Jimmycomelately Ecosystem Restoration








Monitoring Report 2004-2011

Jamestown S'Klallam Tribe
1033 Old Blyn Highway
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May 1, 2012

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Jimmycomelately Ecosystem Restoration Project documents:
Other relevant project documents are available at the Jamestown S'Klallam Tribe website as downloadable PDF files: http://www.jamestowntribe.org/programs/nrs/nrs_jimmy.htm

JIMMYCOMELATELY ECOSYSTEM RESTORATION MONITORING REPORT (Years 2004 – 2011)

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JIMMYCOMELATELY ECOSYSTEM RESTORATION MONITORING REPORT (Years 2004 – 2011)

EXECUTIVE SUMMARY

Revisiting the history of the salmon's decline in our neighborhoods is depressing, but stream work and habitat revival is full of high-spirited comradeship and the small epiphanies of recognition and connection that bloom when what you've done actually works … Restoration then becomes restorying the landscape with tales of its essential beauty.

Tom Jay, *Reaching Home: Pacific Salmon, Pacific People*[1]

Human land use over the past century degraded and fragmented the historically linked riverine and estuarine habitats in the Jimmycomelately Watershed. The cumulative effect of human activities was fragmentation of the natural landscape into smaller pieces with diminished functions and services for both natural resources and people. Seven (7) adult summer chum salmon (*Oncorhynchus keta*)—an ESA-listed species—returned to Jimmycomelately Creek (JCL) to spawn in 1999. Annual flooding of JCL and its estuary threatened the survival of salmonids and other natural resources, as well as the lives and livelihoods of people living adjacent to the creek and the whole Olympic Peninsula community that is dependent on Highway 101 remaining open as a transportation corridor.

Planning for the Jimmycomelately Ecosystem Restoration Project (the Jimmy Project) began in the late 1990's, and the multiple project partners (27 total) recognized early on that this landscape-scale project could potentially serve as a model for stream channel and estuary restoration in other Puget Sound watersheds.

The vision was to realign Jimmycomelately Creek into one of its historical channels, and integrate this with restoration of the estuary functions.

The vision of the Jamestown S'Klallam Tribe, Clallam County, Washington Department of Fish and Wildlife, Clallam Conservation District, Washington State Department of Transportation, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, Washington Department of Natural Resources, local private landowners, and other partners was to: *realign Jimmycomelately Creek into one of its historical, sinuous channels; integrate this channel realignment with improvements in, and restoration of, the estuary functions; and reestablish the pre-disturbance linkage between the fluvial and tidal energy regimes* (Shreffler 2000)[2].

The stated restoration goals (Shreffler 2000) were to:

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[1] Fobes, N., B. Matsen, and T. Jay. 1994. *Reaching Home: Pacific Salmon, Pacific People*. Alaska Northwest Books. Anchorage, Alaska.

[2] Shreffler, D. 2000. *A Preliminary Plan for Restoring Jimmycomelately Creek and the Lower Sequim Bay Estuary.* Phase I report prepared by Shreffler Environmental for Jamestown S'Klallam Tribe, Sequim, Washington. Available at: http://www.jamestowntribe.org/programs/nrs/jcl-Prelim-Final.pdf

(1) restore feeding, refuge, and breeding habitat for resident and migratory waterfowl and shorebirds;
(2) restore feeding, refuge, and spawning habitat for ESA-listed summer chum salmon, coho salmon, winter steelhead, and sea-run cutthroat trout, as well as for shellfish;
(3) reduce the existing flood hazards to the local private landowners, and local, state, and tribal infrastructure;
(4) restore the summer chum salmon population so that it is naturally self-sustaining;
(5) develop rigorous monitoring requirements, contingency actions, and reporting requirements; and
(6) develop this project as a model for stream and estuary restoration and management.

This report is structured to mirror two monitoring plans—one for the JCL channel (Shreffler 2001)[3] and one for the estuary (Shreffler 2004)[4]—that were designed to evaluate whether the six stated restoration goals were met. These two monitoring plans called for pre-project baseline monitoring, during-project implementation monitoring, and post-project performance monitoring of ecological processes, habitat conditions, and biological responses.

The Jimmy Project has won local, state, and national awards, but these awards have largely been based on the process and the partnerships that made the restoration possible (see Lessons Learned Report, Shreffler 2008)[5] and not the on-the-ground results of project monitoring.

In this report, for the first time, we provide a comprehensive overview of some of the success stories and causes for concern based on our monitoring:

Ecological Processes

- **Hydrology & Flood Conveyance**: JCL low flows are sufficient to support spawning and rearing of salmonids and high flows are moderate enough to allow egg to fry survival of salmonids. We have observed no evidence of flooding that threatens property or infrastructure. However, the number of annual flood events is cause for concern.
- **Sediment Transport**: The restored JCL channel flushes gravel into Lower Sequim Bay to maintain the form and function of the stream mouth, and delivers fine-grained sediment to the estuary supporting a detritus-based food web for juvenile salmonids, shellfish, and shorebirds.

Habitat Conditions

- **Channel Morphology**: The JCL channel and floodplain morphology are still evolving in response to the channel realignment, large woody debris (LWD) additions, and the reconnection of fluvial and tidal energy. Channel maintenance (gravel and LWD additions) was done at two locations in 2005 and one location in 2006. The realigned JCL channel shows greater habitat connectedness, length, and complexity than the former JCL channel. The extent of channel incision, particularly in the middle reach of the realigned channel, is of concern.
- **Water Quality**: Post-project monitoring results indicate that there has been a significant decrease in fecal coliform bacteria levels in JCL Creek and Dean Creek. Total Nitrogen and Total Phosphorous levels in JCL Creek and Dean Creek are elevated relative to water quality standards; the reasons are unknown at this point. Turbidity, pH, and temperature for JCL Creek met the

[3] Shreffler, D. 2001. *Jimmycomelately Creek-Lower Sequim Bay Estuary Restoration Project. Phase I Monitoring Plan: Jimmycomelately Creek Realignment.* Prepared by Shreffler Environmental for Jamestown S'Klallam Tribe, Sequim, Washington. Available at: http://www.jamestowntribe.org/programs/nrs/jcl-Monitoring%20Plan%20(final).pdf

[4] Shreffler, D. 2004. *Jimmycomelately Creek-Lower Sequim Bay Estuary Restoration Project: Estuary Monitoring Plan.* Prepared by Shreffler Environmental for Jamestown S'Klallam Tribe, Sequim, Washington. Available at: http://www.jamestowntribe.org/programs/nrs/jcl-Estuary%20Monitoring%20Plan-Final.pdf

[5] Shreffler, D. (ed.). 2008. *Jimmycomelately Ecosystem Restoration Lessons Learned Report.* Prepared for the Jamestown S'Klallam Tribe, Sequim, Washington. Available at: http://www.jamestowntribe.org/programs/nrs/jcl-lessionslearned10-31-08.pdf

Washington State water quality standards; dissolved oxygen (DO) did not. Benthic Index of Biotic Integrity (B-IBI) ratings improved (but still indicate compromised habitat integrity) moving upstream and away from the more urbanized lower JCL watershed. Intra-gravel dissolved oxygen (IGDO) levels at 67% of sites sampled were below the State surface water standard and low IGDO levels could be affecting salmonid egg survival.

- **LWD & Pool/Riffle Habitat**: LWD additions to the realigned JCL channel appear to have functioned as designed, creating vital pool and riffle habitat for salmonids, as well as providing bank stabilization and sediment trapping, and influencing channel morphology and complexity. There is a higher quantity and quality of LWD and pools in the realigned JCL channel than in the former dredged, straightened, and rip-rapped channel. Although the realigned JCL channel is showing some disturbing signs of downcutting, LWD additions may be locally minimizing this.
- **Habitat Gains**: We have documented significant habitat gains for tidal marsh and marsh channels, mudflat and mudflat channels, creek channels, terrestrial vegetation, and estuary wetland vegetation. The performance targets for each of these habitat types were met.

> Overall, the post-project monitoring results indicate that the performance criteria for most of the stated monitoring parameters have either been met or are on a trajectory toward being met.

Biological Responses

- **Riparian & Floodplain Vegetation**: The performance criterion of 75% survival of planted native species after three years was met. The performance criterion of 90% native plant cover after 10 years has not yet been met. After five years, native trees and shrubs are estimated to cover 73% of the surveyed area along the JCL channel, but the percent cover of native species is increasing annually and on a trajectory to meet the 90% native plant cover criterion.
- **Invasive Vegetation Removal/Management**: The performance criteria that the project area should not contain greater than 5% cover by area of invasive plant species after 10 years has not yet been met. However, we have documented significant decreases in non-native plant species in the JCL Estuary, including Japanese knotweed, Scotch broom, reed canary grass, and Himalayan blackberry. As of 2010, invasive plant species (reed canary grass, Himalayan blackberry, and two invasives species of thistle) are estimated to cover 27% of the surveyed area along the JCL channel. The management strategy has been to avoid or minimize the use of herbicides. Significant effort at manual control of these invasive plants (2006 to date) has shown mixed results, but without these efforts the percentage of invasive species would be much worse.
- **Estuary Wetland Vegetation**: The performance criteria for estuary wetland vegetation species composition and percent cover have been met, and wetland vegetation detritus now forms the base of the food web for multiple macroinvertebrate, fish, and wildlife species that use the restored estuary and Lower Sequim Bay.
- **Eelgrass Recovery**: Eelgrass is naturally re-colonizing areas that were impacted by activities at the former log yard; eelgrass beds west of the log yard have increased in area relative to pre-restoration. In 2011, eelgrass was found to a much greater extent within the former log yard footprint than in any previous post-restoration year.
- **Shellfish Recovery**: Recovery within the former log yard footprint is unknown. Clam survey efforts to date have focused on the area to the east of the former log yard footprint. Tribal members are once again harvesting safe-to-eat shellfish from the eastern part of Lower Sequim Bay, but not from within the log yard footprint.
- **Adult Salmonid Use**: ESA-listed chum salmon spawner numbers have increased dramatically from 7 in 1999 to an average of 1,259 between 2004 and 2010, with a peak of 4,027 in 2010. The performance criterion target of 330 natural-production spawners per year was exceeded every

year from 2004 to 2010, and this suggests that the Jimmycomelately Creek summer chum salmon are at a self-sustaining level.

- **Juvenile Salmonid Use**: Beach seining and tidal channel monitoring indicate that juvenile salmonids are accessing and using the full suite of freshwater and estuarine habitats available to them post-restoration. Smolt trap monitoring indicates that JCL produces, in general, fewer coho smolts, steelhead smolts, steelhead parr, and juvenile cutthroat than other comparable streams along the Eastern Strait of Juan de Fuca (i.e., Matriotti Creek, McDonald Creek, and Siebert Creek). However, annual coho smolt production for JCL has reached or approached the carrying capacity of the stream (2,000 – 2,500 smolts) in most years post-project, and coho egg-to-smolt survival and smolt-to-adult survival have been within the same range as those on comparable streams.

> Probably no story about the Jimmycomelately Ecosystem Restoration Project better demonstrates success than the returns of adult summer chum salmon to the restored Jimmycomelately Creek.

- **Waterbird Use**: Waterbird species diversity is the same post-restoration vs. pre-restoration. Overall waterbird abundance has decreased post-restoration, with some groups of waterbirds (e.g., shorebirds) more abundant pre-restoration and some groups (e.g., dabbling ducks) more abundant post-restoration.

Overall, the post-project monitoring results indicate that the performance criteria for most of the above monitoring parameters have either been met or are on a trajectory toward being met (Table E.1). It is important to point out that for most parameters the two monitoring plans set performance criteria for the ten-year time frame. This report describes our evaluation of the stated performance criteria at the five to seven year mark (depending on the particular monitoring parameter and when post-project monitoring began).

The two primary concerns at this point in our post-project monitoring are water quality issues (i.e., low DO, high Total Nitrogen and Total Phosphorus, compromised B-IBI rating, and low IGDO) and the extent of invasive vegetation (especially reed canary grass) still present within the project area. Also of concern are the number of annual floods and the extent of incision along the realigned JCL channel.

Table E.1. Jimmycomelately Ecosystem Restoration Project results for each monitoring parameter.

Monitoring Parameter	Results	
	JCL Channel	Estuary
Ecological Processes		
Hydrology & Flood Conveyance	☺	☺
Sediment Transport	☺	NF
Habitat Conditions		
Channel Morphology	▲	NPC
Water Quality	▼	NF
LWD & Pool/Riffle Habitat	☺	NF
Habitat Gains	N/A	☺
Biological Responses		
Riparian & Floodplain Vegetation Establishment	▲	NF
Estuary Wetland Vegetation Establishment	N/A	☺
Invasive Vegetation Removal	▼	☺
Eelgrass Recovery	N/A	▲
Shellfish Recovery	N/A	▲
Adult Salmonid Use	☺	☺
Juvenile Salmonid Use	☺	☺
Waterbird Use	NPC	▲

☺ = performance criteria are being met.

▲ = performance criteria not yet met, but trajectory is positive.

▼ = performance criteria are not being met, and trajectory is negative or cause for concern

NF = no funding to do monitoring

NPC = no performance criteria established

N/A = not applicable

Jimmycomelately Creek and Estuary appear to be on an overall trajectory toward restored ecosystem health. Probably no story about the Jimmycomelately Ecosystem Restoration Project better demonstrates success than the returns of adult summer chum salmon to the restored Jimmycomelately Creek. The combination of habitat restoration, harvest regulations, and the summer chum salmon recovery program may have succeeded in saving JCL summer chum salmon from extinction. Salmon are such a tangible messenger of the project's success because the public can wrap their brains AND their arms around these fish. Community volunteers love the Jimmy Project and invest 100s to 1000s of hours annually to ensure the continued health of the Jimmycomelately Ecosystem.

In this report, we provide a synthesis of all the monitoring performed through the 2011 calendar year. Each chapter is a stand-alone ―story" with background, methods, results, discussion, and literature cited for each monitoring parameter. Each chapter is authored by the individual or individuals that were primarily responsible for the monitoring. Our intent is that this report will provide valuable insights to planners, biologists, engineers, and other restoration practitioners contemplating similar restoration projects in other Puget Sound watersheds. This report is also a celebration of a long restoration journey, and thus represents our attempt to share with the public what we have learned along the way.

Thus far, the Jimmy Project appears to be a success not only from a technical perspective, but also from the perspective of ―restorying the landscape with tales of its essential beauty." Monitoring is ongoing as funding allows, and the story of the Jimmy is still unfolding.

ACKNOWLEDGMENTS

Funding for this report was provided by U.S. Environmental Protection Agency, Region 10. Hansi Hals of the Jamestown S'Klallam Tribe (JST) was the project manager and a calm voice of reason as multiple authors converged on the common goal of sharing what we've learned through our monitoring of the Jimmycomelately Ecosystem Restoration Project.

The authors wish to acknowledge the numerous project partners that made this monitoring report possible. Chris Evans of Washington Department of Ecology was responsible for maintaining the stream gage, developing the stage/discharge rating curves, and providing us with mean annual discharge and flood modeling reports. Streamkeepers of Clallam County provided us their annual water quality and macroinvertebrate data for Jimmycomelately Creek; they also collected velocity data to help build the stream gage rating curves. Washington Department of Health provided us with their annual fecal coliform monitoring reports for Lower Sequim Bay. Katie Anderson of Northwest Indian Fisheries Commission analyzed our temperature data. Glen Gately of Jefferson County Conservation District was invaluable in providing technical assistance for sampling intra-gravel dissolve oxygen. Washington State Department of Transportation provided us with their annual vegetation monitoring reports for the former Eng property. Randy Cooper of Washington Department of Fish and Wildlife provided us with annual summer chum and coho escapement numbers, as well as spawning ground data. Battelle Marine Sciences Laboratory loaned us fish sampling gear.

We also wish to acknowledge the many volunteers without whom some of our monitoring activities would have been severely reduced or eliminated altogether. Walt Johnson volunteered countless hours over the last seven years as our ―database guru." Gene Kridler conducted bird counts in Lower Sequim Bay from November 1996 to February 2002 when Karen Holtrop took over; she has performed all of the bird monitoring on a volunteer basis over the last ten years. A long list of North Olympic Salmon Coalition (NOSC) volunteers, coordinated by Cheri Scalf, spent hundreds of hours every year since 1999 maintaining the Jimmycomelately adult fish trap and providing us with summer chum spawning and escapement numbers.

We are also grateful to the Peninsula College (PC) students that helped with tidal channel fish sampling and/or data entry, and the many community volunteers, NOSC volunteers, and PC students that helped with beach seining in Lower Sequim Bay. Steve Irish, under contract to JST, made significant contributions to site stewardship with his role in thinning alder, nursery maintenance, invasive species control, and monitoring and re-planting the native species installed on site.

JST technicians and interns helped with data entry and QA/QC. Tribal youth helped biologists perform various monitoring tasks and were mentored by JST staff members. Pam Edens (GIS/Data Management Specialist) and Randy Johnson of JST assisted with GIS support and graphics production. The photos and graphics in each chapter are by the author(s), unless otherwise noted. The final formatting and document layout was done by Betty Oppenheimer (Publications Specialist) of JST.

EDITOR'S NOTE

I am honored that the Jamestown S'Klallam Tribe asked me to be a contributing author and editor of this report. Since 1999 I've had the incredible fortune to be part of all aspects of the Jimmy Project. No project in my career has been as rewarding, and I applaud the Tribe for their clear vision, forceful leadership, and strategic thinking that led to the restoration of the Jimmycomelately Ecosystem.

In the introductory chapter to *Restoration of Puget Sound Rivers*, Montgomery et al. (2003) wrote that: —*The degree to which society is willing to give back space in the landscape to rivers will define the degree to which rivers can eventually recover their natural ecological processes, functions, and dynamics.* ”[6] I am grateful to the Blyn community for their unwavering support of the Jimmy Project, and for having the courage to give back space to Jimmycomelately Creek.

The year 1999 was a big one in the world of salmon recovery. Hood Canal summer chum salmon, bull trout, and Chinook salmon were all listed as threatened under the Endangered Species Act. Nine federal agencies known as the Federal Caucus released their —Four H” working paper on salmon recovery in the Pacific Northwest, which outlined a range of alternatives to human activities that harm salmon (habitat degradation, hatchery production, harvest activities and hydropower operations). The National Research Council published *New Strategies for America's Watersheds* (NRC 1999).[7] The Washington State Governor's Salmon Recovery Office prepared a *Statewide Strategy to Recover Salmon* (GSRO 1999).[8]

Also in 1999, the same year our restoration planning efforts began on Jimmycomelately Creek, Jim Lichatowich published *Salmon Without Rivers*.[9] This seminal book was a devastating look at the roots and evolution of the salmon crisis in the Pacific Northwest, and simultaneously a clarion call for change: *"We simply cannot have salmon without healthy rivers. But it's not just the salmon than need healthy rivers. We do too. We live in the same ecosystem as the salmon, so we cannot stand apart, manipulate, control, and simplify those ecosystems without at some fundamental level diminishing ourselves."*

The Jimmy Project represents for me, both at a professional and personal level, an attempt to answer Jim Lichatowich's plea for healthy rivers. And while any technical report is ultimately just a collection of words, graphs, and pictures, this report feels like more than that to me. I hope the reader will get a sense of what Tom Jay called the *"high-spirited comradeship and the small epiphanies of recognition and connection*" made possible by our humble attempts to restore a healthy river … for salmon and for people.

– Dave Shreffler, May 2012

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[6] Montgomery, D.R., S. Bolton, D.B. Booth, and L. Wall. 2003. Restoration of Puget Sound Rivers. University of Washington Press, Seattle, WA.

[7] NRC (National Research Council). 1999. New Strategies for America's Watersheds. National Academy Press, Washington, D.C.

[8] GSRO (Governor's Salmon Recovery Office). 1999. Statewide Strategy to Recover Salmon: Extinction is Not an Option. State of Washington, Governor's Salmon Recovery Office, Olympia, WA.

[9] Lichatowich, J. 1999. Salmon Without Rivers: A History of the Pacific Salmon Crisis. Island Press, Washington, D.C.

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JIMMYCOMELATELY ECOSYSTEM RESTORATION MONITORING REPORT (Years 2004 – 2011)

INTRODUCTION

Intended Audience for this Report

Our intent is that this report will provide valuable insights to planners, biologists, engineers, and other restoration practitioners contemplating similar restoration projects in other Puget Sound watersheds. In particular, this report should be viewed in conjunction with the *Lessons Learned* report (Shreffler 2008), which summarizes the range of technical, engineering, financial, social, and political challenges faced by the Jimmycomelately Ecosystem Restoration Project (the —Jimmy" Project). The *Lessons Learned* report and other project documents are available as downloadable pdf files at: http://www.jamestowntribe.org/programs/nrs/nrs_jimmy.htm

Project Need

The Jimmycomelately Watershed comprises an area of 15.4 square miles, with Jimmycomelately Creek (JCL) being the major tributary flowing into Sequim Bay (Figure I.1). JCL is an unfortunate example of human degradation of a natural ecosystem. In contrast to the network of structurally and functionally connected habitats that historically occurred in JCL and Lower Sequim Bay, the existing habitats had become isolated and fragmented.

The history of degradation and fragmentation of the Jimmycomelately Watershed is described in greater detail in *A Preliminary Plan for Restoring Jimmycomelately Creek and the Lower Sequim Bay Estuary* (Shreffler 2000).

The cumulative effect of human activities was fragmentation of the natural landscape into smaller pieces with diminished functions and services for both natural resources and people. This dysfunctional state:

(1) limited the ability of JCL and the estuary to provide optimal feeding, rearing, and breeding habitats in support of critical biological resources, including ESA-listed summer chum salmon, other anadromous fish species, shorebirds, shellfish, and waterfowl;
(2) placed property owners and local, state, and tribal infrastructure at a greater risk of flood damage; and
(3) highlighted the urgent need to develop and implement integrated restoration actions in JCL and the estuary.

In the late 1990's, the Jamestown S'Klallam Tribe, Clallam Conservation District, Clallam County, Washington Department of Fish and Wildlife, Washington State University Cooperative Extension, and many other partners began to address the two major problems in the watershed: declining salmon populations (only 7 adult summer chum salmon—an ESA-listed species—returned to spawn in 1999) and annual flooding of Jimmycomelately Creek and its estuary.

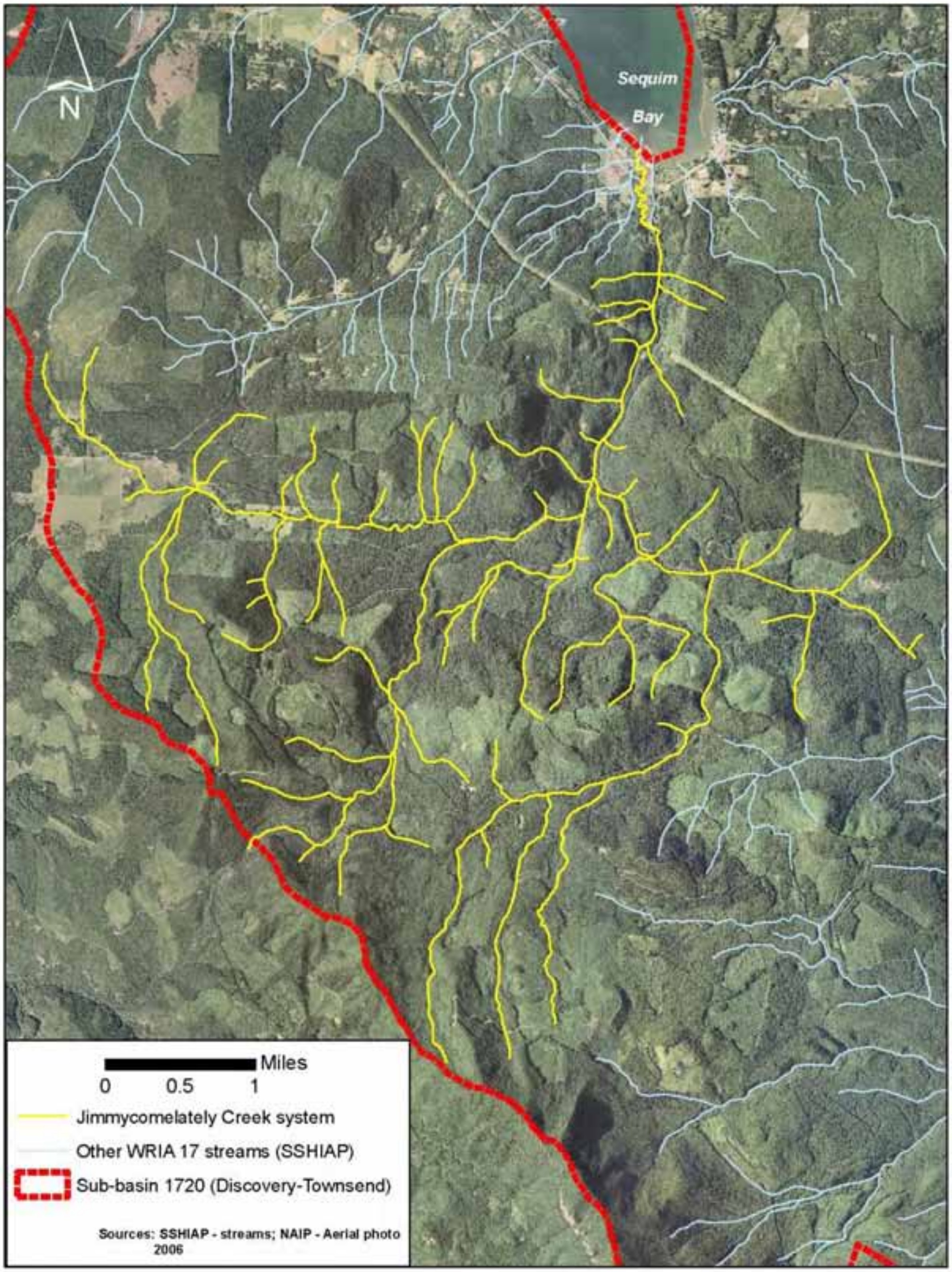


Figure I.1. Map of the Jimmycomelately Creek Watershed (graphic by Pam Edens).

Project Vision and Goals

The Jimmy Project was an attempt to remove, to the extent possible, human infrastructure and stressors on the Jimmycomelately-Sequim Bay ecosystem and thereby restore more natural ecosystem processes and functions. Stated simply, the partners dubbed the project: ―A vision of undevelopment.” The sense of a unified vision among the 27 project partners not only gave the project needed momentum, but also led to the cooperative spirit that was a hallmark of this landscape-scale restoration project.

> The partners dubbed the project “A vision of undevelopment.” The sense of a unified vision among the 27 project partners not only gave the project needed momentum, but also led to the cooperative spirit that was a hallmark of this landscape-scale restoration project.

The stated restoration goals (Shreffler 2000) were to:

(1) restore feeding, refuge, and breeding habitat for resident and migratory waterfowl and shorebirds;
(2) restore feeding, refuge, and spawning habitat for ESA-listed summer chum salmon, coho salmon, winter steelhead, and sea-run cutthroat trout, as well as for shellfish;
(3) reduce the existing flood hazards to the local private landowners, and local, state, and tribal infrastructure;
(4) restore the summer chum salmon population so that it is naturally self-sustaining;
(5) develop rigorous monitoring requirements, contingency actions, and reporting requirements; and
(6) develop this project as a model for stream and estuary restoration and management.

To accomplish these goals, technical experts recommended realigning JCL Creek into one of its historic sinuous channels, reconnecting the link between the creek and the tidal actions of the estuary, and restoring estuary habitat. Restoration actions included removal of fill and roads, the construction of a new Highway 101 Bridge, revegetation with native trees and shrubs, and land acquisition required to accomplish the restoration goals; also included in the project were low-impact public access and small-scale educational activities.

Although the Jimmy Project preceded the *Strategic Needs Assessment* of the Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) (Schlenger et al. 2011) by a decade, it is worth noting that the Jimmy Project addressed all four of the top restoration priorities identified in that study: 1) restore the connectivity and size of large river deltas; 2) restore sediment input, sediment transport, and sediment accretion processes; 3) restore embayments to increase distribution, shoreline complexity, and length; and 4) enhance landscape heterogeneity and ecological connectivity.

The Jimmy Project was implemented in four phases between 2002 and 2005 (Shreffler 2008):

- Phase 1: JCL Channel Realignment (Completed 2004);
- Phase 2: Estuary Restoration / Fill Removal (Completed 2005);
- Phase 3: New Highway 101 Bridge (Completed 2004); and
- Phase 4: Diversion of JCL Creek Flow (Partial Diversion 2004, Full Diversion 2005).

Monitoring Plans

The project partners recognized early on that this project could serve as a model for estuary and channel restoration in other Puget Sound watersheds. Toward that end, technical teams developed two comprehensive monitoring plans for the project; one for the channel restoration (Shreffler 2001a) and one for the estuary restoration (Shreffler 2004). We also developed supplemental monitoring plans for the Dean Creek channel realignment (Shreffler 2001b) and for summer chum salmon recovery in Jimmycomelately Creek (Shreffler 2001c).

This report is structured to mirror these monitoring plans, which were designed to evaluate whether the restoration goals stated above were met. These monitoring plans called for pre-project baseline monitoring, during-project implementation monitoring, and post-project performance monitoring of ecological processes, habitat conditions, and biological responses.

The monitoring plans were based on landscape ecology principles and a clear understanding that ecological processes create the structure of habitats, which support ecological functions for species and people (Shreffler and Thom 1993). The Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) subsequently referred to this as a ―process-based approach to restoration” (Simenstad et al. 2006). Greiner (2010) concluded the key to successful restoration is ensuring that the physical, ecosystem-forming processes that maintain landscape structure are restored to their natural spatial and temporal scales.

By monitoring ecological processes, habitat conditions, and biological responses, before, during, and after the on-the-ground restoration actions, the JCL technical teams believed that we would have a scientifically-defensible approach for evaluating the successes or failures of the process-based Jimmycomelately Ecosystem Restoration Project. As noted by Ralph and Poole (2003) and Roni (2005), accountable monitoring programs must be designed *before* any restoration actions occur.

This report summarizes post-project monitoring data collected between 2004 and 2011. Monitoring data are compared, where appropriate, to pre-project baseline data and performance criteria that were established in the monitoring plans. Monitoring is ongoing, as funding is available.

It is important to emphasize that we are still in the early years since the final phase of restoration actions were completed in 2005. As noted in the literature, restored estuarine habitats often take 50 – 100 years to reach an equilibrium state comparable to natural reference sites (Simenstad and Thom 1996, Zedler and Callaway 1999, Simenstad and Cordell 2000, Independent Science Panel 2000). To detect a doubling of juvenile salmonid abundance may require 10 to more than 50 years (Roni et al. 2003).

Performance Criteria

Prior to any on-the-ground restoration, the Channel Design Group (CDG) established the performance criteria listed in Table I.1 as essential for the Jimmycomelately Creek channel and Table I.2 as essential for the Dean Creek channel. The Estuary Design Group (EDG) established the performance criteria listed in Table I.3 as essential for the JCL Estuary. Additional ―recommended” monitoring tasks were identified in Appendices of the two monitoring reports.

Most of the Jimmy Project monitoring was conducted by Jamestown S’Klallam Tribe (JST) Natural Resources staff, along with a few hired consultants, some local volunteers, and several project partners. There was no single grant that paid for annual monitoring. In fact, JST struggled each year to cobble together small amounts of funding from multiple grants to direct toward the Jimmy Project monitoring. The original vision the Jimmy Project partners had of dedicated monitoring funding over 10 years was never achieved.

Table I.1. JCL channel monitoring plan essential monitoring tasks and performance criteria.

Essential Monitoring Tasks	**Performance Criteria**	**Status***
Ecological Processes		
Water Conveyance (Hydrology)	1. Mean discharge from JCL below 2 cfs during Aug-Oct low flow period would trigger the need for potential	**D**
	2. Mean annual discharge and tidal elevation for the realigned JCL Creek should be measurably improved relative to mean annual discharge and tidal elevation for the existing JCL Creek after 10 years.	**NF**
Sediment Transport & Deposition	1. Excessive sediment aggradation could trigger the need for contingency measures.	**NF**
Habitat Conditions & Functions		
Channel Morphology & Topography	No performance criteria have been established; instead trigger points for further evaluation were identified (see text)	**D**
Water Quality	within the JCL channel shall: a) not exceed state water quality standards, and b) show improvement over water quality parameters for the existing JCL channel.	**D for (a); ND for (b)**
Large Woody Debris	LWD placements that move to locations where they pose a threat to infrastructure, properties, or the channel morphology would trigger the need for potential contingency measures.	**D**
Flood Conveyance	1. The channel will convey a 2-year bankfull flood of 185 cfs with no avulsions.	**D**
	initial site stabilization.	**D**
Biological Responses		
Riparian Vegetation Establishment	1. Percent cover of riparian vegetation (native trees, shrubs, and groundcovers) should be stable or increasing over time, and cover not less than 90% of the revegetated area at the end of 10 years.	**D**
	2. Survival of riparian plantings in each cover class category (herb, shrub, trees) should be at least 75% at the end of	**D**
Freshwater Wetland Vegetation Establishment	1. Within 10 years, the percent cover of wetland vegetation should be stable or increasing within portions of the project site with elevations suitable to wetland vegetation establishment.	**NF**
	appropriate reference sites after 10 years.	**NF**
Invasive Vegetation Removal	The project area should not contain greater than 5% cover by area of invasive plant species after 10 years.	**D**
Salmonid Use	1. At the end of 10 years, juvenile salmonid abundance within the restored JCL channel should be higher than the pre-project abundance within the former JCL channel.	**ND**
	2. With improved habitat access, greater spawning area, and improved spawning gravel available in the new JCL channel, chum and coho spawner abundances should be higher than the pre-project abundances within the former	**D**
	3. After 10 years, summer chum abundance and productivity numbers for JCL should be on a clear trajectory toward meeting the PNPTC/WDFW planning targets of 520 spawners (productivity =1.0) and 330 spawners	**D**
Upland Bird Use	Diversity and abundances of birds using the restored JCL site and the area within 50 meters of the site should exceed bird diversity and abundances in the vicinity of the existing channel within 10 years post-construction.	**I D**

* Status codes: D = data to assess; ND = no data to assess; I D = insufficient data to assess; NF = dropped due to no funding

Table I.2. Dean Creek channel monitoring plan essential monitoring tasks and performance criteria

(note: all Dean Creek monitoring was dropped due to lack of funding, except one water quality monitoring site).

Essential Monitoring Tasks	**Performance Criteria**
Ecological Processes	
Water Conveyance (Hydrology)	The realigned channel below HWY 101 shall not be a losing reach, as demonstrated by the relative water height difference between the staff gage above HWY 101 and the staff gage below HWY 101.
Sediment Transport & Deposition	within the new Dean Creek channel.
Habitat Conditions & Functions	
Channel Morphology & Topography	No performance criteria have been established; instead trigger points for further evaluation were identified (see text)
Water Quality	1. Water quality parameters (water temperature, dissolved oxygen, conductivity, pH, turbidity, nitrate, and fecal coliform) within the new Dean Creek channel shall not exceed state water quality standards.
	2. Sediment quality parameters (metals, organics, TPH, TSS) within the new Dean Creek channel shall not exceed state water
Large Woody Debris	1. In Year 10, 80% or more of the LWD placements should be in the same general location as originally placed.
	2. LWD placements that move to locations where they pose a threat to infrastructure, properties, or the channel morphology would trigger the need for discussion of potential contingency measures.
	3. LWD placements shall maintain pool depth and channel form as intended.
Flood Conveyance	No evidence of flooding that threatens property or infrastructure will be observed after a one-year period of initial site stabiliz
Biological Responses	
Riparian Vegetation Establishment	1. Percent Cover of riparian native plantings and native pioneers (trees and shrubs) should be at least 50% in year 5, 60% in
	2. Plant survival: If mortality of the native plantings is greater than 30% in any given year, then evaluate planting scheme (species composition and location) and make necessary adjustment for replanting area(s) of mortality.
Freshwater Wetland Vegetation Establishment	1. Within 10 years, the areal extent (percent cover) of wetland vegetation should be stable or increasing within portions of the project site with elevations suitable to wetland vegetation establishment. In Year 2 – 25% cover, Year 5 – 60% cover, and Year 10 - 90%.
	2. Species composition of native wetland plant species should be comparable (greater than 80%) to that of appropriate referen
Invasive Vegetation Removal	The project area should contain less than 5% cover by area of invasive plant species after 10 years.
Salmonid Use	1. At the end of 10 years, juvenile salmonid abundance within the restored Dean Creek channel and estuary should be higher than the pre-project abundance within the former Dean Creek channel.
	2. At the end of 10 years, coho spawner abundances in the restored Dean Creek channel should be higher than the pre-project abundances within the former Dean Creek channel.
Upland Bird Use	is already being monitored as part of the JCL channel monitoring (Shreffler 2001) and the estuary monitoring (Shreffler 2003).

Table I.3. Estuary monitoring plan essential monitoring tasks and performance criteria.

Essential Monitoring Tasks	Performance Criteria	Status*
Ecological Processes		
Hydrology	1. A functioning hydrological connection shall be restored and self-maintaining between JCL and the estuary, and De	**D**
	2. The constructed tidal basins shall result in a net increase of tidal prism (i.e., tidal flushing) relative to pre-project c	**ND**
Sediment Transport & Deposition	1. Within 10 years following removal of the log yard pier, log yard fill, and delta cone, sediment that was formerly aggraded in these areas will be redistributed by the restored longshore drift cell.	**NF**
	2. Tidal ―flushing" capacity of the estuary tidal basins shall be sufficient to transport sediment out into Sequim Bay.	**I D**
Habitat Conditions & Functions		
Habitat Gains	Targets: intertidal = 20 acres; eelgrass = comparable to densities of existing beds at project edges; creek channels = 1,000 linear feet; tidal channels = 2,730 linear feet; terrestrial plant communities = 9 acres.	**D**
Water & Sediment Quality	new JCL channel and the new Dean Creek channel than in the existing channels. For JCL, the salinity wedge shall reach the McLaughlin property south of HWY 101. For Dean Creek, the salinity wedge shall reach approximately 300 ft upstream of the mouth.	**NF**
	mouth of the new Dean Creek channel, and within the footprint of the former pilings shall not exceed state, federal, or tribal water quality standards.	**D**
	the new Dean Creek channel, and within the footprint of the former pilings shall not exceed state, federal, or tribal water quality standards.	**NF**
	4. Post-project fecal coliform concentrations shall not exceed pre-project concentrations, and shall not exceed state,	**D**
Large Woody Debris	1. 80% or more of the LWD placements should be present in Year 10.	**NF**
	morphology.	**NF**
	3. LWD placements shall maintain pool depth and channel form as built.	**NF**
Biological Responses		
Terrestrial Vegetation Establishment	1. Percent Cover of riparian native plantings and pioneers (trees and shrubs) should be at least 50% in year 5, 60% in	**NF**
	plantings is >30% in any given year, then replant.	**NF**
Wetland Vegetation Establishment	and 80% comparable after 10 years.	**D**
	2. Species composition of native wetland plant species should be 60% comparable to that of appropriate reference sites after 5 years and 80% comparable after 10 years.	**D**
Invasive Vegetation Removal	The project area shall contain not greater than 5% cover by area of invasive plant species after 10 years.	**D**
Eelgrass Recovery	should eventually be comparable to the surrounding areas that currently support eelgrass; this will likely take >10 years. No signs of natural eelgrass recovery after 5 years would trigger the need for potential contingency measures.	**D**
Shellfish Recovery	If the site conditions allow for natural recovery, then shellfish species composition and abundances should be comparable, after 10 years, to the surrounding areas that currently support shellfish. No signs of natural shellfish	**D**
Salmonid Use	1. No stranding of adult chum salmon or other anadromous species returning to spawn in JCL or Dean Creek, and no stranding of juvenile salmonids in the tidal channel networks on the Log Yard, RV Park, and Eng properties.	**D**
	abundance within the former estuary.	**ND**
Invertebrate Use	The species diversity, density (no. m-2), and standing stock (g wet m-2) of benthic macroinvertebrates and insects within the restored estuary shall: 1) equal or exceed species diversity, density, and standing stock for the existing estuary at the end of 10 years, and 2) be comparable to the Salmon Cr. reference site at the end of 10 years.	**NF**
Bird Use	Within 10 years post-restoration, species richness and abundance of breeding, wintering, and migrating birds using the estuary shall equal or exceed pre-restoration species richness and abundance.	**D**

* Status codes: D = data to assess; ND = no data to assess; I D = insufficient data to assess; NF = dropped due to no funding

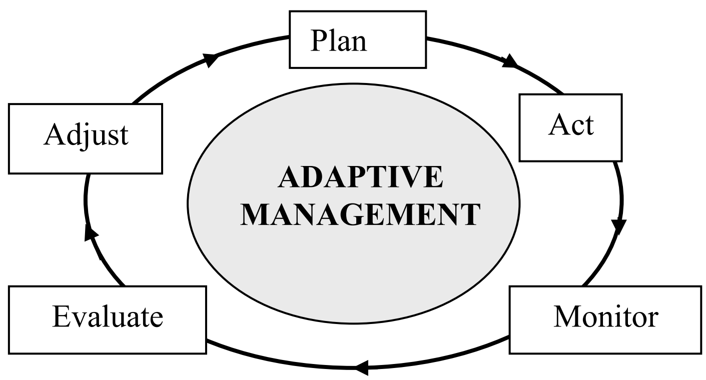
Many of the JCL channel monitoring parameters that were originally deemed “essential” by the CDG had to be dropped due to lack of funding, including all of the Dean Creek monitoring parameters, as well as ecological processes monitoring for hydrology (staff gage, tide gage, tidal basin discharge measurements), sediment transport and deposition (pebble counts, sieve bar counts, and suspended sediment monitoring), and freshwater wetland vegetation establishment.

Similarly, many of the estuary monitoring parameters that were originally deemed “essential” by the EDG had to be dropped due to lack of funding, sediment transport and deposition, water and sediment quality, large woody debris, terrestrial vegetation establishment, and invertebrate use.

> One of the most important take home messages of this report is that funding to monitor a restoration project is difficult to find. The project partners had a far easier time securing millions of dollars to implement the on-the-ground restoration actions than finding tens of thousands of dollars annually to implement the monitoring plans for the Jimmy Project.

In addition, without the incredible generosity of local volunteers, several more of the JCL channel and estuary monitoring parameters would also have been dropped (e.g., juvenile salmonid use and bird use). None of the “recommended” monitoring for the JCL channel or estuary was conducted due to lack of funding.

One of the most important take home messages of this report is that funding to monitor a restoration project is exceedingly difficult to find. The project partners had a far easier time securing millions of dollars to implement the on-the-ground restoration actions than finding tens of thousands of dollars annually to implement the monitoring plans for the Jimmy Project. In our discussions with other restoration practitioners, it is clear that the lack of funding for restoration project monitoring is not unique to the Jimmy Project. This is a national problem and has been for at least two decades (NRC 1992, Thayer 1993, Shreffler et al. 1995, NRC 1996, Restore America’s Estuaries 2002a, Restore America’s Estuaries 2002b, Thayer et al. 2005).



The unfortunate corollary is that monitoring funding is readily available for compensatory mitigation projects. So, if we had destroyed critical wetland habitat and attempted to mitigate for that habitat loss somewhere else, the local, state, and national regulatory framework is set up to require (and pay for) monitoring—often over a 5-year to 10-year period. Yet, monitoring of restoration projects is rarely required, resulting in unfunded or under-funded monitoring programs that suffer from either small sample sizes or monitoring periods that are too short. This prevailing paradigm must change if the science of restoration is to continue advancing.

Adaptive Management & Contingency Measures

Adaptive management was defined in the original monitoring plans (Shreffler 2000, Shreffler 2004) as the process of: stating restoration goals (plan), implementing restoration actions (act), collecting credible data (monitor), determining if performance criteria are met (evaluate), and deciding what actions to take (adjust). A flow diagram depicting this process is presented below (modified from Thom and Wellman 1996), and the rationale for rigorously applying adaptive management in coastal and estuarine ecosystem restoration projects is reviewed in Thom et al. (2004).

For the Jimmy Project, adaptive management was the process that the Channel Design Group (CDG) and Estuary Design Group (EDG) envisioned for collectively analyzing monitoring data, determining the implications for restoration success or failure, and instituting actions or policies to make mid-course corrections.

We recognized, given the proposed ten-year timeframe of the Jimmy Project monitoring plans, that changes to the plans were inevitable. It turns out that we made all five of the kinds of envisioned changes listed in the monitoring plans:

1. Changes in monitoring tasks: The frequency of sampling for some monitoring parameters was changed (for example from annual monitoring to bi-annual).The number of monitoring sites for some parameters was changed, and some monitoring sites were added, moved, or eliminated.
2. Elimination of monitoring tasks: As previously noted, many monitoring tasks were dropped due to no funding.
3. Addition of new monitoring tasks: We added intra-gravel dissolved oxygen (IGDO) monitoring because of its importance to salmonid survival. We also added tidal channel monitoring and pool/riffle habitat surveys.
4. Changes in lead responsibilities for monitoring tasks: Almost all of the monitoring tasks ended up with JST as the lead, rather than multiple partners as originally specified in the monitoring plans.
5. Modification of project goals: While the project goals were not changed, the performance criteria for evaluating whether the project met the stated restoration goals were, in some cases, dropped or modified.

Microsoft Access Database for the Jimmy Project

With the help of a local database expert, JST established a Microsoft Access database to house all of the Jimmy Project data, maps, as-built drawings, aerial photos, and ground photos. The intent was that this database would serve as the central repository for the project team, but also be available to the public. Our goal was that it would be a user-friendly tool for other restoration practitioners.

The database is configured to mirror the two monitoring plans and their respective performance criteria. There are tabs for ecological processes, habitat conditions, and biological responses. Within each of these three tabs, there are sub-tabs for each of the monitoring parameters. An example screen shot is shown below with the habitat conditions tab highlighted (Figure I.2).

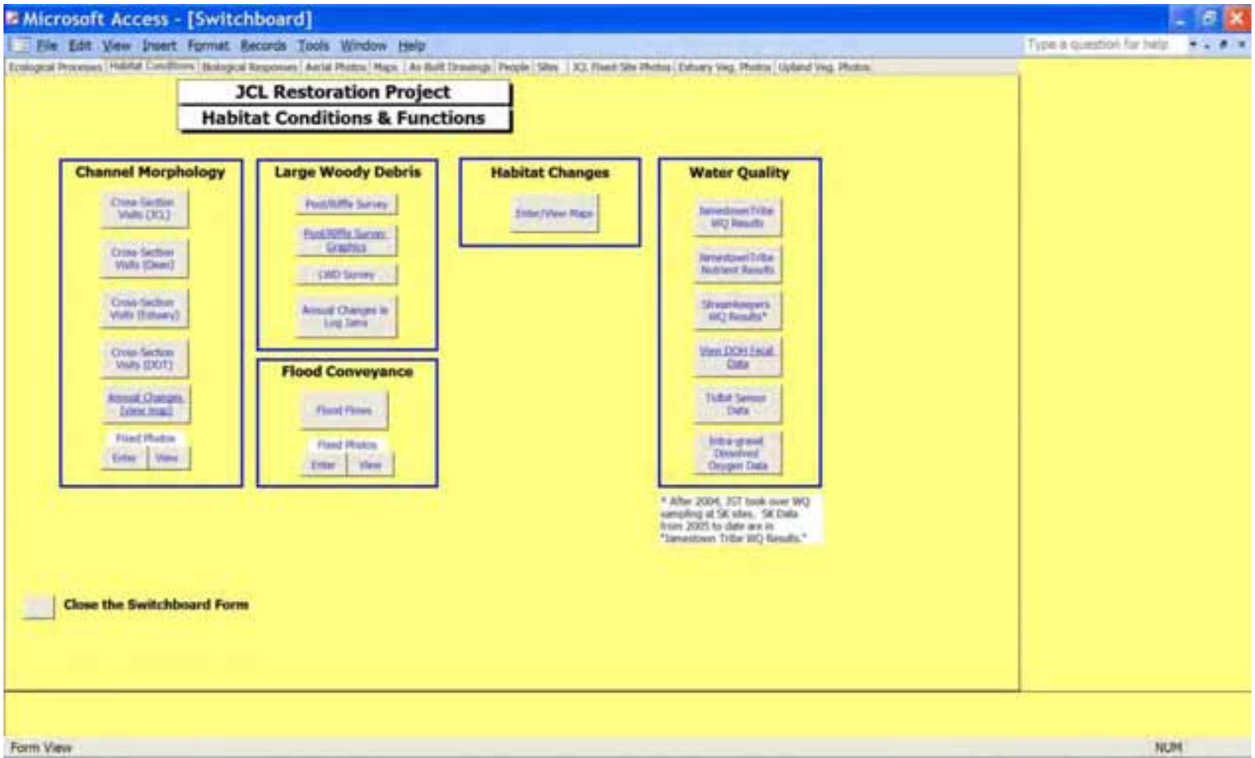


Figure I.2. Screenshot of the Microsoft Access database for the Jimmycomelately Ecosystem Restoration Project.

The remainder of this report is based on analysis of data from the database. We have found that having one central database was essential to our ability to track, QA/QC, query, analyze, and report our Jimmy Project data. We highly recommend this approach to other restoration practitioners.

Road Map for this Report

Although declining populations of summer chum salmon and annual flooding of Jimmycomelately Creek were the two key drivers for the Jimmy Project, this report is not just about salmon and floods. What follows is an ecosystem-wide look at the pre-project vs. post-project ecological processes, habitat conditions, and biological responses for the Jimmy Project.

In this report, we provide a synthesis of all the monitoring performed through the 2011 calendar year. Each chapter is a stand-alone story with background, methods, results, discussion, and literature cited for each monitoring parameter. Each chapter is authored by the individual or individuals that were primarily responsible for the monitoring.

While this report is primarily technical in nature, it is also a celebration of a long, restoration journey, and thus represents our attempt to share what we have learned along the way. Browse individual chapters or read from start to finish; either way, we hope you will enjoy the journey.

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ECOLOGICAL PROCESSES

CHAPTER 1. HYDROLOGY

– BYRON ROT (JAMESTOWN S'KLALLAM TRIBE) AND
CHRIS EVANS (WASHINGTON DEPARTMENT OF ECOLOGY)

BACKGROUND

Restoration Objective – JCL Channel (Shreffler 2001)
The restoration objective relative to hydrology was to restore the natural channel and floodplain configurations of JCL and the estuary by realigning JCL into one of its historic, sinuous channels.

Restoration Rationale – JCL Channel (Shreffler 2001)
By restoring natural channel and floodplain configurations of JCL, there would once again be a free, functional connection between the creek and the estuary, and semi-diurnal tidal fluctuations would also be restored. The Channel Design Group (CDG) believed that a free, functional connection would facilitate use of the restored JCL Creek by invertebrates, fish, and birds.

Restoration Objective – Estuary (Shreffler 2004)
The restoration objective relative to hydrology was to restore the natural channel and floodplain configurations of JCL, Dean Creek, and the estuary by realigning JCL and Dean Creek into sinuous channels with access to the floodplain, and by removing channel constrictions in the estuary (i.e., roads, culverts, and other fill).

Restoration Rationale – Estuary (Shreffler 2004)
By removing roads, culverts, and other fill and restoring natural channel and floodplain configurations of JCL and Dean Creek, there would once again be a functional hydrologic connection between these creeks and the estuary. Semi-diurnal tidal fluctuations would also be restored. The Estuary Design Group (EDG) believed that a functional connection between each creek, its floodplain, and the estuary would improve habitat of both restored creeks and the estuary for invertebrates, fish, and aquatic birds.

Based on visual observations during a very challenging channel construction (summer and fall 2002-2003), about 2/3 of the length of the new channel and floodplain were constructed into clay/silt wetland soils, and about 1/3 of the new channel into fine sandy-loam soils that at times had an embedded gravel layer at our constructed floodplain elevation (see Shreffler et al. 2003). The underlying geology affects timing, rate, and magnitude of groundwater flow into streams; in short, underlying geology affects the stream hydrology both in terms of low flows and high flows (flooding). The relationship of the channel form with the underlying geology will be discussed in Chapter 2 Sediment Transport and Channel Morphology.

With the channel realignment, we recreated a similar channel and floodplain configuration as found upriver of the project and also one supported by channel restoration design models (Shreffler et al. 2003). The focus of this chapter is to describe the discharge data collected primarily by the Washington State Department of Ecology (DOE), and whether the flows post-project meet our performance criteria. In addition, the flow data were crucial to tracking the progress of ESA-listed summer chum salmon and other salmonids. Flow data were also used to help analyze JCL water quality and coho salmon smolt production data.

METHODS

Performance Tasks

The JCL channel monitoring plan (Shreffler 2001) called for three performance monitoring tasks:

1. Permanently install a continuous recording stream gage above tidal influence to monitor discharge and report time/flow data on a monthly basis.

2. Permanently install a tidal elevation monitoring device to track tidal elevation (MLLW), fluctuation, and duration at the mouth of Jimmycomelately Creek. The tidal data would be compared to pre-project data collected at the old mouth to understand the changes in tidal elevation, fluctuation and duration.

3. Measure stream flow at a series of locations from the proposed diversion point to the mouth of the new JCL channel. Compare flows in the new JCL channel to pre-project flows similarly collected in the old JCL channel to determine how much the new JCL channel gained groundwater compared to the old channel.

Performance Monitoring Status

Task 1. DOE maintained a stream gage (17C070) in the old Jimmycomelately Creek channel from August 2002 through April 2005 (Figure 1.1). The new JCL channel has been gaged by DOE from June 2005 to the present (17C075). All discharge data is available as 7-day and 30-day hydrographs, as well as, raw 15-minute data. This data is updated in near real-time every 1-3 hours and can be found on the DOE gaging web page (https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?sta=17C075).

Task 2. The Jamestown S'Klallam Tribe installed a pressure-transducer type tidal gage at the mouth of JCL. No pre-project tidal data had been collected from the mouth of the old channel. The tidal gage was on-line August 2004 and data was downloaded through April 2008. During that time period we also attempted to use the gage data to understand the relationship of tidal elevation to the flushing capability of the tidal basin. It was hypothesized that the old channel had built a tongue of sediment out into the bay due to a truncated tidal basin that did not have enough energy to flush sediment from the mouth. We were unable to GPS the boundary of the tidal basin in real-time with a continuously changing tide. In 2008, the stream channel moved away and buried the gage sensor. We decided to no longer maintain this gage. Tidal data was not analyzed for this report. Given this, the performance monitoring task was not met.

Task 3. Although discharge was measured six to eight times a year at the DOE gage, we were unable to collect flow data within additional reaches of both the old and new channels.

RESULTS

The JCL stream gage period of record is from October 1, 2002 through September 30, 2011 (Figure 1.2). The gage was operational August 24, 2002; however, the low flow data from August 24 through September 30, 2002 is not graphed for ease of viewing. Any flooding for water year (WY) 2005 is not reflected in Figure 1.2. Water year is a hydrologic year starting October 1 and ending September 30. For example WY 2011 starts October 1, 2010 and ends September 30, 2011. During the fall and winter of 2004/2005, the gage was tracking the ―nursery flows" required for salmon egg incubation in the old channel, not flows in the new channel.

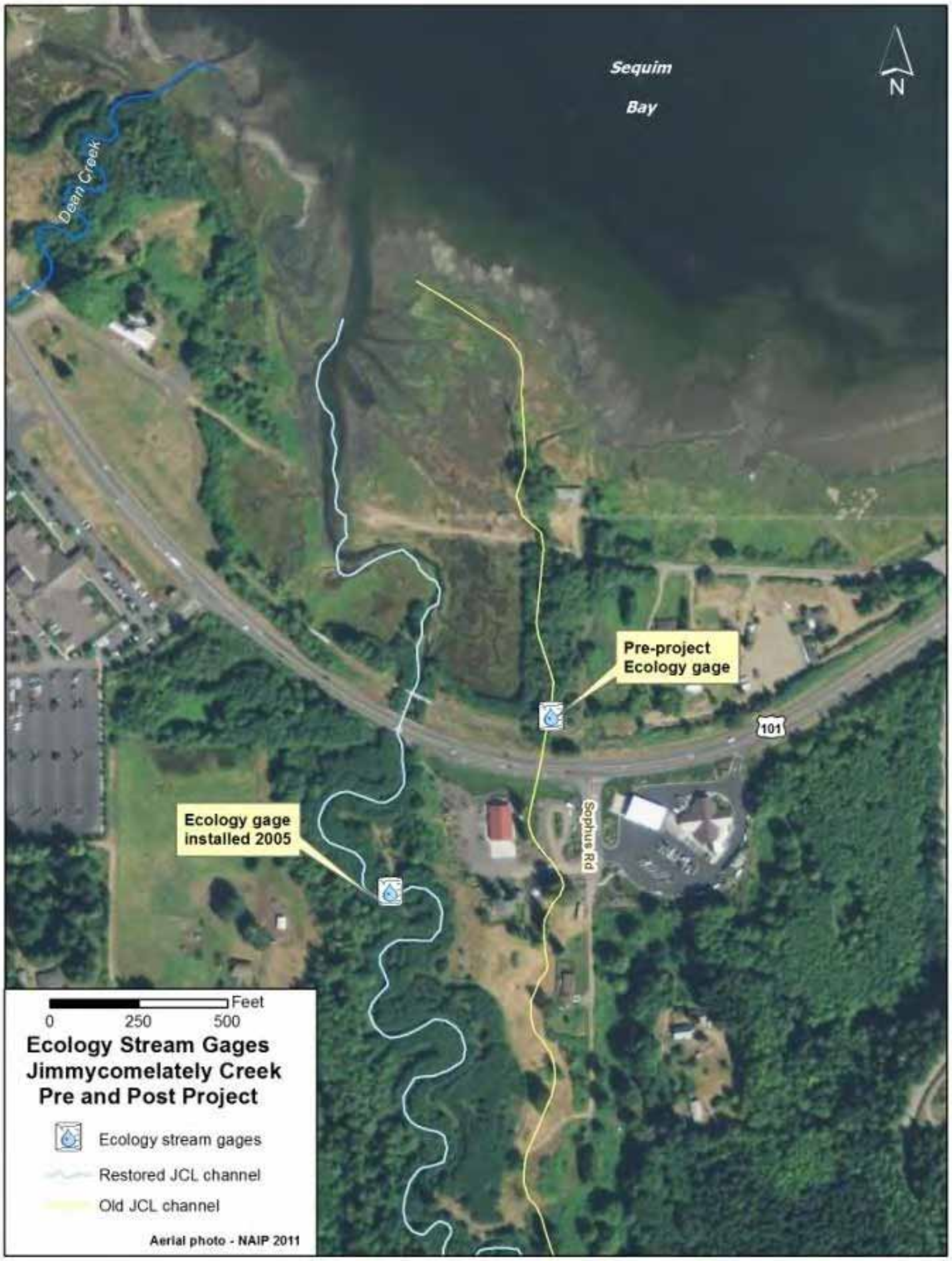

Figure 1.1. **DOE (Ecology)stream gage locations for the old and new Jimmycomelately Creek channel (graphic by Byron Rot).**

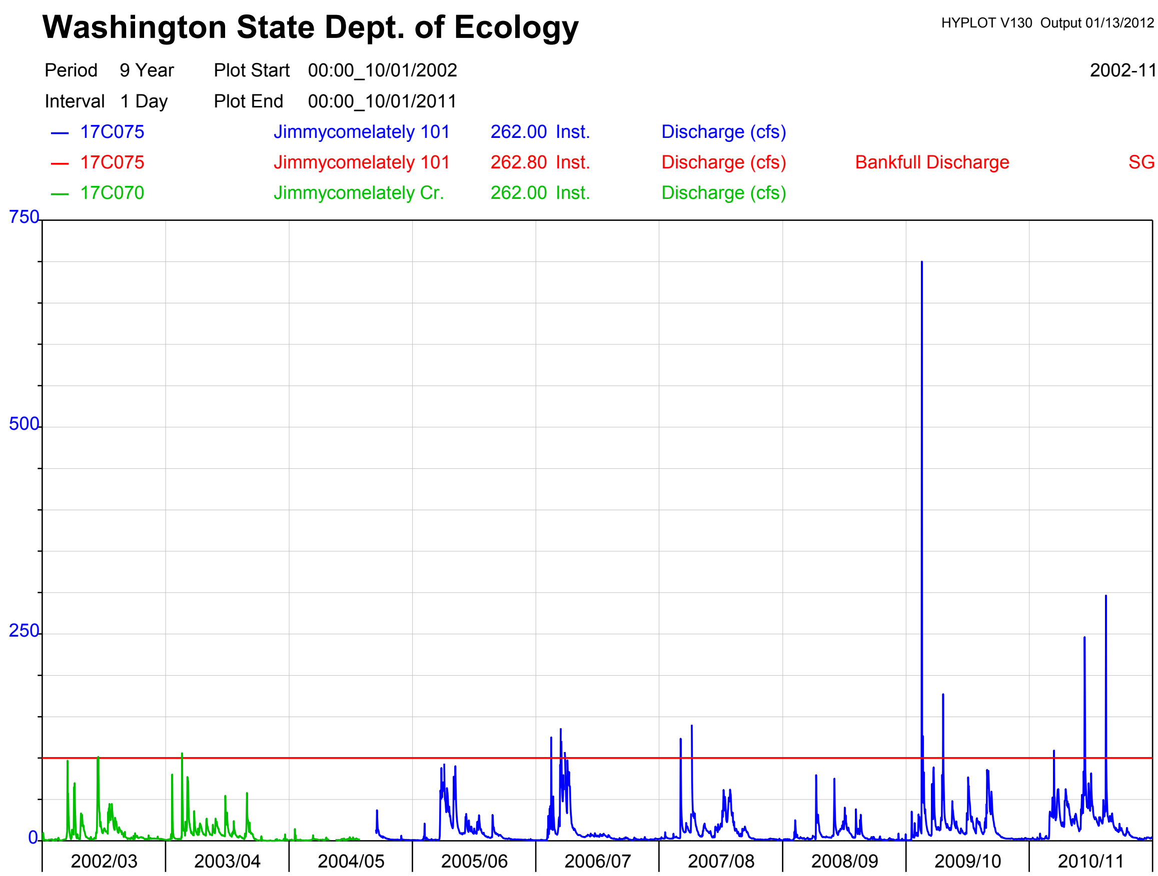

Figure 1.2. **JCL hydrograph for the period of record, years 2002-2011. The DOE gage for October 2002 – April 2005 was in the old JCL channel about 150 ft downstream of Hwy 101. From June 2005 – September 2011 the DOE gage was in the new JCL channel about 500 ft upstream of Hwy 101.**

The gage data is separated in terms of the 15-minute hydrograph representing both flood data and low flow data below 2 cfs. In this way, the data can be used as a baseline while also addressing our performance criteria.

When we opened the new channel to flow in October 2004, we had the problem that practically the entire summer chum salmon run for 2004 had already spawned in the old channel during late August, September and early October. Additionally, we had an untold number of juvenile coho salmon and trout rearing in the old channel. The solution was to maintain a nursery flow of generally 1-2 cfs (max 10 cfs) into the old channel during the winter of 2004 and spring of 2005 to ensure the chum salmon eggs would develop and the fry would be free to outmigrate (Figure 1.3). At our request, DOE left the gage in the old channel to monitor flows that winter to ensure chum survival. DOE then re-installed the gage in the new channel in June 2005.

Figure 1.3. **Left photo: Filling in old JCL channel Oct 25, 2004 (muddy channel in background). Note nursery flow pipe and control structure. New JCL channel flows right to left in foreground. Right photo: Same site during flood on Jan 18, 2005. Note the control structure (CS) (photo center downstream of tree) is almost under water (photos by Byron Rot).**

A stream gage measures water depth. In order to convert the depth into discharge, a rating curve must be calculated. The rating curve is the relationship between water depth and discharge (Figure 1.4). Following the USGS Mid-Section Method (http://hydroacoustics.usgs.gov/midsection/index.shtml), water velocity has been measured using an acoustic Doppler hand-held velocity meter. These measurements are used to calculate the discharge in cubic feet/second (cfs) for the selected cross-section. DOE has taken a discharge measurement at the gage six to eight times a year beginning in water year 2005. The streambed, including the gage cross-section, consists of loose sand and medium gravels. Thirteen separate rating curves have been developed during the 7-year period of record. Overall, these shifts are trending toward a cross-sectional scour. In addition, over the past few years, the banks have experienced some undercutting and erosion. Depending on channel conditions, discharge measurements were all taken within 100 ft. of the gage.

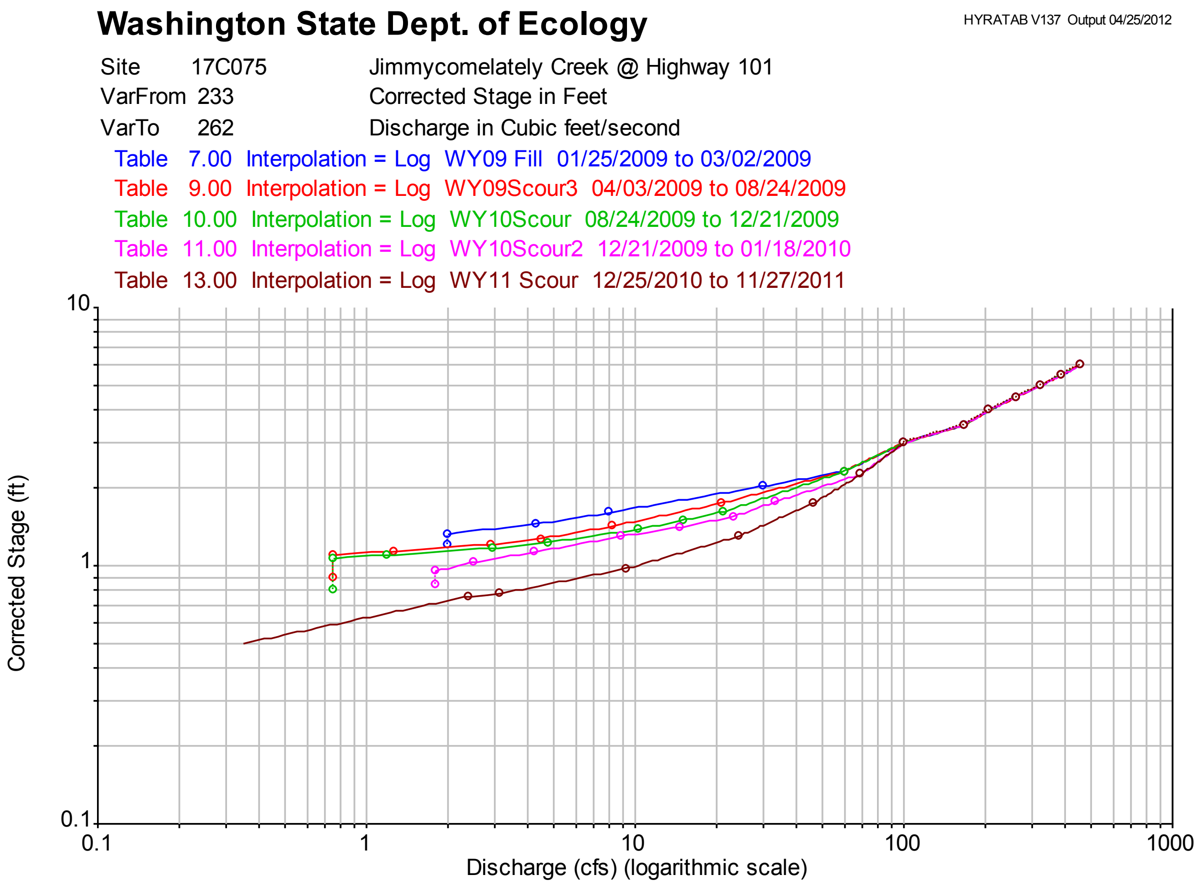

Figure 1.4. **Rating plot on a log-log scale for WY 2009 and 2010. These curves change with channel erosion and deposition. The curve establishes the relationship of stage height to discharge at the DOE stream gage**.

For scientists, an important flow is one which floods every 1.5 years, called a “bankfull flood” (see middle photo Figure 1.5). At and above a bankfull flood, theoretically, more physical change occurs to the stream channel than below a bankfull flood (Leopold 1997). For JCL, the bankfull height has been determined to be 3.0 ft. relative to the staff gage. This bankfull height equates to a discharge of 100 cfs. The 3.0-ft. staff gage value is important, because it represents the stage at which the stream leaves its channel and begins filling the engineered floodplain. Discharge exceeding bankfull height has been calculated for WY 2005-2011 using sub-section discharge calculations (Figure 1.6). The reported peak stage values recorded at the gage were also verified by surveying the high water marks from the November 2009 and March 2011 high water events. From this, the peak discharge for the period of record has been determined to be near 450 cfs during the November 2009 event.

Figure 1.5. Three photos at gage site: left August 2003 before flow introduced, middle January 2005 the first winter flood (flood not gaged), and right February 2006 (photos by Byron Rot).

To use a sub-section method, the width of the control channel, the width of the wetted surface, and the depth at flood stage must be known. However, the use of only depth and channel width will provide a coarser calculation then that of a calculation using a complete cross-sectional survey. Therefore, the use of a cross-sectional survey is preferred as to provide a more accurate wetted perimeter at the peak depth.

To begin, the cross-section of a channel is assumed to be composed of several distinct subsections with each subsection different in roughness from the others. For example, an alluvial channel subject to seasonal floods generally consists of a main channel and two side overbank channels. The overbank channels are usually found to be rougher than the main channel; so the mean velocity in the main channel is greater than the mean velocities in the overbank sections or in the overbank flow region. For such composite sections, the routine calculation of hydraulic radius from the total area divided by the total wetted perimeter and the direct application of Manning's equation will result in large errors. This is because such calculations imply the effect of boundary resistance is uniformly distributed throughout the flow cross-section, which is not the case. Furthermore, accurate estimation of the effective value of *n (roughness)* is virtually impossible because *n* for each subsection may be very different (Jobson and Froehlich, 1996).

This method of treating such problems is derived by assuming that the total section is composed of parallel channels separated by vertical boundaries across which there is no shear. Because water-surface elevation is generally horizontal across a channel, the slope of each of the subsections is assumed to be identical. Writing Manning's equation for each subsection and summing, it is seen that the slope can be factored out because it is a constant. Factoring out the slope indicates that the total discharge is equal to the slope times the sum of the conveyances for each subsection (Jobson and Froehlich 1996).

