EVALUATING WATERSHED RESPONSE TO LAND MANAGEMENT AND RESTORATION ACTIONS:

INTENSIVELY MONITORED WATERSHEDS (IMW) 2006 PROGRESS REPORT

Submitted to

Washington Salmon Recovery Funding Board

Prepared by

The IMW Scientific Oversight Committee

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EXECUTIVE SUMMARY

The Intensively Monitored Watershed (IMW) program has been funded by the Salmon Recover Funding Board (SRFB) since June 2003 to evaluate the efficacy of habitat restoration in increasing salmon production. The basic premise of the IMW program is that the complex relationships controlling salmon response to habitat conditions can best be understood by concentrating monitoring and research efforts at a few locations. Focusing efforts on a relatively few locations enables enough data on physical and biological attributes of a system to be collected to develop a comprehensive understanding of the factors affecting salmon production in freshwater. This report describes work completed in FY2006 and outlines restoration and research plans for FY 2007.

There are three sets of IMW sites (complexes) in western Washington focusing on coho salmon and steelhead trout and the Skagit River estuary focusing on ocean-type chinook (Figure 1). Planned restoration projects will be complete in the Strait of Juan de Fuca (SJF) complex by fall 2006. Mark-recapture studies using permanent PIT tag readers in the SJF indicate that a substantial proportion of the juvenile coho salmon migrate to salt water in the fall rather than the typical March-June spring migration. Fall migrants were significantly smaller when tagged suggesting that they have been competitively displaced from the available habitat.

Coho production in three of the Hood Canal streams reached record highs, 160, 182, and 693% of the long-term average, in Stavis, Seabeck, and Little Anderson Creek, while Big Beef production was slightly above the average. The extraordinary increase in production in Little Anderson Creek, also observed in preliminary data from 2006, coincides with a culvert replacement on Anderson Hill Road in 2003 which removed a partial barrier to upstream fish migration.

Efforts in the Lower Columbia complex continue to focus on extending and improving the database of pre-restoration data. Restoration is planned to begin in 2009. The Lower Columbia Fish Recovery Board and the Cowlitz County Conservation District will develop a restoration plan for these basins, based on the approved recovery plan. This will form the basis for implementing restoration projects.

We have worked with the Skagit River System Cooperative and the Northwest Fisheries Science Center to integrate and expand their existing monitoring to address questions specific to the effects of estuary restoration on juvenile chinook growth and survival.

A study plan detailing the entire IMW program was delivered to the Independent Science Panel in April, 2006. It is currently under review and will be revised as needed based on this review.

INTRODUCTION

The Intensively Monitored Watershed (IMW) program has been funded by the Salmon Recover Funding Board (SRFB) since June 2003 to evaluate the efficacy of habitat restoration in increasing salmon production. The basic premise of the IMW program is that the complex relationships controlling salmon response to habitat conditions can best be understood by concentrating monitoring and research efforts at a few locations. Focusing efforts on a relatively few locations enables enough data on physical and biological attributes of a system to be collected to develop a comprehensive understanding of the factors affecting salmon production in freshwater.

There are three sets of IMW sites (complexes) in western Washington focusing on coho salmon, and steelhead and cutthroat trout plus the Skagit River estuary focusing on ocean-type chinook (Figure 1).

This report details the progress to date in meeting the objectives listed in Attachment C (Statement of Work) to the Amendment to IAC Project Number 05-1232N and the monitoring and research planned for the next fiscal year. A study plan containing objectives for each IMW complex was presented for review by the Independent Science Panel on April 26, 2006. After the review, a revised copy of the study plan will be posted online at the IAC website (http://www.iac.wa.gov/). Background information for the Skagit River Estuary work can be found at http://www.skagitcoop.org/. Previous IMW Progress Reports are at http://www.iac.wa.gov/srfb/docs.htm under Validation Monitoring.

OBJECTIVES OF THE IMW PROJECT AGREEMENT

The objectives for FY2006 were:

1. Monitor smolt outmigration and spawner escapement in all 10 streams in the Strait of Juan de Fuca, Hood Canal, and Lower Columbia IMW complexes.
2. Determine summer juvenile fish abundance in all 10 streams in the Strait of Juan de Fuca, Hood Canal and Lower Columbia IMW complexes.
3. Conduct habitat assessments in all 10 streams in the Strait of Juan de Fuca, Hood Canal and Lower Columbia IMW complexes and integrate the data into a GIS-based data management system.
4. Conduct water quantity and quality monitoring in all 10 streams in the Strait of Juan de Fuca, Hood Canal and Lower Columbia IMW complexes and post the data to Ecology's web site as collected and verified.
5. Work with the Skagit River System Cooperative, NOAA-Fisheries Northwest Fisheries Science Center, and WDFW to implement monitoring to test the effectiveness of estuary restoration projects on juvenile Skagit River chinook salmon.
6. Provide progress update to SRFB as needed, issue joint written progress report, and make the information available through the Natural Resources Data Portal.
7. Submit a study plan for review by the Independent Science Panel.

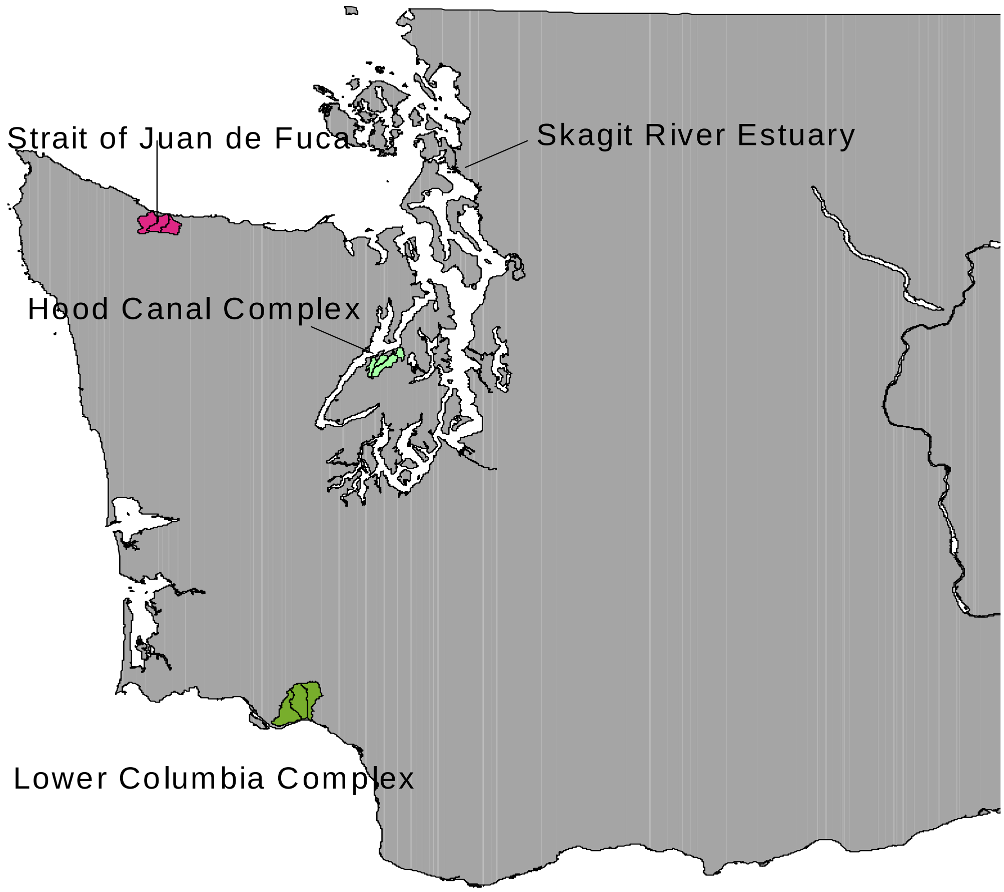

Figure 1. Locations of the three IMW basin complexes, Straits Juan de Fuca (SJF), Hook Canal, and Lower Columbia, and the Skagit River Estuary chinook salmon IMW.

Objectives 1-4

Objectives 1 through 4 are specific to the collection and accessibility of the baseline biological and physical data in the three IMW complexes in western Washington (Strait of Juan de Fuca, Hood Canal, and Lower Columbia). These tasks are similar across all basins and progress to date is described below (Table 1).

<u>Water Quantity and Quality</u>

- *Stream Flow*-Continuous stage height recorders are operational in all basins and data are available online. The West Twin River gauge will be relocated due to a channel shift during high flows. The Abernathy Creek gauge will be relocated to avoid interference from the adult weir (installed in 2005).
- Continous turbidity sensors have been installed at all gauge sites
- *Water temperature* is measured at all flow gauges and temperature loggers were deployed throughout each basin in April 2005 to record changes in water temperature from headwaters to the mouth.

Water chemistry-Water samples have been collected since October 2004 at the gauge site for chemical analysis. Water quality and flow monitoring has been integrated into the Department of Ecology's ongoing ambient stream monitoring program.

Table 1. Variables measured in all three coho, steelhead, and cutthroat IMW complexes.

	Frequency	Status	Data available
Water Quality & Quantity			
Flow	Continuous	Ongoing	https://fortress.wa.gov/ecy/wrx/wrx/flows/regions/state.asp
Water temperature	Continuous	Ongoing	https://fortress.wa.gov/ecy/wrx/wrx/flows/regions/state.asp or by request
Water chemistry	Monthly	Ongoing	http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html
Turbidity	Continous	Ongoing	By request at https://fortress.wa.gov/ecy/wrx/wrx/flows/regions/state.asp
Habitat			
Probabilistic sampling	Annual	Completed	http://www.wdfw.wa.gov/hab/imw/index.htm
Fish			
Smolt production	Annual	2005 data reported, 2006 data collection in progress through June.	http://wdfw.wa.gov/fish/wild_salmon_monitor/publications.htm
Juvenile abundance	Annual	Completed	Database under development
Spawners	Annual	Completed	http://www.wdfw.wa.gov/hab/imw/index.htm

Habitat

- Habitat surveys were conducted in the Straits, Hood Canal, and Lower Columbia Complexes using the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP). The EMAP measures will be repeated annually. The EMAP-based approach was conducted on 10 randomly selected sites in each of the 10 basins. The datasets have been incorporated into a GIS database. Summary data are available online (Table 1). Data from individual sampling points is available by request.

- A study of the relationship between fall stream flow and spawner distribution, and between summer stream flow and available habitat was initiated in 2005. Approximately 20 staff gauges were deployed in each basin at existing EMAP habitat sites. These are read periodically, across a range of flows, and correlated with available habitat and fish distribution data.

Fish

- *Smolts*- Outmigrants from each of the 10 watersheds in the three complexes were monitored in spring 2006. Smolt production estimates for spring 2005 for the Hood Canal and Lower Columbia included in this report are preliminary until completion of the internal WDFW review. Estimates from the Straits are included in the graphs below and are available by request.
- *Juveniles*-Juvenile fish were collected by electroshocking from randomly-selected stream reaches in all 10 study watersheds during summer 2005. Approximately 1000 fish were captured and marked, either by clipping the adipose fin or using PIT tags, and released in each Hood Canal and Lower Columbia Complex basin. The rate of recapture of the tagged fish and the ratio of tagged to untagged outmigrating smolts enable us to estimate overwinter survival and summer juvenile population size.
- Including the juveniles marking mentioned above, over 10,000 fish were captured and PIT tagged in East Twin River and West Twin River in the Straits Complex as part of a study of juvenile survival and migration timing conducted by the NWFSC and the Lower Elwha Tribe for the IMW. Tagged fish movement out of the basin was monitored continuously using permanent PIT tag readers in order to track migration timing and survival. Preliminary results of this work are summarized in this report.
- *Spawners*-Spawner and redd counts and location within the stream system were recorded at 7-10 day intervals throughout the spawning period. These data have been compiled and are being integrated into a spatial database linked to the GIS stream coverage to evaluate changes in distribution over time as a function of restoration or other effects. Summary fish distribution data are available online (Table 1).

Objective 5. Skagit River chinook

The IMW oversight committee entered into agreements with the Skagit River System Cooperative and NOAA-Fisheries NWFSC to supplement ongoing monitoring of chinook salmon in the Skagit River delta (SRSC) and Skagit Bay (NWFSC) in order to detect changes in juvenile chinook abundance, distribution, growth, and survival due to estuary restoration projects. Monitoring of juvenile chinook in the Skagit River tidal delta, and the Skagit Bay nearshore and offshore was successfully conducted as described in the study plan. These data were used to refine the study plan for the Skagit estuary and are included in study plan. The Skagit River estuary restoration monitoring is described in detail in the IMW study plan and is summarized in this report.

