had come to capture almost 5% of all Skagit spawners based on WDFW spawning escapement estimates. Spawner use or proportion of the available escapement should level off at a high rate and remain relatively constant as multiple cycles of spawners home on the project. This type of stability reflects the protection enhanced habitats have from the ravages of winter flooding and summer stranding mortality typical of most streams and unprotected areas.

Mean spawner density per square meter of available spawning area has been higher in the Skagit (0.39 per square meter) than the Stillaguamish (0.08 per square meter). The Skagit mean has been strongly influenced by the ground water channel projects in that drainage that don't exist in the Stillaguamish. Additionally, the channel projects have received high spawner use immediately after construction. No channel opportunities have been identified in the Stillaguamish. Spawning habitat constructed in the Stillaguamish has only been as part of off-channel pond development and access.

Applying the mean Skagit smolt production figure to all Skagit projects indicates a production potential of 175,207 fish annually or 18% of the total basin production based on nine years of scoop trap data from 1990 to 1998 (D. Seiler, Washington Department of Fish and Wildlife, Fish Management Program, unpublished data). A similar smolt production estimate for all our Stillaguamish projects using the mean value indicates our sites are potentially able to contribute 142,448 smolts or about 38% of the total basin production. This is based on three years of scoop trap data from 1979 to 1982 covering a wide range of parent broods from 9,000 to 36,000 spawners (escapement goal of 18,000) (D. Seiler, Washington Department of Fish and Wildlife, Fish Management Program, unpublished data). All project area, however, is not equally productive and several of the large pond projects will never likely produce fish at the average rate. Some large sites such as those on the upper South Fork Stillaguamish will probably always be limited by low escapements that will keep their production low on a square meter basis.

Where possible, we are making efforts to improve smolt production at sites where yield has been less than the basin average. Additional excavation work at County Line Ponds in 1996, for example, was designed to improve ground water flow and attractiveness to both juveniles and adult spawners. In part, this work may have been responsible for the eight fold increase in smolt production measured in 1998. Continued trapping over the next several years will evaluate this higher production rate further. We are also continuing to expand the area for inside spawning at several sites to help insure full project seeding with juveniles by attracting a sufficient number of adults. Additionally, we closely monitor our projects with fishways to insure they function properly and conduct needed maintenance quickly. And although beaver dams can be strong habitat assets, they can seriously hinder fish access to project sites and are regularly removed or modified as needed.

However, critical physical attributes of several projects cannot be easily modified and their performance will vary widely over time. Two examples are Cascade Millpond and Marsh Pond that seem to rely on average or better water years to have sufficient outflow for fish attraction.

Production at the upper South Fork Stillaguamish projects, upstream of the canyon reach, may always be lower than the rest of that basin and never achieve the basin mean value. The Granite Falls Fishway has seldom performed well and passage through the canyon upstream will always remain difficult and flow dependent. Structural modifications and improved management of the fishway in the next few years may soon, however, improve its ability to pass spawners. A favorable rainfall pattern in spring and summer, though, will likely continue to be the major factor determining fish passage at both the fishway and in the canyon with its steep falls and cascades. Loss of several sequential year classes from canyon blockages in the early 1990's will also slow stock recovery in the upper watershed.

Predation is probably another factor limiting production at some sites in ways we cannot control. Carey’s Slough, for example, is a large slough complex on the lower Skagit heavily populated with spiny ray piscivores. Tracking marked fish from one trap at the upper end of the slough to another at the outlet showed considerable loss presumably due to predation. In spite of the high

habitat diversity of the slough and seemingly adequate escape cover, fish are lost at a high rate probably from predators that actively seek them in their outward migration. Replacement of the impassable culvert at the mouth of Little Carey's Creek, a small slough tributary, may help by providing additional spawning and rearing area largely free of these predacious fish. Where avian and mammal predation seemed to be significant (perhaps in addition to piscivores), we have attempted to provide adequate escape cover in the form of complex submerged woody debris. Adding debris, however, is usually expensive, difficult and not always accepted by landowners. Because predation can almost totally negate the value of an otherwise good project, we consider its importance in all project planning and implementation. But predation is another factor that may prevent a site from performing at a high rate.

One important production feature we have not evaluated is the contribution some projects are very likely making to pre smolt parr which move out of upper river sites to finish rearing in downstream areas. These are additional parr to the system which help seed existing slough and off-channel habitat. An intensive year-around evaluation of a channel project in Canada (Foy, 1985) found this contribution to be significant. Since some sites produce fry substantially in excess of numbers required to fully seed available rearing area on the project, we believe the excess juveniles do emigrate downstream and contribute to system-wide production. We have not, however, had sufficient resources to study this behavior intensively. We strongly suspect, however, that this is a major occurrence at our Constant Channel site. Electrofishing estimates of the early summer and early fall parr population made in 1994 and 1995 found the site to be fully seeded. However, smolt production the following years was much lower than expected. Since predation did not seem to be a problem and water conditions through winter were excellent, we have assumed the parr moved out of the project in late fall possibly to avoid the aggressive activity of adult spawners. It may also have been a residual response from pre project conditions when flows at the site went intra-gravel every summer. Late summer and/or fall emigration may have been an evolved response to successfully deal with the stranding problem. This may be especially true because there is an extensive natural high quality rearing slough area a short distance downstream at the mouth of the Suiattle River. Late fall recruitment of downstream migrating juveniles to replace those that leave may not occur here since there is little coho spawning upstream and the steep gradient location of the project in the Sauk River prevents fish from easily finding the small project outlet. For Constant Channel, smolt production may not be a good measure of project performance. Ensuring adequate adult escapement may be sufficient for good production.

Another enhancement feature our projects provide which has not been measured is the availability of off-channel areas for short term residence of emigrating smolts . We know smolts seek these areas during their spring migration for temporary rearing, moving into them for refuge until they are physiologically ready for seaward migration and then leaving. The greater availability of this temporary refuge habitat provided by our projects likely increases size and survival of those pre smolts and smolts fortunate enough to find them.

Although project evaluation through smolt trapping has limitations, it will in combination with spawner surveys continue to be the easiest and most comparative method to judge site performance and productivity. Evaluation efforts at specific projects will need to done over several years, at least, to average different escapement levels, weather patterns and fish behaviors. Smolts, though, should be considered only one measure of project site productivity not the total basis for project comparison. Unfortunately, year-round trapping and extensive marking and tracking of fry and pre smolts to accurately ascertain exactly how different habitats and project types are used in various areas of the watersheds is beyond the scope of this program.

Overwinter Survival

Trapping and marking a sample of fall recruits at the Hazel site, with subsequent enumeration the following spring, has consistently shown overwinter survival to be near 50%. Nearly identical figures have been found at Rowan and Harrison Pond. We believe this survival rate to be indicative of other quality off-channel pond sites and a considerable improvement over the 10-30% estimated survival [Tschaplinski and Hartman (1983), Groot and Margolis (1991)] for fish unable to access this type of off-channel habitat. In addition to increased freshwater survival, accelerated growth of pond reared coho produces a larger smolt and increases the probability of marine survival (Hartman and Scrivner, 1990).

1999 PROJECT CONSTRUCTION

Stillaguamish River Basin

The following two fish passage projects were completed along with the School Yard WSDOT project reported on page 6.

Schoolyard Creek - Timm Project

The next upstream project in this sub-basin recovery effort was the total removal of a private culvert with the associated fill without replacement. The old culvert was extremely undersized and configured so as to present a total fish barrier. Work immediately downstream at SR 530 would not have been justified without addressing this problem also.

The road served by the fill and crossing had generally been abandoned by the landowner who was most cooperative in allowing its removal. The estimated 3,500 cubic yards of soil removed were placed in a stable location adjacent to the site where they were likely originally excavated many years ago. After the old culvert was removed, a new streambed was built through the site to match the existing grade and rock grain size. A substantial amount of base rock was used to provide the needed stability and accommodate future channel meander. The high banks where material was removed were cut to match the existing slopes and then terraced for stability. All exposed areas were heavily planted with native shrubs and trees and covered in jute matting to encourage vegetative recovery quickly. Streambed restoration through the site also included placement of native woody debris anchored into the margins to help recover its value as fish habitat as well as a migration corridor. Financial assistance was provided by the Tulalip Tribe.

Schoolyard Creek - Bergstrom Project
The last project in this sequence was the replacement of a barrier driveway culvert. With excellent cooperation from the landowner, we replaced a failing three feet diameter concrete pipe with an eight feet diameter culvert fitted with welded baffles. The baffles enabled a sloped installation of the pipe reducing the number of downstream weirs to three keeping impact to the private property minimal. The new longer pipe also made for a larger fill prism with stable side slopes and provided a safer wider driveway. Being immediately upstream of the Timm project, work was also needed at this site for a successful recovery effort. A special effort was made to complete all three projects in one season for economy of the construction activity and maximum fish benefit. Financial assistance for the Bergstrom project was also provided by the Tulalip Tribe.

Lake Bosworth Outlet Fishway
Habitat inventory work had discovered the old drum screen structure at the lake outlet that was part of the WDFW Access Area posed a complete blockage to upstream migrating salmonids. Originally, the rotating drum screen had been used to keep planted trout in the lake for maximum fishery recovery but had been removed in the 1970's. The remaining concrete structure served only as a spillway with stop-logs maintained to keep the lake at a stable height for the lakefront properties.

Our project was to design and construct a concrete fishway that was integral to the spillway and maintained the lake level at the existing elevation. Using as much of the old structure as possible, we built a nine step pool and weir fish ladder attached to the side of the spillway. The concrete structure was formed and poured in place. The exit was focused at the overflow from the spillway for maximum attraction. It was sized to accommodate the entire lake outflow as much of the time as possible to eliminate false attraction problems. The spillway was also modified to make ladder entry easier and more assured. Steps between pools were sized to allow easy juvenile passage for maximum colonization potential from downstream spawning.

The fishway work also stabilized and strengthened the old spillway structure ensuring a much longer life without failure.

Skagit River Basin

Lornezan Creek
Permit difficulties with this project were finally resolved in 1998 enabling us to proceed with construction in 1999. This project was a culvert replacement at the confluence of the creek with the Skagit River mainstem. The old culvert crossed under the Dalles-Grassmere Road intersection on a level grade before dropping the stream 12-14 feet to the river creating a total fish blockage. The new installation restored fish access to the entire stream drainage. The new culvert was a 190 feet long corrugated metal pipe set on a 7.4% grade with welded baffles making it effectively a pool and weir fishway. A long steep pipe was needed to not only cross

the road intersection but to meet statute fish requirements for migrating juvenile salmonids over a significant height without allowing any upstream regrade. The project was coordinated with Skagit County, owners of the structure.

Harrison Slough Gravel
We made another significant addition to the spawning area we have been building at the upper end of the slough. Gravel we previously placed had been well used indicating additional area would help provide more fry to help seed this off-channel enhancement site. Spawning area must be added since little natural spawning habitat is available (the slough is predominately a ponded area). Although this project site is of high quality, it is located far off the main river channel and will require its own imprinted spawner population for maximum benefit.

SCHEDULED PROJECTS FOR 2000

Stillaguamish River Basin

Pilchuck Creek
We have been working cooperatively with a private homeowners association to replace two failing barrier driveway culverts on each of two tributary streams immediately above their confluence. Some preliminary downstream work with bed controls has been completed by Adopt-A-Stream Foundation and this work will complement and finish the task of restoring durable and efficient upstream fish passage. Each of the existing three feet diameter pipes will be replaced with six feet diameter pipes of greater length to accommodate stable side slopes less subject to fail. The new pipes will also be set at level grade to allow natural streambed establishment throughout making for maximum habitat recovery. The large culverts will not only meet or exceed required hydraulic capacities but be sufficiently large for easy physical entry to remove debris do any other maintenance.

Skagit River Basin

Illabot 2
High fish use of our current Illabot Channel project built in 1995 and the presence of abundant ground water in the area led us to develop an expansion that would fork off the current site. About 1,400 feet of additional channel will be constructed east of the existing channel. The new project will cross the high tension power line right-of-way. All activity will be entirely on Seattle City Light property. Project design will be nearly identical to the existing project with some minor improvements we made at the Taylor Channel. As with both projects, deeper cover trenches with secured woody debris will be inter-spaced with predominately gravel sections for a productive combination of spawning and rearing area to accommodate needs of both chum and coho salmon, the target species.