The general procedure for computing discharge (*Q*) in a composite cross-section is to first compute the conveyance (*K*) for each subpart of the cross-section wherein the roughness (*n*) and depth are similar. The subsection *K* is then summed to arrive at a total *K* for the desired depth of the cross-section (Jobson and Froehlich 1996). *K* and *A* are then used to determine the velocity head coefficient for the cross-section. To calculate *Q*, independent of slope, the total area (*A)* of the sub-section is multiplied by the velocity head coefficient ($\propto$**).**

$$\propto = \sum_{i=1}^{N} \frac{K_i^3}{A_i^2} \Big/ \frac{K^3}{A^2} = \text{velocity head coefficient} \qquad K = \frac{1.49}{n} AR^{.66} = \text{conveyance}$$

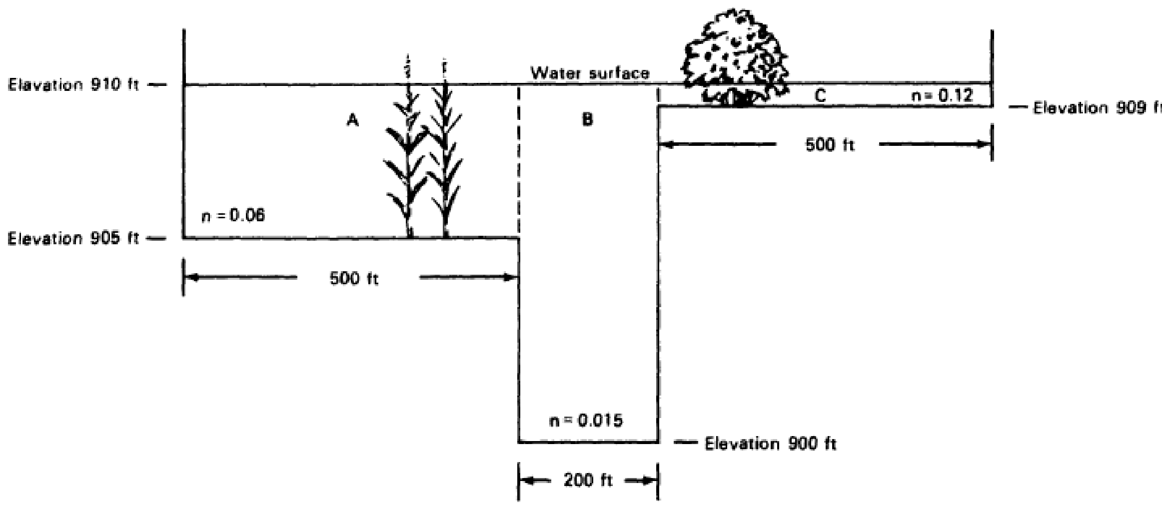

Figure 1.6. Sub-section discharge method diagram. An example of how peak discharge was calculated. (Jobson and Froehlich, 1996). The Cowan method (n = (n_0 + n_1 + n_2 + n_3 + n_4)m_5) was used to determine the roughness coefficient "n" of each sub-section (Cowan 1956).

Per performance task three, flow was not measured at a series of locations in the old JCL channel prior to moving it to its new location. We did observe in the old channel, downstream of Highway 101, that the bed of the creek was higher than the surrounding floodplain. Following flood events in 1996, multiple braids were created that drained water away from the main JCL channel directly into the bay. Qualitatively it appeared that JCL lost flow to groundwater downstream of Highway 101.

Observationally, there are one or two springs entering the new JCL channel. To adequately quantify the amount of water a creek loses or gains to groundwater and where that occurs, a synoptic flow and groundwater exchange study would need to be conducted. A study this large is beyond the scope, expertise, and funding for our group.

Stream gage results – high flows above 100 cfs

Orsborn and Orsborn (1999) estimated the discharge for a 50-year peak flow as 645 cfs, and 800 cfs for the 100-year peak flow. A 50-year peak flow has a 2% chance of occurring; the 100 year peak flow has a 1% chance of occurring. Thus the November 16, 2009 flood was between a 50-yr and 100-yr flood. Since it was opened, the new JCL channel has experienced flood events every year since, except for WY 2009 (October 1, 2008 – September 20, 2009) (Table 1.1). The magnitude of these flood events exceeds probable flood return intervals. For example, the statistical probability is one 100 cfs flood event every year or two, instead of two to five events per year.

Table 1.1. Number of floods exceeding 100 cfs and mean annual discharge for water years 2003-2011.

Water Year (WY)	Number	Months	Mean annual discharge (cfs)
2003	n/a	n/a	Old Channel
2004	n/a	n/a	Old Channel
2005	No data	-	-
2006	0	-	11.3
2007	3	Nov, Dec(2)	12.0
2008	2	Dec, Jan	12.8
2009	0	-	6.6
2010	3	Nov (2), Jan	19.1
2011	3	Dec, Mar, May	21.7

Mean annual discharge was substantially higher for WY 2010 and 2011 when compared to WY 2006-2009 (Table 1.1). Mean annual discharge is not affected by the number of peak flows.

Stream gage results – low flow below 2 cfs

The JCL design team felt that flows below 2 cfs (Table 1.2) were low enough to be of concern for rearing summer chum salmon juveniles and spawning summer chum adults (Shreffler 2001). The year 2004 was omitted from Table 1.2 because the gage was used October 2004-April 2005 to monitor nursery flow in the old channel; the gage was moved into the new channel in June 2005. Please note that 2010 was an anomaly with no summer low flow, or flows below 2 cfs (Table 1.2). There appears to be a connection between no summer low flows in 2010 and better coho growth and survival: coho smolt size was larger in 2010 than from 2005 to 2009, and egg-to-smolt survival was higher in 2010 than all other years post-channel realignment, except 2008 (see Figure 11.28, Chapter 11).

Table 1.2. Number of days less than 2 cfs between July 1 and October 31 (calendar year not water year) for years 2002-2010.

Calendar Year	Number of days less than 2 cfs (July 1 – Oct 31)	Percentage of days less than 2 cfs (July 1 – Oct 31)	Percentage of days less than 2 cfs from Sept 1 – Oct 15 (summer chum spawning)
2002	65	53%	93%
2003	25	20%	56%
2005	97	79%	100%
2006	101	82%	96%
2007	57	46%	36%
2008	74	60%	51%
2009	72	59%	89%
2010	0	0	0

DISCUSSION

By its nature, hydrology is commonly considered a fixed input and used as baseline data to analyze other data. For the JCL, hydrology provides context for how the ecosystem responded to the restoration project. In this case, we also are analyzing hydrology in terms of performance criteria. Are low flows sufficient to support spawning and rearing summer chum salmon? Are high flows moderate enough to allow egg to fry survival? Is the tidal basin flushing gravel out into the bay to maintain form and function of the stream mouth?

The Channel Design Group (CDG) had three hydrology performance criteria for the JCL channel (Shreffler 2001):

1. *If the mean discharge from the JCL channel falls below 2 cubic feet per second (cfs) during the August to October low flow period, this would trigger the need for the JCL technical team to meet and discuss potential contingency measures.*

2. *Mean annual discharge for the realigned JCL Creek should be measurably improved relative to mean annual discharge for the existing JCL Creek after 10 years*.

3. *Mean tidal elevation at the mouth of the new JCL Creek should be measurably improved relative to mean tidal elevation at the mouth of the old JCL Creek after 10 years.*

The team did not meet when flows dropped below 2 cfs and given only two years of pre-project data, it is impossible to really know whether the project improved low flows (Table 1.2). However, we moved the channel west to the low part of the valley (Figure 1.1), capturing wetland flows in an intermittent channel that independently flowed into the bay. The relative change to groundwater infiltration through these wetland soils relative to groundwater infiltration at the old channel is unknown. The percent of flows below 2 cfs from September 1 through October 15 is a concern (Table 1.2).

Please note while the rating curve shows a roughly 1 ft. depth below 2 cfs (Figure 1.4), this is not a water depth but a relative scale. The channel bed can move up and down, as seen in the various rating curves through time, however the staff gage is fixed in space (Figure 1.4). Observationally, below 2 cfs, flows in riffles can drop to a depth of inches making it challenging for returning adult summer chum. For 2010, adult summer chum likely found favorable spawning conditions (Table 1.2). Fortuitously, 2010 was also the largest summer chum return ever recorded for JCL (see Chapter 10 Adult Salmonid Use: Chum and Coho Escapement).

The number of flood events is also a concern (Table 1.1) with major floods occurring most years, exceeding the probability of one modest flood every year or two. The watershed is flashy and responds quickly to hard rain (Figure 1.2). Everything being equal, we expect the restored floodplain and channel would reduce the flooding impact to fish, when compared to the old channel, by reducing the amount of stream power from a flood. The diked and rip rapped old channel had a minimal floodplain from the upstream end of the project downstream to Highway 101 (Figure 1.1).

> We could not say whether or not mean annual discharge "measurably improved" for the realigned JCL channel vs. the old JCL channel.

Mean annual flow almost doubled in WY 2010 and 2011 compared to previous years (Table 1.1). However this flow is driven by local and regional precipitation patterns (e.g., La Nina/El Nino). We could not say whether or not mean annual discharge "measurably improved" for the realigned JCL channel vs. the old JCL channel.

The tidal basin appears to be working as we hypothesized, in terms of flushing gravel out into the bay. The point where stream power becomes effectively zero is near the cedar tree (Figure 1.7). Note the gravel bar adjacent to the tree but not downstream. That would imply the tidal basin is flushing any gravel downstream of its outlet (across from the cedar tree) into the bay. However we were not able to collect data to prove that, and could not answer the third JCL channel performance criteria.

The tidal basin appears to be working as we hypothesized, in terms of flushing gravel out into the bay. The point where stream power becomes effectively zero is near the cedar tree (Figure 1.7). Note the gravel bar adjacent to the tree but not downstream. That would imply the tidal basin is flushing any gravel downstream of its outlet (across from the cedar tree) into the bay.

Figure 1.7. **2006 oblique aerial of JCL north of Hwy 101. The JCL flows from the bottom of the photo toward the center, and adjacent to the western red cedar tree with the shadow. The tidal basin outlet is just downstream of the cedar (photo by David Woodcock).**

The Estuary Design Group (EDG) also had two hydrology performance criteria for the estuary (Shreffler 2004):

1. *A functioning hydrologic connection shall be restored and self-maintaining between JCL and the estuary, and Dean Creek and the estuary.*

   This criterion is addressed in Chapter 5 (see Figure 5.2 and Figure 5.9).

2. *The constructed tidal basins shall result in a net increase of tidal prism (i.e., tidal flushing) relative to pre-project conditions.*

   Despite our best efforts to address this performance criterion, it just was not possible given the size of the estuary tidal basins, our study design, and the few staff at hand. As mentioned in the methods, we did install a tidal gage at the location of Old Blyn Highway as one piece of our flood and ebb discharge data collection efforts. The gage was operational from 2004 to 2008. However, the stream channel moved away and buried the gage sensor in 2008, and we decided to no longer maintain this gage. To estimate the post-project tidal prism, we attempted to GPS the water edge for the entire perimeter of the tidal basin during an ebbing tide. This effort proved unsuccessful because the tide was completely out by the time we completed GPS measurements of the perimeter. Thus, it was not possible to measure the rate of tidal change quickly enough. If future funding were available, the way to address the tidal prism question would be to have a series of aerial photos taken through an entire tidal cycle. These photos would allow us to see the water edge, measure water depths at various spots in the estuary, and calculate the amount of tidal prism post-project.

The Channel Design Group (CDG) had two flood conveyance performance criteria for the JCL channel (Shreffler 2001):

1. *The channel will convey a 2-year bankfull flood of 185 cfs with no avulsions*.

   This performance criterion is an artifact of the old JCL channel with insufficient culvert capacity due to sediment deposition in the culvert and upstream, and a perched channel bed downstream. The 185 cfs was the 2-yr bankfull flood flow estimated by Orsborn and Orsborn (1999). However, our calculations at the gage in the realigned JCL channel show the 2-yr flow is actually100 cfs. The realigned JCL channel will convey flood flows of either 100 cfs or 185 cfs; however, the concern with the realigned JCL channel is not avulsion, but bed degradation (channel downcutting). In the new channel location there is a thin layer of gravel underlain by fine sedimentary geology (silty/sand-clay). The real question is whether there is enough gravel for the creek to transport during floods? The stream energy will be expended somehow, either in transporting sediment (gravel), or eroding banks or the bed. So, it is not avulsion that is the issue, but bed degradation. We will continue to monitor bed degradation as funding allows.

2. *No evidence of flooding that threatens property or infrastructure will be observed after a one-year period of initial site stabilization*.

   No property or infrastructure has been threatened post-project. The realigned JCL channel was constructed as a low-flow meandering channel set within the 2-year peak flow channel, which is set within an excavated floodplain designed to contain the 100-year flood (Shreffler et al. 2003). The project engineer calculated the constructed JCL floodplain would convey the 100-yr flood with 2.0 feet to spare going under the new Highway 101 Bridge without wetting the bridge superstructure. Following the highest observed flood event of 729 cfs flow in the realigned JCL channel [close to the 800 cfs for a 100-yr flood calculated by Orsborn and Orsborn (1999)], several feet deep of wrack material was observed on the trees in the floodplain. At the 729 cfs flood height there was still an estimated 3 feet of freeboard remaining under the bridge, which is a large margin of safety.

ACKNOWLEDGMENTS

We would like to thank DOE and the Clallam County Streamkeepers for their assistance in collecting velocity data to help build the gage rating curves. Chris Evans, DOE Hydrologist, was responsible for maintaining the gage, developing the stage/discharge rating curves (Figure 1.4), mean annual discharge reports, and the flood modeling this report draws upon.

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CHAPTER 2. SEDIMENT TRANSPORT AND CHANNEL MORPHOLOGY
– BYRON ROT (JAMESTOWN S'KLALLAM TRIBE)

BACKGROUND

Sediment Transport

Restoration Objective – JCL Channel (Shreffler 2001)
The restoration objective relative to sediment transport was to improve the routing of sediment through the fluvial system and into the tidal system, by restoring a functional connection between JCL and its estuary that would enable the estuary to function once again as a sediment —pump.”

Restoration Objectives – Estuary (Shreffler 2004)
The restoration objectives relative to sediment transport were to:

1. Restore the natural pattern of longshore sediment transport by removing the log yard pier, log yard fill, and delta cone, and

2. Allow the routing of sediment through the fluvial system and into the tidal system, by removing estuary blockages (Log Deck Road, Old Blyn Highway, delta cone, culverts, dams, and other fill) and restoring a functional connection between JCL Creek, Dean Creek, and their combined estuary that would enable the estuary to function once again as a sediment —pump" [note: construction of a tidal channel network on the RV Park (WDFW) and Eng (WSDOT) properties should also facilitate the routing of sediment into the estuary].

Restoration Rationale – JCL Channel (Shreffler 2001) and Estuary (Shreffler 2004)
Sediment mobility is critical to the ecological health of a river system, and —dynamically stable" channels transport sediment downstream at the same rate that it is delivered to the system from upstream. Dynamically stable channels maintain their general morphology over the time frame of centuries, although their stable pattern does not preclude lateral migration and associated dynamics such as bank erosion and sediment deposition. The Channel Design Group (CDG) and Estuary Design Group (EDG) believed that by restoring natural hydrology and sediment supply (suspended load and bedload) to the project area, sediment transport and deposition would occur within the range of natural systems and proceed along a trajectory toward natural conditions.

The accumulation of fine-grained sediment is indicative of environments that support the buildup of organic matter and a detritus-based food web (Penttila 2007). Organic-rich sediments provide an environment where benthic invertebrate prey resources flourish, and hence provide the capacity for fish and wildlife to forage. Thus, transport of fine sediments to the estuary is critical in terms of providing habitat for juvenile salmonids, other estuarine fish, shellfish, and shorebirds. Similarly, the deposition of appropriate-sized gravel in the realigned JCL channel is important in providing suitable spawning habitat for adult salmonids.

Channel Morphology

<u>Restoration Objective– JCL Channel (Shreffler 2001)</u>
The restoration objective relative to channel morphology was to restore channel morphology that is representative of natural systems, as indicated by attributes of habitat connectedness, area, and complexity.

<u>Restoration Rationale– JCL Channel (Shreffler 2001)</u>
The Channel Design Group (CDG) believed that dynamically stable channel formation would occur as a result of restoration of fluvial and tidal connection and re-establishment of a functional tidal prism.

The new JCL channel was constructed primarily during the summer of 2002 and 2003. The design was for a ―low-flow meandering channel set within the 2-year peak flow channel, which is set within an excavated floodplain that will contain the 100-year flow" (Shreffler et al. 2003). Our operating hypothesis prior to construction was that ―the JCL channel naturally migrated across the alluvial fan, prior to the time when roads, Highway 101, dikes, and railroads constricted channel movement. By 1926, the JCL channel had been moved, straightened, and diked into its current location" (Shreffler 2000). Our expectation, based also upon early soil test pits, was that a lens of gravel representing a historic channel would be found at or above our constructed channel and floodplain. It is with this background that we consider sediment transport and channel morphology in the realigned JCL channel.

METHODS

The channel monitoring plan (Shreffler 2001) and estuary monitoring plan (Shreffler 2004) called for these performance monitoring tasks:

1. Establish and survey 6 permanent channel cross-section monuments (2 monuments in each of the 3 reaches) along the new JCL channel above Highway 101.
2. Conduct pebble counts at six cross sections within the realigned JCL channel.
3. Install 12 scour chains along six transects (2 transects in each of the 3 channel reaches) to measure channel bed scour from flooding.
4. Sample suspended sediment during high flooding events and sieve to determine grains sizes at three sampling locations: 1 near the diversion point, 1 mid-channel, and 1 near the mouth.
5. Photo-document changes in the new JCL channel morphology and topography, at minimum, four times per year in winter, spring, summer, and fall.
6. Take high-resolution (1 inch = 500 feet) aerial photographs vertically over the project area and Salmon Creek (as a reference area) annually. Produce maps depicting JCL channel morphology immediately post-construction, at 5 years, at 10 years, and predicted conditions at 50 years (based on photo-interpretation and best professional judgment).
7. Install permanent cross-sections across selected tidal channels in the Eng tidal basin, RV Park tidal basin, and log yard tidal basin to map the evolution of those constructed channels.

<u>Task 1 Channel Cross-sections.</u>
Instead of just six cross-sections called for in the channel monitoring plan (Shreffler 2001), 20 cross-sections were established (Figure 2.1). It was felt that six cross-sections were too few to adequately capture how the new channel evolved over time.

For each cross-section (looking downstream), on the left bank (LB) at ―0" feet, a surveyed and permanent monument was installed with a steel cap inset into concrete. The actual elevation is stamped on the steel cap; this allows us to compute actual elevation for each cross-section.

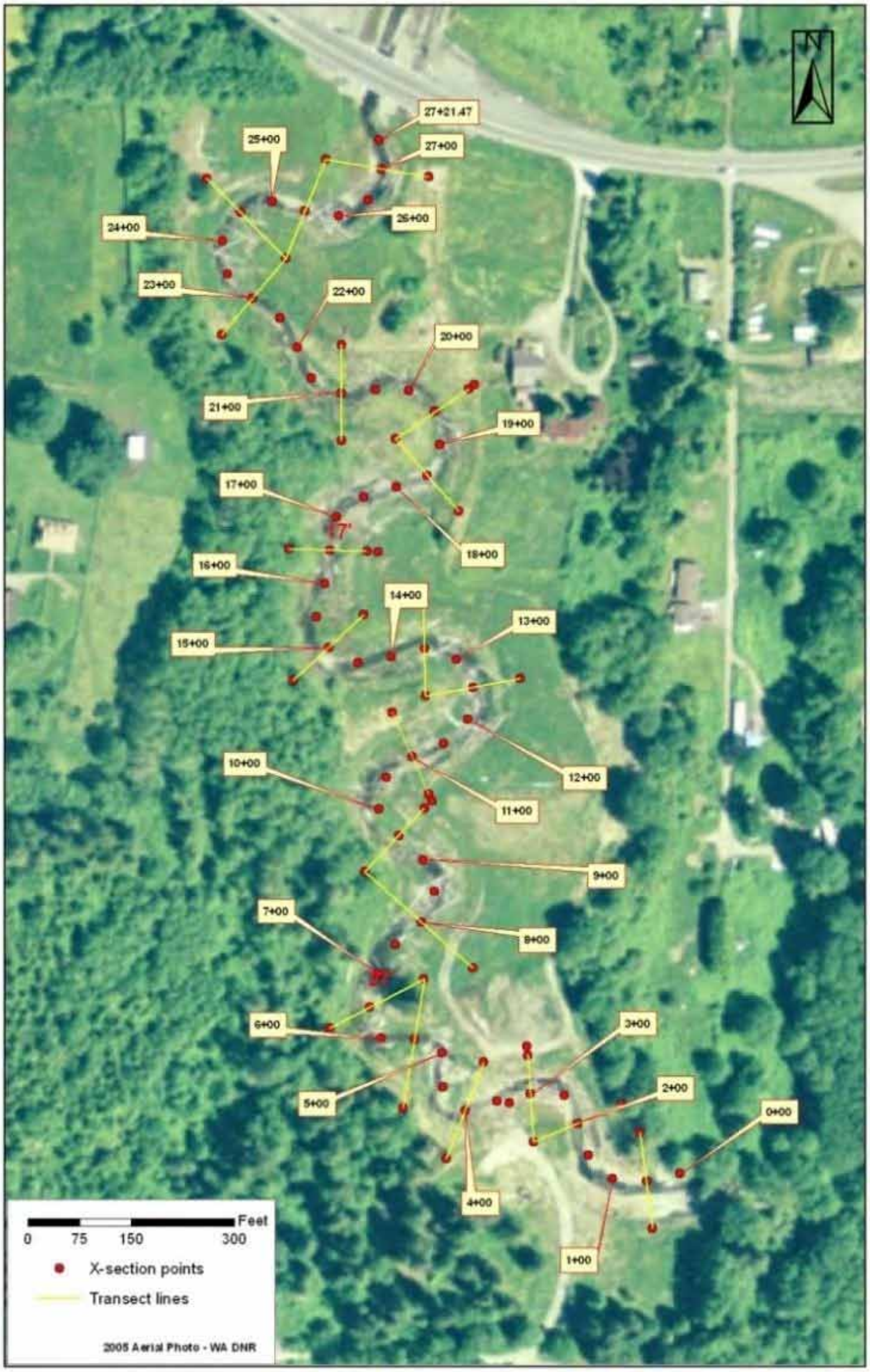

Figure 2.1. **Location of JCL Creek channel cross-sections. To interpret the numbering, 2+00 is 200 ft. downstream of the upstream end of the channel realignment project (Graphic by Pam Edens)**

The equation to compute actual elevation is:
Actual elevation = elevation stamped on the LB monument – (stadia rod at a given point – stadia rod at the monument).

Cross sections were surveyed in December 2004, April/May 2006, March-May 2008, February/March 2009, February/March 2010, and April 2011. A Topcon RL-HB laser level was used with a 200 ft. tape and stadia rod in feet/inch increments (Figure 2.2). The floodplain was measured every two feet, the channel every one foot. Initially we measured each increment whether on top of a log or not but that created —lost” data points, so in later years we just measured the ground surface.

Figure 2.2. **2008 cross-section survey photos. Left photo: setting up laser level. Right photo: measuring channel bed elevation in JCL Creek (photos by Byron Rot).**

Performance Criteria for Task 1
Due to the uncertainty with channel migration, no performance criteria were set for the channel morphology monitoring parameter (Shreffler 2001). Instead these *triggers* were identified to spur further action:

- Greater than 3 feet of incision at the riffle crests any time in the first 10 years.
- Straightening of the channel meander geometry.
- Channel avulsions that cause a secondary channel (i.e., side channel) to become primary.
- Decreases in channel meander amplitude.

<u>Tasks 2, 3, and 4, Sediment Transport Monitoring (Pebble counts, scour chains, suspended sediment)</u>
Sediment transport was not monitored due to limited funds and was dropped from the monitoring plan. More recently, EPA funded a sediment budget study to understand whether further additions of gravel and wood were warranted to mitigate observed channel bed degradation (Entrix 2010). Most floods are at night, and thus collecting actual sediment data to create the sediment budget is costly. Given Entrix's time constraints and JST's limited funds, Entrix instead used models to create a sediment budget (Entrix 2010). Entrix collected pebble count data, and used the Ecology stream gage data along with our cross-section data to provide input to the models. This report updates the Entrix 2004 to 2009 analysis of channel morphology and cross-sections with 2011 data.

Performance Criteria for Tasks 2-4

1. Pebble counts will provide an indication of whether unexpected sediment aggradation is occurring at undesirable locations within the realigned channel. Indications of excessive sediment aggradation could trigger the need for discussion of contingency measures.

2. Scouring will be monitored in each reach of the new JCL channel to ensure that scour depth is less than reported literature values for salmon redd depths of various species.

Task 5, Fixed Photo Monitoring

Fourteen photo points were established along the stream channel. Five photo points were established in the upland. It was decided that taking photos four times a year was infeasible for tribal staffing and workload; we tried to capture the photo points annually during fall-winter. Stream channel photos were taken: November 2004, January 2006, October 2007, February 2009, and November 2009. Stream channel photos were taken looking upstream, downstream, and across. Supplemental photos along the channel were also taken in some years. Upland photos were taken July 2007 and March 2008, standing on a 6 ft. ladder. Upland photos were discontinued in 2008 due to thick sapling tree cover that rendered the photos useless.

Performance Criteria for Task 5

None

Task 6, Aerial Photos

Aerial photos at 1:6000 scale (1 inch = 500 ft.) were contracted by Jamestown S'Klallam Tribe (JST) and flown for the years 1994, 1995, 1997-2010. JST also has non-JST photos from 1956 and 1971. Photos are in stereoscopic pairs for 3D analysis and cover the JCL channel and South Sequim Bay estuary. Photos are delivered as paper copies and more recently also as .tiff files. See Chapter 5 Habitat Change Analysis for analysis of the aerial photos.

Performance Criteria for Task 6

None

Task 7, Estuarine Cross-sections

Estuarine cross-sections were collected adjacent to and parallel to the old log yard pier to understand whether or not longshore drift redistributed sediment stored updrift of the pier. Tidal cross-sections were also collected in the Eng (DOT) property to observe the evolution of these channels. Due to space limitations, neither of these datasets will be examined in this report.

Performance Criterion for Task 7

Tidal flushing capacity of the tidal basin shall be sufficient to transport sediment out into Sequim Bay.

RESULTS

JCL channel cross-section results

From 2004 to 2011 in the upstream 200 ft. (reach A) of the project, the channel bed aggraded (Figure 2.3) and functioned as an alluvial fan (Entrix 2010). This was consistent with our design expectation (Shreffler et al. 2003). From distance 2+00 to 16+50 (reach B), the channel bed incised most commonly around 2 ft, but also less in several areas (Figure 2.3, see also Figures 2.5 and 2.6). From 16+50 to 24+50 (reach C) the channel bed both incised and aggraded, but the floodplain generally aggraded throughout the reach (see also Figures 2.7 and 2.8). From 24+50 to 27+50 the bed again incised several feet (see also Figure 2.9).

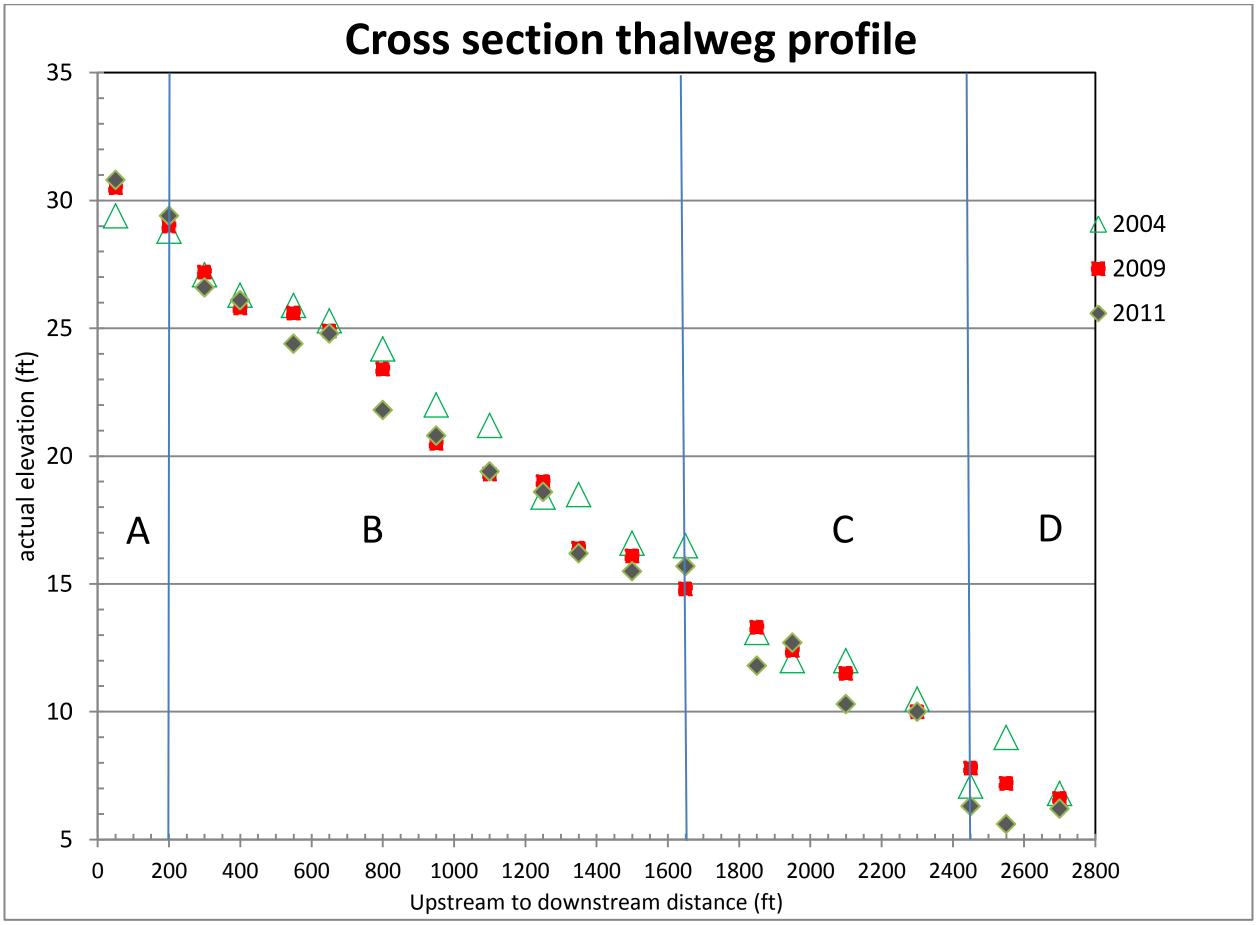

Figure 2.3. **JCL Creek channel thalweg profile of the restoration project from the upstream end to the Hwy 101 Bridge. The profile is the channel thalweg (estimated as the minimum elevation in the cross-section) at each cross-section. With 2004 as baseline, if 2009 or 2011 are higher elevation than 2004 the channel is aggrading at that point; if 2009 or 2011 are lower elevation than 2004 the channel is incising at that point. The project was divided into four reaches A, B, C, and D (Entrix 2010).**

A qualitative field assessment of channel bed incision from spring 2011 somewhat agrees with the above thalweg analysis; however more extensive bed incision was observed in the lower ½ of the restoration project (Figure 2.4). In this assessment, the ―downcutting channel" (shown in red in Figure 2.4) includes 5+00 to 6+50, 9+00 to 9+50, 10+50 to 12+00, 13+50 to 18+00, 20+50 to 24+00, and 25+00 to Hwy 101. In general, the bed incised into the relatively wood-free riffles and either aggraded or maintained elevation in the wood-rich pools. During construction, single-log structures to prevent headcutting were placed at the end of riffles at 23+00, 20+00, 18+50, 14+50, and 12+00.

A total of 20 cross-sections were collected. Shown below are five cross-sections—2+00 (Figure 2.5), 8+00 (Figure 2.6), 16+50 (Figure 2.7), 21+00 (Figure 2.8), and 25+50 (Figure 2.9)—that are representative of the four reaches, A, (2+00), B (8+00 and 16+50), C (21+00), and D (25+50), depicted in Figure 2.3. As a reminder, 8+00 means it is 800 ft. downstream from the start of the JCL channel realignment project. In reach B, one cross section is continuing to incise (8+00) and one has recently begun to re-aggrade (16+00).

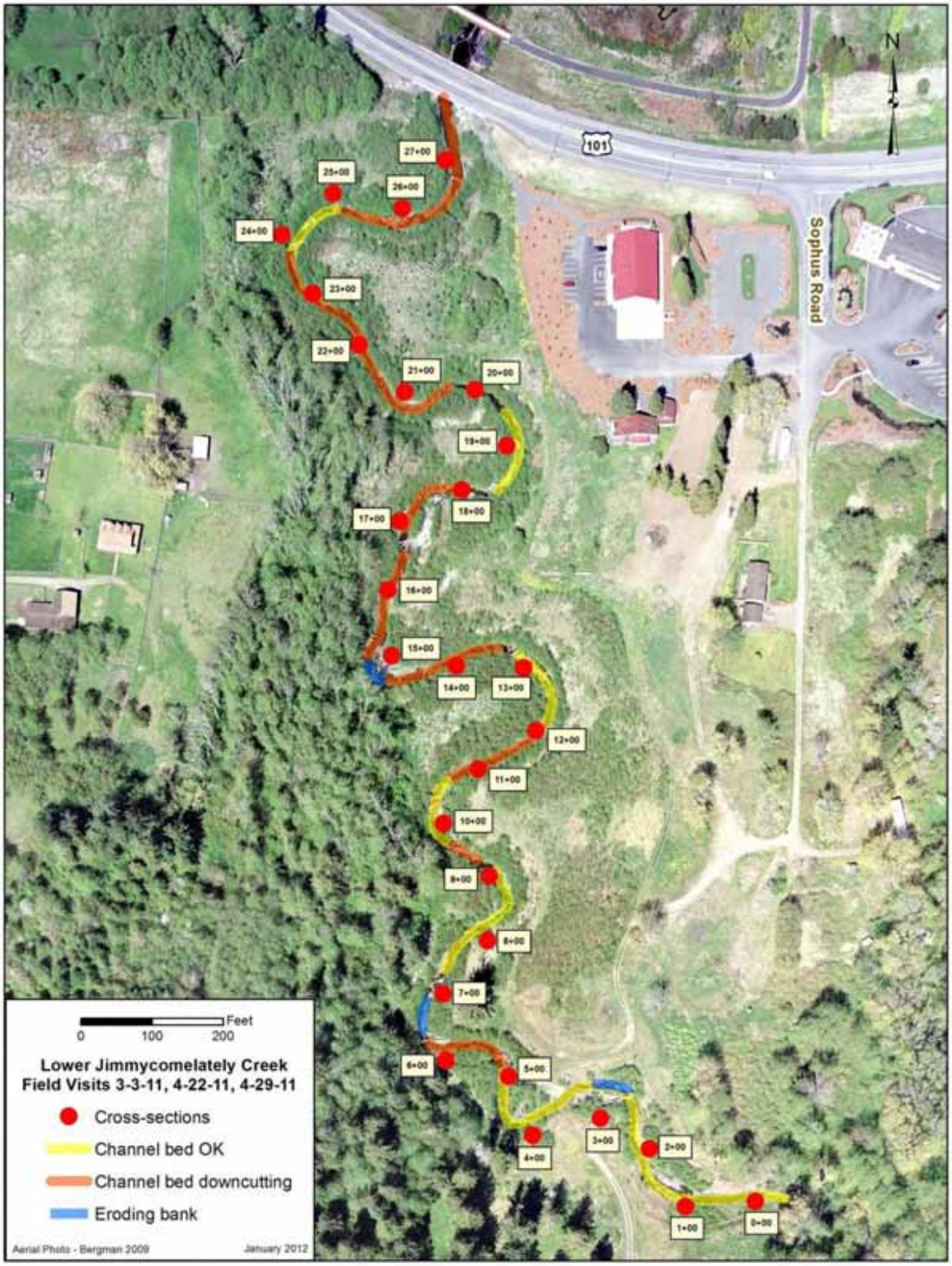

Figure 2.4. Areas of the JCL Creek channel where the channel bed is stable (yellow), downcutting (orange), and eroding (blue), based on March and April 2011 field visits (Graphic by Pam Edens).

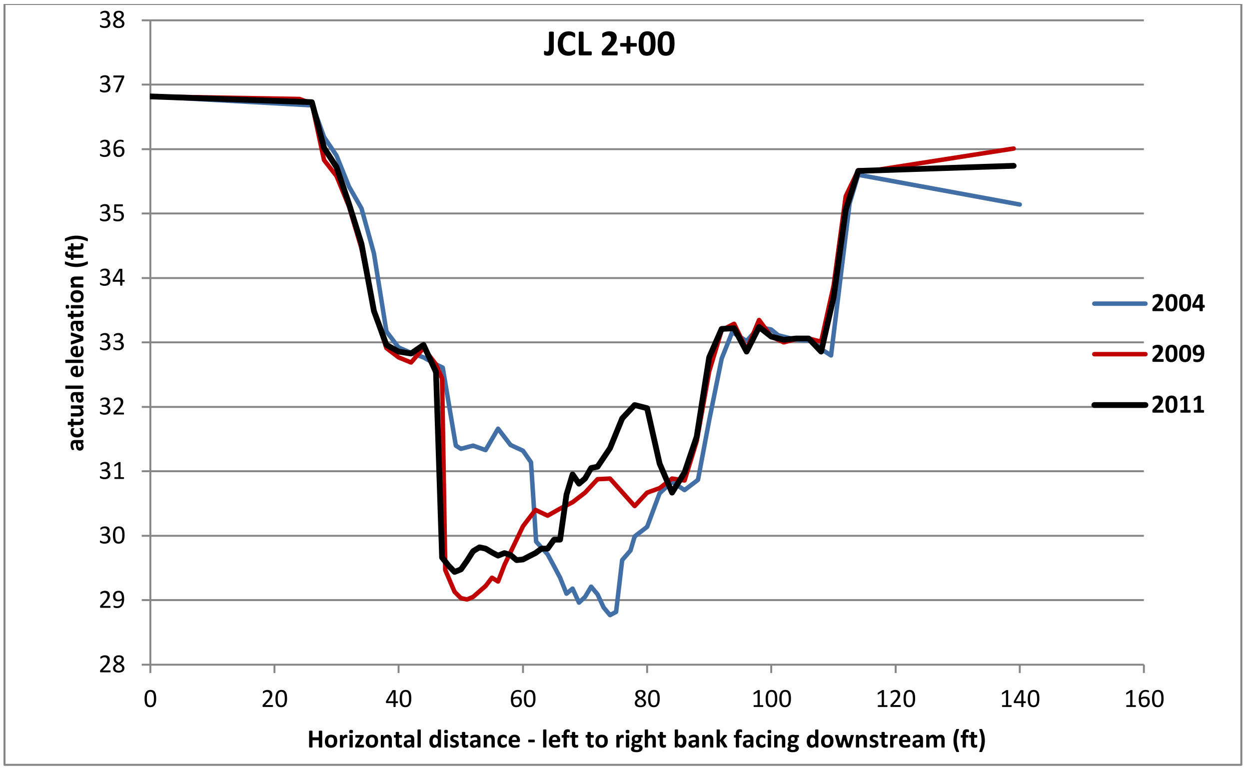

Figure 2.5. Sample JCL channel cross-section (JCL 2+00) for the years 2004, 2009 and 2011.

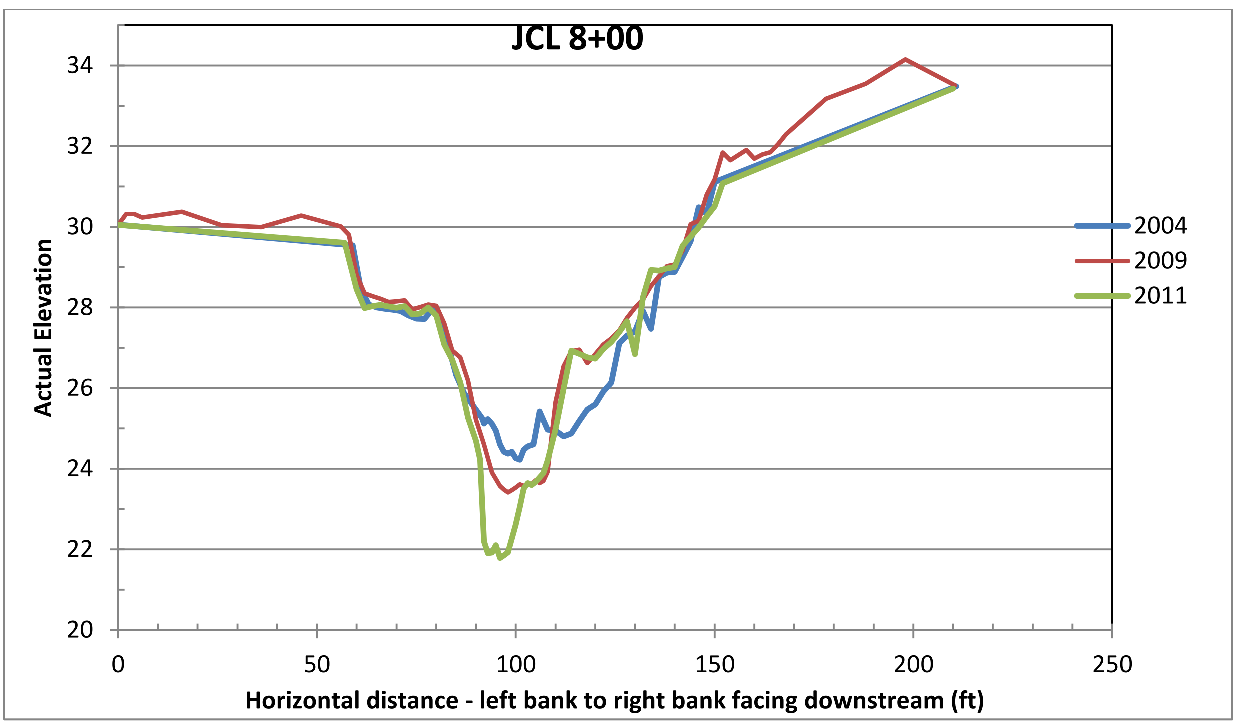

Figure 2.6. Sample JCL channel cross-section (JCL 8+00) for the years 2004, 2009 and 2011.

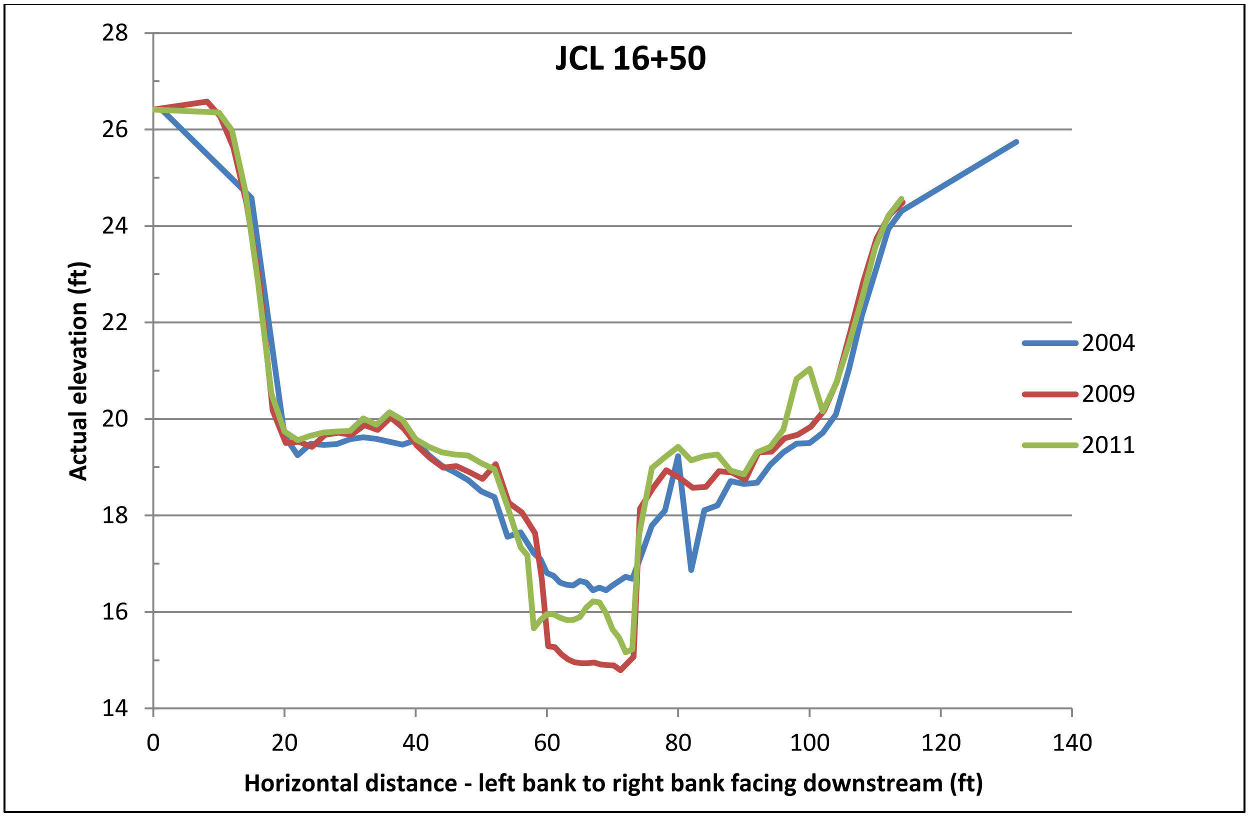

Figure 2.7. Sample JCL channel cross-section (JCL 16 + 50) for the years 2004, 2009 and 2011.

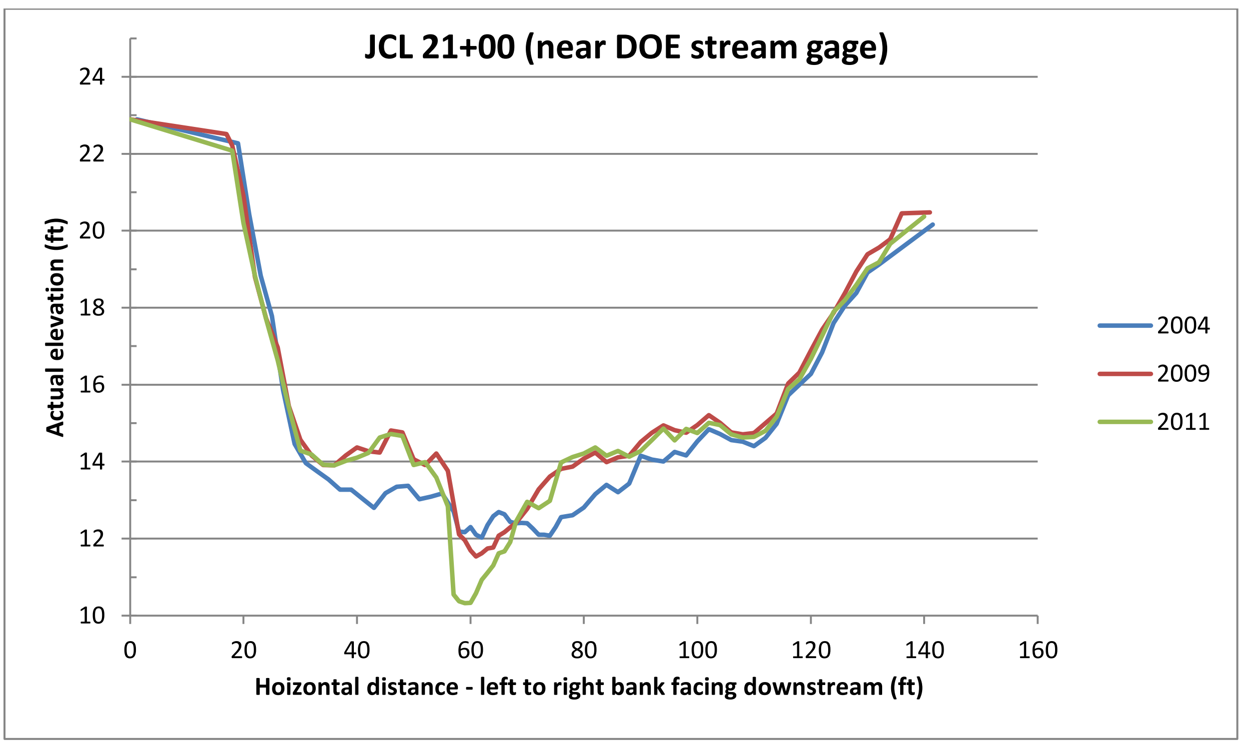

Figure 2.8. Sample JCL channel cross-section (JCL 21+00) for the years 2004, 2009 and 2011.

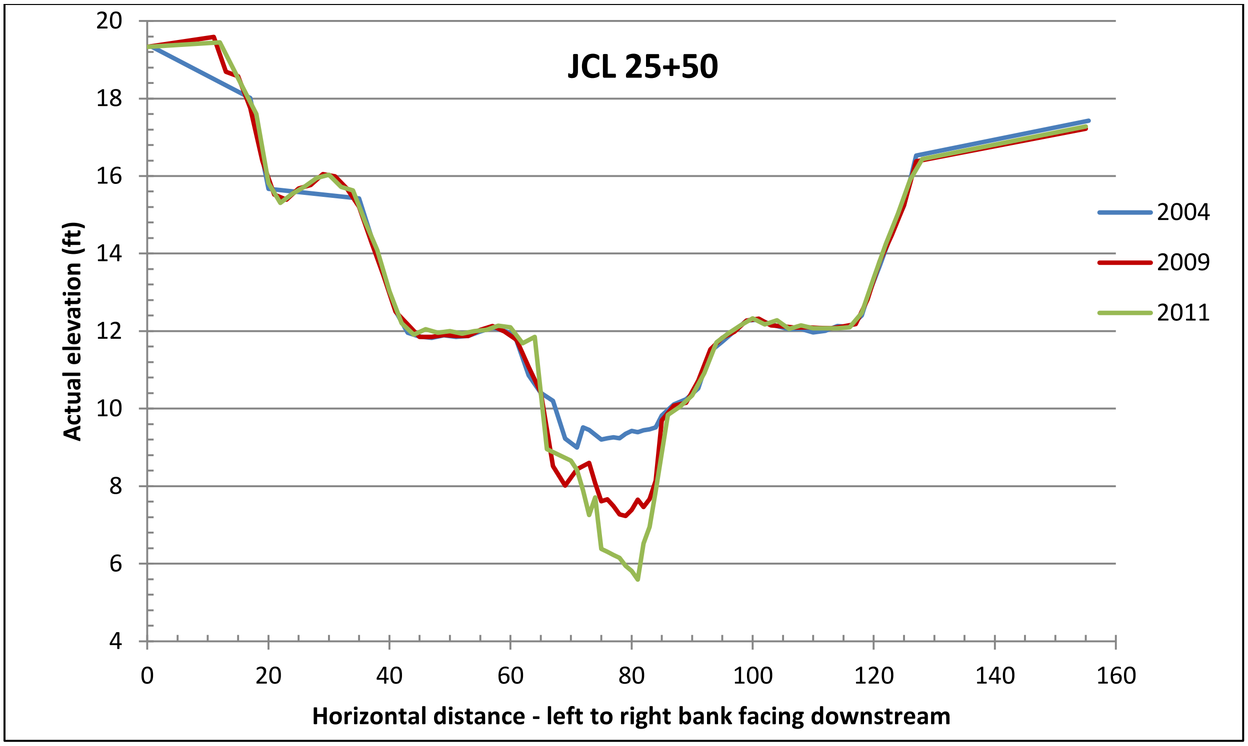

Figure 2.9. Sample JCL channel cross-section (JCL 25 + 50) for the years 2004, 2009 and 2011.

<u>Sediment Budget</u>
Entrix (2010) developed a sediment budget for the realigned JCL channel (Table 2.1). Sediment *input* was regarded as the supply transported into the upstream end of the project reach. Sediment *storage* was the change in mass within the project reach. Sediment *output* was the sediment that leaves the project downstream as it enters Sequim Bay, in other words the difference between sediment input and storage. *Suspended sediment* is the volume that is small and mobile and mostly transports out into Sequim Bay. Suspended sediment was estimated at 82% of the total sediment load, based on data from the Elwha River (Entrix 2010). *Bedload* is what is seen in the channel bed.

Table 2.1. JCL sediment budget (Entrix 2010).

Sediment Type	**Input (cu yds/yr)**	**Storage (cu yds/yr)**	**Output (cu yds/yr.)**
Suspended – sand and clay	457 +/- 100	73 +/- 50	384 +/- 100
Bedload			
Sand	16 +/- 16	73 +/- 50	-57 +/- 50
Gravel and cobble	84 +/- 0	81 +/- 50	3 +/- 50
TOTAL	557 +/- 100	227 +/- 50	330 +/- 100

Sediment budgets are an estimate of sediment movement, which accounts for the wide error estimates. The budget provides valuable information for planning and interpreting channel cross-section data (see Discussion).

Photo monitoring
Fixed-photo point monitoring has been difficult at best and arguably useless at this phase of forest development (Task 5, Figure 2.10). By 2008, the naturally re-colonizing red alder (*Alnus rubra*) was very dense, despite the fact we have thinned much of the upland alder two to three times to its current 4-6 ft. spacing. Floodplain alder has been thinned once, and not within 5 ft. of the channel bank.

Figure 2.10. JCL ground photos from November 2004 (left) and February 2009 (right). The images were taken at slightly different angles from the same fixed photo point (photos by Byron Rot).

While the channel has evolved, tracking that using aerial photos is difficult for a small stream like the JCL (Task 6, Figure 2.11). Subtle channel movement on the order of a few feet is almost impossible to detect on an aerial photo with overhanging vegetated banks. Based on field visits, these portions of the channel have seen channel movement up to 5 ft: 1+00 to 3+00, 6+00, 10+00, 15+00, 16+50 to 18+00, 21+00, and 26+00.

DISCUSSION

Once channel construction began, it became obvious that incision, not aggradation, would be the primary concern.

I was standing next to a surveyor from the Washington State Department of Transportation during the fall of 2002; he was helping us survey the new JCL channel at the downstream end of the project (see 2003, Figure 2.11). We were constructing a ―finished channel” in the lowest reach of the project. We observed glacial wetland soils as far as we could see (Figure 2.12). ―What was here before?” he asked. ―Wetland,” I said (see year 2000, Figure 2.11). He replied, ―You might consider excavating even further and building both the channel and floodplain from imported gravel.”I discounted his comments due to our time constraints and the additional money that we didn't have; however his words have stayed with me.

Our channel was designed to migrate, but since it is set into wetland clay, silt, and some sand, migration can input fines into the system that may smother salmon redds. When we designed the channel and created the monitoring plans, our concern was too much gravel, which was the management issue in the old JCL channel. For example, our pebble count performance criteria for sediment transport stated: ―pebble counts will provide an indication of whether unexpected sediment aggradation is occurring at undesirable locations within the realigned channel. Indications of excessive sediment aggradation could trigger the need for discussion of contingency measures" (Shreffler 2001). Once channel construction began, it became obvious that incision, not aggradation, would be the primary concern.

Figure 2. 11. JCL channel evolution from 12+00 to Hwy 101. Photos are pre-project – 2000, during construction – 2003, spring 2004 prior to channel opening in the fall, spring 2005 following channel opening in October 2004, spring 2007, and spring 2010 (graphic by Randy Johnson).

Figure 2.12. JCL floodplain construction near 22+00. The new 100 yr floodplain is at the bottom of the trough; the new channel was inset several feet below the floodplain. The surveyor is standing at ground level (October 2002, photo by Byron Rot).

The channel was opened to flow in October 2004. What we found during construction was that a consistent lens of gravel only extended the first 300 ft. downstream from the old channel. The new channel, constructed mostly into fine-grained sediments, rapidly evolved the first winter following a large flood (January 18, 2005), which exposed extensive sections of clay in the channel bed (see Figures 1.2 and1.3, Chapter 1 Hydrology). While there was wood present, it was mostly buried into the banks and we felt there was not enough wood to prevent further rapid channel evolution. The following summer (2005), we reconstructed several riffles, adding roughly 250 cy of gravel spread out at riffles located at 3+50, 4+50, 7+50, 11+00, and 16+50. In addition we added throughout the channel many more pieces of large alder, which we pushed over from the estuary, plus log boomsticks (see Figure 2.11 and compare 2004 with 2005). During the fall and winter of 2005/2006, we had four more floods, with the largest on New Year's Day (see Chapter 1 Hydrology). The wood we had placed the previous summer was substantially re-distributed; the channels that we reconstructed in the summer of 2005 were reworked, resulting in large changes everywhere (Figure 2.11, photos 2004 and 2005). In the summer of 2006, we completed channel construction at 15+50, which was too wet to access during 2003 construction. We also constructed two overflow channels where the creek was about to shortcut a meander. All three channel enhancements are still functioning as constructed.

Figure 2.3 presents a mixed message, while channel incision is continuing it is occurring sporadically and focused generally in the lower ½ of the project (Figure 2.4). Figure 2.3 is a series of point estimates at the channel cross-section, and any point in the channel can be influenced locally by logjams (e.g., incision or aggradation). The Entrix (2010) model incorporated the large amount of sediment stored upstream of the natural channel-spanning logjam at the upstream end of the project. Given that, reach A (Figure 2.3) continues to function as designed as an alluvial fan (Figure 2.5, 2+00). An alluvial fan occurs where a steeper, more confined section of stream opens into a wider, flatter section of stream. It is a natural sediment deposition area, and a place where the channel is also more active. In this case, we designed this reach to be an alluvial fan because we were worried about sediment aggradation (Shreffler et al. 2003).

Reach A will continue to store additional sediment until a channel slope is reached where new gravel entering this reach moves downstream instead of being stored here (Entrix 2010). A significant portion of the coarse gravel and cobble coming into the project is stored in this reach. Unknown is the amount of annual transport removed by the natural logjam upstream of the project and how much further storage is needed in reach A until equilibrium is achieved. These two factors are why substantial channel incision occurs in reach B (Figure 2.6, 8+00). Entrix identified a channel headcut just downstream of cross section 8+00 (A. Kopp personal communication), where an incision into the bed is migrating upstream. In 2011, 8+00 showed additional substantial incision from 2009, so incision at 8+00 is something to monitor closely (Figure 2.6).

Reach C (Figure 2.3) is mixed in terms of channel aggradation and incision, however there is substantial floodplain deposition occurring. Notice that 16+50 (Figure 2.7) shows a bit of floodplain sediment deposition, while 21+00 (Figure 2.8) has substantial floodplain sediment deposition. Virtually all that deposition is sand or silt. Also 21+00 is near the JCL stream gage; the channel incision there means extra work for Chris Evans the Ecology hydrologist (see Chapter 1 Hydrology). Reach C, especially between 21+00 and 24+00, is where we constructed an approximately 10 year floodplain instead of a 100 yr floodplain. The fine sediment stored here in the floodplain would otherwise remain in the channel smothering salmon eggs, or would be transported out into the bay.

At the upstream end of reach D is our channel-spanning logjam constructed to catch any logs transported from upstream areas before they reached the Hwy 101 Bridge. While no logs have yet made it past this logjam, for a time in 2004, the logjam did store sediment upstream of it (Figure 2.9, 25+50). The creek has cut other channels through the logjam, and that stored sediment has flushed downstream and out into the bay. The logjam site continues to incise. During construction it was the location of a deep hole that was used to pump water; this activity may have destabilized the channel bed.

Preventing bed destabilization and overflow cutoff channels (see channel triggers in Methods) were the impetus for the 2005 and 2006 channel maintenance. The current channel maintenance plan is to add gravel at several locations in the creek as a band-aid until the creek bypasses the natural logjam upstream of the project.

Photo monitoring

The monitoring team will have to decide whether it is effective to continue ground-based photo monitoring. At some point in the future, photo monitoring may again be useful, but that could be 10 or 20 years from now. The alder must grow tall enough for the canopy to be above the photographer. Also the trees need to be more widely spaced either naturally or through our crews thinning work. Upland photos will not be continued at this time.

Tidal flushing capacity

The design engineer calculated that stream power to transport gravel effectively becomes zero downstream of Hwy 101 at the cedar tree (see Chapter 1 - Hydrology, Figure 1.7). As a result, we located our tidal basin outlet at that site. It appears to be functioning, while Entrix (2010) observed bar development upstream of the tidal basin, few bars exist downstream of the outlet.

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HABITAT CONDITIONS

CHAPTER 3. WATER QUALITY MONITORING IN JIMMYCOMELATELY CREEK AND DEAN CREEK

– LORI DELORM AND HANSI HALS (JAMESTOWN S'KLALLAM TRIBE)

BACKGROUND

Restoration Objective – JCL Channel (Shreffler 2001) and Estuary (Shreffler 2004)
The restoration objective was to improve water and sediment quality by realigning Jimmycomelately (JCL) Creek and Dean Creek and reconnecting these creeks to the estuary, as well as removing roads, culverts, and other fill, removing creosote-treated pilings, and improving stormwater management.

Restoration Rationale – JCL Channel (Shreffler 2001) and Estuary (Shreffler 2004)
Water and sediment quality can be degraded by nearly all human activities that affect the landscape. The quality of water is the most important category of environmental factors affecting the biota of stream ecosystems (Koski 1992). Thus, the Channel Design Group (CDG) and Estuary Design Group (EDG) believed that removing and better managing anthropogenic stressors in the JCL ecosystem would improve water quality post-restoration.

People are dependent upon abundant clean water. We share this in common with all creatures, so water quality is an essential test of ecological health. Salmon especially are sensitive to water quality; they need clear, cold water, high in dissolved oxygen. They need clean gravels where eggs and alevins can develop. Determining whether the Jimmycomelately (JCL) Creek realigned channel provides these necessities is one test of its success.

The Washington State Department of Ecology sets water quality standards. The purpose is to sustain public health and public enjoyment of the waters, and the propagation and protection of fish, shellfish, and wildlife. Each surface water is designated by the beneficial uses it provides and the water quality criteria established to protect that use. The use warranting the most protection (or most stringent standards) is considered the designated use, and the corresponding water quality criteria for that use must be met, or else it is considered an impaired waterbody. For example, char spawning/rearing has a more stringent and protective temperature criterion than salmonid spawning/rearing and if they both occur in the same stream, the char criterion prevails.

The tributaries of the Jimmycomelately/Blyn basin are protected for the designated uses of: salmonid spawning, rearing, and migration; primary contact recreation; domestic, industrial, and agricultural water supply; stock watering; wildlife habitat; harvesting; commerce and navigation; boating; and aesthetic values. Additionally, these tributaries are also to be protected for the designated uses of core summer salmonid habitat and extraordinary primary contact recreation because they drain to Sequim Bay which is designated as extraordinary quality marine waters (WAC 173-201A-612).

This chapter will discuss the water quality of Jimmycomelately Creek and Dean Creek. Bacteria data for these creeks exist for pre- and post-project completion; water chemistry, temperature and intra-gravel dissolved oxygen data is mostly limited to post-project. Therefore, bacteria data is analyzed for changes in respect to the restoration project, as well as whether Washington State (State) water quality criteria are met. Water chemistry and temperature are analyzed for whether State water quality criteria are met. Intra-gravel dissolved oxygen (IGDO) is analyzed as to whether it is supportive of salmonid egg incubation and early life cycle needs. Finally, benthic macroinvertebrate data are considered in accordance with the benthic index of biological integrity (B-IBI), which is an established index providing insight into the overall health of Puget Sound small streams (Karr 1997, see also http://www.cbr.washington.edu/salmonweb/bibi/biomonitor.html#refs).

The Jamestown S'Klallam Tribe (Tribe) has a vested interest in the water quality of the Sequim Bay watershed because of its reliance on the aquatic resources that need good water quality to thrive. The Sequim Bay Watershed has provided the Tribe with an abundance of fish and shellfish since traditional times (Gunther 1927). The Tribe has been monitoring the surface waters of the Sequim Bay Watershed for over 15 years, in conjunction with the Washington State Department of Health (DOH) and the Clallam County volunteer group, Streamkeepers.

Clallam Indians Harvesting Salmon in Sequim Bay

Oyster Aquaculture off of Jimmycomelately Estuary

Sequim Bay is classified by DOH as an approved commercial growing area for shellfish. The Tribe is actively growing shellfish in Sequim Bay on its tidelands adjacent to JCL Creek and Dean Creek. Tribal citizens commonly harvest subsistence shellfish, and commercial clam digs are held several times a year for Tribal harvesters. Clam fisheries on tribal tidelands in Sequim Bay provided significant harvest opportunity for Tribal diggers in 2011 (Jamestown S'Klallam Tribe 2012).

The Tribe has measured bacteria, water temperature, dissolved oxygen, turbidity, and nutrients, and collected and identified invertebrates in JCL Creek and Dean Creek. The following descriptions of each parameter have been excerpted from *State of the Waters of Clallam County* (Clallam County 2004) to provide readers with an understanding of what each parameter reveals in terms of water quality.

Bacteria are a common contaminant of water. The data collected is the number of fecal coliform present that are from the digestive tract of warm-blooded animals, like mammals and birds. The presence of bacteria suggests that feces or sewage may be getting into the water, either from humans, their livestock or pets, or wild animals. Since pathogens and viruses travel with bacteria, an increase in the amount of bacteria in the water means that there is an increased risk of disease for the people who swim, wade, drink or eat shellfish from contaminated water. Bacteria do not usually directly harm fish and aquatic invertebrates, but their presence may often indicate other problems, such as low dissolved oxygen.

Water temperature controls the metabolic and reproductive activities for aquatic life. An increase in temperature may mean an increase in metabolic activity, providing conditions for disease-causing organisms and undesirable algae, as well as lowering the amount of instream dissolved oxygen. Weather, streamflow, the amount of intact streamside vegetation, groundwater, industrial inputs, irrigation diversions and human-related stormwater impacts can influence water temperatures. Optimal temperature levels for salmonids have been determined, and temperatures above those levels can be lethal; salmon eggs, juveniles and spawning adults are especially sensitive to high water temperatures.

Dissolved oxygen (DO) is the oxygen that is present in water and therefore available for fish and other aquatic animals to use. The amount of DO in a stream is critical, and low DO levels may indicate the presence of pollutants. Large rivers and streams that have high water volumes or steep channels usually stay well oxygenated. Small streams or streams impacted heavily by water withdrawals may be more easily depleted of DO. Altitude, streamflow, water temperature, quantity and types of plants, and sediment affect DO concentrations in streams. Because oxygen is more easily dissolved in cold water, warm water holds less oxygen than cold water. Human activities such as the removal of riparian plants can cause water temperatures to increase and DO levels to decrease. In addition, nutrients and other organic waste discharged into streams are decomposed by bacteria that use oxygen in the water, thus leaving less oxygen in the stream for other aquatic wildlife. Fish and aquatic invertebrates are impaired below certain levels of DO.

Turbidity is a measurement of the amount of light that is scattered or absorbed in water. Suspended silt and clay, organic matter and plankton can contribute to turbidity. Suspended sediment can increase turbidity and reduce light penetration, lowering the productivity of aquatic vegetation and invertebrates. The ability of salmonids to find and capture food is impaired in turbid conditions. Sediment deposited on the stream bottom can fill gravel spaces, and smother eggs and juvenile fish.

Nitrogen (ammonia, nitrates) and phosphorus are basic nutrients required for plant growth, usually occurring at low levels in surface waters. High levels of these nutrients can result from fertilizers and the breakdown of organic matter (including animal waste) in excessive amounts. Excessive nutrients over-stimulate plant growth, which leads to increased algae blooms and rapid growth of other plants and causes the over-enrichment of water bodies (eutrophication). Phosphorus occurs naturally in water; excessive amounts can occur from fertilizers, detergents, cleaning agents, sewage and food residues, soil erosion and decomposing vegetation in groundwater. Salmon and trout are sensitive to increased nitrogen levels, and ammonia (an unstable form of nitrogen) can be toxic to fish. Nitrates are also a concern for humans in groundwater used for drinking.

Benthic macroinvertebrates, small insects living on rocks and in stream channels, are critical as food sources for aquatic wildlife, including salmonids, other fish, and birds. By collecting, classifying by taxa, and counting these macroinvertebrates, a determination can be made about the health of the stream. Some types of aquatic insects (e.g., mayflies, caddis flies, and stoneflies), which are the preferred prey of salmonids, need cold, clear water to survive, as do salmonids. Other species of fish can eat insects that tolerate warmer stream temperatures, and these other species of fish may also be able to tolerate some types of pollution (e.g., low dissolved oxygen and turbid conditions), which salmonids cannot.

METHODS

All water quality monitoring was performed in accordance with an approved Quality Assurance Project Plan (QAPP). The Tribe's monitoring was conducted under an Environmental Protection Agency (EPA)-approved QAPP: *Sequim Bay Quality Assurance Project Plan for the Sequim Bay Watershed*, which was initially approved in 2003 and has been updated over time with the most recent version being 2010 (Jamestown S'Klallam Tribe 2010). The Streamkeepers monitoring was conducted under a QAPP approved by Washington State Department of Ecology: *Quality Assurance Project Plan for Streamkeepers of Clallam County Environmental Monitoring Program*, which has also been updated over time with the most recent revision in 2011 (Clallam County 2011).

Bacteria

Sampling methods for bacteria were adapted from Washington Department of Ecology (DOE)-approved Streamkeepers of Clallam County field manual (http://www.clallam.net/streamkeepers/html/quality_assurance.htm). There are 10 sites that the Tribe and Streamkeepers have monitored for bacteria over the past two decades (Figure 3.1). Since 1998, monitoring has occurred at least quarterly at each site; some sites were sampled once every other month. Currently the Tribe monitors for fecal coliform bacteria quarterly at two sites: Dean Creek 0.17 and JCL 0.3. The number following the creek name represents the mile post on the stream, with the mouth being river mile 0.0. Bacteria samples are taken as grab samples, placed on ice, and then transported to a Washington State accredited laboratory within 24 hours of sampling. Fecal coliform samples are analyzed using the membrane filter method, SM18 Membrane Filter 9222D.

Figure 3.1. Jimmycomelately Creek and Dean Creek water quality monitoring sites (graphic by Pam Edens).