Objective 6. Reporting and data availability

The progress report serves as our update to the SRFB. The study plan (covering all four IMWs) was updated and is currently under review by the Governor's Independent Science Panel. Individual datasets may be obtained via the web sites listed in Table 1. Where summary data are online, the complete database is available on request. The databases listed as under development are being incorporated into a GIS spatial database.

Objective 7. Submit study plan for review.

Study plan was submitted on April 26, 2006 to the ISP for review.

IMW COMPLEXES

The SRFB's IMW Program funding directly supports monitoring and research in three IMW complexes and the Skagit River estuary. The IMW complexes focus on coho salmon and steelhead trout in smaller watersheds and the Skagit estuary effort focuses on the effects of estuary restoration on ocean-type chinook salmon. Below we summarize the current fish production and spawner data and outline the restoration projects and monitoring planned for the next fiscal year.

The three coho/steelhead/cutthroat IMW watershed complexes vary in physical characteristics, land use patterns, climate and relative abundance of the focal species (Table 2) as well as the length of the outmigrant monitoring record. The range in conditions will enhance our ability to extend our results to other watersheds and will provide an opportunity to address a wider range of factors contributing to habitat degradation than would be the case if all watersheds were similar.

Table 2. Characteristics of the three coho/steelhead IMW complexes in western Washington.

	Straits of Juan De Fuca	Hood Canal	Lower Columbia
Watersheds	**West Twin East Twin Deep**	**Stavis Little Anderson Seabeck Big Beef**	**Germany Abernathy Mill**
Focal Species	**coho steelhead**	**coho steelhead**	**coho cutthroat chinook**
Land Use	**forestry – private, state, and federal**	**rural residential, forestry, urban,**	**Forestry, agriculture, rural residential**
Total Area	**111 km^2**	**75 km^2**	**206 km^2**
Geology	**mixed sedimentary and metamorphic**	**glacial till**	**flow basalt w/ interbedded sandstone**
Precipitation	**190 cm**	**105 cm**	**160 cm**

Strait of Juan de Fuca

The watersheds in this complex (West Twin Creek, East Twin Creek, and Deep Creek) have been logged since the late 19th century (Figure 2). As a result, much of the wood that historically created pools and regulated the movement of sediment and organic matter in these watersheds had been depleted. Wood loss contributed to channel incision at some sites, isolating the floodplain and reducing access to off-channel habitats. In response to declines in habitat quality and in populations of native anadromous fish, the Lower Elwha Klallam Tribe has been actively attempting to restore fish populations. A restoration strategy, based on a watershed analysis (USFS 2002) was developed with the goal of reestablishing the dominant physical processes that control the identified limiting factors, including:

- Reduction in the rate of mass wasting to historical background rates
- Reestablishment of late successional, conifer-dominated riparian forests.
- Reintroduction of functional, high quality in-channel LWD.
- Restoration of off-channel habitats.

Relatively little timber harvest or road construction will occur in these watersheds over the next decade. Therefore, interpreting any responses of the fish to the restoration treatments at the watershed scale will not be complicated by other activities that might affect habitat condition.

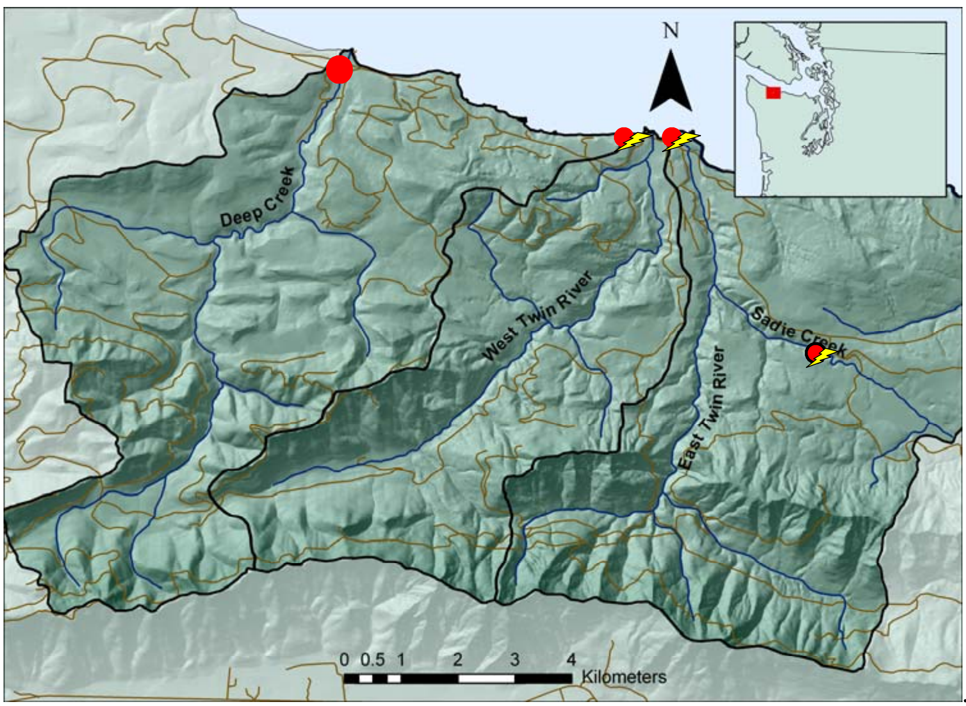

Figure 2. Deep Creek, and West Twin and East Twin Rivers watersheds. Dots represent smolt trap locations and lightening bolts indicate traps with adjacent PIT tag readers.

<u>Fish Production</u>

Populations of fall chum (*Oncorhynchus keta*), fall coho salmon (*Oncorhynchus kisutch*), winter steelhead (*Oncorhynchus mykiss*), and resident and anadromous cutthroat trout (*Oncorhynchus clarki*) utilize the Deep Creek and Twin Rivers watersheds (Table 3). Historical accounts mention chinook salmon (*Oncorhynchus tshawytscha*) in these watersheds but it is unclear if these were the results of hatchery outplants that occurred in the 1970's. Chinook salmon have not been observed in recent years.

Table 3. Status of salmonid stocks in the Deep/Twins Watershed.

Species	Race	Production	Stock origin	Stock status (WDF et al. 1993)	Stock status (McHenry et al. 1996)
Chum	Fall	Wild	Native	Healthy	Critical
Coho	Fall	Wild	Mixed	Depressed	Stable
Steelhead	Winter	Wild	Unresolved	Healthy	Depressed

Sporadic spawning ground surveys by WDFW in Deep Creek from 1950 to 1970 reported counts as high as 206 fish/mile. Repeatable surveys of index areas have been conducted in Deep Creek and Sadie Creek (E Twin tributary) since 1984 by WDFW. These index areas provide an indication of trends, but cannot be reliably expanded into an estimate of watershed-level spawner abundance. Significant efforts have been made since 1998 to improve estimates of total spawning salmon abundance in Deep Creek and East and West Twin rivers. A habitat based system of spawning ground surveys was initiated in 1997 involving WDFW and the Makah and Lower Elwha Klallam Tribes. A random stratified sampling system of available habitat types was instituted. This new system enables estimation of total escapement for each of the three watersheds in this complex (Figure 3). Relative escapement to each individual watershed has been consistent for four of the five years from 1997 through 2002 with Deep Creek supporting the highest number of spawning coho followed by West Twin then the East Twin River. Deep Creek exhibited a decline in spawner abundance relative to the other two watersheds in 2002.

Formal steelhead escapement surveys were initiated in 1998 (Figure 4). This stock is currently managed for wild production and no hatchery outplants have been released in the Deep/Twin complex since the early 1980's. Winter steelhead adults enter the watershed beginning in December and continue through May. Spawning occurs in February through early June.

Smolt trapping was initiated by the Elwha Klallam Tribe in Deep Creek in 1998 and in the East and West Twin Rivers in 2001. Traps, consisting of a fence weir and live box, capture the entire population of emigrating smolts. Trapping begins in late April and continues through mid-June with peak outmigration in late May. Data collected to date are in Figures 5 and 6. As with the adult counts, interannual variation in smolt production appears consistent among the three watersheds.

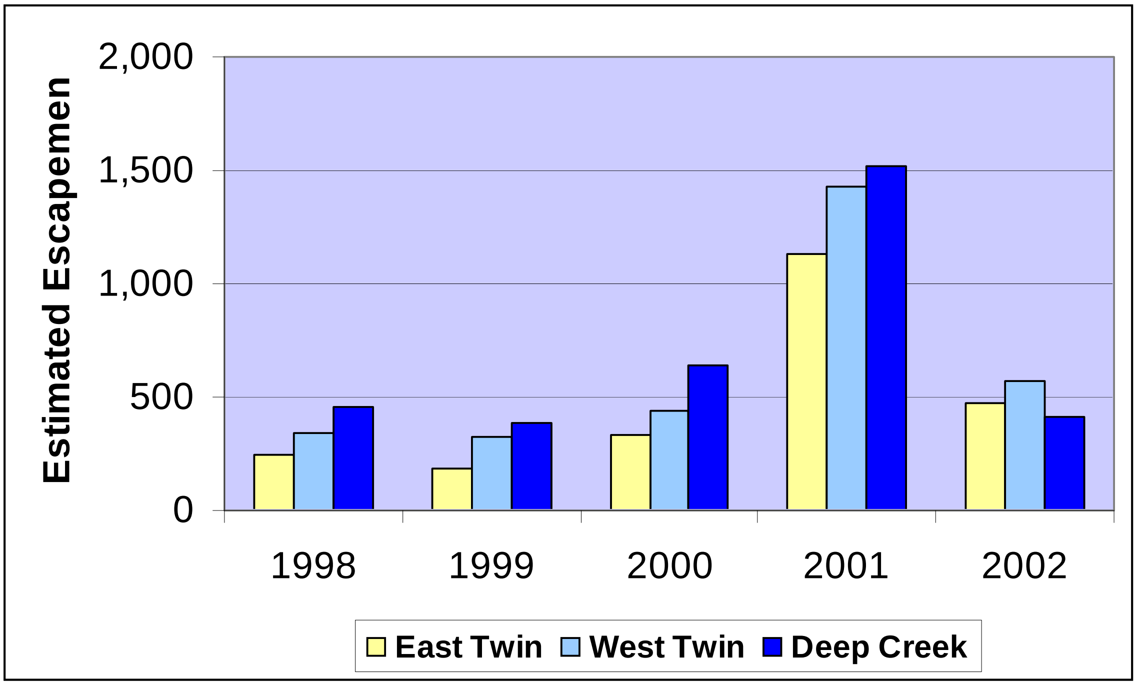

Figure 3. Coho salmon escapement to Deep Creek, East Twin and West Twin Rivers, 1998-2002.