Barnaby 3
The Barnaby 2 project in 1998 removed rip rap from the left bank of the mainstem near Barnaby Slough to restore unobstructed flow down a natural side channel returning it to productive salmonid spawning and rearing habitat. The Barnaby 3 project will remove additional rip rap from the river bank nearby to further enhance side channel flow and better encourage natural river and channel forming function and process.

PROJECTS PROPOSED FOR 2000 AND FUTURE YEARS

Program planning in the SSHEAR Section has required development of three and preferably five year project plans. This planning has been done for the North Sound Program with firm projects defined through 2003 and tentative projects through 2005. The list will, however, be dynamic to allow unique opportunities to work with available funding sources and landowners such as counties and federal agencies. Habitat inventory work is still not complete and more projects will likely be developed from this effort and help shape future project plans.

Table 3. Completed North Sound projects through 1999.

Project	River Basin	Year Completed	Habitat Benefit	Cost	Landowner
Skagit River Basin					
Newhalem	Skagit River	1991	81,000 m^2	$283,000[a]	Seattle City Light
County Line Ponds	Skagit River	1991, 1996	22,000 m^2	$114,000[a]	Seattle City Light
Cascade Park	Cascade River	1991	2,030 m^2	$14,764[a]	Cas. Park Assoc.
Cascade Mill	Cascade River	1989	7,000 m^2	$27,200[b]	Cramer
Barnaby Slough	Skagit River	1995	26,302 m^2	$41,490[a]	WDFW
Harrison Pond	Skagit River	1990	141,600 m^2	$68,120[c]	Seattle City Light
Harrison Pond	Skagit River	1995	141,600 m^2	$100,000[a]	Seattle City Light
Illabot Channel	Skagit River	1995	1,672 m^2	$160,377[a]	Seattle City Light
Constant Channel	Sauk River	1991	2,800 m^2	$130,000[a e]	USFS
Suiattle Slough	Suiattle River	1988	3,120 m^2	$68,270[c]	Wash. DNR
Careys[d]	Skagit River	1986	169,000 m^2	$15,240[b]	City of Hamilton
Little Careys	Skagit River	1991	1,920 m^2	$13,400[a e]	Crown Pacific
Marsh Pond	Suiattle River	1992	3,800 m^2	$32,000[a e]	USFS
Boundary	Suiattle River	1994	830 m^2	$41,092[a e]	USFS
Park Slough Ext.	Skagit River	1992	1,400 m^2	$78,000[a]	NPS
Grouse Marsh	Cascade River	1996	13,150 m^2	$101,214[a]	USFS
O'Brian Slough	Illabot Creek	1998	300 m^2	$30,575	Seattle City Light
Barnaby 2 Slough	Skagit River	1998	2,868 m^2	$10,612	WDFW
Harrison Slough	Skagit River	1998	200 m^2	$11,907	Seattle City Light
Taylor Channel	Skagit River	1998	5,694 m^2	$437,260	USFS
Lornezan	Skagit River	1999	18,000m^2	$118,139	Skagit County
TOTAL SKAGIT BASIN			504,686 m^2		
Stillaguamish River Basin					
Granite Falls	S.F. Stillaguamish R.	1988,93	17,900 m^2	$20,880[b]	McEwen, Ind. Hills Community Park
Rowen Pond	N.F. Stillaguamish R.	1992	4,000 m^2	$38,300[c]	Charley
Hazel Pond	N.F. Stillaguamish R.	1987	9,580 m^2	$17,280[c]	Snoh. County

Project	River Basin	Year Completed	Habitat Benefit	Cost	Landowner
Forts on Ponds[d]	N.F. Stillaguamish R.	1989,90,92,93	47,180 m^2	$3,585[b]	Grandy Lake F.A.
Gold Basin	S.F. Stillaguamish R.	1989	5,000 m^2	$51,710[b e]	USFS
Stilly Canyon	S.F. Stillaguamish R.	1994	60 miles	$34,523[a]	Hancock
Oso Pond	N.F. Stillaguamish R.	1994	32,368 m^2	$31,382[a]	Snoh. County
Spring Cr. Culvert	S.F. Stillaguamish R.	1994	32,300 m^2	$21,518[a e]	Snoh. County
Spring Cr. Dikes	S.F. Stillaguamish R.	1993	32,300 m^2	$43,500[a]	Folker, Wheatley
Kackman Creek	Stillaguamish R.	1993	1,920 m^2	$15,500[a e]	Klein
Rowen Creek	N.F. Stillaguamish R.	1995	156 m^2	$49,193[a]	Phillips
Forts on Ponds[d]	N.F. Stillaguamish R.	1995	200 m^2	$11,593[a]	Grandy Lake F.A.
Big Four Creek	S.F. Stillaguamish R.	1995	220 m^2	$5,360[a]	USFS
Marsh Creek	S.F. Stillaguamish R.	1993	100,000 m^2	$93,200[a e]	Snoh. County
Trout Creek	S.F. Stillaguamish R.	1996	28,000 m^2	$99,186[a]	Snoh. County
Jordan Creek	S.F. Stillaguamish R.	1996	400 m^2	$7,302[a]	Lundberg
Trout Farm Creek	S.F. Stillaguamish R.	1996	200 m^2	$3,651[a]	Brenner
Mud Lake	S.F. Stillaguamish R.	1997	500 m^2	$22,870	Hancock
Dazzling Howie	S.F. Stillaguamish R.	1998	1,247 m^2	$126,374	Snoh. County
WF Church Creek	Stillaguamish R.	1998	42,514	$17,101	Wash. DOT
Schoolyard DOT	N.F. Stillaguamish R.	1999	2,377	$360,289	Wash. DOT
Schoolyard Timm	N.F. Stillaguamish R.	1999	Incl. w/ Sch. DOT	$59,883	Timm
Schoolyard Bergstrom	N.F. Stillaguamish R.	1999	Incl. w/ Sch. DOT	$54,897	Bergstrom
Lake Bosworth	S.F. Stillaguamish R.	1999	25,000m^2	$144,020	WDFW
TOTAL STILLAGUAMISH BASIN			351,122 m^2		
TOTAL NORTH SOUND			855,808 m^2		

[a]Cost figure includes design, development, construction and post project evaluation as recorded by WDFW accounting system (AFRS) which began in 1991 for individual projects.
[b]Cost figure developed from methodology of Sekulich (1991) which approximates AFRS closely for work completed before 1991.
[c]Cost figure is a combination of AFRS and Sekulich (1991) because portions of the project were completed before and after 1991.
[d]Only that portion of the project completed in this program is included.
[e]Project cost shared with another contributor(s).

Table 4. Summary of project performance where evaluation trapping and spawner surveys have been conducted since 1986.

Project Site	WRIA	Area (m^2)	Current Production		Comments
			Mean Annual Smolts/m^2 [1]	Mean Annual Spawners/m^2 [2]	
SKAGIT RIVER BASIN					
Suiattle Slough	03.0710A	3,116	1.14	0.108	The strong perennial flow, excellent spawning areas, and recent improvements in fishway attraction function to seed a large ponded area with excellent cover for juvenile rearing.
Cascade Millpond	03.1411B	7,050	0.05	0.23	Outflow has dropped significantly since construction (during recent six year drought) decreasing ability of site to attract both spawners and juveniles.
Careys Slough	03.0354	169,000	0.11	0.337	Large fish predator population will not likely allow this site to produce smolts at a higher level. Additionally, incidental catch of coho during in-river steelhead fishery may be reducing numbers of inside spawners.
Barnaby Slough	03.1343	72,800	0.14	No estimate available	Production from site with temporary access. Formal fishway built in 1995 should help improve production by providing efficient assess.
Harrison Pond	03.1340	140,000	0.03	No estimate available	Poor fishway attractiveness and denial of spawner entry have led to low production levels. Changes in management of the site and a new fishway constructed in 1995 now provide free spawner access and improved juvenile attraction.
Constant Channel	03.0111A	2,350	0.18	0.090	Trapping problems have not allowed an accurate smolt production estimate. Additionally, low flows as a consequence of recent drought since construction have likely reduced potential smolt production. Preliminary late summer evaluation suggests pre-smolt parr contribution to downstream areas may be significant (4.1 parr/m^2).
Boundary	03.0710H	830	0.19	2.0	Inside spawning area built in 1995 and 1996.
Marsh Pond	03.0807	3,800	0.05	no inside spawning areas	Recent drought since construction has reduced flows below acceptable levels for significant smolt production. The site will always be naturally flow dependent. Pre-project production from years when fish had temporary access indicated site is capable of smolt production in range of 0.5-0.8/m^2.
Park Slough	03.1859A,B	4,400	1.03	0.031	Perennial ground water channel provides excellent spawning and rearing habitat.
County Line Ponds	03.1853B	22,250	0.33	0.261	Additional pond excavation in 1996 improved outflow and fish production.
Newhalem Ponds	03.1864A	81,000	0.19	0.076	Not all of the large pond area is likely contributing to site production.
TOTAL and MEANS (w/ 95% C.I.)		506,596 m^2	×=0.31 ±0.26	×=0.39 ±0.56	
STILLAGUAMISH RIVER BASIN					
Forts on Ponds	05.0254A	47,180	0.27	0.343	Spawning area additions in 1995 will likely boost pre smolt production seeding downstream areas but smolt production may not change given its stable level over a number of years.
Gold Basin	05.0401A	5,000	0.53	0.007	Project is very productive when upper South Fork has had an escapement.
Granite Falls	05.0358C	17,900	0.10	0.009	Production has varied considerably over 5 years of evaluation possibly being influenced by large fish predator population.
Rowen	05.0220A	4,000	0.88	0.026	Spawning area expansion and stream rehabilitation in 1995 should increase production in 1997 and future years.
Hazel	05.0228	9,584	0.46	0.024	Production has been constant over evaluation period.
TOTAL and MEANS (w/ 95% C.I.)		83664 m^2	×=0.53 ±0.36	×=0.08 ±0.18	

[1] Mean values for years of record with project in current design configuration.

[2] Per square meter of available spawning area. Mean value for years of record available for each site with inside spawning capability. Spawner density derived from fish days use assuming a spawner life of 14 days.

Table 5. Summary of juvenile coho migrant trapping at 17 off-channel habitat enhancement project sites on the Skagit and Stillaguamish River basins from 1985 to 1999.

Season	Trap Site	RM	Area	Total Ups	Mean Length UPS (SD) [N]	Total Downs [a]	Mean Length Downs (SD) [N]	%Change Length	Out migrant/ m^2	Out migrant / acre
SKAGIT										
1986-87	Suiattle	2.0[b]	3116 m^2	---[p]	---	3054	95 mm (10.0)[149]	---	0.98	3966
1987-88	Suiattle	"	"	80	---	1396	104 mm (19.6)[508]	---	0.45	1821
1988-89	Suiattle	"	"	116[c]	80 mm (13.1)[72]	2041	100 mm (11.6)[1732]	---[t]	0.65	2630
1989-90	Suiattle	"	"	---	---	2006	96 mm (16.4)[1936]	---	0.64	2589
1992-93	Suiattle	"	"	---	---	3314	89 mm (17.2)[843]	---	1.06	4289
1993-94	Suiattle	"	"	---	---	3656	91 mm (20.2)[1275]	---	1.17	4734
1994-95	Suiattle	"	"	---	---	3742	89 mm (12.9)[555]	---	1.20	4855
1993-94	Boundary Cr.	11.75	830 m^2	---	---	208[au]	101 mm (7.3)[192]	---	0.25	1014
1994-95	Boundary r.	"	3138 m^2	---	---	115	110 mm (12.5)[74]	---	0.04	162
1995-96	Boundary Cr.	"	"	---	---	400	98 mm (10.0)[180]	---	0.13	516
1996-97	Boundary Cr.	"	"	---	---	770	96 mm (12.0)[235]	---	0.25	993
1997-98	Boundary Cr.	“	“	—	—	967	94 mm (9.2([315]	—	0.31	1246
1998-99	Boundary Cr.	“	“	—	—	427	108mm(12.0)[290]	—	0.14	551
1989-90	Cascade Mill	1.5[w]	7050 m^2	---	---	496	---	---	0.07	283
1990-91	Cascade Mill	"	"	---	---	260	---	---	0.04	162
1991-92	Cascade Mill	"	"	---	---	337	106 mm (no data)[no data]	---	0.05	202
1992-93	Cascade Mill	"	"	---	---	74	? (no data)[no data]	---	0.01	40
1998-99	Cascade Mill	“	“	—	—	638	119mm(8.9)[297]	—	0.09	366

Table 5. (continued) Summary of juvenile coho migrant trapping at 17 off-channel habitat enhancement project sites on the Skagit and Stillaguamish River basins from 1985 to 1999.