Nutrients

Sampling methods for nutrients were adapted from the DOE-approved Streamkeepers of Clallam County field manual (link above). Nutrients have been sampled as funding allowed and have usually been collected quarterly. Currently the Tribe monitors nutrients (Total Nitrogen and Total Phosphorus) at two sites: Dean Creek 0.17 and JCL 0.3. All samples have been analyzed at the University of Washington or

Twiss Analytical Laboratories. Most samples have been analyzed for Total Nitrogen (TN) and Total Phosphorous (TP), and some have been analyzed for nitrate (NO_3).

Water Chemistry
At the time of grab sampling for bacteria and/or nutrients, water chemistry parameters were measured in the field. Instantaneous field measurements of pH, dissolved oxygen and turbidity were recorded using a Hydrolab Quanta multiprobe. The calibration and maintenance of the Hydrolab was performed according to the manufacturer's directions. The Jamestown S'Klallam Tribe and Clallam County Streamkeeper program both own Hydrolabs that were used in the collection of this data. We have field verified the readings for both Hydrolabs on multiple occasions.

Temperature
Temperature monitoring methods are adapted from the Timber Fish and Wildlife Ambient Monitoring Protocol (Pleus et al. 1999). The Washington State temperature criterion requires that the 7-day average stream temperature does not exceed a maximum of 16˚C from September 1-July 1. The Tribe collected stream temperature data in the ―old" JCL channel (pre-realignment) at approximately RM 0.2 from January 2000 through June 2004. From July 2004 to December 2010 stream temperature data were collected in the ―new" JCL channel (post-realignment) at the DOE stream gage at RM 0.3 as shown in Figure 3.2.

Macroinvertebrates
Streamkeepers of Clallam County performed the macroinvertebrate sampling using a Surber sampler of 500-micron mesh and sieves. The required time period for B-IBI sampling of benthic macroinvertebrates is Sept. 1 – Oct. 15 (Karr 1999). Invertebrate identification and quality control was performed by a professional taxonomic lab. Scores and ratings are for the genus-level and presented in accordance to the B-IBI for Puget Sound lowland streams (Karr and Chu 1997, Fore 1999). The macroinvertebrate sites sampled are shown in Figure 3.3 (*note: it appears that Streamkeepers used a different starting point for numbering their sampling sites than what the Tribe used; thus river miles on Figure 3.1, 3.2, and 3.3 are not consistent across the three figures. For example, JCL_SK_0.2a on Figure 3.2 is upstream of JCL_0.3 on Figure 3.1 and Figure 3.3. The key point is that the mapped locations of sampling sites are correct on all three figures, even though the river mile labels are not consistent*).

Intra-gravel Dissolved Oxygen
Intra-gravel dissolved oxygen (IGDO) is the dissolved oxygen level within the gravel bed. IGDO monitoring methods and protocols were adapted from Jefferson County Conservation District (Gately et al. 2009). Nine sites were established as simulated redd sites for monitoring (Figure 3.4). The simulated redds were composed of 4-inch aquarium air stones and tubing buried 7 inches below the substrate surface. Seven of these redds were placed between river mile (RM) 0.12 and RM 0.4. The two upper most sites were above the restoration project at RM 0.5 and RM 0.68. IGDO sampling was conducted once per month from October 2010 to December 2011. The IGDO field measurement is of the dissolved oxygen in the water of the tubes attached to the aquarium stones.

Figure 3.2. Jimmycomelately Creek temperature monitoring site at the DOE stream gage in the realigned channel (graphic by Pam Edens).

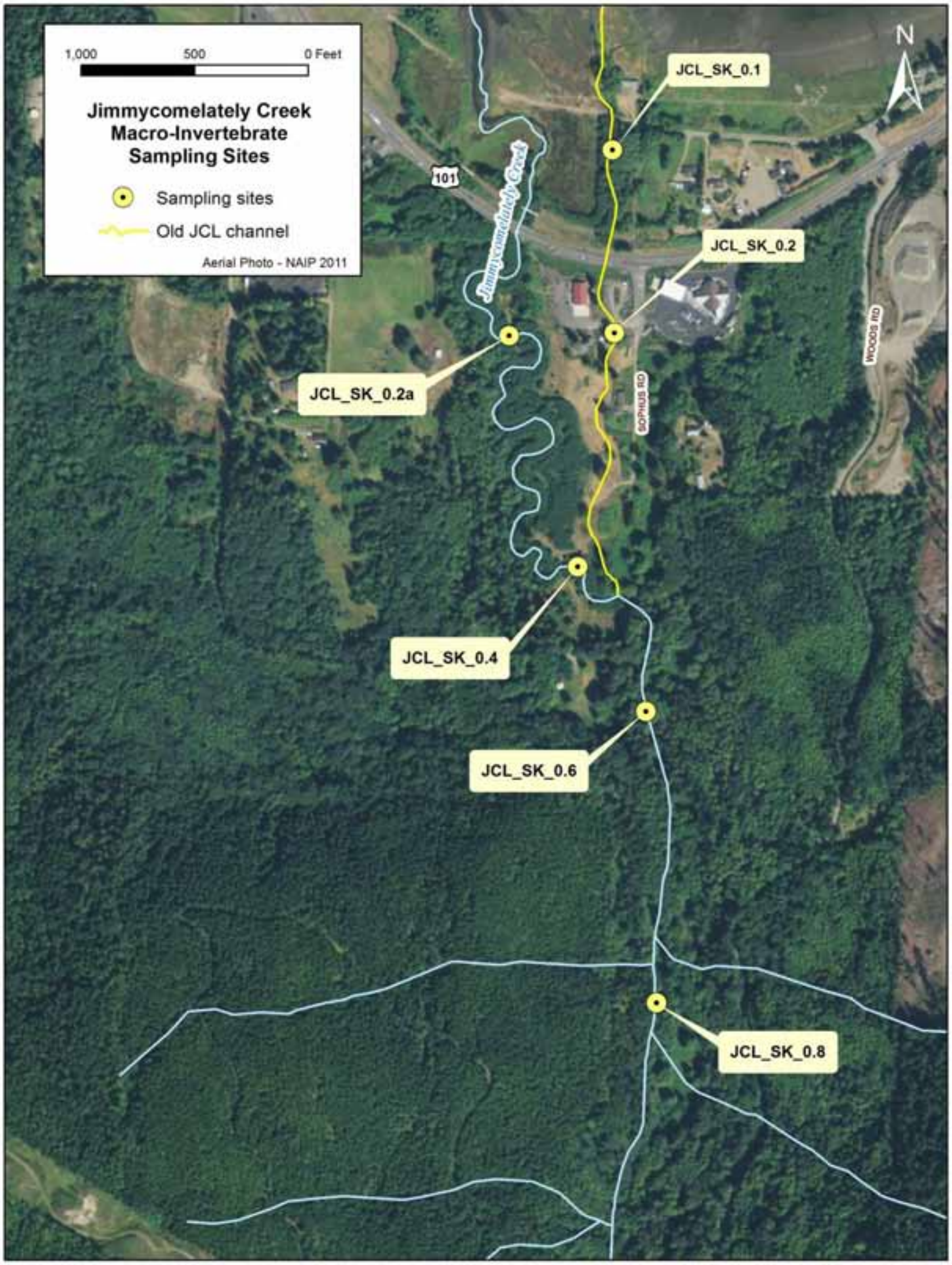

Figure 3.3. Streamkeepers macroinvertebrate sampling sites on Jimmycomelately Creek (graphic by Pam Edens).

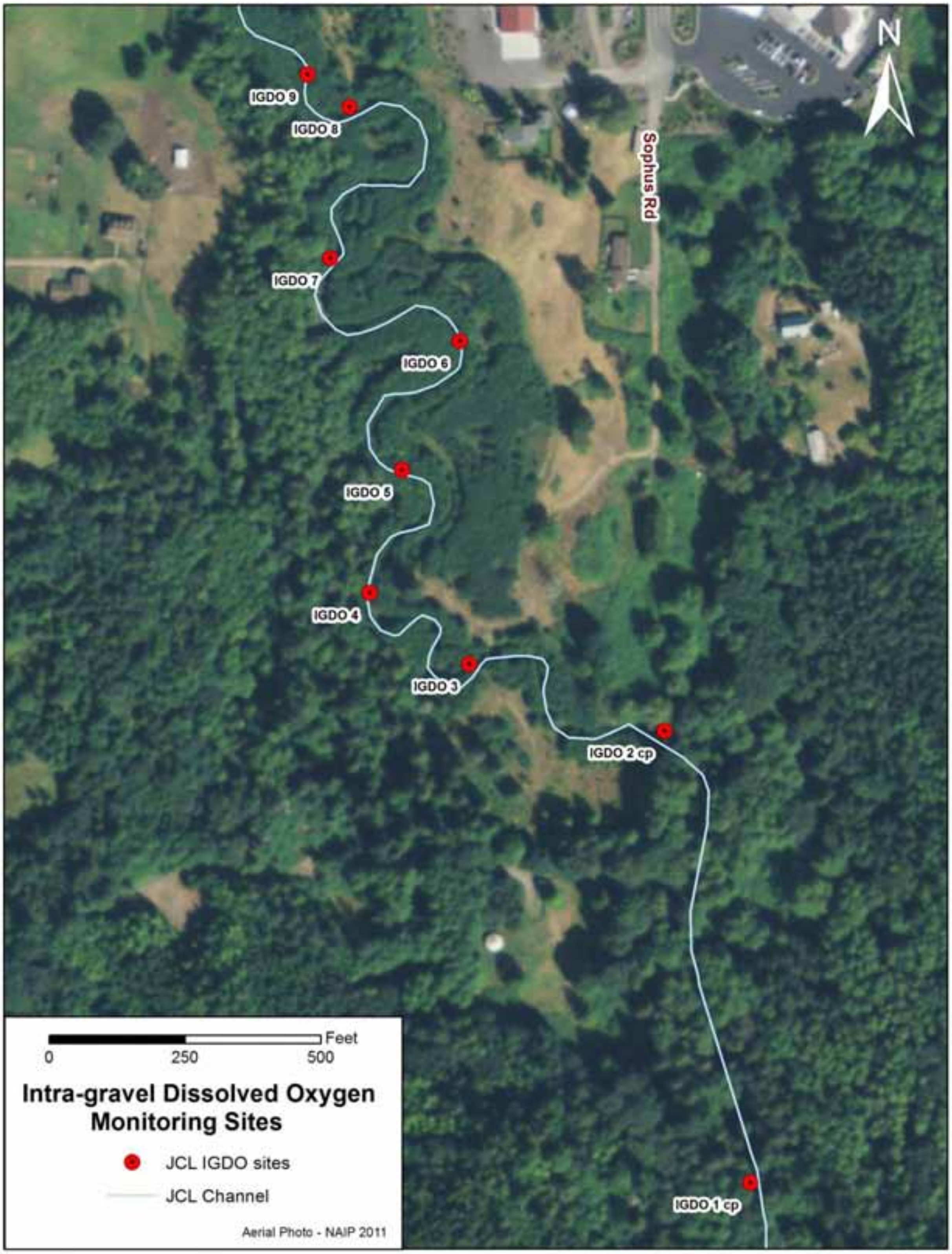

Figure 3.4. **Intra-gravel dissolved oxygen (IGDO) sites in the realigned JCL channel (graphic by Pam Edens).**

RESULTS

Bacteria

The Washington State fecal coliform (FC) bacteria standards for a designated waterbody that is a tributary to marine waters of extraordinary quality are as follows: 1) the geometric mean values shall not exceed 50 FC/100 mL, and 2) not more than 10% of the samples shall exceed 100 FC/100 mL. Additionally, it is important to note that the Washington State Department of Health (DOH) applies guidelines for shellfish harvest in its commercial shellfish waters classification program. Because Sequim Bay is the site of commercial, recreational, and subsistence shellfish harvest, the DOH criteria are important. For an approved shellfish growing classification, two requirements must be met: 1) the geometric mean is not to exceed 14 FC/100 mL, and 2) the 90th percentile is not to exceed 43 FC/100 mL.

The surface waters of Jimmycomelately Creek and Dean Creek have been sampled for fecal coliform bacteria by the Tribe since 2004 and 2007, respectively, at sites JCL 0.3 and Dean 0.17, identified on Figure 3.1. Pre-project data was collected on JCL Creek at site JCL 0.17 by Clallam County Streamkeepers from 1986-2003 (Figure 3.1). The nearest site monitored post-project is JCL 0.3, which is used for comparison to site JCL 0.17. There is no pre-project data available for Dean Creek, so post-project data are compared to the State water quality standard for bacteria.

Table 3.1 and Table 3.2 display the fecal coliform geometric mean values for both Jimmycomelately Creek and Dean Creek relative to State water quality criteria. For pre- and post-project comparison sites JCL 0.17 (Streamkeepers) and JCL 0.3 (Tribe) are being used. Years have been grouped to increase the number of samples analyzed.

Pre-project fecal coliform data from 1986 to 2003 show that JCL did not meet the State water quality criterion because of exceedance of the 90th percentile. Since the 2004 channel realignment, JCL Creek has met the criteria for both the geometric mean and 90th percentile in the second data group of years 2007 – 2010. Dean Creek meets the State water quality criterion for fecal coliform. Most significantly, the geometric mean for JCL has improved since the channel realignment and it is now low enough to meet the shellfish growing area approved designation. Figure 3.5 displays the geometric mean and 90th percentile fecal coliform results for JCL Creek from 1986 to 2010 and for Dean Creek from 2007 to 2010.

Table 3.1. Fecal coliform results (cfu/100 ml) for Jimmycomelately Creek (JCL) pre-project – Streamkeepers.

Site and Monitoring Period	Sample Size	Geometric Mean	WQ Criterion Geometric Mean	Meets Criterion?	90th Percentile	Maximum	# of Samples >100 cfu/100 ml	WQ Criterion 10% Not to Exceed	Meets Criterion?
JCL 0.17									
1986-1988	48	29	50	Yes	203	360	10 of 48	100	**No**
1989-2003	36	21	50	Yes	175	425	6 of 36	100	**No**

Table 3.2. Fecal coliform results (cfu/100 ml) for Jimmycomelately Creek (JCL) and Dean Creek post-project – Jamestown S'Klallam Tribe.

Site and Monitoring Period	Sample Size	Geometric Mean	WQ Criterion Geometric Mean	Meets Criterion?	90th Percentile	Maximum	# of Samples >100 cfu/100 ml	WQ Criterion 10% Not to Exceed	Meets Criterion?
JCL 0.3									
2004-2007	10	14	50	Yes	108	134	2 of 10	100	**No**
2007-2010	11	10	50	Yes	48	88	0 of 11	100	Yes
Dean 0.17									
2007-2008	6	4	50	Yes	18	19	0 of 6	100	Yes
2009-2010	7	10	50	Yes	87	80	0 of 7	100	Yes

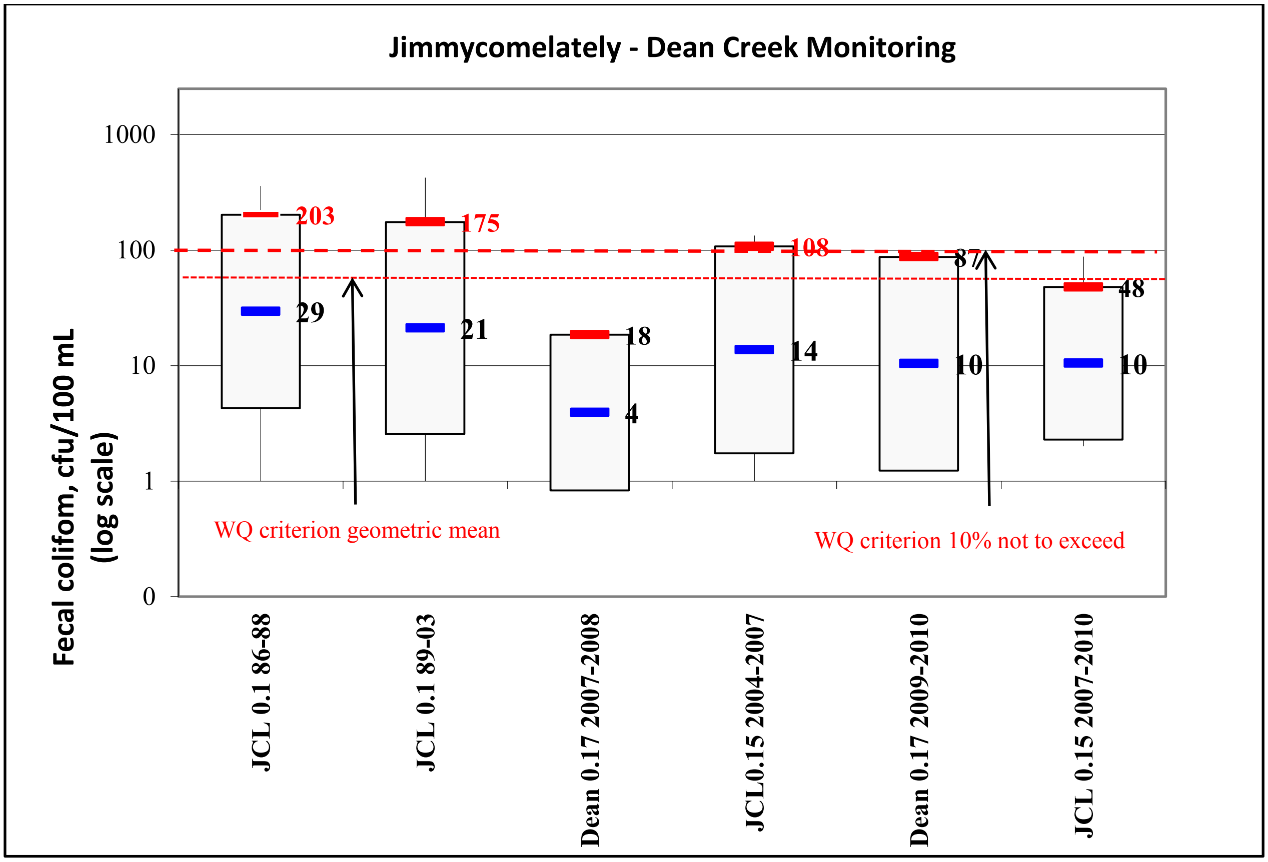

Figure 3.5. **Jimmycomelately Creek and Dean Creek geometric mean and 90th percentile fecal coliform concentrations.**

Nutrients

According to the State-EPA Nutrient Innovations Task Force (2009), nutrient pollution ranks as one of the top causes of surface water quality impairment in the United States. Nutrients are chemical compounds that contain nitrogen and phosphorus. Both these compounds are essential nutrients for plant growth, but in high concentration they can become contaminants. Nutrient over-enrichment can cause a host of problems in both fresh and marine waters. Harmful algal blooms, fish kills, eutrophication, outbreaks of shellfish poisoning, and hypoxia/anoxia are all related to elevated nutrients. This is a serious concern for JCL Creek and Dean Creek because they drain to the intertidal area in which the Tribe grows shellfish and practices treaty harvest.

Washington State has not developed water quality criteria for nutrients in streams or estuaries. However, EPA has established ecoregions within the U.S., defined as ―regions of relative homogeneity in ecological systems" (EPA 2000). JCL Creek and Dean Creek are in Ecoregion II– Western Forested Mountains. Within Ecoregion II, both JCL Creek and Dean Creek are classified as Level III – Puget Sound Lowlands. EPA has developed water quality recommendations for Total Nitrogen (TN) and Total Phosphorus (TP) for the Puget Sound Lowlands (Table 3.3).

Table 3.3. EPA ambient water quality recommendations for Total Nitrogen (TN) and Total Phosphorus (TP) in the Puget Sound Lowlands based on 25th percentile.

		Reported Values		25th percentile based on all seasons for the decade
Parameter	**No. of streams**	**Min**	**Max**	**P25-all seasons**
TN (mg/L)	37	0.08	2.62	0.24 (240 µg/L)
TP (µg/L)	133	2.5	330	19.5

The criteria in Table 3.3 are intended to evaluate whether elevated nutrient concentrations may impact aquatic life and resources. Using these EPA recommended criteria for Puget Sound Lowlands, TN in JCL Creek (772.54 µg/L) is more than three times above the recommended 240 µg/L, and TP in JCL Creek (38.06 µg/L) is nearly twice the recommended 19.5 µg/L (Table 3. 4). Nearly 90% of all JCL Creek samples from January 2009 – December 2010 exceed the EPA criteria for TN and TP. Dean Creek TN (1697.27µg/L) is more than 7 times above the EPA criterion, and TP (85.29µg/L) is more than 4 times above the EPA criterion. Dean Creek exceeds the EPA criteria for both TN and TP 100% of the time from January 2009-December 2010.

Table 3.4. Nutrient values for JCL Creek and Dean Creek (2007-2010). Bold values are in exceedance of the EPA recommended criteria for rivers and streams in Ecoregion II.

Parameter	Max Value ug/L	Min. Value ug/L	Mean ug/L	Sample Count
Jimmycomelately Creek 0.15				
Ammonia	24.47	3.52	9.89	8
Nitrate	995.16	50.92	305.2	8
Nitrite	13.31	0.8	2.9	8
Total Nitrogen	**2408.85**	**215.41**	**772.54**	8
Total Phosphorus	**142.3**	6.19	**38.06**	8
Phosphorus	29.72	11	17.01	8
Silicate	13560.7	8038.72	9427.15	8
Dean Creek 0.17				
Ammonia	21.84	4.65	9.81	7
Nitrate	2310.74	148.35	710.35	7
Nitrite	14	1.11	3.71	7
Total Nitrogen	**5389.55**	**505.75**	**1697.27**	7
Total Phosphorus	**323.39**	**31.52**	**85.29**	7
Phosphorus	50.38	19.84	28.66	7
Silicate	14,122.72	8,512.71	10,292.87	7

Nitrogen and phosphorus are naturally occurring elements in marine and freshwater. However, they are typically concentrated by human activities such as agricultural or residential fertilizer use and collection, treatment and discharge of human waste, detergents, and animal waste. While elevated nitrogen inputs can be mostly natural because of nitrogen-fixing species (e.g., red alder), this is an unlikely explanation for phosphorus. Future monitoring should evaluate upstream land use and possible sources of the elevated TN and TP in JCL Creek and Dean Creek (Newton et al. 2002).

Water Chemistry
A multiprobe Hydrolab was used to measure dissolved oxygen (DO), pH, and turbidity in JCL Creek and Dean Creek. Table 3.5 displays the maximum, minimum, and mean value of the parameters measured compared to the State water quality standards. State standards were met for all parameters except DO for JCL Creek. Dissolved oxygen can be a very difficult parameter to measure and great care and precise calibration are essential to ensure a valid result. The Tribe's Hydrolab DO meter has been calibrated and tested side by side with Department of Ecology's and Streamkeepers of Clallam County's Hydrolab DO meters. The consistent results indicate that indeed there are low levels of DO in Jimmycomelately Creek, especially in the summertime.

Table 3.5. Water chemistry results (DO, pH, turbidity) for JCL and Dean Creek, 2004-2010.

Parameter	Max Value	Min. Value	Mean	Sample Count	WA State Standard	Standard Met?
Jimmycomelately Creek 0.3						
DO mg/L	17.8	7.84	12.51	23	9.5 mg/L – lowest 1 day minimum	**No**
pH	8.14	7.35	7.72	21	pH shall be within the range of 6.5-8.5 with a human-caused variation within the above range of less than 0.2 units	Yes
Turbidity NTU	47.6	0.82	13.67	19	Turbidity shall not exceed 5 ntu over background when background is 50 ntu or less: or a 10% inc. in turbidity when the background turbidity is more than 50 ntu.	Yes
Dean Creek 0.17						
DO mg/L	13.84	9.6	11.74	12	9.5 mg/L – lowest 1 day minimum	Yes
pH	9.65	7.63	8.04	11	pH shall be within the range of 6.5-8.5 with a human-caused variation within the above range of less than 0.2 units	Yes
Turbidity NTU	90.5	1.26	22.33	10	Turbidity shall not exceed 5 ntu over background when background is 50 ntu or less: or a 10% inc. in turbidity when the background turbidity is more than 50 ntu.	Yes

Temperature
From January 2000 to June 2004 the stream temperature in JCL Creek did not exceed the State criterion of 7-day max of 16˚C from September 1 to July 1 (Figure 3.6).The 2004 data immediately after the JCL channel realignment (July 2004 – December 2004) also met the State criterion, but showed an increase in temperature to an average of 9.84˚C for the September to December time period.

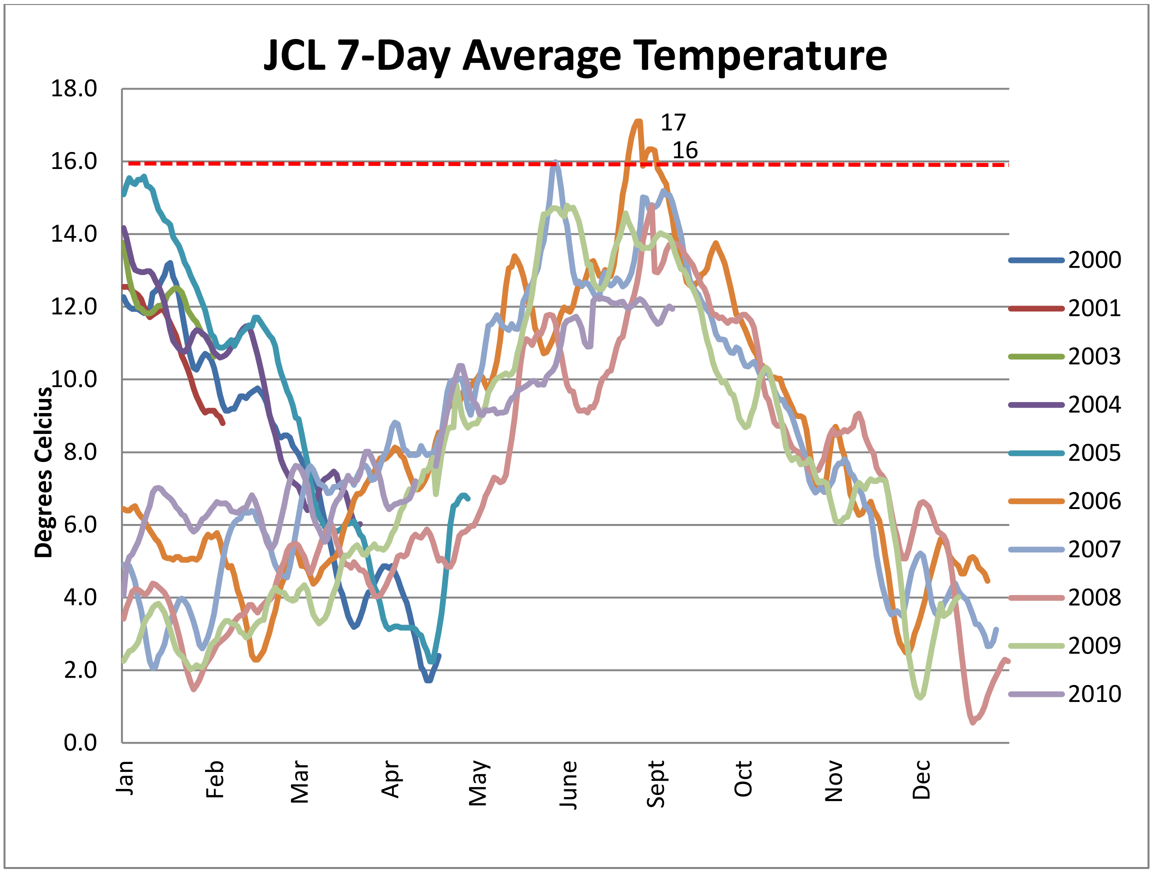

Figure 3.6. **JCL 7-day average temperature at RM 0.2 pre-channel realignment (2000-2004) and RM 0.3 post-channel realignment (2005-2010). The red, dashed line is the State threshold that cannot be exceeded from September 1 to July 1. There are no data for 2002.**

In fall/winter 2004 the realigned JCL channel had new conifer and shrub plantings that were just beginning their growth. By 2006 we saw a drop in the average stream temperature to 8.8˚C for the same time period; a developing canopy of conifers and alders was providing shade to the creek, and presumably contributing to the decrease in average stream temperature. Between 2006 and 2010, the State criterion of 16˚C max was only exceeded once, for one week from September 1 to September 8, 2006.

Macroinvertebrates

Streamkeepers monitored benthic macroinvertebrates in JCL Creek from 2000 to 2009. Macroinvertebrate monitoring allows us to understand more about the processes occurring in our watersheds by determining what organisms are found in a stream and comparing them to what organisms are expected to be present in a healthy stream. The benthic macroinvertebrate population reflects the biological condition of a stream and has a direct effect on the health of a salmon population (Karr 1999). Figure 3.3 shows the six sites that were sampled for benthic macroinvertebrates. Table 3.6 displays the benthic index of biotic integrity (B-IBI) scores for each sampling event from 2000-2004 (pre-project) and from 2005-2009 (post-project). The post-project data show that most of the sampling sites ranged from *compromised* to *highly impaired*, with the only *healthy* rating occuring in 2009 at site Jimmycomelately 0.6, which is upstream of the portion of JCL that was realigned in 2004. Two collection sites on the realigned channel (0.2a and 0.4) show that the B-IBI scores have improved over time since channel construction.

Table 3.6. Benthic – Index of Biological Integrity (B-IBI) scores for pre- project (2000-2004) and post-project (2005-2009).

Site/Date	Score	Rating
Jimmycomelately 0.1		
9/30/2000	34	Impaired
9/29/2001	38	Compromised
10/10/2002	42	Compromised
10/5/2003	36	Compromised
Jimmycomelately 0.2		
10/5/2000	34	Impaired
10/10/2002	38	Compromised
Jimmycomelately 0.2a		
9/25/2004	14	Critically Impaired
9/25/2005	18	Highly Impaired
10/4/2006	36	Compromised
10/7/2007	32	Impaired
9/4/2009	34	Impaired
Jimmycomelately 0.4		
10/22/2004	24	Highly Impaired
9/25/2005	34	Impaired
10/4/2006	40	Compromised
Jimmycomelately 0.6		
10/1/2001	36	Compromised
10/11/2002	32	Impaired
10/5/2003	48	Healthy
10/16/2004	42	Compromised
9/4/2009	46	Healthy
Jimmycomelately 0.8		
10/11/2002	38	Compromised
10/3/2005	42	Compromised
10/10/2007	42	Compromised

Intra-gravel Dissolved Oxygen

Salmonid eggs need the proper level of intra-gravel dissolved oxygen (IGDO) in order to survive. While there is no State criteria for IGDO, DO levels required by salmonid eggs in the gravel are no less than they are for salmonids above the gravel. Levels that are 7-8 mg/L have no production impairment, while levels of 5-6 mg/L have moderate to slight production impairment and levels of 4 mg/L have severe production impairment. DO levels <3 mg/L are lethal to salmonids (Malcolm et al. 2003).

It is critical that adequate IGDO levels are maintained during the 6-7 month incubation period of salmonid eggs in the gravel. For the purposes of this report, all tubes at each site were averaged for the 11 months of data collected (Figure 3.7). Sites one and two are in the ―control" area above the restoration project site (see IGDO1cp and IGDO2cp in Figure 3.4). If the State surface water standard of 9.5 mg/L lowest 1 day minimum is applied to the IGDO results, six of the nine sites would not meet the standard.

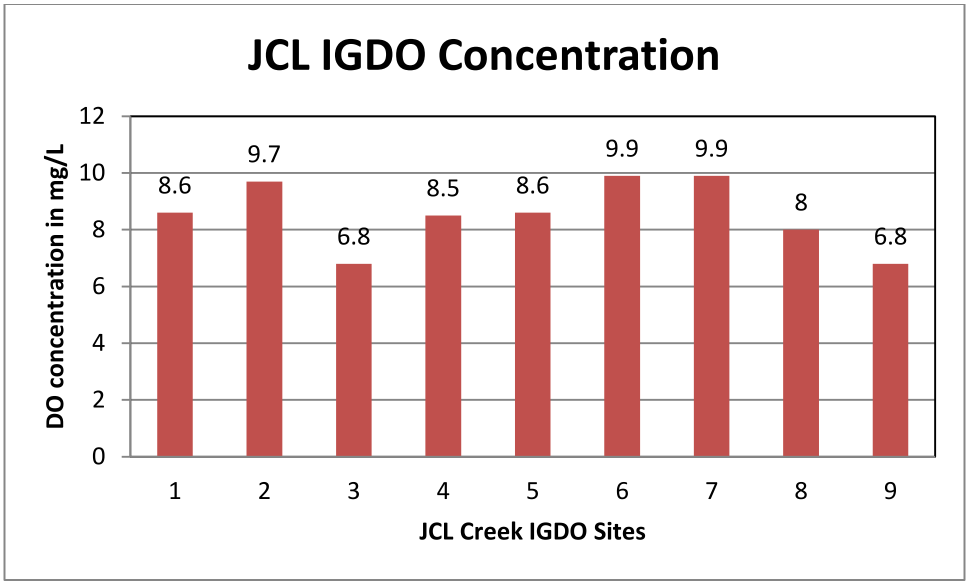

Figure 3.7. **Intra-gravel dissolved oxygen (IGDO) concentration for nine monitoring sites in Jimmycomelately Creek. The reported concentration for each site is the average concentration for 11 months from October 2010 – December 2011.**

DISCUSSION

The technical teams for the Jimmycomelately Ecosystem Restoration Project established the following performance criteria to assess water quality pre-project vs. post-project:

Performance Criterion – Channel (Shreffler 2001)
Water quality parameters (continuous water temperature, dissolved oxygen, conductivity, pH, turbidity, nitrate, and fecal coliform) within the new JCL channel shall: a) not exceed state water quality standards, and b) show improvement over most water quality parameters for the existing JCL channel.

Conductivity was not monitored post-project; all other parameters are discussed below.

Performance Criteria-Estuary (Shreffler 2004)
1) *Salinity measurements post-restoration shall demonstrate that the salinity wedge extends further upstream in the new JCL channel and the new Dean Creek channel than in the existing channels. For JCL, the salinity wedge shall reach the McLaughlin property south of HWY 101. For Dean Creek, the salinity wedge shall reach approximately 300 ft. upstream of the mouth.*

This monitoring was dropped due to lack of funding.

2) *Water quality parameters (water temperature, D.O., and turbidity) at the mouth of the new JCL Creek channel, the mouth of the new Dean Creek channel, and within the footprint of the former pilings shall not exceed state, federal, or tribal water quality standards. [Note: DOE standards for freshwater are: water temperature < 13 degrees centigrade; DO > 7.0 mg/L, and turbidity not less than 5 NTU or 10% above background levels; At this time DOE has no standards for temperature, D.O., and turbidity in waters that are >10 parts per thousand salinity].*

This monitoring was dropped due to lack of funding, which is unfortunate because tidal wetlands have been documented to maintain high water quality by: 1) intercepting and physically filtering sediments and associated contaminants in freshwater runoff with subsequent burial in marsh sediments; 2) supporting geochemical environments in both oxygenated and non-oxygenated sediments, which promote denitrification and other chemical reactions that remove certain chemicals from the water; 3) supporting the extremely high productivity of marsh vegetation, which reduces the pool of inorganic nutrients that might drive eutrophication in the Sound through high nutrient uptake and subsequent burial in sediments; and 4) maintaining a diverse array of decomposers and decomposition processes that trap and remove organic matter from the tidal system (Fresh et al. 2011).

3) *Sediment quality parameters (metals, organics, TPH) at the mouth of the new JCL Creek channel, the mouth of the new Dean Creek channel, and within the footprint of the former pilings shall not exceed state, federal, or tribal water quality standards*.

This monitoring was dropped due to lack of funding.

4) *Post-project fecal coliform concentrations shall not exceed pre-project concentrations, and shall not exceed state, federal, or tribal water quality standards*.

Fecal coliform results relative to this performance criterion are discussed below.

Bacteria

Post-project monitoring results show that there has been a significant decrease in fecal coliform bacteria levels in Jimmycomelately Creek. Dean Creek has consistently met State water quality criteria since we began post-project monitoring. Both creeks now have bacteria loads that are low enough to support safe shellfish harvest in accordance with the National Shellfish Sanitation Program standards (WA DOH Growing Area Classifications, http://www.doh.wa.gov/ehp/sf/grow.htm).

Both JCL Creek and Dean Creek have post-restoration bacteria loads that are low enough to support safe shellfish harvest.

It is possible that there was a decrease in fecal coliform pollution starting in 2004 due to the realignment of the JCL channel. The channel was moved a significant distance from four possible septic sources and one other potential source from nearby horses that grazed near the creek prior to 2004. Additionally, an element of the JCL restoration project was riparian planting, which is discussed in Chapter 6 Riparian and Floodplain Vegetation Establishment. The revegetation is important in relation to bacteria inputs because riparian vegetation is known to filter and reduce bacteria entering surface waters (Mitsch and Gosselink 2007). It is likely that the dense vegetation has reduced the amount of fecal coliform bacteria entering JCL Creek.

Continuing to monitor for fecal coliform bacteria is important in ensuring human health for both the Tribe and the general public. The Tribe plans to continue sampling for fecal coliform in both JCL Creek and Dean Creek. Beneficial uses for JCL Creek and Dean Creek include: aquatic life use, core summer habitat, recreation use, salmonid spawning, salmonid rearing, and salmonid migration. Fecal coliform can compromise these beneficial uses.

Nutrients

Although Washington State has not developed water quality criteria for nutrients in streams or estuaries, our monitoring from 2007 to 2010 indicates that Total Nitrogen and Total Phosphorous levels in JCL

Creek and Dean Creek are elevated relative to the Maryland Coastal Bays Program criteria for protecting seagrass.

Excessive nutrients promote algae blooms that can create a suite of environmental problems including smothering eelgrass and shellfish beds, and when the algae bloom are consumed by bacteria, low dissolved oxygen, as well as producing biotoxins. It is beyond the scope of this report, but it is noteworthy that in the summertime of 2011 recreational shellfishers were sickened with diarrhetic shellfish poisoning, which is the result of a marine biotoxin in association with an algae bloom (Hard 2012).

The restoration project was not designed to reduce nutrient levels and in fact, we would expect to see, temporarily, a net increase in nitrogen exported from the JCL stream. Red alder, the dominant early successional tree species along the JCL channel (see Chapter 6 Riparian and Floodplain Vegetation Establishment), is a nitrogen fixer and documented to be an exporter of nitrogen through surface water (Newton et al. 2002). Over time, and with continued thinning of red alder, conifer species will outcompete red alder and this nitrogen source will decline.

Human activities on land and near streams can accelerate the problems associated with nutrient over-enrichment by increasing the amount of nutrients being delivered to the marine environment. Sources of nutrients include wastewater treatment, failing septic systems, chemical fertilizers, agricultural practices, urban runoff, and the burning of fossil fuels. Several of these sources could be contributing to the elevated levels of nutrients in JCL Creek and Dean Creek. The Tribe is currently reviewing surrounding land uses to identify and minimize freshwater inputs of nitrogen. Hopefully, the prominence of the JCL project will help motivate neighboring land managers to minimize or control their nutrient inputs.

Water Chemistry

Turbidity and pH for JCL Creek met the State water quality standards; dissolved oxygen did not.

Interestingly, post-project water column DO levels appear to be declining since JCL realignment. In Figure 3.8, the Hydrolab DO and temperature measurements were compared. It appears that there may be a decrease in DO since project completion. While this is noteworthy, it is important to recognize the inverse relationship between water temperature and dissolved oxygen. In 2006, following channel construction, September temperatures exceeded 15° Celsius. Warm water has less capacity to absorb dissolved oxygen, and so we expect that decreases in stream temperature resulting from a more established riparian canopy will also increase the dissolved oxygen levels in the realigned JCL channel.

Further investigation should include additional temperature and DO monitoring. Site selection should include a site in the upper watershed above the restoration project and several in the new JCL channel. Sample design should include year-round temperature monitoring and DO measurements so that seasonal comparisons can be made. This would also provide the opportunity to analyze data during the time of salmonid alevin emergence from the gravel.

Temperature

Stream temperatures met the State criterion prior to JCL channel realignment. Post-realignment the JCL stream temperatures increased relative to pre-alignment with one exceedance of the State temperature criterion between September 1 and September 8, 2006. However, from September 8, 2006 through our last results, October 1, 2010, the State temperature criterion was not exceeded. The developing riparian canopy of conifers and alders along JCL Creek appears to be providing shade and lowering stream temperatures. This trend should continue as the canopy matures.

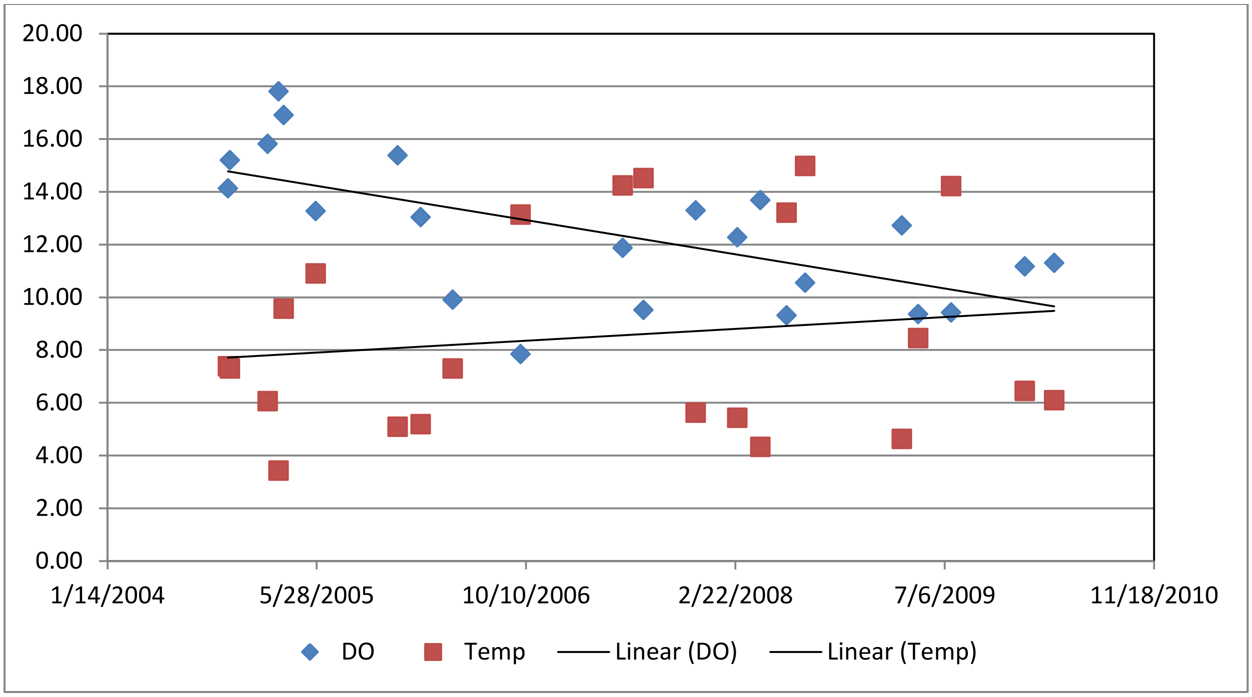

Figure 3.8. Comparison of dissolved oxygen (DO) and temperature in the realigned JCL channel (2004-2010).

Macroinvertebrates
The B-IBI ratings indicate that the habitat integrity ranged from *healthy* to *critically impaired* in Jimmycomelately Creek prior to the restoration project. The *State of the Waters* report concluded that sedimentation and temperature were the limiting factors in the ability for salmonids to successfully feed, spawn and rear in JCL (Clallam County 2004). Both of these limiting factors were addressed by the JCL Ecosystem Restoration Project. As discussed in Chapter 2 Sediment Transport and Channel Morphology, sediment transport has dramatically improved post-project and turbidity results indicate that JCL is not impaired by turbid conditions. As noted above, temperature appears to have increased immediately following JCL realignment, but is now decreasing as the riparian vegetation becomes established.

Nevertheless, post-project B-IBI ratings indicate that the habitat integrity of JCL Creek is still not healthy. Ratings varied by site and year between 2004 and 2009 with sites 0.2a and 0.4 being of particular concern. In general, the B-IBI ratings improve (but are still compromised) moving upstream and away from the more urbanized lower JCL watershed.

Intra-gravel Dissolved Oxygen
Developing salmonid eggs as well as alevins depend on adequate supply of oxygen for their survival (Quinn 2005). The JCL Creek IGDO levels indicate a potential salmonid production impairment; individual tube results had DO levels as low as 1 mg/L (levels < 3.0 mg/L are lethal to salmonids).

Future analysis is needed to explain these low IGDO levels and investigate the implications for egg and alevin survival. As reported in Chapter 11 Juvenile Salmonid Use: Smolt Production, coho egg-to-smolt survival has dramatically improved post-project. Thus, the IGDO results reported here are confounding because we do not see a decline in coho egg-to-smolt survival post-project as might be expected given the low IGDO levels we observed.

ACKNOWLEDGMENTS

The Tribe would like to acknowledge and thank our partners who contributed to project design, data collection and analysis. Glen Gately of Jefferson County Conservation District was invaluable in providing technical assistance for sampling intra-gravel dissolved oxygen. Katie Anderson of Northwest Indian Fisheries Commission provided analysis of the temperature data. Without Katie's help, we would not have been able to perform the 7-day criteria exceedance analysis. Streamkeepers has been a stalwart monitoring partner for many years. We wish to recognize their staff and volunteers who performed the initial sampling until 2004 for most parameters, as well as all of the benthic macroinvertebrate collection.

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WA DOH Growing Area Classifications, http://www.doh.wa.gov/ehp/sf/grow.htm.

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CHAPTER 4. LARGE WOODY DEBRIS AND POOL/RIFFLE HABITAT SURVEYS
– HILTON TURNBULL (JAMESTOWN S'KLALLAM TRIBE)

BACKGROUND

Restoration Objective (Shreffler 2001)
The restoration objective relative to large woody debris (LWD) was to install LWD as both a hydraulic feature of the channel and as a functional habitat, because there was unlikely to be any significant LWD recruitment to the realigned JCL channel or the estuary for at least 20-50 years.

Restoration Rationale (Shreffler 2001)
LWD is critical for fish and aquatic invertebrate habitat (e.g., forming pools and riffles, providing cover), sediment trapping, and nutrient cycling, as well as controlling channel morphology and complexity. By installing LWD into the realigned JCL channel, the JCL Channel Design Group (CDG) hoped to ―jumpstart" physical and biological processes within the realigned JCL channel, until a healthy riparian corridor developed and LWD began to naturally recruit to the system.

Although discussed by the CDG during the planning phases of the Jimmy Project, no LWD was installed into the estuary, and monitoring of naturally-recruited LWD in the estuary was dropped due to lack of funding.

LWD was placed in the realigned JCL channel and floodplain and also buried to scour depths both in the channel and floodplain to ensure that the stream would interact with LWD at all flow levels and meander patterns (see as-built drawings, Appendix A, Shreffler et al. 2003). LWD was also placed specifically to protect infrastructure, such as properties adjacent to the new JCL floodplain and the Highway 101 Bridge.

The realigned JCL channel had a meander pattern that was engineered to maintain itself in the absence of LWD. However, LWD was critical to creating flow complexity and providing habitat for fish. In addition, LWD was used in the short-term (until the realigned stream banks were supported by root strength) to stabilize key meander bends where newly exposed wetland soil conditions warranted LWD additions. and eventually new LWD as the riparian forest aged and contributed new trees to the channel (Montgomery et al. 2003).

The CDG believed that over time the realigned JCL channel would become a wood-forced, pool-riffle channel (Montgomery and Buffington 1997). That is, the JCL channel structure would be determined initially by its interaction with installed large woody debris jams and buried floodplain LWD as it meanders downstream, and eventually by new LWD, as the riparian forest ages and contributes new trees to the channel (Montgomery et al. 2003). LWD was intended to serve the following functions in the realigned JCL channel and floodplain (Shreffler et al. 2003):

- provide refuge from predation and prey sources for juvenile salmonids and resident fish species;
- increase structural diversity in and adjacent to the realigned channel;
- minimize potential negative effects of peak river flows;
- form and maintain pools, riffles, and meanders;
- maintain the physical and ecological integrity of the JCL stream banks;
- maintain water quality; and
- trap logs upstream so they do not present a hazard to Highway 101 Bridge supports.

With this background in mind, this chapter will assess pre- and post-project changes in the size and frequency of habitat units (i.e., pools and riffles) in response to changing inputs of sediment, stream flows, and large woody debris.

METHODS

Prior to the realignment of the JCL channel and LWD additions, a habitat survey of the impaired JCL channel was conducted by Peninsula College Fisheries Sciences students in 2004. Using the Timber, Fish, and Wildlife (TFW) Ambient Monitoring Manuals for Large Woody Debris (Schuett-Hames et al. 1999) and Habitat Unit Survey (Pools/Riffles) (Pleus and Schuett-Hames 1999), the students assessed the old JCL channel from its mouth at Sequim Bay up to about river mile (RM) 0.8, the point at which the channel was to be placed in its new alignment. For consistancy, and because monitoring results generated by TFW methods can be compared to established metrics for stream health (NOAA 1996), the follow-up habitat surveys of the restored channel used these same TFW methods for the 2006 installed log survey (Schuett-Hames et al. 1999) and the 2007 and 2009 pool/riffle surveys (Pleus and Schuett-Hames 1999).

The JCL habitat surveys included in-stream measurements of aquatic habitat units and an inventory of large woody debris. The type and amount of habitat units in a stream can be used as an indicator of its suitability for a particular salmonid species or life history stage (Pleus and Schuett-Hames 1999). Also, the relative abundance and characteristics of various habitat units respond to changes in local and watershed-scale processes that determine sediment supply, runoff during storm events, and recruitment of large woody debris (Pleus and Schuett-Hames 1999).

Aquatic habitat units were identified as either pools or riffles. In pool habitats, maximum depth and pool tail-out depths were recorded. Residual pool depth was calculated from the maximum pool depth and pool tail-out depth (Figure 4.1).

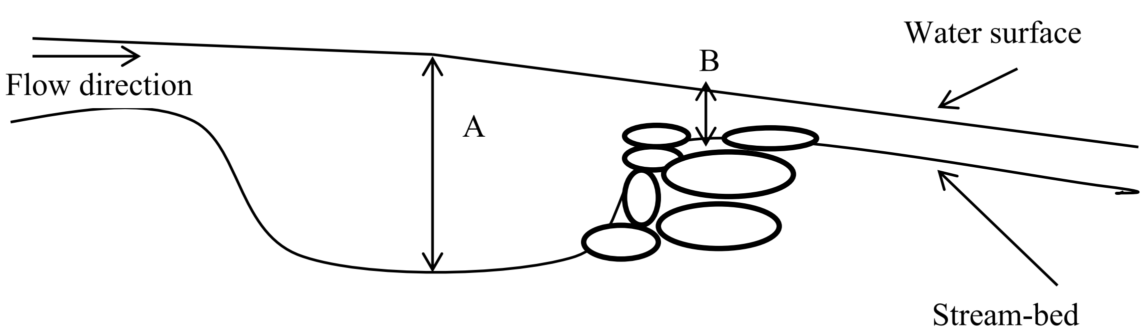

Figure 4.1. **Measuring residual pool depth. The deepest point of the pool (A) minus the depth at the hydraulic control of the pool (B) is the residual pool depth. The hydraulic control has been described as where the last trickle of water would run out if the water were "turned off".**

Habitat units were defined by Pleus and Schuett-Hames (1999):

Pool: Areas where scouring water has created a non-uniform depression in the channel bed where water has been dammed behind channel blockages and hydraulic controls such as logjams or bedform. To qualify as a pool in the TFW method, a unit must meet the minimum surface area size criteria and the minimum residual depth requirement based on a bankfull width scale (see Table 4.1 and Table 4.2).

Riffle: Riffles are shallow, low gradient areas that do not meet the residual pool depth requirement. Riffles exhibit surface turbulence associated with increased velocity and shallow water depth over gravel or cobble beds. However, the riffle classification also includes shallow areas without surface turbulence such as glides, or runs that do not meet the minimum pool depth requirement.

Table 4.1. Minimum unit size by channel bankfull width.

Channel Bankfull Width (meters)	Minimum Unit Size (square meters)
0 - 2.5	0.5
2.5 - 5	1.0
5 – 10	2.0
10 – 15	3.0
15 – 20	4.0
>20	5.0

Table 4.2. Minimum residual depth criteria for pools by bankfull width.

Channel Bankfull Width (meters)	Minimum Residual Pool depth (meters)
0 – 2.5	0.10
2.5 – 5	0.20
5 – 10	0.25
10 – 15	0.30
15 – 20	0.35
>20	0.40

The frequency of each habitat unit (HU) was calculated for the surveyed stream segment (the number of times the HU occurred standardized by length of stream inventoried) and compared to published frequency values from natural conditions for this area. The methodology for evaluating these parameters is outlined below.

Riffle habitat was quantified by calculating the surface area of wetted stream channel classified as riffles. This number was then used to calculate the total percentage of stream habitat classified as riffle habitat. According to Peterson et al. (1992), an equal proportion of pool and riffle habitat is often considered optimum; the riffle fraction should be from 40% to 60%.

Pool habitat was quantified by calculating the surface area of wetted stream channel classified as pools. The percentage of total stream habitat identified as pools was also calculated. Pool frequency benchmarks have been proposed by a number of sources. Peterson et al. (1992) noted that pools should comprise 50%, by area, in streams with less than 3% gradient. The National Marine Fisheries Service (NMFS) Matrix of Pathways and Indicators (NOAA 1996) suggested that 26 pools/mile for a stream such as the Jimmycomelately Creek that averages ~40 ft. wide indicates ―properly functioning conditions” for the purpose of implementing the Endangered Species Act (ESA).

Large Woody Debris (LWD) was defined as logs at least 6 ft. (1.8 m) in length and at least 6 in. (15.2 cm) in diameter (Peterson et al. 1992), or rootwads of any size. All pieces of wood within the bankfull width and spanning the channel were counted. The length and diameter of each piece of installed LWD was measured, recorded, and numbered with a numeric metal tag nailed into the piece. The position (relative center of the log or root wad) was also recorded using hand-held, mapping-grade Global Positioning Satellite (GPS) receivers, in the hopes of using this data to track wood movement over time. LWD pieces in a debris jam were calculated based on the parameter of 10 qualifying (size) pieces that are touching to give a total number of jams per reach.

RESULTS

Pre-project Habitat Survey

Pre-realignment, the riparian corridor of the JCL channel had been reduced or eliminated, stable log jams were functionally non-existent, side channels and associated wetlands had been eliminated or cutoff from the main channel, and LWD and pool habitat were scarce (Shreffler et al. 2003). The results of a pre-project habitat survey conducted in 2004 to assess baseline conditions in the degraded channel (Table 4.3) helped further justify the need for restoration of Jimmycomelately Creek by showing that habitat conditions in the old JCL channel were not properly functioning.

Both pool and LWD habitat in the 2004 pre-project survey failed to meet the NOAA (1996) properly functioning criteria. Pool frequencies were far below the standard of 70 pools/mile at the average bankfull width of 14 ft. for the surveyed segment. Only 36 qualifying LWD pieces were found throughout the survey reach, and these pieces did not meet the properly functioning criteria of >80 pieces/mile >24” diameter >50 ft. length.

Post-project Habitat Surveys

Following the completion of the restoration project, which included channel construction, installation of large woody debris, and floodplain/upland vegetation plantings, LWD was tallied in 2006 and physical habitat surveys (pools/riffles) were conducted in 2007 and 2009. Figure 4.2 is a side-by-side comparison map of the 2007 and 2009 pool/riffle surveys showing the changes in pool and riffle lengths. Table 4.4 summarizes pool and riffle frequency and pool and riffle percentage of total area for 2007 and 2009.

Table 4.3. Pre-project habitat survey of the old JCL channel in 2004.

Summary Results for the Jimmycomlately Creek Habitat Assessment: Pools and Wood from mouth to head of restoration site

Channel Segment	Channel Type	Channel Length (m	Average BFW (m)	Pool Frequency (CH. Wdth / Pool)	Pool Frequency Rating	Average Residual Pool Depth (cm)	% Pools (by Length) PRR?	% Pools Rating for Channel Class	% Pools Formed by LWD (incl. Jams)	% Pools Formed by Jams (alone)	LWD Pieces per Channel Width	LWD Pieces per Ch. Width Rating	Key Pieces per Channel Width	Key Pieces per Channel Rating	% of Jams With Pool Forming Attributes	Total % Of LWD Acting To Form Pools
Mouth to HWY 101	<2%; <49 ft	544	5.63	9	Fair	51.3	22%	Poor			2	Fair	0.05	Poor	0%	55%
HWY 101 to RM 1.0	<2%; <49 ft	695	3.1	7	Fair	55.8	17%	Poor	73%		3	Good	0.08	Poor	0%	73%

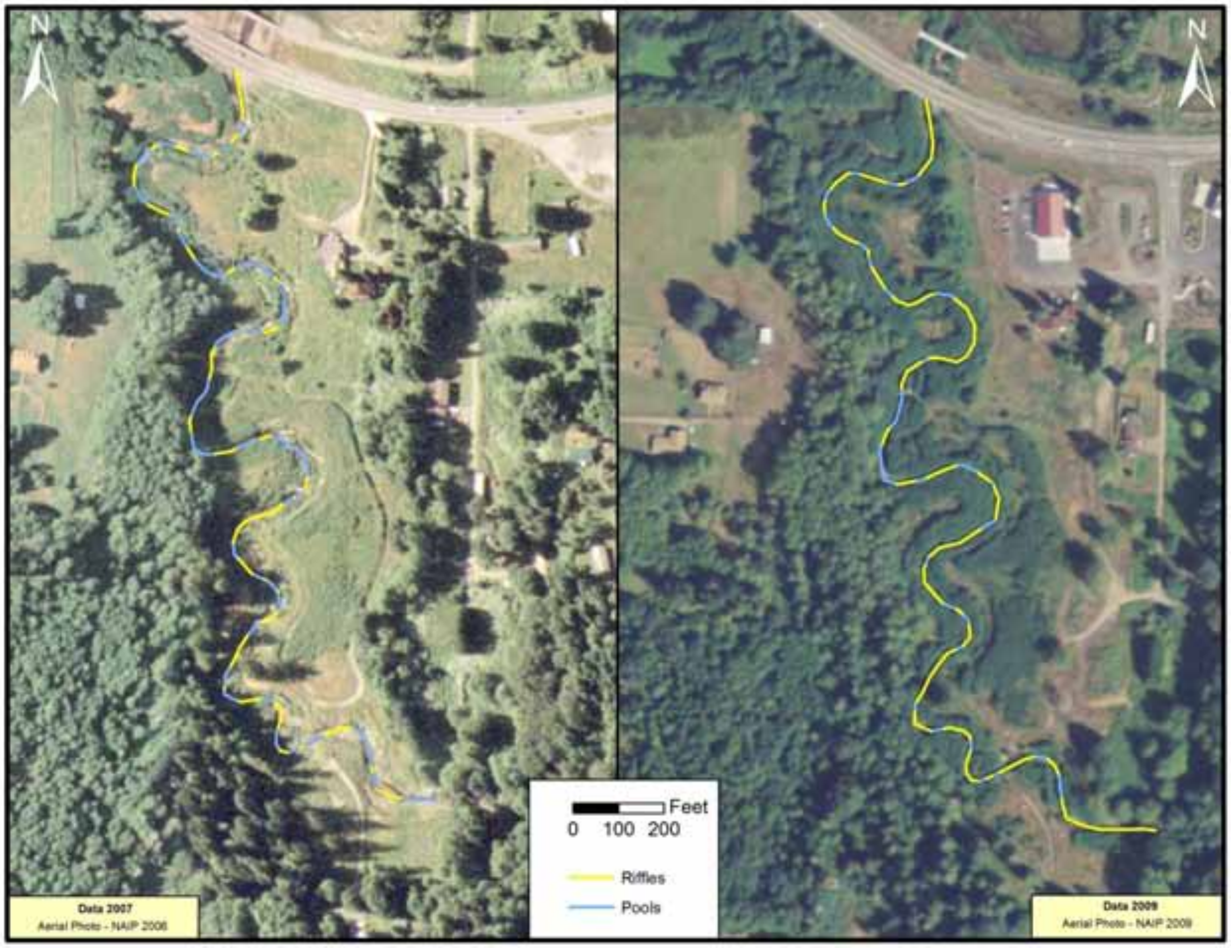

Figure 4.2. Post-project pool/riffle length comparisons 2007 vs. 2009 (graphic by Pam Edens).

Table 4.4. Post-project pool and riffle frequency and percentage of total area for 2007 and 2009.

	Frequency	Percentage of Total Area
2007 Pools	45/mile	53%
2007 Riffles	40/mile	47%
2009 Pools	27/mile	49%
2009 Riffles	28/mile	51%

Pool area in the realigned JCL channel comprised 53% in 2007 and 49% in 2009; thus the Peterson et al. (1992) criterion of 50% pools by area was met in 2007 and nearly met in 2009. Peterson et al. (1992) also suggested that an equal proportion of pool and riffle habitat is often considered optimum for salmon. The realigned JCL channel had pool/riffle ratios of 53/47 in 2007 and 49/51 in 2009.

NOAA (1996) pool frequency standards cite a certain number of qualifying pools/mile based on channel width. The channel width (approximately 40 ft.) of the realigned JCL channel falls between the published

25 ft. (47 pools/mile) and 50 ft. (26 pools/mile) pool frequency indicators for properly functioning conditions. Pools/mile in the realigned JCL channel were 45/mile in 2007 and 27/mile in 2009, indicating that the NOAA (1996) criterion for properly functioning pool frequency was met in both survey years. These data indicate how much fish habitat conditions have improved in the restored JCL channel when compared to the pre-project habitat survey done in 2004 in the former impaired JCL channel (Table 4.3). In 2004, 16 pools/mile were found in the surveyed reach, and the old JCL channel had an average bankfull width of 14 ft. According to NOAA (1996) standards, properly functioning conditions for a channel width of 15 ft. would require 70 pools/mile.

Following construction of the restored JCL channel, 735 pieces of large woody debris (LWD) were installed in the stream and along the floodplain. In 2006, biologists physically tagged each individual piece of LWD and recorded its, length, diameter, and species. Individual log locations were GPS'd (generally at the center point) to enable us to track wood movements through the restoration site over time. Several factors made it very difficult to replicate the 2006 total log survey. Mapping grade GPS was not accurate enough to map individual log locations and track them over time. We were dealing with several sources of error that compounded when transferring raw field data into the GIS system, such as multipath error and misalignment of geo-rectified aerial photographs. In addition, when groundtruthing our previous wood census it became clear that as wood decayed and moved around it was harder to identify individual tagged logs.

So, while the data we collected did not provide us with an easy, repeatable survey method, we did have an accurate accounting of what LWD went into seeding the restoration site in terms of structure and roughness. Of the 735 installed pieces, 47 were rootwads that averaged 6 ft. (1.8 m) in length and 13.5 in. (34 cm) in diameter. The remaining logs averaged 24 ft. (7.3 m) in length and 6 in. (15.2 cm) in diameter, exceeding the Peterson et al. (1992) criteria for functional logs of 6 ft. (1.8 m) in length and at least 6 in. (15.2 cm) in diameter. Throughout the restoration reach, 18 log jams were formed (10 or more qualifying interconnected pieces) that met the NOAA (1996) ―properly functioning conditions." The total frequency of LWD installed in the realigned JCL channel is within the range of published values for PNW natural conditions.

DISCUSSION

Prior to human inhabitation of the Blyn area, Jimmycomelately Creek was likely bordered by a mixture of large, old conifer trees, younger deciduous trees in areas more recently disturbed, and forested wetlands. This forest community would have extended to the edge of tidal influence. Natural recruitment of large woody debris would have contributed to a complex and dynamic channel full of wood, in which pools, riffles, and other habitat features were continually reworked and reformed. It is highly likely that the historic stream channel was controlled by the presence of wood, rather than fluvial function alone (Shreffler et al. 2003).

A 1998 habitat survey of the lower 1.7 miles of the JCL channel found wood loading of just one piece of wood every 55 ft. (with the majority of LWD above the JCL project area), and 98% of that wood was smaller than 12 inches (30.5 cm) in diameter (Resources Northwest 1999). Loss of LWD and confinement of the channel by bank hardening had reduced channel complexity, resulting in sediment aggradation, increased peak flows, and increased bed scour. Scour of redds was believed to be the dominant limiting factor for summer chum salmon in the lower reaches of JCL (Shreffler 2000).

By installing LWD into the realigned JCL channel and floodplain, the Channel Design Group (CDG) hoped to ―jumpstart" physical and biological processes within the realigned JCL channel, until a healthy riparian corridor developed and LWD began to naturally recruit to the system. CDG established only one performance criterion for the realigned JCL channel (Shreffler 2001): *LWD placements that move to* *locations where they pose a threat to infrastructure, properties, or the channel morphology would trigger the need for discussion of potential contingency measures.*

While tracking movement of individual tagged pieces of wood through the realigned JCL channel over time proved to be problematic, we can say with certainty that no LWD placements have moved to locations where they pose a threat to infrastructure, properties, or the channel morphology.

However the CDG's single performance criterion for LWD was not useful in assessing pre- and post-project changes in the size and frequency of JCL habitat units (i.e., pools and riffles) in response to changing inputs of sediment, stream flows, and large woody debris. Thus, habitat data collected for JCL pools/riffles and LWD were compared to benchmark standards widely accepted as indicators of quality habitat for Pacific Northwest streams.

Pool frequency data from both JCL post-restoration habitat surveys (2007 and 2009) indicate the realigned JCL channel morphology meets the NOAA (1996) standards for properly functioning conditions.

For the 2007 and 2009 JCL habitat inventories, results were compared to the NMFS Matrix of Pathways and Indicators (NOAA 1996), which suggested that 26 pools/mile for a stream such as Jimmycomelately Creek that averages 40 ft. wide indicates ―properly functioning conditions" for the purpose of implementing the Endangered Species Act (ESA). Pool frequency data from both JCL post-restoration habitat surveys (2007 and 2009) indicate the realigned JCL channel morphology meets the NOAA (1996) standards for properly functioning conditions. Although the total number of pools decreased and riffle length increased between 2007 and 2009.,. In addition, the 49/51 pool/riffle ratio in 2009 was close to the 50/50 pool/riffle ratio cited by Petersen et al. (1992) as being ―optimum" for salmon.

As noted in Chapter 2 Sediment Transport and Channel Morphology, the realigned JCL channel is continuing to evolve in response to the channel realignment, large woody debris (LWD) additions, and the reconnection of fluvial and tidal energy. Seven years after channel realignment, a healthy riparian corridor and floodplain is developing (see Chapter 6 Riparian and Floodplain Vegetation Establishment), side channels and associated wetlands are re-forming, functional log jams are present in the realigned channel, and LWD and pool/riffle habitat are abundant and properly functioning. There is a higher quantity and quality of LWD and pools in the realigned JCL channel than in the former dredged, straightened, and rip-rapped JCL channel. We will continue to monitor changes in LWD and pool/riffle habitat in the realigned JCL channel as funding allows.

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CHAPTER 5. HABITAT CHANGE ANALYSIS

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AND RANDY JOHNSON (JAMESTOWN S'KLALLAM TRIBE)

BACKGROUND

Restoration Objective– Estuary (Shreffler 2004)
The restoration objective was to increase the total acreage of properly functioning habitats, including emergent marsh (low and high marsh), eelgrass, tidal channels, mudflat, and native riparian and terrestrial plant communities relative to current conditions.

Restoration Rationale–Estuary (Shreffler 2004)
The Estuary Design Group (EDG) predicted that gains in total acreage of properly functioning habitats would result in corresponding gains in the species richness and abundance of flora and fauna that depend on those habitats.

The EDG established the following targets for habitat gains (see Shreffler 2004):

- Intertidal: up to 20 acres (includes brackish marsh, salt marsh, unvegetated mudflats, and intertidal areas that formerly supported eelgrass and other benthic and epibenthic plant and animal communities);
- Eelgrass: natural recolonization to densities comparable to existing eelgrass beds at project edges;
- Creek channels (JCL and Dean): 1,000 linear feet;
- Tidal channels: 2,730 linear feet; and
- Terrestrial: 9 acres (includes all native terrestrial plant communities; not all of this acreage would be forested).

The purpose of this chapter is to evaluate post-project changes in properly functioning habitats relative to pre-project conditions, including a determination of whether the above targets for habit gains were met.

METHODS

The habitat change analysis was a photo interpretation exercise using a combination of high resolution color orthophotos, Adobe Photoshop software, and Geographic Information System (GIS) software (Johnson 2008). High resolution color orthophotos were professionally taken annually between 2001 (pre-project) and 2010 at an altitude of approximately 3,000 feet and with coverage of approximately 4,500 x 4,500 feet. This rendered a 9 inch x 9 inch photograph at a scale of 1 inch equals 500 feet. In digital form, resolution was a minimum of 600 pixels per inch (ppi), which equals 5,400 pixels x 5,400 pixels and a file size (uncompressed) of 83.4 megabytes (Mb).

All photos were color corrected in Photoshop using adjustment layers. At least two photos were combined each year in order to get the geographic coverage required to encompass Jimmycomelately Creek, Dean Creek, and the estuary. Once adjustment layers were created, the combined photos were saved in PSD (Photoshop) file format.

We then created a master PSD file containing all the master orthophotos we were likely to use. This was done by the following process:

- We ensured that all the orthophotos were georectified (after color correction).
- In GIS, we zoomed into the desired coverage.
- We exported each orthophoto as a separate file. In the export dialog box, we set the resolution sufficiently high to match or exceed the resolution of the highest-resolution orthophoto. Then we used the same resolution setting for each export.
- In Photoshop, we created a new, empty PSD file that was large enough to contain the exported orthophotos.
- Finally, we opened each orthophoto file and dragged the background layer into our new file. We renamed each layer to reflect the year of the orthophoto. We arranged all the orthophotos directly on top of each other and placed all the orthophoto layers into a new folder named ―photos.” We were now set to produce products of appropriate resolution for print, web, electronic viewing, or PowerPoint use.

A side-by-side comparison of ―clean” (no polygons or lines) versions of the 2001 master orthophoto and the 2010 master orthophoto is shown in Figure 5.1.

We documented habitat changes, as follows:

- While zoomed in on the 2001 master orthophoto, we drew polygons and/or lines on separate layers in Photoshop to depict distinct habitat types (e.g., tidal marsh, Jimmycomelately Creek channel) in the pre-project, baseline condition.
- In GIS, we calculated the area represented within the polygons or the length represented by the lines we drew in Photoshop.
- When deemed necessary, we field verified our habitat type classifications.
- We then drew polygons and lines on the 2010 master orthophoto and compared changes in habitat areas (total acreage) and channel lengths between baseline conditions (2001) and post-restoration conditions (2010). We also analyzed orthophotos for 2006, 2007, 2008, and 2009, but those graphics are not part of this report. Orthophotos for 2011 have not been analyzed.
- We saved our graphics products as layer comps (a state with certain layers turned on and others turned off) within our master PSD file.