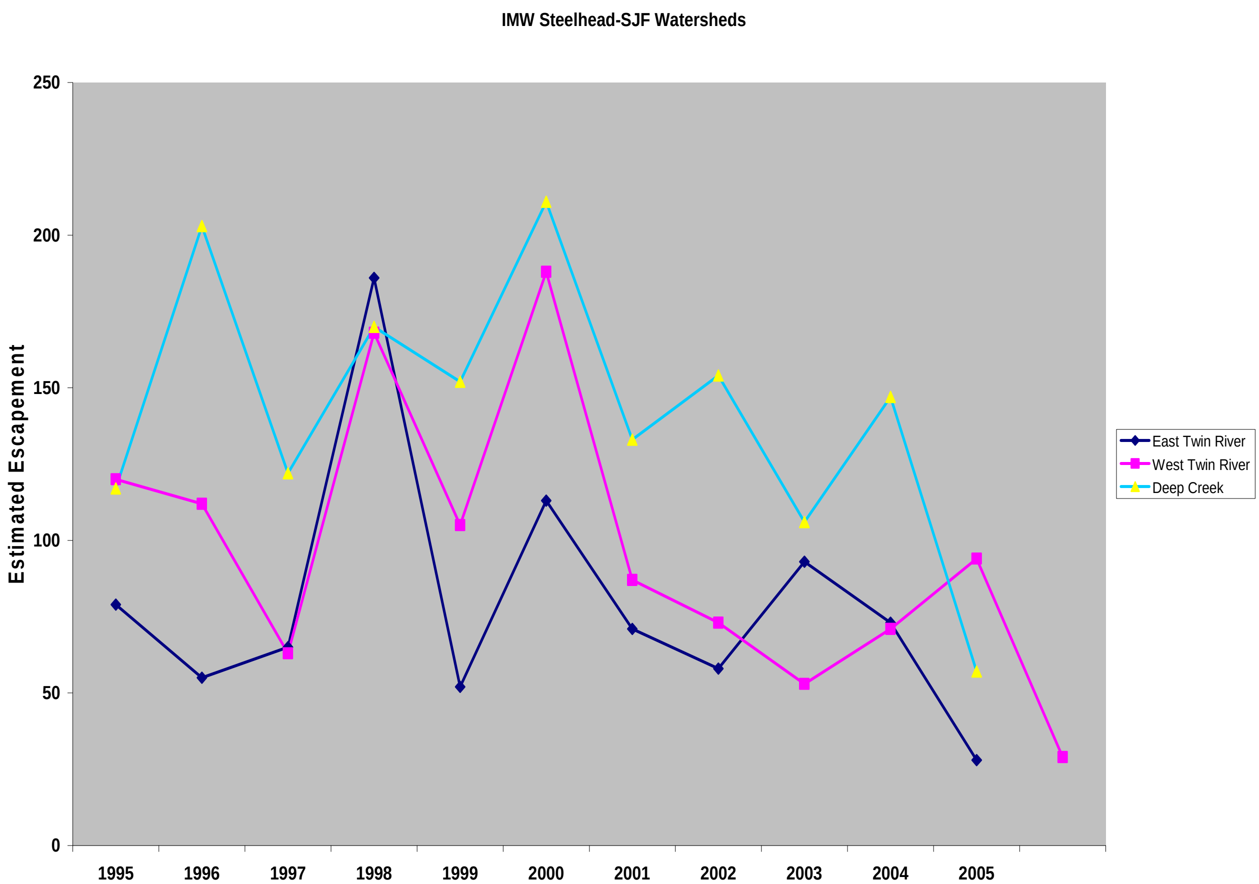

Figure 4. Steelhead escapement to Deep/Twin Rivers, 1995-2005.

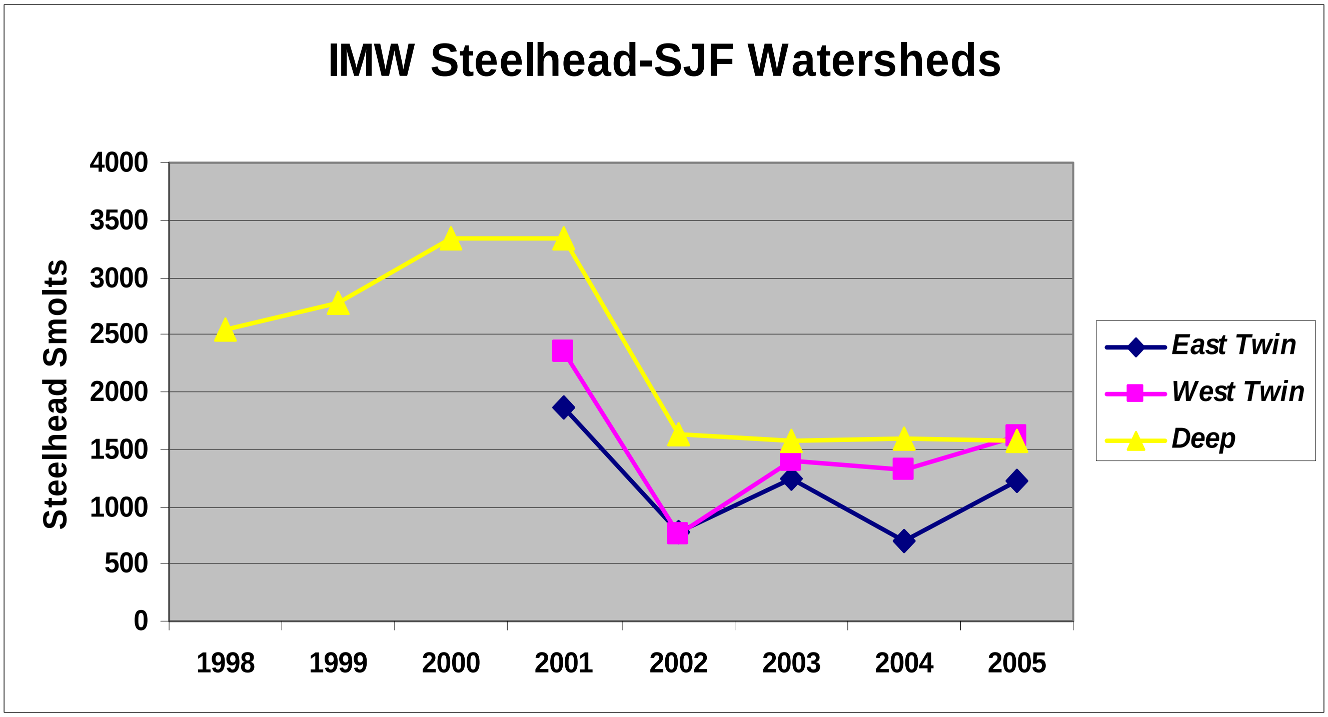

Figure 5. Steelhead smolt production from Deep/Twin Rivers, 1998-2005.

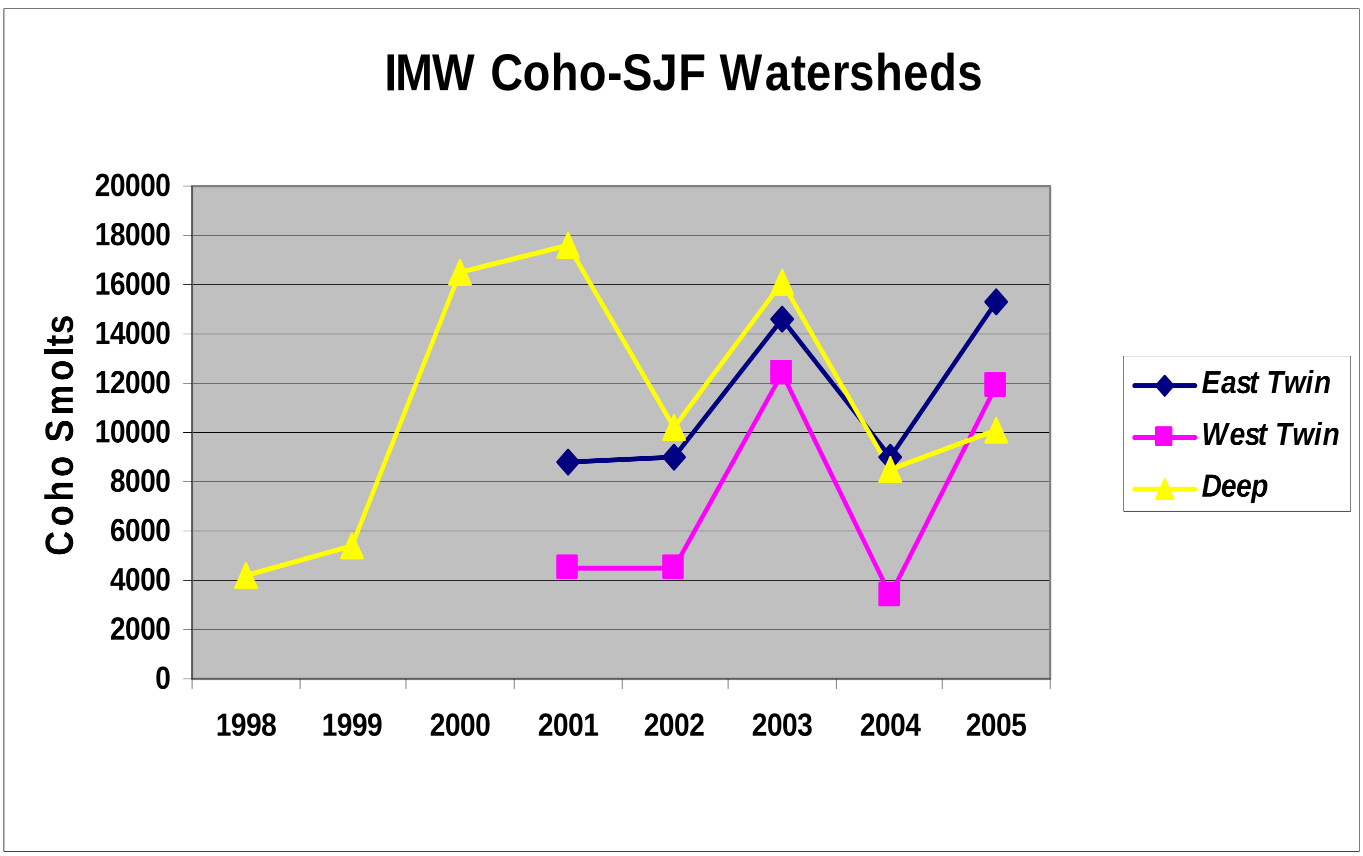

Figure 6. Coho smolt outmigration from Deep/Twin Rivers, 1998-2005.

Habitat Treatments

In response to declines in both habitat quality and populations of native anadromous fish, the Lower Elwha Klallam Tribe has been actively attempting to restore fish populations. A restoration strategy was developed with the goal of reestablishing the dominant physical processes that controlled the identified limiting factors. This strategy is outlined in McHenry et al. (1995) and includes the following:

- Reduction in the rate of mass wasting to historical background rates
- Reestablishment of late successional, conifer-dominated riparian forests.
- Reintroduction of large pieces of wood (LWD) to channels.
- Re-creation of off-channel habitats.

Deep Creek

A number of habitat conditions in the Deep Creek watershed, related to historic timber harvest and road construction, were identified during watershed assessments conducted in the 1990s (Table 4, Figure 7). Compromised conditions varied among reaches but generally included alterations in habitat quality, temperature, sediment, large wood, and channel stability.

Channel restoration activities on Deep Creek are focusing on using LWD to accomplish specific goals, depending upon the dominant impact at the reach level. For example, above RM 1.3, the 1990 dam-break flood resulted in severe scour of the bed and the almost complete loss of in-channel LWD. Conversely, below RM 1.3, the impacts were primarily associated with sediment deposition (pool filling, channel widening). Because of the inherent channel instability observed below RM 1.3, restoration activities were initiated above this point (RM 1.0 to 4.0). Between 1997-2002 LWD and rock was placed in an attempt to convert this plane-bed reach into a forced pool-riffle reach. Over 1,500 individual pieces of LWD have been used in the following configurations: log revetments, engineered log jams, constructed log jams, deflectors, log weirs, and rock/log structures. Additionally rock weirs were used in some locations to build channel bed features. To date, 4.0 miles of Deep Creek, 0.5 miles of Sampson Creek, and 0.4 miles of Gibson Creek (Deep tributaries) have received in-stream restoration treatments, while riparian vegetation improvements have been conducted on 2.5 miles of riparian forest. The riparian vegetation projects included manipulation of existing stands to promote the growth of conifer-dominated riparian stands. Four off-channel, winter rearing habitat projects have been implemented.

East Twin River

A watershed analysis (USFS 2002) conducted in the 1990s identified the same suite of factors affecting habitat condition in East and West Twin rivers as Deep Creek. However, logging related disturbances have been less severe in the Twin Rivers than Deep Creek.

Restoration efforts in the East Twin River were initiated in 1998 (Table 4, Figure 7), when an off-channel rearing pond was constructed on private property near river mile 1.0 (km 1.6). Large scale LWD reintroductions were initiated in 2002 by the Elwha Klallam Tribe when a Salmon Funding Recovery Board awarded a restoration grant to fund these efforts. In the summer of 2002 over 450 metric tons of LWD was placed with a helicopter into Sadie Creek at forty sites in river mile 0-2.0 (km 0.0-3.2) and at 30 sites in the East Twin River in river mile 2.0-3.0 (km 3.2-4.8). These efforts were followed in 2003-04 with ground-based placement at an additional 35 sites in the East Twin at river mile 1.2-2.0 (km 2.0 and 3.2). Additional ground based treatments were completed by the Tribe in 2005 between river mile 0.3-1.0, with the addition of complex LWD structures at 16 sites.

West Twin River

No restoration will be conducted in West Twin River. This watershed will serve as a reference watershed and habitat conditions and fish populations will be compared over time to Deep Creek and East Twin River where active restoration is underway.

Table 4. Summary of in-channel restoration activities conducted on Deep Creek, 1997 to 2004.