Season	Trap Site	RM	Area	Total Ups	Mean Length UPS (SD) [N]	Total Downs [a]	Mean Length Downs (SD) [N]	%Change Length	Out migrant/ m^2	Out migrant / acre
1985-86	Careys	39.2	169000 m^2 [v]	---	---	3725	---	---	0.02	81
1986-87	Careys	"	"	---	---	5488	---	---	0.03	121
1987-88	Careys	"	"	1579	---	6432	111 mm (11.0)[506]	—	0.04	162
1988-89	Careys	"	"	3473	80 mm (10.6)[1481]	2636[f]	100 mm (10.4)[1441]	---[t]	0.02	81
1989-90	Careys[n]	"	"	6023[l]	79 mm (8.8)[944]	18730	112 mm (12.8)[3731]	---[t]	0.11	445
1989-90	Upper Careys[s]	"	51708 m^2 [u]	4381[l]	84 mm (8.7)[96]	4165	104 mm (9.3)[2510]	---[t]	0.08	324
1994-95	Barnaby Slough[ay]	68.8	72828 m^2	---	---	12277	107.3 mm (9.4)[1220]	---	0.17	682
1995-96	Barnaby Slough	"	"	---	---	7415		---	0.10	412
1996-97	Barnaby Slough	"	"	---	---	10177	106 mm (13.6)[1597]	---	0.14	565
1997-98	Barnaby Slough	"	"	—	—	3881	109 mm (9.8)[707]	—	0.05	216
1990-91	Harrison	68.8	140000 m^2	665[aa ab]	91 mm (12.0)[576]	2023	121 mm (9.9)[1767]	33%	0.01	40
1991-92	Harrison[an]	"	"	---	86 mm (9.4)[1375][ai]	3379	125 mm (15.0)[2406]	40%[aq]	0.02	81
1992-93	Harrison[ao]	"	"	---	78 mm (12.9)[288][ap]	1301	146 mm (30.0)[265]	58%	0.01	40
1993-94	Harrison[at]	"	"	---	7 4 mm (10.1)[142]	1876	134 mm (28.1)[994]	68%	0.01	40
1994-95	Harrison	"	"	---	---	1973	127 mm (15.3)[308]		0.01	40
1995-96	Harrison	"	"	---	---	4777			0.03	138
1996-97	Harrison	"	"	---	---	1286	106 mm (11.3)[504]	---	0.01	37

Table 5. (continued) Summary of juvenile coho migrant trapping at 17 off-channel habitat enhancement project sites on the Skagit and Stillaguamish River basins from 1985 to 1999.

Season	Trap Site	RM	Area	Total Ups	Mean Length UPS (SD) [N]	Total Downs [a]	Mean Length Downs (SD) [N]	%Change Length	Out migrant/ m^2	Out migrant / acre
1997-98	Harrison	"	"	—	—	3806	109 mm (9.9)[820]	—	0.03	110
1998-99	Harrison	"	"	—	—	5796	107mm(9.1)[776]	—	0.04	168
1990-91	Constant	27.6	1000 m^2 [af]	---	---	48[ac]	87 mm (10.4)[39]	---	0.05	202
1991-92	Constant	"	2350 m^2	---	---	756	88 mm (10.7)[756]	---	0.32	1294
1992-93	Constant	"	"	---	---	450[ax]	69 mm (12.5)[255]	---	0.19	769
1993-94	Constant	"	"	---	---	483	79 mm (12.8)[352]	---	0.21	850
1994-95	Constant	"	"	---	---	381	84 mm (18.1)[151]	---	0.16	647
1995-96	Constant	"	"	---	---	417	83 mm (16.9)[179]	---	0.12	718
1985-86	Marsh Pond and Creek	16.4[am]	5280 m^2 [ak]	---	---	2778[aj]	---	---	0.53	2144
1986-87	Marsh Pond and Creek	"	"	---	---	1799[aj]	---	---	0.34	1376
1987-88	Marsh Pond and Creek	"	"	---	---	1570[aj]	---	---	0.30	1214
1988-89	Marsh Pond and Creek	"	"	---	---	3075[aj]	---	---	0.58	2347
1989-90	Marsh Pond and Creek	"	"	---	---	786[aj]	---	---	0.15	607
1990-91	Marsh Pond	"	3800 m^2 [ak]	---	---	320[aj]	?	---	0.08	324
	Marsh Pond and Creek	"	5280 m^2 [ak]	---	---	337[aj]	?	---	0.06	243
1991-92	Marsh Pond	"	3800 m^2 [ak]	---	---	76[aj]	?	---	0.02	81

Table 5. (continued) Summary of juvenile coho migrant trapping at 17 off-channel habitat enhancement project sites on the Skagit and Stillaguamish River basins from 1985 to 1999.

Season	Trap Site	RM	Area	Total Ups	Mean Length UPS (SD) [N]	Total Downs [a]	Mean Length Downs (SD) [N]	%Change Length	Out migrant/ m^2	Out migrant / acre
	Marsh Pond and Creek	"	5280 m^2 [ak]	---	---	1900[aj]	?	---	0.36	1456
1992-93	Marsh Pond	"	3800 m^2	---	---	12	?	---	0.01	40
1992-93	Marsh Pond and Creek	"	5280 m^2	---	---	996	?	---	0.19	769
1993-94	Marsh Pond	"	3800 m^2	---	---	29	107 mm (8.8)[22]	---	0.01	40
1994-95	Marsh Pond	"	"	---	---	475	130 mm (10.7)[177]	---	0.13	526
1992-93	Park Sl. Old	91.5	3000 m^2	---	---	3430	89 mm (11.1)[1743]	---	1.14	4612
1992-93	Park Sl. New	"	1400 m^2	---	---	2832	89 mm (13.1)[1476]	---	2.02	8173
1992-93	Park Sl. Combined	"	4400 m^2	---	---	6262	89 mm (12.1)[3219]	---	1.42	5745
1993-94	Park Sl. Old	"	3000 m^2	---	---	3441	75 mm (16.0)[3195]	---	1.15	4653
1993-94	Park Sl. New	"	1400 m^2	---	---	1299	74 mm (23.4)[1218]	---	0.93	3763
1993-94	Park Sl. Combined	"	4400 m^2	---	---	4740	75 mm (18.0)[4413]	---	1.08	4370
1994-95	Park Sl. Old	"	3000 m^2	---	---	1235	84 mm (14.4)[1198]	---	0.41	1659
1994-95	Park Sl. New	"	1400 m^2	---	---	1305	94 mm (15.9)[1199]	---	0.93	3763
1994-95	Park Sl. Combined	"	4400 m^2	---	---	2540	89 mm (15.8)[2397]	---	0.58	2347
1995-96	Park Sl. Old	“	3000 m^2	---	---	1284	67 mm (14.5)[1281]	---	0.43	1732
1995-96	Park Sl. New	“	1400 m^2	---	---	2315	70 mm (16.6)[2314]	---	1.65	6690
1995-96	Park Sl. Combined	“	4400 m^2	---	---	3599	69 mm (16.0)[3595]	---	0.82	3309
1996-97	Park Sl. Old	“	3000 m^2	---	---	1951	83 mm (21.5([1945]	---	0.65	2623
1996-97	Park Sl. New	“	1400 m^2	---	---	752	81 mm (13.6)[747]	---	0.54	2185
1996-97	Park Sl. Combined	“	3400 m^2	---	---	2703	83 mm (19.7)[2692]	---	0.80	3237

Table 5. (continued) Summary of juvenile coho migrant trapping at 17 off-channel habitat enhancement project sites on the Skagit and Stillaguamish River basins from 1985 to 1999.

Season	Trap Site	RM	Area	Total Ups	Mean Length UPS (SD) [N]	Total Downs [a]	Mean Length Downs (SD) [N]	%Change Length	Out migrant/ m^2	Out migrant / acre
1997-98	Park Sl. Old	"	3000 m^2	—	—	2168	76 mm (13.2)[2162]	—	0.72	2924
1997-98	Park Sl. New	"	1400 m^2	—	—	1066	78 mm (12.6)[1057]	—	0.76	3081
1997-98	Park Sl. Combined	"	4400 m^2	—	—	3234	77 mm (13.0)[3219]	—	0.73	2974
1998-99	Park Sl. Old	"	2000m^2	—	—	2853	84mm(13.6)[2214]	—	0.95	3848
1998-99	Park Sl. New	"	1400m^2	—	—	1587	80mm(12.7)[1433]	—	1.13	4586
1998-99	Park Sl. Combined	"	4400m^2	—	—	4440	83mm(13.3)[3647]	—	1.01	4083
1992-93	County Line	89.0	22,250 m^2	---	---	447	116 mm (8.3)[187]	---	0.02	81
1993-94	County Line	"	"	---	---	1925	112 mm (9.9)[1891]	---	0.08	324
1994-95	County Line	"	"	---	---	1259	114 mm (9.3)[974]	---	0.06	243
1995-96	County Line	"	"	---	---	2766	98 mm (9.5)[2760]	---	0.12	503
1996-97	County Line	"	"	---	---	1835	99 mm (7.4)[1829]	---	0.08	334
1997-98	County Line	"	"	—	—	16,141	93 mm (6.2)[13,677]	—	0.73	2935
1998-99	County Line	"	"	—	—	3821	89mm(10.7)[1399]	—	0.17	695
1990-91	Newhalem	90.5	1393 $m^{2\,ag}$	---	---	133[ad]	---	---	0.09	364
1997-98	Newhalem[bb]	"	81,000 m^2	—	—	16,453	105 mm (8.9)[1585]	—	0.20	823
1998-99	Newhalem	"	"	—	—	13,616	105mm(11.3)[1138]	—	0.17	680
					STILLAGUAMISH					
1984-85	Fortson Ponds	27.8	47180 $m^{2\,x}$	---	---	16000	108 mm (7.2)[240]	---	0.34	1376
1984-85	Fortson-enhanced channel below ponds	"	3325 m^2	---	---	5913	100 mm (10.6)[347]	---	1.78	7202

Table 5. (continued) Summary of juvenile coho migrant trapping at 17 off-channel habitat enhancement project sites on the Skagit and Stillaguamish River basins from 1985 to 1999.