2001 2010

Figure 5.1. **Side-by-side comparison of "clean" (no polygons or lines) versions of the 2001 master orthophoto (left) and the 2010 master orthophoto (right) (graphic by Randy Johnson).**

RESULTS

We did 2001 vs. 2010 habitat change comparisons for:

- Jimmycomelately Creek and Dean Creek channel lengths (Figure 5.2). Jimmycomelately Creek has shown a 16.4% increase in channel length, and Dean Creek a 50.8% increase from 2001 pre-project conditions. The increases in channel length for the two creeks are mostly attributable to the restored sinuosity.
- Tidal marsh and tidal marsh channels area (2001 see Figure 5.3; 2010 see Figure 5.4). Jimmycomelately tidal marsh covered 17.2 acres in 2010, a 157% increase vs. 2001. Jimmycomelately tidal marsh channels covered 0.7 acres in 2010, a 250% increase vs. 2001. These habitat gains are mostly attributable to the removal of fill from the former log yard, the former Sequim RV Park, the former Eng property, the delta cone, and road beds (see Figure 5.5).
- Mudflat and mudflat channels area (2001 see Figure 5.6; 2010 see Figure 5.7). Mudflat covered 17.6 acres in 2010, a 7% increase vs. 2001. Mudflat channels covered 1.5 acres, a 75% increase vs. 2001. The gain in mudflat habitat is mostly attributable to the lagoon feature constructed as part of the log yard restoration. The gain in mudflat channel habitat is due to the reconnection of tidal and fluvial energy, which has led to wider, and in some cases deeper, mudflat channels.
- Forest area (Figure 5.8). There was a net gain of 0.6 acres of forest between 2001 and 2010. However, as depicted in Figure 5.8, some forest did not change (10.0 acres), some was lost (8.6 acres), and some was gained (9.2 acres). We expect to continue to see a net gain in forest habitat as the planted trees and naturally re-colonizing trees mature.

We did channel morphology comparisons for 1957, 2004 old channel (pre-restoration), 2004 new channel (post-restoration), 2005, and 2009 for Jimmycomelately Creek and Dean Creek (Figure 5.9). The morphology of the restored JCL and Dean channels (2004 new, 2005, and 2009) indicates that these channels are fairly stable and have not seen any dramatic changes (e.g., avulsions, truncation of meanders) post-restoration. The channel morphology of the two creeks is scheduled to be analyzed again in 2014 (10 years post-restoration).

We also did shoreline morphology comparisons for 1870, 1957, 2003, and 2005 (Figure 5.10). The 1870 and 1957 shoreline conditions were critical in determining where the historic Jimmycomelately Creek Estuary was located. The comparison of the 1957 shoreline to the 2003 shoreline demonstrated dramatic progradation (seaward advance) of the delta at the mouth of the old Jimmycomelately channel prior to realignment. The 2005 shoreline depicted in Figure 5.10 represents the new baseline for post-project comparisons of changes in shoreline morphology.

Finally, we did 2001 vs. 2009 habitat change comparisons for:

- Freshwater emergent wetlands area
- Blackberries area
- Japanese knotweed area
- Reed canary grass area
- Scotch broom area.

However, photo analysis was dropped in 2010 for the above habitat types due to limited funding, as well as concerns that without the resources to ground truth these habitat types in the field, our identification of vegetation types solely from aerial photos could be quite inaccurate.

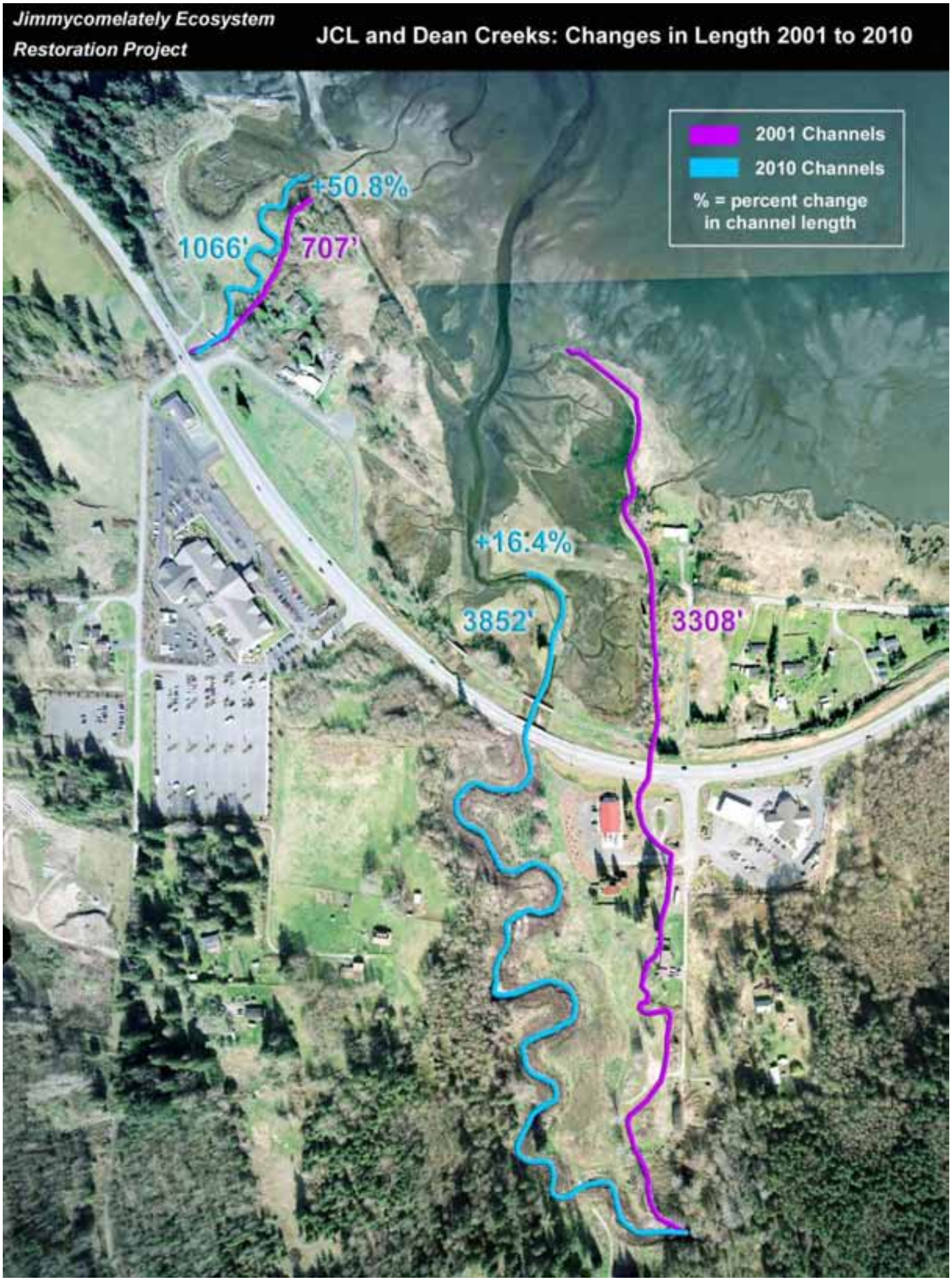

Figure 5.2. JCL Creek and Dean Creek changes in channel length 2001 to 2010 (2010 photo) (graphic by Randy Johnson).

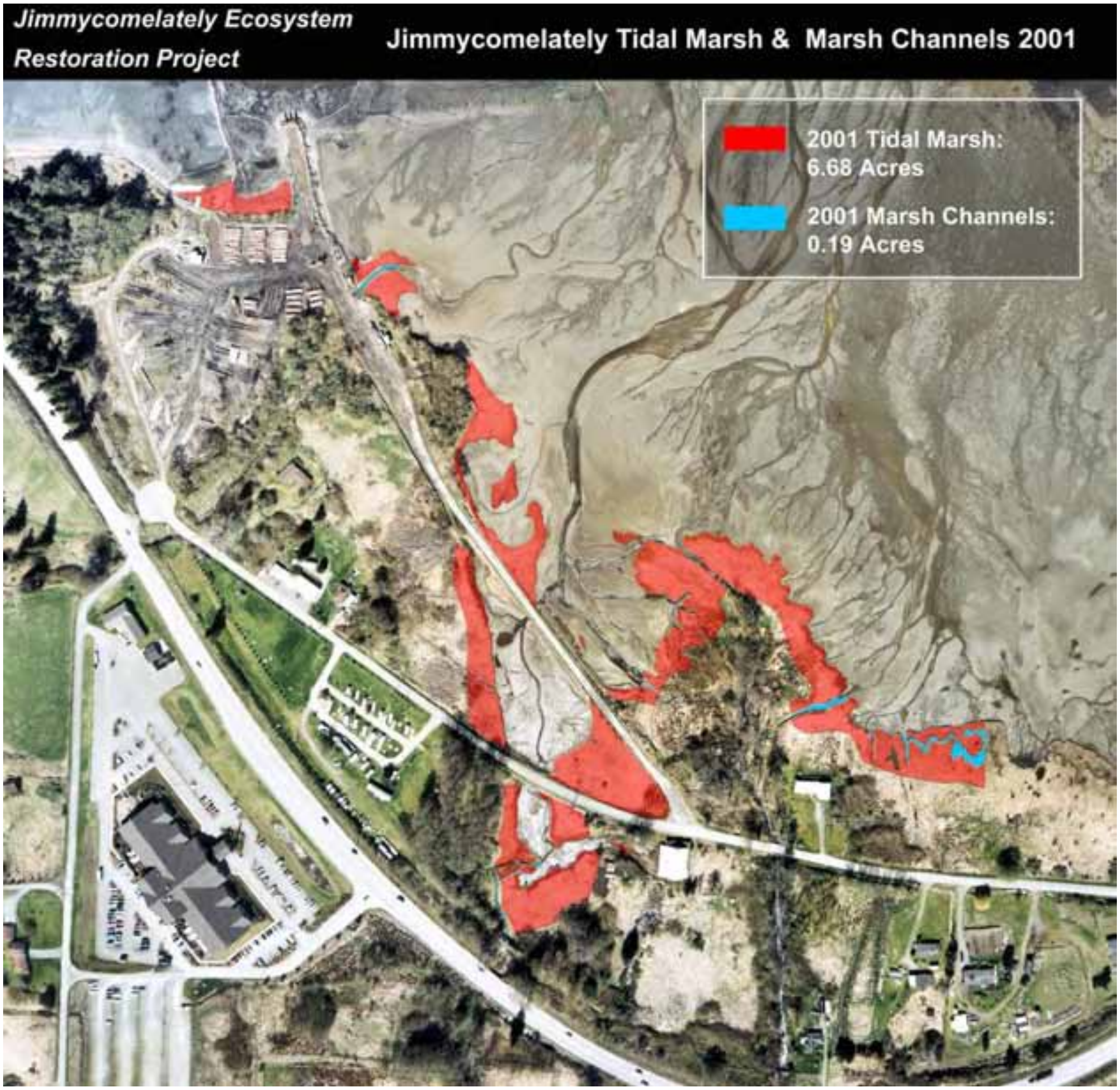

Figure 5.3. Jimmycomelately tidal marsh and tidal marsh channels in 2001 (2001 photo) (graphic by Randy Johnson).

Figure 5.4. Jimmycomelately tidal marsh and tidal marsh channels in 2010 (2010 photo) (graphic by Randy Johnson).

Figure 5.5. **Restoration actions proposed and implemented in the Jimmycomelately Creek Estuary (2003 photo) (graphic by Randy Johnson).**

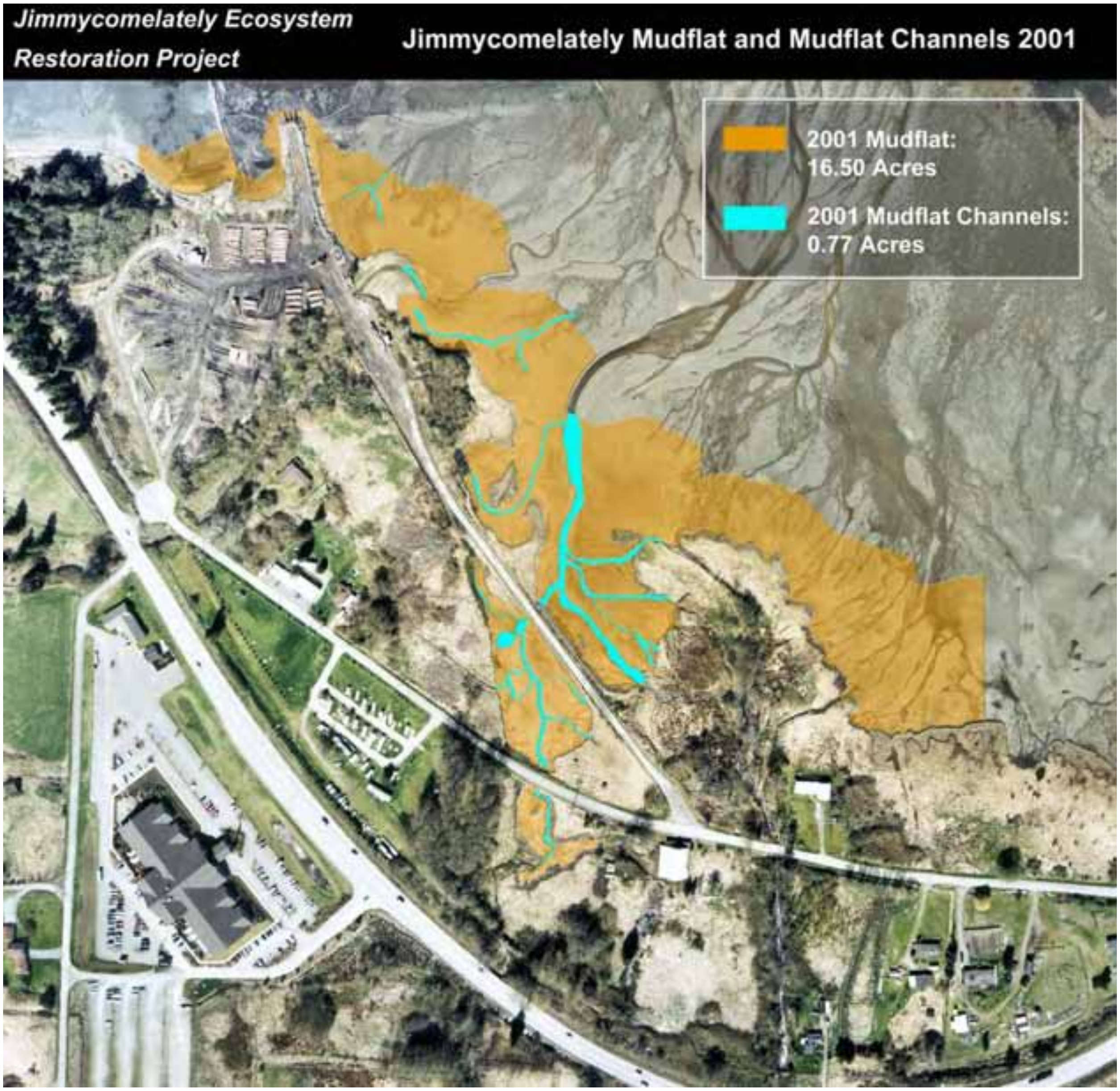

Figure 5.6. **Jimmycomelately mudflat and mudflat channels in 2001 (2001 photo) (graphic by Randy Johnson).**

Figure 5.7. Jimmycomelately mudflat and mudflat channels in 2010 (2010 photo) (graphic by Randy Johnson).

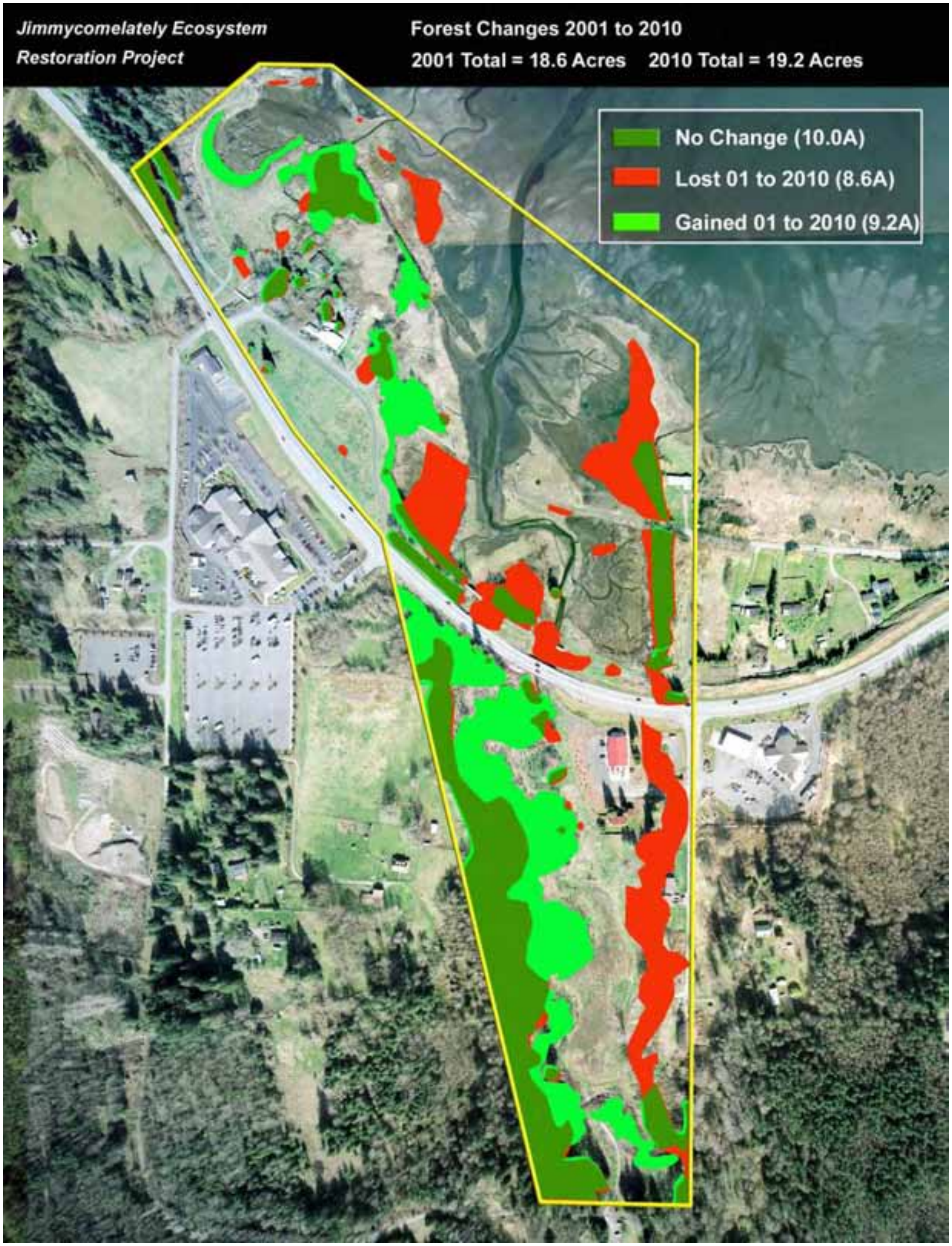

Figure 5.8. Jimmycomelately Creek and Estuary forest changes 2001 to 2010 (2010 photo) (graphic by Randy Johnson).

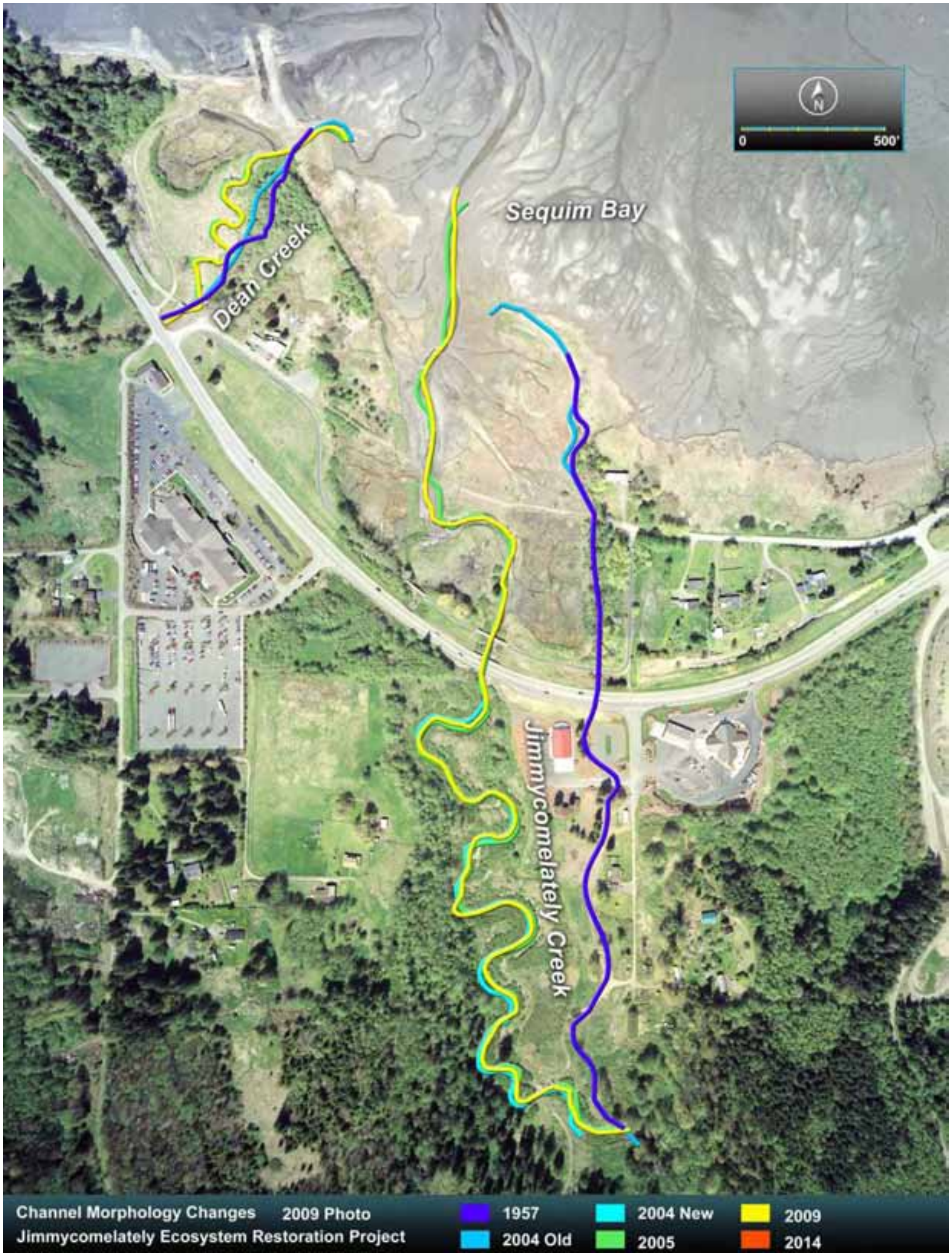

Figure 5.9. **JCL Creek and Dean Creek channel morphology changes 1957 – 2009 (2009 photo) (graphic by Randy Johnson).**

Figure 5.10. Lower Sequim Bay shoreline morphology changes 1870 – 2009 (2005 photo) (graphic by Randy Johnson).

DISCUSSION

The Jimmycomelately Creek Monitoring Plan (Shreffler 2001) listed the following changes to habitat structure that were essential for restoring the creek and estuary to provide ―increased primary productivity and detritus supply, improved shade and cover, better water and sediment quality, and more prey organisms for fish and birds:"

(1) Restore the natural channel and floodplain configurations of JCL by realigning the creek into one of its historic, sinuous channels;
(2) Restore and revegetate the riparian corridor along the realigned JCL with native plants;
(3) Restore and revegetate freshwater wetlands along the realigned JCL with native plants;
(4) Enhance instream habitat using whole trees with root wads and/or engineered logjams;
(5) Remove and improve bridges, culverts, roads, and fill.

The Estuary Monitoring Plan (Shreffler 2004) listed the following changes to habitat structure that were essential for restoring the creek and estuary to provide ―better ecosystem functions and services for salmonids, shellfish, birds, and people:"

(1) Restore the tidal flats and channels within the estuary;
(2) Restore salt marsh and brackish marsh habitats within the estuary;
(3) Restore eelgrass and mudflats within the estuary;
(4) Improve the connections of JCL and Dean Creek to the estuary;
(5) Remove (selectively) aggraded sediment within the estuary;
(6) Remove and/or improve bridges and culverts;
(7) Remove (selectively) roads and other terrestrial fill.

All of these proposed creek and estuary restoration actions were implemented, with the exception that the JCL freshwater wetlands were allowed to naturally recolonize and were not planted with native plants. Overall, from a qualitative perspective, the restored habitats appear to be functioning as designed. There have been no major ―surprises" post-restoration with either unanticipated habitats forming or anticipated habitats not forming.

The EDG established the following quantitative performance criteria for habitat gains (Shreffler 2004):

- Intertidal: up to 20 acres (includes brackish marsh, salt marsh, unvegetated mudflats, and intertidal areas that formerly supported eelgrass and other benthic and epibenthic plant and animal communities);
- Eelgrass: natural recolonization to densities comparable to existing eelgrass beds at project edges (note: this performance criteria is discussed in Chapter 8 Eelgrass Recovery);
- Creek channels (JCL and Dean): 1,000 linear feet;
- Terrestrial: 9 acres (includes all native terrestrial plant communities; not all of this acreage will be forested);
- Tidal channels: 2,730 linear feet.

Based on our orthophoto analysis, all of these performance criteria were exceeded. Intertidal habitats now comprise much greater than 20 acres: tidal marsh = 17.2 acres and unvegetated mudflat = 17.6 acres. Creek channels have increased by 903 linear feet since 2001 (Jimmycomelately Creek by 544 feet and Dean Creek by 359 feet) and totaled 4,918 linear feet in 2010. Terrestrial plant communities now cover 19.2 acres.

Instead of calculating total linear feet of tidal channels, we calculated tidal channel area as a more illustrative metric of post-restoration habitat changes. Tidal marsh channel area has increased by 250% from 0.19 acres in 2001 to 0.70 acres in 2010.

Intertidal habitats now comprise much greater than 20 acres: tidal marsh = 17.2 acres and unvegetated mudflat = 17.6 acres. Creek channels have increased by 903 linear feet since 2001 (Jimmycomelately Creek by 544 feet and Dean Creek by 359 feet) and totaled 4,918 linear feet in 2010. Terrestrial plant communities now cover 19.2 acres.

Interpretation of aerial photos has proven to be one of the most cost effective and informative of all the monitoring parameters. Developing the methods for color correction, georectification, and photo interpretation was time consuming in the first year (2006). However, once we established a repeatable procedure, the subsequent annual data analysis in years 2007 through 2010 was straightforward and quicker.

While the documented habitat gains are one indicator of restoration success, what is equally important is an assessment of how these restored habitats are functioning in support of shellfish, salmonids, invertebrates, and birds. Precisely for this reason, we also developed performance criteria for biological responses to the changes in habitat conditions. The biological responses are discussed in subsequent chapters of this report: Chapter; Chapter 7 Estuarine Wetland Vegetation Establishment; Chapter 8 Eelgrass Recovery; Chapter 9 Shellfish Recovery; Chapter 10 Adult Salmonid Use; Chapters 11, 12 and 13 Juvenile Salmonid Use; and Chapter 14 Bird Use.

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BIOLOGICAL RESPONSES

CHAPTER 6. RIPARIAN AND FLOODPLAIN VEGETATION ESTABLISHMENT & INVASIVE VEGETATION REMOVAL/MANAGEMENT

– HILTON TURNBULL (JAMESTOWN S'KLALLAM TRIBE)

BACKGROUND

Riparian Vegetation Establishment

Restoration Objective – JCL Channel (Shreffler 2001)
The restoration objective relative to riparian vegetation establishment was to re-establish native riparian vegetation along the entire meandering stream course of the realigned JCL channel, wherever soil types will support this vegetation.

Restoration Rationale – JCL Channel (Shreffler 2001)
The riparian corridor provides direct and indirect support to a variety of fish and wildlife species. Native trees and shrubs provide a buffer from adjacent residential and commercial land uses. Insects from riparian vegetation are deposited in the water and can provide an important prey resource for fish. Leaf litter enhances detritus-based food webs. Large woody debris (i.e., trees and limbs that fall into the creek) is important for habitat structure. A review of the multitude of specific functions of riverine-riparian habitats is provided in Shreffler (2000) and Mitsch and Gosselink (2007). The Channel Design Group (CDG) believed that restoring JCL's riverine-riparian habitats would improve these functions.

Monitoring of upland vegetation in the estuary as proposed by the Estuary Design Group (Shreffler 2004) was dropped due to lack of funding; monitoring of wetland vegetation in the estuary is reported in Chapter 7 Estuary Wetland Vegetation Establishment.

Floodplain Vegetation Establishment

Shreffler (2001) established a restoration objective, restoration rationale, and performance criteria for freshwater wetland vegetation establishment. For the purposes of this report, we have changed the word ―wetland" to ―floodplain," because floodplain is a more descriptive term that encompasses not only obligate freshwater wetland species but also other species that were found within the floodplain during post-project monitoring.

Restoration Objective – JCL Channel (Shreffler 2001)
To re-establish native floodplain vegetation along the entire meandering stream course of the realigned JCL channel at elevations capable of supporting floodplain vegetation.

Restoration Rationale – JCL Channel (Shreffler 2001)
Floodplain vegetation provides habitat structure, facilitates sediment trapping, and serves as a critical source of organic matter to support detritus-based food webs for juvenile salmonids, shorebirds, and waterfowl. A review of the multitude of specific functions performed by floodplain vegetation is provided in Shreffler (2000) and Mitsch and Gosselink (2007).

Invasive Vegetation Removal/Management

Restoration Objective – JCL Channel (Shreffler 2001)
The restoration objective relative to invasive vegetation removal was to completely eliminate non-native, invasive species from the restoration site.

Restoration Rationale – JCL Channel (Shreffler 2001)
Non-native, invasive plant species compete with native plant species that provide higher quality habitat and food for a variety of wildlife species, which, in turn, have evolved in conjunction with native plant communities.

Our efforts to address invasive plant species management in the project area will be discussed in this chapter as they relate to overall riparian and floodplain vegetation establishment.

One of the overall goals (Goal 2) of the Jimmycomelately (JCL) Creek Realignment Monitoring Plan was to restore the JCL channel as feeding, refuge, and spawning habitat for ESA-listed summer chum salmon, coho salmon, winter steelhead, and sea-run cutthroat trout, as well as habitat for shellfish and upland birds (Shreffler 2001). Two specific restoration objectives for Goal 2 were to: 1) restore and revegetate the riparian corridor along the realigned JCL with native plants, and 2) restore and revegetate freshwater wetlands along the realigned JCL with native plants (Shreffler 2001).

Prior to JCL channel realignment in summer 2004, the riparian corridor in the lower 0.5 miles had been reduced to a narrow strip of small-diameter, deciduous trees with few remnant conifers. The channel realignment project recreated a similar channel and floodplain configuration as found upriver of the project. Riparian vegetation establishment in the newly realigned JCL channel area was designed to mimic reference conditions found upstream and in other similar North Olympic Peninsula stream corridors. The new meandering JCL channel was constructed to the west of the creek's channelized reach, through wetland soils with transitional habitat on non-hydric soils. These soil types should support both native wetland and riparian ecotypes, with the overarching objective of creating a conifer-dominated stream corridor throughout the restored stream reach. The focus of this chapter is to describe post-project vegetation monitoring surveys and compare the results to the performance monitoring criteria established in the monitoring plan for the JCL channel (Shreffler 2001).

METHODS

Riparian areas are dynamic systems where plant communities evolve as conditions change. When changing conditions are driven by human activities such as excavation, grading, or modification of the hydrological regime, the evolution of plant communities is difficult to predict. Because of this, riparian areas and stream bank re-vegetation projects are challenging to monitor. Static monitoring plans fail to account for dynamic changes in the plant communities they are trying to measure. Therefore, the Jamestown S'Klallam Tribe (JST) uses the principles of adaptive management to guide monitoring activities.

Adaptive management is a process with two key requirements (Elzinga et al. 1998). First, monitoring should only be initiated if opportunities for management change exist. Second, monitoring must be driven by objectives. The overall objective describes the desired end condition and a subset of management objectives are designed to meet the overall objective. In turn, monitoring activities are designed to determine if the overall objective has been achieved. Valid monitoring data is critical to making meaningful management decisions designed to help the site meet the overall objective.

Our monitoring plan and our strategy for evaluating performance criteria are based on how we believe the restored site will develop over time. If the dynamic plant communities at the site develop differently than anticipated, the monitoring plan will be modified to ensure valid data is used to guide site management decisions.

Mortality assessments of planted species (native shrubs and trees) were conducted annually for the first three years following initial site establishment. This was done to ensure planting success and in order to replace plants that did not survive. Survival estimates are generally not reported after the first few years, as natural recruitment and mortality can confound survival results. In order to measure vegetation establishment of both plantings and volunteer species that germinated naturally on site, survey efforts were conducted in 2006 and 2010.

In 2006, the site was in its second year of development with distinctive upland and floodplain (scrub shrub/emergent zone) communities. Because the communities were still relatively young without complete canopy closure, a point-line sampling method (Bonham 1989, Coulloudon et al. 1999) was chosen. Twenty fixed transects were established on existing surveyed stations marking channel cross-section locations (Figure 6.1). Transects were extended beyond the survey end points to make sure all plant communities and zones on the site were sampled.

A systematic random sampling method (Elzinga et al. 1998) was used to sample the plant communities along each transect. With the point-line method, a vertical rod tipped with a pin was lowered from above the tallest vegetation. All plant species intercepted by the pin were recorded. If the pin intercepted no plant species, the ground surface was recorded as bare soil or structure (e.g., large woody debris). Data were collected every two feet along the transect in the upland zones, and every one foot in the floodplain.

In 2010 the plant communities were better established, and the floodplain (and much of the upland) had a dense red alder (*Alnus rubra*) canopy. Because the tree and shrub components were so well established by this time, the line intercept method (Coulloudon et al. 1999) was chosen to be the vegetation sampling method. Line intercept is best suited to measuring cover of shrub and tree species.

As in 2006, a systematic random sampling method (Elzinga et al. 1998) was used in 2010 to establish 20 temporary transects along a baseline. Each transect was extended from one edge of the site to the other. In 2010, cover data for woody and herbaceous species was collected along sampling transects using the line intercept method (Bonham 1989; Coulloudon et al. 1999). All vegetation intercepting a tape measure stretched the length of each sampling transect was identified and the length of each canopy intercept was recorded. The sum of the canopy intercept lengths was divided by the total length of all transects to calculate a mean aerial cover value. Additionally in 2010, trees per acre were determined by establishing fixed plots (www.forestandrange.org) (see Figure 6.2). Using a random numbers table (Zar 1999), two $1/20^{th}$-acre fixed plots were established along each transect (one in the floodplain zone and one in the upland) and all tree and shrub species within each plot were counted.

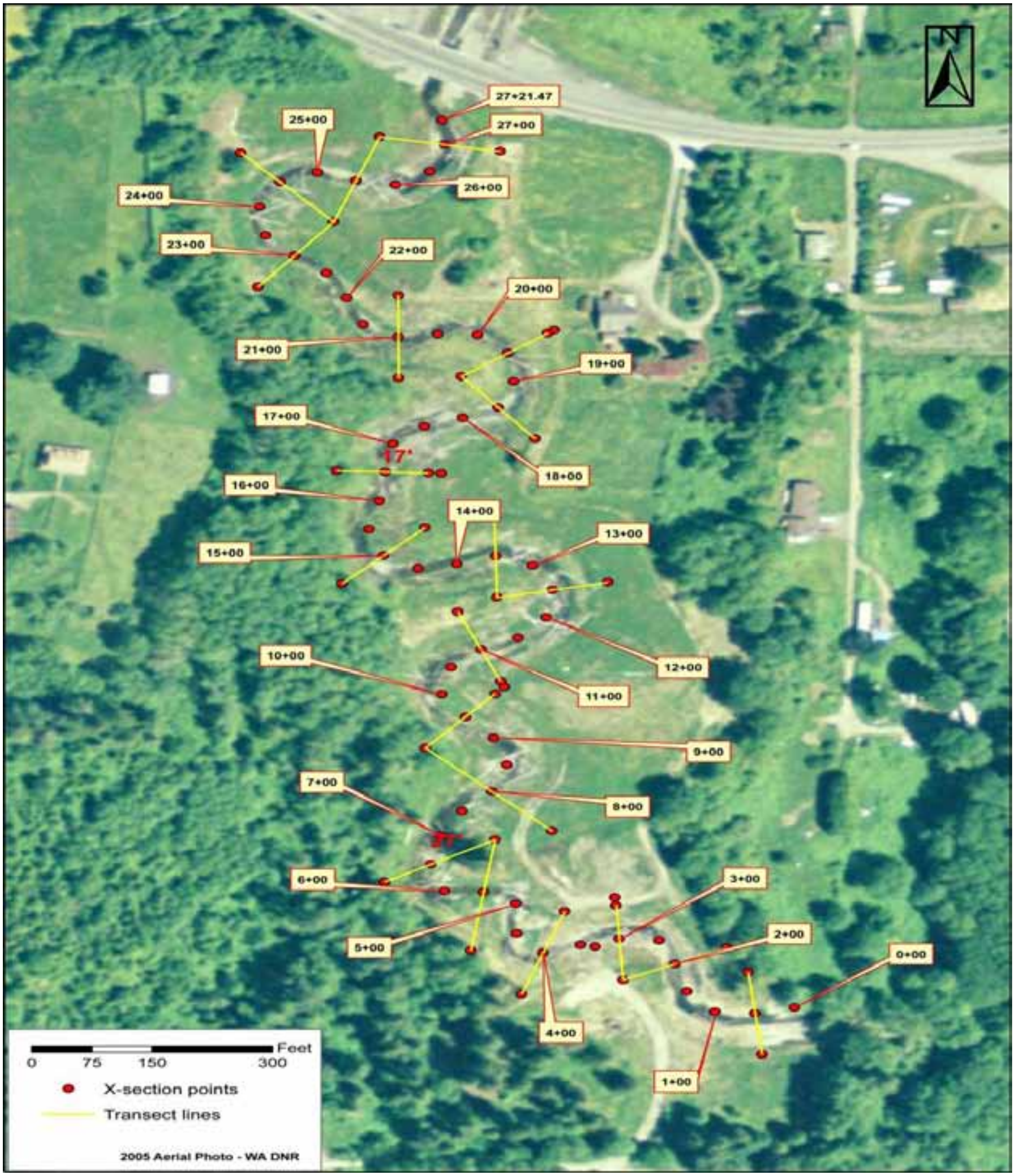

Figure 6.1. 2006 Point-line vegetation sampling locations (graphic by Pam Edens).

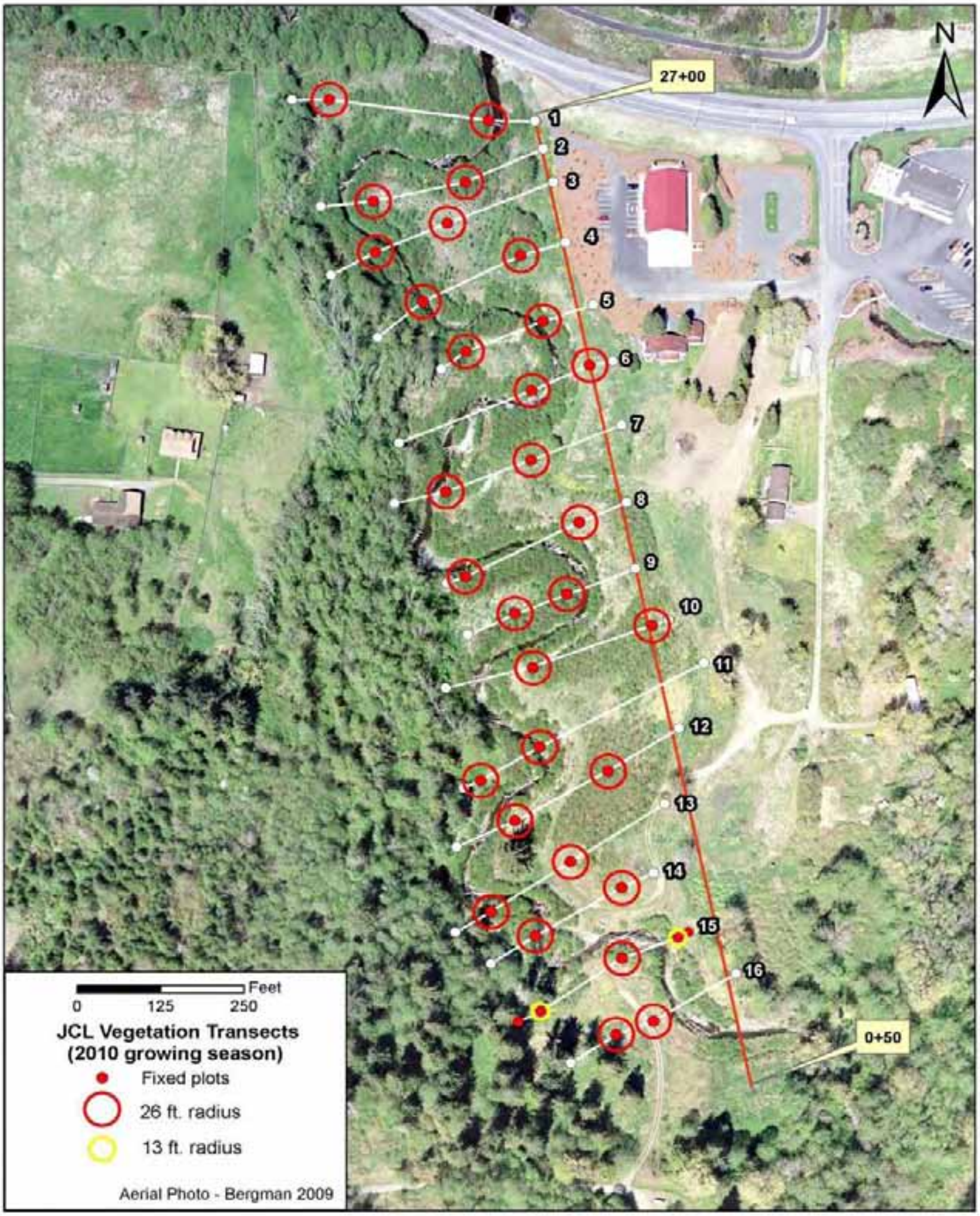

Figure 6.2. 2010 Line intercept and fixed plot vegetation sampling locations (graphic by Pam Edens).

RESULTS AND DISCUSSION

Riparian and Floodplain Vegetation Establishment

A total of 65 native herbaceous and woody tree and shrub species were encountered during the 2006 survey, comprising 90% of the vegetation cover. Data analysis showed that 63% of the floodplain and 27% of the upland zones were comprised of native vegetation. The dominant woody species onsite was red alder (*Alnus rubra*), which accounted for 24% areal cover. Five invasive species were encountered making up about 10% cover. Thistle species (*Cirsium arvense and C. vulgare*) and reed canary grass (*Phalarus arundinacea*) each made up about 4% and together were the dominant invasive species encountered. Himalayan blackberry (*Rubus armeniacus*) and Robert's geranium (*Geranium robertianum*) made up trace amounts at about 1% each.

Thirty-five native tree and shrub species were encountered during the 2010 survey. Herbaceous species were not recorded for the 2010 survey except for invasive herbaceous species or where long intercepts of a particular herbaceous species were noted. By 2010 the restoration site was almost completely covered by vegetation except for the active channel area, and structures within it such as large woody debris. We sampled a total of 5,052 linear feet along the 20 transects spanning the realigned JCL channel. Because the intercepts of overlapping canopies were recorded, the total percent cover exceeds 100%. Of the sampled area, 86% of the total plant cover was native tree species, 69% of which was made up of red alder. By comparison, big leaf maple, Western red cedar, and Sitka spruce, each made up 3% to 4% of the overall tree species. Native shrubs made up about 7% of the site.

Below are Tables comparing the top fourteen species by percent cover during survey years 2006 (Table 6.1) and 2010 (Table 6.2). These are species that represented 1% or greater cover throughout the sampled area. Keep in mind that different sampling methods were used during the respective survey years, so no statistical inference or sample-size analysis can be made between the data sets to compare them. Also note that only woody vegetation (trees and shrubs) and invasive species were sampled during 2010. Herbaceous cover was not sampled in 2010 because the riparian upland and floodplain zones had developed almost complete canopy closure. A robust ground cover of native (and invasive where noted) herbaceous plants covered the whole site by 2010.

The fixed plot data where trees-per-acre (TPA) were calculated paint a more promising picture of overall site development. The thirty-two 1/20th-acre plots covered about two acres of the site. Data analysis showed 5,284 trees and shrubs counted, yielding 3,302 trees per acre on site. Because the fixed plots were equally distributed in both the floodplain and upland zones we were able to estimate 980 TPA in the upland and 2,322 TPA in the floodplain.

Invasive Vegetation Removal/Management

Despite ongoing management and control efforts (2006 to date), three invasive plant species covered 27% of the sampled area in 2010; an increase of 17% relative to 2006. Reed canary grass was found to occupy around 19% of the sampled area, with invasive thistle species and Himalayan blackberry comprising about 4% each. The invasive vegetation at the restored site was due in part to the fact that the new JCL channel and floodplain were excavated out of relic pasture areas that had previously been grazed.

JST has devoted a half-time employee to conduct invasive species control and site maintenance since 2006. The primary method of invasive species control was weed whacking, and was designed to enhance native conifer and shrub establishment. The invasive species requiring management are almost

Table 6.1. Dominant plant species by % cover in 2006.

Common Name (Species)	% Cover
Red Alder (*Alnus rubra*)	24.0
Horsetail (*Equisetum* spp.)	12.0
Common Velvet Grass (*Holcus lanatus*)	9.0
Common Rush (*Juncus effusus*)	6.0
Bare Ground	4.8
Creeping Bent Grass (*Agrostis alba*)	4.0
Cleavers/Bedstraw (*Gallium aparine*)	2.5
White Clover (*Trifolium repens*)	2.2
Sawbeak Sedge (*Carex stipata*)	2.0
Watson Willow Herb (*Epilobium ciliatum*)	2.0
Creeping Buttercup (*Ranunculus repens*)	1.6
Dagger Leaf Rush (*Juncus ensifolius*)	1.3
Orchard Grass (*Dactylis glomerata*)	1.2
Red Fescue (*Festuca rubra*)	1.0

Table 6.2. Dominant plant species by % cover in 2010.

Common Name (Species)	% Cover
Red Alder (*Alnus rubra*)	69
Grass spp. (native/introduced *Graminae spp.*)	19
Reed Canary Grass (*Phalarus arundinacea*)	19
Canadian Thistle (*Cirsium arvense*)	4
Sitka Spruce (*Picea sitchensis*)	4
Himalayan Blackberry (*Rubus armeniacus*)	4
Big Leaf Maple (*Acer circinatum*)	3
Western Red Cedar (*Thuja plicata*)	3
Native Rose ssp. (combined cover)	2
Salmonberry (*Rubus spectabilis*)	1.3
Douglas Fir (*Pseudotsuga menziesii*)	1.2
Stinging Nettle (*Urtica dioica*)	1.2
Pacific Willow (*Salix lucida*)	1
Common Snowberry (*Symphoricarpos albus*)	1

exclusively in the upland portions of the site and have not interfered with channel processes of the restored stream. Robert's geranium, an invasive herbaceous annual plant, occurs sporadically throughout the floodplain and is believed to be establishing itself from upstream patches where plant material and seed are moved downstream during flood events. It was manually controlled onsite in 2007-2009 by volunteer weed pulling parties. In 2010, the habitat biologist and a field crew working under an Aquatic Noxious Weed Permit applied herbicide to infested sites upstream and then throughout the restoration project. JST will continue to monitor and control this plant's spread in the project area. Invasives are mainly a concern with conifer establishment and it is thought that, over time and with continued maintenance/control, native tree and shrub species will shade-out the competing invasives. Site maintenance also included thinning of red alder from 2006 to 2010 to allow planted conifers to thrive.

Site maintenance activities in the estuary portion of the project area included weed whacking and mowing of Himalayan blackberry, injection of a patch of Japanese knotweed near the mouth of Dean Creek, and hand pulling/weed wrenching of Scotch broom. Reed canary grass in the estuary was removed with an excavator at the time of estuary restoration activities in 2004 – 2005. Subsequent control of reed canary grass was not necessary, as salt water inundation appears to have completely eliminated this species from the estuary. From 2001 to 2009 aerial photo interpretation (as explained in Chapter 5 Habitat Change Analysis) was performed annually to evaluate the cover of invasive species (i.e., Himalayan blackberry, reed canary grass, Japanese knotweed, and Scotch broom). However, resources were not available to ground truth the aerial photo interpretation in the field, and thus this monitoring was dropped after 2009.

Evaluation of Performance Criteria

The performance criteria for riparian vegetation establishment, floodplain vegetation establishment, and invasive vegetation removal were designed to assess post-project biological responses of the vegetation communities in the restoration area. They were modeled after similar and widely accepted success standards for other stream and coastal restoration projects at the time (Shreffler 2001). However, they were also written with specific restoration goals for this project in mind and designed to provide feedback for future management actions. The monitoring period outlined in the JCL channel realignment monitoring plan (Shreffler 2001) had success standards for the ten-year time frame. This chapter describes our progress towards achieving the stated performance criteria at the mid-point or at the five-year mark.

Riparian Vegetation Establishment:

1. *Percent cover of riparian vegetation (native trees, shrubs, and groundcover) should be stable or increasing over time, and cover not less than 90% of the revegetated area at the end of ten years.* At the end of five years, the percent cover of riparian vegetation is 73%.

2. *Survival of riparian plantings in each cover class category (herb, shrub, trees) should be at least 75% at the end of three years.* At the end of three years, survival of riparian plantings was 90%.

Floodplain Vegetation Establishment:

1. *Within 10 years, the percent cover of floodplain vegetation should be stable or increasing within areas of the project site with elevations suitable to floodplain vegetation establishment.* After five years, the percent cover of native floodplain species has increased from 63% in 2006 to 70% in 2010.

2. *Species composition of native plant species in the floodplain zone should be greater than 80% after 10 years*. At the end of five years, the percent cover of native floodplain vegetation is 70%.

Invasive Vegetation Removal/Management:

1. *The project area should not contain greater than 5% cover by area of invasive plant species after 10 years*. At the end of five years, the percent cover of invasive vegetation is 27%.

The data collected during 2006 and 2010 vegetation surveys provide indicators of how the vegetation communities on the restored site are developing through time. We also have annual fixed photo point data starting from 2004 (the beginning of the post-project monitoring period) through 2009 available on the JCL monitoring project database. Below are photos taken from the same location and aspect in 2006 (Figure 6.3) and 2009 (Figure 6.4) respectively, showing vegetation development.

Figure 6.3. 2006 view across the realigned JCL Channel from fixed photo point 3. The Washington State Department of Ecology (DOE) stream gage is a landmark (photo by Lori Delorm).

Figure 6.4. 2009 view across the realigned JCL Channel from fixed photo point 3. The Washington State Department of Ecology (DOE) stream gage is a landmark (photo by Lori Delorm).

Data analysis from the two vegetation sampling surveys (2006 and 2010) indicate the restored site is already close to meeting the ten year performance criteria for “success” in year five, with the exception of percent cover of invasive species. Despite establishing a stable or increasing community of native vegetation throughout the project area, the percent cover of invasive species has grown. Overall percent cover of invasive species in the sampled area has grown from 10% in 2006 to 27% in 2010. Reed canary grass is the most problematic invasive plant species and has increased from 4% cover in 2006 to 19% cover in 2010.

Data analysis from the two vegetation sampling surveys (2006 and 2010) indicate the restored site is already close to meeting the ten year performance criteria for “success” in year five, with the exception of percent cover of invasive species.

To this point, JST has focused on manual control methods for all the plant species whose presence on site triggers a management response. This approach has proven effective in ensuring survival of planted tree species, and it is hoped that as the native vegetation matures it will shade out the competing invasive plant species. JST has sought to limit the use of herbicide within the project area because we are trying to restore a salmon stream. However, we may be forced to take a more aggressive approach in areas of the site where mechanical means alone are not sufficiently controlling reed canary grass. Several factors have contributed to the success of non-native species on this site. Prior to construction, many non-native grass species were dominant on this site. Invasive species (reed canary grass, in particular) are notoriously adept at colonizing recently disturbed areas. That being said, the surveyed portion of the restored site is currently composed of roughly 73% native trees and shrubs, and with ongoing maintenance we expect to see native cover continue to increase through time and invasive species decrease.

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CHAPTER 7. ESTUARY WETLAND VEGETATION ESTABLISHMENT – DAVE SHREFFLER (SHREFFLER ENVIRONMENTAL)

BACKGROUND

Restoration Objective– Estuary (Shreffler 2004)
The restoration objective was to allow native estuarine wetland vegetation to naturally recolonize and re-establish in the estuary at elevations capable of supporting wetland vegetation.

Restoration Rationale– Estuary (Shreffler 2004)
Wetland vegetation provides habitat structure, facilitates sediment trapping and nutrient cycling, maintains water quality, and serves as a critical source of organic matter to support detritus-based food webs for juvenile salmonids, shorebirds, and waterfowl. As demonstrated by Kwak and Zedler (1997) using stable carbon isotopes, wetlands are typically the primary organic matter source for the detritus-based food webs of estuaries. One of the most prominent functions of estuarine wetlands, especially those associated with large deltas, is that they support extended rearing of several species of juvenile salmon, including chum, chinook, and coho (Fresh et al. 2011). A review of the multitude of specific functions performed by estuarine wetlands is provided in Shreffler (2000) and Mitsch and Gosselink (2007). Barbier et al. (2011) reviewed the ecological services performed by estuarine and coastal ecosystems.

The Estuary Design Group (EDG) believed that the existing wetland vegetation seedbed was sufficient to allow natural recolonization of the estuary, and the only planned planting was approximately 700 *Carex lyngbyei* plants that were grown from seeds harvested at the site in 1999. Those plants were installed in the restored log yard area in November 2003.

Estuarine wetlands are the habitat type that has experienced the greatest loss in total acreage in the Puget Sound Basin and Straits of Juan de Fuca; in particular, two classes of estuarine wetlands—tidal freshwater and oligohaline transition—have experienced greater than 95% loss over the last 150 years (Simenstad et al. 2011). Thus, the EDG believed that restoring estuarine wetlands was a top priority for the Jimmycomelately Ecosystem Restoration Project.

METHODS

The Estuary Monitoring Plan (Shreffler 2004) called for three essential monitoring tasks:

- Task 1: Mid-summer, once/year in years 1, 2, 3, 5, and 10 post-restoration identify the percent cover of wetland vegetation on aerial photographs, or use GPS or traditional survey techniques to map the perimeter of wetland vegetation patches.
- Task 2: Establish permanent transects and survey these transects mid-summer, once/year in years 1, 2, 3, 5, and 10 post-restoration to determine species composition within a minimum of ten 0.25m x 0.25m quadrats randomly distributed along each transect line.
- Task 3: Establish fixed camera points and photograph the areas that have naturally re-colonized with wetland vegetation in mid-summer, once/year in years 1, 2, 3, 5, and 10 post-restoration.

The methods, results, and discussion relative to Task 1 are reported in Chapter 5 Habitat Change Analysis.

For Task 2, 18 permanent transects were established between 2004 and 2006 (Figure 7.1). The start and end location for each transect were marked with wood stakes whose positions were recorded using GPS. The length and compass bearing of each transect are reported in Table 7.1. Transects 1, 2, 3, 4, 5, 9, and 10 were established as reference transects in portions of the project area that would not be excavated as part of the estuary restoration activities. Transects 6, 7, 8, 11, 12, 13, 14, 15, 16, 17, and 18 were established post-restoration and were intended to allow us to document natural re-colonization and re-establishment of estuary wetland vegetation.

Transects were surveyed annually by Shreffler Environmental in mid July from 2004 to 2010 (Table 7.2). On standardized data forms, we recorded visual estimates of plant percent cover and all plant species observed (including invasives, not just wetland species) within a $0.25m^2$ quadrat placed every 10 feet along a tape stretched between the start stake and end stake of each transect. If no vegetation was observed within all or a portion of a quadrat, then ―bare" was recorded along with the percentage of bare ground. If a plant species was not identifiable in the field, a specimen was placed in a labeled Ziploc bag and taken to a botanist for identification. On the field data form, ―unidentified species ___" was recorded and then later filled in after positive identification by a botanist.

The field data were transferred from the standardized forms into the MS ACCESS database maintained by JST. QA/QC was done on 100% of the data by an individual that was not part of the field team.

For Task 3, we took digital photographs at each transect from the start stake looking toward the end stake and from each end stake looking toward the start stake. Each photograph was carefully labeled to indicate which direction it was taken. For example, EST_WV_1_head indicated a picture taken at transect 1 looking from the head of the transect toward the tail of the transect; similarly, EST_WV_1_tail was taken at transect 1 looking from the tail toward the head. These fixed point photos allowed us to qualitatively visualize the changes in percent cover and species composition between 2004 and 2010.

RESULTS

Percent Cover

Percent cover was determined using two methods: 1) aerial photo analysis to map the perimeter of estuary wetland vegetation patches; and 2) visual estimates of percent cover of every plant species within a $0.25m^2$ quadrat placed every 10 feet along each transect line. The results for the aerial photo analysis method are presented in Chapter 5 Habitat Change Analysis. The results for the visual estimates of percent cover are presented below.

For the 2010 data set (the most recent), we made paired comparisons between restored site transects and reference site transects, but not every restored site had a suitable reference site as shown in Table 7.3. Restored site transects 12 and 13 were on the bed of the compacted former Log Deck Road, and there was no comparable reference site within the project area. Reference site transects 4 (transitional wetland/upland) and 9 (Dean Creek berm) were sufficiently different in elevation and plant species composition that they were not comparable to any of the restored site transects.

For the paired transects where comparisons were feasible, we looked at the total percent cover of all species combined for the restored transect vs. the reference transect in 2010 (Table 7.4).

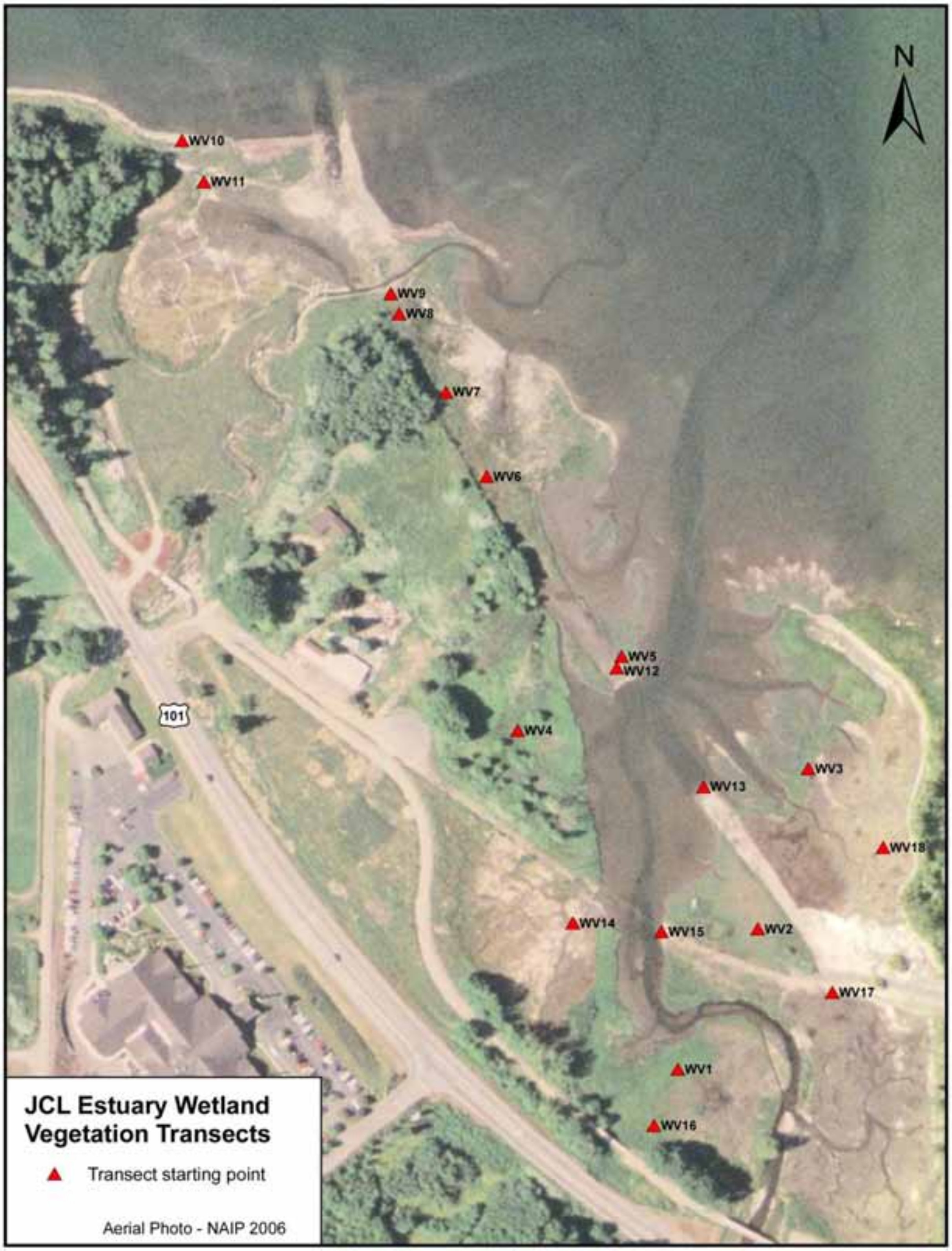

Figure 7.1. Jimmycomelately Creek Estuary wetland vegetation transects. Red triangles denote the transect starting point ("head" of transect) (graphic by Pam Edens).

Table 7.1. Summary of estuary wetland vegetation transect details.

Transect #	Year Established	Transect Length (ft.)	Compass Bearing	Notes
EST_WV_1	2004	100'	300°	**Reference Transect**
EST_WV_2	2004	150'	300°	**Reference Transect**
EST_WV_3	2004	200'	300°	**Reference Transect**
EST_WV_4	2004	125'	90°	**Reference Transect**
EST_WV_5	2004	170'	0°	**Reference Transect**
EST_WV_6	2004	200'	30°	Post-Restoration Transect
EST_WV_7	2004	125'	30°	Post-Restoration Transect
EST_WV_8	2004	150'	130°	Post-Restoration Transect
EST_WV_9	2004	150'	30°	**Reference Transect**
EST_WV_10	2004	200'	90°	**Reference Transect**
EST_WV_11	2004	200'	90°	Post-Restoration Transect
EST_WV_12	2005	200'	300°	Post-Restoration Transect
EST_WV_13	2005	200'	120°	Post-Restoration Transect
EST_WV_14	2005	190’	220°	Post-Restoration Transect
EST_WV_15	2005	200'	90°	Post-Restoration Transect
EST_WV_16	2005	200'	40°	Post-Restoration Transect
EST_WV_17	2006	200'	150°	Post-Restoration Transect
EST_WV_18	2006	200'	300°	Post-Restoration Transect

Table 7.2. Summary of sampling dates and estuary wetland vegetation transects surveyed, 2004-2010.

Sampling Dates	Transects Surveyed	Notes
July 15-16, 2004	1-11	
July 19-20, 2005	1-16	Transects 12-16 were added in 2005
July 12-13, 2006	1-18	Transects 17 & 18 were added in 2006
July 16-18, 2007	1-18, not 8	Transect 8 was dropped in 2007 due to impenetrable *Typha latifolia*
July 15-16, 2008	1-18, not 8 or 15	Transect 15 (former Old Blyn Highway) was dropped in 2008 because it was too high in elevation, too gravelly, and too compacted to ever become marsh.
July 20-21, 2009	1-18, not 8 or 15	
July 21-22, 2010	1-18, not 8 or 15	

Table 7.3. 2010 Restored site vs. reference site transect pairings.

Restored Site Transect	Paired Reference Site Transect
EST_WV_6	**EST_WV_5**
EST_WV_7	**EST_WV_5**
EST_WV_8	No comparison made; transect 8 dropped in 2007
EST_WV_11	**EST_WV_10**
EST_WV_12	No comparable reference site; compacted road bed
EST_WV_13	No comparable reference site; compacted road bed
EST_WV_14	**EST_WV_2**
EST_WV_15	No comparison made; transect 15 dropped in 2008
EST_WV_16	**EST_WV_1**
EST_WV_17	**EST_WV_3**
EST_WV_18	**EST_WV_3**

Table 7.4. Comparison of total % plant cover for 2010 restored site vs. reference site transect pairings.

Restored Site Transects Total % Plant Cover	Paired Reference Site Transects Total % Plant Cover	Difference Between Restored Site Transects & Reference Site Transects
EST_WV_6 = 89.29%	EST_WV_5 = 89.44%	0.15%
EST_WV_7 = 78.46%	EST_WV_5 = 89.44%	10.98%
EST_WV_11 = 81.5%	EST_WV_10 = 95.24%	13.74%
EST_WV_14 = 82.89%	EST_WV_2 = 93.75%	10.86%
EST_WV_16 = 75.48%	EST_WV_1 = 81.19%	5.71%
EST_WV_17 = 47.62%	EST_WV_3 = 59.52%	11.9%
EST_WV_18 = 51.75%	EST_WV_3 = 59.52%	7.77%

All of the restored site transects had a lower total % plant cover (i.e., more bare ground) than their paired reference transects in 2010. Yet, taking into account paired transect comparisons for all years (2005-2010), all of the 2010 restored site transects appear to be on trajectories toward plant cover comparable to reference site transects. In particular, restored site transects 6, 16, and 18 are very similar to their paired reference site transects after five years. While the low (<60%) total percent plant cover for restored transects 17 and 18 would typically be of concern, these transects transition from high marsh to unvegetated mudflat and thus have more bare ground than the other transects. It is also important to note that reference transect 3, which is paired with restored transects 17 and 18, also had <60% total plant cover.

Species Composition

A total of 24 native plant species were found along all of the restored site transects and reference site transects combined (Table 7.5).

For the paired transects where comparisons were feasible, we looked at the similarity in species composition of the top three dominant (in terms of percent cover) native plant species for the restored site transects vs. the reference site transects in 2010 (Table 7.6).

The top three dominant species for all of the restored site transects were obligate wetland species (OBL), facultative wet wetland species (FACW), or facultative wetland species (FAC); none of the dominants were facultative upland species (FACU). None of the restored site transects had the same three dominant species as their paired reference site transects, indicating there is significant variability in plant species composition across the project area. Restored site transects 7, 11, 16, and 19 had two of the same dominants as their paired reference site transects. Restored site transects 6, 14, and 17 had one of the same dominants as their paired reference site transects.

Salicornia virginica (pickleweed) was one of the dominant species for five of the seven paired transect comparisons. The two restored site transects (16 and 17) where pickleweed was not one of the three dominant species are higher in elevation and have more freshwater influence than the other restored site transects (6, 7, 11, 14, 18). No species other than pickleweed was a dominant in more than three of the restored site transects. *Triglochin maritima* (seaside arrow-grass) was a dominant for three of the seven transects. *Carex lyngbyei* (Lyngby's sedge) was a dominant for two transects (6, 14). *Agrostis stolonifera* (redtop bentgrass) was a dominant for two transects (7, 16). *Distichlis spicata* (seashore saltgrass) was a dominant for two transects (7, 18). *Deschampsia cespitosa* (tufted hairgrass) was a dominant for two transects (11, 17). *Plantago maritima* was a dominant for two transects (11, 18). *Typha latifolia* (common cattail), *Potentilla anserina pacifica* (Pacific silverweed), and *Cotula coronopifolia* (common brass buttons) were only dominant species for one of the seven restored site transects.

Table 7.5. List of native wetland plant species found along transects in 2010.

Scientific Name	Common Name	USFWS Indicator Status*
Agrostis stolonifera	redtop bentgrass	FAC
Atriplex patula	fat-hen saltbush	FACW
Carex lyngbyei	Lyngby's sedge	OBL
Cuscuta salina	saltmarsh dodder	FACW
Deschampsia cespitosa	tufted hairgrass	FACW
Distichlis spicata	seashore saltgrass	FAC+
Eleocharis palustris	creeping spike-rush	OBL
Epilobium watsonii	Watson willow herb	FACW
Equisetum arvense	common horsetail	FAC
Grindelia integrifolia	gumweed	FACW
Hordeum brachyantherum	meadow barley	FACW
Juncus bufonius	toad rush	FACW
Juncus effusus	common rush	OBL
Lotus corniculatus	birds-foot trefoil	FAC
Melilotus alba	white sweet-clover	FACU
Plantago maritima	seaside plantain	FACW+
Potentilla anserina pacifica	Pacific silverweed	OBL
Salicornia virginica	pickleweed	OBL
Schoenoplectus americanus	chairmaker's bullrush	OBL
Schoenoplectus maritimus	seacoast bullrush	OBL
Spergularia marina	saltmarsh sandspurry	OBL
Trifolium wormskjoldii	marsh clover	FACW+
Triglochin maritima	seaside arrowgrass	OBL
Typha latifolia	common cattail	OBL

*OBL = Obligate wetland species; >99% wetlands probability
FACW=Facultative wet wetland species; 67-99% wetlands probability
FAC=Facultative wetland species; 34-66% wetlands probability
FACU=Facultative upland species; 1-33% wetlands probability

Table 7.6. Comparison of top three native plant species for 2010 restored site vs. reference site transect pairings (USFWS indicator status for each species is in parentheses and code designations are below).