Year Constructed	**Number of Structures**	
	Deep Cr	**East Twin R**
1997	40	
1998	53	
1998	7*	
1999		1
2000	25	
2002	25	70
2003		35
2004	17	

*sponsored by Clallam Conservation District

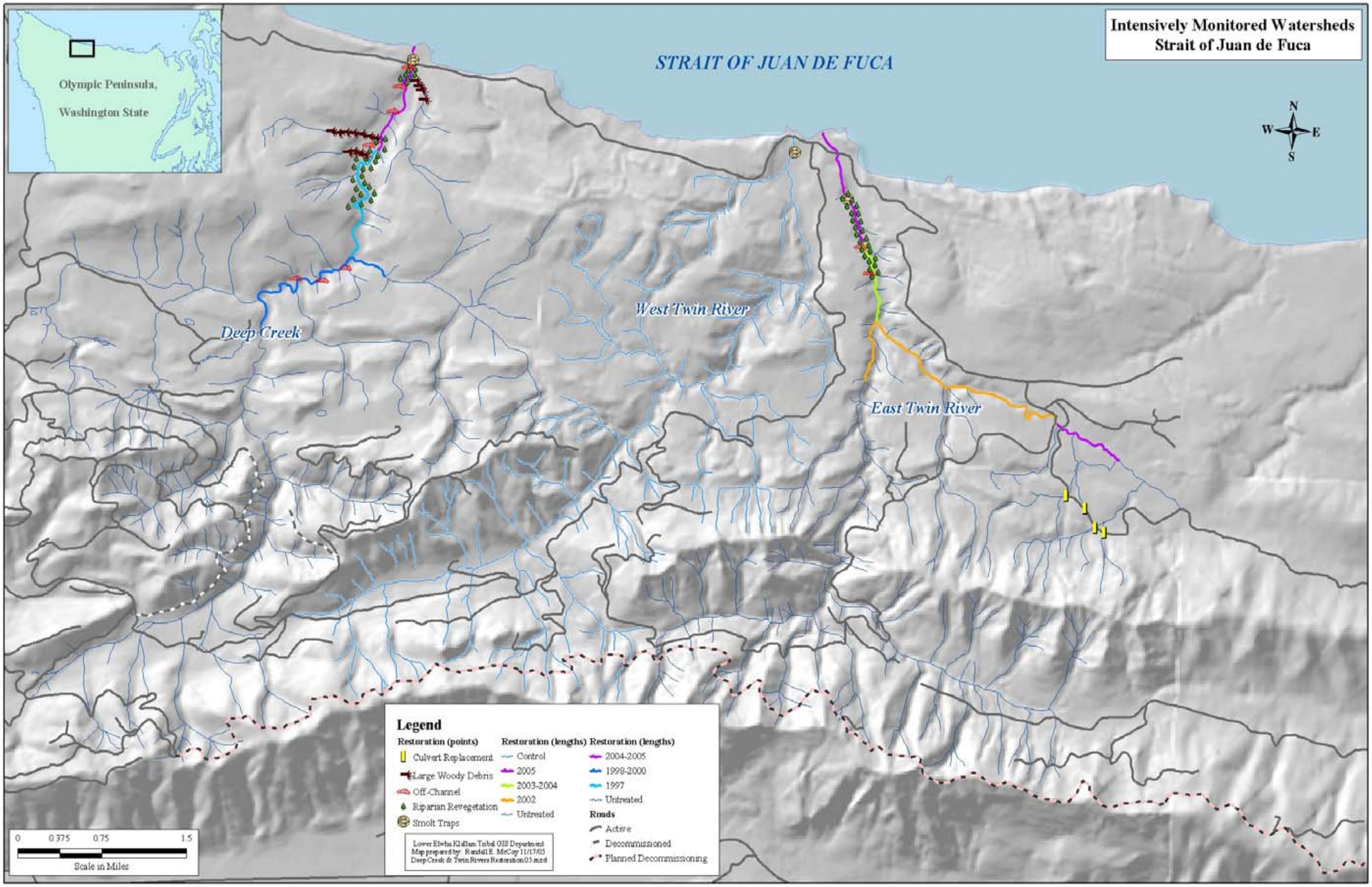

Figure 7. Restoration projects in Deep Creek and East Twin River.

Research and monitoring results

The standard juvenile, smolt, and adult monitoring in the Straits IMW complex provides some information on the effects of restoration on fish abundance. This information is being augmented through the use of passive integrated transponder (PIT) tags. Prior to the development of PIT tag technology and the more recent development of remote detectors, collecting accurate survival, movement and migration information was difficult. The recent improvements in this technology have enabled us to compare fish abundance, survival, movement and migration timing (life history) among watersheds, reaches, and habitats before and after completion of restoration treatments. Specifically, we are focusing on the following questions:

1. What is the effect of habitat restoration activities throughout the watersheds on survival, growth and migration timing of fish?
2. Do survival, growth and movement differ among tributaries and reach types within the watersheds? Will the application of restoration projects cause differential responses in these variables among locations and reach types?
3. What is the effect of reach-level restoration efforts on local movements and growth of fish?
4. Does survival, growth and movement differ among habitat types (e.g., pools, riffles, glides) and can we improve survival by creating more pool habitats?

Initially, we set out to answer the third question by examining differences in survival and movement between restored (complex habitat with high levels of LWD) and unrestored reaches (simple no LWD placement) in East Twin river. This effort served as a pilot study to assess the capabilities of new PIT tag technologies and provided us with the methodologies required to address the remaining questions.

Stationary multiplex PIT tag readers were installed in East and West Twin Creek in the summer/fall of 2004 allowing for the detection of PIT tagged fish passing the readers (Figure 8). These were located approximately 1000 m and 500 m from saltwater in East and West Twin, respectively (Figure 2). These detectors run throughout the year, although they are occasionally inoperable when damaged by high flows. Deep Creek currently has no PIT tag detector, although we are attempting to identify funding to enable installation.

To address hypothesis three and examine survival and whether fish moved between restored and unrestored reaches, we examined fish movement in two simple and two complex (LWD enhanced) 100-meter-long reaches in East Twin River in 2003 and 2004. During late summer (August and September), about 800 trout and coho were collected by electrofishing, anesthetized, measured, weighed, PIT tagged, and released into their habitat of origin. Movement of the tagged fish was monitored with a hand-held reader used to interrogate fish encountered during periodic snorkel surveys. This work is part of a University of Washington masters thesis (T. Bennett).

Continuous PIT tag detectors were not in place in spring 2004. Surprisingly, only about 5% of the fish PIT tagged in late summer 2003 were captured in smolt traps in spring 2004. The low tag recovery rate in 2003 also suggested that large numbers of fish (>1,500) needed to be tagged. The reason for this low recovery rate could have been high mortality rates or migration of tagged fish from East Twin River prior to the installation of the smolt trap. A stationary PIT tag reader, located near the site of the smolt trap, was installed in 2004 to determine if early emigration of the fish was the cause of the low, spring recovery rate.

In 2004 nearly 3000 fish were tagged in in East and West Twin (Table 5). The stationary PIT tag reader indicated that large numbers of coho and trout parr emigrated from the study watersheds in the autumn. As a result of this finding, overwinter survival is being calculated by dividing the number of tagged spring migrants by the total number of tagged fish minus the fall emigrants (survival = spring migrants/ (total tagged – fall migrants)).

The number of PIT tags deployed in the study streams was further increased in 2005 and a permanent tag reader was installed on West Twin. We PIT tagged 9,300 juvenile coho and trout in East and West Twin in August and September 2005. About one third of these fish were tagged at randomly selected reaches and the remainder was tagged in the lower few kilometers of the East and West Twin where most of the anadromous fishes are concentrated and we could efficiently collect large numbers of fish. This broad-scale spatial tagging effort in 2005 will not only allow us to compare fish survival, growth, and migration between the treatment (East Twin) and control (West Twin) (question 1), but also allow us to answer questions 2 and 3 as fish were tagged throughout the watersheds and we have information on reach types and habitat types where fish were tagged. We will continue tagging approximately 3,500 juvenile coho and trout in each watershed each year, including Deep Creek in 2006 if funding is available.

Preliminary analysis and results

Differences in survival, growth, and migration among tributaries, reaches and habitats are being compared using an ANOVA or t-tests (survival, growth), graphical analysis (migration timing), and chi-square test or Kolmogorov-Smirnov goodness of fit tests (movement, migration timing). As we collect multiple years of data for each watershed, we will utilize specific metrics such as median migration date and proportion of fall migrants etc. to compare among treatment and control watersheds and among years. These will be compared using parametric statistics such as ANOVA or ANCOVA assuming data are normally distributed. If not, we will apply graphical or nonparametric statistics to examine differences among watersheds and years.

<u>Watershed scale</u>

Data from the PIT tag readers and marked fish indicated that unexpectedly large numbers of parr (primarily coho) migrated to sea during fall months (Figure 8, Table 6). Relatively few parr migrated during winter (January through March) and the largest numbers emigrated as smolts in the spring. A t-test indicated that fall-migrating coho were significantly smaller at tagging than spring coho migrants (64.1 and 74 mm, respectively) (Figure 9). This suggests that smaller, less fit fish are forced out in the fall or seek other foraging opportunities outside the watershed. The relative contribution of fall and spring-migrating coho to adult returns will be assessed as returning tagged adults are detected at the permanent PIT tag readers and by examining carcasses for tags

Total numbers of tagged smolts captured in the East Twin smolt trap in spring 2005 was 228 coho, 2 cutthroat trout, 32 steelhead, and 7 age 1+ trout, a total of 269 tagged fish. However, 388 passed the PIT reader located a short distance upstream from the smolt trap. Possible explanations for this discrepancy include trap avoidance, predation on tagged fish, and smolts moving past the trap during a very high flows when trap panels were pulled (May 23 and May 25) nearly at the height of migration.

After the installation of the West Twin reader in 2004, we recorded four PIT tagged fish moving between East Twin River and West Twin River during the summer. Although this represents a very small proportion of tagged fish, it was surprising that 500 m of saltwater between the two river mouths did not present a barrier to movement of these fish. The West Twin PIT tag reader was damaged by high flows in late 2004, so that little data from West was available for this report.

As indicated earlier, 9,300 juvenile salmonids were tagged in East Twin and West Twin in the summer of 2005. Preliminary analysis of these data (smolt trapping continues through June) shows a similar pattern of fall migration in both East Twin and West Twin but suggests that overwinter survival rates may be substantially higher in East Twin River than in West Twin River.

Reach scale

Percentage of fall migrants was not significantly different between treatment and control reaches (t-test, $p > 0.10$; Table 9. Similarly, survival estimates from the complex and simple reaches did not differ (t-test, $p > 0.10$), but complex reaches had higher densities of fish.

Habitat scale

Data are currently being analyzed and collected to examine differences in survival, growth and migration among pools, riffles, glides and between natural and constructed habitats.

Other observations

Maintaining the permanent PIT tag readers presents some challenges. The readers require a substantial amount of continuous power. Power was initially supplied by eight, deep-cycle 12-volt, batteries that needed to be replaced/recharged on a weekly basis. The battery system on the East Twin River reader was replaced in June 2004 with a thermoelectric generator powered by liquid propane stored in a 100-gallon propane tank. This power supply is much more reliable and can power the system for 60 days without service. This option is being assessed for the reader on West Twin. The West Twin reader suffered serious damage when it was inundated in a large flood. It was subsequently replaced and has been operational since then.

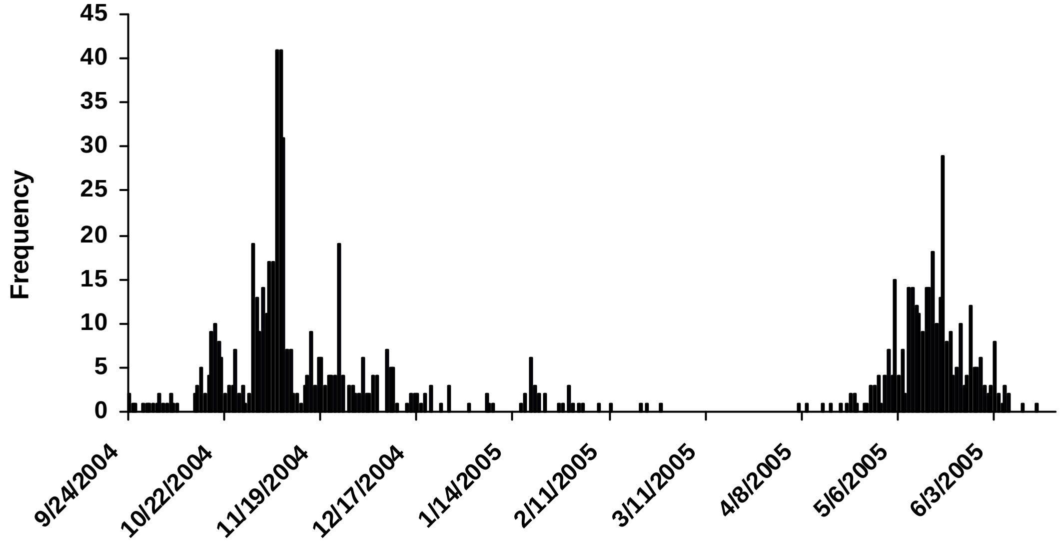

Figure 8. Fall 2004 and winter 2005 migration of East Twin River juvenile coho and trout tagged in August and September of 2004. A total of 459 trout and coho were detected by the PIT tag reader leaving the system between September 24 and December 31, 2004, while 356 fish were detected leaving the system between January 1 and June 20, 2005.