Season	Trap Site	RM	Area	Total Ups	Mean Length UPS (SD) [N]	Total Downs [a]	Mean Length Downs (SD) [N]	%Change Length	Out migrant/ m^2	Out migrant / acre
1985-86	Fortson Ponds	"	47180 m^2	---	---	7200[g]	112 mm (8.8)[100]	---	0.15	607
1985-86	Fortson-enhanced channel below ponds	"	3325 m^2	---	---	3756	no data	---	1.13	4572
1986-87	Fortson Ponds	"	47180 m^2	---	---	13400	111 mm (21.0)[382]	---	0.28	1133
1986-87	Fortson-enhanced channel below ponds	"	3325 m^2	---	---	6938	96 mm (14.6)[288]	---	2.09	8456
1987-88	Fortson Ponds	"	47180 m^2	---	---	7633[m]	---	---	0.16	647
1988-89	Fortson Ponds	"	47180 m^2	---	---	12992	112 mm (11.6)[4258]	---	0.27	1092
1988-89	Upr Fortson	"	41270 m^2	---	---	11552[h]	113 mm (11.7)[3134]	---	0.28	1133
1988-89	Lwr Fortson	"	5910 m^2	---	---	1440	109 mm (10.7)[1124]	---	0.24	971
1989-90	Gold Basin	49.0	5000 m^2	---	---	---[q]	---	---	---	---
1990-91	Gold Basin	"	"	---	---	1218	107 mm (5.8)[1215]	---	0.24	971
1991-92	Gold Basin	"	"	---	---	2657	103 mm (7.8)[1865]		0.53	2144
1992-93	Gold Basin	"	"	---	---	152[al]	127 mm (7.9)[150]	---	0.03	121
1993-94	Gold Basin	"	"	---	---	767[av]	108 mm (7.9)[763]	---	0.15	607
1994-95	Gold Basin	"	"	---	---	2848	99 mm (7.0)[609]	---	0.57	2306
1998-99	Gold Basin	“	“	—	—	536	104mm(11.3)[289]	—	0.11	434
1988-89	Hazel[i]	22.3	9584 m^2	1054	78 mm (11.9)[511]	3804	108 mm (7.0)[201][r]	38%	0.40	1618
							112 mm (7.5)[633][j]	---		

Table 5. (continued) Summary of juvenile coho migrant trapping at 17 off-channel habitat enhancement project sites on the Skagit and Stillaguamish River basins from 1985 to 1999.

Season	Trap Site	RM	Area	Total Ups	Mean Length UPS (SD) [N]	Total Downs [a]	Mean Length Downs (SD) [N]	%Change Length	Out migrant/ m^2	Out migrant / acre
1989-90	Hazel[o]	"	"	4124	80 mm (13.4)[1282]	4469	111 mm (6.71)[840]	39%	0.48	1942
							110 mm (8.3)[3584][j]	---		
1990-91	Hazel[y]	"	"	2365	84 mm (12.0)[729]	3872[z]	106 mm (7.5)[3155][ah]	---	0.40	1618
1991-92	Hazel	"	"	---	---	4386	106 mm (9.3)[2904]		0.46	1861
1995-96	Oso Pond	13.3	28300 m^2	---	---	3188	99.6 mm (8.6)[454]	---	0.11	456
1996-97	Oso Pond	"	"	---	---	1753	106 mm (9.5)[331]	---	0.06	251
1990-91	Gnite Falls	32.2	17900 m^2	---	---	283[ae]	119 mm (13.3)[283]	---	---	---
1991-92	Gnite Falls	"	"	---	---	1896	109 mm (9.1)[1896]	---	0.10	405
1994-95	Gnite Falls	"	"	---	---	1513	127 mm (9.6)[324]	---	0.08	324
1998-99	Big Four	64.0	3278 m^2	—	—	576	90 mm (11.9)[315]	—	0.18	711
1998-99	Marsh Creek	44.2	100,000 m^2	—	—	244	115 mm (7.5)[231]	—	0.01	10
1987-88	Rowen	20.6	4000 m^2	---	---	1160	90 mm (7.6)[466]	---	0.29	1173
1988-89	Rowen	"	"	967	77 (11.6)[690]	941	101 mm (9.9)[825]	31%[as]	0.23	931
1992-93	Rowen[ar]	"	"	---	82 (9.1)[256][ap]	2376	91 mm (9.7)[802]	11%[as]	0.59	2387
1993-94	Rowen[at]	"	"	---	81 (9.2)[497][ap]	1570[aw]	95 mm (8.6)[914]	17%[as]	0.39	1578
1994-95	Rowen[az]	"	"	---	85 (7.3)[490]	3224	99 mm (8.5)[502]	16%[as]	0.81	3277

Table 5. (continued) Summary of juvenile coho migrant trapping at 17 off-channel habitat enhancement project sites on the Skagit and Stillaguamish River basins from 1985 to 1999.

Season	Trap Site	RM	Area	Total Ups	Mean Length UPS (SD) [N]	Total Downs [a]	Mean Length Downs (SD) [N]	%Change Length [s]	Out migrant/ m^2	Out migrant / acre
1995-96	Rowen[ba]	"	"	---	74 (7.0)[222][ap]	3856	92 mm (9.4)[553]	24%	0.96	3910
1996-97	Rowen[ba]	"	"	492	86 mm (6.2)[167]	6032	98 mm (11.7)[1165]	14%	1.51	6101
1997-98	Rowen	"	"	—	—	2927	89 mm (9.7)[747]	—	0.73	2961

aTotal downs represent juveniles recruited previous fall plus progeny of spawners within the site (which occurred at all projects).
[b]82 miles from mouth of Skagit River
[c]488 downstream migrants were enumerated from 10/19 - 2/13 for a net loss of 372 fish but late trap installation missed undetermined number of early upstream migrants.
[f]Inadequate seal allowed undetermined number of fish to pass uncounted most of spring season.
[g]Trap flooded or leaking significantly only 2 days of season.
[h]Trap flooded with undetermined number of fish passing uncounted 7 days of season.
[i]Pelvic clips (1054) not entirely enumerated in spring to enable survival calculation (clip difficult to see, considerable fin regrowth). 63 downstream migrants yielded (1054-63)=991 net ups.
diseased fish only, presumably progeny of inside spawning (none of the marked fall immigrants showed the disease the following spring); fluke (neascus) not seen at other sites.
represents growth of marked fall immigrants only.
[l]Represents only partial count since trap was inoperable after mid November from frequent flooding and significant immigration likely occurred after this date.
[m]Derived by assuming 68% of total Forts on out migrants (ponds and stream) were attributable to ponds alone. Traps operated simultaneously immediately downstream of the ponds and at lower end of the stream in 1985, '86 and '87 showed pond contribution was 73%, 66% and 66% respectively (mean=68%). Only trap data from lower end of the stream was available (Tulalip Tribe) for 1988.
[n]Overwinter survival was 25% based on marked group (approximately one half of enumerated immigrants). Low survival attributed to large predator population including spiny rays.
[o]Overwinter survival was 44% based on marked group (approximately one half immigrants)
[p]Dashes indicate no trapping was done or data taken was incomplete or unreliable.
[q]Effort to out migrant trap in 1990 failed from freshets overtopping trap. New trap installation design planned for out migrant trapping 1991.
[r]Represents size of out migrants marked as immigrants fall 1988.
[s]This was the first season the upper portion of Careys was separated from the total enumerated. All fish trapped at Upper Careys were released and again enumerated at the lower trap. However, based on several marked groups through the season, only about 43% of the fish released at the upper trap ever appeared at the lower trap suggesting significant mortality presumably from high predation rates.
[t]Percent change cannot be calculated because immigrants were not marked and out migrants measured were a combination of immigrants plus progeny of inside spawning.
[u]This area included within the 169000 m^2.
[v]Wetted area during winter, summer area approximately 125000 m^2.
[w]80 miles from mouth of Skagit River.
[x]Wetted area during summer, the effective or limiting habitat (production at this site is assumed to be reliant on inside spawning only; very little juvenile recruitment is thought to occur during fall through the fishway below the lower pond). Winter area of the large pond is 1.7 times larger; the smaller pond has about the same area year-round.
[y]Overwinter survival was 46% based on marked group which was about one third of fall recruits.
[z]310 1+ coho were upstream trapped from 3/18 to 5/18.

[aa]Dike breached at fishway site by flood waters which could have allowed an undetermined number of juveniles to enter the pond.
[ab]Overwinter survival was 22% based on marked group which was 88% of recruits trapped. 665 recruits trapped does not represent total immigration since some fish entered during fall flooding when trap was submerged and additional fish entered during construction via raceways.
[ac]27567 0+ coho were trapped and electroshocked from this enhancement site in addition to smolts shown in table.
[ad]745 0+ coho were trapped and electroshocked from this 1991 enhancement site in addition to smolts shown in table.
[ae]Represents partial count only since trap not installed until 5/7.
[af]Area before project, area after project is 2350 m^2.
[ag]Area accessible before project, area after project is 81000 m^2.
[ah]Both diseased (Neascus) and non-diseased fish combined.
[ai]The 1375 fish trapped were only a portion of immigrants. Trapping was done only to assess fishway performance. Of the 1375, 818 were marked to evaluate overwinter survival.
[aj]Data from trapping by Skagit System Cooperative.
[ak]Available pond area estimated only, exact area used cannot be determined.
[al]Two year old residuals only, there was virtually no spawner escapement to upper South Fork in 1991 or 1992.
[am]95 miles from mouth of Skagit River.
[an]Overwinter survival was 47% based on marked group.
[ao]Overwinter survival was 50% based on marked group.
[ap]Only a sample of emigrants was trapped and marked for overwinter survival estimate.
[aq]Length change calculation derived by excluding all marks greater than 136 mm which are assumed to be 2+ out migrants based on scale sampling conducted at this site in '93.
[ar]Overwinter survival was 41% based on marked group which may have been low because a large number of juveniles were already in the site as progeny of inside spawning leading to intense competition.
[as]Mean length of marked out migrants was not significantly different than all out migrants enabling accurate calculation based on sample group.
[at]Overwinter survival was 20% based on marked group.
[au]Preproject production before culvert replacement and creation of impoundment.
[av]Production from 1-2 redds located inside the project site which were virtually the only redds located in the upper South Fork in 1992.
[aw]Production was reduced by heron predation on emigrant smolts immediately above the trap.
[ax]Fish leaked from trap and it was sufficiently back watered to be non functional much of the season.
[ay]Preproject enumeration when only juvenile fish were able to access slough area.
[az]Overwinter survival was 48% based on marked group.
[ba]Overwinter survival could not be calculated because the site was back watered during floods of 1995 and 1996 and many of the marked fish are assumed to have left.
[bb]First smolt evaluation since the project was completed in 1991.
NOTE: Mean smolt production for all Skagit project sites in their existing condition is 1457 smolts per acre. Mean smolt production from all Stillaguamish project sites in their existing condition is 1780 smolts per acre. Difference between rivers is not statistically significant.

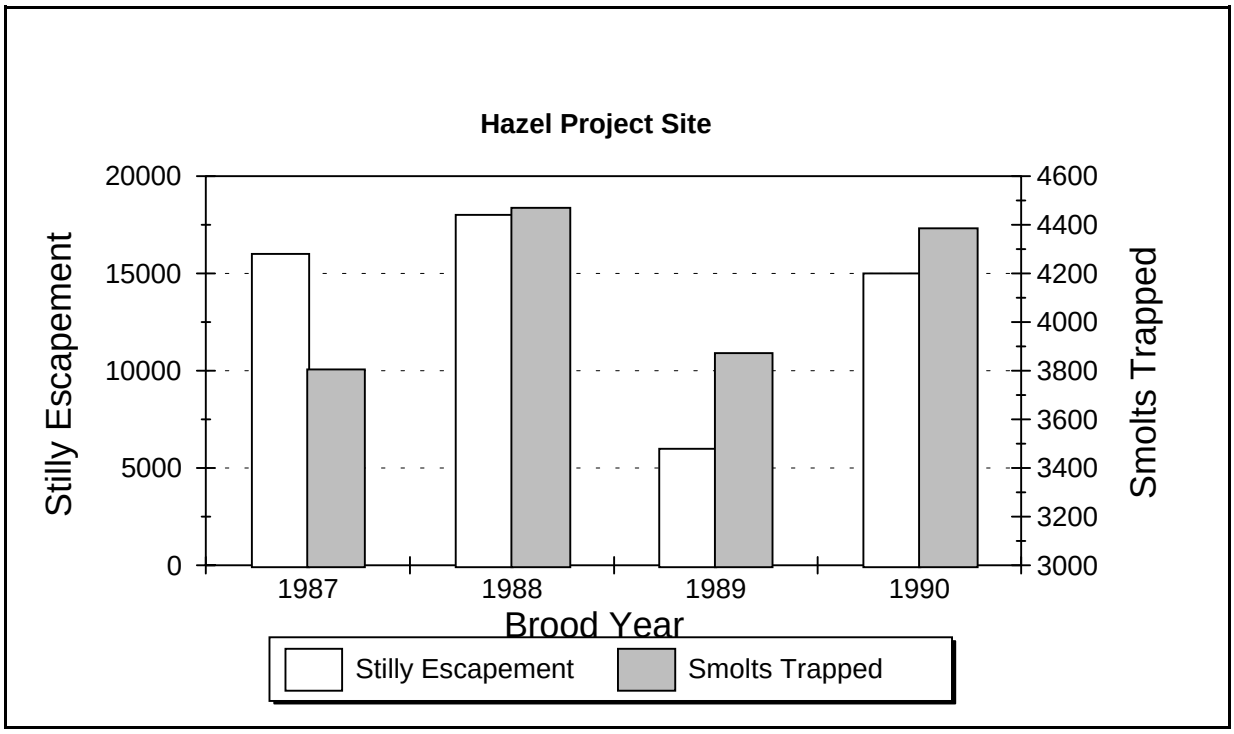

Figure 2. Coho smolt production from four brood years showing the stability off-channel projects can provide even when basin escapement is low.