Restored Site Transects Three Dominant Species	Paired Reference Site Transects Three Dominant Species
EST_WV_6 1. *Salicornia virginica* (pickleweed) (OBL) 2. *Carex lyngbyei* (Lyngby's sedge)(OBL) 3. *Triglochin maritima* (seaside arrow-grass)(OBL)	**EST_WV_5** 1. *Salicornia virginica* (pickleweed) (OBL) 2. *Potentilla anserina pacifica* (OBL) 3. *Distichlis spicata* (FAC+)
EST_WV_7 1. *Agrostis stolonifera* (redtop bentgrass) (FAC) 2. *Salicornia virginica* (pickleweed) (OBL) 3. *Distichlis spicata* (seashore saltgrass) (FAC+)	**EST_WV_5** 1. *Salicornia virginica* (pickleweed) (OBL) 2. *Potentilla anserina pacifica* (OBL) 3. *Distichlis spicata* (seashore saltgrass) (FAC+)
EST_WV_11 1. *Salicornia virginica* (pickleweed) (OBL) 2. *Deschampsia cespitosa* (tufted hairgrass) (FACW) 3. *Plantago maritima* (goose tongue) (FACW+)	**EST_WV_10** 1. *Salicornia virginica* (pickleweed) (OBL) 2. *Distichlis spicata* (seashore saltgrass) (FAC+) 3. *Plantago maritima* (goose tongue) (FACW+)
EST_WV_14 1. *Carex lyngbyei* (Lyngby's sedge)(OBL) 2. *Salicornia virginica* (pickleweed) (OBL) 3. *Triglochin maritima* (seaside arrow-grass)(OBL)	**EST_WV_2** 1. *Distichlis spicata* (seashore saltgrass) (FAC+) 2. *Atriplex patula* (fat-hen saltbush) (FACW) 3. *Salicornia virginica* (pickleweed) (OBL)
EST_WV_16 1. *Agrostis stolonifera* (redtop bentgrass) (FAC) 2. *Typha latifolia* (common cattail) (OBL) 3. *Potentilla anserina pacifica* (Pacific silverweed) (OBL)	**EST_WV_1** 1. *Agrostis stolonifera* (redtop bentgrass) (FAC) 2. *Potentilla anserina pacifica* (Pacific silverweed) (OBL) 3. *Schoenoplectus maritimus* (seacoast bulrush) (OBL)
EST_WV_17 1. *Triglochin maritima* (seaside arrow-grass)(OBL) 2. *Schoenoplectus maritimus* (seacoast bulrush) (OBL) 3. *Deschampsia cespitosa* (tufted hairgrass) (FACW)	**EST_WV_3** 1. *Salicornia virginica* (pickleweed) (OBL) 2. *Distichlis spicata* (seashore saltgrass) (FAC+) 3. *Schoenoplectus maritimus* (seacoast bulrush) (OBL)
EST_WV_18 1. *Salicornia virginica* (pickleweed) (OBL) 2. *Distichlis spicata* (seashore saltgrass) (FAC+) 3. *Plantago maritima* (goose tongue) (FACW+)	**EST_WV_3** 1. *Salicornia virginica* (pickleweed) (OBL) 2. *Distichlis spicata* (seashore saltgrass) (FAC+) 3. *Schoenoplectus maritimus* (seacoast bulrush) (OBL)

OBL = Obligate wetland species; >99% wetlands probability
FACW=Facultative wet wetland species; 67-99% wetlands probability
FAC=Facultative wetland species; 34-66% wetlands probability
FACU=Facultative upland species; 1-33% wetlands probability

Fixed Photo Points

Annual photos from fixed photo points are a very useful and inexpensive way to qualitatively track changes in plant cover and species composition. Figure 7.2 shows a comparison of annual photos from 2005 to 2010 for estuary wetland transect EST_WV_14 at the restored former Sequim RV Park site. What is immediately apparent from these photos is the much greater percent cover of native plants in 2010 vs. 2005. From these photos in combination with the quantitative data collected at transect EST_WV_14, we determined that *Salicornia virginica*, *Agrostis stolonifera*, *Atriplex patula*, and *Triglochin maritima* were the early colonizing species in 2005 when 87% of the transect area was bare ground. By 2010 only 17% of that transect's area was bare ground, and the dominant species (in terms of % cover) were *Carex lyngbyei, Salicornia virginica,* and *Triglochin maritima*. In 2005, a total of four native species were observed at this transect; in 2010 there were 10 native species observed and an alder canopy that fringes the wetland now completely obscures the roof of the Seven Cedars Casino visible from 2005 to 2008. The former Sequim RV Park site appears to be well on the way toward a diverse, functional high salt marsh.

Figure 7.3 shows a comparison of annual photos from 2005 to 2010 for estuary wetland transect EST_WV_12 along the former Log Deck Road. This site, because it was very compacted from years of road use, was slower to establish a native plant community than transect EST_WV_14. In 2005, >95% of the transect area was bare ground and a total of two native species (*Salicornia virginica* and *Atriplex patula*) were observed at this transect. In 2010, 57% of the transect area was bare ground and six native species were observed; the dominant species were *Salicornia virginica* and *Triglochin maritima*. The former Log Deck Road is on a trajectory toward becoming a high salt marsh community, but will take longer than other restored areas because of the compaction of the site.

Here, for the sake of space, we provide just the two annual photo comparisons for restored site transect 12 (Figure 7.2) and 14 (Figure 7.3), but similar annual photo comparisons could be made for all of the restored site transects. For the remaining restored site transects, we show a photo comparison from the start of vegetation monitoring (either 2005 or 2006) and the most recent vegetation monitoring (2010). Figure 7.4 shows a comparison of 2005 vs. 2010 fixed point photos for restored site transects 6, 7, and 11. Figure 7.5 shows a comparison of 2005 vs. 2010 fixed point photos for restored site transects 13 and 16, and a comparison of 2006 vs. 2010 fixed point photos for transects 17 and 18.

WSDOT Monitoring at Former Eng Property

WSDOT has monitored wetland vegetation at the former Eng Property (lower right corner of Figure 7.1 with tidal channel network) in 2006, 2008, and 2010. Acquisition of this property by WSDOT was critical to the Jimmycomelately Ecosystem Restoration Project, because the historic Jimmycomelately channel meandered through this property. WSDOT purchased this property as advanced wetland mitigation for future transportation projects along Highway 101, and thus wetland monitoring every other year was mandated for 10 years (2006-2015).

The WSDOT monitoring plan calls for evaluation of five performance measures at the 6.34-acre mitigation site:

- Performance Measure 1: A functioning hydrological connection shall be restored and self-maintaining between JCL Creek and the estuary.

- Performance Measure 2: Eighty percent or more of the large woody debris (LWD) placements should be present in Years 1-10.

- Performance Measure 3: The natural recolonization of estuarine vegetation shall be documented with photo points and general site observations, including a plant list.

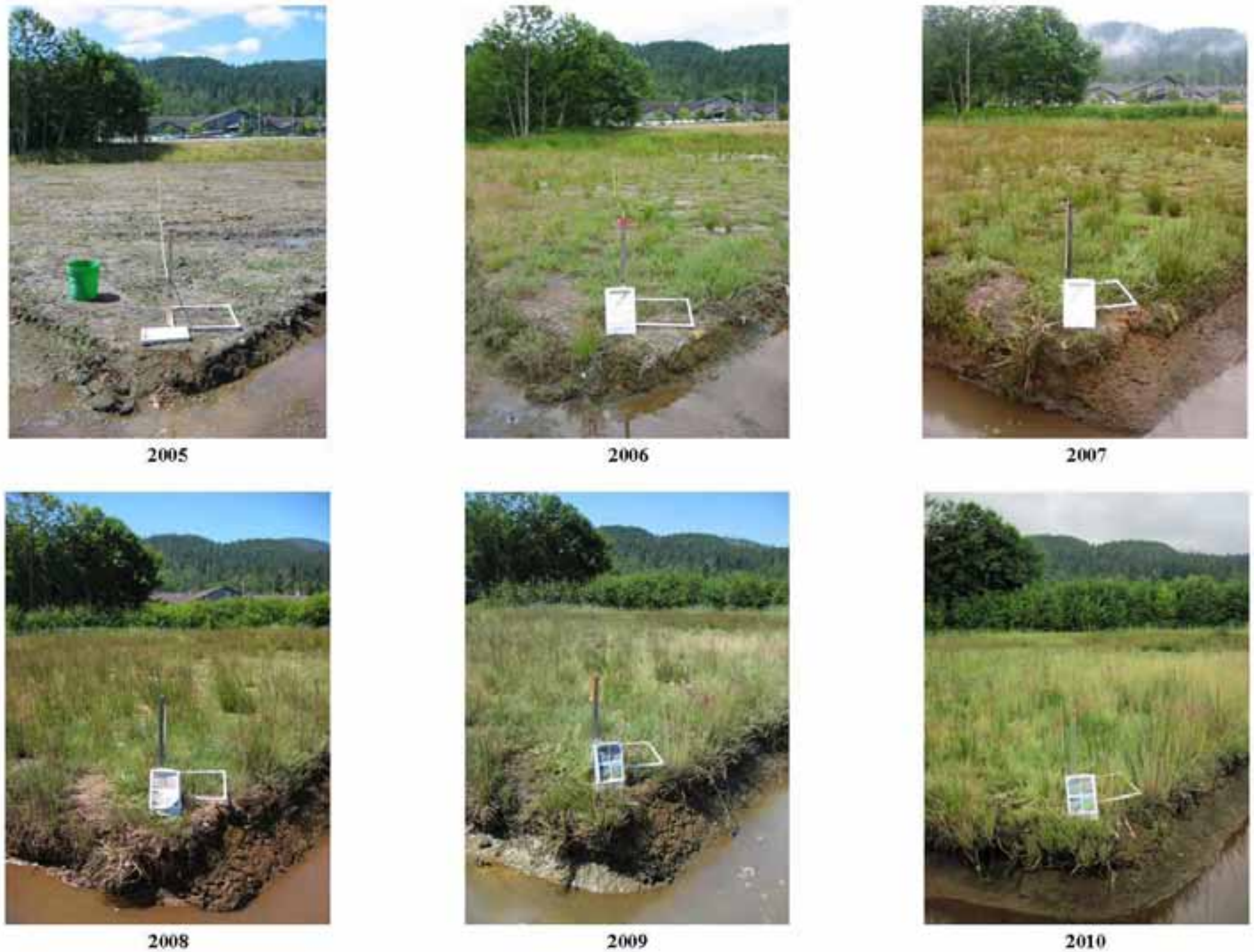

Figure 7.2. 2005—2010 Photos Showing the View from the Head to the Tail of Estuary Wetland Transect EST_WV_14 at the restored Sequim RV Park site.

Figure 7.3. 2005—2010 Photos Showing the View from the Tail to the Head of Estuary Wetland Transect EST_WV_12 at the former Log Deck Road site.

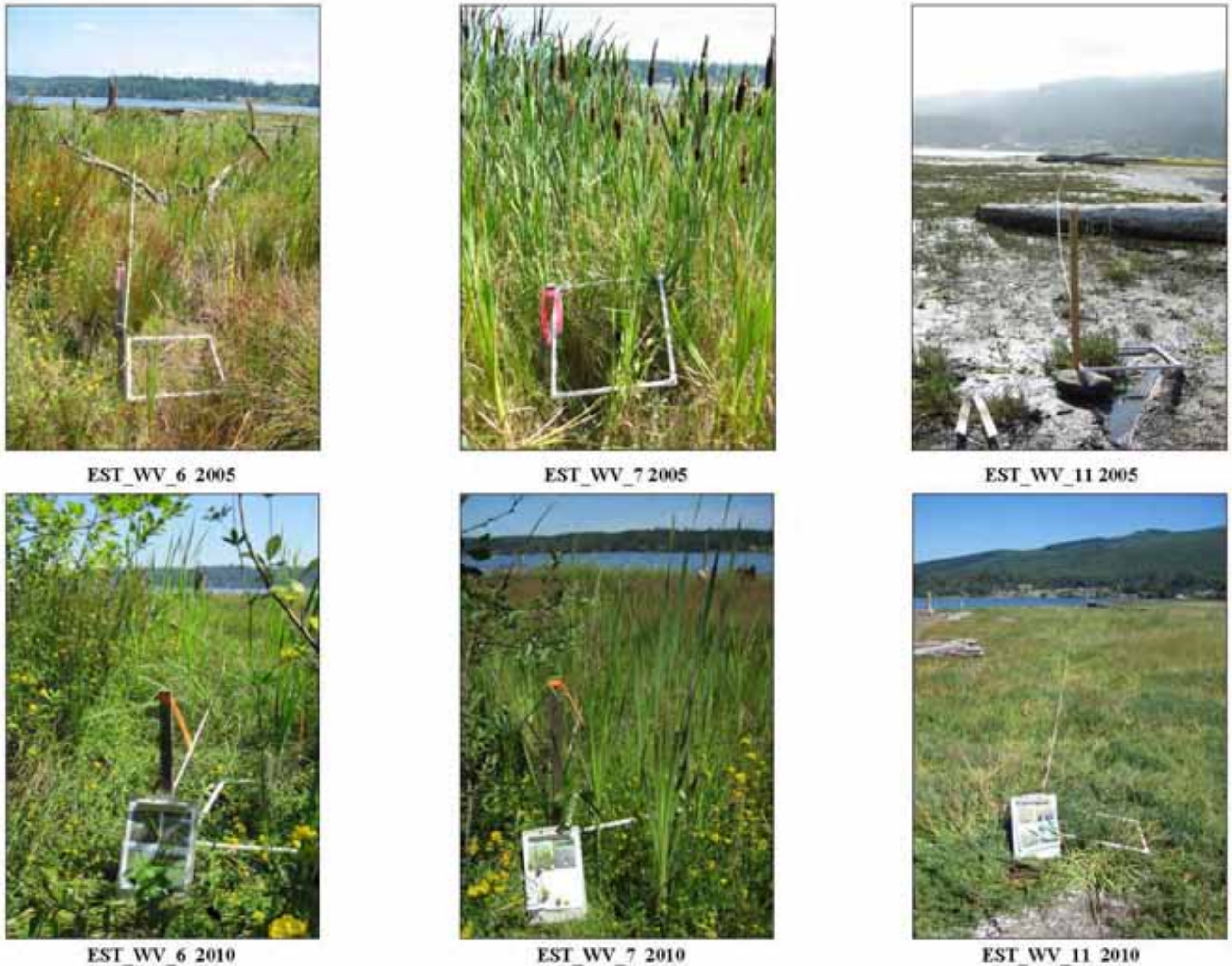

Figure 7.4 Photo comparisons (2005 vs. 2010) for estuary wetland restored site transects 6, 7, and 11.

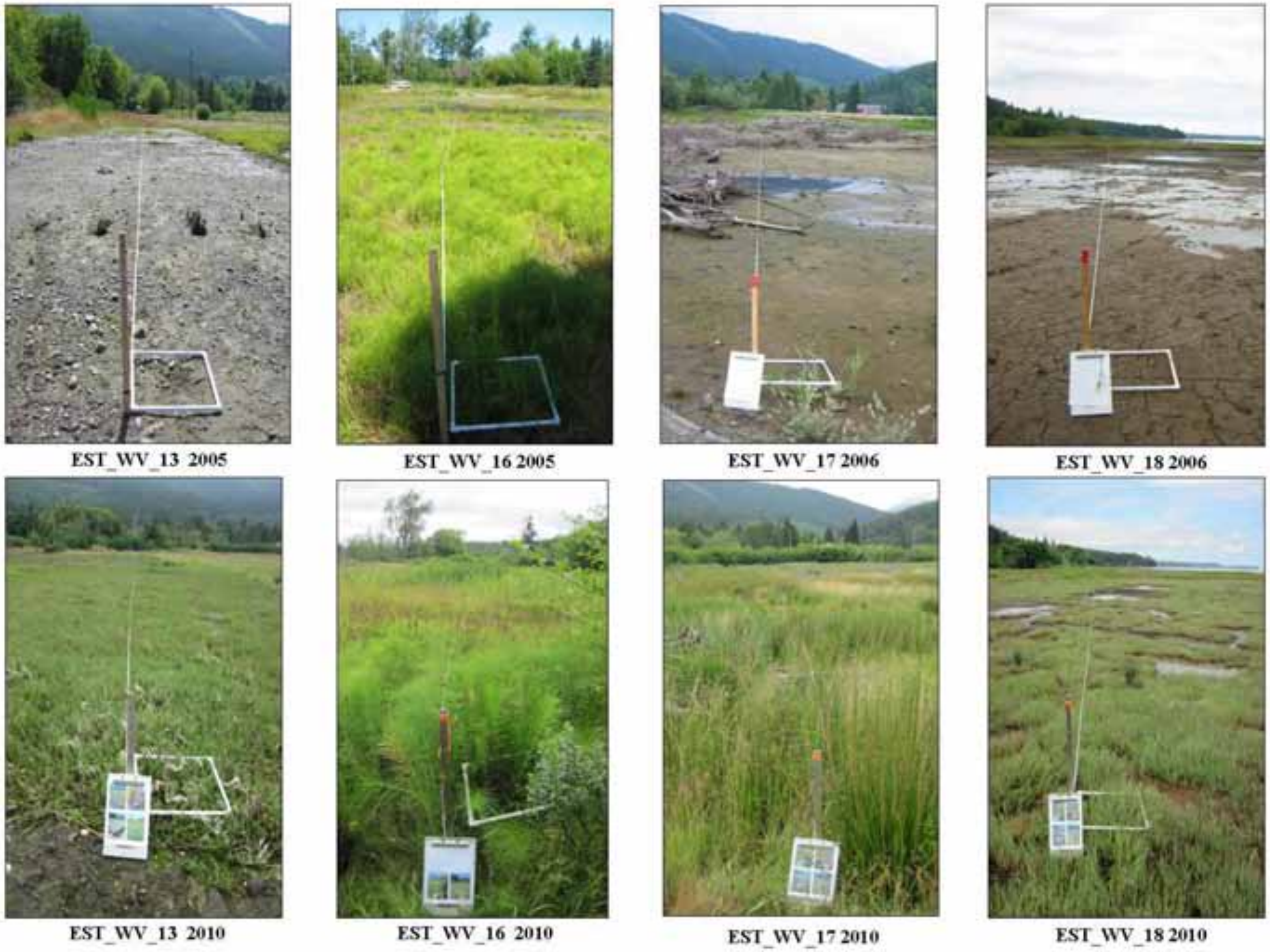

Figure 7.5. Photo comparisons: 2005 vs. 2010 for estuary wetland restored site transects 13 and 16, and 2006 vs. 2010 for transects 17 and 18.

- Performance Measure 4: Native planted woody vegetation in the buffer will achieve a minimum of 20 percent aerial cover.

- Performance Measure 5: Noxious weeds will not exceed 20 percent aerial cover over the entire site. The site shall contain less than 5 percent aerial cover by *Cirsium arvense* (Canada thistle), *Cirsium vulgare* (bull thistle), *Cytisus scoparius* (Scot's broom), *Lythrum salicaria* (purple loosestrife), *Phalaris arundinacea* (reed canarygrass), *Phragmites australis* (common reed), *Polygonum bohemicum* (Bohemian knotweed), *Polygonum cuspidatum* (Japanese knotweed), *Polygonum polystachyum* (Himalayan knotweed), *Polygonum sachalinense* (giant knotweed), and *Spartina alterniflora* (smooth cordgrass).

2010 monitoring results relative to these performance measures are summarized in Table 7.7.

Table 7.7. Summary of monitoring results and management activities (2010) for the Highway 101 Jimmycomelately Creek Estuary mitigation site (WSDOT 2011).

Performance Measure	2010 Results	Management Activities
Maintain a hydrological connection between Jimmycomelately Creek (JCL) and the associated estuary.	Present and functioning	
80% of the large woody debris (LWD) present.	78% present	
Document estuarine vegetation with photo points, site observations, and a plant list.	See Appendix 2 for a plant list and Appendix 5 for photos	
Native planted woody vegetation in the buffer will achieve a minimum of 30% aerial cover (75% in year-10).	77% cover (CI80% = 71-84%)	Installed plants and bark mulch.
Less than 20% aerial cover of noxious weeds over the entire site. The site shall contain less than 5% aerial cover by specific species.	3% cover on entire site and 2% of target species	Hand pulling and herbicide application of non-native and invasive species.

Four of the five WSDOT performance measures were met in 2010. The one measure that was not met (for LWD placements) was within 2% of being met. A total of 20 native wetland species were observed at the former Eng Property in 2010. The full WSDOT report for 2010 is available at: http://www.wsdot.wa.gov/NR/rdonlyres/10318247-CEAB-4E3F-8925-FE200EE9DD2E/0/2010Jimmycomelately.pdf

DISCUSSION

The estuary wetland vegetation performance criteria established in the Estuary Monitoring Plan (Shreffler 2004) were:

1. Aerial extent (percent cover) of wetland vegetation should be 60% comparable to that of appropriate reference sites after 5 years and 80% comparable after 10 years.

2. Species composition of native wetland plant species should be 60% comparable to that of appropriate reference sites after 5 years and 80% comparable after 10 years.

Seven years post-restoration, performance criteria 1 has been met. The percent cover of wetland vegetation in the restored sites is at least 76% comparable to appropriate reference sites, and restored transects 6, 16, and 18 are >90% comparable to paired reference sites.

For performance criteria 2, the exact criteria of –60% comparable" species composition between the restored sites and reference sites after 5 years is not possible to assess due to: 1) the lack of comparable paired reference sites for some of the restored sites; and 2) the degree of annual variability in species composition both in the reference sites and the restored sites. However, we can say that, seven years post-restoration, the species composition of native wetland plant species in the restored sites is on a trajectory to be comparable to the reference sites in terms of the top three dominant species, as well as overall species composition. After only seven years, we are already seeing the natural re-colonization of the estuary by a diverse range of native plant species that are typical of salt marsh habitats in this region.

As reported in Shreffler (2004), the Estuary Design Group (EDG) believed that the existing seedbed would be sufficient to allow natural re-colonization of the estuary. The only planting that occurred in the JCL Estuary was 700 *Carex lyngbyei* (Lyngby's sedge) plants that were grown from seeds harvested at the site in 1999. Those plants were installed in the restored log yard area in November 2003. As of 2010, none of the Lyngby's sedge plants remain. We do not know for certain why the transplanted Lyngby's sedge all died. Since no Lyngby's sedge naturally recruited to the restored log yard area, we assume there must be something about the site conditions (e.g., soils, salinity, elevations) that will not allow this plant species to establish at this location despite our expectations that it would. Lyngby's sedge has naturally recruited to other locations within the project area, and as noted in Table 7.5 is one of the top three dominant species at restored site transects 6 and 14.

Wetland vegetation monitoring in the JCL Estuary was intended to occur in years 1, 2, 3, 5, and 10 post-restoration (Shreffler 2004). Thus far, post-restoration monitoring has been performed annually in year one (2004) through year seven (2010). A period of monitoring longer than 10 years is often necessary to demonstrate whether or not ecological processes, habitat conditions and functions, and biological responses are likely to be restored to the desired level. Indeed, the ecological literature suggests that restoration sites may follow a hypothetical path of development (a trajectory), which will eventually approach natural reference sites (the target) through time, but this may take upwards of 50 years for brackish or salt marsh habitats (Simenstad and Thom 1996; Zedler and Callaway 1999, Simenstad and Cordell 2000).

Field observations within the sheltered Jimmycomelately Creek Estuary suggest that the restored estuary vegetation is providing habitat for macroinvertebrates, juvenile salmonids, shorebirds, waterfowl, and wildlife.

The sheltered condition of embayments makes them important habitat for native shellfish, fish, and shorebirds (Fresh et al. 2011). Field observations within the sheltered Jimmycomelately Creek Estuary suggest that the restored estuary vegetation is providing habitat for macroinvertebrates, juvenile salmonids, shorebirds, waterfowl, and wildlife. Although not quantified, the amount of wetland vegetation detritus exported to Lower Sequim Bay from the restored Jimmycomelately Creek Estuary is clearly much higher than the pre-restoration condition. This exported detritus forms the base of the food web for multiple macroinvertebrate, fish, and wildlife species that use the restored estuary and Lower Sequim Bay.

Gammarid amphipods are especially abundant in the estuary detrital mats. Juvenile crabs are commonly observed in the estuary tidal channels and tidal flats. Juvenile salmonids have been documented in the realigned JCL stream channel (see Chapter 11 Juvenile Salmonid Use: Smolt Production), Lower Sequim Bay (see Chapter 12 Juvenile Salmonid Use: Beach Seine Monitoring), and JCL Estuary tidal channels (see Chapter 13 Juvenile Salmonid Use: Tidal Channel Monitoring). Many species of birds have also been documented using the restored site (see Chapter 14 Bird Use). Deer, coyotes, river otters, and raccoons are occasionally observed in the restored site, and elk tracks and mole mounds have been reported (WSDOT 2011). Bull frogs (non-native), red-legged frogs (native), and garter snakes are also commonly seen. In short, the Jimmycomelately Creek Estuary appears to be a thriving, healthy ecosystem.

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CHAPTER 8. EELGRASS RECOVERY
– LOHNA O'ROURKE (JAMESTOWN S'KLALLAM TRIBE)

BACKGROUND

Restoration Objective– Estuary (Shreffler 2004)
The restoration objective for eelgrass (*Zostera marina,* see photo below from http://www.botos.com/marine/egrass01.html) was to remove anthropogenic impairments (i.e., pier, pilings, fill) and allow existing eelgrass to recover and expand into the footprint of the area formerly impacted by historic log rafting, dredging, and related log yard operations. It is believed that the log yard, in operation from 1892 until 2001, resulted in the direct loss of valuable fish, shellfish, and wildlife habitat.

Restoration Rationale– Estuary (Shreffler 2004)
The Estuary Design Group (EDG) anticipated that removing anthropogenic impairments and their associated disturbance (e.g., shading, wood debris, impaired water quality, etc.) would enable eelgrass to colonize the area naturally, thereby fulfilling an objective of one of the project's primary goals: to restore in perpetuity the river and estuarine habitat of JCL Creek and South Sequim Bay for fish, shellfish, waterfowl, and wildlife (Shreffler 2000).

The log yard area was restored during Phase 2 of the Jimmycomelately Ecosystem Restoration Project through the following activities:

- Log yard pier and wetland fill were removed (completed in 2003);
- Shoreline contour was restored to conditions prior to log yard operations, using 1870 T-sheet maps as the template(completed in 2004);
- Log Deck Road was removed (completed in 2004);
- Creosote-treated log yard pilings were removed (completed in 2005); and
- DeanCreek was realigned (completed in 2005).

Prior to Phase 2, a series of eelgrass surveys was conducted to produce an inventory of marine habitat at the south end of Sequim Bay so that restoration performance could be tracked and measured through post-project monitoring. In 1999, Battelle Marine Sciences Laboratory (Antrim 1999) surveyed the entire south end of the bay using underwater videography, excluding the area within the boundaries of the log yard pilings and log rafts because the log sorting and transportation facility was still in operation at that time. In 2000, staff from the Jamestown S'Klallam Tribe (JST) conducted an intertidal survey by walking transects between the ~ 0 ft. to -2.0 ft. tide line relative to mean lower low water (MLLW); the transects extended from the western edge of the log yard property east to the JCL channel. In 2001 and 2003, JST staff used GPS to delineate eelgrass east of the JCL channel at a -3.0ft. tide MLLW.

In 2002, Battelle (Sargeant et al. 2002) conducted a diver survey within the pilings of the log yard facility – the log yard ―footprint" – to cover the majority of the area that was excluded during the 1999 video survey. During the 2002 survey, Battelle scientists established two baselines, Baseline A and B, (Figure 8.1) along the pilings and swam transects at fixed headings every 20 meters along the baseline. No eelgrass was found during the survey. The highest concentrations of woody debris were seen in the shoreward area of Area B, closest to where it adjoins Area A. Battelle scientists also conducted a snorkel survey to confirm the location of the continuous eelgrass bed to the west of the log yard recorded during the 1999 video survey (Antrim 1999). The edge of the bed was located approximately 100 m from the pilings (Baseline B) (Sargeant et al. 2002). Shoot counts were not included in any of these surveys. The location of all eelgrass recorded during these pre-project surveys was mapped on a 1998 aerial photo (Figure 8.1).

METHODS

The Estuary Monitoring Plan (Shreffler 2004) called for the following two post-project (effectiveness) monitoring tasks:

- Task 1: Repeat the JST low tide monitoring annually in years 1-10, with emphasis on the western edge of the existing eelgrass bed to the east of the log yard footprint and the eastern edge of the existing eelgrass bed to the west of the log yard footprint.

- Task 2: In years 5 and 10, repeat the diving survey within the former log yard footprint, using the same transects as in year 0.

Actual post-project monitoring was conducted as JST staffing and scheduling permitted.

In September 2006, JST Natural Resources (NR) staff replicated the 2002 Battelle survey (Sargeant et al. 2002) using both intertidal and SCUBA methods. On September 5, staff wearing chest waders laid out a 200 meter lead line pre-marked at 20-m intervals using the coordinates provided from the 2002 survey for Baseline A. On September 5, 6, and 7, working within the confines of the tide, 100-m tapes were laid following a 160º magnetic bearing. Dominant substrate, type and density of vegetation, and presence/absence and density of woody debris were recorded at 10-m intervals along the transect using 0.25 m^2quadrats. Additionally, on September 7, the eastern edge of the existing eelgrass bed to the west of the log yard was delineated using GPS.

On September 12 and 13, 2006, JST NR staff used the tribal boat to lay out the 200-m lead line for Baseline B. Staff divers on SCUBA then used the same protocol as that used for Baseline A, but transects were on a compass bearing of 65º magnetic.

In the summer of 2008, a JST NR staff member wearing chest waders used GPS to delineate the eastern edge of the existing eelgrass bed to the west of the log yard. The metadata for this survey was unable to be found, so the actual date and therefore tide information is not known.

On July 22, 2009, a JST NR staff member wearing chest waders used GPS to again delineate the eastern edge of the eelgrass bed to the west of the log yard. From that edge, transects were walked starting at approximately the 0 ft. tide line perpendicular to shore to the greatest possible depth (low tide was -3.0 ft. at approximately 10:30 am). The surveyor then turned and walked back to shore, parallel to the prior transect and at a distance that allowed full lateral visual coverage between transects. This protocol

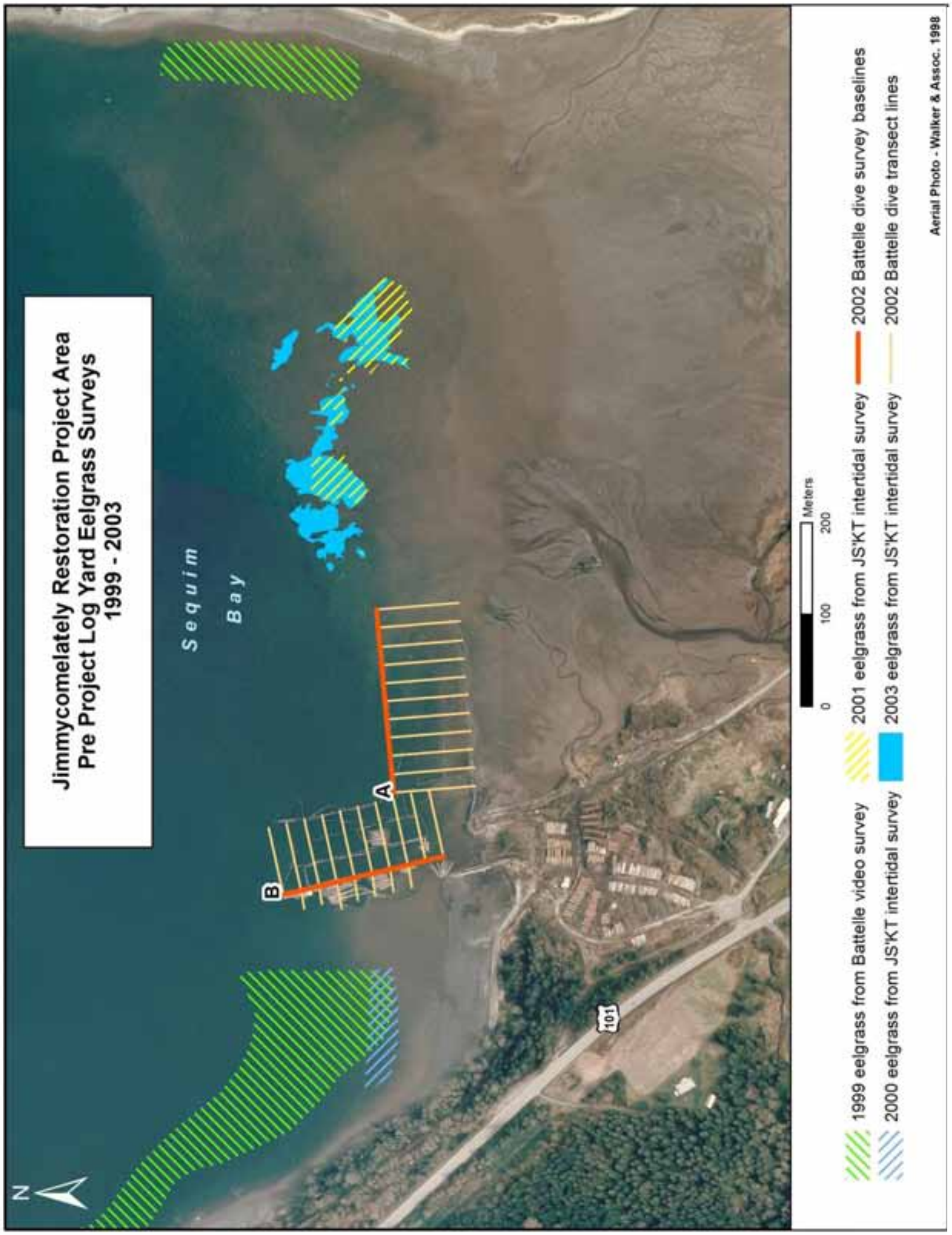

Figure 8.1. Pre-project eelgrass surveys from 1999 through 2003 (graphic by Pam Edens).

continued through the footprint of the log yard eastward as far as the JCL channel. Observed eelgrass was marked as a GPS waypoint, and the approximate size of each eelgrass patch was noted.

On July 29, 2011, a JST NR staff member used the same protocol as that used during the 2009 survey to again delineate the eastern edge of the eelgrass bed to the west of the log yard and continue with transects eastward until reaching the JCL channel. On this occasion, however, eelgrass patches less than one foot in diameter were marked as a GPS waypoint. Patches larger than one foot in diameter were recorded as a GPS line segment. Low tide was -1.7 ft. at 9:30 am. Post-project eelgrass surveys (2006-2011) are summarized in Table 8.1.

Table 8.1. Summary of post-project eelgrass surveys (2006-2011).

Survey Date	Survey Method	Survey Location	Lowest Tide Elevation [height (ft.) /time]
September 5-7, 2006	Intertidal	All of Baseline A and eastern edge of continuous bed west of log yard	On 9/5, -1.4 / 8:27 a.m. On 9/6, -1.4 / 9:15 a.m. On 9/7, -1.0 / 10:00 a.m.
September 12-13, 2006	SCUBA	All of Baseline B	N/A
Summer 2008 (date unknown)	Intertidal	Eastern edge of continuous bed (as above) only	unknown
July 22, 2009	Intertidal	Eastern edge of continuous bed (as above) and log yard footprint	-3.0 / 10:31 a.m.
July 29, 2011	Intertidal	Eastern edge of continuous bed (as above) and log yard footprint	-1.7 / 9:30 a.m.

Surveys of eelgrass to the east of the JCL channel were dropped due to intensive aquaculture operations in that immediate vicinity beginning in 2008.

RESULTS

In 2006, 2200 linear feet were visually inspected for the presence of eelgrass within the logyard footprint, and benthic conditions were recorded for a total of 60.5 m^2 (0.25m^2quadrats x 242). No eelgrass was found within the quadrats or along the transect lines. However, two small patches less than one foot in diameter were observed within the survey area of Baseline A (Area A) (Figure 8.2). The intertidal region of the eastern boundary of the eelgrass bed to the west of the log yard was delineated by GPS and mapped (Figure 8.2). Based on the mapped location of the eelgrass bed to the west of the log yard in 1999 (Antrim 1999) and its reported distance of approximately 100 m from the western edge of the pilings (Sargeant et al. 2002), it is estimated that between 1999 and 2006, the portion of the bed that was able to be surveyed intertidally expanded eastward approximately 3,520 m^2.

The 2008 survey indicated that the eastern boundary of the eelgrass bed to the west of the log yard approximated that observed in 2006. However, two new patches were found within a few meters of the eelgrass bed (Figure 8.2, insert). The closet patch was about two feet in diameter and the furthest was about four feet in diameter.

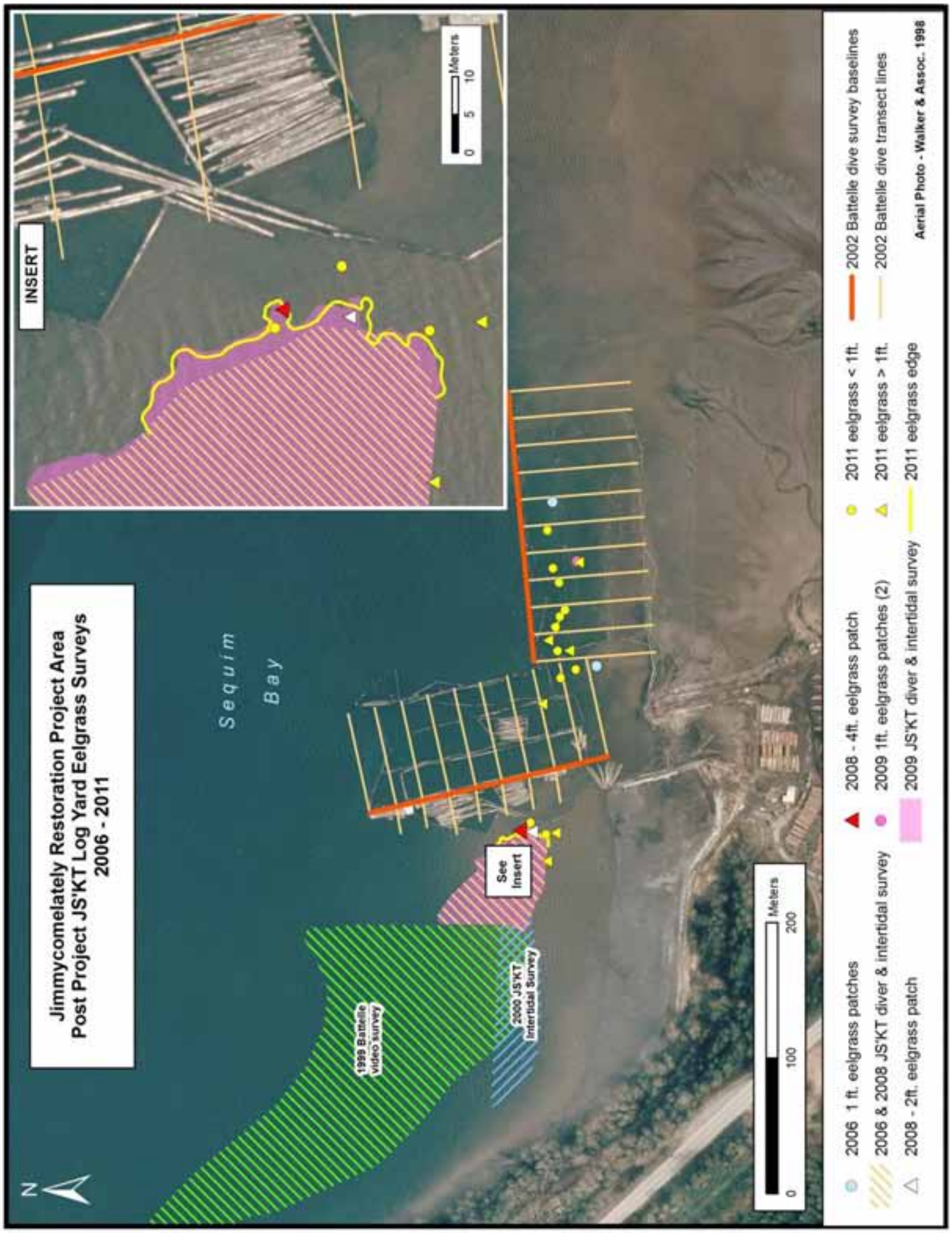

Figure 8.2. Post-project eelgrass surveys from 2006 through 2011 (graphic by Pam Edens).

The 2009 survey indicated that the eastern boundary of the eelgrass bed discussed above continued to expand eastward and it would appear that the continuous bed incorporated the two individual patches that were seen in 2008 (Figure 8.2, insert). Between 2008 and 2009, it is estimated that this area of the bed expanded eastward by another roughly 135 m^2. Two additional patches less than 1 foot in diameter were found close together within Area A (Figure 8.2).

The eastern boundary of the eelgrass bed in 2011 approximated that observed in 2009; however, there were several new small patches within ten meters of the bed (Figure 8.2). Remarkably, there were 13 new patches found within the logyard footprint, primarily in Area A. For the first time, however, eelgrass was also found in the Baseline B survey area (Area B) (Figure 8.2). Four of the thirteen patches (3 in Area A and 1 in Area B) were > 1ft. in diameter; the other nine patches were< 1 ft. in diameter.

DISCUSSION

> The fact that we are seeing a pattern of natural eelgrass expansion eastward through the project area is very encouraging.

Eelgrass provides a wide variety of ecological functions in nearshore ecosystems (see reviews in Mumford 2007, Simenstad et al. 2008). Of particular importance to the Jimmycomelately Ecosystem Restoration Project is the role eelgrass serves in helping to fuel the detritus-based food web (Penttila 2007) that provides preferred prey items for juvenile salmonids, especially threatened summer chum salmon. Eelgrass also provides cover and protection from predation for juvenile salmonids during their estuarine residency and nearshore migration. Marine-associated birds feed extensively on the many small invertebrates and fish that inhabit eelgrass beds, and eelgrass is also an important nursery habitat for commercially important shellfish species. There is also a direct link between Pacific herring spawning and eelgrass (Penttila 2007).

Eelgrass beds were lost or impaired during the 1892 – 2001 period of log yard operation in Lower Sequim Bay (Shreffler 2004). Although we have no direct evidence linking the decline in summer chum salmon populations to declines in eelgrass beds, the loss of eelgrass habitat likely impacted the health of salmonids, Pacific herring, shellfish, or marine-associated birds in Sequim Bay.

The eelgrass recovery performance criterion established by the Estuary Design Group (EDG) in the Estuary Monitoring Plan (Shreffler 2004) was simply that any natural recovery of eelgrass into the formerly impacted log yard area where eelgrass did not exist would be an indication of restoration success, and that eelgrass abundance and shoot density in the log yard area should eventually be comparable to the adjacent, existing eelgrass if site conditions allowed. No signs of natural eelgrass recovery after 5 years would trigger the need for potential contingency measures.

With the possible exception of an area where there was high concentrations of woody debris (surface coverage from 25% to 100%) where Area B adjoined Area A (Sargeant et al. 2002), the dominant substrate of sand, mud, and mixed fines in the log yard area is considered supportive of eelgrass growth. Subtidal growth of eelgrass in the Pacific Northwest is primarily vegetative through the spreading of rhizomes from existing eelgrass rather than through sexual reproduction (Philips 1984). While the rate of growth is difficult to predict and depends largely on site conditions, eelgrass has been shown to expand rapidly in some areas. For example, an existing eelgrass bed in British Columbia expanded over 30m $year^{-1}$ as a result of a major improvement in water clarity (Harrison 1987). We have seen a similar rate of expansion in at least a portion of the eelgrass bed west of the log yard since pier and piling removal and the cessation of log yard operations.

The long term success of the many new patches seen in Area A and B will remain to be seen. Unlike subtidal growth, Philips (1984) found a direct relationship between the degree of disturbance (temperature regime and other conditions) in the intertidal area and the dependence on sexual reproduction. *Zostera* m. has shown high interannual variability with respect to seed production and seedling recruitment (Fonseca et al. 1998). This may account for the large number of very small patches that showed up within just a two year time period (2009 – 2011). However, seedling recruitment success in the long term is believed to be minimal (Fonseca et al. 1998). A study conducted in Denmark (Olesen and Sand-Jensen 1994) found that mortality of small patches, defined as having less than 32 shoots with a mean age of less than 5 yrs, was over 75% within 2.5 years. Nonetheless, the fact that we are seeing a pattern of natural eelgrass expansion eastward through the project area is very encouraging.

It is important to note that all post-project surveys – with the exception of the diver survey of only a portion of the log yard footprint in 2006 – were conducted in the intertidal – and therefore we cannot speak to the presence and growth of eelgrass deeper than that seen during the walking surveys. Hence, in addition to continuing the intertidal surveys, it is recommended that another dive or snorkel survey be conducted in 2012 to map the subtidal area of the project area not covered during the previous surveys. If resources permit, it also recommended that density measurements (shoot counts) be conducted on both a portion of the existing eelgrass bed and any patches encountered within the footprint, as this was not done in any of the previous surveys.

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CHAPTER 9. SHELLFISH RECOVERY

– LOHNA O'ROURKE AND CHRIS KAPLAN (JAMESTOWN S'KLALLAM TRIBE)

BACKGROUND

Restoration Objective– Estuary (Shreffler 2004)
The restoration objective for shellfish was to remove anthropogenic impairments (i.e., log yard pier, pilings, and fill) and allow shellfish to recover and expand (to harvestable levels) into the footprint of the area formerly impacted by historic log rafting, dredging, and related log yard operations. The log yard, in operation from 1892 until 2001, likely resulted in the direct loss of valuable fish, shellfish, and wildlife habitat.

Restoration Rationale– Estuary (Shreffler 2004)
The Estuary Design Group (EDG) anticipated that removing the impairments would enable shellfish to re-colonize the area naturally, thereby fulfilling an objective of one of the project's primary goals: *to restore in perpetuity the river and estuarine habitat of JCL Creek and South Sequim Bay for fish, shellfish, waterfowl, and wildlife* (Shreffler 2000).

The log yard area was restored during Phase 2 of the Jimmycomelately Ecosystem Restoration Project through the following activities:

- Log yard pier and wetland fill were removed (completed in 2003);
- Shoreline contour was restored to conditions prior to log yard operations, using 1870 T-sheet maps as the template(completed in 2004);
- Log Deck Road was removed (completed in 2004);
- Creosote-treated log yard pilings were removed (completed in 2005); and
- Dean Creek was realigned (completed in 2005).

Shellfish population surveys were conducted in the log yard area by Jamestown S'Klallam Tribe Natural Resources staff in 2001/2002 (combined survey), and 2003 (Figure 9.1). These baseline surveys were conducted to estimate the number and biomass of clams on the beach, and the relative distribution of the population for both native Pacific littleneck (*Protothaca staminea*) and manila (*Venerupis philippinarum*) clams. Also calculated were harvestable pounds (Table 9.1), based on the following two requirements of the Point No Point Treaty Council (PNPTC) and the Washington Department of Fish and Wildlife (WDFW): 1) The minimum legal size for littlenecks and manilas is 38mm, since this size (and age class of 3 plus) allows for at least one reproductive cycle before harvest, and 2) the annual harvest rate applied to the entire harvestable population, and believed to sustain a healthy population, is 25% for littlenecks and 33% for manilas (PNPTC 1998).

Table 9.1. Summary of harvestable pounds of littleneck and manila clams in 2002/2002 and 2003.

	2001/2002		2003	
	Littleneck	Manila	Littleneck	Manila
Total lbs ≥ 38 mm	23.59	7.88	39.86	18.44
Total lbs. in survey area	55,171	18,426	179,645	83,100
Harvestable Pounds	13,793	6,081	44,911	27,423

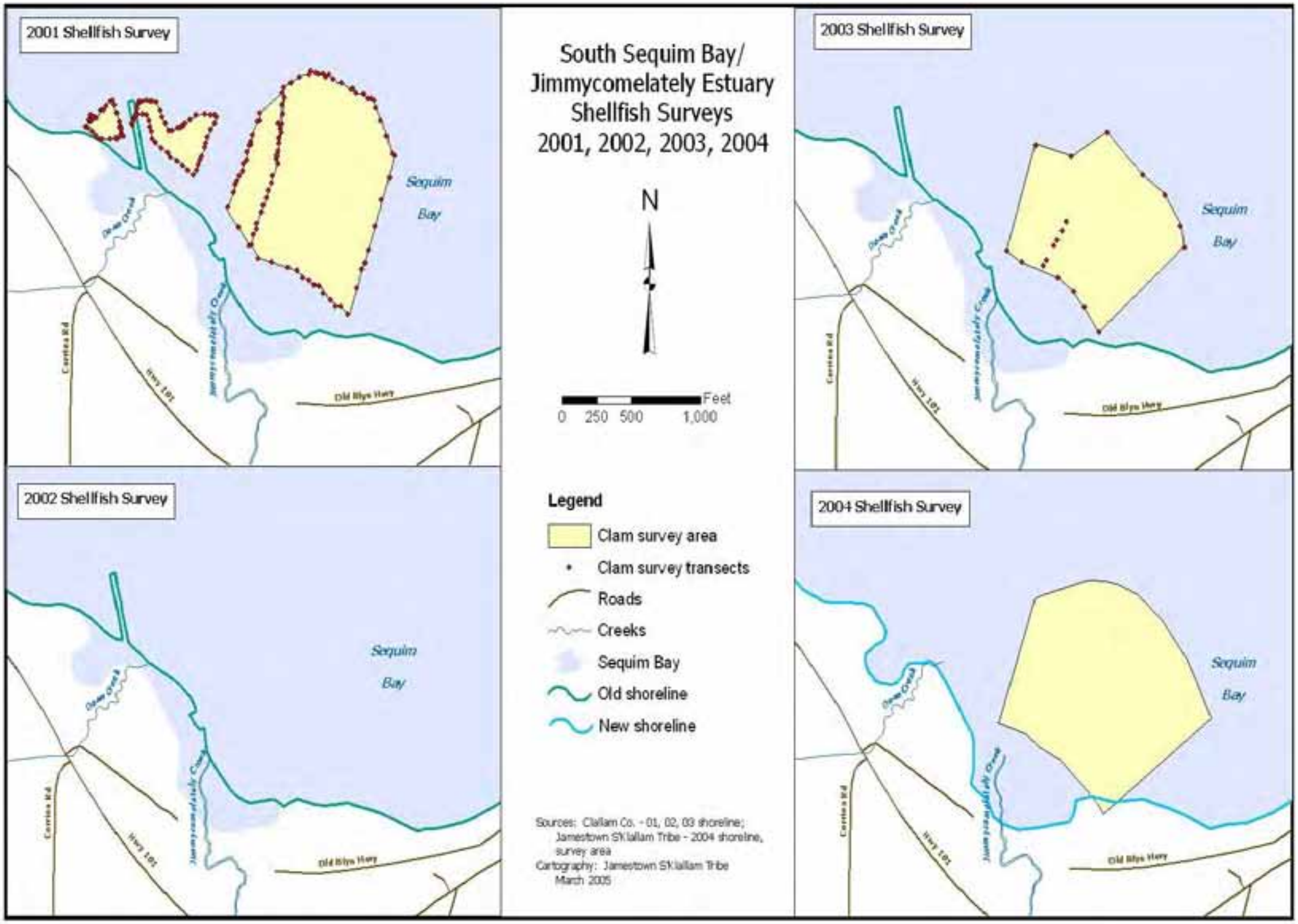

Figure 9.1. Pre-project shellfish surveys from 2001/2002 through 2004 (graphic by Pam Edens).

The 2001/2002 survey included the area of the log yard directly west and east of the former log yard pier (Figure 9.1), which increased the total area surveyed compared to the area surveyed in 2003 (1,590,369 sq. ft. versus 910,404 sq. ft.). There were no harvestable clams found in the former log yard area. However, since this area was still averaged in with the productive area eastward, densities were considerably lower in the 2001/2002 survey.

METHODS

The Estuary Monitoring Plan (Shreffler 2004) called for the following post-project (effectiveness) monitoring tasks:

- Task 1: Repeat the shellfish population surveys using the same methods in years 3, 5, and 10.

It is important to note at the outset that all subsequent shellfish surveys after 2003 were conducted solely to set annual harvest limits for Tribal commercial clam digs. They were not intended to monitor shellfish recovery within the former log yard footprint. Although this area is commonly referred to as the Log Yard Beach, it is included in a larger area identified as Jamestown Reservation Tidelands, South End/Blyn, Beach ID No. 250069, certified for commercial harvest by the Washington State Department of Health. Because there were no harvestable clams within the log yard footprint itself, and there was concern about potential toxicity to shellfish in the vicinity of the former creosote pier and pilings, all harvest to date has been east of the former log yard footprint.

Clam surveys have been conducted by JST Natural Resources staff once annually through 2009 (Table 9.2) following the same protocols used in the pre-project surveys, as sanctioned by the Point No Point Treaty Council (1998). As a result of a new commercial dig management strategy, there was no clam survey conducted in 2010.

Table 9.2. Summary of annual clam surveys conducted at the Log Yard Beach (2004-2009).

Survey Date	Number of Transects	Total Number of Samples
August 2, 2004	10	87
July 19, 2005	8	80
July 10, 2006	14	67
July 30, 2007	9	58
July 2, 2008	8	44
September 2, 2009	13	54

Clam surveys are conducted at a low tide of -1.0 ft. Mean Lower Low Water (MLLW) or lower. At the -1.0 ft. tide, the surveyor walks and flags the water line along the entire length of the survey area. Then, at one end of the beach boundary, the surveyor takes a compass bearing along the pre-determined upper clam boundary (UCB). Using a random number table, the surveyor selects a number between 0-100. From the starting point, the surveyor paces that distance in feet along the compass bearing and places a survey flag in the substrate, thereby marking the start point of Transect 1. The distance from the start point to the first transect point is recorded as the first buffer width. From this first flag, the surveyor proceeds along the UCB bearing, pacing out and flagging every 100 feet to mark the start points of the subsequent transects. When the distance along the UCB from a transect line to the end of the beach is less than 100 feet, the surveyor ends the flagging and records the remaining distance as the second buffer width.

From the start of each transect flag, the surveyor determines a bearing that is approximately 90° from the direction of the UCB, and perpendicular to the water's edge. Using a random number table, the surveyor selects a number between 0-50 and paces that distance along the transect bearing. That becomes the first sample point along the transect and is marked with a flag through a sample bag that contains a water-proof label with the sample number. The surveyor continues to pace 50-foot intervals down the transect line to the -1.0 foot waterline, placing stakes and sample bags at each interval and records each distance paced and the sample number at each point. The surveyor repeats this process for each transect, using a new random number for the placement of the first sample station on each subsequent transect.

Other members of the survey team dig each sample to a depth of 8-12 inches within a 2-ft.^{2} wire frame, collecting and bagging all littleneck and manila clams ≥25mm. When the survey is complete and all samples have been dug, the contents of each sample are identified to species and measured to the nearest millimeter. Length measurements by species are entered into a computer spreadsheet developed by the Northwest Indian Fisheries Commission to analyze the survey data. Clam lengths are subsequently converted to weights using a standardized chart. The total weight for each clam species from all samples is calculated. Clams ≥ 25mm and clams ≥ 38mm are displayed separately. Survey data including compass bearings and transect lengths are entered into the spreadsheet to assist in calculating the total area of the survey. The average weight of each species of clam ≥ 38mm per square foot is extrapolated to the survey area and then to the entire beach area (910,404 ft.^{2}) to calculate the harvestable biomass for each species for that year.

RESULTS

While there was considerable annual variability with the location and amount of area surveyed, the Log Yard Beach has been shown to consistently have harvestable quantities of littleneck and manila clams, despite varying rates of harvest pressure (Table 9.3). As previously noted, ―Log Yard Beach" is a somewhat misleading name, as it does not include the former log yard footprint. The area surveyed between 2003 and 2009, and referred to as ―Log Yard Beach," was east of the former log yard footprint.

Table 9.3. Summary of harvestable clams at the Log Yard Beach (2004-2009).

Year	Species	Survey Area	Total Count ≥ 25mm	Total Weight (g) ≥ 25mm	Count ≥ 38mm	Weight (g) ≥ 38mm	Harvestable biomass (lb)
2004	Littleneck	910,404	876	17891	483	1337	11,668
2004	Manila	910,404	232	6962	219	6804	23,970
2005	Littleneck	341,210	1234	21097	621	14563	45,671
2005	Manila	341,210	211	5575	181	5248	21,725
2006	Littleneck	284,179	849	15138	351	9918	31,289
2006	Manila	284,179	151	3821	125	3532	17,764
2007	Littleneck	240,000	525	8410	212	5226	22,604
2007	Manila	240,000	153	3577	128	3265	18,644
2008	Littleneck	227,000	539	9824	287	7003	39,931
2008	Manila	227,000	148	3836	120	3526	26,534
2009	Littleneck	807,482	1118	19538	576	13514	82,874
2009	Manila	807,482	409	9166	321	8083	8,267

DISCUSSION

The S'Klallam people have used Sequim Bay as a traditional shellfish harvesting area for thousands of years (Gunther 1927). Currently Lower Sequim Bay continues to support both subsistence and Tribal commercial harvest operations. The lower bay is believed to be a nursery area for many species of fish and shellfish (See Chapter 12 Juvenile Salmonid Use: Beach Seine Monitoring).

Dethier (2006) documented the critical role native shellfish play in Puget Sound nearshore ecosystems. In addition to recreational, subsistence, and commercial harvest opportunities, native hardshell clams contribute to improved water quality by filtering nearshore waters and serve as predictable sources of food for natural predators such as moonsnails, seastars, crabs, and even diving seabirds.

The Estuary Design Group (EDG) believed that shellfish beds were lost or impaired within the log yard footprint during the 1892 – 2001 period of log yard operation in Lower Sequim Bay (Shreffler 2004); likely impacts included direct loss of habitat due to pier and piling construction, dredging, changes in sediment supply and grain size, accumulation of wood waste on the bottom, reduction in the area and density of eelgrass beds, and potential toxicity issues associated with creosote-treated pilings.

The shellfish recovery performance criterion established by the EDG in the Estuary Monitoring Plan (Shreffler 2004) was that any natural recovery of shellfish into the formerly impacted log yard footprint where harvestable shellfish did not exist would be an indication of success; and, that species composition and abundance should eventually be comparable to the adjacent areas currently supporting shellfish if site conditions allowed. No signs of natural shellfish recovery within the log yard footprint after 5 years would trigger the need for potential contingency measures.

Again, it should be noted that all post-project surveys and areas harvested to date have been east and outside of the log yard footprint. Anecdotally, there have been clams seen in one area of the former log yard that has suitable habitat of sand and gravel (Figure 9.2), but much of the former log yard area continues to be very muddy and hold differing quantities of woody debris from prior log yard operations (Figure 9.3) that would likely prevent shellfish from thriving within the former log yard footprint.

A reconnaissance survey is needed to determine if there are harvestable quantities of littleneck or manila clams in the former log yard area.

In order to determine if the criterion has actually been met in the formerly impacted log yard footprint, a reconnaissance survey should be conducted and would likely be sufficient to determine if there are harvestable quantities of littleneck or manila clams. Unlike the extensive surveys that are required to quantify biomass in order to set harvest limits, a reconnaissance survey can be used to subjectively assess relative clam density and size class. A reconnaissance survey consists of walking that portion of the beach at a low tide (-1.0 ft. or lower) and digging test holes at selected locations. Such an assessment would provide a qualitative picture of the status of the clam population and could provide direction for ―next steps" (e.g., are contingency measures warranted, such as removing wood waste in the prime elevation areas, supplementing the beach with sand and gravel, and seeding the area with littleneck or manila clams).

If clams are found within the former log yard footprint in harvestable quantities, a full survey should be conducted. Another appropriate action would be to ensure that the clams and surrounding sediments are free from residual polycyclic aromatic hydrocarbons (PAHs) that were leached from the 99 creosote-treated pilings removed in 2005 as part of the restoration effort. While rigorous testing of sediments and clam tissue was conducted before and after piling removal and found to be within acceptable levels according to the Washington Department of Ecology sediment standards and United States Environmental Protection Agency health risk assessment standards (Weston Solutions and Pasco Environmental Consulting 2006), it would be prudent to test sediments and tissue prior to any harvest of clams from within the former log yard footprint.

Figure 9.2. A band of clams within the former log yard footprint (photo by Chris Kaplan).

Figure 9.3. Woody debris beneath the surface in the former log yard footprint (photo by Chris Kaplan).

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CHAPTER 10. ADULT SALMONID USE: CHUM AND COHO ESCAPEMENT

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BACKGROUND

Restoration Objective – JCL Channel (Shreffler 2001) and Estuary (Shreffler 2004)
The restoration objective relative to salmonid use was to restore free access to the realigned JCL channel and the estuary for juvenile salmonids and returning adult spawners at all tidal elevations, and to provide better rearing and spawning habitat than what was available in the former JCL channel. The long-term goal is to restore the populations of salmonids in JCL to harvestable levels.

Restoration Rationale – JCL Channel (Shreffler 2001) and Estuary (Shreffler 2004)
The Channel Design Group (CDG) believed the Jimmycomelately Ecosystem Restoration Project would result in an increase in both habitat area and habitat functions, and that more habitat and better functioning habitat would result in more salmonids using the realigned JCL channel and estuary.

> On March 25, 1999 Hood Canal summer chum salmon were listed as threatened under the Endangered Species Act.

Anadromous fish species in the Jimmycomelately Watershed include summer chum salmon (*Oncorhynchus keta*), coho salmon (*O. kisutch*), winter steelhead (*O. mykiss*), and sea-run cutthroat trout (*O. clarki clarki*). These are all wild populations; no hatchery salmonids are released into JCL either at present, or have been historically (Shreffler 2000), with the exception of an emergency supplementation program (1999-2010) for summer chum salmon (see JCL Summer Chum Salmon Recovery Program below, as well as Scalf 2012).

Salmonids travel through Jimmycomelately (JCL) Creek both as juveniles during their seaward migration and as adults returning to spawn in JCL. In this chapter, however, we will focus on post-restoration monitoring results specifically for adult summer chum salmon and coho salmon escapement. Monitoring results for juvenile chum and coho use of JCL Creek and estuary are summarized in subsequent chapters of this report: Smolt Production (Chapter 11), Beach Seine Monitoring (Chapter 12), and Tidal Channel Monitoring (Chapter 13).

On March 25, 1999 Hood Canal summer chum salmon were listed as threatened under the Endangered Species Act. The summer chum salmon run to Jimmycomelately (JCL) Creek declined dramatically during the mid-1980s and was determined to be a genetically-distinct, native stock at high risk of extinction (WDFW and PNPTT 2000). Bernthal et al. (1999) rated the following limiting factors as having the highest impact to summer chum salmon in JCL: reduced channel complexity, sediment aggradation, diminished riparian area and functions, and lost and degraded estuarine habitat.

In August 1999 a summer chum salmon recovery plan was implemented in conjunction with an extensive habitat restoration plan that included returning the lower segment of JCL Creek to a sinuous channel, excavating a floodplain, and removing road and culvert constrictions to restore hydrologic functions to the lower channel and estuary. The new channel realignment was completed in 2004 and extensive estuary restoration occurred in 2005. Summer chum have returned to spawn in the new JCL channel since Brood Year 2005.

Summer Chum Salmon Life History

Of the salmonid species present in JCL, summer chum salmon are of the greatest concern, because of their dramatic population declines and federal listing as a threatened species. Chum salmon have the widest geographic distribution of all Pacific salmon species and historically chum salmon may have constituted up to 50% of the annual biomass of Pacific salmon in the North Pacific Ocean (Salo 1991).

The life history of summer chum salmon is unique among the five species of Pacific Salmon, because summer chum are among the earliest fish to return to their natal streams to spawn. In virtually every region of the chum salmon's geographic distribution, there are genetically distinct early and late returning stocks to the natal stream. Early or ―summer" chum can be distinguished from late or ―fall" chum by: (1) earlier entrance into spawning streams; (2) more developed reproductive products at time of entry into these streams; (3) an earlier spawning period; (4) smaller adult body size; (5) lesser fecundity; (6) larger egg size (7) earlier fry emergence; and (8) earlier downstream migration (Salo 1991, Tynan 1997).

These life history differences (i.e., spatial and temporal variations in spawning, rearing, and migration) ensure that summer chum and fall chum are reproductively isolated, and therefore genetically distinct. Self-sustaining summer chum populations require a mosaic of complex, dynamic, and interconnected freshwater, estuarine, and marine habitats through which they move to complete their life cycle (Bernthal et al. 1999). There are no fall chum in Jimmycomelately Creek.

In Jimmycomelately Creek, summer chum salmon return to spawn from late August through late October after two to five years of rearing in the northeast Pacific Ocean. Spawning fish are characterized by a calico pattern of purplish-red marks down each side and the metamorphosis of the head with its prominent canine-like teeth (Salo 1991, Tynan 1999, see photo below by Dave Shreffler).

The timing of the spawning migration typically coincides with the most frequent annual low flow period in JCL between September and November (see Chapter 1 Hydrology). Summer chum salmon have fecundities of 2,000 to 3,000 eggs/female on average. Eggs reach the eyed stage after 4-6 weeks of incubation in nests in the gravel called ―redds", and hatching occurs approximately 8 weeks after spawning. Alevins develop in the redds for an additional 10-12 weeks before emerging as fry between February and the last week of May. Peak fry emergence and downstream migration typically take place between March and April (see Chapter 12 Beach Seine Monitoring), but the exact timing varies year-to-year and is a function of water temperature and the number of temperature units (TU's) required for hatching and development.

METHODS

JCL Summer Chum Salmon Recovery Program

The goal of the recovery program was to contribute (within a 12-year time frame from 1999 to 2010) to the restoration of a healthy, natural, self-sustaining population of summer chum salmon that will maintain the genetic characteristics of the native JCL Creek stock (Scalf 2012). Artificial incubation and short term rearing were implemented to increase both the egg-to-fry survival rate and to supplement the number of adults returning to JCL Creek.

Using wild fish in a hatchery program to help recover a wild population is a relatively new approach and care was taken to address potential risks. WDFW and the Tribes developed and applied rigorous standards to minimize potential negative effects of the hatchery program. To fully represent the genetics and other characteristics of the JCL summer chum, the program was set up to use nearly all of the summer chum returning to JCL in the program since the returns were so low when the program was started. Adults were also collected proportional to the timing, weekly abundance, and duration of the entire adult return to JCL so that those characteristics were well represented. In addition, adults were collected near the most downstream point of observed spawning activity in JCL, so nearly all of the adults could be represented in the program. These and other standards for when to begin supplementing, how to supplement, and when to stop supplementing were successfully applied to the JCL program (WDFW and PNPTT 2000, 2007).

Returning summer chum adults were captured in a temporary trap in JCL Creek in the vicinity of the Highway 101 Bridge (Figure 10.1). The trap was in place from approximately mid-August through late-October each year between 1999 and 2010. A percentage of the returning spawners that were “ripe” (i.e., ready to spawn) were sacrificed to collect eggs and milt (sperm) (Figure 10.2). These sacrificed fish were called the “broodstock.” Adults in excess of the broodstock goal were passed upstream to spawn naturally (Figure 10.3).

The ripe broodstock fish were hand-spawned, and eggs and milt were placed in separate ziplock bags and transferred to coolers with ice (Figure 10.4). Ovarian fluid, kidney samples, and spleen samples were collected from the broodstock fish and sent to the WDFW Fish Pathology Lab to certify that these fish were disease-free (Figure 10.5). Scales, otoliths, and DNA samples were also taken from broodstock, as well as natural-spawned carcasses (Figure 10.6). After all biological sampling was completed, the carcasses of the sacrificed broodstock were carried upstream of the trap and deposited in the stream to provide nutrients back to the ecosystem (Figure 10.7).

The eggs and sperm collected at the trap site were then transported to the WDFW Hurd Creek Hatchery for initial incubation. Eggs were fertilized using factorial crosses, water hardened in iodophor solution, and placed in incubation units for rearing. Each female’s eggs were incubated in separate isolation buckets until the eggs were “eyed up.”

The eyed broodstock eggs were then divided into two groups and given distinct thermal otolith (ear bone) marks (Figure 10.6b). The thermal mark schedule was developed by Jeff Grimm of the WDFW Otolith Lab. The eyed eggs were then shipped to two incubation and rearing facilities along Jimmycomelately Creek: one at Valhalla Fish Farm off of Jimmycomelately Road, and one called the Woods Site off of Woods Road. The details of incubation and freshwater rearing at these two facilities are documented in Scalf (2012). Once the broodstock fry reached approximately one gram in size they were released into JCL Creek at the trap site (Figure 10.8).

Figure 10.1. Returning summer chum adults were captured in a temporary trap in JCL Creek, near the Highway 101 Bridge. The photos above show the trap site in August 2011 before and after trap installation (photos by Cheri Scalf).

Figure 10.2. Under the supervision of WDFW, a crew of NOSC volunteers sacrificed a percentage of the ripe summer chum spawners to collect eggs and milt (photo by Mike Hovis).

Figure 10.3. Adult summer chum in excess of the broodstock goal were passed upstream to spawn naturally (photo by Cheri Scalf).

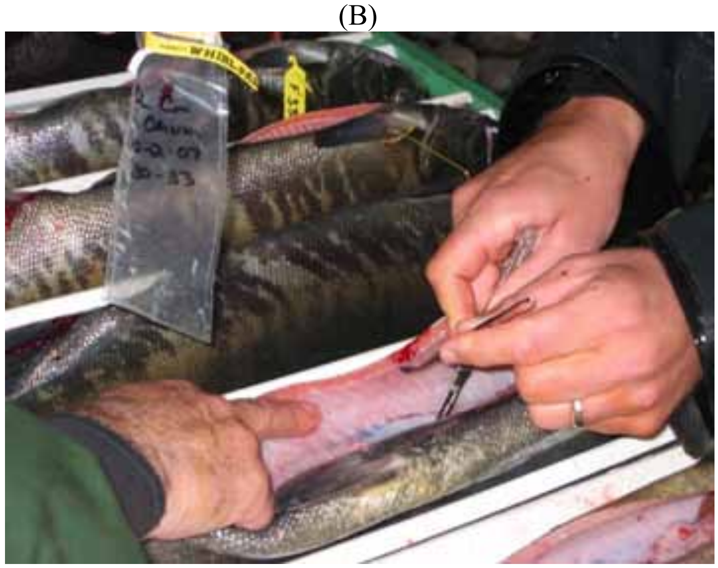
(A)

(B)

Figure 10.4. The ripe broodstock fish were hand spawned, and eggs (A) and sperm (B) were placed in separate ziplock bags and transferred to coolers with ice (photos by Dave Shreffler).

(A)

(B)



(C)

Figure 10.5. Ovarian fluid (A), kidney samples (B), and spleen samples (C) were collected from the broodstock fish (photos by Dave Shreffler).