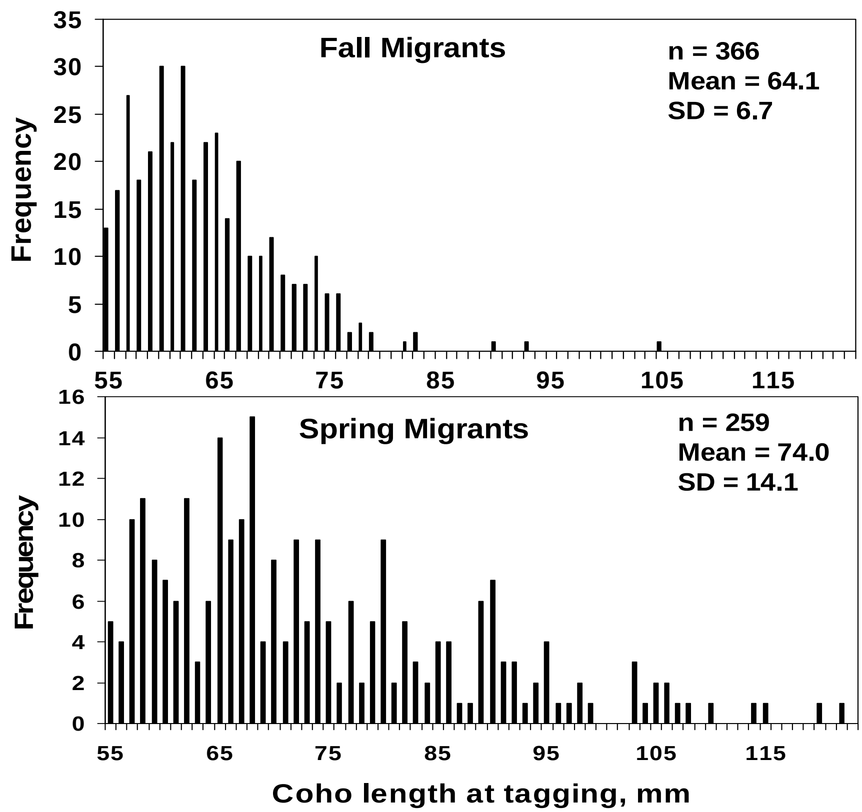

Figure 9. Length at tagging of juvenile coho salmon tagged in 2004 moving past the East Twin Creek PIT tag reader in fall 2004 and spring 2005.

Table 5. Number of trout and coho PIT tagged in 2004, 2005, and proposed tagging in 2006.

	2004		2005		2006 (proposed)	
	E. Twin	**W. Twin**	**E. Twin**	**W. Twin**	**E. Twin**	**W. Twin**
Coho	2,208	189	3,200	2,913	2,500	2,500
Trout	475	92	1477	1710	1,500	1,500
Total	2,964		9,300		8,000	

Table 6. Estimates of % fall migrants and overwinter survival for coho tagged in simple and complex reaches and East Twin versus Sadie Creek (East Twin tributary) in 2004. Fall migrants are the number of tagged fish detected passing the PIT readers before January 1. Overwinter survival was calculated as the # spring migrants/ (total # tagged fish - # fall migrants). Number in parenthesis is number of PIT tagged fish detected in fall or spring.

	Percentage (#)			
	Simple	**Complex**	**East Twin**	**Sadie Creek**
Fall migrants	20.9 (151)	20.1 (148)	21.6 (351)	2.6 (15)
Overwinter Survival	9.3 (53)	10.2 (60)	10.2 (130)	22.4 (127)

Hood Canal Complex

Land use in the four watersheds in this complex range from urban and residential in Little Anderson Creek to almost entirely forestry in Stavis Creek, where a substantial proportion of the watershed is managed by the Washington Department of Natural Resources (Figure 10). In Little Anderson Creek, lack of wood and off-channel habitat has been identified as likely factors constraining fish production (Table 7). Seabeck Creek displays evidence of channel incision in many locations and significant amounts of sediment deposition in other channel segments. The incision in this watershed may actually be contributing to low summer flows by reducing groundwater storage. Big Beef Creek has a small impoundment that impacts water temperature downstream and provides habitat for various warm water fishes that may prey on coho and steelhead smolts.

Because we expect continued residential development in all basins, but especially in Little Anderson Creek and Big Beef Creek, this complex offers the best opportunity to evaluate the impact of urban and residential development on our ability to increase salmon production with restoration efforts. These watersheds also offer the advantage of being quite small making it possible to treat a significant proportion of the channel network relatively easily. However, social, logistical and financial constraints may preclude the implementation of some restoration measures (e.g., improved stormwater control, reducing the effects of the impoundment on Big Beef Creek).

Table 7. Primary production constraints are listed by IMW basin**.**

Constraint	**L Anderson**	**Big Beef**	**Seabeck**	**Stavis**
Low summer flow	X	X	X	X
Fall spawner flows		X		X
Predation by exotics		X		
High water temp		X		
Sediment input	X	X	X	X
Lack of LWD	X	X	X	X

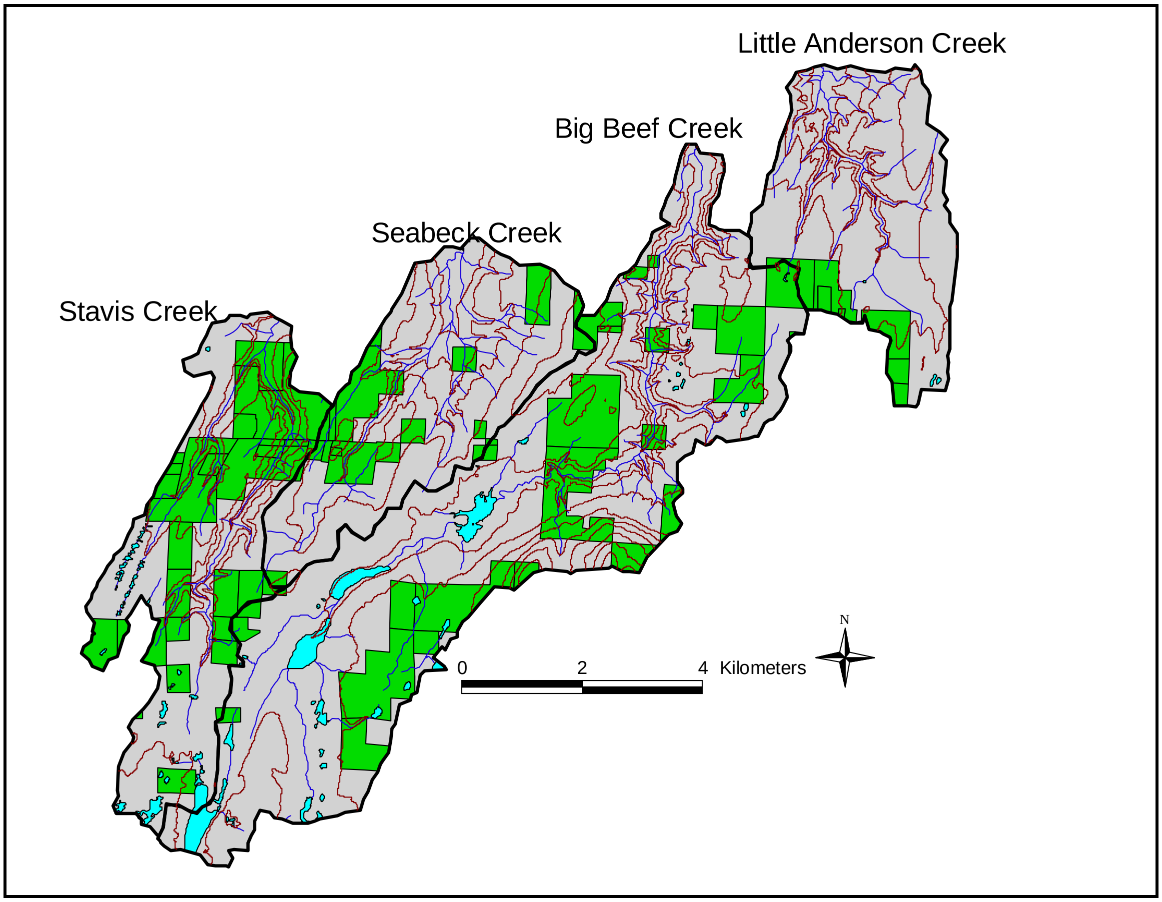

Figure 10. Hood Canal IMW Complex. Washington Department of Natural Resources land is green. Lakes and wetlands are blue.

<u>Fish production</u>

Naturally produced salmonids from the Hood Canal Complex include coho salmon, fall chum salmon, cutthroat trout, and a small population of steelhead. Efforts are being made to establish a naturally-produced population of summer chum in Big Beef Creek.

Because returning adults must pass through the weir, accurate spawner counts are available for Big Beef Creek since 1976 (Table 8). In 2003 the IMW began weekly November-December spawner counts on reaches known to support anadromous fishes in all four basins. Additional surveys were conducted in 2004 on stream reaches where there was a question about access for coho salmon or steelhead in order to develop a comprehensive understanding of the extent of spawner distribution in these four watersheds. The improved knowledge on spawner distribution will be used to improve the accuracy of escapement estimates in future spawner surveys.

Smolt counts began in Big Beef Creek in 1978 and 1992 or 1993 in the other streams (Table 8; Figures 11-14). Coho smolt production ranges from the hundreds per year in Little Anderson Creek to tens of thousands per year in Big Beef Creek. Steelhead production is relatively low in all basins.

Table 8. Period of record and data collected at each smolt trap.

Smolt trap	Watershed analysis?	Juveniles		Adults	
		Since	Species	Since	Species
Anderson Cr	Yes, 1998	1992	coho	-	
Big Beef Cr	Yes, 1998	1978	coho, cutthroat, steelhead	1976	chinook, chum, coho
Seabeck Cr	Yes, 1998	1993	coho	-	
Stavis Cr	Yes, 1998	1993	coho	-	

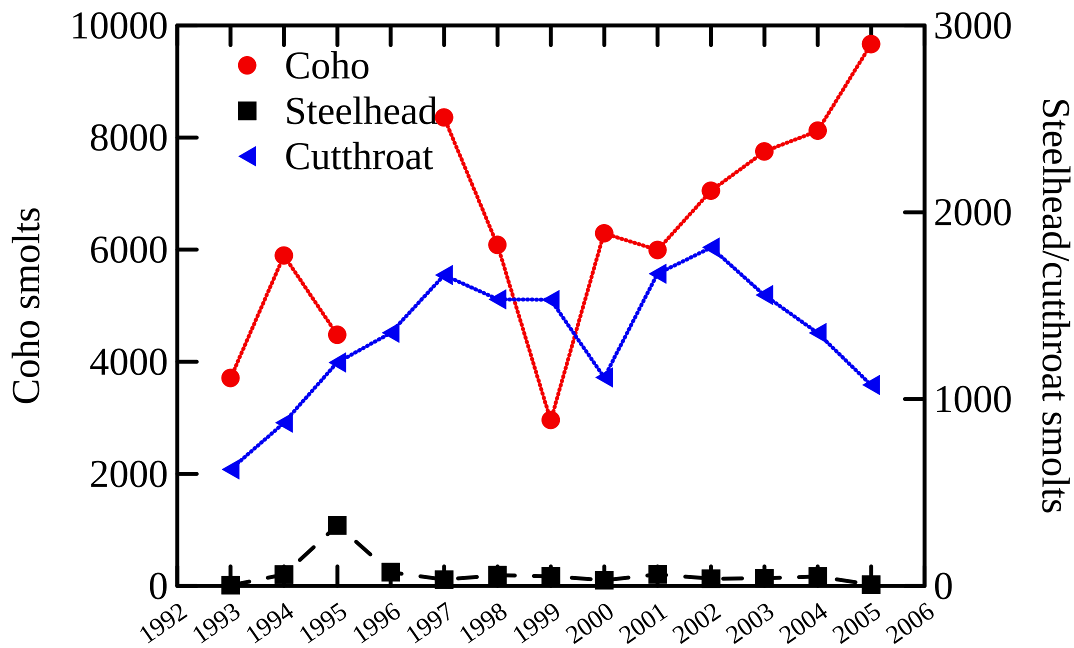

Figure 11. Stavis Creek wild coho, steelhead, and cutthroat smolt production.