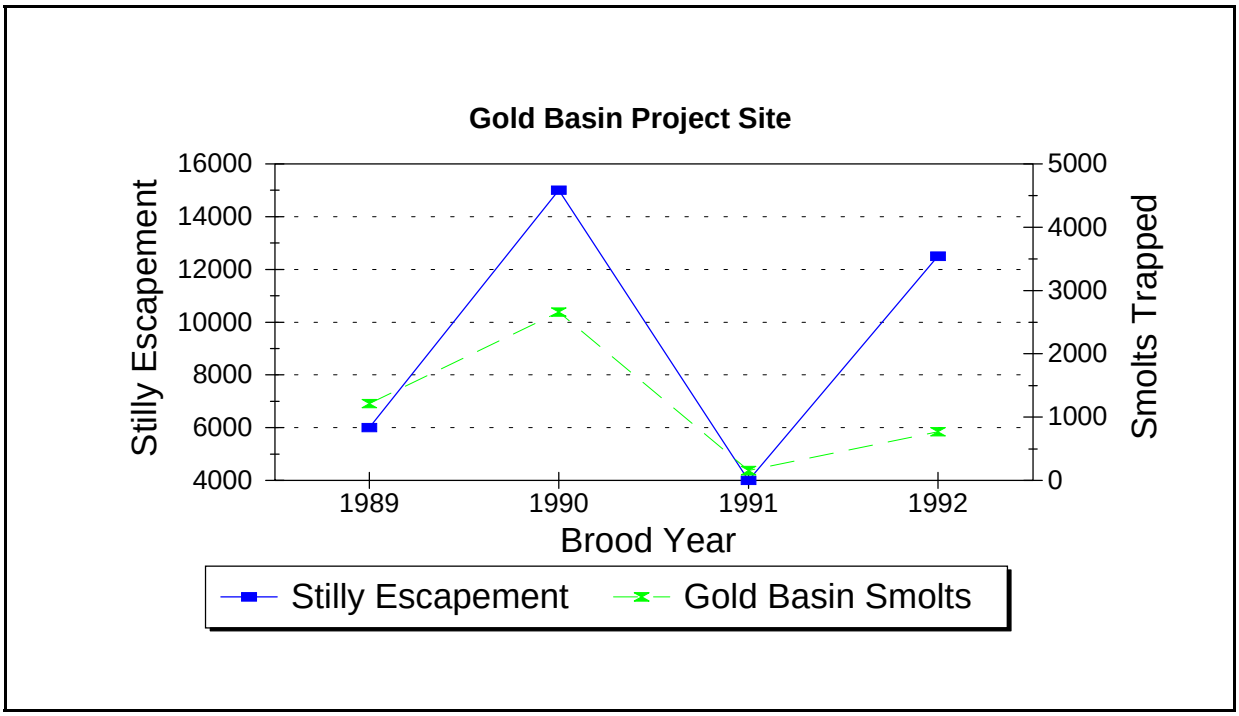

Figure 3. Smolt production from off-channel projects without significant inside spawning to track brood year escapement trends.

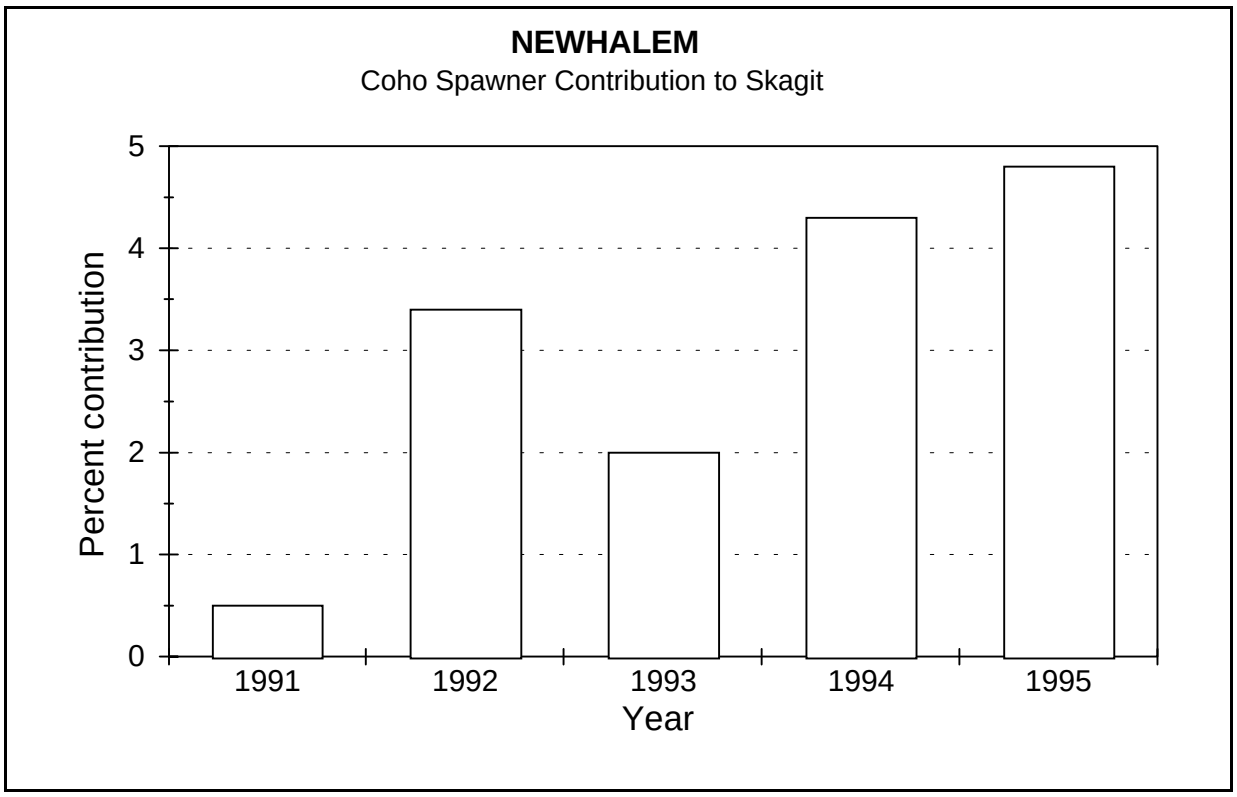

Figure 4. The large Newhalem off-channel project has cycled up to a high level of production in five years and is now responsible for a significant proportion of the total Skagit River escapement.

NORTH COAST

ABSTRACT

During 1999, we continued to inventory off-channel spawning and rearing habitat in the Sol Duc River with emphasis on the its tributary streams. The North Coast inventory project is about 80% complete for the main stems of the Queets/Clearwater, Hoh, Bogachiel, Calawah, Sol Duc, and Dickey Rivers and about 30% complete for their major tributaries. In 1999, several major fish habitat enhancement projects were completed on the Sol Duc River including the installation of a large baffled culvert at the mouth of a spring-fed pond and channel on the upper river and the improvement of fish access on a spring channel tributary on the lower River. Also, an old abandoned beaver dam on a spring channel of the east fork Dickey River was fortified with a wooden weir to maintain a large off-channel pond.

Maintenance and repair work was performed on several existing projects using contract labor from the Clearwater Corrections Center.

The habitat inventory team also identified several potential habitat enhancement opportunities in the Sol Duc and Dickey River systems and these are scheduled for completion during the summer of 2000.

Existing and potential habitat enhancement projects were evaluated by monitoring fish use (including spawning activity) and overall function. In 1998, adult coho salmon escapement to the Hoh River system was 4,931 fish, considerably larger than the escapement goal of 2,000 fish. Coho escapements have exceeded 4,000 fish for five out of the past eight years.

The Environmental Restoration Division has developed 13 projects in the Hoh River system to date. These projects have the potential to produce about 14 percent of the estimated total coho smolt production in the Hoh watershed. The Quillayute system has 24 projects that have the potential to produce over 12 percent of the total smolt output. In the Bogachiel River, nine projects have the potential to produce about 20 percent of the total coho smolt output.

METHODOLOGY

Site Inventory

Aerial photos and U.S.G.S. maps are used to identify potential off-channel spawning and rearing habitat. Field surveys are then conducted to locate and confirm the existence of specific habitat. The land adjacent to each bank of the river is divided into a series of manageable areas. Each area is separated from the next by a distinct geographic landmark (e.g., high cut bank, tributary, bend in the river, bridge, etc.). Within each area are a number of specific habitat sites (channels, ponds, etc.). The areas within a river system and the sites within each area are identified, using

an alphanumeric system, beginning at the mouth of each river. For example, H-L1-1 describes a site along the (H) Hoh River which is on the (L) left bank as you face downstream. The first (1) identifies the first group of habitat sites moving upstream from the mouth and the second (1) identifies the first site within that area. In most cases, local names are also used to help identify the sites.

Each site which has existing and/or potentially fish habitat is surveyed, and data on the following characteristics such as flood susceptibility, water source and quantity, water quality, juvenile fish access and current use, channel entrance conditions, machinery accessibility, substrate type are recorded. The evaluations for potential enhancement projects are based, in part, on this information. Since many sites are de-watered, or nearly so, during the summer, follow-up surveys sites are conducted after the onset of the autumn rains to provide additional information on water levels and flow.

Project Evaluation

Coho production from these enhancement projects is evaluated primarily by enumerating fish movement. Upstream/downstream migrant traps. Traps are made of ½-inch plywood and are 4 feet long by 3 feet wide by 4 feet high with 4-inch diameter circular openings on the upstream and downstream ends. A removable 1/4-inch mesh screen separates the interior of the trap. One half is open to upstream migrating fish and the other half to downstream migrating fish. Each half is lined with a 1/8-inch nylon mesh net to facilitate fish removal and lessen the chance of handling injury. Cones formed from 1/4-inch mesh plastic screening and placed over the entrances to both halves of the trap to keep fish from finding their way back out. These cones taper from 4 inches to 1.5 inches. The fish are funneled into the trap openings by placing 1/4-inch mesh screen wing panels in a "V" formation upstream and downstream from the trap. The screens are made of galvanized, stainless steel, or plastic coated hardware cloth. The galvanized wire tends to corrode in one or two years and are being replaced with more expensive coated and stainless wire which should last five years.

A sample of fish is randomly selected at each trap and anesthetized with tricaine methane sulfonate (MS-222). The fork length of each fish in the sample is recorded and every fish is checked visually for freeze brands or paint marks since some of the coho may be holdovers from the previous year.

At selected trapping sites, a sample of the upstream migrants are marked with a freeze brand or a fluorescent dye to help determine overwinter survival. The freeze branding tool, made of brass and silver, is inserted into a mixture of dry ice and acetone and then placed on the left side of the fish below the dorsal fin for two to four seconds. This leaves an identifiable mark that can be visually detected in the spring, yet disappears soon after the smolts begin to grow in the ocean environment. The dye mark is injected into the base of the anal fin using a “Syrijet” brand pneumatic medication inoculator which forces the dye into the tissue without breaking the surface of the tissue. At other inventoried sites, fish use information is collected by using an electro-shocker and/or by setting wire mesh minnow traps baited with salmon roe.