(A)

(B)

(C)

Figure 10.6. Scales (A), otoliths (B) and DNA samples (C) were also taken from broodstock fish, as well as natural-spawned carcasses (photos by Tina Vogel (A-left), Dave Shreffler (A-right), Tina Vogel (B-left), WDFW Otolith Lab (B-right), Tina Vogel (C-left), Dave Shreffler (C-right)).

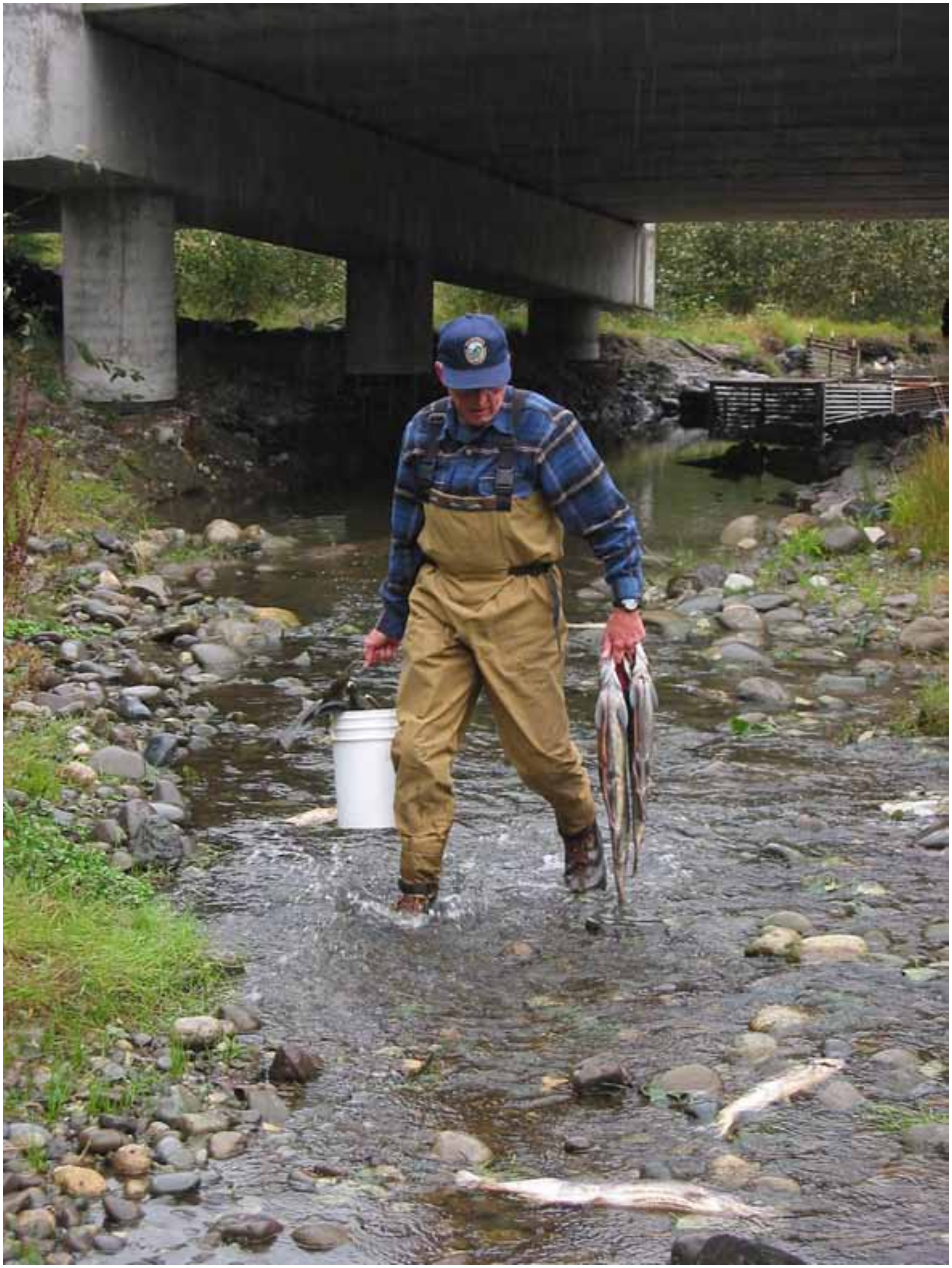


Figure 10.7. **After all biological sampling was completed, the carcasses of the sacrificed broodstock were carried upstream of the trap and deposited in the stream to provide nutrients back to the ecosystem (photo by Dave Shreffler).**

Figure 10.8. Releasing broodstock summer chum salmon fry into Jimmycomelately Creek (photos by Mike Hovis (left) and Luke Cherney (right).

NOSC volunteers, under the supervision of WDFW staff, contributed the majority of the monitoring and labor required to make the summer chum salmon recovery project successful; a remarkable total of 9,269 hours between 1999 and 2011 (Table 10.1).

Table 10.1. Jimmycomelately Creek summer chum salmon recovery project volunteer hours (1999-2011).

Year	Volunteer Hours
1999	143
2000	412
2001	785
2002	708
2003	959
2004	789
2005	872
2006	810
2007	775
2008	912
2009	921
2010	938
2011	247
TOTAL	**9,269**

<u>Summer Chum Upstream Extent of Spawning</u>

JCL Creek was surveyed annually by WDFW from 2005 to date to determine the upstream extent of summer chum spawning. The locations of all redds were recorded using a GPS unit, so that a map could be created of spawning locations. Summer chum are known as ―mass spawners,” meaning that one female will lay her eggs right on top of another females. In years with large numbers of returning spawners, it is not uncommon to see fish lined up from one bank to the other in some sections of the newly realigned JCL channel (Figure 10.9).

Figure 10.9. JCL summer chum salmon spawning upstream of the trap site (photo by Dave Shreffler).

Coho Redd Surveys
WDFW has surveyed JCL annually (1984-date) between river mile 0.0 (RM 0.0) and river mile 1.5 (RM 1.5), their ―index reach" for coho redds (Cooper 2012). Index reach surveys are conducted every 7 to 10 days for coho from late October to early January. There is a waterfall at RM 1.9, which is an impassable barrier that coho cannot get above.

Dates for first and last surveys include the earliest and latest spawning activity for coho. Data collected on index surveys include new and previously marked redd counts as well as live and dead fish counts. All redds observed are flagged to identify species number, week number, and consecutive redd number. To estimate the total number of coho adults within the index section, surveyors multiply the total number of new redds counted for the season by two adults (1 female and 1male per redd).

Detailed methods for redd identification, redd flagging, and spawning ground survey field forms are summarized in Cooper (2012).

RESULTS

Summer Chum Adult Trap

For each brood year from 1999-2010, we summarized the natural escapement, number spawned at the trap (male vs. female), number of redds downstream of the trap, total run size, percent of total run size removed for broodstock, total number of green eggs, total number of eyed eggs, number of fry released, fry release size, eyed egg to fry release survival, and fry release dates (Table 10.2).

Total run size varied from a low of 7 adult spawners in 1999 to a high of 4,027 spawners in 2010; the average escapement between 2004 and 2010 was 1,259 summer chum.

The total number of broodstock fry released varied from a low of 3,880 in 1999 to a high of 92,200 in 2009; the average number of broodstock fry released/year was 59,100. If the low release of 3,880 in 1999 is excluded, the average number of broodstock fry released/year was 64,120. Eyed egg to broodstock fry release survival was above 93% in 8 of the 12 brood years, and averaged 90.3% between 1999 and 2010.

Total run size varied from a low of 7 adult spawners in 1999 to a high of 4,027 spawners in 2010; the average escapement between 2004 and 2010 was 1,259 summer chum. A comparison of natural production vs. supplemented production is provided in Figure 10.10. Natural production refers to fish originating from eggs naturally spawned in Jimmycomelately Creek, both in the ―old” channel (pre-restoration) and in the ―new” channel following restoration of the creek in 2004. Supplementation production refers to fish produced from the JCL summer chum salmon recovery program between 1999 and 2010. Summer chum adults produced by fry releases from the supplementation program first returned to JCL in 2001. The program has been very successful and contributed 9, 55, 387, 1049, 817, 380, 185, 481, 2101 and 3288 summer chum adults to JCL during 2001 through 2010, respectively. Natural production has also increased from a range of 30 to 98 adults during 1996-1998 (prior to supplementation) to a range of 345 to 739 adults during 2004-2010 (after supplementation).

The magnitude and timing of summer chum returns to JCL between 2000 and 2011 is shown in Figure 10.11. The peak of the return was in September in every year, although in some years the peak was in early September and in other years it was later in September. During most years, the first adult returns were the week of August 22 – August 28and the last returns were the week of October 24 – October 30.

The age composition of the 2010 returning spawners (according to the scales from the 401 fish sampled) is as follows: 2 two-year olds (0.5%), 299 three-year olds (75.7%), 94 four-year olds (23.8%), and zero five-year olds (0%) (Scalf 2012). Six scales were unreadable. In 2010, zero (0) two-year olds, 63 three-year olds (76.8%), 19 four-year olds (23.2%) and zero five-year olds were sacrificed to be broodstock (Scalf 2012).

Summer Chum Upstream Extent of Spawning

Between 2005 and 2011, the upstream extent of summer chum natural spawning was upstream of the location where the old JCL channel was diverted into the realigned JCL channel in 2004 (Figure 10.12). In other words, while the majority of fish are spawning each year in the realigned portion of the JCL channel (the lower ~3/4 mile), some fish are definitely spawning each year in the unaltered natural channel above the diversion location. The furthest upstream extent of spawning was in 2010, which was also the year of the largest recorded return of JCL summer chum (4,027). As available spawning space becomes limited, more fish spawn further upstream.

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Table 10.2. Summary of JCL trap data and fry releases from the recovery program (1999-2010).

JIMMYCOMELATELY CREEK SUMMER CHUM SUPPLEMENTATION

BROOD YEAR	NATURAL ESCAPEMENT	NUMBER SPAWNED AT TRAP MALE	FEMALE	NUMBER REDDS DOWNSTREAM	TOTAL RUN	PER CENT REMOVED [a]	TOTAL NUMBER OF GREEN EGGS	TOTAL NUMBER OF EYED EGGS	NUMBER OF FRY RELEASED	RELEASE SIZE (gms)	EYED EGG TO RELEASE SURVIVAL	RELEASE DATES
1999	1	2	4	1	7	85.7%	6,257	4,130	3,880	1.0	93.9%	4/8/00
2000	9	33	13		55	83.6%	27,566	26,268	25,900	1.0	98.6%	4/20, 4/28/01
2001	192	36	32	20	284	26.1%	70,666	61,034	54,515	0.9-1.2	89.3%	4/17, 4/26/02
2002	6	21	15	4	57	85.7%	28,240	24,884	20,887	0.8-1.1	83.9%	4/7, 4/21/03
2003	369	37	39	25	458	17.1%	86,753	78,919	49,897	0.9-1.2	63.2%	3/26, 4/7, 4/16, 4/22, 4/26/04
2004	1,601	30	31	46	1,698	3.7%	85,380	82,276	76,982	0.7-1.0	93.6%	3/25, 3/30, 4/1, 4/8, 4/15/05
2005	1,223	31	30	24	1,310	4.9%	87,128	80,027	57,300	0.9-1.1	71.6%	3/27, 4/3, 4/14/06
2006	648	33	32	4	723	9.1%	92,412	80,851	79,428	1.0-1.2	98.2%	3/21, 3/30, 4/4, 4/10/07
2007	577	39	37	18	654	11.8%	96,117	75,757	73,811	1.0-1.2	97.4%	4/3, 4/10, 4/17, 4/24/08
2008	967	37	35	5	1,054	6.9.%	103,550	90,697	88,766	1.0-1.3	97.9%	3/16, 3/24, 3/30, 4/6,4/18/09
2009	2,540	43	43	2	2,628	3.3%	109,106	94,117	92,200	1.0-1.5	98.0%	3/13, 3/24, 3/27, 3/31, 4/7/10
2010	3,927	41	41	7	4,027	2.0%	109,996	87,373	85,630	1.1-1.6	98.0%	3/29, 3/31, 4/5, 4/16, 4/14/11

[a/] includes broodstock mortalities and excludes pre-escapement loss.

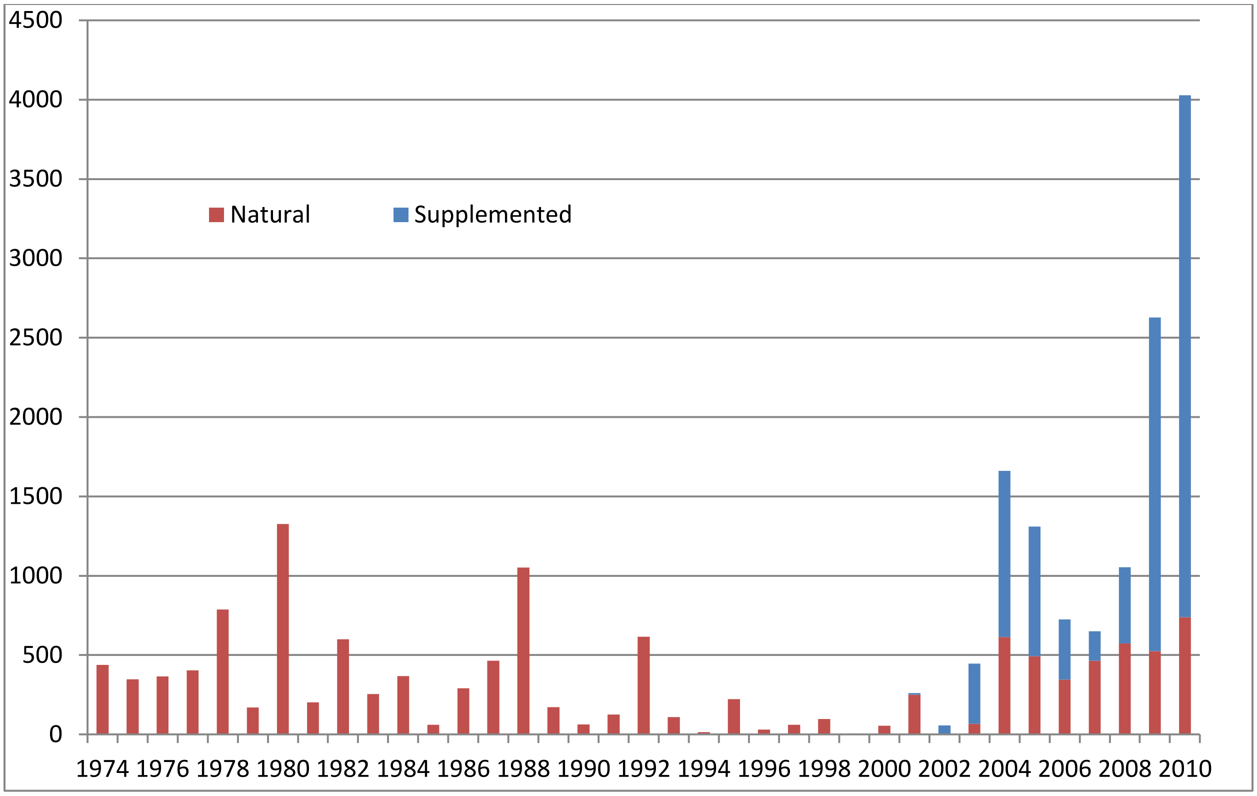

Figure 10.10. Comparison of natural production (red) vs. supplemented production (blue) for JCL Creek Summer Chum (1974-2010).

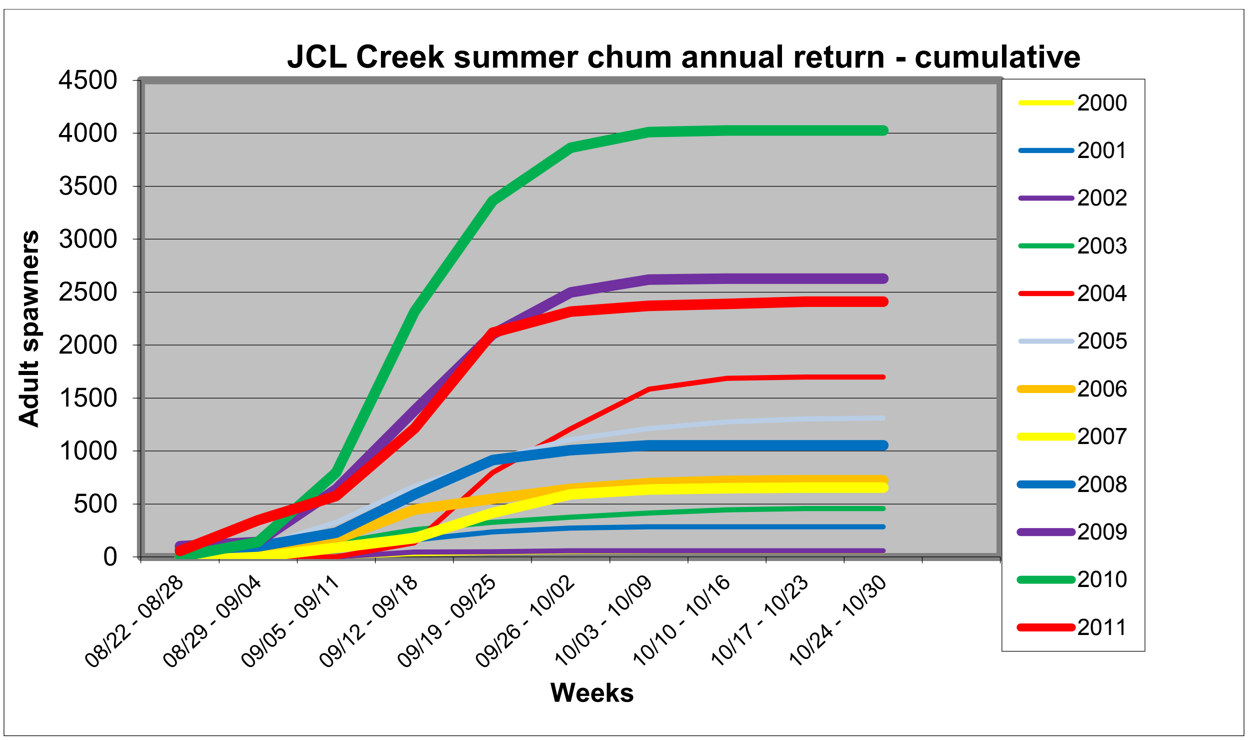

Figure 10.11. Magnitude and timing of summer chum salmon returns to JCL Creek (2000-2011).

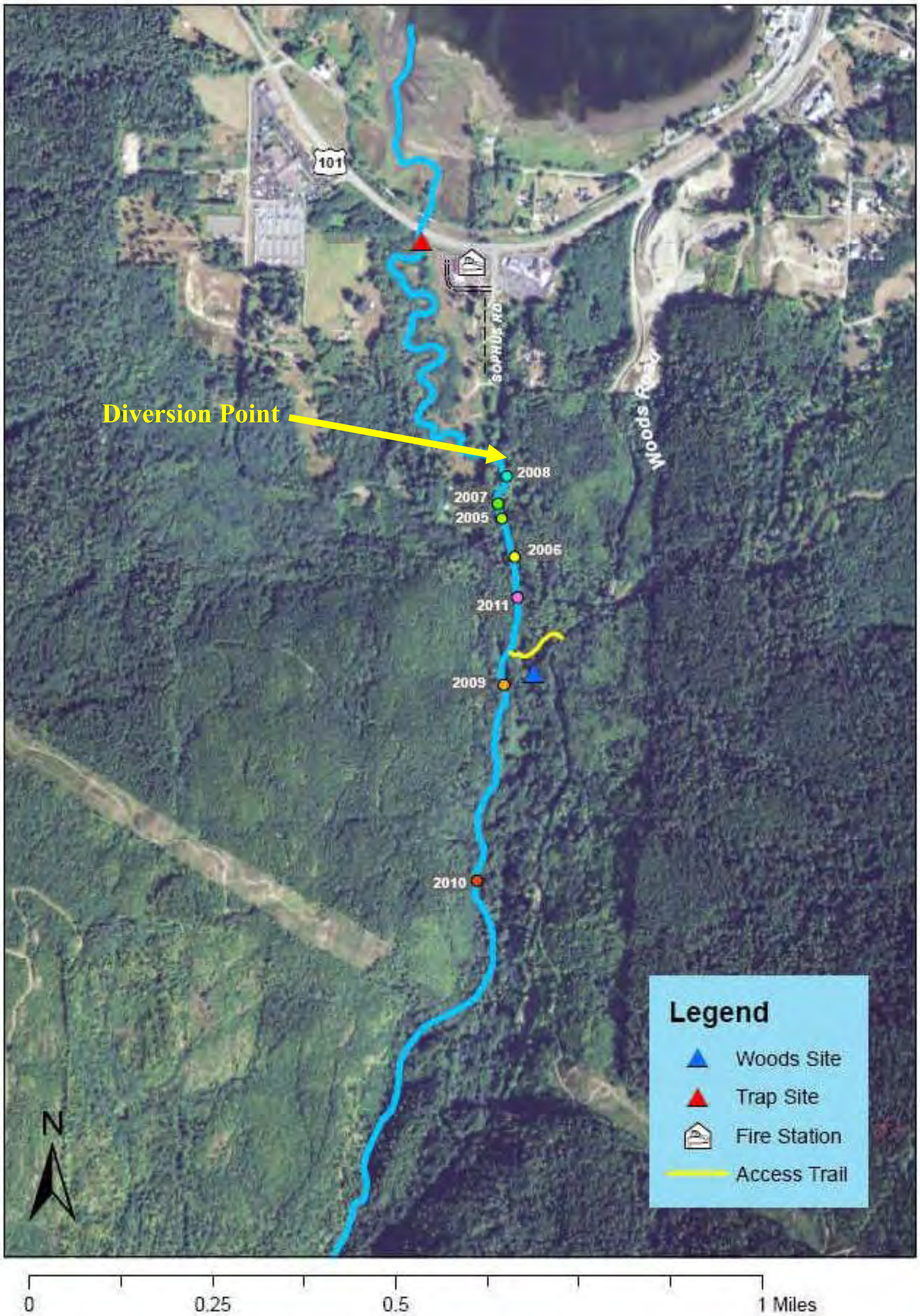

Figure 10.12. Upstream extent of summer chum spawning in Jimmycomelately Creek (2005-2011) (graphic by Cheri Scalf).

Coho Redd Surveys

Between 1984 and 2010, an average of 48 coho redds were found in JCL Creek, with a high of 213 redds in 2004 (Figure 10.13). There is no data for 1986. In 2011, 52 coho redds were found.

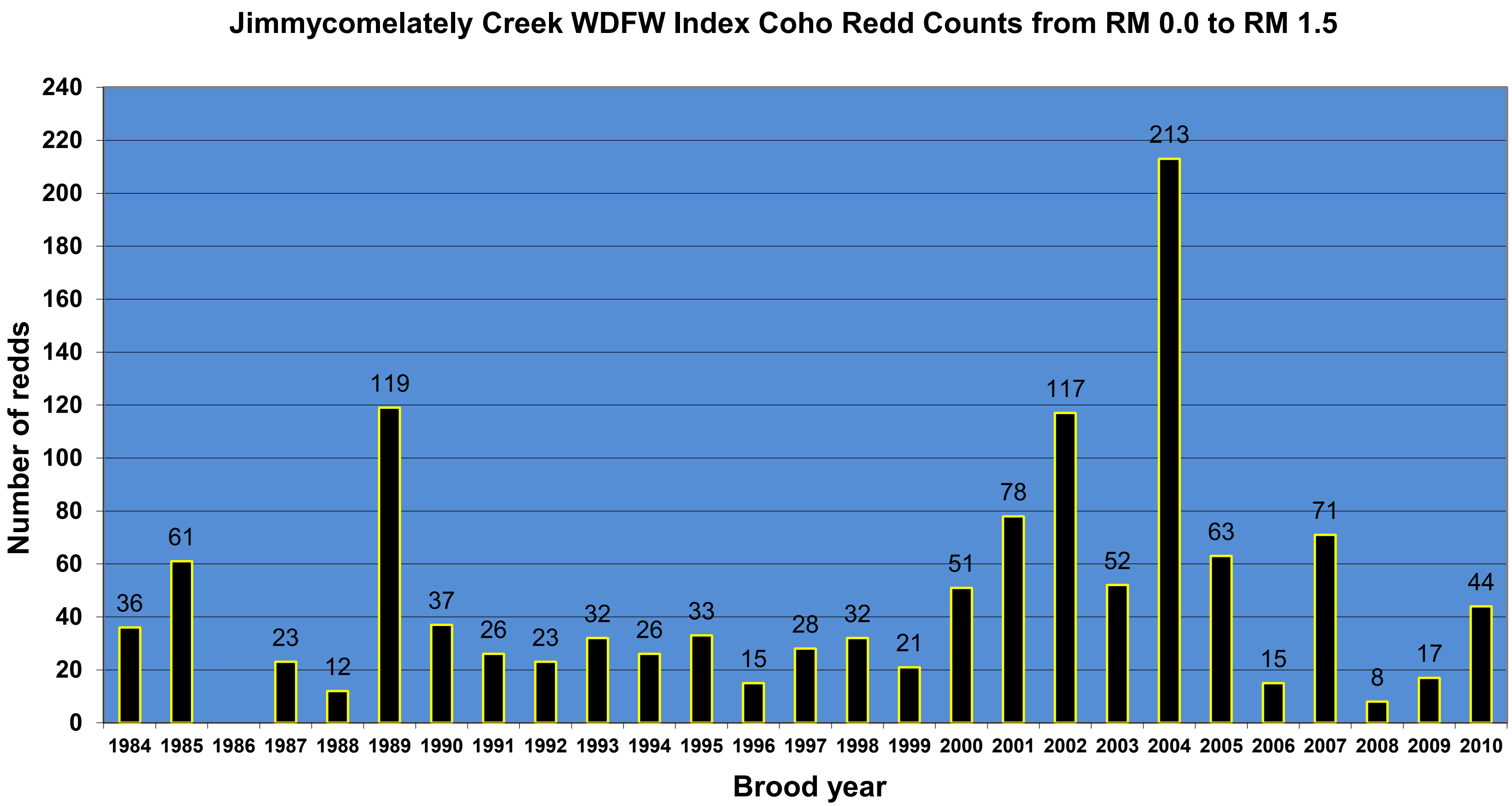

Figure 10.13. Jimmycomelately Creek coho redd counts from RM 0.0 to RM 1.5 for brood years 1984 – 2010.

DISCUSSION

Wild salmonids are an icon, a symbol of the “good life” in the Pacific Northwest (Kitchell 1997). Yet, much has been written about the precipitous decline of wild salmonids and the plethora of causes leading to the Pacific salmon crisis (Nehlson et al. 1991, NRC 1996, Stouder et al. 1997, Lichatowich 1999, Montgomery 2004, Lackey et al. 2006, and Fresh et al. 2011 to name a few). Thom et al. (2005) suggested that the challenge of balancing coastal development with restoring nearshore marine and estuarine ecosystems was the top priority for coastal researchers in this century.

Salmonids are often considered the ultimate integrator of ecosystem changes across a multitude of spatial and temporal scales in the Pacific Northwest, because of their complex anadromous life histories spanning the continuum of watershed, estuary, and ocean ecosystems.

Process-based restoration has been both hailed as part of the solution to the salmon crisis, and derided as a waste of time and money. While there is no consensus, the trend seems to be toward protection of remaining intact aquatic ecosystems, while simultaneously making strategic decisions on restoring important ecological processes and functions of impaired stream and nearshore habitats (Ralph and Poole 2003). Fresh et al. (2011) concluded that: “Coupling restoration with protection actions (which include reducing the likelihood of future degradation, such as through regulatory actions) offers the best opportunity to successfully restore Puget Sound.”

Salmonids are often considered the ultimate integrator of ecosystem changes across a multitude of spatial and temporal scales in the Pacific Northwest, because of their complex anadromous life histories spanning the continuum of watershed, estuary, and ocean ecosystems (Bottom et al. 1998, Wissmar and Simenstad 1998). As suggested by Vannote et al. (1980) and Bilby et al. (1996), large-scale declines of salmonid populations in many coastal watersheds may represent significant losses of trophic productivity and nutrient capital in Pacific Northwest streams and rivers, and reduced export of nutrients and organic matter from these streams and rivers may affect production in aquatic systems downstream from areas in which spawning occurs.

Salmonid carcasses and eggs have been shown to make a significant contribution of marine-derived nutrients to the freshwater ecosystems they inhabit (Kline et al. 1994, Bilby et al. 1996). Salmonid-derived organic matter is incorporated into stream biota through direct consumption of eggs and carcasses and by sorption onto the streambed substrate of dissolved organic matter released by decomposing eggs and carcasses. Salmonid eggs and carcasses are also a critical seasonal food source for as many as 30 species of wildlife, waterfowl, and raptors, and are incorporated into terrestrial vegetation through microbial processes. Decomposing salmonid carcasses and eggs may provide up to 40% of the diet of salmonid fry in some rivers and streams of the Pacific Northwest. Spawning salmonids are thus an ecologically significant source of organic matter and nutrients for coastal watershed ecosystems like the Jimmycomelately-Sequim Bay Ecosystem. Both metaphorically and literally, salmonids feed trees, and trees feed salmonids. Salmonids are a keystone species upon which the proper functioning of the entire continuum of freshwater, estuarine, and marine ecosystems depends (Shreffler 2000).

The influence of habitat restoration on numbers of returning adult spawners and the early life history of salmonids (especially Chinook salmon) has been investigated for other river systems. For example, Beamer et al. (2005) demonstrated how restoration of estuarine habitats could translate directly into an increase in the number of returning adult Chinook salmon in the Skagit River system. Long-term studies on the Salmon River, Oregon have documented an increase in the early life history pattern of Chinook salmon coinciding with an increase in habitat complexity resulting from estuarine habitat restoration (Bottom et al. 2005).

For Jimmycomelately Creek, the performance criterion established for adult summer chum salmon was (Shreffler 2003): *After 10 years, summer chum abundance and productivity numbers for JCL should be on a clear trajectory toward meeting the PNPTC/WDFW planning targets for 520 natural-production spawners (productivity = 1.0) and 330 natural-production spawners (productivity = 1.6). Escapement* is the number of natural-production adults that escape fisheries (i.e., supplemented-production fish from the summer chum salmon recovery project are not included). *Productivity* is a measure of survival, expressed here as recruits produced per spawner. *Recruits* are defined as the number of adult returns prior to fisheries interceptions.

The escapement criterion for JCL summer chum was not only met, but exceeded. Productivity data (recruits/spawner) were not available at the time this report was published, but productivity is being monitored by WDFW. We can see from Figure 10.10 that the performance criterion target of 330 natural-production spawners per year was exceeded every year from 2004 to 2010.

All indications at this point in time are that the combination of habitat restoration, harvest management, and the summer chum salmon supplementation program have put JCL summer chum salmon on a trajectory for recovery and may have saved them from extinction.

In 2010, 73 of the 398 sampled summer chum adult spawners (18.3%) were unmarked (i.e., natural-production origin); when expanded to the total returning spawner run (4,027), we calculated that 737 (18.3 % of 4,027) of the fish returning were of natural origin. The 737 natural origin spawners in 2010 along with the natural origin spawners from 2004 -2009 suggest that the Jimmycomelately Creek summer chum salmon are at a self-sustaining level (Scalf 2012). All indications at this point in time are that the combination of habitat restoration, harvest management, and the summer chum salmon supplementation program have put JCL summer chum salmon on a trajectory for recovery and may have saved them from extinction.

ESA-listed summer chum salmon spawner numbers (natural production + supplemented production combined) have increased dramatically from 7 in 1999 to an average of 1,259 between 2004 and 2010. The last year of summer chum salmon supplementation from the broodstock recovery program was 2010. Broodstock fry from 2010 could return as early as 2012, but most are predicted to return in 2013 (as 3-year old adults) or 2014 (as 4-year old adults). WDFW volunteers will continue to install and monitor the adult summer chum trap through at least 2014 or 2015, but all captured chum will be counted and released.

No performance criterion for adult coho salmon has been established by the State and Tribal co-managers or in the JCL monitoring plans. During the period from 1984 through 2010, the number of coho redds observed in JCL has been quite variable and has ranged from 8 redds to 213 redds per season (Figure 10.13). It is difficult to assess at this time, however, whether there are any changes in the number of coho redds that can be attributed to the JCL restoration project. The number of coho redds will continue to be monitored and, as more information becomes available, the relationship to the restoration of JCL habitats will be examined.

As noted by Roni et al. (2003), monitoring adult salmon returns is rarely the best strategy for detecting population effects of changes in freshwater habitat. Thus, because juvenile numbers are inherently less variable and more precise than adult counts, we report in the next three chapters on juvenile salmonid use of the Jimmycomelately Ecosystem.

ACKNOWLEDGMENTS

Washington Department of Fish and Wildlife made the adult summer chum and coho data available to us. In addition, we wish to acknowledge the amazing efforts of multiple North Olympic Salmon Coalition (NOSC) volunteers, too many to list, that have donated thousands of hours to ensure the recovery of JCL summer chum salmon. NOSC provided financial support for the salmon recovery supplementation project with an ALEA grant. Finally, Thom Johnson of the Point No Point Treaty Council improved this chapter with a thorough peer review and helpful suggestions and edits.

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CHAPTER 11. JUVENILE SALMONID USE: SMOLT PRODUCTION

- CHRISTOPHER BURNS (JAMESTOWN S'KLALLAM TRIBE)
AND THOM JOHNSON (POINT NO POINT TREATY COUNCIL)

BACKGROUND

Unlike for other monitoring parameters, neither of the two Jimmycomelately Ecosystem Restoration Project monitoring plans (Shreffler 2001, Shreffler 2004) specified a restoration objective, restoration rationale, or performance criteria for JCL smolt production.

Jimmycomelately (JCL) Creek supports populations of anadromous coho salmon, steelhead, cutthroat, and summer chum salmon and some resident fish (cutthroat and sculpins). Based on the amount and quality of available habitats, a stream like JCL can only successfully rear a certain number of each species. The number of juvenile salmonids outmigrating from JCL on their journey to saltwater is a good measure of anadromous fish freshwater production.

METHODS

Smolt trap monitoring began in Jimmycomelately (JCL) Creek in May of 2002 to determine freshwater production of juvenile salmonids in the system. Between 2002 and 2004 the smolt weir was located just upstream of Highway 101 in the ―old" JCL channel. In the spring of 2005 two downstream weirs were located in JCL Creek. One was located in the ―old" JCL channel slightly upstream of Highway 101, and another was located in the newly constructed channel, slightly downstream of Highway 101.

After 2005, and the abandonment of the old channel, Jamestown S'Klallam Tribe (JST) staff continued to trap smolts in the newly constructed channel in the vicinity of the Highway 101 Bridge. The weirs are essentially a fence in a "V" shape with the apex of the ―V" pointing downstream. A back-dam is placed at the apex of the weir to reduce approach velocity on the screens and to increase head pressure. A fish box was placed below the weir. All weir trap components were secured in the streambed and banks on top of Mirafi® anti erosion fabric using 7-ft. long, heavy-duty, steel fence posts, gravel bags and a series of steel cables (Figures 11.2 and 11.3). During high water events, weir screens are cleaned frequently of debris to prevent trap failure. ―Pop-out" panels were built into the weir panels; these panels can be pulled out during extremely high flows to allow the stream to flow through the trap with little resistance. The traps were fished 24 hours a day, 7 days a week from early April until late June, which is the typical time period of juvenile salmonid outmigration. There were some periods in some years during extremely high flows, however, when trap panels were removed and some fish likely migrated downstream without being counted.

All fish (salmonids and non-salmonids) outmigrating were counted by species, except chum fry which were small enough to pass through the weir screens. *Smolts* are juvenile salmonids that are going through an internal metabolic process (smoltification) that allows juvenile salmonids to adapt from freshwater to seawater with minimum stress. Salmonids undergoing smoltification become silver in appearance. *Parr* are juvenile salmonids in fresh water in their first or second year of life that have not gone through smoltification. Parr are darker than smolts and have dark spots and parr marks or dark bands on their sides. Parr tend to be smaller than smolts, usually less than 100 mm. *Juvenile* is used to describe young salmonids of all age groups.

Salmonid smolts were periodically measured for length (to the nearest millimeter) and weighed (to the nearest gram) to formulate length frequencies and to estimate condition factor throughout the trapping season. Length frequency provides a measure of the size distribution for each species. After the fish are counted and measured they are placed in a recovery container in the stream before being released downstream of the trap.

Other streams along the Eastern Strait of Juan de Fuca were trapped beginning in 1998 and compared to JCL. These streams included Bell Creek, Matriotti Creek (a tributary to the Dungeness River), McDonald Creek and Siebert Creek (Figure 11.1).

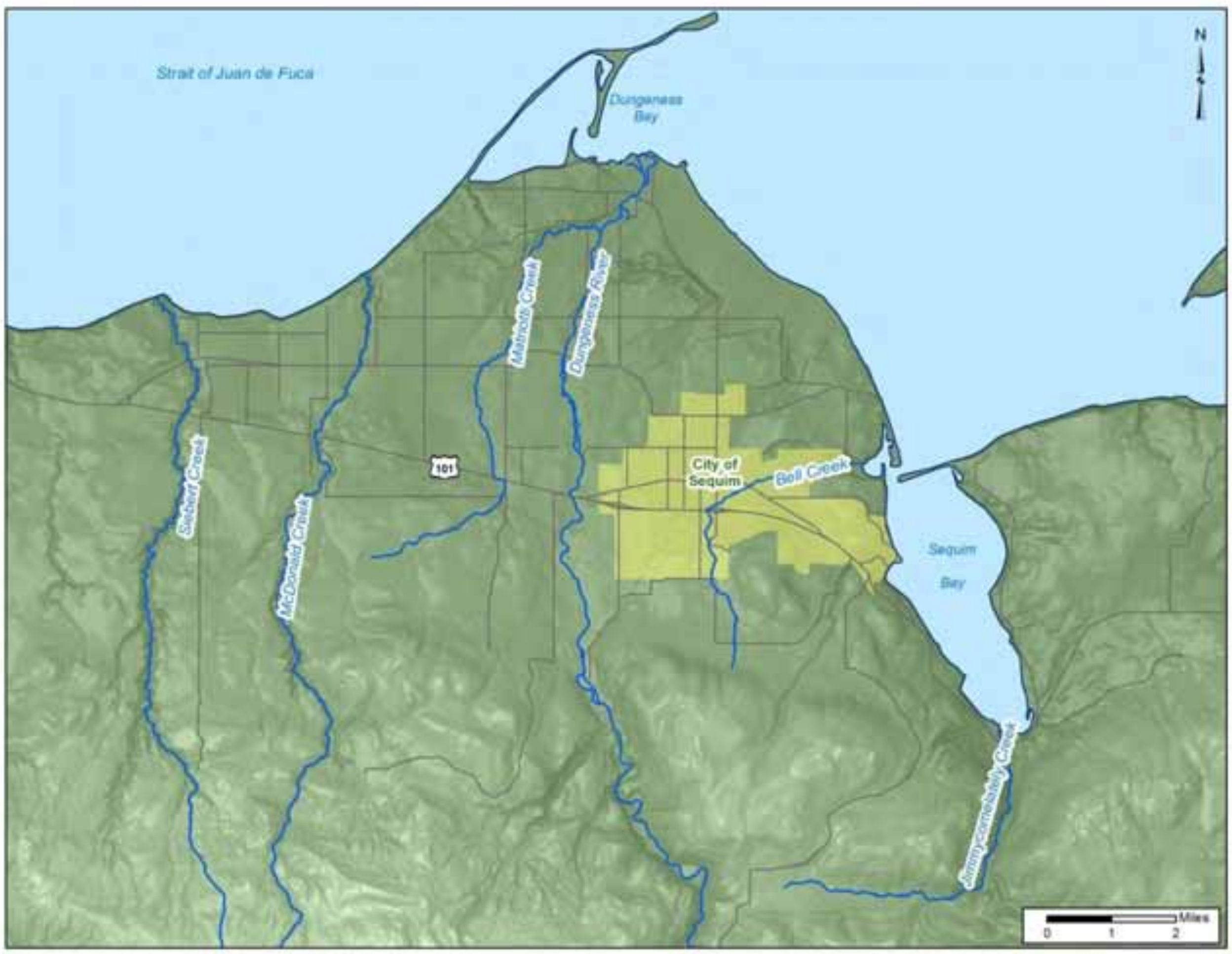


Figure 11.1. Tributaries along the Eastern Strait of Juan de Fuca monitored for freshwater production (via smolt-trapping) by the Jamestown S'Klallam Tribe (graphic by Christopher Burns).

Figure 11.2. Smolt weir in Jimmycomelately Creek, as seen from the Highway 101 Bridge looking downstream (photo by Christopher Burns).

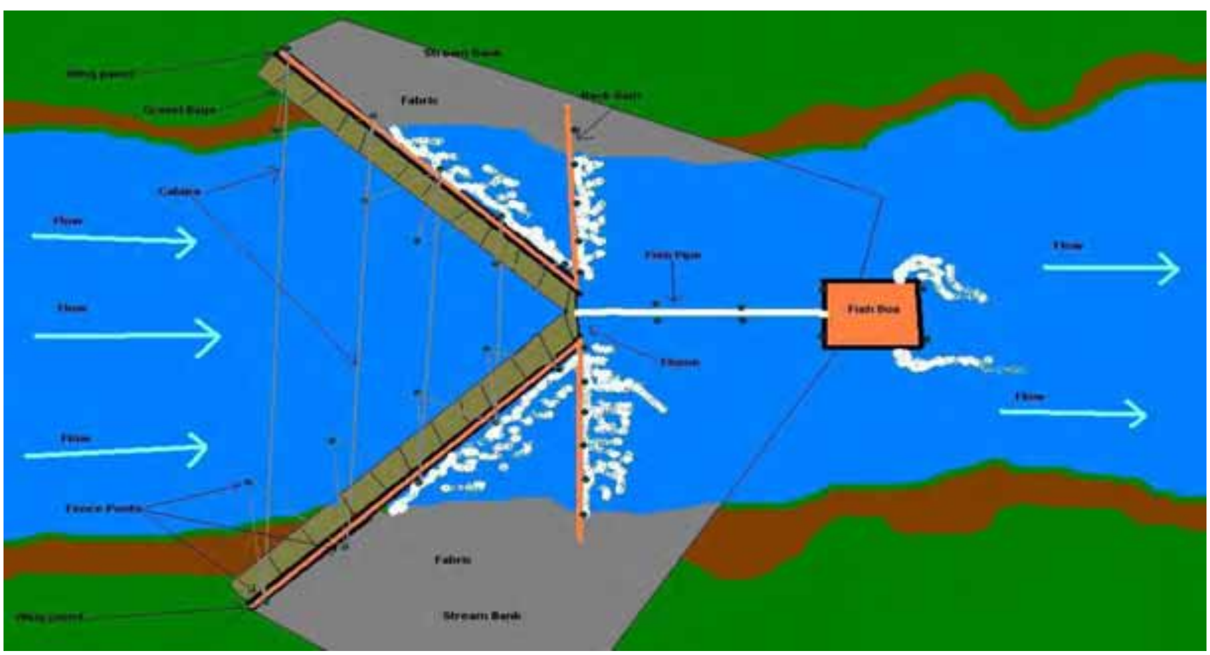
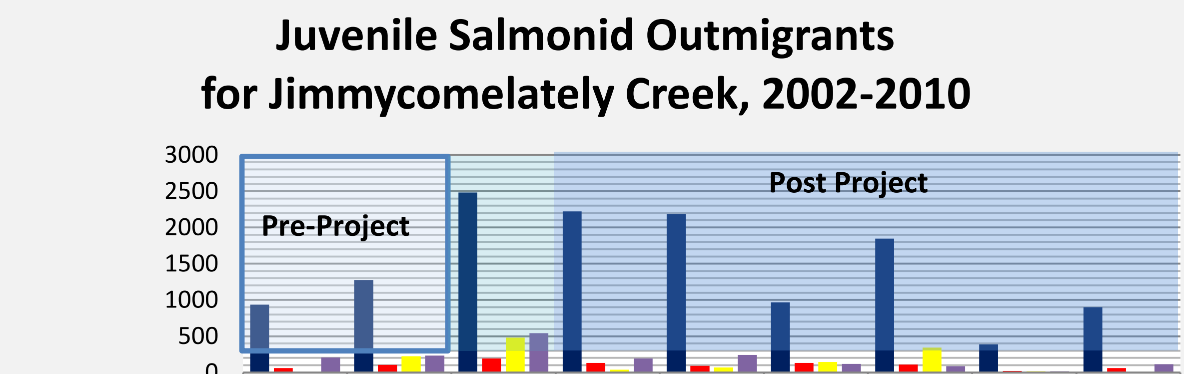


Figure 11.3. Diagram of a typical fence weir designed to trap outmigrating smolts (graphic by Christopher Burns).

RESULTS

Juvenile Salmonid Abundance

Salmonid outmigrant (coho smolts, steelhead smolts, steelhead parr, and juvenile cutthroat combined) production in Jimmycomelately Creek (JCL) has been variable since smolt monitoring began in 2002. Coho smolts are the most abundant salmonid smolts in the JCL system and have ranged from a low of 387 smolts in 2009 to a high of 2,482 smolts in 2004, with an average of 1,467 smolts from 2002 to 2010. Coho production was on an upswing leading up to and during new JCL channel construction and remained fairly steady through the opening of the new channel and de-watering and elimination of the old channel. Juvenile steelhead and cutthroat are not as abundant in the system as coho; however, steelhead and cutthroat followed the same production trends as coho pre- and post-project. Juvenile steelhead, cutthroat, and coho production numbers fell dramatically in 2009 and show a slight uptick in 2010 (Figure 11.4).



	2002	2003	2004	2005	2006	2007	2008	2009	2010
Coho Smolts	934	1274	2482	2220	2188	965	1846	387	902
Steehead Smolts	62	105	191	130	91	133	108	20	62
Steelhead Parr	0	224	481	39	68	146	342	17	1
Juvenile Cutthroat	208	234	541	195	242	118	87	14	112

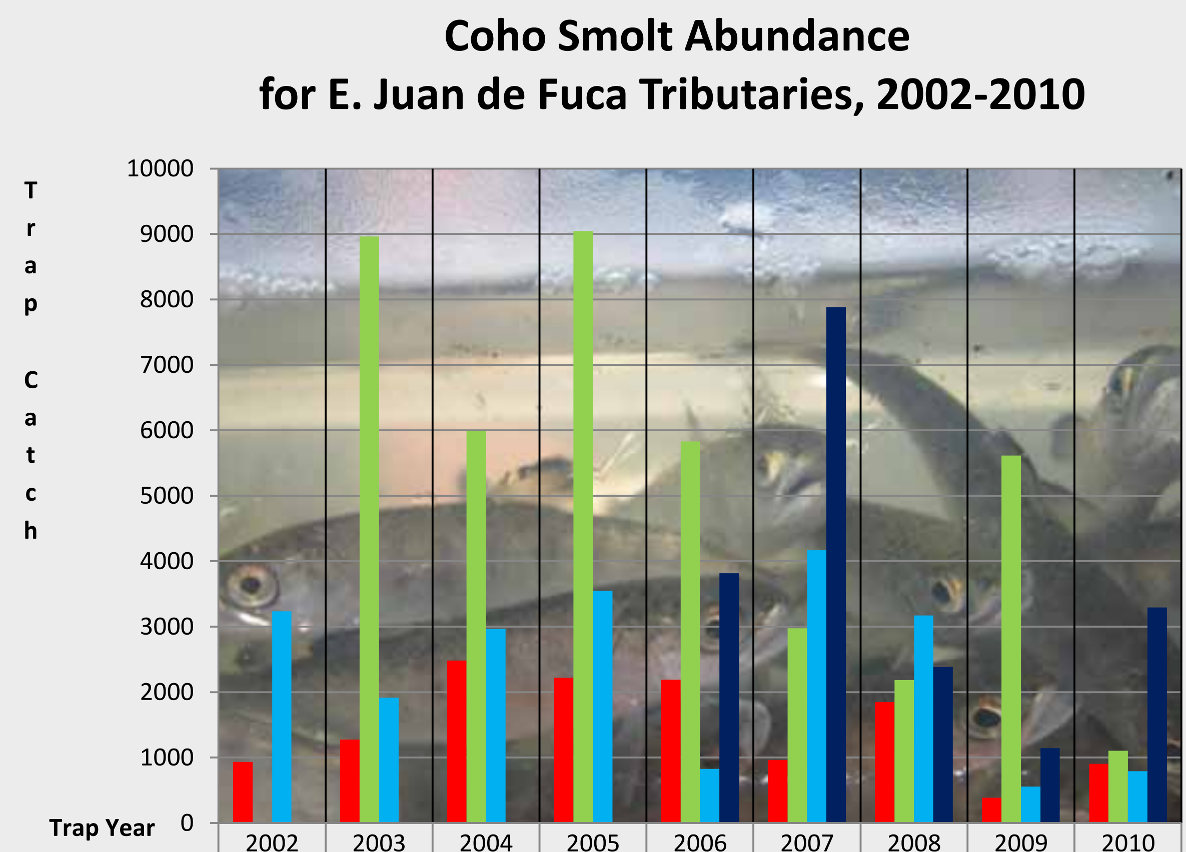
■ Coho Smolts ■ Steehead Smolts ■ Steelhead Parr ■ Juvenile Cutthroat

Figure 11.4. Juvenile salmonid outmigrants in Jimmycomelately Creek, smolt year 2002-2010. "Juvenile cutthroat" are smolts and parr combined.

Coho Smolt Production Estimates

When compared with other streams in the area, smolt production in JCL followed similar trends as neighboring streams along the Eastern Strait of Juan de Fuca from 2002 to 2007. In 2008 coho production in JCL nearly doubled relative to 2007, while production in Matriotti, McDonald, and Siebert decreased in 2008 relative to 2007.

Coho smolt trap catches in JCL, McDonald, and Siebert decreased from previous years during the 2009 outmigration season, while Matriotti showed a dramatic increase in coho production. In 2010 coho production in JCL and Siebert remained very low, while coho production in McDonald increased sharply. The data show significant year to year variability in coho smolt production both within creeks and between creeks (Figure 11.5).

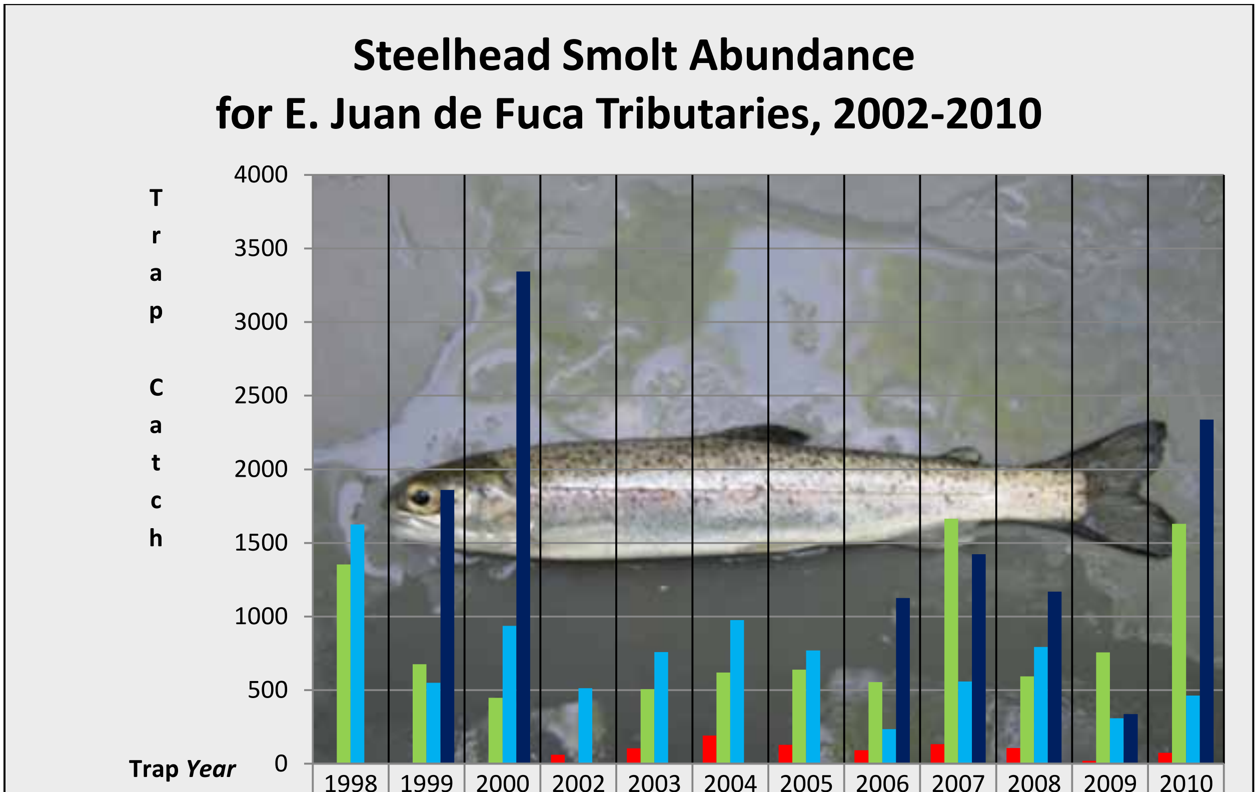


Trap Year	2002	2003	2004	2005	2006	2007	2008	2009	2010
JCL Coho	934	1274	2482	2220	2188	965	1846	387	906
Matriotti Coho	0	8963	5991	9045	5828	2974	2183	5613	1102
Siebert Coho	3235	1915	2966	3547	828	4167	3172	559	790
McDonald Coho	0	0	0	0	3818	7883	2387	1145	3294

Figure 11.5. Coho smolt abundance estimates for JCL, Matriotti, Siebert, and McDonald Creeks, 2002-2010.

Steelhead Smolt Abundance Estimates

Average steelhead smolt production between 2002 and 2010 was an estimated 102 steelhead smolts per year. Juvenile steelhead production in JCL has been very low overall since trapping began in 2002. When compared with other streams in the area, steelhead smolt production in JCL followed similar production trends as neighboring streams along the Eastern Strait of Juan de Fuca from 2002 to 2010 (Figure 11.6).

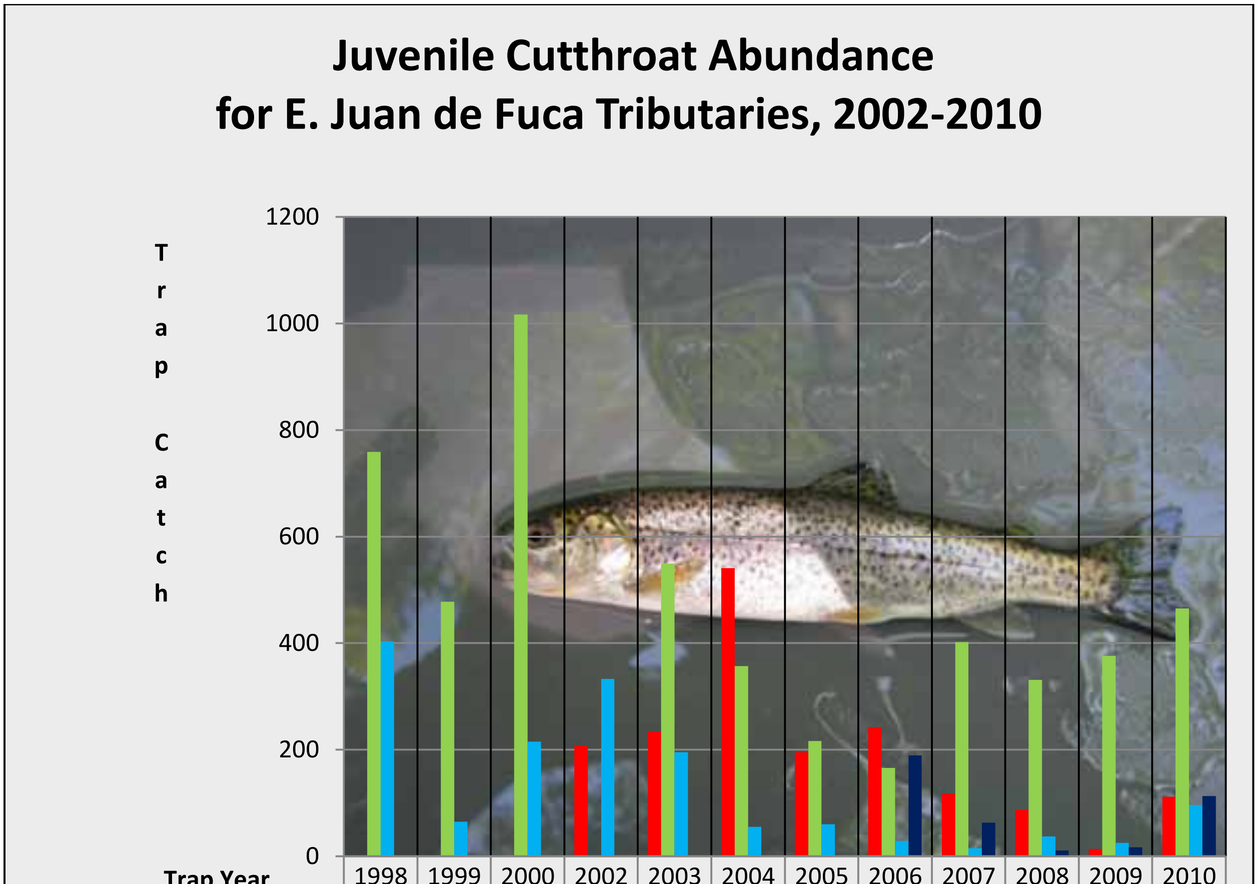


Trap Year	1998	1999	2000	2002	2003	2004	2005	2006	2007	2008	2009	2010
JCL Steelhead	0	0	0	62	105	191	130	91	133	108	20	74
Matriotti Steelhead	1353	676	448	0	508	619	640	555	1665	593	756	1629
Siebert Steelhead	1626	551	937	513	758	975	769	235	558	793	309	463
McDonald Steelhead	0	1861	3343	0	0	0	0	1125	1424	1170	337	2337

Figure 11.6. **Steelhead smolt abundance estimates for JCL, Matriotti, Siebert, and McDonald Creeks, 1998-2010. No trapping occurred in 2001.**

Juvenile Cutthroat Abundance Estimates

Average juvenile cutthroat production between 2002 and 2010 was an estimated 195 juvenile cutthroat of all age groups per year. When compared with other streams in the area, juvenile cutthroat production in JCL has not followed similar production trends as neighboring streams along the Eastern Strait of Juan de Fuca from 2002 to 2006. From 2007 to 2010 juvenile cutthroat production in JCL followed similar production trends as Siebert and McDonald, declining through 2009 and exhibiting a slight increase in production in 2010. In all years except 2004 and 2006, Matriotti Creek had the highest cutthroat smolt production among the four creeks (Figure 11.7).

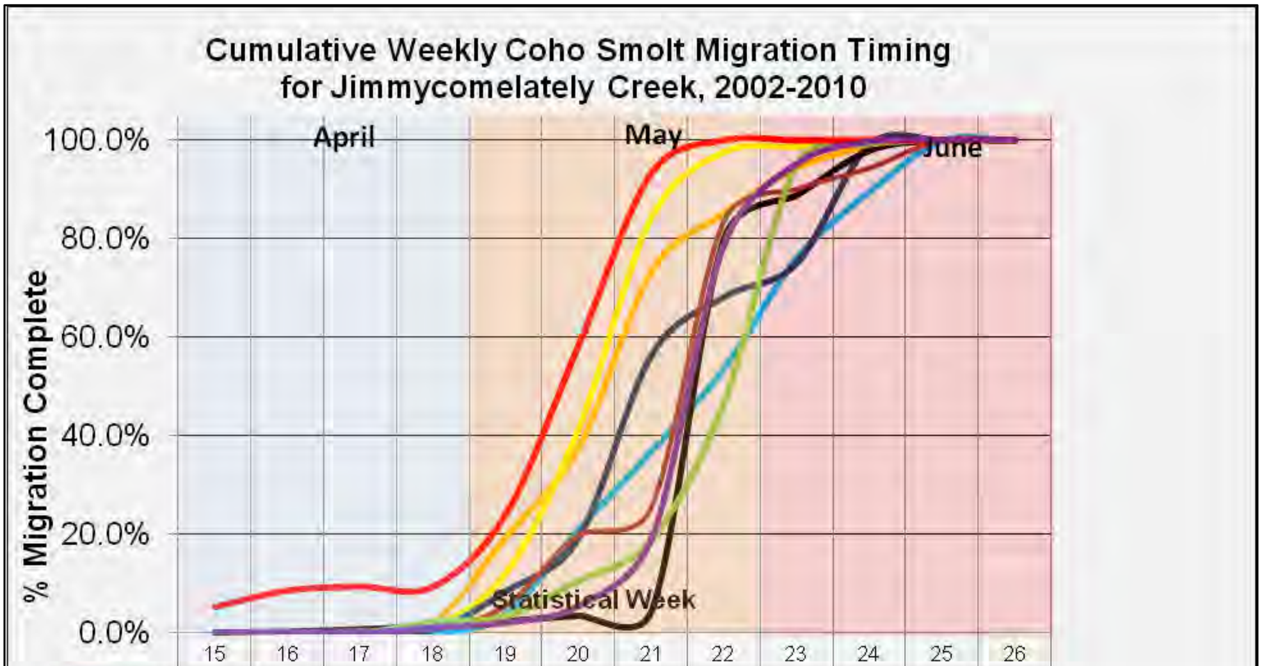


Trap Year	1998	1999	2000	2002	2003	2004	2005	2006	2007	2008	2009	2010
JCL Juv. Cutthroat	0	0	0	208	234	541	195	242	118	87	14	112
Matriotti Juv. Cutthroat	759	478	1017	0	549	357	216	166	402	331	376	465
Siebert Juv. Cutthroat	403	65	215	333	195	55	60	29	15	37	25	96
McDonald Juv. Cutthroat	0	0	0	0	0	0	0	189	63	11	17	113

Figure 11.7. **Juvenile cutthroat abundance estimates for JCL, Matriotti, Siebert, and McDonald Creeks, 2002-2010.No trapping occurred in 2001.**

Coho Smolt Outmigration Timing for Jimmycomelately

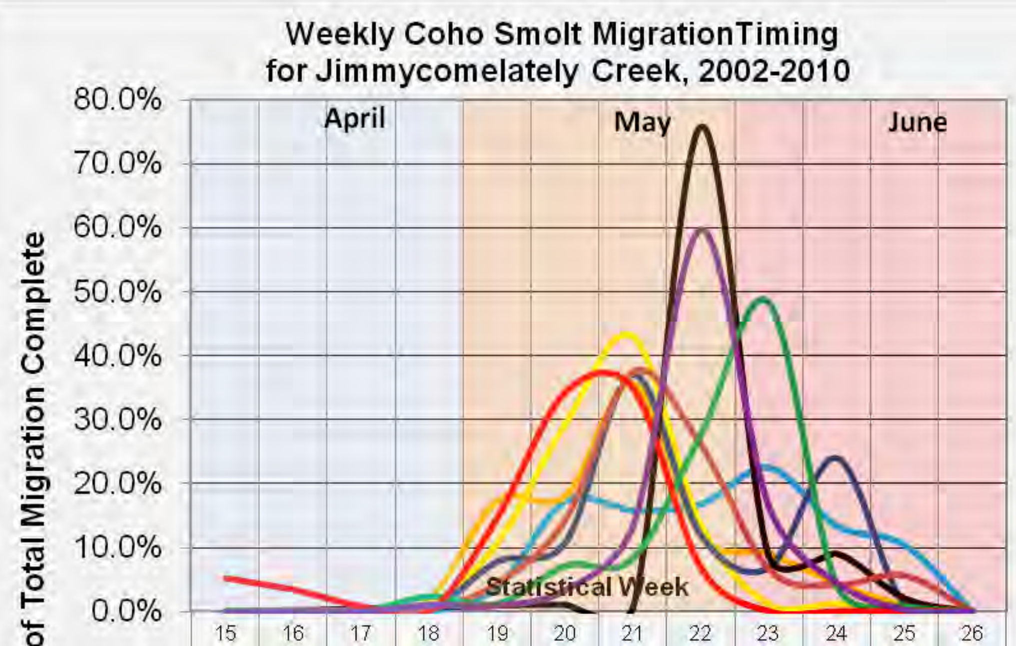
During 2002-2010, coho smolt migration timing in JCL consistently started in mid- to late April and ended around mid-June (Figure 11.8).



	15	16	17	18	19	20	21	22	23	24	25	26
2002	0.0%	0.0%	0.0%	0.0%	3.9%	21.1%	36.9%	53.7%	76.2%	89.6%	100.0%	100.0%
2003	0.0%	0.0%	0.0%	2.1%	19.5%	37.7%	73.4%	85.3%	94.4%	98.9%	100.0%	100.0%
2004	0.0%	0.0%	0.3%	1.4%	12.1%	41.4%	84.3%	97.7%	98.8%	99.9%	100.0%	100.0%
2005	0.0%	0.0%	0.4%	0.6%	8.5%	19.3%	56.4%	68.2%	75.1%	99.1%	100.0%	100.0%
2006	0.0%	0.2%	0.7%	1.3%	2.3%	3.4%	4.3%	80.2%	88.8%	97.9%	100.0%	100.0%
2007	0.0%	0.3%	0.5%	1.0%	5.5%	19.9%	25.3%	83.4%	90.1%	94.3%	100.0%	100.0%
2008	0.0%	0.0%	0.0%	2.3%	3.5%	10.6%	19.0%	46.8%	95.1%	99.1%	99.9%	100.0%
2009	5.17%	8.5%	9.3%	9.3%	24.0%	58.4%	93.3%	100.0%	100.0%	100.0%	100.0%	100.0%
2010	0.0%	0.0%	0.0%	1.1%	2.1%	5.5%	19.1%	78.8%	95.1%	99.7%	100.0%	100.0%

Figure 11.8. Cumulative weekly coho smolt migration timing for Jimmycomelately Creek, 2002-2010.

Coho smolt migration timing for JCL peaked at slightly different times from year to year. Generally migration began in April and peaked between mid-May and early June and ended in late June (Figure 11. 9).

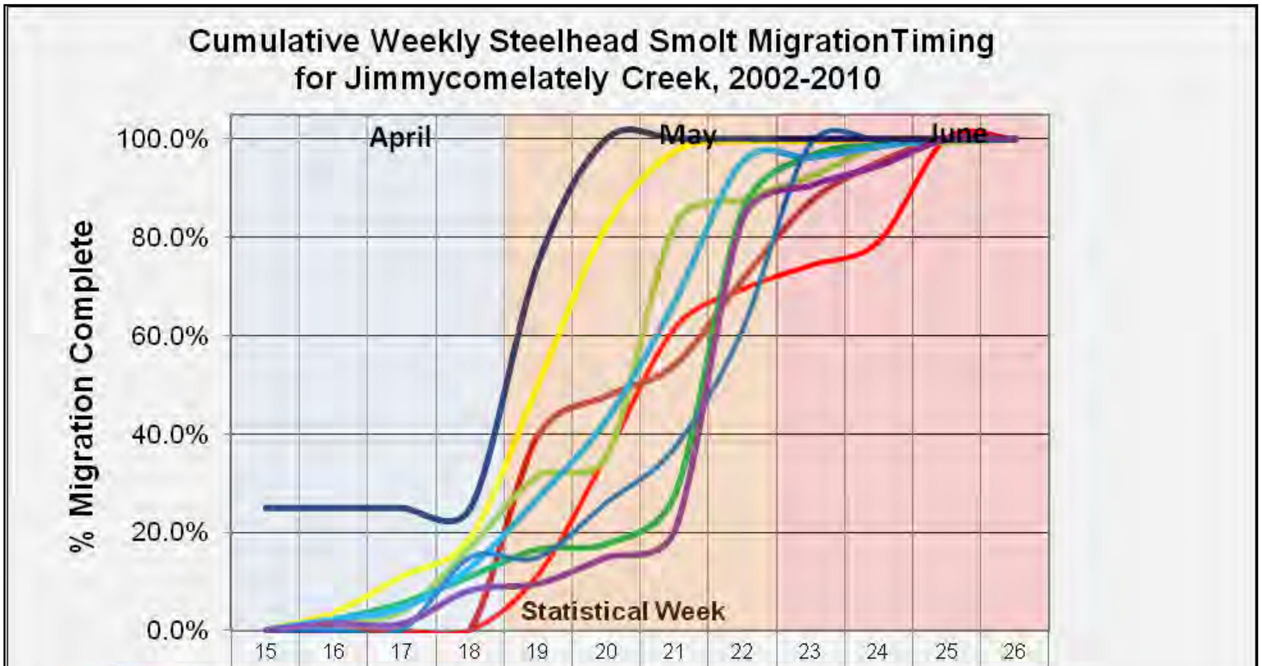


	15	16	17	18	19	20	21	22	23	24	25	26
2002	0.0%	0.0%	0.0%	0.0%	3.9%	17.2%	15.8%	16.8%	22.5%	13.4%	10.4%	0.0%
2003	0.0%	0.0%	0.0%	2.1%	17.4%	18.1%	35.7%	11.9%	9.1%	4.5%	1.1%	0.0%
2004	0.0%	0.0%	0.3%	1.1%	10.7%	29.3%	42.9%	13.3%	1.1%	1.2%	0.1%	0.0%
2005	0.0%	0.0%	0.4%	0.2%	7.9%	10.8%	37.1%	11.8%	6.9%	24.0%	0.9%	0.0%
2006	0.0%	0.2%	0.5%	0.6%	1.0%	1.1%	0.9%	75.9%	8.6%	9.1%	2.1%	0.0%
2007	0.0%	0.3%	0.2%	0.5%	4.5%	14.4%	37.5%	26.0%	6.6%	4.2%	5.7%	0.0%
2008	0.0%	0.0%	0.0%	2.3%	1.1%	7.2%	8.3%	27.8%	48.3%	4.0%	0.8%	0.1%
2009	5.17%	3.36%	0.78%	0.00%	14.73	34.37	34.88	6.72%	0.00%	0.00%	0.00%	0.00%
2010	0.0%	0.0%	0.0%	1.1%	1.0%	3.4%	13.6%	59.7%	16.3%	4.5%	0.3%	0.0%

Figure 11.9. Weekly coho smolt migration timing for Jimmycomelately Creek, 2002-2010.