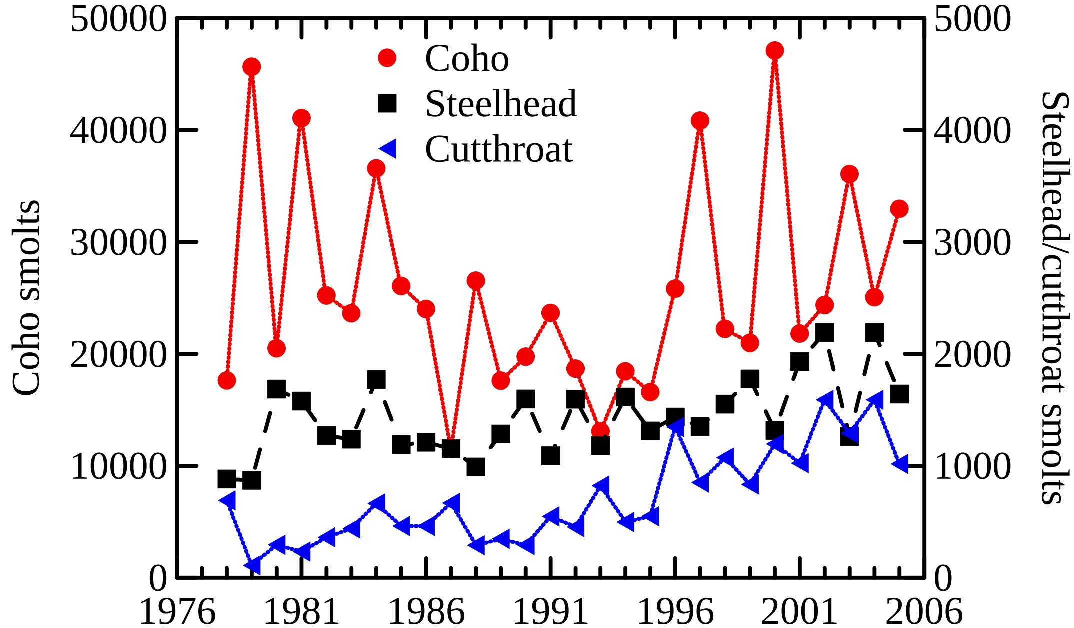

Figure 12. Big Beef Creek coho, steelhead, and cutthroat smolt production.

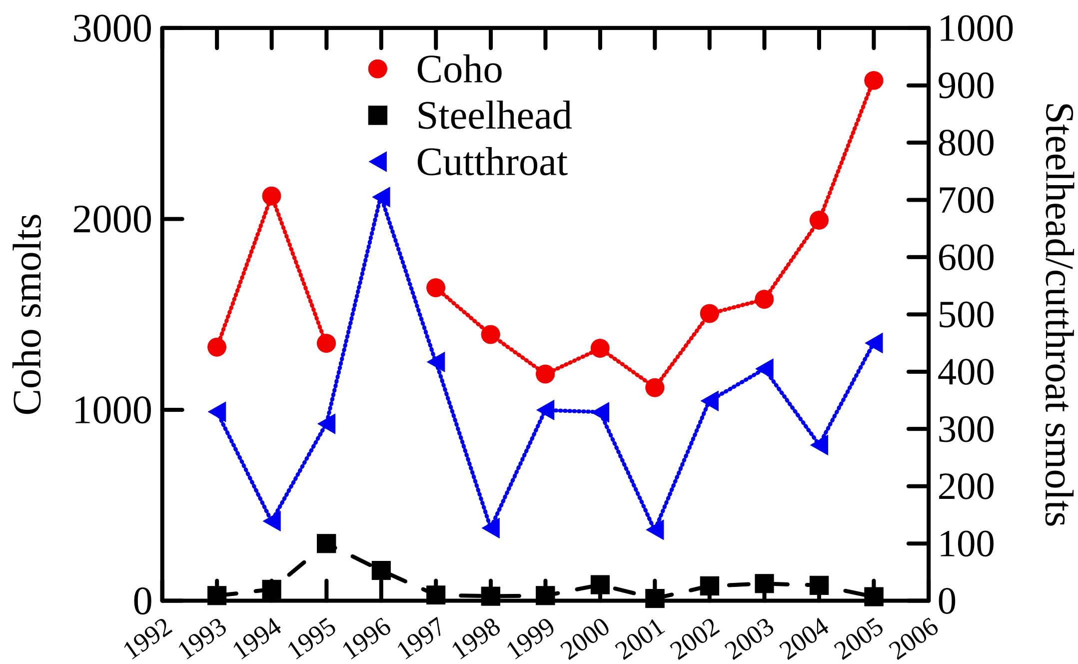

Figure 13. Wild coho, steelhead, and cutthroat smolt production from Seabeck Creek.

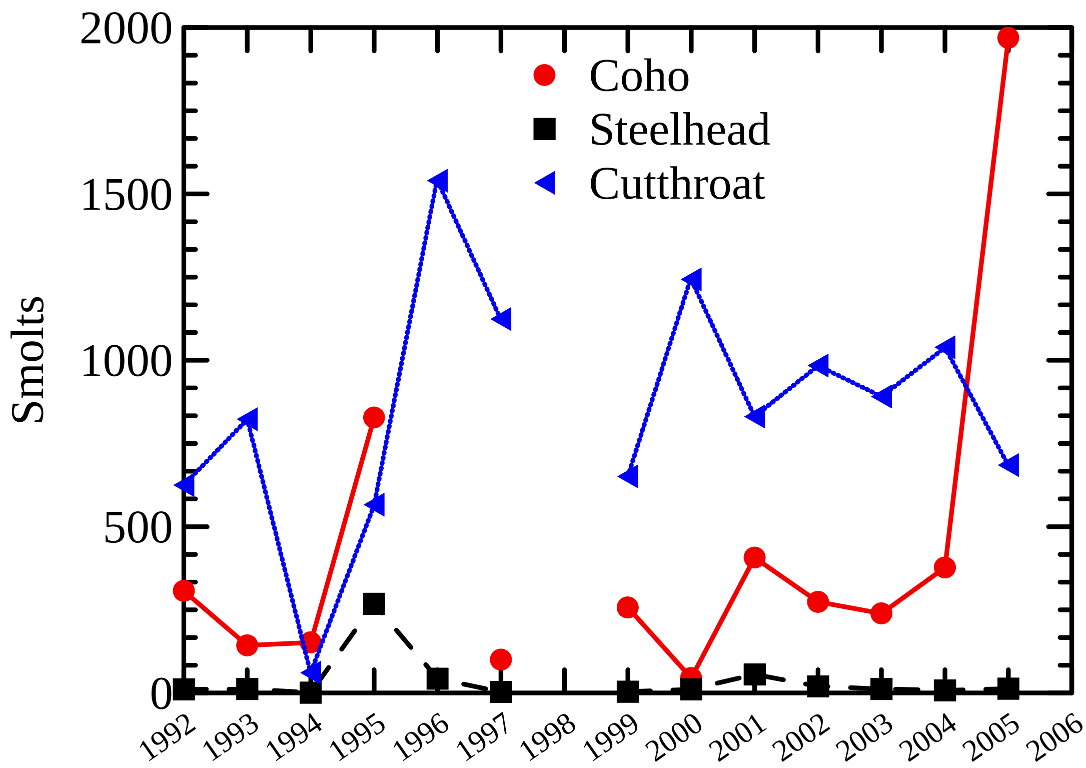

Figure 14. Annual production of coho, steelhead, and cutthroat smolts from Little Anderson Creek.

Coho smolt production in 2005 was the highest ever recorded in Stavis, Seabeck, and Little Anderson Creek. Production was 160, 182, and 693 percent above the long-term average, respectively, in these streams, while Big Beef Creek production was well within the observed range. Preliminary estimates for 2006 indicate that production in all streams was above average but was more that six times the long-term average in Little Anderson Creek. The increase in Little Anderson production coincides with the replacement of a culvert that formed a partial barrier at Anderson Hill Road. Because the IMW program was initiated after this occurred, no pre culvert replacement habitat or juvenile density data are available for comparison. However, coho smolt production in Little Anderson Creek, which averaged 284 smolts/ year prior to 2005 with a high of 833 smolts in 1996, jumped to 1969 and 1707 smolts in 2005 and 2006, respectively. This could be due to improved access to spawning and rearing habitat.

Restoration Projects

Restoration will focus on Little Anderson Creek for the coming year, then move on to Seabeck and Big Beef Creek over the next two years. The Anderson Landing Preserve (http://www.kitsapgov.com/parks/pdfs/parks%20pdfs/web_anderson.pdf), is owned by Kitsap County and encompasses 68 acres of land bordering the lower 0.7 km of Little Anderson Creek. The stream channel is unstable and has obviously meandered across the valley bottom, as evident from the old channels. Although the current habitat condition is relatively poor, beavers have been present at his site since at least 2004 and the dam building and tree felling has had a noticeable beneficial effect on habitat. We propose to continue to observe the area as it stabilizes and recovers naturally rather than deliberately manipulating the channel.

A restoration project to enhance habitat upstream of Anderson Hill Road is under development and will be implemented in fall 2006 or spring 2007. The project will place LWD on approximately 1100m of stream and will enhance a large proportion of the newly accessible anadromous fish habitat above Anderson Hill Road.

Research and Monitoring
Although the suspected limiting factors in Hood Canal, sediment and lack of LWD, are similar to the Straits, the causes are more complex and will require more effort to determine the solutions. Sediment deposition in the lower end of all watersheds is apparent and the sources are likely bank erosion and incision of stream channels in the upper watershed. In the more developed watersheds, these conditions may be exacerbated by high peak stream flows as storm runoff from impervious surfaces is directed into the channel system rather than percolating into the groundwater. Stream channel incision occurs in all basins but is especially widespread in Seabeck Creek. There is anecdotal evidence that summer flows in this system are much lower than historically, possibly a product of the channel incision. Before proposing widespread instream habitat restoration, we will examine the likely causes of channel incision, sources of sediment and changes in flow.

In 2006 we will continue to focus on:

- quantifying the relationship between summer low flow and available rearing habitat.
- quantifying spawner and redd distribution as a function fall flows
- evaluation of peak and minimum stream flows in the system as a function of development and road density

Lower Columbia Complex
The Lower Columbia Complex is comprised of Mill Creek, Abernathy Creek, and Germany Creeks, located within the Elochoman WRIA (25), in Cowlitz and Wahkiakum Counties. Most of the complex is managed as industrial timberland and owned by Washington Department of Natural Resources (DNR) and industrial forest landowners. Residential development is light, although projected to increase substantially within WRIA 25 by 2020, and concentrated along public roads in the lower portion of the three basins. Some agriculture occurs in the lower end of Abernathy Creek and Germany Creek.

Lack of large wood in the channels, reduction in off-channel habitat, and alterations in sediment delivery and transport are likely to be factors that have influenced habitat conditions in these watersheds (Table 9).

Table 9. Constraints to smolt production

Factors limiting smolt production
low habitat diversity
poor channel stability
poor riparian function
reduced floodplain function
altered streamflow
high stream temperature
excess sediment input

Many of these production constraints are correlated and can be attributed to clearing of riparian vegetation for agriculture or timber harvest, road construction in the floodplains, effects of historic commercial forest operations, and direct manipulation of the stream channel.

Fish Production

Historically, escapement estimates were limited to chinook salmon and steelhead in the watershed in this complex (using the index reach method). We expanded these surveys in 2004-2005 to include chum and coho salmon and extended them throughout the known anadromous zone. This intensified procedure will enable us to assess spawner and redd distribution and to estimate total numbers. In 2005 a fish weir was installed on Abernathy Creek to better quantify escapement and evaluate the current fish distribution data collection efforts.