Project Design
Each proposed project is rigorously reviewed by a team consisting of the lead Environmental Engineering Services (EES) engineer, the SSHEAR construction superintendent, and the lead SSHEAR Division Environmental Specialist. Once the projects are approved for development, an engineering survey of the site is conducted and a preliminary design is produced. After final review and approval of the design by the project team, landuse agreements are negotiated and applications are submitted for the necessary environmental permits. A project time line is developed that identifies the date for materials purchasing and construction.

Construction
The SSHEAR Construction Unit prepares for the construction of each project by ordering necessary materials and renting the appropriate equipment. The primary pieces of equipment used to complete construction work on the projects include hydraulic excavators, front-end loaders, dozers, and dump trucks.

RESULTS

Habitat Inventory
During 1999, off-channel rearing habitat inventory work continued on the Sol Duc River mainstem and it's tributaries. These data are loaded into a database and is available to various resource managers, including local Habitat Management biologists, to help them when reviewing environmental permit applications. This database has improved WDFW's ability to protect key coho producing habitat. To date, this habitat inventory work has been completed on about 80% of the North Coast river systems.

This habitat inventory information has become a key component of the Watershed Analysis process being conducted on these river systems. All new habitat sites are being identified and cataloged with the WDFW water resource inventory area (WRIA) numbering system which is the standard identifier for all waters of the State. The inventory has located many miles of previously undocumented waterways. These streams have been assessed for fish use and then recommended for water type classification and inclusion into the Department of Natural Resources water type maps. In some cases, fish use can be documented in streams that have been previously classified as non-fish baring. This information assists habitat managers in their efforts to protect critical stream habitat.

Fish passage at human-made structures such as culverts has become a high priority. Any human-made fish barriers encountered during our surveys are documented and included in the SSHEAR fish barrier database.

Project Evaluations
The goal of project evaluation is to collect information that will assist in the refinement of current habitat enhancement techniques. So far the data indicates that coho over-winter survival is higher at projects with large amounts of complex submerged woody debris and certain species of submergent and emergent aquatic vegetation. In recent studies in Oregon, the addition of woody debris to constructed overwintering habitat greatly improved the over-winter survival and size of fish. (Rodgers et al., 1993). Coho and trout juveniles use the wood and vegetation as cover to avoid avian and mammalian predators. This complex cover also encourages aquatic insect production which supplies necessary forage for the juvenile fish. We have found that fast-growing shrubs and trees planted along the pond perimeters soon after construction quickly supply shade, soil stability, and an insect food source.

Evaluation work at selected sites will continue into the year 2000.

Hoh River Overview
The adult coho escapement to the Hoh river in the Fall of 1998 was 4,931 fish, (Mike Gross, Roger Mosley, WDFW personal communication). This is the fifth time in the past eight years that the escapement has been over 4,000 fish, (Figure 6). The escapement goal is between 2,000 and 5,000 fish. The Summer of 1999 was fairly wet and, no doubt, improved the rearing conditions for juvenile fish. We operated two way juvenile fish traps at three existing project sites on the Hoh river during the winter of 1998/99. Using a measured mean production of 0.22 smolts per square meter, the 13 projects on the Hoh are producing about 15 percent of the total smolt output of the entire watershed..

Dismal Pond (Hoh River)
In the summer of 1989, the former Washington Department of Fisheries (WDF) deepened and expanded an existing gravel removal site to create one acre of shallow pond habitat. The pond was then connected to a nearby wall-base channel which flows into the Hoh River. Water flow was supplemented by diverting nearby spring flow into the pond. Rayonier Timberlands (RTOC)

granted land use rights for construction and maintenance to WDF, at no cost. Additional woody debris have been added to the pond several times during the life of the project to keep the cover complexity at a high level.

During the fall of 1999, the average fork lengths of the juvenile immigrant coho entering Dismal Pond are following the trend from the past ten years and we are seeing a very strong, inverse relationship ($r^2 = 0.90$) between the size Hoh river coho escapement for the brood year and mean fork length of their progeny measured in the autumn as they enter over-wintering habitat (Figure 8). In other words, as adult coho escapement increases, the size of their progeny decreases. This information suggests that the summer growth rate of coho young of the year is density dependent.

In the spring of 1999, 33.6 percent of the coho marked as they entered Dismal Pond in the fall of 1998 were recovered in the out-migrant trap. Unfortunately, the pond's outlet stream went dry

before the out migration was completed. During the fall of 1999, another 2 percent of the previous year's marked coho were captured as they moved downstream when the pond outlet started flowing again. This increases the mark recovery rate to 35.6 percent (Table 6). There was also one day (in mid-December) during the upstream migration when the trap was flooded by the backwater curve of the Hoh River. Juvenile fish could have left the project at that time without detection so the marked recovery rate of 35.6 percent should be viewed as a minimum estimate.

In the previous ten years of evaluation at this site, mark-recapture rates have averaged 31 percent. This is significantly lower than the post enhancement, over-wintering survival rate of 56% reported by Cederholm, et al., (1988) on their study of Paradise Pond, a Clearwater River tributary located on Washington's Olympic Peninsula. However it is near the average for all sites trapped on the Hoh over the past ten years. Visual observations at Dismal Pond suggest that predation by otters and birds predation may be reducing the coho survival rate. During 1999, we added more woody debris cover to the pond to reduce predation.

In the fall 1999 over 6,700 juvenile coho moved into Dismal Pond from the Hoh River (Table 7). This is well above the ten years average immigration of 1,975 coho.

Hoh Springs (Hoh River)

Hoh springs is a spring water-fed tributary of Dismal Creek and was identified as a site with excellent potential for habitat enhancement. As part of a pre-project evaluation, an upstream/downstream migrant trap was set up in the entrance to the springs during the fall of 1992. Based on mark-recapture data from this trap, the pre-project over-winter survival rate was estimated at 15 percent. In the summer of 1993, a habitat enhancement project enlarged the available pre-project rearing and spawning habitat area by a factor of ten. The work included the widening of the channel, the placement of log controls, and the construction of two small fishways. Two refuge bays were also created in the upper project. A foot path was built alongside part of the project and interpretive signs were installed along the trail. This work was completed in cooperation with the landowner, Rayonier Timber Company. Post-project, mark-recapture data collected during the winter of 1993/94 indicates that over-winter survival of juvenile coho in Hoh Springs increased to 30 percent or double the pre-project survival rate. This season, the over-winter survival was estimated at about 35 percent, (Table 6) and four coho redds were observed on the project.. Since the project was built, the average overwinter survival has been 33 percent. Trapping operations have been discontinued at this site, however WDFW will continue to monitor spawning activity at the project.

Lewis Channel (Hoh River)

This 1,650 foot long ground water-fed spawning and rearing channel was constructed in 1994 in cooperation project with the Department of Natural Resources. During the first two years of trapping, we observed low numbers of marked fish leaving the channel each spring. Possible

explanations for the low recapture rates might be heavy predation by birds and/or cutthroat or unusually high natural mortality. However very few birds were observed feeding in the channel nor were significant numbers of cutthroat were captured. Also, no distressed or dying fish were observed.

A more likely explanation for the low recapture rate is that since the trap was opened periodically to allow adults to pass into the project, a considerable number of juvenile coho left the project. Apparently the juveniles were disturbed by the spawning activity of the 60+ adult coho that entered the area. This phenomenon has been observed at other channels of this type (C. Detrick and D. King, Washington Department of Fish and Wildlife, Lands and Restoration Services Program, personal communication).

During the autumn of 1996, and effort was made to document the downstream movement of juvenile coho in response to the presence of adult spawners but no such movement was observed.

During the 1997/98 season this evaluation effort was repeated and the trap was left in place over the summer of 1998 to monitor any juvenile fish movement. Minnow traps set in the channel upstream from the main trap towards the end of the spring out-migration revealed that there were still coho smolts in the project. Through the summer almost 500 coho fry entered the project while only five coho smolts were captured leaving the project. Trapping during the winter of 1998/99 showed a very low over-winter survival of 3.8% (Table 6). Trapping operations at this site have been discontinued, but adult use is still being monitored. During the fall of 1999, 32 coho redds were found within the project.

Quillayute System Overview

The Quillayute watershed consists of the Quillayute mainstem, Dickey, Sol Duc, Calawah, and Bogachiel Rivers. Coho escapement for 1998 was good and resulted in good recruitment of juveniles to off-channel habitat in the autumn of 1999. Spawner returns in 1999 are also predicted to be good coming off a good brood year in 1996. A two-way juvenile fish trap was operated at one site on the Sol Duc river. The mean smolts per square meter measured at selected project sites is about 0.35. Using the 24 project sites within the entire watershed we calculate that they are producing about 12 percent of the total Quillayute smolt output. The nine projects on the Bogachiel are estimated to be producing close to 20 percent of its entire smolt yield.

Thomas Springs (Sol Duc River)

This site is a 1150 meter long, spring-fed wall base channel. Water quality at this site is excellent and trapping results for the winter of 1998/99 indicated about 45 % of the juvenile coho entering the springs survived until the spring out-migration (Table 6). The coho smolts produced at this site averaged 130 mm in length and are some of the largest observed in the Quillayute system.

Prior to the project, coho fry access to the upper reaches of the channel was blocked by a small culvert under a road fill located about 300 meters upstream from it's mouth. During the summer of 1999 the culvert was removed, opening up about 850 linear feet of channel to fish use. .Trapping operations were discontinued at this site, however, we will continue to monitor the project.

Rayonier Channel (Bogachiel River)
This project site was identified during habitat inventory work in the Bogachiel river floodplain. A 1,200 foot long groundwater-fed channel was excavated to create overwinter rearing habitat for coho. Since its construction, we have observed juvenile salmonids using it for summer rearing also. A two-way migrant trap was installed in the fall of 1999 and we have enumerated over 1,700 juvenile coho migrating into the project from the Bogachiel river, (Table 7).

1999 CONSTRUCTION PROJECTS

Project costs and habitat benefitted for 1999 projects is summarized in table 8. An entire list of projects that have been constructed since 1988 are shown in Figure 5 with details on each project shown in Table 9.

Eagle Creek Springs (Sol Duc River)
This project was completed in cooperation with the Pacific Coast Salmon Coalition. It consisted of replacing an undersized culvert with a larger diameter pipe in which baffles were welded to simulate a pool and weir fishway. The Coalition provided the funding for the culvert and we developed the design and constructed the project. This project will provide year around fish use in a high quality spring water-fed channel. Juvenile and adult fish were observed using the project during the fall of 1999.

Thomas Springs (Sol Duc River)
This site is located on the lower Sol Duc river on a high quality spring-fed channel which serves primarily as an overwintering site for juvenile salmonids. An earthen dam was constructed across this channel many years ago forming a large impoundment upstream. A culvert was installed in the dam to carry the stream flow, but was undersized and created fish passage problems at times. We removed the culvert and installed a cedar plank control at the dam to maintain the pond level and then a roughened channel was constructed through the dam with a series of plank controls placed at streambed level throughout this channel to step the gradient down gradually. This allows both adult and juvenile fish to access 850 meters of additional habitat.

Big Beaver Springs (East Fork Dickey River)
This site is a spring-fed channel which flows into the East Fork Dickey river near it's confluence with the West Fork Dickey. A large beaver dam had created a substantial pond in the channel,

but the beavers had recently abandoned the area and the dam failed. Using hand labor from the Clearwater honor camp, a cedar plank control was installed to simulate the former beaver dam. An outlet channel was built to allow access from the river for juvenile fish.

Other maintenance and repair work was done during the summer at various existing project sites using a contract labor crew from the Clearwater Corrections Center.

SCHEDULED PROJECTS FOR 2000

Prairie Fall Creek (Sol Duc River)
During the 1940's, the US Navy did some work on the Quillayute road where this creek once flowed under an old bridge. The bridge was not replaced and the creek was rerouted down a road-side ditch and forced to plunge 25 feet into the Sol Duc river. WDFW- SSHEAR proposes to install a large culvert under the road and return the creek to it's original channel. This is a cooperative project with the Pacific Coast Salmon Coalition, the Quileute tribe, People for Salmon, Rayonier Timber Company, and Clallam county.