Steelhead Smolt Outmigration Timing for Jimmycomelately

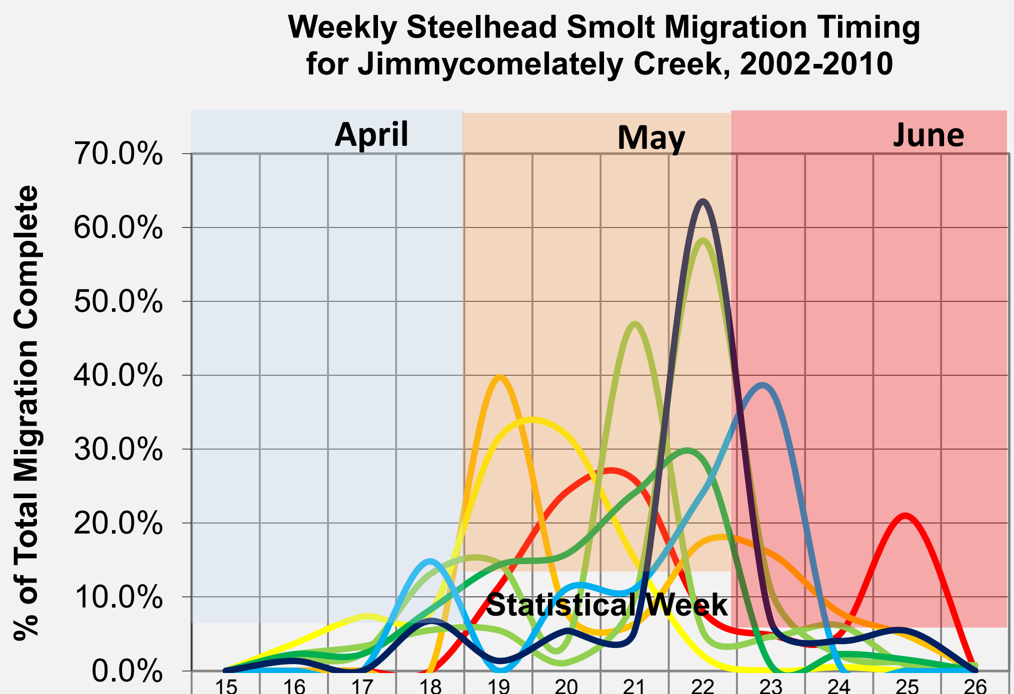
During 2002-2010, steelhead smolt migration timing in JCL consistently started in early April and ended around late June (Figure 11.10).



	15	16	17	18	19	20	21	22	23	24	25	26
2002	0.0%	0.0%	0.0%	0.0%	11.3%	35.5%	61.3%	69.4%	74.2%	79.0%	100.0	100.0
2003	0.0%	0.0%	0.0%	0.0%	39.7%	47.6%	54.0%	71.4%	87.3%	95.2%	100.0	100.0
2004	0.0%	3.7%	11.0%	18.8%	50.3%	82.2%	97.4%	99.5%	99.5%	100.0	100.0	100.0
2005	0.0%	1.5%	3.8%	16.9%	31.5%	35.4%	82.3%	87.7%	92.3%	98.5%	99.2%	100.0
2006	0.0%	2.2%	5.5%	11.0%	16.5%	17.6%	27.5%	85.7%	96.7%	98.9%	100.0	100.0
2007	0.0%	2.3%	4.5%	12.8%	27.1%	42.9%	66.9%	95.5%	96.2%	98.5%	100.0	100.0
2008	0.0%	0.0%	0.0%	14.8%	14.8%	25.9%	37.0%	61.1%	99.1%	100.0	100.0	100.0
2009	25.00	25.0%	25.0%	25.0%	75.0%	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2010	0.00%	1.4%	1.4%	8.1%	9.5%	14.9%	20.3%	83.8%	90.5%	94.6%	100.0	100.0

Figure 11.10. Cumulative weekly steelhead smolt migration timing for Jimmycomelately Creek, 2002-2010.

Steelhead smolt migration timing for JCL varied a bit from year to year. For all years, migration generally began in April with major peaks occurring during May or early June and ending in late June. During 2002 the migration peaked during mid-May followed by a lesser peak in mid-June. Year 2003 was similar to 2002 in that outmigration peaked in early May followed by a lesser peak in late May. During the 2005 and 2008 seasons steelhead migration started with a small peak in late April and early May followed by major peaks in late May and early June. During other years steelhead migration peaked only once. During 2004 the steelhead migration peaked in early May. During 2006, 2007 and 2010 the steelhead migration peaked during the last week of May. During 2009 steelhead catches were sporadic and few, making migration timing calculations extraneous; thus, 2009 data are not included in Figure 11.11.

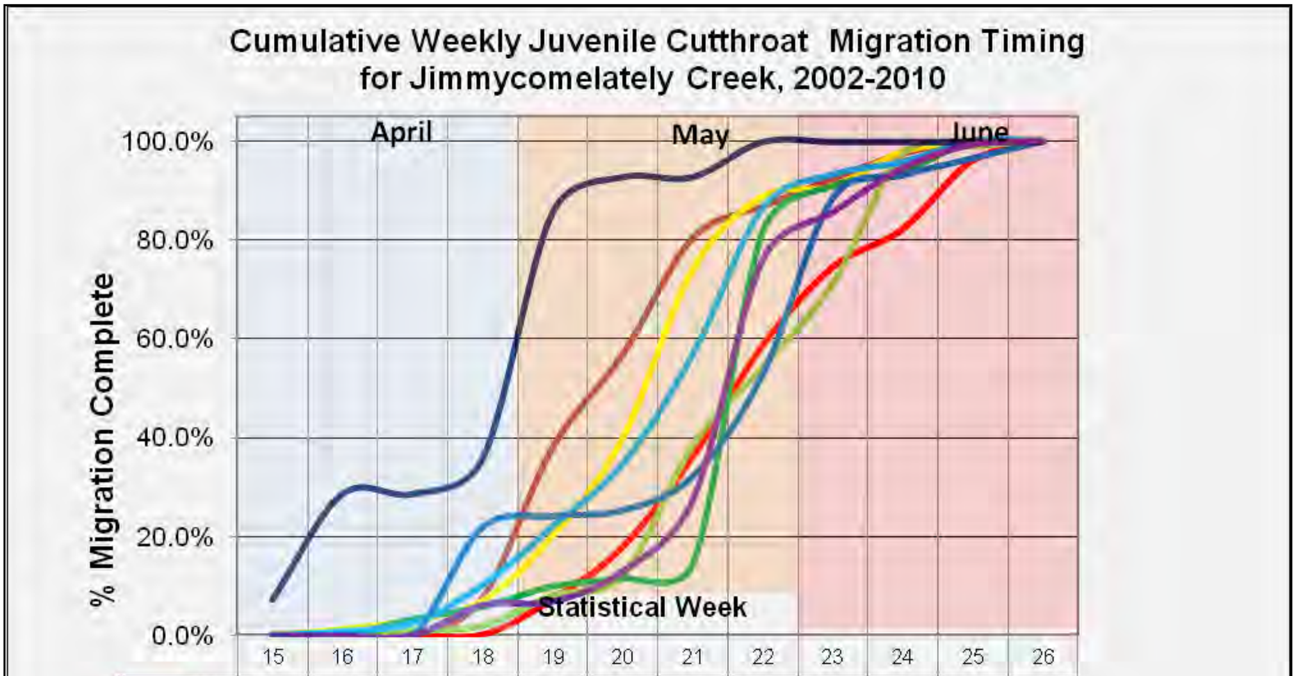


	15	16	17	18	19	20	21	22	23	24	25	26
2002	0.0%	0.0%	0.0%	0.0%	11.3%	24.2%	25.8%	8.1%	4.8%	4.8%	21.0%	0.0%
2003	0.0%	0.0%	0.0%	0.0%	39.7%	7.9%	6.3%	17.5%	15.9%	7.9%	4.8%	0.0%
2004	0.0%	3.7%	7.3%	7.9%	31.4%	31.9%	15.2%	2.1%	0.0%	0.5%	0.0%	0.0%
2005	0.0%	1.5%	2.3%	13.1%	14.6%	3.8%	46.9%	5.4%	4.6%	6.2%	0.8%	0.8%
2006	0.0%	2.2%	3.3%	5.5%	5.5%	1.1%	9.9%	58.2%	11.0%	2.2%	1.1%	0.0%
2007	0.0%	2.3%	2.3%	8.3%	14.3%	15.8%	24.1%	28.6%	0.8%	2.3%	1.5%	0.0%
2008	0.0%	0.0%	0.0%	14.8%	0.0%	11.1%	11.1%	24.1%	38.0%	0.9%	0.0%	0.0%
2010	0.0%	1.4%	0.0%	6.8%	1.4%	5.4%	5.4%	63.5%	6.8%	4.1%	5.4%	0.0%

Figure 11.11. Weekly steelhead smolt migration timing for Jimmycomelately Creek, 2002-2010.

Juvenile Cutthroat Outmigration Timing for Jimmycomelately

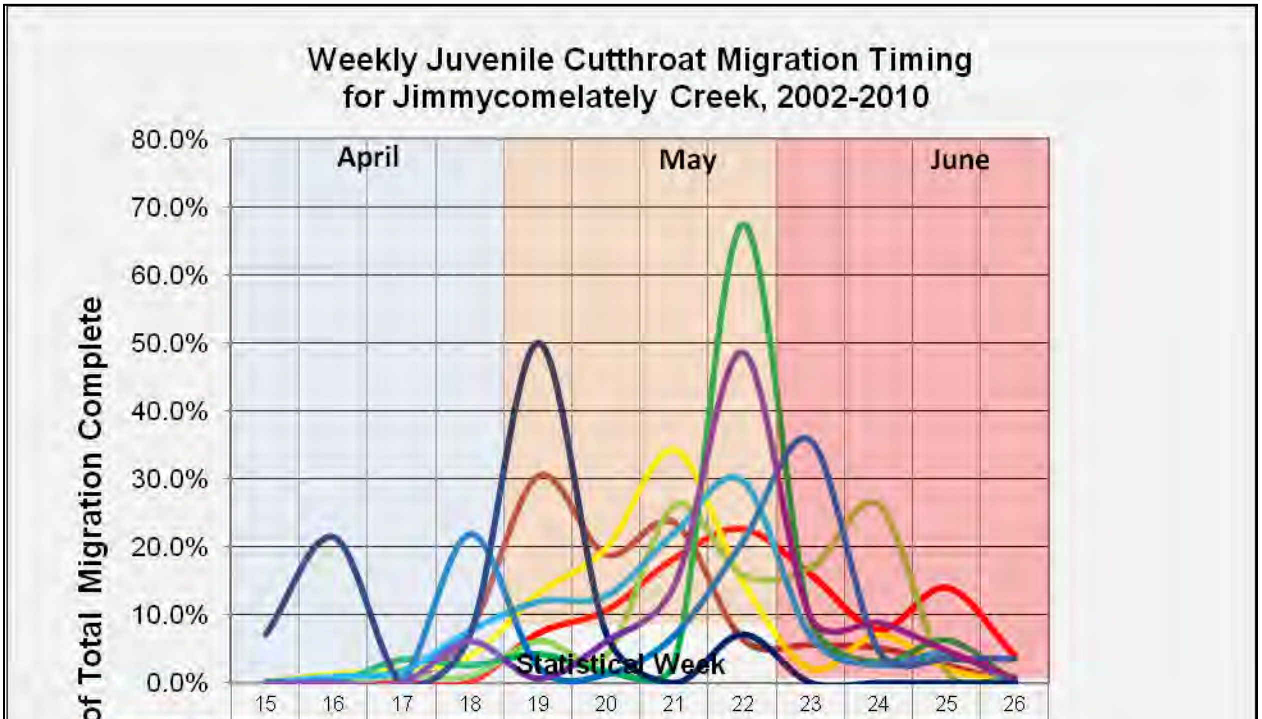
Juvenile cutthroat migration timing in JCL from 2002-2010 consistently started in early April and ended during late June (Figure 11.12).



	15	16	17	18	19	20	21	22	23	24	25	26
2002	0.0%	0.0%	0.0%	0.0%	7.2%	17.8%	36.1%	58.7%	74.5%	82.2%	96.2%	100.0
2003	0.0%	0.0%	0.0%	7.7%	38.0%	56.8%	80.3%	86.8%	92.3%	97.4%	100.0	100.0
2004	0.0%	1.3%	3.1%	7.0%	20.1%	39.9%	74.1%	88.9%	90.9%	98.0%	100.0	100.0
2005	0.0%	0.0%	1.0%	2.1%	8.2%	12.3%	38.5%	54.4%	71.3%	97.4%	99.0%	100.0
2006	0.0%	0.0%	3.3%	5.8%	9.9%	11.6%	14.5%	81.8%	90.9%	93.8%	100.0	100.0
2007	0.0%	0.8%	2.5%	10.2%	22.0%	34.7%	56.8%	86.4%	93.2%	95.8%	100.0	100.0
2008	0.0%	0.0%	0.0%	21.8%	24.1%	25.3%	32.2%	52.9%	88.5%	93.1%	96.6%	100.0
2009	7.1%	28.6%	28.6%	35.7%	85.7%	92.9%	92.9%	100.0	100.0	100.0	100.0	100.0
2010	0.0%	0.0%	0.0%	6.2%	6.8%	13.0%	27.4%	76.0%	85.6%	94.5%	99.3%	100.0

Figure 11.12. Cumulative weekly juvenile cutthroat migration timing for Jimmycomelately Creek, 2002-2010.

Juvenile cutthroat migration timing for JCL peaked at slightly different times from year to year. For all years migration generally began in April, peaked between May and early June, and ended in late June (Figure 11.13).

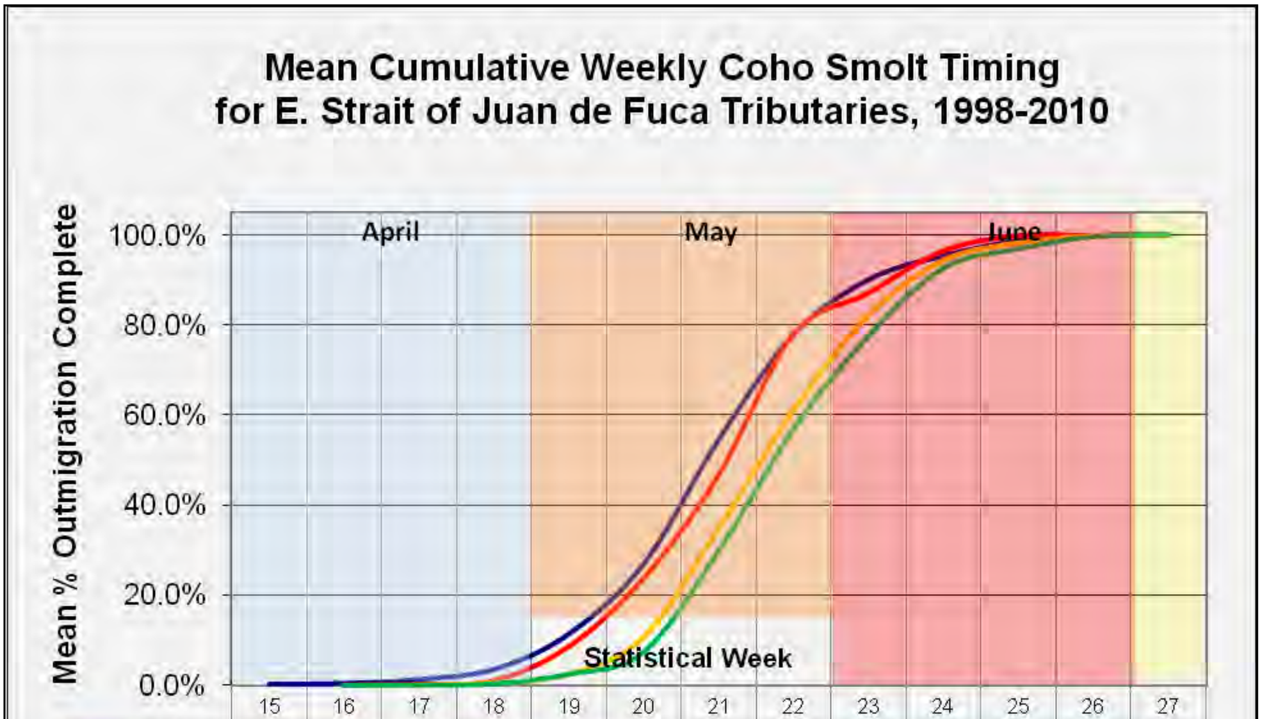


	15	16	17	18	19	20	21	22	23	24	25	26
2002	0.0%	0.0%	0.0%	0.0%	7.2%	10.6%	18.3%	22.6%	15.9%	7.7%	13.9%	3.8%
2003	0.0%	0.0%	0.0%	7.7%	30.3%	18.8%	23.5%	6.4%	5.6%	5.1%	2.6%	0.0%
2004	0.0%	1.3%	1.8%	3.9%	13.1%	19.8%	34.2%	14.8%	2.0%	7.0%	2.0%	0.0%
2005	0.0%	0.0%	1.0%	1.0%	6.2%	4.1%	26.2%	15.9%	16.9%	26.2%	1.5%	1.0%
2006	0.0%	0.0%	3.3%	2.5%	4.1%	1.7%	2.9%	67.4%	9.1%	2.9%	6.2%	0.0%
2007	0.0%	0.8%	1.7%	7.6%	11.9%	12.7%	22.0%	29.7%	6.8%	2.5%	4.2%	0.0%
2008	0.0%	0.0%	0.0%	21.8%	2.3%	1.1%	6.9%	20.7%	35.6%	4.6%	3.4%	3.4%
2009	7.1%	21.4%	0.0%	7.1%	50.0%	7.1%	0.0%	7.1%	0.0%	0.0%	0.0%	0.0%
2010	0.0%	0.0%	0.0%	6.2%	0.7%	6.2%	14.4%	48.6%	9.6%	8.9%	4.8%	0.7%

Figure 11.13. Weekly juvenile cutthroat migration timing for Jimmycomelately Creek, 2002-2010.

Outmigration Timing for JCL Compared with Other Eastern Strait of Juan de Fuca Tributaries

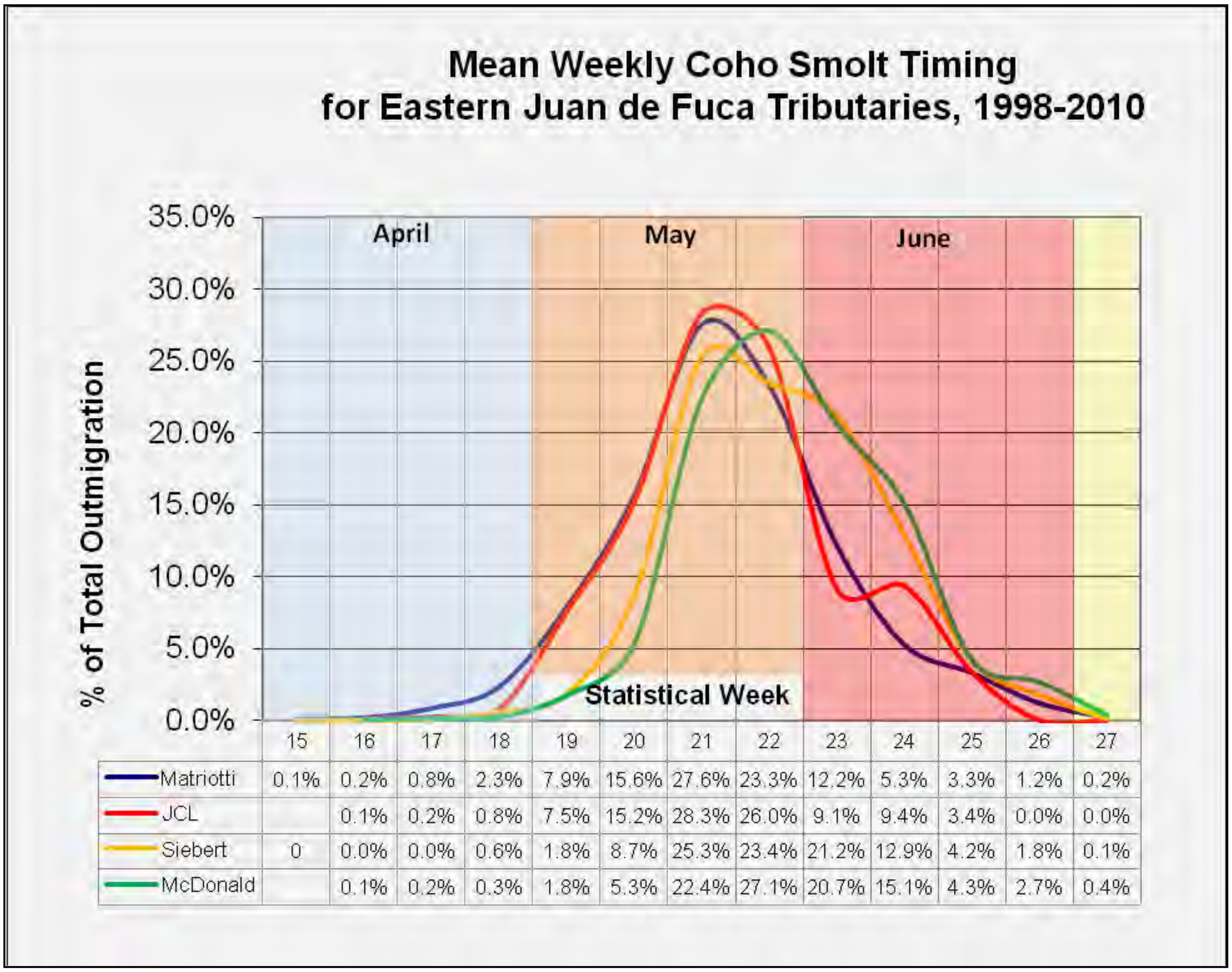
Similar to other Eastern Strait of Juan de Fuca tributaries, coho smolt outmigration in JCL begins around week 17 or 18 (mid- to late-April). Coho smolt outmigration in JCL usually ends around week 24 (mid-June), which is slightly earlier than the other streams. Coho smolt outmigration in Matriotti, McDonald, and Siebert usually ends in late June (around the end of week 25). By the end of June coho smolt outmigration in Eastern Strait of Juan de Fuca tributaries is 100% complete (Figure 11.14).



	15	16	17	18	19	20	21	22	23	24	25	26	27
Matriotti	0.1%	0.3%	1.2%	3.5%	11.3%	26.9%	54.5%	77.8%	90.0%	95.3%	98.6%	99.8%	100.0%
JCL		0.1%	0.3%	1.1%	8.6%	23.8%	46.8%	78.1%	87.2%	96.6%	100.0%	100.0%	100.0%
Siebert		0.0%	0.0%	0.6%	2.5%	10.7%	34.9%	61.2%	82.2%	94.4%	98.3%	99.9%	100.0%
McDonald		0.0%	0.1%	0.3%	2.5%	7.4%	29.8%	56.9%	77.6%	92.7%	96.9%	99.6%	100.0%

Figure 11.14. Mean cumulative weekly coho smolt outmigration timing for Eastern Strait of Juan de Fuca tributaries, 1998-2010.

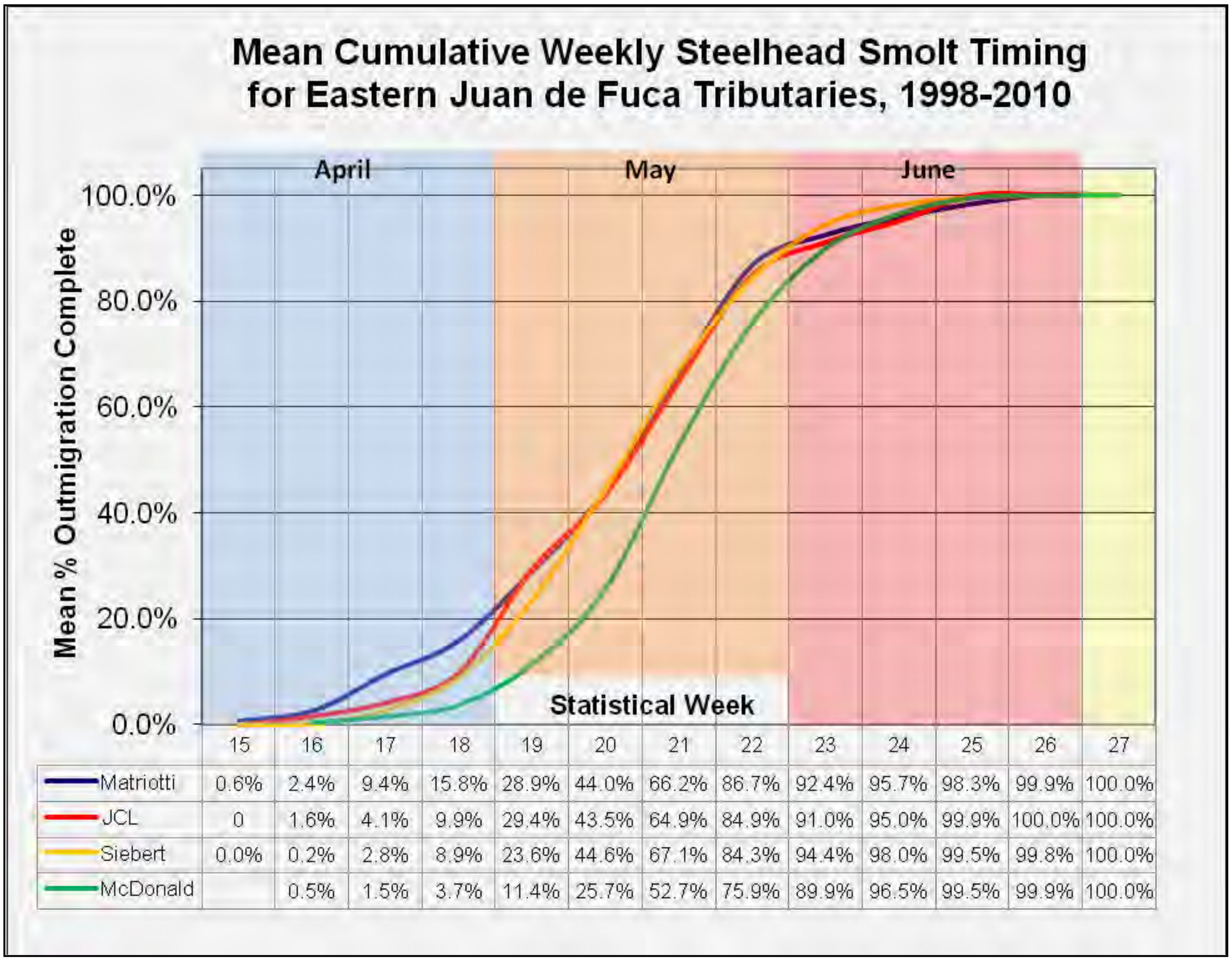
When compared with other Eastern Strait of Juan de Fuca tributaries, coho smolt timing in JCL is similar to Siebert and Matriotti in that outmigration tends to peak during week 21 in mid-May. McDonald tends to peak during week 22 towards the end of May. By the end of week 22 coho smolt outmigration in JCL and Matriotti declines sharply, while coho smolt outmigration declines gradually in Siebert and McDonald through early to mid-June (weeks 23-27) (Figure 11.15).



	15	16	17	18	19	20	21	22	23	24	25	26	27
Matriotti	0.1%	0.2%	0.8%	2.3%	7.9%	15.6%	27.6%	23.3%	12.2%	5.3%	3.3%	1.2%	0.2%
JCL		0.1%	0.2%	0.8%	7.5%	15.2%	28.3%	26.0%	9.1%	9.4%	3.4%	0.0%	0.0%
Siebert	0	0.0%	0.0%	0.6%	1.8%	8.7%	25.3%	23.4%	21.2%	12.9%	4.2%	1.8%	0.1%
McDonald		0.1%	0.2%	0.3%	1.8%	5.3%	22.4%	27.1%	20.7%	15.1%	4.3%	2.7%	0.4%

Figure 11.15. Mean weekly coho smolt outmigration timing for Eastern Strait of Juan de Fuca tributaries, 1998-2010.

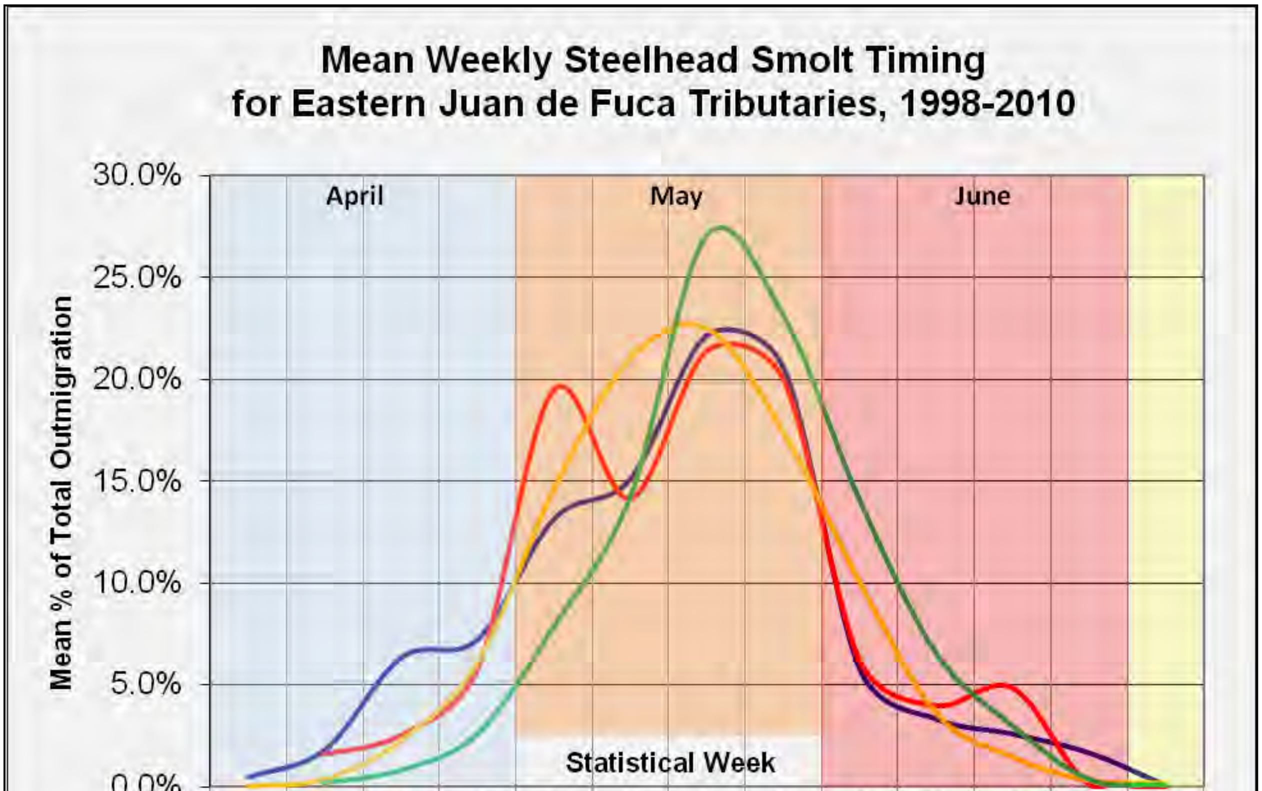
Similar to other Eastern Strait of Juan de Fuca tributaries, steelhead smolt outmigration in JCL begins around week 16 or mid-April. Coho smolt outmigration in JCL usually ends around week 25, which on average is one week earlier than the other streams. Steelhead smolt outmigration in Matriotti, McDonald, and Siebert usually ends in late June during week 26. By the end of June, steelhead smolt outmigration in Eastern Strait of Juan de Fuca tributaries is 100% complete (Figure 11.16).



	15	16	17	18	19	20	21	22	23	24	25	26	27
Matriotti	0.6%	2.4%	9.4%	15.8%	28.9%	44.0%	66.2%	86.7%	92.4%	95.7%	98.3%	99.9%	100.0%
JCL	0	1.6%	4.1%	9.9%	29.4%	43.5%	64.9%	84.9%	91.0%	95.0%	99.9%	100.0%	100.0%
Siebert	0.0%	0.2%	2.8%	8.9%	23.6%	44.6%	67.1%	84.3%	94.4%	98.0%	99.5%	99.8%	100.0%
McDonald		0.5%	1.5%	3.7%	11.4%	25.7%	52.7%	75.9%	89.9%	96.5%	99.5%	99.9%	100.0%

Figure 11.16. Mean cumulative weekly steelhead smolt outmigration timing for Eastern Strait of Juan de Fuca tributaries, 1998-2010.

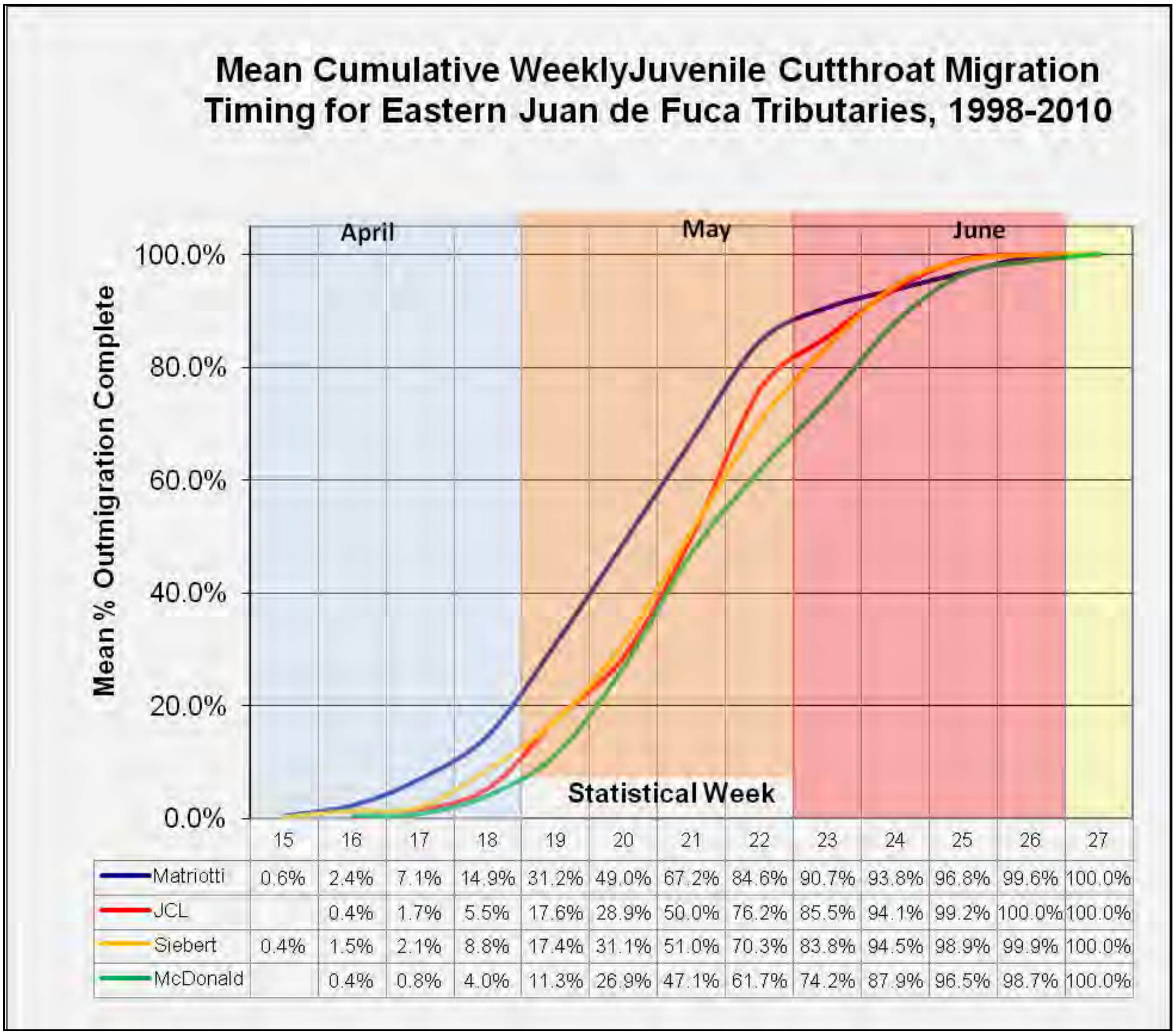
When compared with other Eastern Strait of Juan de Fuca tributaries, steelhead smolt timing in JCL is unique in that it has two peaks in outmigration timing: one during week 19 (early May), and the other during week 21 (mid-May). Matriotti, Siebert, and McDonald have one peak in timing distribution during week 21(mid-May). Steelhead smolt timing declines gradually in all of the streams from mid-May through June (Figure 11.17).



	15	16	17	18	19	20	21	22	23	24	25	26	27
Matriotti	0.4%	1.8%	6.3%	7.2%	13.1%	15.1%	22.1%	20.5%	5.7%	3.3%	2.6%	1.6%	0.1%
JCL		1.6%	2.5%	5.8%	19.5%	14.1%	21.4%	20.0%	6.2%	4.0%	4.9%	0.1%	0.0%
Siebert	0.0%	0.4%	2.3%	6.1%	14.7%	21.0%	22.5%	17.4%	10.0%	3.6%	1.5%	0.3%	0.2%
McDonald		0%	0.8%	2.6%	7.9%	14.3%	27.1%	23.1%	14.1%	6.6%	3.0%	0.4%	0.1%

Figure 11.17. Mean weekly steelhead smolt outmigration timing for Eastern Strait of Juan de Fuca tributaries, 1998-2010.

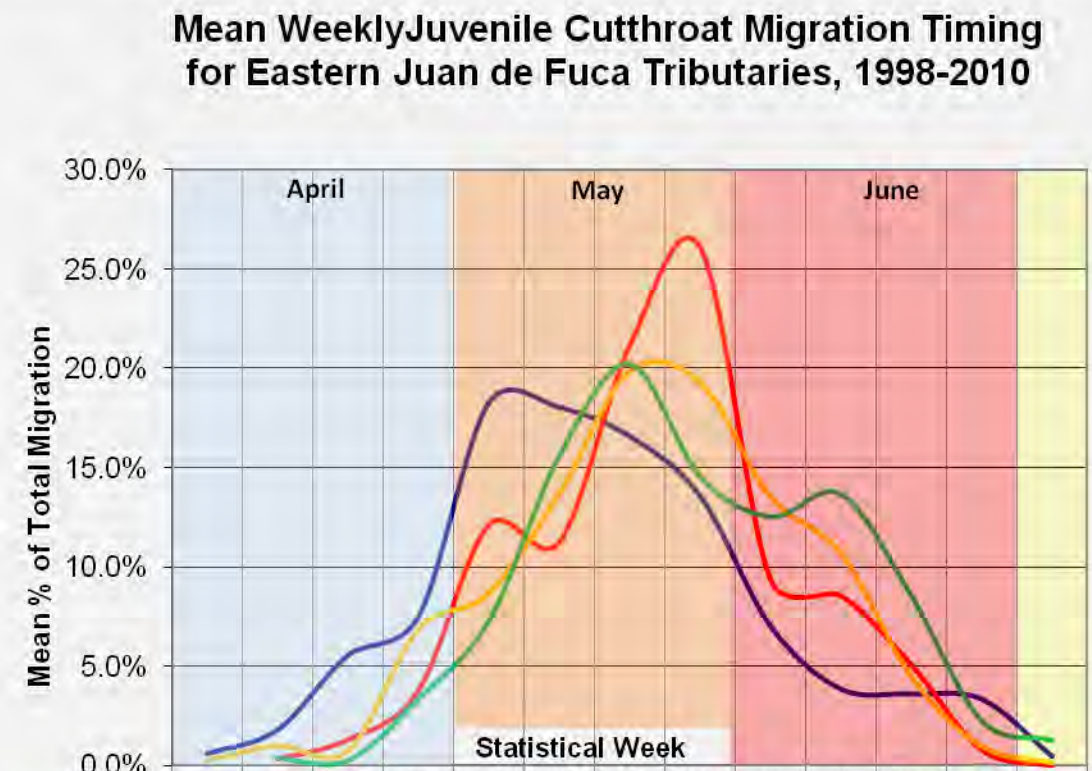
Similar to other Eastern Strait of Juan de Fuca tributaries, juvenile cutthroat outmigration of all age groups in JCL begins around week 16 or mid-April. Juvenile cutthroat outmigration in JCL usually ends around week 25 (mid-June), which is on average one week earlier than the other streams. Juvenile cutthroat outmigration in Matriotti, McDonald, and Siebert usually ends in late June (around the end of week 26). By the end of June, juvenile cutthroat outmigration in Eastern Strait of Juan de Fuca tributaries is 100% complete (Figure 11.18).



	15	16	17	18	19	20	21	22	23	24	25	26	27
Matriotti	0.6%	2.4%	7.1%	14.9%	31.2%	49.0%	67.2%	84.6%	90.7%	93.8%	96.8%	99.6%	100.0%
JCL		0.4%	1.7%	5.5%	17.6%	28.9%	50.0%	76.2%	85.5%	94.1%	99.2%	100.0%	100.0%
Siebert	0.4%	1.5%	2.1%	8.8%	17.4%	31.1%	51.0%	70.3%	83.8%	94.5%	98.9%	99.9%	100.0%
McDonald		0.4%	0.8%	4.0%	11.3%	26.9%	47.1%	61.7%	74.2%	87.9%	96.5%	98.7%	100.0%

Figure 11.18. **Mean cumulative weekly juvenile cutthroat outmigration timing for Eastern Strait of Juan de Fuca tributaries, 1998-2010.**

When compared with other Eastern Strait of Juan de Fuca tributaries, juvenile cutthroat outmigration timing in JCL is unique in that there is a distinct peak during week 22 (late May) and then a sharp decline through weeks 23 and 24 (mid-June). Outmigration timing in JCL then gradually declines through week 26 (late June). Matriotti tends to peak gradually through weeks 19 and 20 (early to mid-May) and then declines gradually through week 27 (late June). McDonald and Siebert both peak during week 21 (mid-May) and then decline slowly through week 26 (late June) (Figure 11.19).



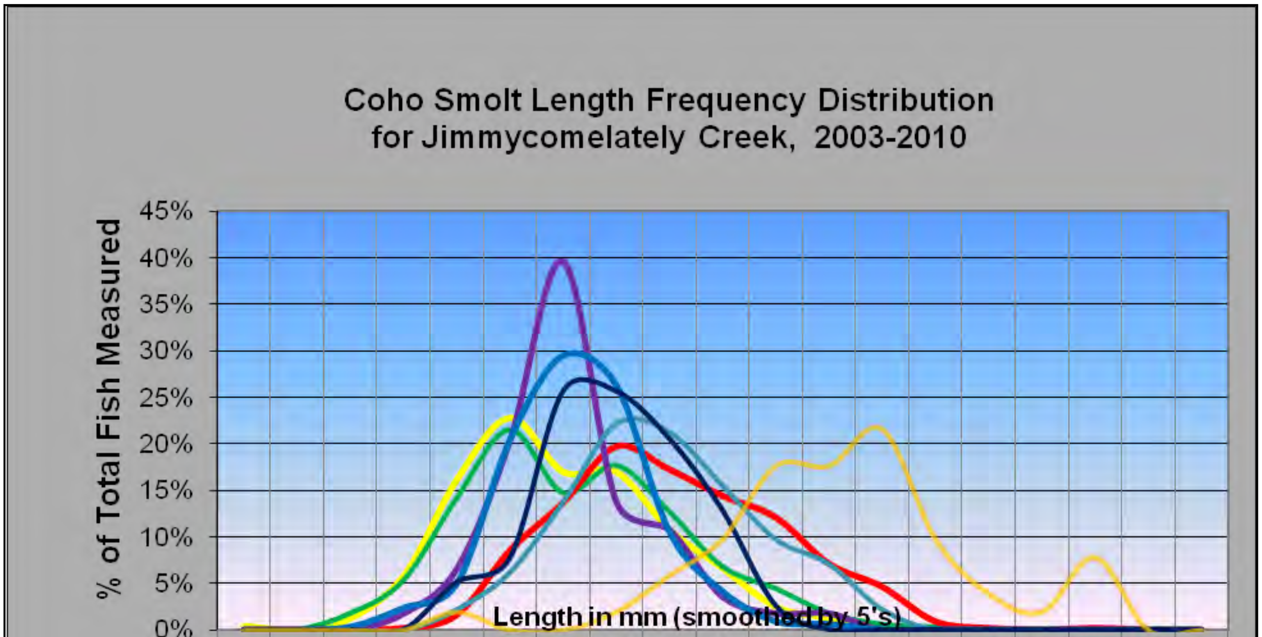
	15	16	17	18	19	20	21	22	23	24	25	26	27
Matriotti	0.6%	1.8%	5.5%	7.5%	18.3%	18.0%	16.6%	13.6%	7.0%	3.8%	3.6%	3.3%	0.4%
JCL		0.4%	1.3%	3.8%	12.1%	11.3%	21.2%	26.1%	9.4%	8.6%	5.1%	0.8%	0.0%
Siebert	0.2%	1.0%	0.7%	6.9%	8.6%	13.7%	19.8%	19.3%	13.5%	10.7%	4.5%	0.9%	0.1%
McDonald		0%	0.3%	3.4%	7.3%	15.6%	20.2%	14.6%	12.5%	13.7%	8.6%	2.3%	1.3%

Figure 11.19. Mean juvenile cutthroat outmigration timing for Eastern Strait of Juan de Fuca tributaries, 1998-2010.

Juvenile Salmonid Size Distribution for Jimmycomelately Creek

Coho

Coho smolt size distribution (length frequencies) did not vary much from year to year in JCL Creek during 2003-2010. Coho smolts ranged from around 70 mm to 150 mm with most measuring between 90 mm and 115 mm fork length. In 2010 coho smolts were larger than in years past, ranging from 80 mm to 150 mm, with most measuring between 105 mm and 130 mm (Figure 11.20).

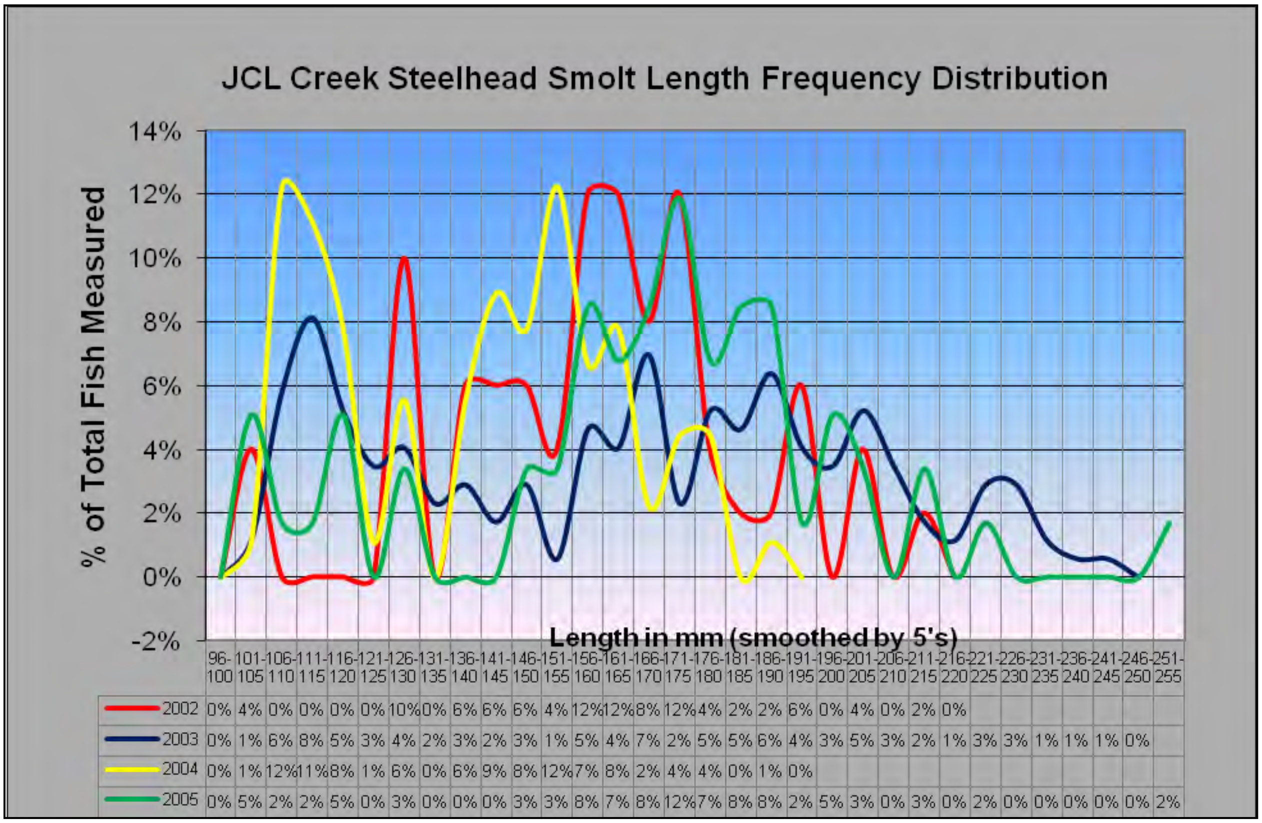


	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100	101-105	106-110	111-115	116-120	121-125	126-130	131-135	136-140	141-145	146-150	151-155
2003	0%	0%	1%	6%	16%	23%	17%	17%	11%	7%	2%	1%	0%	0%	0%	0%	0%	0%	0%
2004	0%	0%	2%	5%	14%	22%	15%	18%	13%	7%	4%	2%	1%	0%	0%	0%	0%	0%	0%
2005	0%	0%	0%	0%	2%	8%	14%	20%	17%	14%	12%	7%	5%	1%	0%	0%	0%	0%	0%
2006	0%	0%	0%	2%	7%	20%	40%	14%	11%	4%	2%	2%	0%	0%	0%	0%	0%	0%	0%
2007	0%	0%	0%	0%	2%	6%	14%	22%	21%	15%	10%	7%	2%	0%	0%	0%	0%	0%	0%
2008	0%	0%	0%	2%	5%	20%	30%	26%	11%	4%	1%	1%	0%	0%	0%	0%	0%	0%	0%
2009	0%	0%	0%	0%	5%	8%	26%	26%	21%	13%	3%	0%	0%	0%	0%	0%	0%	0%	0%
2010	0%	0%	0%	0%	2%	0%	0%	2%	6%	10%	18%	18%	22%	10%	4%	2%	8%	0%	0%

Figure 11.20. Coho smolt length-frequency distribution for Jimmycomelately Creek, 2003-2010.

Steelhead

Steelhead smolt size distribution (length frequencies) was quite variable from year to year, and even more so within years in JCL Creek. Steelhead smolts ranged from around 95 mm to 255 mm fork length. When analyzed using the mean composite for all years, most steelhead smolts measured between 140 mm and 180 mm. The number of steelhead smolts measured between 2006 and 2010 was not large enough to calculate reasonable length frequencies (Figure 11.21).



	96-100	101-105	106-110	111-115	116-120	121-125	126-130	131-135	136-140	141-145	146-150	151-155	156-160	161-165	166-170	171-175
2002	0%	4%	0%	0%	0%	0%	10%	0%	6%	6%	6%	4%	12%	12%	8%	12%
2003	0%	1%	6%	8%	5%	3%	4%	2%	3%	2%	3%	1%	5%	4%	7%	2%
2004	0%	1%	12%	11%	8%	1%	6%	0%	6%	9%	8%	12%	7%	8%	2%	4%
2005	0%	5%	2%	2%	5%	0%	3%	0%	0%	0%	3%	3%	8%	7%	8%	12%

	176-180	181-185	186-190	191-195	196-200	201-205	206-210	211-215	216-220	221-225	226-230	231-235	236-240	241-245	246-250	251-255
2002	4%	2%	2%	6%	0%	4%	0%	2%	0%							
2003	5%	5%	6%	4%	3%	5%	3%	2%	1%	3%	3%	1%	1%	1%	0%	
2004	4%	0%	1%	0%												
2005	7%	8%	8%	2%	5%	3%	0%	3%	0%	2%	0%	0%	0%	0%	0%	2%

Figure 11.21. Steelhead smolt length-frequency distribution for Jimmycomelately Creek, 2002-2005.

Juvenile Cutthroat

Juvenile cutthroat size distribution (length frequencies) in JCL Creek did not vary much during years when sufficient length data was available to calculate length frequencies. Juvenile cutthroat were measured to fork length in millimeters. Juvenile cutthroat ranged from around 80 mm to 210 mm, with most measuring between 110 mm and 150 mm (Figure 11.22).

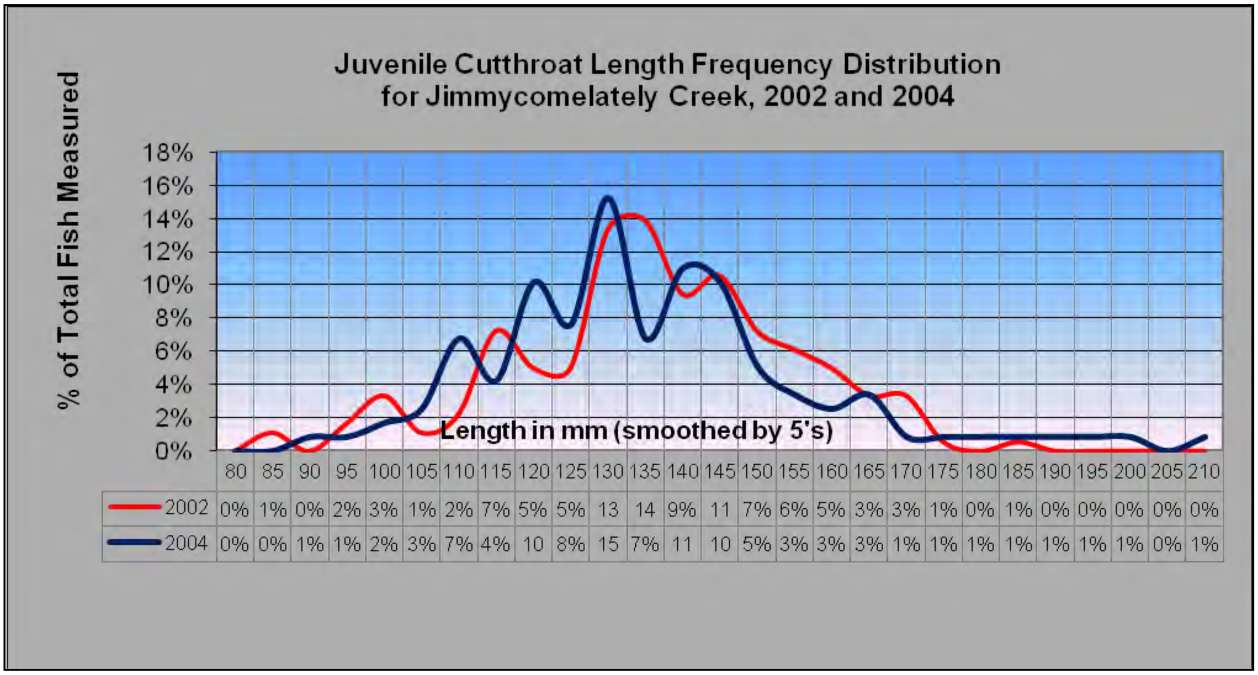
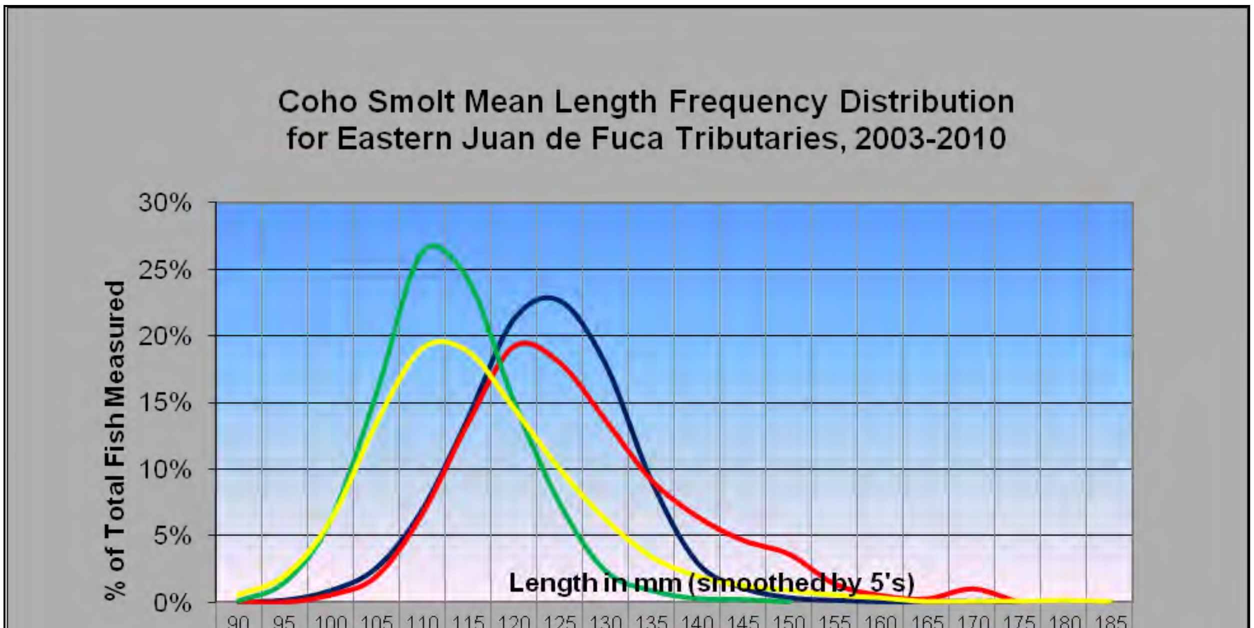


Figure 11.22. Juvenile cutthroat length-frequency distribution for Jimmycomelately Creek, 2002 and 2004.

Juvenile Salmonid Size Distribution (Length Frequency) for Jimmycomelately Creek Compared with Other Eastern Strait of Juan de Fuca Tributaries.

Coho

When compared with other Eastern Strait of Juan de Fuca tributaries, coho smolt mean length-frequency distribution in JCL Creek was very similar to Siebert Creek. Most of the coho smolts in JCL and Siebert measured between 105 mm and 135 mm. Most of the coho smolts in Matriotti and McDonald measured between 95 mm and 125 mm. JCL and Matriotti were similar in that they had a wider range of sizes than Siebert and McDonald. JCL coho smolt mean lengths ranged from 90 mm to 170 mm, and Matriotti mean lengths ranged from 90 mm to 185 mm. Siebert coho smolts mean lengths ranged from 95 mm to 155 mm. McDonald coho smolts mean lengths ranged from 95 mm to 135 mm (Figure 11.23).

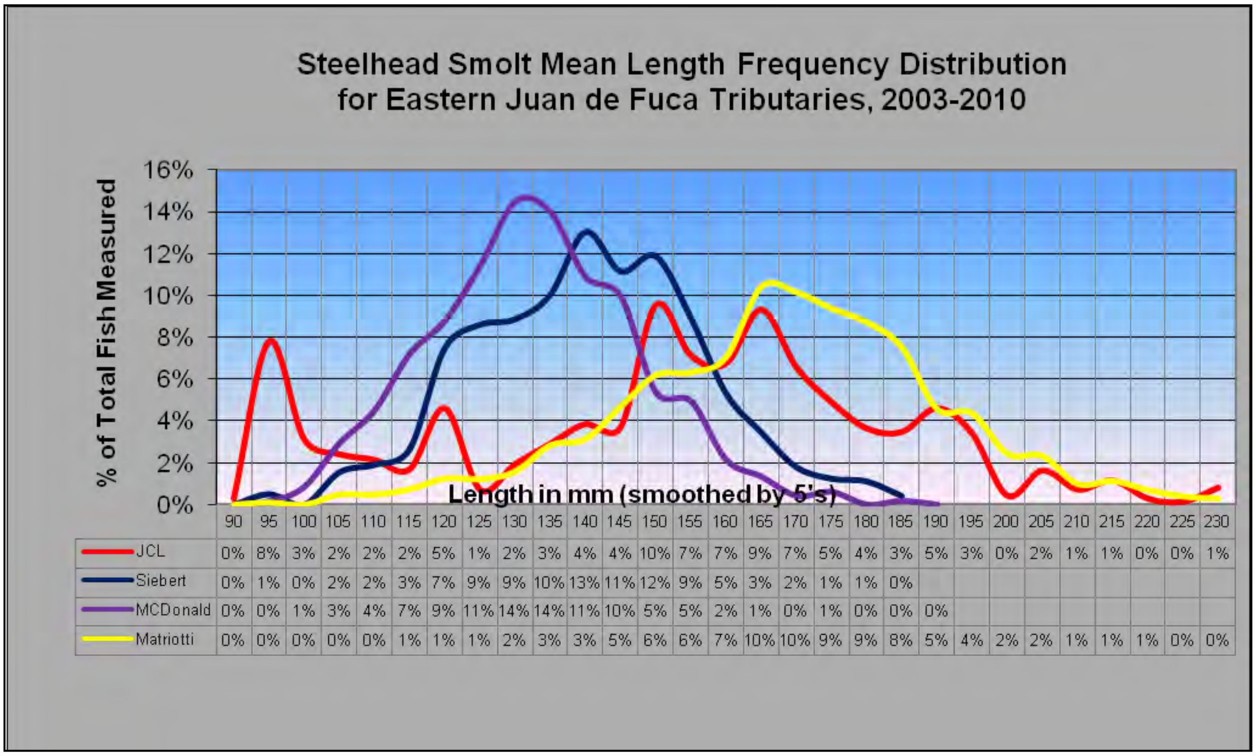


	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185
Siebert	0%	0%	1%	3%	7%	14%	21%	23%	18%	9%	3%	1%	0%	0%	0%	0%	0%	0%		
JCL	0%	0%	1%	2%	7%	13%	19%	18%	14%	9%	6%	5%	4%	1%	1%	0%	1%	0%		
McDonald	0%	1%	6%	16%	26%	24%	15%	7%	2%	1%	0%	0%	0%							
Matriotti	1%	2%	6%	13%	19%	19%	15%	10%	6%	3%	2%	1%	1%	1%	0%	0%	0%	0%	0%	0%

Figure 11.23. Coho smolt mean length-frequency distribution for JCL, Siebert, McDonald and Matriotti Creeks, 2003-2010.

Steelhead

When compared with other Eastern Strait of Juan de Fuca tributaries, steelhead smolt mean length-frequency distribution in JCL Creek was similar to Matriotti Creek, as both creeks had a wider range of lengths than the others. JCL and Matriotti steelhead smolt mean lengths ranged from 90 mm to 230 mm. Steelhead mean lengths in Siebert and McDonald ranged from 90 mm to 175 mm with most smolts measuring between 100 mm and 160 mm. Most of the steelhead smolts in JCL and Matriotti measured between 140 mm and 180 mm. JCL had more steelhead smolts between 90 mm and 100 mm than the other streams (Figure 11.24).

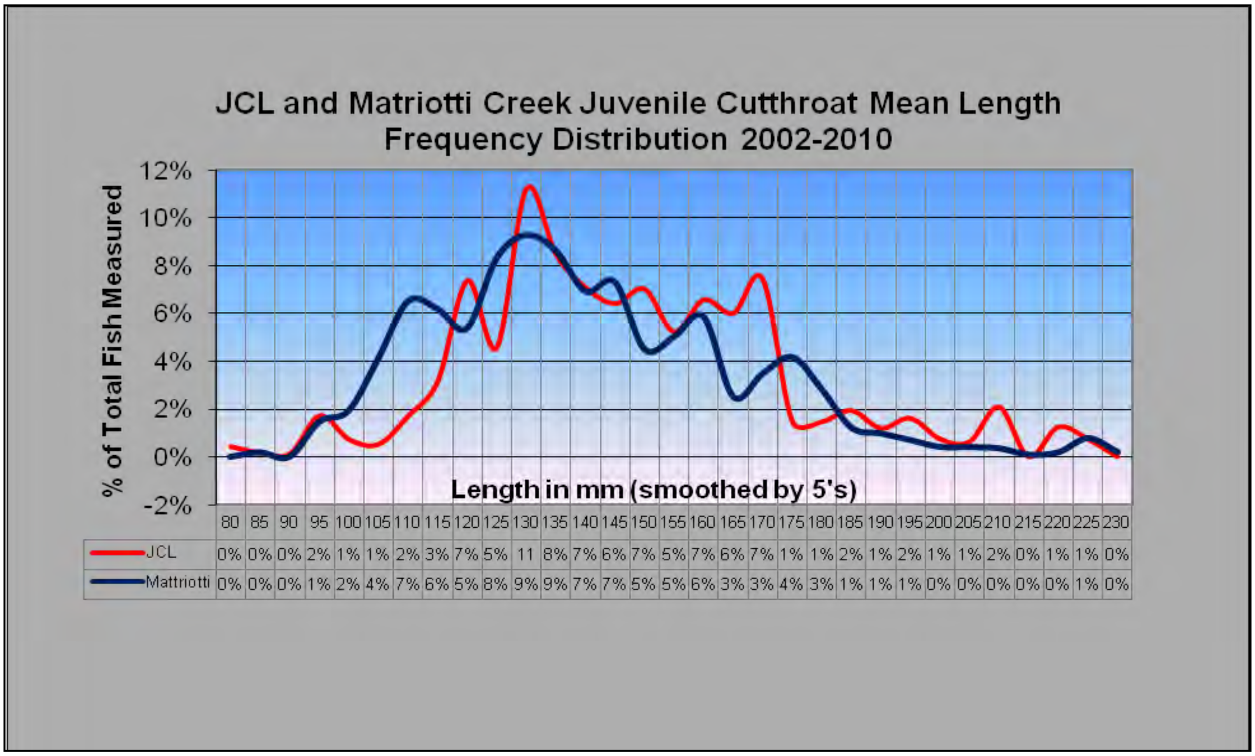


	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230
JCL	0%	8%	3%	2%	2%	2%	5%	1%	2%	3%	4%	4%	10%	7%	7%	9%	7%	5%	4%	3%	5%	3%	0%	2%	1%	1%	0%	0%	1%
Siebert	0%	1%	0%	2%	2%	3%	7%	9%	9%	10%	13%	11%	12%	9%	5%	3%	2%	1%	1%	0%									
MCDonald	0%	0%	1%	3%	4%	7%	9%	11%	14%	14%	11%	10%	5%	5%	2%	1%	0%	1%	0%	0%	0%								
Matriotti	0%	0%	0%	0%	0%	1%	1%	1%	2%	3%	3%	5%	6%	6%	7%	10%	10%	9%	9%	8%	5%	4%	2%	2%	1%	1%	1%	0%	0%

Figure 11.24. Steelhead smolt mean length-frequency distribution for JCL, Siebert, McDonald and Matriotti Creeks, 2002-2010.

Juvenile Cutthroat

Juvenile cutthroat mean length-frequency distribution in JCL Creek was similar to Matriotti Creek. Matriotti was the only stream along the Eastern Strait of Juan de Fuca monitored by the Jamestown S'Klallam Tribe with sufficient juvenile cutthroat length data to make a comparison with JCL. JCL and Matriotti juvenile cutthroat mean lengths ranged from around 80 mm to 230 mm. Most of the juvenile cutthroat measured between 105 mm and 180 mm (Figure 11.25).



	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230
JCL	0%	0%	0%	2%	1%	1%	2%	3%	7%	5%	11	8%	7%	6%	7%	5%	7%	6%	7%	1%	1%	2%	1%	2%	1%	1%	2%	0%	1%	1%	0%
Mattriotti	0%	0%	0%	1%	2%	4%	7%	6%	5%	8%	9%	9%	7%	7%	5%	5%	6%	3%	3%	4%	3%	1%	1%	1%	0%	0%	0%	0%	0%	1%	0%

Figure 11.25. Juvenile cutthroat mean length-frequency distribution for JCL Creek and Matriotti Creek, 2002-2010.

Coho Spawning

As described in Chapter 10, coho spawning ground surveys are conducted on a yearly basis by the Washington Department of Fish and Wildlife starting in early November and ending in mid-January. From the 1984 through 2010 brood (spawning) years, the cumulative number of coho redds per season ranged from 12 redds in 1988 to 213 redds in 2004 and there were more than 70 redds in four of the twenty-five years (Figure 11.26).

For the 2000 through 2010 brood years, there was a good range in the cumulative number of coho redds per season (between 8 redds in 2008 to 213 redds in 2004) and there were more than 70 redds in five of these nine years.