Smolt traps are located within a kilometer of the stream mouths (Figure 15). Smolt monitoring has been conducted in the Lower Columbia Complex since 2001 (Table 10, Figures 16-17). The low level of coho production in the Lower Columbia Complex may relate to the higher stream gradients, poor habitat condition, or even low coho escapements, which were not measured until last year. Wild steelhead smolt production per square kilometer of watershed averaged 20 in Mill Creek, 108 in Abernathy Creek, and 130 in Germany Creek. These levels are much higher than are observed in Stavis Creek, a stream in the Hood Canal complex, over the same two years (4 steelhead smolts/km^2). The pattern of land use in Stavis Creek is similar to that of the Lower Columbia watersheds but Stavis Creek is a much smaller and lower gradient stream.

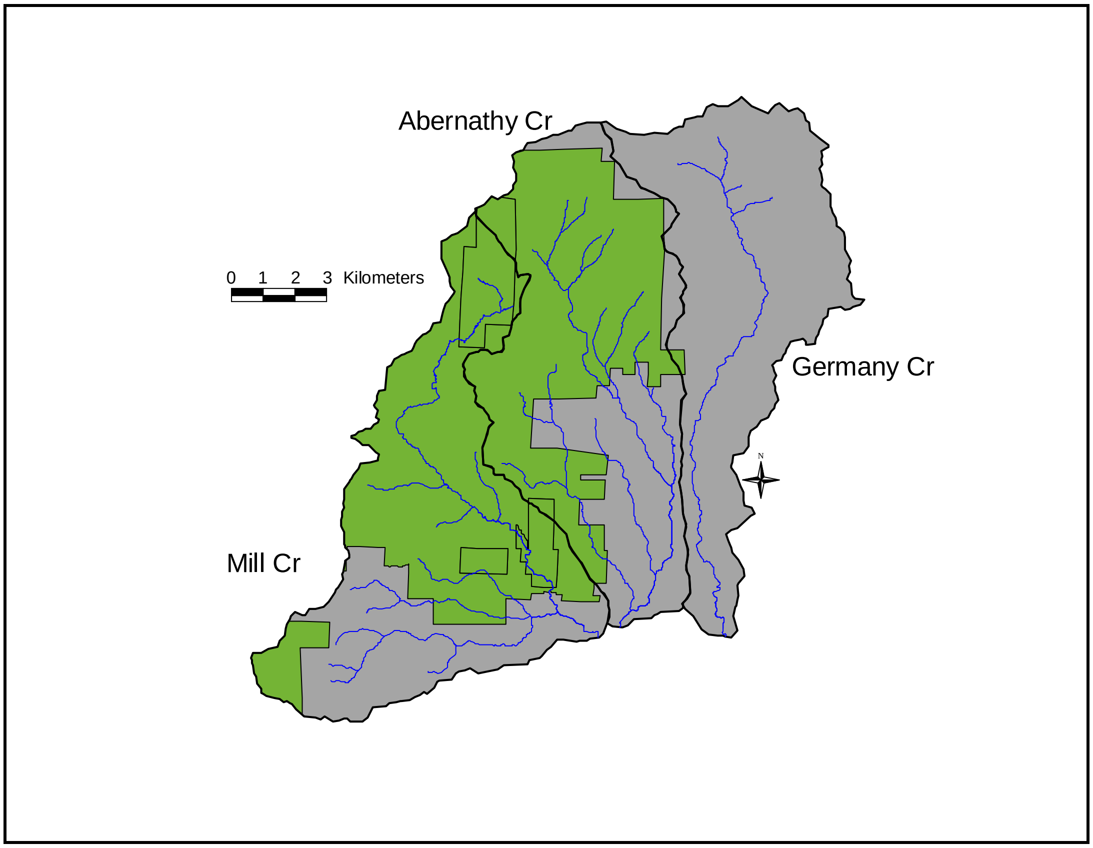

Figure 15. Lower Columbia IMW Complex. Land managed by the Washington Department of Natural Resources is shaded green.

Table 10. Data record in Lower Columbia complex

Lower Columbia Complex				
Smolt trap	*Watershed analysis?*	*Juveniles*		*Adults*
		Since	*Species*	*Species*
Mill Cr Abernathy Cr Germany Cr	No	2001	chinook, coho, cutthroat, steelhead	chinook, steelhead coho

<u>Restoration Projects</u>

Because of the short smolt record, we have concentrated on collecting pre restoration smolt, habitat, juvenile, and adult data. Active implementation in these basins is tentatively scheduled to begin in 2009. We are working through the Lower Columbia Fish Recovery Board and the Cowlitz County Conservation District to develop a prioritized restoration plan based upon the recovery plan (LCFRB 2004) for this complex.

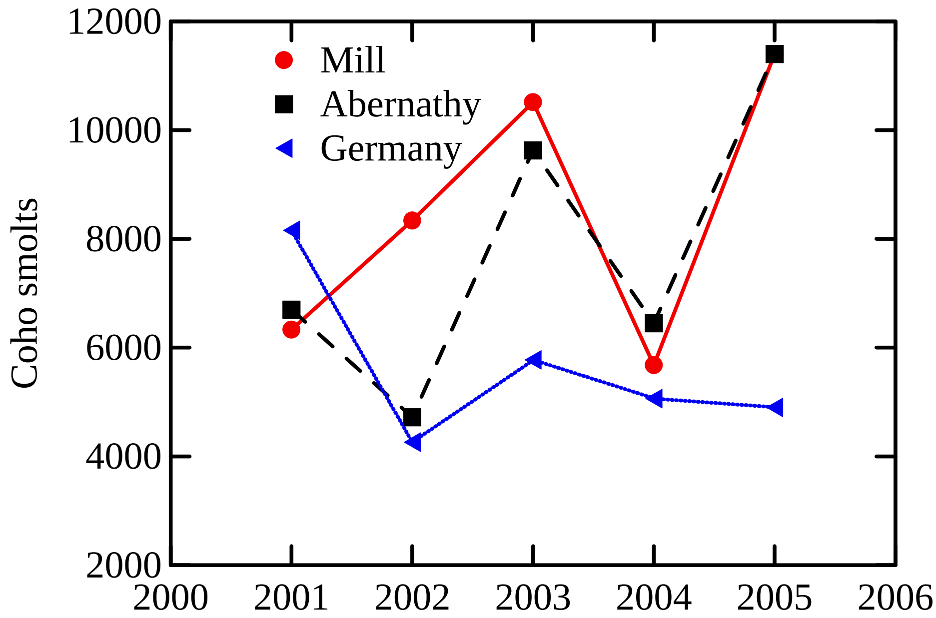

Figure 16. Coho production estimates from the Lower Columbia Complex.

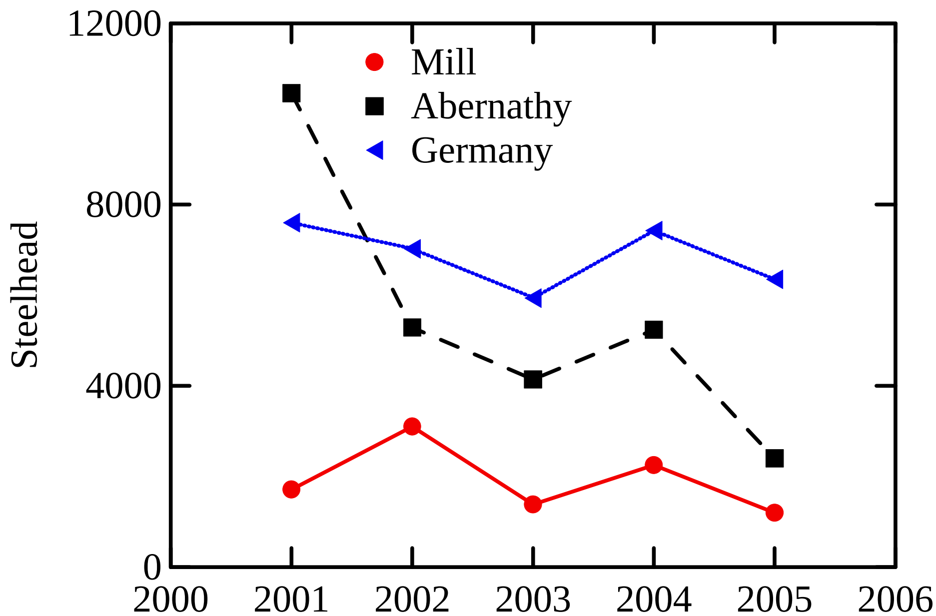

Figure 17. Steelhead production estimates from the Lower Columbia Complex.

Skagit River Estuary

Pre-IMW monitoring Chinook salmon in the Skagit estuary started from several premises: 1) Chinook salmon are federally threatened in the Pacific Northwest, 2) Chinook salmon require estuary habitat for successful rearing and transition to the marine environment, and 3) estuary habitat loss and degradation in the Skagit system has resulted in reduced capacity for salmon. While the first of these premises was supported by other researchers (Myers et al. 1997) at the time monitoring began, the other premises had weak (if any) support. Therefore, for the last 10 years, the monitoring goals have been to examine population characteristics and habitat use of the Skagit estuary by different life history types of Chinook salmon, with the goal of identifying their limiting factors.

These efforts provided strong support for the second two premises. They have documented that the majority of fish use the tidal delta during rearing for up to eight weeks, and may reside in Skagit Bay for several months (Beamer et al. 2000; Beamer and Larsen 2004). Furthermore, research has shown that the density of fish in the tidal delta increases with increasing numbers of outmigrating juveniles, that body size declines as a function of tidal delta density, and that the frequency of one life history subtype – fry migrants – increases as a function of the abundance of the outmigrants entering the tidal delta (Fig. 18). In addition, the return rate of adult salmon is limited by the abundance of juveniles (Greene et al. 2005). All these findings support the third premise, and provide a strong argument for restoration of habitat in the Skagit estuary. The Skagit River System Cooperative and WDFW produced a recovery plan that emphasizes estuary restoration as the centerpiece for recovery of Chinook salmon in the Skagit River (Skagit River System Cooperative and Washington Department of Fish and Wildlife 2005). This plan features several restoration projects already completed or in preparation (Table 11), as well as some that are currently at conceptual stages. The result will be the first large-scale experiment on the effects of estuary restoration on Chinook salmon populations.

<u>Hypotheses</u>

How will estuary restoration affect Skagit Chinook salmon? If we interpreted the results in Figure 18 strictly and applied it equally to the entire Skagit estuary, we would expect restoration in the Skagit tidal delta to reduce local tidal delta Chinook salmon densities, thereby causing increases in body size and overall population abundance and a decrease in the frequency of fry migrants.

However, because of variation in the accessibility and the current availability of habitat across the estuary, hypotheses should differ in different areas of the estuary. We used a system-scale approach to generate hypotheses about how restoration of tidal delta capacity and connectivity and pocket estuary capacity effect juvenile Chinook abundance, size, and the frequency of life history types (Table 11).

We developed sub-delta monitoring hypotheses by thinking how current delta habitat is being utilized by juvenile Chinook salmon (Figure 19) and then by hypothesizing how juvenile Chinook salmon would respond to planned delta restoration (Figure 20). In Figures 19 and

20, the arrow directions depict how juvenile Chinook salmon move through delta habitat and into Skagit Bay. The pathways within the delta are based where delta distributary channels are located or planned to be restored. The pathways for fish moving from delta habitat to Skagit Bay were derived from drift buoy data (see Beamer et al. 2005). Arrow thickness represents the number of juvenile Chinook salmon using each pathway based on the current or restored habitat amount and configuration. Figure 20 shows planned restoration areas in pink. Because of limitations in the migratory pathways that fish can take within delta habitat, we do not expect the entire delta will respond to specific restoration projects in a homogeneous fashion. The sub-delta areas that we do expect to respond similarly are numbered and circled in Figure 20. Monitoring hypotheses are stated for each area in Table 11. All monitoring hypotheses are interpreted as functions to account for varying outmigration population sizes, habitat conditions (e.g. channels with deep areas with low tide impoundments v. channels without these features), and environment (e.g., floods, temperature, salinity).