Labrador Creek (West Fork Dickey River)
An undersized plugged culvert will be replaced with a sloping roughened channel to maintain a large wetland that has been created as a result of the culvert plugged. This is a cooperative project with Green Crow Timber Company, the landowner and the Pacific Coast Salmon Coalition.

M & R Springs (Sol Duc River)
A series of cedar plank weirs will be installed in an existing spring-fed channel to create more winter and summer rearing habitat for juvenile salmonids. This is also a cooperative project with Merrill and Ring timber company and the Pacific Coast Salmon Coalition.

Maintenance
Existing project sites will be inspected for maintenance needs and work will be performed as necessary. Stumps and other woody debris will be added to projects that appear to have inadequate cover.

SUMMARY

During 1999, the North Coast area experienced above normal precipitation during the summer and which probably resulted in increased habitat availability as stream flows were maintained at a higher level. This may explain why the number of upstream migrating juvenile coho was larger than would have been expected from the coho escapement in 1998. This year the major juvenile salmonid upstream migration occurred in a more normal pattern during October and November and coincided with the onset of the autumn rains.

The high-quality rearing and spawning areas which were either created or enhanced in 1999 should provide excellent overwintering habitat for wild juvenile coho and other salmonids. The evaluation of past projects is providing us with information and effective techniques which are being used to improve the overall quantity and quality of off-channel, over-wintering habitat in the North Coast Watersheds.

Waterfowl, otters, and trout appear to be the major predators of juvenile coho in our enhancement projects. Large amounts of complex woody debris are now being incorporated into all projects with the intent of reducing predation.

Because of the good number of coho spawners on the Hoh river in 1998 and the higher water conditions of late summer 1999, we expected to see a corresponding increase in juvenile immigrants into the project areas during the autumn of 1999. All of the evaluation sites met or exceeded the average recruitment.

At Dismal Pond over the past ten years we have seen a close inverse relationship ($r^2 = 0.90$) between the Hoh river coho brood year escapement size and the brood year's progeny mean fork length measured the next Fall (Figure 8). The average size of this year's juvenile coho immigrants into Dismal Pond is about 86 mm. Based on the above relationship, we would have expected an average around 78mm.

Preliminary estimates show the 1999 coho run to the Hoh river to be similar to 1998. With the number of spawners being closely related to the number of following year fall juvenile coho recruits to the Dismal Pond site, it indicates that a higher spawner escapement is needed to fully seed project areas. Until this happens, the sites may never cycle up to production capacity.

Off-channel rearing habitat inventory work continued on the Sol Duc river and it's tributaries in 1999. Habitat enhancement project work, consisting of new construction and maintenance, was completed in the summer on the Hoh, Bogachiel, Dickey, Clearwater and Sol Duc rivers.

During 1999, the Clearwater Corrections Center labor crews, which are supervised by the Department of Natural Resources (DNR), were contracted to perform various parts of the hand labor construction including much of the re-vegetation.

The Rayonier Timber Company, DNR, and the Campbell Group Timber Company also provided funds fish enhancement projects on their properties. WDFW will continue to develop cooperative projects with timber companies and any other landowners.

Project evaluation work continues at selected sites. The data collected is providing valuable information on the numbers and the quality of fish being produced, over-winter survival rates, and overall project function. The data indicates a need for more complex submerged woody debris and specific types of aquatic vegetation to provide better protection from predatory birds and mammals. This type of improvement is being incorporated into existing and future projects.

FUTURE WORK

The habitat inventory work will continue on the North Coast streams. Supplemental survey work must be continued throughout the year to monitor potential project sites under a wide range of environmental conditions.

Evaluation work has also required more time than anticipated. The additional effort required to identify and type new streams and wetlands, participate in Watershed Analysis and other technical advisory groups, and implement the new culvert inventory process has slowed the pace of the habitat inventory by 20 percent.

The Olympic National Park (ONP) and the Quinalt Tribe have only recently agreed to allow us to survey watershed within their jurisdiction. This will include most of the Queets system as well as those portions of the Hoh and Bogachiel rivers (and their major tributaries) contained within the ONP boundary.

Because of concerns for fish life, construction work within the streams' ordinary high water mark is limited to a brief period between June 15 and October 15. This combined with the increasingly lengthy and complex process needed to secure the required environmental permits, pre-project evaluation, planning and engineering effectively limits the number of projects that can be completed. However, potential habitat enhancement projects are continually being identified and several are scheduled for completion in the year 2000.

Table 6. North Coast upstream/downstream migrant trapping summary for Fall 1998 and Spring 1999.

Site	River Basin	Coho In	Coho Out	Marked Group Recovery	Trout In	Trout Out
Dismal Pond	Hoh	1,935	1,315	35.6%	269	78
Hoh Springs	Hoh	909	639	34.9%	243	239
Lewis Channel	Hoh	2,397	237	3.8%	490	249
Thomas Springs	Sol Duc	1,097	871	45.3%	166.	89

Note: All sites have 0+ coho fry moving into them over the summer when the traps aren't operating and, as a result, the number out does not reflect the Fall immigrant population marking study done at each trap.

Table 7. North Coast upstream migrant trapping summary for Fall 1999.

Site	River Basin	Location (RM)	Coho In	Trout In
Dismal Pond	Hoh	26.0	6,778	382
Rayonier Channel	Bogachiel	18.3	1,702	11

Table 8. North Coast habitat enhancement projects completed in 1999

Project	River Basin	Project Type	Habitat Benefitted	Project Cost	Landowner
Eagle Ck. Springs	Sol Duc	Fish Passage	2,200 m^2	$83,872	Private
Thomas Springs	Sol Duc	Fish Passage	2,800 m^2	$20,138	Private
Big Beaver Spgs.	E.Fk.Dickey	Off-channel	7,400 m^2	$35,133	Rayonier
		TOTALS	12,400 m^2	$139,143	

Table 9. Project sites listed on study area map.

PROJECT SITE	RIVER BASIN	YEAR COMPLETED	HABITAT BENEFITTED	COST	PROPERTY OWNER
Airport Pond	Clearwater	1988/89	30,000 m²	$16,900	Rayonier
Rayonier Pond	Hoh	1988	4,048 m²	$19,000	Rayonier
Barlow Pond	Hoh	1988/89	8,100 m²	$26,600	Private
Anderson Ponds	Hoh	1988/89	10,150 m²	$45,900	Private
Pole Creek	Hoh	1988/90	6,100 m²	$45,300	Forest Service
Peterson Pond	Hoh	1989	2,000 m²	$22,500	Private
Dismal Pond	Hoh	1989	4,048 m²	$25,700	Rayonier
Anderson Cr. Channel	Hoh	1990	3,000 m²	$16,500	Rayonier
Nolan Pond	Hoh	1990	8,000 m²	$ 3,200	State
Wilson Springs	Bogachiel	1990	3,200 m²	$41,600	Private
Tall Timber	Bogachiel	1990	800 m²	$10,000	Rayonier
Smith Road Pond	Bogachiel	1990	2,000 m²	$15,600	Rayonier
Dahlgren Springs	Bogachiel	1990	600 m²	$ 7,300	Private
* Morganroth Springs	Bogachiel	1991	14,100 m²	$13,400	Forest Service
* W.F. Dickey	Dickey	1991	23,000 m²	$28,000	Rayonier
* Mosley Springs	S.F.Hoh	1991	4,048 m²	$21,000	State
* Lear Springs	S.F.Hoh	1991	800 m²	$18,100	State
* Upper Mosley	S.F.Hoh	1992	690 m²	$23,000	State
Bogey Pond	Bogachiel	1992	13,640 m²	$24,700	Rayonier
Falcon Walrus	Bogachiel	1992,1995	740 m²	$20,600	Rayonier
Calawah Springs	Calawah	1992	900 m²	$50,300	John Hancock Ins.
Colby Springs	Dickey	1992	9,200 m²	$13,500	Rayonier
Elkhorn Pond	Dickey	1992	5,400 m²	$ 9,100	State
W.F.Marsh Ck.	Dickey	1992	3,000 m²	$ 6,200	Rayonier
* Hoh Springs	Hoh	1993,1995	3,450 m²	$86,000	Rayonier
Soot Cr. Springs	E.Fk.Dickey	1993	2,100 m²	$64,000	Rayonier
T-Bone Springs	Dickey	1993	745 m²	$33,000	Rayonier
* Young Slough	Hoh	1994	3,000 m²	$158,000	John Hancock Ins.
* Lewis Channel	Hoh	1994	2,000 m²	$135,000	State
Tassel Springs	Sol Duc	1994	600 m²	$16,000	Private
Laforrest Pond	Bogachiel	1995/96	2,520 m²	$133,000	Private
*Nolan Channel	Hoh	1996	1,800 m²	$151,000	Rayonier
*Huelsdonk Creek	Hoh	1996	12,000 m²	$18,000	DOT
Manor Springs	Clearwater	1996	960 m²	$21,550	DNR
*Cascade Springs	W.Fk.Dickey	1996	3,000 m²	$42,000	Rayonier
*Powell Springs	Sol Duc	1997	2,000 m²	$76,000	Rayonier
Rootstock Springs (I)	Calawah	1997	200 m²	$12,000	Rayonier
Rayonier Channel	Bogachiel	1998	1,700m²	$135,000	Rayonier
Tyee Pond	Sol Duc	1998	2,800m²	$80,000	Rayonier
Rootstock Springs (II)	Calawah	1998	600m²	$22,000	Rayonier
*Eagle Creek Springs	Sol Duc	1999	2,200m²	$84,000	Private
Thomas Springs	Sol Duc	1999	2,800m²	$20,000	Private
Big Beaver Springs	E.Fk. Dickey	1999	7,400m²	$35,000	Rayonier
* Cost share projects with timber companies, DNR, DOT, Salmon Coalition, Counties and/or Tribes.					

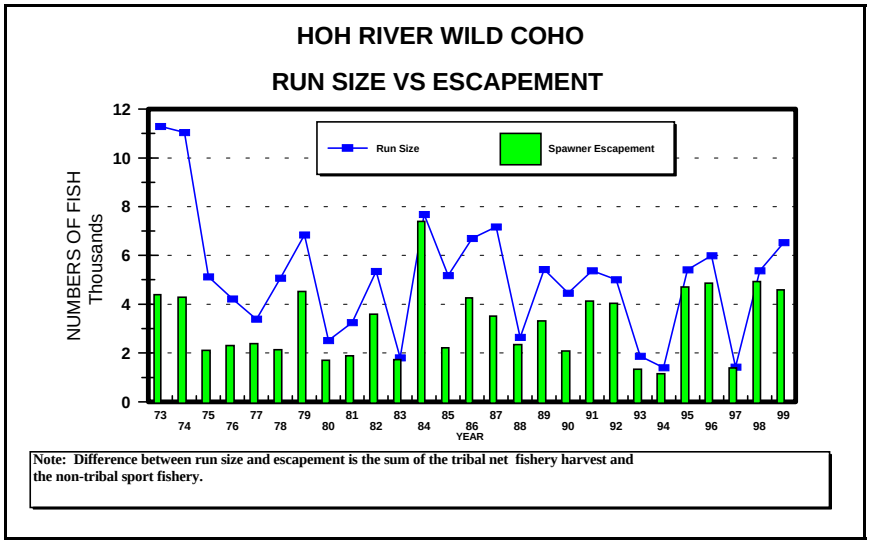

Figure 6. Hoh River wild coho run size and escapement for the years 1973 through 1999.

1999 FISH SCREENING

INTRODUCTION

The Yakima Screen Shop (YSS) is the eastern Washington component of SSHEAR (Salmonid Screening, Habitat Enhancement and Restoration Division) in the Habitat Program's Environmental Restoration Division. The YSS is organized into the following three work units: Screen Fabrication, Fish Screen/Fishway Inspection, Operation & Maintenance (O&M), and Fish Facility Capital Construction. Program management is provided by a Fish & Wildlife Biologist 4 with local responsibility for all YSS functions, a Construction & Maintenance Superintendent 1 (CMS 1), and support staff (a Supply Control Technician and a part-time Senior Office Assistant). Funding for YSS Screening Program administration totals about $160,000 annually split between state O&M and state capital budgets. Two Plant Mechanic Supervisors (PMS) provide day-to-day supervision of the Fabrication and Capital Construction crews. This report summarizes calendar year 1999 program accomplishments in each of the three work units.