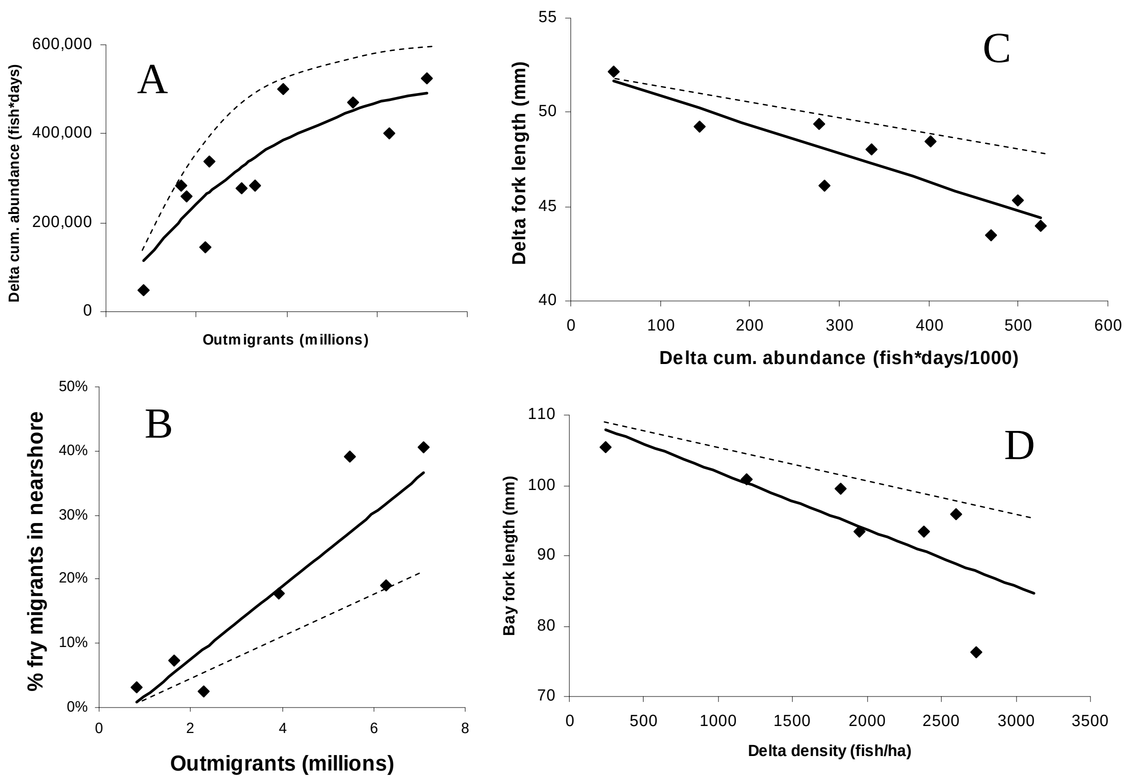

Figure 18. Functional relationships for wild juvenile Chinook salmon from the Skagit River, delta and nearshore (from Beamer et al 2005). Points and solid lines represent the results of a decade of field study while dashed lines illustrate conceptually how these relationships should respond to habitat restoration planned for the Skagit tidal delta. (A) The relationship between freshwater smolt outmigration population size and the density of juvenile Chinook in tidal delta habitat. (B) The relationship between freshwater smolt outmigration population size and the percentage of juvenile Chinook in nearshore habitat that exhibit the fry migrant life history type. (C) The relationship between Chinook salmon density in tidal delta habitat and the size of juvenile Chinook in tidal delta habitat. (D) The relationship between Chinook salmon density in tidal delta habitat and the size of juvenile Chinook in nearshore habitat.

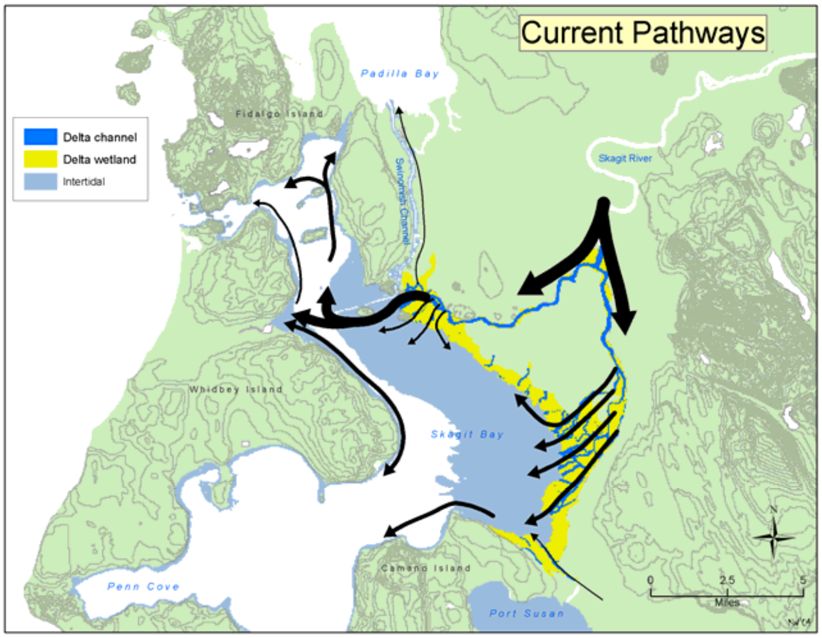

Figure 19. Current juvenile Chinook salmon pathways in the Skagit River estuary. The arrow directions depict how fish move through the tidal delta and into Skagit Bay. Arrow thickness represents the number of Chinook salmon following these pathways, based on current habitat configuration and area.

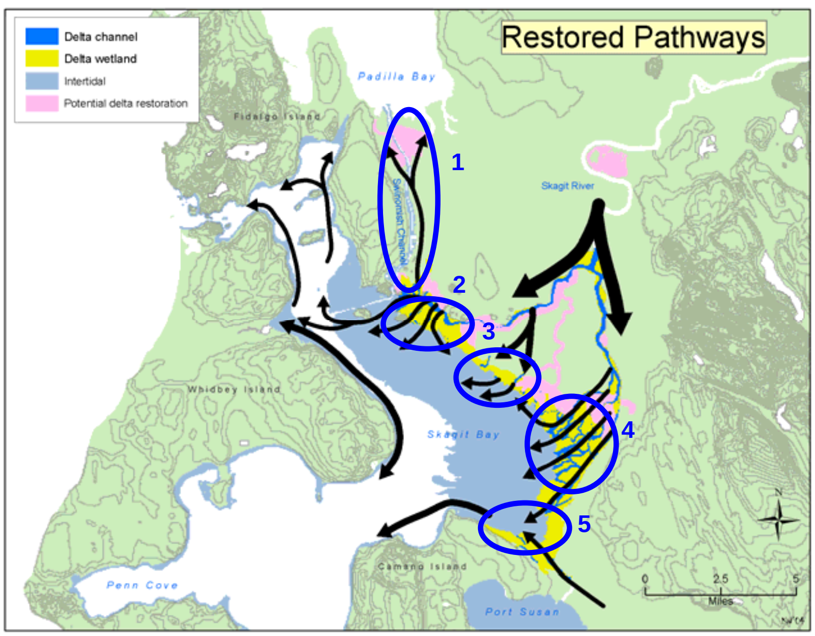

Figure 20. Future juvenile Chinook salmon pathways in the Skagit River estuary after restoration. The arrow directions depict how fish move through the tidal delta and into Skagit Bay. Arrow thickness represents the number of Chinook salmon following these pathways, based on restored habitat area and connectivity. Conceptual habitat restoration areas are shown in pink. Subsets of delta habitat that are expected to respond in similar ways are circled and numbered. Monitoring hypotheses for each area are in Table 11.

Table 11. Draft monitoring hypotheses for juvenile Chinook salmon abundance in sub-delta polygons shown in Figure 18.

Sub-delta polygon # and name	Potential Restored Area (acres)	Juvenile Chinook response Pre-restoration	Juvenile Chinook response Post-restoration
#1 Swinomish Channel Corridor	770	Density lowest of all sub-delta polygons	Density increases due to increased connectivity with the North Fork Population abundance & body size increase due to increased capacity along the Swinomish Channel Corridor
#2 North Fork Delta	980	Density highest of all sub-delta polygons	Density decreases due to increased connectivity to other areas within the delta Population abundance & body size increases due to increased capacity within the North Fork Delta
#3 Central Fir Island Delta	470	Density 2nd lowest of all sub-delta polygons	Density increases due to increased connectivity via a cross island corridor restoration project Population abundance & body size increases due to restored capacity within Central Fir Island
#4 South Fork Delta	630	Density is intermediate of all sub-delta polygons	Density remains the same. Population abundance & body size increases due to increased capacity with the South Fork Delta
#5 Stanwood/English Boom Delta Fringe	None Currently Identified	Density lowest of all sub-delta polygons	Density and population increases due to increased source population increase originating from Skagit and Stilliguamish Rivers.

Specific tasks funded through the IMW include (Table 12):

Fyke trapping in the tidal delta (SRSC). Sites will be monitored biweekly from February through July. This monitoring includes sites on the North and South Forks of the Skagit River, and effectiveness monitoring of Deepwater Slough.

Beach seining of nearshore sites in Skagit Bay (SRSC). 28 sites will be monitored biweekly from February through September. This monitoring includes sites contiguous to the North and South Forks of the Skagit as well as pocket estuaries.

Townetting of offshore sites in Skagit Bay (NWFSC). Sites will be monitored monthly from April to October. This monitoring includes sites contiguous to the North and South Forks of the Skagit and pocket estuaries, as well as sites adjacent to the exit points from Skagit Bay to Puget Sound (Crescent Harbor, Deception Pass).

Table 12. Current monitoring tasks in the Skagit River estuary.

Method	**Habitat**	**Sampling regime**	**# index sites**	**# years at index sites**	**Random sites** (# per sample trip/ # per year)
Fyke trapping	Tidal delta & Swinomish Channel	Biweekly: Feb-July Monthly: August	11	12	4/40
Beach seining	Nearshore[1] & Swinomish Channel	Biweekly: Feb-August Monthly: Sept-Oct	18	10	12/192
Townetting	Offshore	Monthly: Mar-Oct	4	4	16/112

[1]Includes 4 pocket estuary sites: Lone Tree Lagoon, Arrowhead Lagoon, Grasser's Lagoon, and Turner's Lagoon. Pocket estuary sampling started in 2002.

Restoration projects

This project capitalizes on a number of estuary restoration efforts either already completed or likely to be completed within the next four years (Table 13). These restoration projects involve dike removal and restoration of habitat forming processes such as riverine and tidal inundation and improved connections to existing habitat. In total these projects will result in restoration and reconnection of over 700 acres of wetlands, and therefore will greatly improve habitat availability for juvenile Chinook salmon.

Table 13**.** List of delta restoration projects completed or currently under feasibility/design.

Site Name	**Sub-delta Polygon (Fig. 3)**	**Project type (Area restored to river/tidal hydrology)**	**Year complete**	**First Year juveniles could benefit**
Deepwater Slough	#4	Capacity/Connectivity (221 ac)	2000	2001
Smokehouse Floodplain	#1	Capacity (62 ac)	2005-7	2006-8
Milltown	#4	Capacity (212 ac)	2006/7	2007/8
South Fork Dike Setback	#4	Capacity (40 ac)	2004	2005
Wiley Slough	#4	Capacity/Connectivity (161 ac)	2007	2008
Swinomish Channel Causeway	#1	Connectivity (na)	2008	2009
Fisher Slough	#4	Capacity (68 ac)	2008	2009

BUDGET SUMMARY

We estimate that the IMW program will be underspent for the FY 2006 by approximately $100,000 of the $1.09 million allocated. This was due to:

- Less than anticipated monitoring of specific projects in Hood Canal and Lower Columbia complexes and
- Flow and water quality monitoring equipment ordered but that may not be delivered before the end of the fiscal, so that the cost will not show up until July 2007.

We request that the unspent funds be reallocated to FY07.

The IMW program has coordinated with and contributed to ongoing monitoring and research efforts by the Lower Elwha Klallam Tribe, WDFW, NWFSC, and the SRSC (Table 14). In addition, several IMW cooperators have committed substantial in kind support of staff time to the monitoring effort and to program oversight. This coordination with existing monitoring and in-kind support comprise a substantial contribution to the IMW program.

Table 14. Estimated in-kind contributions toward oversight and monitoring and cost of the existing monitoring efforts within the IMW complexes with which we are coordinating.

IWM collaborator	**Estimated In-kind**	**Existing monitoring**
WDOE	$53,000	
WDFW	$87,000	$200,000
NWFSC	$58,000	$200,000
Elwha Klallam	$24,500	$90,000
Weyerhaeuser	$78,900	
Skagit R Sys Coop		$158,000
Total	**$301,400**	**$648,000**

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