Screen Fabrication

The Yakima Screen Shop is a fully-equipped metal fabrication shop with the capability to build nearly anything out of mild steel, stainless steel or aluminum. Prior to 1985, a small crew performed operation and maintenance (O&M) on existing fish screens, but new construction was very limited. The acquisition of high production fabrication equipment and the recruitment of highly skilled metal fabricators has allowed the YSS mission to expand. The gradual expansion of the Screen Fabrication unit, beginning in 1987, provided capability for "production-level" fabrication of new rotating drum, traveling belt, vertical flat plate fish screens and miscellaneous metalwork (lifting gantries, walkways, handrail, fish bypass control gates, etc.).

The expanded mission and the accompanying shop enhancement has been driven by the Northwest Power Planning Council's (NWPPC) Fish & Wildlife Program. Since 1985, the YSS has been the Bonneville Power Administration's (BPA) primary supplier of fish screens and miscellaneous metalwork for Yakima Basin and Umatilla Basin fish screen projects. The recent ESA listings of bull trout, spring chinook and steelhead in the upper Columbia River basin have greatly expanded the YSS mission, both in scope and geographic area. YSS now builds fish screens for other government entities such as the Idaho Fish & Game Dept., Oregon Dept. of Fish & Wildlife, U.S. Fish & Wildlife Service, U.S. Bureau of Reclamation, the City of Kent and the Okanogan Irrigation District. YSS also provides fabrication services for other WDFW programs. YSS periodically fabricates or rebuilds hatchery intake and rearing pond outlet fish screens for the Hatchery Program. The YSS has also designed and fabricated the cougar and black bear live traps used by WDFW wildlife enforcement agents to capture and relocate dangerous wildlife.

Permanent, full-time staff consists of a PMS, two Welder-Fabricators and a General Repairer. As annual workload expands or contracts, temporary welder-fabricators and/or laborers are hired or laid-off. Roughly 90% of the workload is shop fabrication with field delivery and installation of screens and gantries accounting for the rest. BPA funding for screen fabrication in FFY99 was $247,000. BPA Phase 2 fish screen fabrication projects completed in CY99 are summarized in Table 10.

Fish Screen / Fishway Inspection and O&M

The fish screen/fishway inspection and O&M section is primarily a field-oriented work unit responsible for monitoring the operation of 140 active gravity diversion fish screen facilities and eight small fishways. These facilities are located at irrigation diversions in central and southeast Washington on tributaries to the Columbia and Snake Rivers. Permanent staff consists of two PMs stationed at the YSS who divide the upper Columbia Basin into "north" and "south" areas of responsibility. The north area includes the upper Yakima River Basin (upstream of Roza Dam), Wenatchee, Entiat, Methow, and Okanogan River Basins with a total of about 90 active gravity diversion screens and four fishways. The south area includes the lower Yakima Basin including the Naches River, Touchet River Tucannon River, Asotin Creek, and Grande Ronde River with about 50 active gravity screens and three fishways. Six screens and one fishway located in the Dungeness River Basin (Olympic Peninsula) are the responsibility of a half-time General Repairer stationed in Sequim. Nearly all of these facilities were constructed to protect anadromous salmonids, although resident fish also are afforded protection. Very few fish screens are located in "resident fish only" areas of the state. However, three “resident fish only” screens located in the Methow (2) and Okanogan (1) Basins are inspected and/or maintained by YSS O&M personnel.

Monitoring facility performance and maintaining a good working relationship with the water users is the state's obligation and is funded through the O&M budget ($146,000 in CY99). Water users may contract with the YSS to perform all or portion of their statutory O&M obligation utilizing a standardized YSS fish screen service contract. In CY99, 18 diversion owners signed contracts with an estimated value of $26,800.

In 1993, the O&M work unit began performing O&M on BPA-funded Yakima Basin Phase 2 fish screen facilities. In CY99, YSS provided preventive maintenance services on 18 Phase 2 sites with $156,000 in BPA funding. These facilities range in size from a 2' dia. x 4' long paddlewheel-driven, modular screen (2.2 cfs) up to a 150 cfs canal with 8 - 6.5' dia. x 10' electric-drive drum screens.

The O&M work unit also maintained 13 screens and five fishways in the upper Columbia Basin for the National Marine Fisheries Service (NMFS) with $40,944 of FFY99 Mitchell Act funding.

Fish Facility Capital Construction

The Capital Construction work unit is responsible for constructing new fish screens on unscreened or inadequately screened water diversions identified by program management. This work unit has existed since the 1987-89 biennium and initially conducted an inventory of pump diversions in Columbia River tributary subbasins. Staff then developed low cost pump intake screen designs for small irrigation intakes. During the winter, the crew normally fabricates pump intake screens and components for field installation the following year. During the field season, a two-man crew installs the screens on pump intakes. However, in CY99 no pump screen fabrication and installation was performed because of the emphasis on funding only high priority gravity screen and fishway construction.

This work unit constructs rotating drum, traveling belt or fixed plate screens for gravity diversions, including the concrete structure. This crew has also constructed two concrete fishways. In 1991, the capital crew developed a portable, modular paddlewheel-driven drum screen that is completely fabricated in the shop using steel, thereby eliminating concrete forming in the field for diversions less than 4.6 cfs. Field installation takes one or two days, with total costs (including fabrication and installation) ranging from $13,000 -17,000. Seventeen modular drum screens have been installed in Washington through CY99. In CY99, two modular flat plate screens with rotary wiper cleaners were fabricated and installed; one in the Methow Basin, and one in the Walla Walla Basin. The modular flat plate screen is a low cost ($3,000 - 5,000), all metal structure developed by YSS in 1994 for gravity diversions less than 1.5 cfs.

The Capital Crew is allotted 3 FTE's with permanent staff consisting of a PMS and two PM's. Temporary staff are added during the summer field season to assist in pump screen installations or major gravity screen or fishway construction. The fish screen construction capital budget request for FY99 totaled $357,500. However, the legislature denied this funding request, requiring WDFW to compete for funds through the Salmon Recovery Funding Board. One project was successfully funded in this manner. All of the other construction projects for FY99 were funded via cost share (owner, NFMS via Mitchell Act funds) and/or funds expended that were directly reimbursable by the proponent (US Park Service, US Forest Service, Bureau of Indian Affairs). Capital projects completed in 1999 are summarized in Table 11.

Table 10. 1999 Bonneville Phase 2 Screen Fabrication

Project Name	Description	Time Period
Burlingame	Fabricated 7 rotary drum screens for a 100 cfs diversion in the Walla Walla Basin. Fabricated bypass O/U gate, blockout for eighth bay, and fabricated and installed overhead lift gantry.	12/98 to 5/99

Table 11. 1999 YSS Capital Construction		
Project Name	Funding Sources	Time Period
Larson Ditch Portable Rotary Screen	Owner cost share, capital funds FY98	5/99 to 5/99
Whitman Mission Portable Rotary Screen	US Park Service, 100% reimbursable	5/99 to 5/99
Buttermilk Ditch Portable Drum Screen	Owner cost share, capital funds FY98	6/99 to 6/99
Eightmile Ditch Portable Drum Screen	US Forest Service, 100% reimbursable	7/99 to 7/99
Simcoe Creek Portable Drum Screen	BIA, Yakama Nation, 100% reimbursable	7/99 to 7/99
Wolf Creek Drum Screen	NMFS MA cost share, owner cost share, SRFB	10/99 to 11/99

REFERENCES

Bilby, R.E., Fransen, B.R. and Bisson, P.A. 1996. Incorporation of nitrogen and carbon from spawning coho salmon into the trophic system of small streams: evidence from stable isotopes. Can. J. Fish. Aquat. Sci. 53: 164-173.

Bilton, H.T., Alderdice, D.F. and Schnute, J.T. 1982. Influence of time and size at release of juvenile coho salmon (*Oncorhynchus kisutch*) on returns at maturity. Can. J. Fish. Aquat. Sci. 39: 426-447.

Brown, Tom G. and Tom McMahon. 1987. Winter ecology of juvenile coho salmon in Carnation Creek: summary of findings and management implications. in Proceedings of the workshop: applying 15 years of Carnation Creek results. T.W. Chamberlin ed. 239 pp.

Cederholm, C.J., W.J. Scarlett, and N.P. Peterson. 1988. Low-cost enhancement technique for winter habitat of juvenile coho salmon. North American Journal of Fisheries Management 8(4):438-441.

Cederholm, C.J. and W.J. Scarlett. 1981. Seasonal immigrations of juvenile salmonids into four small tributaries of the Clearwater River, Washington, 1977-1981. Pages 98-110 in E. L. Brannon and E. O. Salo, editors. Salmon and trout migratory behavior symposium. University of Washington, Seattle.

Foy, Matthew. 1985. Coho production from upper Paradise Channel. Memorandum, Canada Department of Fisheries and Oceans. 26 pp.

Groot, C. and L. Margolis. 1991. Pacific Salmon Life Histories. Department of Fisheries and Oceans. UBC Press, Vancouver. 564 pp.

Hartman, G.F. and Scrivener, J.C. 1990. Impacts of forestry practices on a coastal stream ecosystem, Carnation Creek, British Columbia. Can. Bull. Fish Aquat. Sci. No. 223.

Johnson, Richard. 1986. An assessment of the Skagit River system's coho rearing potential. Washington Department of Fisheries Technical Report No. 95. 22 pp.

Nickelson, T.E., M.F. Solazzi, S.L. Johnson, and J.D. Rodgers. 1992. Effectiveness of selected stream improvement techniques to create suitable summer and winter rearing habitat for juvenile coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. Can. J. Fish. Aquat. Sci. 49: 790-794.

Peterson, N.P. and L.M. Reid. 1984. Wall-base channels: their evolution, distribution and use by juvenile coho salmon in the Clearwater River, Washington. in Proceedings of the Olympic Wild Fish Conference. Olympic National Park and Peninsula College Publication, Port Angeles, Washington. J.M. Walton and D.B. Houston eds. 308 pp.

Reeves, G.H., F.H. Everest, and T.E. Nickelson. 1989. Identification of physical habitats limiting the productions of coho salmon in western Oregon and Washington. Gen. Tech. Rep. PNW-GTR-245. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. p.18

Rodgers, J.D., S.L. Johnson, T.E. Nickelson, and M.F. Solazzi. 1993. The seasonal use of natural and constructed habitat by juvenile coho salmon (*Oncorhynchus kisutch)* and Preliminary results from two habitat improvement projects on smolt production in Oregon coastal streams. Pages 344-348 *in* L. Berg and P.W. Delaney, editors. Proceedings of the Coho Workshop, Nanaimo, B.C., May 26-28, 1992.

Sekulich, Paul. 1991. Washington Department of Fish and Wildlife, Habitat Management Program, SSHEAR Section, Pre and Post Project Cost Accounting Format as amended on February 26, 1992. WDFW File Memo November 1, 1991. 7 pp.

Skeesick, D.G. 1970. The fall immigration of juvenile coho salmon into a small tributary. Oregon Fish Commission Research Report. 2 (1):90-95.

Tschaplinski, P.J. and G.F. Hartman. 1983. Winter distribution of juvenile coho salmon (*Oncorhynchus kisutch*) before and after logging in Carnation Creek, British Columbia, and some implications for overwinter survival. Can. J. Fish. Aquat. Sci. 40:452-461.

Washington Department of Fisheries, Washington Department of Wildlife, and Western Washington Treaty Indian Tribes. 1993. 1992 Washington State Salmon and Steelhead Stock Inventory. Olympia. 212 pp.

Williams, R.W., R.M. Laramie, and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization. Vol. 1 - Puget Sound. Washington Department of Fish and Wildlife. Olympia.

Williams, R.W., L.A. Phinney, and P.B. Bucknell. 1975. A catalog of Washington streams and salmon utilization. Vol. 2 - Coastal Region. Washington Department of Fish and Wildlife. Olympia.