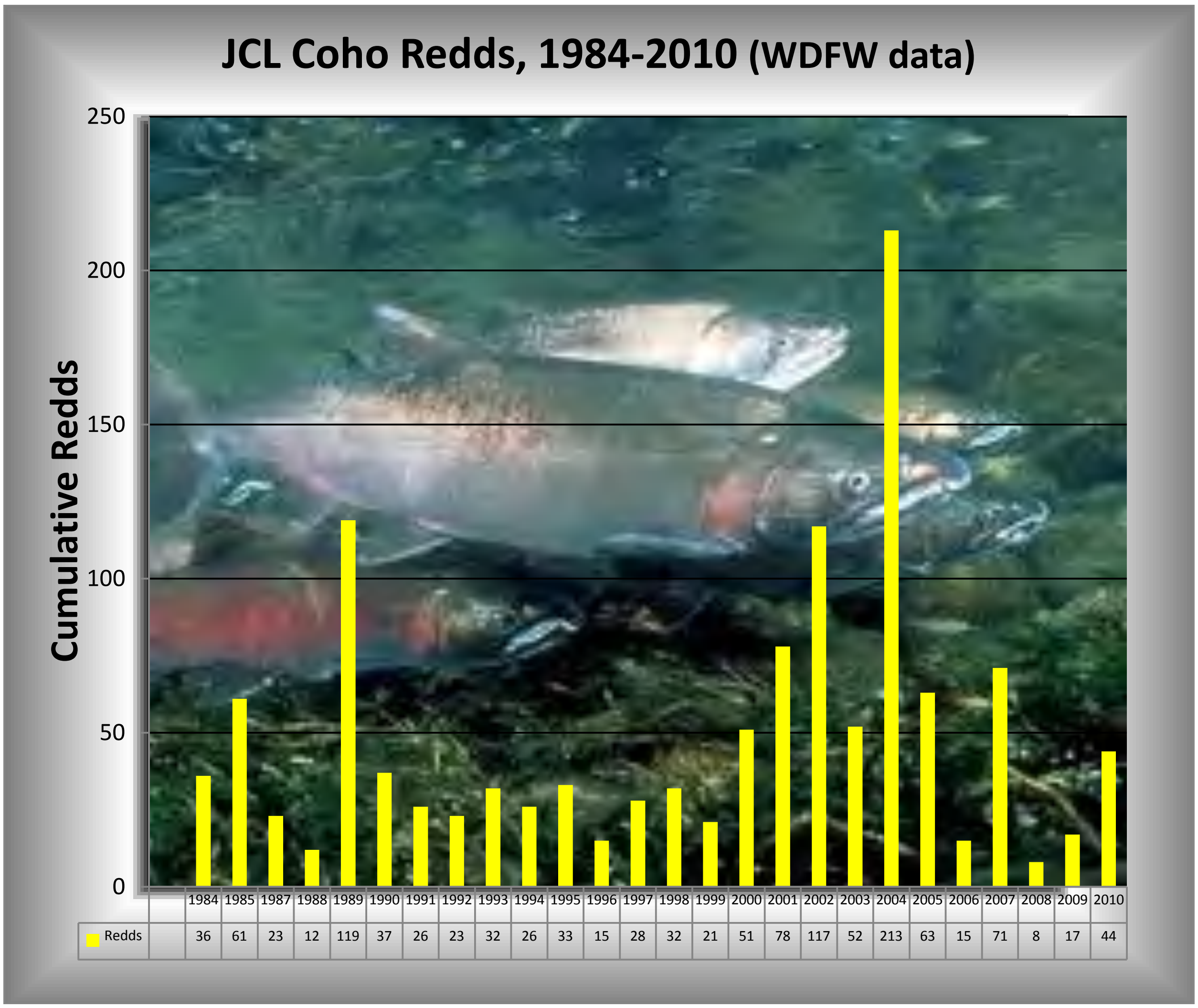


Figure 11.26. **Coho redd counts for Jimmycomelately Creek, 1984-2010. Data collected by Washington Department of Fish and Wildlife; there are no data for 1986.**

Relationship between JCL Coho Spawners and Smolt Abundance

The relationship between the number of coho spawners and coho smolt abundance was examined to better understand the population dynamics of the JCL coho population. The total number of coho spawners was estimated from the number of coho redds by assuming two adults per redd. Coho smolt abundance information for JCL is available beginning with the 2000 brood year (2002 smolt year) (Table 11.1).

Table 11.1. Coho spawners, coho smolts, egg-to-smolt survival, smolts per female, and smolt-to-adult survival for Jimmycomelately Creek, brood (spawning) years 2000 through 2010.

Brood (Spawning) Year	Females [1/]	Total Spawners[1/]	Eggs [2/]	Smolt Year [3/]	Coho Smolts	Egg-to-smolt Survival	Smolts per Female	Smolt-to-adult Survival
2000	51	102	127,500	**2002**	934	0.73%	18	11.1%
2001	78	156	195,000	**2003**	1274	0.65%	16	33.4%
2002	117	234	292,500	**2004**	2482	0.85%	21	5.1%
2003	52	104	130,000	**2005**	2220	1.71%	43	1.4%
2004	213	426	532,500	**2006**	2188	0.41%	10	6.5%
2005	63	126	157,500	**2007**	965	0.61%	15	1.7%
2006	15	30	37,500	**2008**	1846	4.92%	123	1.8%
2007	71	142	177,500	**2009**	387	0.22%	5	22.7%
2008	8	16	20,000	**2010**	906	4.53%	113	
2009	17	34	42,500					
2010	44	88	110,000					

1/Coho females estimated based on 1 female/redd observed and adults estimated based on 2 adults/redd observed; see Figure 11.26 for the number of coho redds

2/Eggs estimated based on 2500 eggs/female

3/Smolt Year = Brood Year + 2

The number of JCL coho spawners is plotted vs. the number of coho smolts in Figure 11.27. There is a good range to the available data and a curvilinear regression was fit to the data points (solid line), but the relationship is not a strong one due to the variability in the data. The general relationship found for salmonid populations typically shows that as the number of spawners increases, the number of smolts also increases until the average maximum number of smolts that the freshwater habitat can produce is reached. This average maximum number of smolts is called the *carrying capacity*. The dashed line in Figure 11.27 represents this general relationship and the carrying capacity is shown as the average of the smolts observed for the 2002, 2003, 2004 and 2006 brood years. Based on the available data for JCL, it seems reasonable to say that the average carrying capacity is between 2,000 and 2,500 coho smolts.

There is no apparent pattern or separation in the data that indicates the relationship between the number of spawners vs. the number of smolts has changed appreciably since the JCL Ecosystem Restoration Project was completed in 2004. In addition, the average carrying capacity was apparently reached (or approached) for both pre-project brood years (2000-2003), and the post-project brood years (2004-2008). It is encouraging that the relatively low number of 15 coho spawners for brood year 2006 was able to produce 1,846 coho smolts (which is approaching carrying capacity).

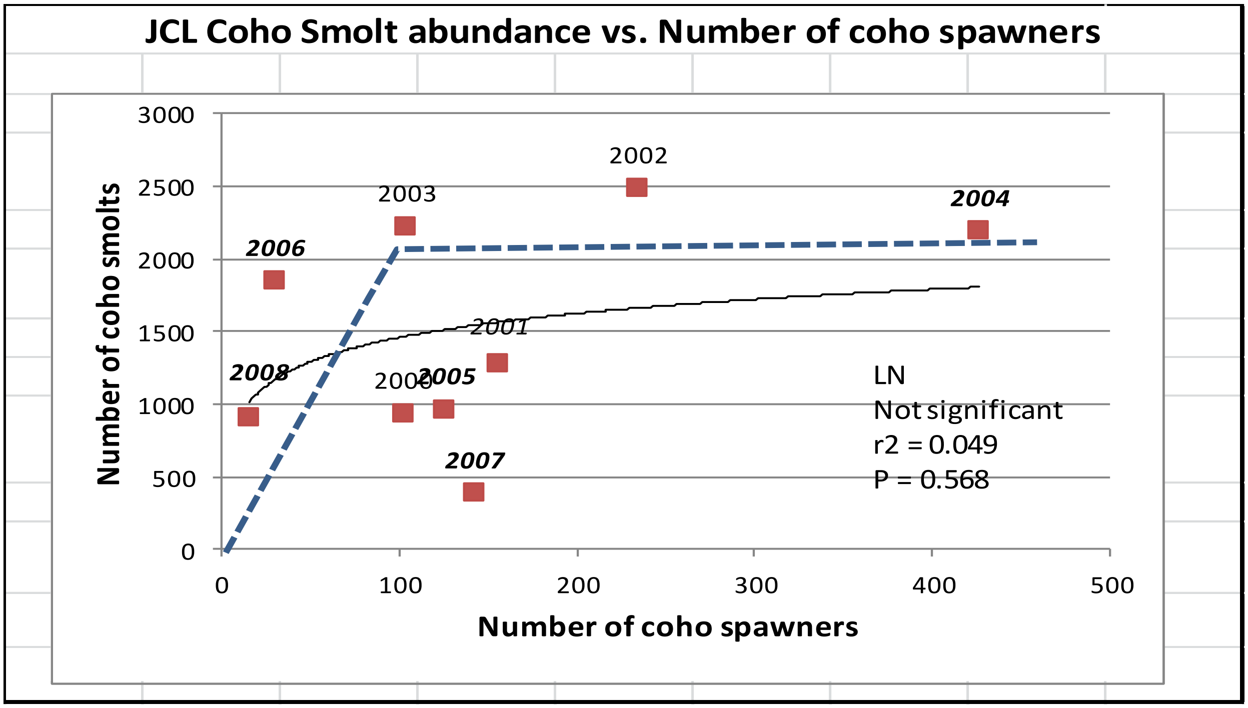


Figure 11.27. **Relationship between JCL coho smolt abundance and the number of coho spawners. Solid line is fit to the JCL data, but it is not a statistically significant relationship. Dashed line represents the general relationship found for salmon populations, and the average of the four highest smolt estimates actually observed in JCL is shown here as the estimate of coho smolt carrying capacity. Data labels show brood (spawning) years after restoration project in bold; smolt year = brood year +2.**

Estimates of Coho Freshwater Survival

Coho Egg-to-Smolt Survival and Smolts per Female

Coho spawn in Jimmycomelately Creek from late fall through early winter, and approximately 2,500 eggs per female are estimated to be deposited in the gravel in each redd. Coho eggs incubate in the gravel until early or late spring depending on water temperature. After the juvenile coho emerge from the gravel, the majority of them spend approximately one year in the stream before migrating to sea. For example, eggs deposited by coho females spawning during fall 2000 would produce smolts that outmigrate from JCL during spring 2002.

Egg-to-smolt survival and the number of smolts produced per female coho each provide a measure of overall survival during the freshwater portion of the coho life cycle. Egg-to-smolt survival is calculated by dividing the total number of coho smolts in a given spring by the estimated number of eggs deposited by all female coho two falls earlier. Coho smolts per female is calculated as the total number of smolts divided by the total number of female spawners that produced them. Smolts per female and egg-to-smolt survival are actually equivalent measures that are expressed in different terms since coho average 2500 eggs per female. For example, for brood year 2000, the estimated 18 smolts per female is the same as the estimated 0.72% egg-to-smolt survival (i.e., 18 smolts/female = 18 smolts/2500 eggs = 0.72% egg-to-smolt survival).

Estimated egg-to-smolt survival has been quite variable in JCL and has ranged from 0.42% to 4.92% during brood (spawning) years 2000 through 2010 (Table 11.1, Figure 11.28). Similarly, the range for JCL coho has been estimated at from 5 to 123 smolts per female (Table 11.1).

The relationship between JCL coho egg-to-smolt survival and smolts per female vs. the number of coho spawners is plotted in Figure 11.29. There is a good range to the available data and a curvilinear regression was fit to the data points (solid line). There is a strong (statistically significant) relationship between egg-to-smolt survival and smolts per female vs. the number of spawners in JCL (Figure 11.29). For salmonid populations, egg-to-smolt survival generally decreases as the number of spawners increases (Quinn 2005); this also appears to be the case for JCL coho.

All of the available data points fit well on the same curve so there is no apparent pattern or separation in the data that indicates the relationship between egg-to-smolt survival and smolts per female vs. the number of coho spawners has changed appreciably since the JCL Ecosystem Restoration Project was completed in 2004.

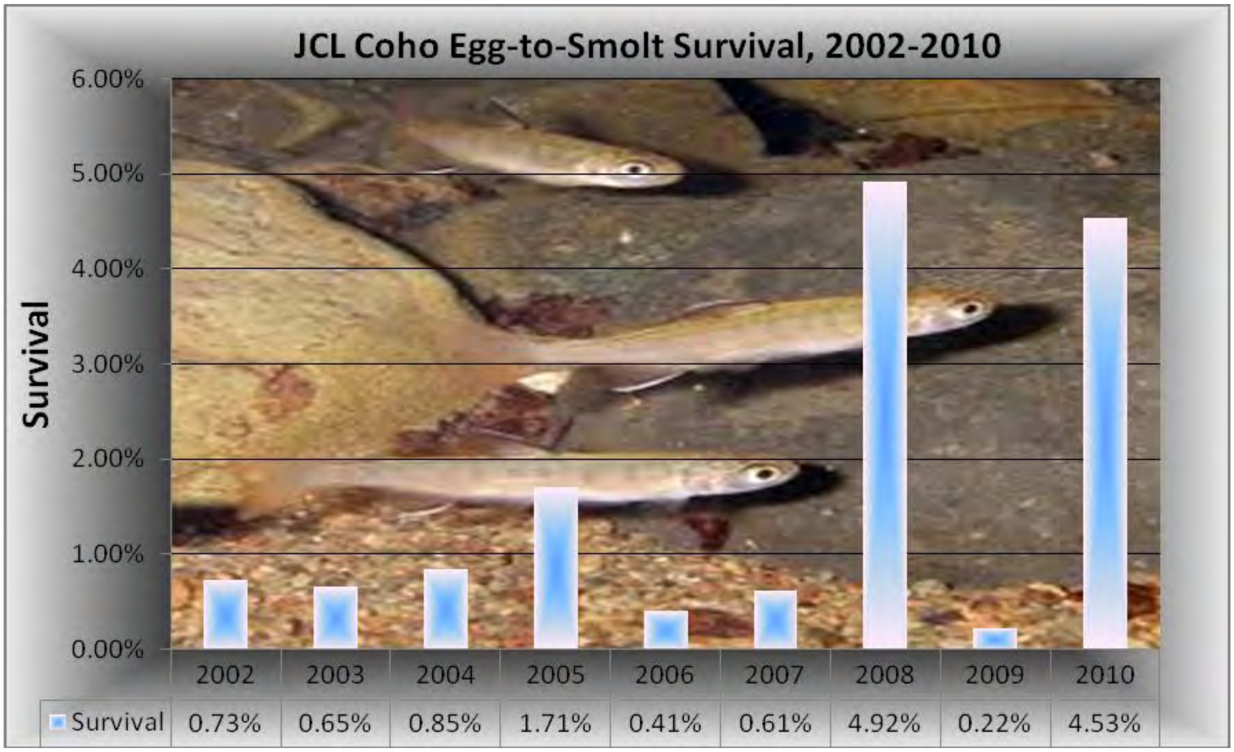


Figure 11.28. Egg-to-smolt survival for Jimmycomelately Creek coho salmon, smolt years 2002-2010 (brood years 2000-2008).

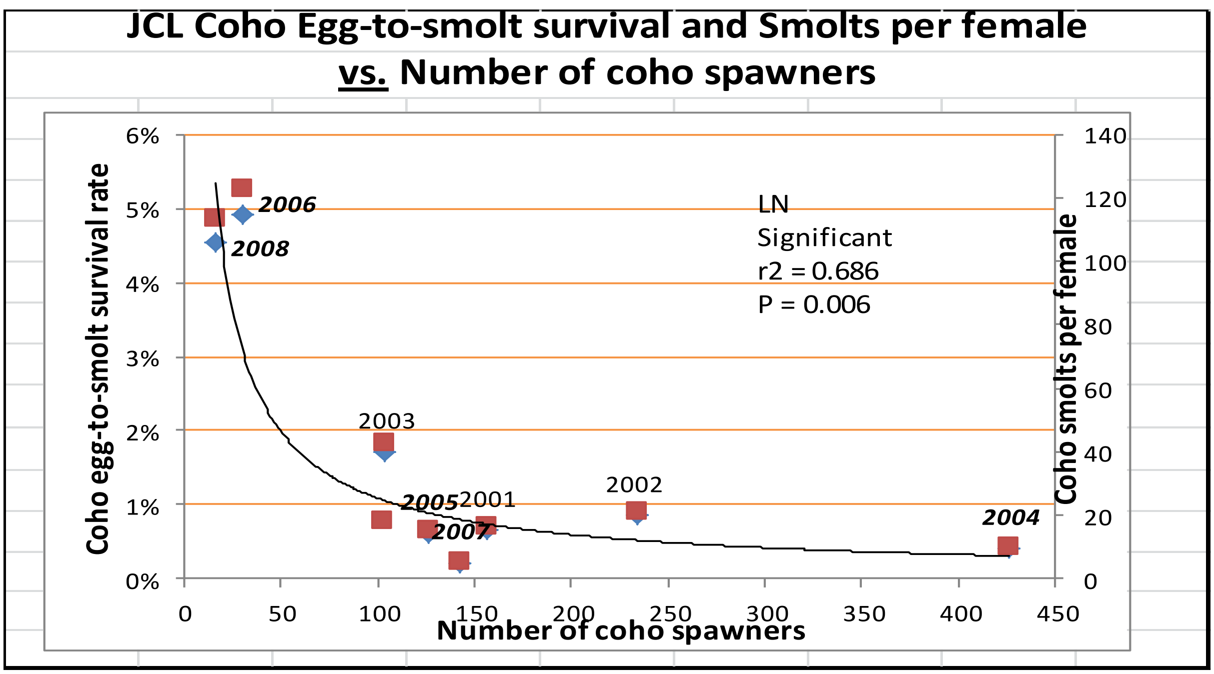


Figure 11.29. Relationship between JCL coho egg-to-smolt survival and smolts per female vs. number of coho spawners. Solid line is fit to the JCL data and fits well with relationships found for other coho populations. Data labels show brood (spawning) years after restoration project in bold; smolt year = brood year +2.

Relationships between Coho Freshwater Survival and Smolt Abundance vs. Stream Flow

Coho egg-to-smolt survival can be affected by the quantity and quality of the JCL freshwater habitat. Factors affecting freshwater survival of coho include the amount of the stream used for spawning, the quality of the intra-gravel environment used for egg incubation and early rearing (prior to fry emergence), high flows during incubation/early rearing and during the period that coho parr over-winter prior to smolting, low flows during summer/fall rearing, the complexity of rearing habitat (log jams, pools, riffles, etc.), and other factors. Information on all of these factors is not available for JCL, but we do have some useful data.

Stream flow has been measured in JCL since 2002 (see Chapter 1 Hydrology), so we examined the relationship between egg-to-smolt survival versus (1) peak high flow during the period that eggs and fry are in the gravel (December through March) and (2) low flows during the summer-fall period. The timing, magnitude, and duration of high flows can potentially harm eggs in the gravel by moving them or driving them completely out of the gravel (referred to as scouring) or by transporting additional sand or gravels on top of the eggs in the redds (referred to as deposition), which could make it harder for the fry to emerge from the gravel into JCL. Sometimes, both scouring and deposition can occur to eggs in the same redd at different times during a single season. The peak high flows from the JCL hydrograph (see Chapter 1 Hydrology) were used as the measure of high flow. In contrast, low flows can limit habitat quantity (e.g., total wetted stream area) and habitat quality (e.g., depth of pools) as coho juveniles try to make a living through the summer-fall period. The JCL design team felt that flows less than 2 cubic feet per second (cfs) were low enough to be of concern for rearing juveniles, so we looked at the number of days with less than 2 cfs flow between July 1 and October 31 (see Chapter 1 Hydrology) for each brood year as the measure of low flow.

The relationships between two measures of JCL coho freshwater survival vs. stream flow and coho smolt abundance vs. stream flow are plotted in Figure 11.30. Neither the number of low flow days < 2 cfs nor the peak high flows that coho experienced while in JCL were related to the two estimates of freshwater survival (egg-to-smolt survival or smolts per female) or coho smolt abundance. The strongest relationship, although not statistically significant, was between coho smolt abundance vs. number of low flow days < 2 cfs. In this case, as the number of low flow days < 2 cfs increased, the number of coho smolts produced declined (Figure 11.30).

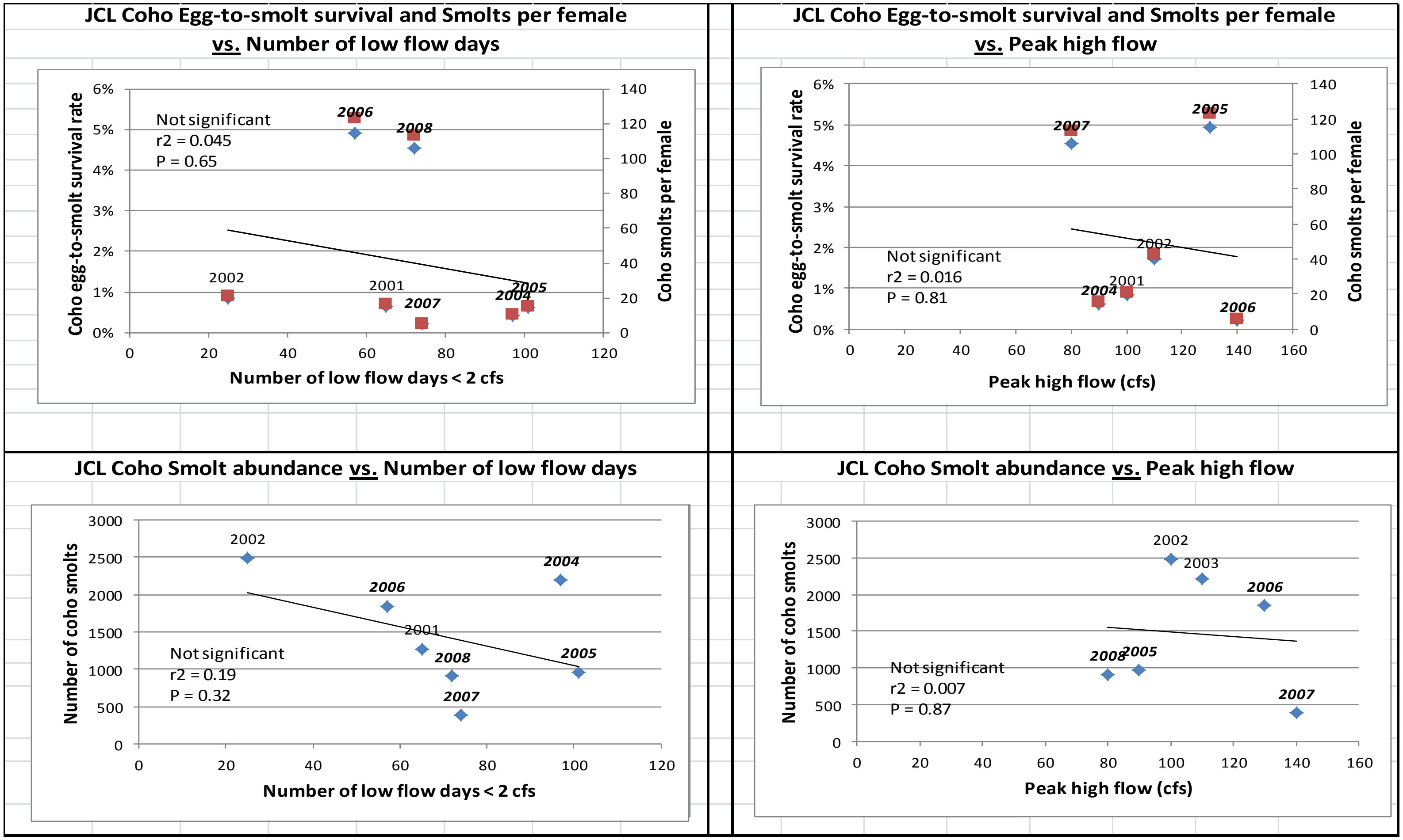


Figure 11.30. **Relationships between number of low flow days < 2 cfs between July 1 and October 31 vs. JCL coho egg-to-smolt survival and smolts per female (top left graph) and JCL coho smolt abundance (bottom left graph). Relationships between peak high flow (cfs) during egg incubation and pre-emergence period (December-March) vs. JCL coho egg-to-smolt survival and smolts per female (top right graph) and JCL coho smolt abundance (bottom right graph). Data labels show brood (spawning) years after restoration project in bold; smolt year = brood year +2. No low flow data available for brood year 2003 (summer-fall 2004). No high flow data available for brood year 2004 (winter 2004/05).**

Estimate of Saltwater Survival

<u>Coho Smolt-to-adult Survival</u>

Juvenile coho spend approximately one year at sea to develop into adults before returning to their stream of origin. For example, smolts that outmigrate from JCL during spring 2002 would produce adults that return to JCL during fall 2003. Coho smolt-to-adult survival is calculated by dividing the number of adult coho that return to the stream in a given year by the number of smolts produced the previous year.

Estimated survival from coho smolt-to-adult has been quite variable and has ranged from 1.4% to 33.4% for smolts which outmigrated from JCL during 2002 through 2009 (Table 11.1, Figure 11.31). During this same period, saltwater survival ranged from 2.1% to 15.9% for coho outmigrating from Snow Creek, a tributary to nearby Discovery Bay (WDFW data).

There is no apparent pattern in the data that indicates coho smolt-to-adult survival has changed appreciably since the JCL Ecosystem Restoration Project was completed in 2004. In addition, coho smolt-to-adult survival is affected by conditions encountered by coho in JCL Estuary, Strait of Juan de Fuca, and ocean habitats, so it will be difficult to attribute changes in saltwater survival to restoration of JCL freshwater and estuary habitats alone.

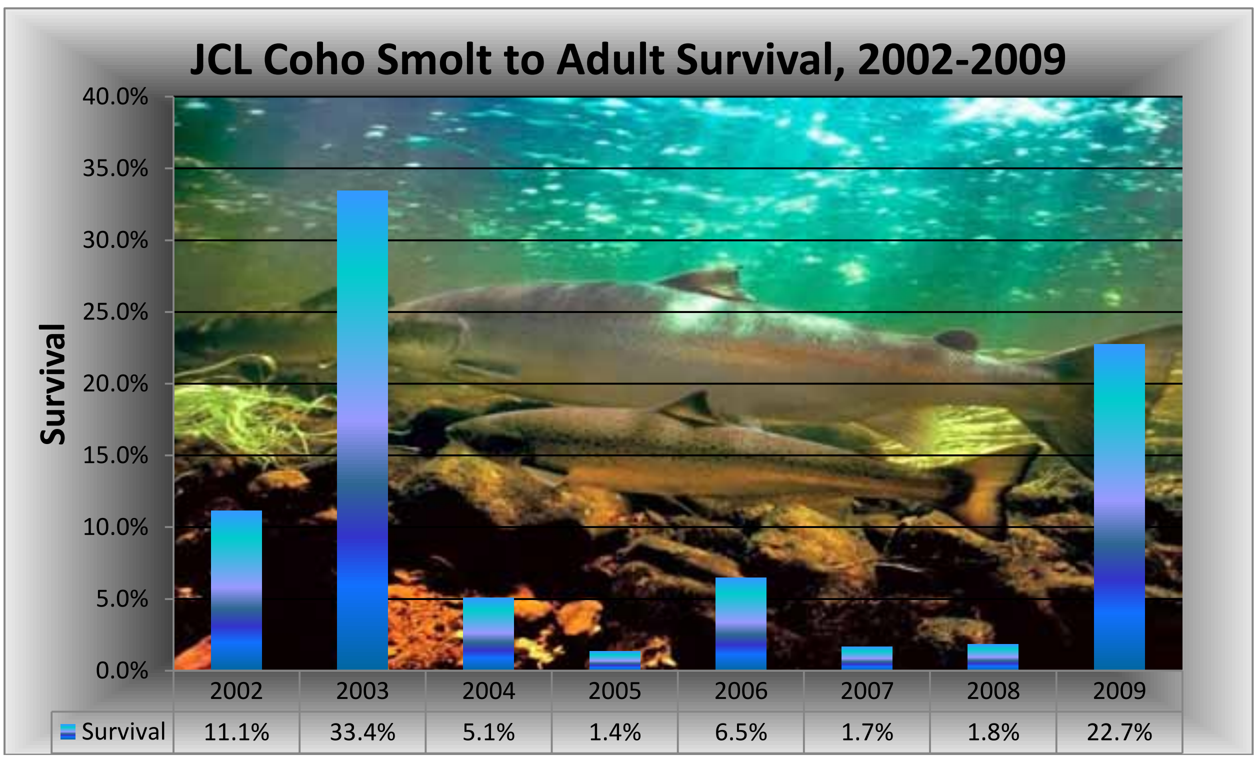


Figure 11.31. Coho smolt-to-adult survival estimates for Jimmycomelately Creek, smolt years 2002-2009.

DISCUSSION

Fresh (2006) determined that restoring and protecting nearshore habitats important to juvenile salmonids *must* (emphasis added) be a part of efforts to rebuild depleted salmonid runs throughout the Puget Sound region. The monitoring plan for the JCL channel (Shreffler 2001) did not establish any specific performance criterion for salmon smolt production. Nevertheless, smolt production is part of ongoing stream monitoring being performed by the Jamestown S'Klallam Tribe at JCL Creek, Siebert Creek, McDonald Creek, and Matriotti Creek. The smolt production data presented here provide one more piece of the puzzle in evaluating whether the Jimmy restoration project is meeting the stated goals in the Introduction Chapter of this report.

Smolt trap monitoring from 2002 to 2010 indicated that JCL Creek produces, in general, fewer coho smolts, steelhead smolts, steelhead parr, and juvenile cutthroat than other comparable streams along the Eastern Strait of Juan de Fuca (i.e., Matriotti Creek, McDonald Creek, and Siebert Creek). However, annual coho smolt production for JCL Creek has reached or approached the carrying capacity of the stream (2,000 – 2,500 smolts) in most years post-project, and coho egg-to-smolt survival and smolt-to-adult survival have been within the same range as those on comparable streams.

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Coho commonly co-occur with steelhead and cutthroat trout in western Washington streams. Coho juveniles are typically more numerous than steelhead or cutthroat, and coho are often the most numerous salmonid, especially in low gradient streams with lots of pools (Quinn 2005). There is a well documented relationship between the density of pools (m^2/km) and the number of coho smolts produced per kilometer in western Washington streams (Sharma and Hilborn 2001). As discussed in Chapter 4 Large Woody Debris and Pool/Riffle Habitat Surveys, there was a significant increase in the size and number of pools in the new JCL channel vs. the old JCL channel. We have not yet examined whether there is a relationship between coho smolts produced and the density of pools in the realigned JCL channel.

Many inter-related factors influence the movement, growth, and survival of juvenile salmonids in streams (see review in Quinn 2005); among these factors are egg size, fry size, emergence date, territorial behavior, metabolism, habitat quality, and density dependence. Undoubtedly all of these factors play a role in use of the realigned JCL stream channel by juvenile salmonids. Because the JCL channel was so recently restored, we suspect habitat quality (i.e., channel morphology, stream flows, and riparian health) significantly influences the survival of salmonid eggs and juveniles, as well as adult spawning success.

As the riparian area surrounding the project area develops and matures, egg and juvenile survival should increase. A healthy riparian zone provides food in the form of insects for the juvenile salmonids. In addition, trees and shrubs along the stream banks provide shade and moderate temperature fluctuations that may be harmful to eggs and young fish. Trees and shrubs along stream banks also provide cover to protect young fish from predators. As the riparian zone matures, trees and shrubs buffer the stream from upland runoff and prevent siltation of eggs that can be detrimental to egg survival. In addition, mature trees that fall into the stream create log and debris jams and pools that provide critical habitat for juvenile and adult salmonids.

The estuary is also very important to juvenile salmonid survival. The estuary provides food, cover and acts as a transitional zone between the freshwater environment of the stream and the saltwater environment in which salmonids spend most of their adult lives. As the riparian forest adjacent to the channel matures and the estuary returns to a normally functioning system, both spawning by adults and survival of eggs and juveniles should increase.

We will continue to monitor the smolt outmigrations in JCL. As more data becomes available, we will again look at the relationships between smolt production and JCL habitat parameters.

ACKNOWLEDGEMENTS

We would like to thank Randy Cooper, WDFW Biologist, and his crew for conducting spawning ground surveys and providing us with many years of valuable spawning ground data. Randy also provided us with data pertaining to coho smolt-to-adult survival from the WDFW's Snow Creek facility.

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CHAPTER 12. JUVENILE SALMONID USE: BEACH SEINE MONITORING

– DAVE SHREFFLER (SHREFFLER ENVIRONMENTAL)

BACKGROUND

Restoration Objective – JCL Channel (Shreffler 2001) and Estuary (Shreffler 2004)
The restoration objective relative to salmonid use was to restore free access to the realigned JCL channel and the estuary for juvenile salmonids and returning adult spawners at all tidal elevations, and to provide better rearing and spawning habitat than what was available in the former JCL channel. The long-term goal is to restore the populations of salmonids in JCL to harvestable levels.

Restoration Rationale – JCL Channel (Shreffler 2001) and Estuary (Shreffler 2004)
The Channel Design Group (CDG) believed this project would result in an increase in both habitat area and habitat functions, and that more habitat and better functioning habitat would result in more salmonids using the realigned JCL channel and estuary.

Historic species and numbers of salmonids using the Jimmycomelately Creek project area are unknown. The S'Klallam people, who have lived in the area for thousands of years, used Jimmycomelately Creek (JCL) and Sequim Bay as traditional hunting, fishing, shellfishing, and gathering areas. Gunther (1927) reports that the S'Klallam caught chum salmon in traps at the mouth of Jimmycomelately Creek starting in late July, which is much earlier than the run now returns. Salo (1991) suggested that historically chum salmon might have constituted up to 50% of the annual biomass of Pacific Salmon in the North Pacific Ocean.

Anadromous fish species documented in the project area include Hood Canal summer chum salmon, coho salmon, winter steelhead, and sea-run cutthroat trout. Of these species, summer chum salmon are of greatest concern because of their dramatic population declines and federal ESA-listing as a threatened species (Shreffler 2000).

METHODS

Following a pilot study in 2005 to determine the feasibility of beach seining in Lower Sequim Bay without causing unacceptable indirect mortality to juvenile salmonids (especially ―take” of ESA-listed Hood Canal Summer chum or Puget Sound Chinook), we embarked on a three-year (2006-2008) beach-seining program to evaluate juvenile salmonid use of Lower Sequim Bay. Our objective was to determine species composition, abundance, and length-frequency distributions of juvenile salmonids in Lower Sequim Bay post-restoration efforts on Jimmycomelately Creek (JCL), Dean Creek, and the estuary, as a measure of chum salmon recovery trends in JCL.

Sampling Sites

We sampled at a total of eleven (11) beach seining sites (EST_BSV1 through EST_BSV11) distributed along the lower end of Sequim Bay, as depicted in Figure 12.1. The sites extend from the Gunstone Property (west of the project area) to the tidal channel network in front of the Howe Property (east of the project area). These sites span a range of different habitat types that juvenile salmonids commonly use for feeding and rearing (i.e., mudflat, sand beach, cobble beach, eelgrass, and stream delta).

Using the geomorphic classification for shorelines developed by the Skagit River System Cooperative (Beamer and Fresh 2004), the shoreline in the lower end of Sequim Bay would be classified as a –stream delta" with the *dominant process* being fluvial and wave deposition, the *primary material* being fluvial and coastal sediments and the *landform* being stream valley.

Figure 12.1. Beach seining sites (EST_BSV1 through EST_BSV11) 2006 – 2008 (graphic by Pam Edens).

Sampling Gear
We used a 37-m long beach seine of the standard Puget Sound Estuary Program (PSEP) design, with the following dimensions: 18-m long x 2-m high wings of 3-cm black stretch mesh, and a bag 2-m high x 2.4-m wide x 2.3-m deep of 0.6cm green stretch mesh (Figure 12.2). The top rope of the net was kept at the surface by ―bullet" floats spaced at approximately 1m intervals. The bottom of the net was held down by a solid-core lead line. The tow ropes were 30-m long and made of floating polypropylene.

To allow comparisons with other previous studies of juvenile salmonid distribution and abundance, we used standard sampling methods. We deployed the beach seine approximately 30 m from shore and parallel to the beach, using an outboard-powered aluminum skiff and three to five field crew. One or two individuals stood on shore holding the 30-m rope attached to one end of the net until the reversing boat had pulled the rope taut. Once the rope was taut, another individual fed the net from the bow of the boat into the water as the skipper slowly motored in reverse to lay out all the net in an arc parallel to shore. The rope on the opposite end of the net was then motored to shore, and the person who had been in the bow of the boat deploying the net jumped ashore with the rope end to assist with retrieving the net. On each end of the net, teams of two individuals—spaced about 40m apart on shore—then pulled the net toward shore at a steady rate. When the net was approximately 10m from shore, the two teams moved together (within 10m of each other) closing down the net. The net was then retrieved onto shore with two people pulling in the float line and two people pulling in the lead line (Figure 12.3).

Sampling Frequency
During the February to June predicted period of the juvenile chum salmon outmigration from Jimmycomelately Creek, we sampled bi-weekly at the eleven sites (or a logical subset depending on weather) between February 27 and June 5, 2006, February 15 and May 30, 2007, and February 21 and June 10, 2008. We selected actual sampling dates based on optimal tide conditions, when the tide was between approximately +8 ft. MLLW and +4 ft. MLLW. Sampling at this tidal range was essential to avoid dragging captured fish through shallow water and mud, and to avoid stranding the boat. It also allowed us to sample closer to the vegetated marsh fringe, rather than only on the unvegetated mud and sand flats. We also scheduled sampling dates to avoid the period within two days following releases of chum fry from the summer chum salmon recovery program (see Chapter 10).

Data Recording
On each sampling date, the data recorder made note of the time of day, air temperature, water temperature, weather conditions, and habitat characteristics on a standard, waterproof data form. We also took digital photos to document our sampling methods, gear types, and fish catches.

Catch Processing
Following each beach seine set, we made a quick visual estimate of the size of the catch, in order to determine whether we could process the entire catch or needed to process a subsample. We made every effort to process the catch quickly and efficiently to minimize handling and stress to the captured fish. We always processed ESA-listed species first. When possible, we released fish directly from the seine collection bag back into the water, rather than dip-netting them and transferring them into 5-gallon buckets (Figure 12.4). In instances where transfer of fish into buckets was necessary, we used battery-operated air stones and frequent water changes to keep the water as well oxygenated and cool as possible (Figure 12.5). When subsampling was necessary, we took several random (i.e., not species or size selective) dip nets out of the seine collection bag. We then transferred the subsample to buckets and processed the fish as outlined below.

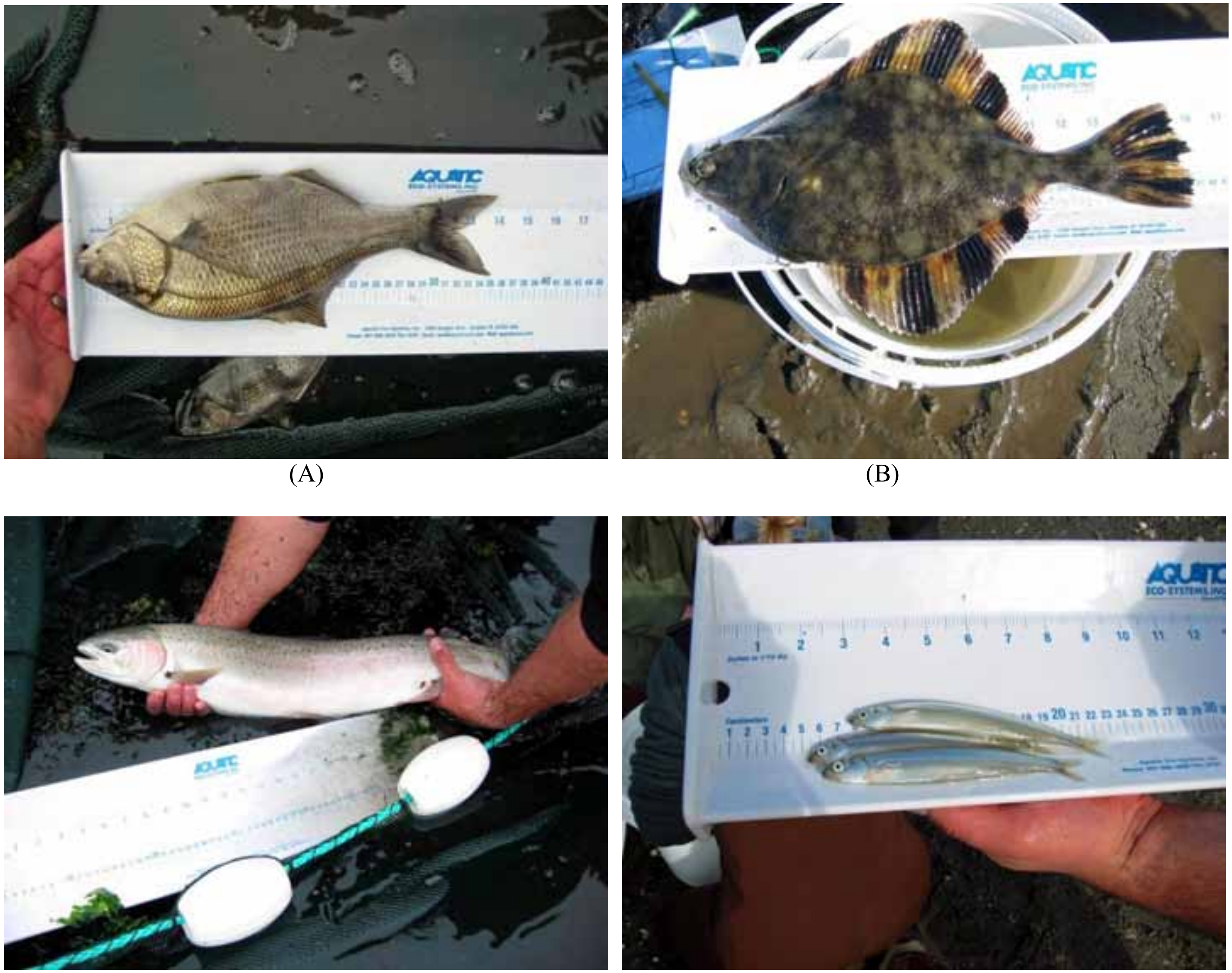
We identified each individual fish to species and recorded fork lengths (mm) or total lengths (mm) for up to 30 individuals of each species (Figure 12.6). All fish (salmonids and non-salmonids) were released alive. There was no intentional lethal take of ESA-listed species as part of this study.

Figure 12.2. Photo of the standard 37-m long beach seine used for 2006-2008 fish sampling (photo by Dave Shreffler).

Figure 12.3. Photo illustrating our beach seine retrieval method (photo by Dave Shreffler).

Figure 12.4. Photo of the field crew releasing an exceptionally large catch (mostly shiner perch) directly from the seine collection bag (photo by Dave Shreffler).

Figure 12.5. Photo of fish catch processing from aerated five gallon buckets (photo by Dave Shreffler).



(A) (B) (C) (D)

Figure 12.6. Photos of measuring fish lengths: (A) pile perch (Damalichthys vacca); (B) starry flounder (Platichthys stellatus); (C) steelhead (Oncorhynchus mykiss); and (D) surf smelt (Hypomesus pretiosus) (photos by Dave Shreffler).

Strategy for Minimizing Potential Mortality of ESA-Listed Species
The following methods were used to minimize mortality of ESA-listed species (in particular, Hood Canal summer chum):

- No sampling took place within 3 days of releases of chum fry from the Jimmycomelately summer chum salmon recovery program.
- If the ―take" thresholds specified in our sampling permit (i.e., 0 chinook fry, 30 chum fry) were exceeded at any time, all sampling stopped.
- ESA-listed species were always processed first.
- Handling of all fish, and especially salmonids, was minimized. When possible, fish were counted in the water and released directly from the net without handling.
- When handling of fish was necessary, wet hands and/or small aquarium dip nets were used. Fish were not handled with bare, dry hands.
- To maximize fish survival if there was a particularly large catch, the catch was separated into oxygenated, 5-gallon buckets.
- If air temperature exceeded 70°F (21°C), fish were only observed and counted but not handled.

RESULTS

Non-Salmonids
We caught a total of 64,680 non-salmonid fish representing 17 species over three years (2006 -2008) (Table 12.1). Pacific staghorn sculpin, shiner perch, and surf smelt were the numerical dominants, representing 67.0%, 17.7%, and 12.0% of the total non-salmonid catch, respectively.

Table 12.1. Total non-salmonid fish catch by year (2006 – 2008).

Common Name	2006	2007	2008	Total
Pacific staghorn sculpin	13696	11183	18475	43354
shiner perch	4714	1841	4913	11468
surf smelt	3653	814	3296	7763
unidentified juvenile flatfish	53	76	887	1016
starry flounder	309	85	139	533
snake prickleback	15	9	246	270
saddleback gunnel	4	59	17	80
three-spine stickleback	18	7	25	50
pile perch	40	2	2	44
herring	4	29	10	43
bay pipefish	2	10	2	14
sand lance	0	8	3	11
arrow goby	0	4	6	10
crescent gunnel	3	4	1	8
English sole	0	5	3	8
unidentified juvenile greenling	0	0	7	7
prickly sculpin	0	0	1	1
Total	22511	14136	28033	64680

The total non-salmonid catch per unit effort (CPUE) (i.e., catch per beach seine set) was 262 in 2006, 163 in 2007, and 298 in 2008 (Table 12.2), with Pacific staghorn sculpin representing a mean catch of 161 fish/set, shiner perch a mean catch of 43 fish/set, and surf smelt a mean catch of 29 fish/set over 3 years.

Table 12.2. Total non-salmonid fish catch per unit effort (2006 – 2008).

	No. caught/set			
Common Name	**2006**	**2007**	**2008**	**Mean**
Pacific staghorn sculpin	159.30	128.50	196.50	161.43
shiner perch	54.81	21.16	52.27	42.75
surf smelt	42.48	9.36	35.06	28.97
unidentified juvenile flatfish	0.62	0.87	9.44	3.64
starry flounder	3.59	0.98	1.48	2.02
snake prickleback	0.17	0.10	2.62	0.96
saddleback gunnel	0.05	0.68	0.18	0.30
three-spine stickleback	0.21	0.08	0.27	0.19
pile perch	0.47	0.02	0.02	0.17
herring	0.05	0.33	0.11	0.16
bay pipefish	0.02	0.12	0.02	0.05
sand lance	0	0.09	0.03	0.04
arrow goby	0	0.05	0.06	0.04
crescent gunnel	0.04	0.05	0.01	0.03
English sole	0	0.06	0.03	0.03
unidentified juvenile greenling	0	0	0.07	0.02
prickly sculpin	0	0	0.01	0.003
Total	261.81	162.50	298.18	

In addition to fish, we also caught crangon shrimp, pandalid shrimp, mysids, graceful crabs, hermit crabs, shore crabs, ctenophores, and jellyfish in our beach seine sets. We did not record numbers of these animals, but there were surprising numbers of juvenile crabs (mostly graceful crab, *Cancer gracilis*) (Figure 12.7).

Salmonids

We caught a total of 2,301 salmonids representing five species over three years (2006 -2008) (Table 12.3). Summer chum salmon (Figure 12.8) were the numerical dominants, representing 99% of the total salmonid catch. Other salmonids were caught in very low numbers: 5 steelhead, 5 coho salmon, 1 Chinook salmon, and 1 cutthroat trout.

Table 12.3. Total salmonid fish catch by year (2006 – 2008).

Common Name	**2006**	**2007**	**2008**	**Total**
Chum salmon	547	1039	703	2289
Steelhead	3	1	1	5
Coho salmon	2	0	3	5
Chinook salmon	0	1	0	1
Cutthroat trout	0	0	1	1
Total	552	1041	708	2301

We did a total of 86 beach seine sets in 2006, 88 sets in 2007, and 94 sets in 2008. The total salmonid catch per unit effort (CPUE) (i.e., catch per beach seine set) was 6 in 2006, 12 in 2007, and 8 in 2008 (Table 12.4), with chum salmon representing a mean catch of 9 fish/set over 3 years.

Figure 12.7. Beach seine collection bag with multiple juvenile graceful crabs (Cancer gracilis) (photo by Dave Shreffler).

Figure 12.8. Photo of juvenile summer chum salmon (Oncorhynchus keta) and their young "chum" (photo by Dave Shreffler).

Table 12.4. Total salmonid fish catch per unit effort (2006 – 2008).

Common Name	2006 (86 sets)	2007 (88 sets)	2008 (94 sets)	Mean
Chum salmon	6.36	11.81	7.48	8.55
Steelhead	0.04	0.01	0.01	0.02
Coho salmon	0.02	0	0.03	0.02
Chinook salmon	0	0.01	0	0.004
Cutthroat trout	0	0	0.01	0.004
Total	6.42	11.83	7.53	

Summer Chum Salmon

The peak of the chum outmigration was in April in all three years (Figure 12.9), with total chum catches of 547 in 2006, 1039 in 2007, and 703 in 2008. Chum fry from the summer chum salmon recovery program had a mark laid down on the otoliths using temperature stress, but we were unable to differentiate in the field between chum fry originating from natural production and recovery program production; thus, the 2,289 chum caught were likely a combination of the two.

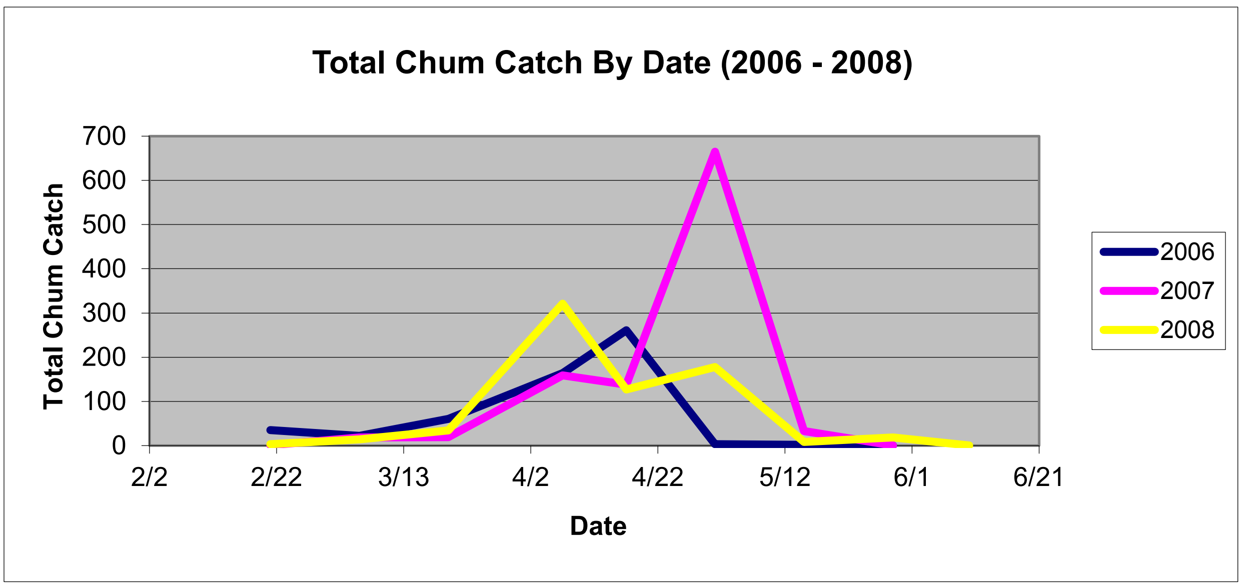


Figure 12.9. Total summer chum salmon catches by date (2006 – 2008).

We caught chum fry at all sites sampled (Figure 12.10). However, we caught more chum fry to the west of the Jimmycomelately delta (sites 1, 2, 3, 4, and 5) and the east of the delta (sites 9, 10, and 11) than at the delta itself (sites 6, 7, and 8).

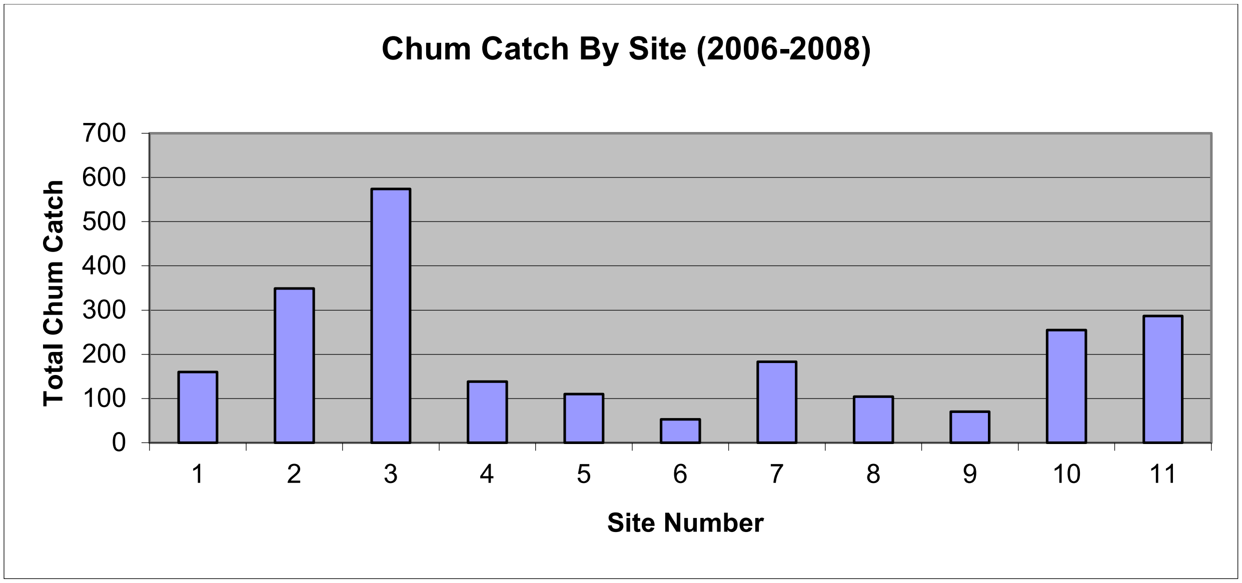


Figure 12.10. Total summer chum salmon catches by site (2006 – 2008).

The mean chum size ranged from 34 to 57 mm, with a mean size over all years of 45.67 mm fork length (Figure 12.11). There was an increase in mean size of chum caught between February and April in each of the three sampling years. The chum captured in April 2006 were larger overall than the chum captured in April 2007 or April 2008. The larger chum fry in 2006 cannot be attributed to the releases of recovery program fry, which were comparable in size in all three years (2006-2008) (Table 12.5). Between 2006 and 2008, a total of 210,540 chum fry were released in March and April from the recovery program.

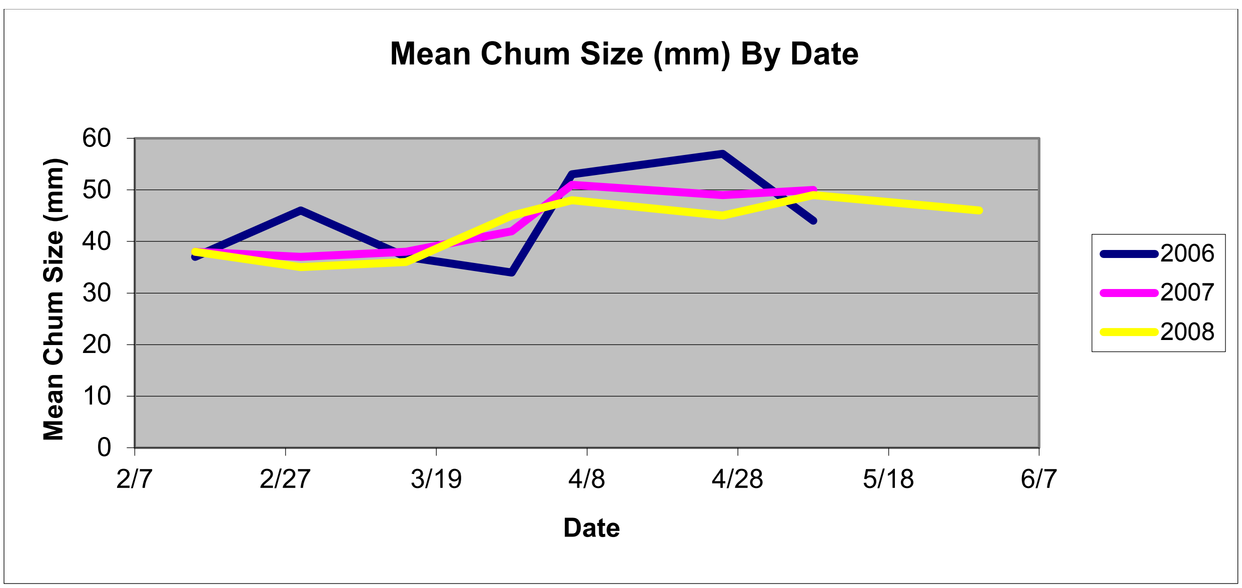


Figure 12.11. Summer chum mean size by date (2006 – 2008).

Table 12.5. Release dates and sizes for summer chum salmon from the Summer Chum Salmon Recovery Program (2006 – 2008).

2006	**3/27/06**	**4/3/06**	**4/14/06**		**Total**
Number released	19,244	19,851	18,205		57,300
Size - weight	1.0 grams	1.1 grams	0.9-1.1grams		
2007	**3/21/07**	**3/30/07**	**4/4/07**	**4/10/07**	
Number released	19,038	17,760	29,812	12,818	79,429
Size - weight	1.0-1.2 grams	1.0-1.1 grams	1.1-1.2 grams	1.0 grams	
2008	**4/3/08**	**4/10/08**	**4/17/08**	**4/24/08**	
Number released	19,333	9,569	27,935	16,974	73,811
Size - weight	1.1-1.2 grams	1.1 grams	0.9-1.1grams	1.1 grams	
					210,540

DISCUSSION

The purpose of the beach seine monitoring was to assess juvenile salmonid abundance in the Jimmycomelately Creek Estuary and Lower Sequim Bay (the nearshore) following restoration actions that occurred in the estuary between 2001 and 2005. The data from this three-year (2006-2008) beach seining study was intended to supplement project studies that addressed other salmonid habitats and life history periods; specifically, the salmonid weir placed in Jimmycomelately Creek to capture returning adult spawners in the fall (see Chapter 10 Adult Salmonid Use), the smolt trap placed in Jimmycomelately Creek to capture outmigrating smolts in the winter/spring (see Chapter 11 Juvenile Salmonid Use: Smolt Production), and tidal channel monitoring in the Jimmycomelately Creek Estuary designed to capture resident and outmigrating juvenile salmonids in the winter/spring (see Chapter 13 Juvenile Salmonid Use: Tidal Channel Monitoring).

The performance criteria established for juvenile salmonid use of the estuary were:

1. No stranding of juvenile salmonids in the tidal channel networks on the Log Yard, RV Park, and Eng properties.

2. At the end of 10 years, juvenile salmonid abundance within the estuary should be higher than the pre-project abundance within the former estuary (Shreffler 2004).

No stranding of adult or juvenile salmonids has ever been observed anywhere within the project area. We are unable to assess the second performance criteria because there are no pre-project, juvenile salmonid abundance data available. What we do know, based on pre- and post-restoration adult returns to Jimmycomelately Creek, is that a significantly higher number of summer chum salmon are returning to spawn since the restoration work occurred (see Chapter 10 Adult Salmonid Use). Thus, we would hypothesize that there has been a corresponding increase in post-project abundance of juvenile salmonids in the estuary, but we have no pre-project data to support or refute that hypothesis.

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The exact timing of chum fry emergence and downstream migration varies year to year and is a function of water temperature and the number of temperature units (TU's) required for hatching and development. We caught chum fry in every month of every sampling period over all three years (total =2,289 chum fry). In all three years, the peak of the chum outmigration period was in April. The most chum fry we caught on any one sampling day (all sites combined) was 665 on April 26, 2007 (16 days after the release of 12,818 broodstock fish on April 10, 2007); the next most were 321 on April 7, 2008 (4 days after a release of 19,333 broodstock fry on April 4, 2006) and 261 on April 24, 2006 (10 days after a release of 18,205 broodstock fry on April 4, 2006).

We were unable to ascertain in the field whether these peak chum catches were the direct result of the releases of chum fry in April from the broodstock recovery program, natural production, or a combination of the two.[10] Most likely it was a combination, as we caught a range of chum sizes, including some fry that were recently buttoned up (having just finished feeding from the yolk sac) and therefore definitively from natural production and others that were in the 40-50 mm range that would have likely come from the broodstock releases into JCL.

Given that a total of 210,540 chum fry were released in March and April from the broodstock program between 2006 and 2008, it is a bit surprising that we did not catch more chum fry in our seine sampling. Sather (2008) found three different life history strategies for juvenile chum in the Dungeness River system: chum that migrate from the river soon after emergence; chum that migrate from the river at slightly larger sizes than the first group (indicating some freshwater rearing); and chum that undergo prolonged freshwater rearing (e.g., weeks to months) before migrating to the estuary at a large size. For the Jimmycomelately Creek Estuary, we hypothesize that the larger fish from the broodstock program may head directly to the Strait of Juan de Fuca and not do any freshwater or estuarine rearing, whereas the natural production fry may have a tendency to rear in freshwater or brackish water and grow in size before heading to the Strait. Unfortunately, we have no data to test this hypothesis.

> We did not detect any preference of chum fry for one particular habitat type over another.

We did not detect any preference of chum fry for one particular habitat type over another. It was somewhat surprising that our chum salmon catches were higher both to the west and east of the Jimmycomelately Creek delta than at the delta itself. One likely explanation is a difference in gear efficiency. At all of the sites to the west and east of the stream delta, we were seining the whole water column from the water surface to the sediment. However, at the sites right at the stream delta the water was deeper and chum fry could have avoided the net by going underneath the lead line. Thus, the efficiency of our gear (and thus our catches) was likely lower at the stream delta sites.

Habitat use by chum appears to be strongly size dependent. Small chum fry (<50 – 60 mm) tend to migrate along the shoreline in shallow water, < 2 meters in depth (Fresh 2006). As chum fry increase in size to >60 mm, they expand the habitats they use to include nearshore surface waters. Migration rates of chum salmon in the nearshore areas depend upon such factors as fish size, foraging success, and environmental conditions (e.g., currents, prevailing winds) (Fresh 2006).

[10]The recovery program fry were marked in the hatchery by inducing a mark on the otolith from temperature stress. However, without sacrificing fish in the field (which we were unwilling to do), there was no way to tell recovery program fry from natural production fry.

Our most unusual beach seine catch was three adult steelhead (2 females and 1 male) in the same set at Site 2 on February 27, 2006. Catching adult steelhead at this site to the west of the JCL delta was further evidence of the efficiency of the seine at these broad sand/mudflat sites. In thousands of seine sets all over the Strait of Juan de Fuca and Puget Sound, I have never before caught adult steelhead; they are typically too fast and simply avoid the net. Catching 40 adult pile perch was also a surprise. Perhaps they were searching for the pilings we had eliminated in order to remove creosote from the marine environment.

Forage fish are small, schooling fishes that are critical prey items for larger predatory fish, especially salmonids, as well as wildlife in a nearshore food web (Penttila 2007). Without healthy populations of forage fish, the Puget Sound ecosystem would likely crash (Fresh et al. 2011). The three most common forage fish species in Puget Sound nearshore areas are Pacific herring, surf smelt, and Pacific sandlance, and all three species have been documented to spawn in Sequim Bay as of October 2005: Pacific herring (mid-January to March), surf smelt (year-round), and Pacific sandlance (unknown) (Penttilla 2007).

During our beach seine surveys in Lower Sequim Bay, surf smelt were the third most abundant fish species caught overall (total = 7,763; mean = 29 fish/set). Pacific herring and Pacific sand lance were caught in very low numbers.

It is unknown whether surf smelt spawn within the restored project area; no spawning ground surveys were performed as part of the Jimmy Project monitoring. Shaffer et al. (2003) reported surf smelt spawning along the Lower Sequim Bay shoreline west of Dean Creek (outside the restored project area). In general, the potential spawning/spawn incubation zone for surf smelt spans the uppermost one-third of the tidal range, from approximately +7 feet up to extreme high water (EHW) in central Puget Sound or the local equivalent (Penttila 2007). Spawning substrate grain size is generally a sand-gravel mix, with the bulk of the material in the 1-7 mm diameter range. The thickness of the spawn-bearing substrate layer on the upper beach will vary with local wave-action and sediment-supply regimes, ranging from 1-10 cm. The physical area of spawning substrate can vary from a discontinuous array of small patches around the high tide line to nearly continuous bands of material several meters wide and several kilometers long.

The Jimmycomelately Creek Estuary and Lower Sequim Bay clearly serve as a nursery area for multiple fish, as highlighted by the diversity (17 non-salmonid species and 5 salmonid species) and abundance of fish species using the sampling area (total cumulative catch = 66.981 fish).

The Jimmycomelately Creek Estuary and Lower Sequim Bay clearly serve as a nursery area for multiple fish, as highlighted by the diversity (17 non-salmonid species and 5 salmonid species) and abundance of fish species using the sampling area (total cumulative catch = 66,981 fish). Based on our observations of Pacific staghorn sculpins eggs and gravid female shiner perch, it seems likely that these species—which represent the numerically dominant species caught—spawn in Sequim Bay. Of particular note was the large number of juvenile Pacific staghorn sculpins we caught during our surveys (total = 43,354; mean = 161 fish/set). Lower Sequim Bay also appears to be a nursery area for crabs (Figure 12.7).

Another indicator of the productivity of Lower Sequim Bay is the prevalence of birds we observed (see Chapter 14 Bird Use) that preferentially eat fish (e.g., great blue herons, goldeneyes, mergansers, double-crested cormorants, scoters, various species of gulls, and Caspian terns). All of these species likely take advantage of the seasonal availability of shiner perch, and the year-round availability of Pacific staghorn sculpins and surf smelt. Pacific staghorn sculpins are documented to be among the preferred prey species for great blue herons (Eissinger 2007), and likely provide a year-round food supply for the ubiquitous herons in Lower Sequim Bay.

In addition, multiple shorebird species that feed on macroinvertebrates (Buchanan 2006) can be observed in the restored tide flats of Lower Sequim Bay (see Chapter 14 Bird Use). Overall, the restored estuary appears to be fueling a healthy, productive, detritus-based food web.

Salmonid productivity depends not on a single habitat or life history period but is a function of all the habitats used by salmonids throughout their life (Beamer and Fresh 2004). Salmonid recovery plans must thus consider the full range of habitats used, from spawning grounds to the ocean. NOAA Fisheries uses four attributes (abundance, population growth rate, spatial structure, and diversity) to define viability of salmonid populations (McElhany et al. 2000). The nearshore of Puget Sound clearly supports the viability and persistence of salmonid populations by contributing to these four Viable Salmonid Population (VSP) attributes (Beamer and Fresh 2004).

As a result of the beach seine sampling, we now have direct evidence of the benefits of restoring Jimmycomelately Creek and Estuary. We have documented or observed that the estuary and Lower Sequim Bay serve as a nursery for many invertebrates, fish, and wildlife. In particular, the detritus-based food web appears to be providing a ―life support system" (Healey 1982, Simenstad et al. 1982) for threatened Jimmycomelately summer chum salmon, and chum fry are likely benefitting from an increase in both the quantity and quality of feeding and refuge habitat available to them.

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The beach seining study would not have been possible without the funding and guidance of Byron Rot and the Jamestown S'Klallam Tribe. A long list of volunteers donated hundreds of hours to make this 3-year study possible through weather that was delightful, bitterly cold, windy, and at times downright challenging: Cheri Scalf, Al Davis, Fred Bailey, Steve Rankin, Laurel Dawson, Eliza Dawson, Chloe Dawson, Mike Dawson, Chris Duff, Ann Soule, Lisa Markli, Sam Baker, Don Schuba, David Kirner, Bill Shaw, Lori DeLorm, Will Nance, Owen French, Lohna O'Rourke, Byron Rot, Steve Irish, Dusty Humphries, Tina Vogel, Nikki Sather, Bob DeLorm, Greg Williams, Hazel Richmond, Jared Johnson, Dave Johnson, and Aleta Erickson. My apology to anyone I missed.

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CHAPTER 13. JUVENILE SALMONID USE: TIDAL CHANNEL MONITORING

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BACKGROUND

Restoration Objective – JCL Channel (Shreffler 2001) and Estuary (Shreffler 2004)
The restoration objective relative to salmonid use was to restore free access to the realigned JCL channel and the estuary for juvenile salmonids and returning adult spawners at all tidal elevations, and to provide better rearing and spawning habitat than what was available in the former JCL channel. The long-term goal is to restore the populations of salmonids in JCL to harvestable levels.

Restoration Rationale – JCL Channel (Shreffler 2001) and Estuary (Shreffler 2004)
The Channel Design Group (CDG) believed this project would result in an increase in both habitat area and habitat functions, and that more habitat and better functioning habitat would result in more salmonids using the realigned JCL channel and estuary.

The objective of tidal channel monitoring was to evaluate juvenile fish use of natural and constructed tidal channels in the restored Jimmycomelately Creek Estuary. Tidal channel monitoring was not originally called for in the estuary monitoring plan (Shreffler 2004), but was added as a pilot study to supplement smolt trap data gathered in Jimmycomelately Creek (Chapter 11) and beach seining data gathered on juvenile salmonid use of Lower Sequim Bay (Chapter 12).

METHODS

Sampling Sites

A field crew of three or four people led by Shreffler Environmental sampled at three natural tidal channels (reference sites R1, R2, and R3) and three constructed tidal channel/channel networks (constructed sites C1, C2, C3) in 2009, as depicted in Figure 13.1. The site descriptions are as follows:

C1 = Outlet of former log yard lagoon (see photo, Figure 13.2)
C2 = Outlet of former RV Park tidal channel network (see photo, Figure 13.2)
C3 = Outlet of Eng tidal channel network (see photo, Figure 13.2)
R1 = Tidally-influenced tributary to JCL (see photo, Figure 13.2)
R2 = Outlet of JST west tidal channel network (see photo, Figure 13.2)
R3 = Outlet of JST east tidal channel network (no photo; this site was dropped)

Gear types

We sampled tidal channels from mid-February through mid-June of 2009 using a combination of one fyke net, two pole seines, and two block nets. Fyke nets (channel trap nets) are designed to capture fishes as they outmigrate from tidal habitats during an ebbing tide. Most motile fishes (e.g., juvenile salmonids) will be captured by fyke nets, because few will occupy burrows and depressions during tidal exposure as will some sedentary fishes (e.g., sculpins). The fyke net we used consisted of a 1.8m x 3.9m trap and two 10.7m x 3.1m wings; all constructed of 0.038mm knotless nylon netting.

We deployed the fyke net at high slack tide, with the wings stretched across the tidal channel near its outlet and staked to the bank. As the tide ebbed, most of the fish in the marsh drainage area of the channel above the net, and in the channel proper, were forced into the live box at the funnel end of the fyke net

(Figure 13.3). When the channel was mostly dewatered at low tide, we collected fish from within the live box and processed them as described below (Figure 13.4).

We also sampled some of the well-defined tidal channels using a two-person pole seine to ―herd” fish from the upper end of a tidal channel(s) down to a block net installed, and secured in place with sand bags, at the outlet of the tidal channel/tidal channel network (Figure 13.5). On some sampling dates, we installed the outlet block nets and fyke net during an evening or nighttime high tide and then returned the next morning at low tide to pole seine and capture fish trapped behind the block nets or fyke net.

Sampling Frequency

We sampled at a subset of the six sites bi-weekly from mid-Feb through mid-June 2009 (nine sampling periods total). Sampling dates, times, and gear types used are summarized in Table 13.1. The timing of sampling was driven by the tidal cycle, and thus both day and night sampling were required on some sampling dates. Given our manpower and gear constraints, it was not logistically possible to sample all six sites on any one tidal cycle. We also scheduled our tidal channel sampling to avoid the period within three days after fry releases from the summer chum salmon recovery program (Table 13.2).

Table 13.1. Sampling dates, times, locations, and gear types for 2009 tidal channel monitoring.

Sampling Date & Start Time	Sampling Date & End Time	Location & Gear Type
February 20, 2009 10:11am	February 20, 2009 3:23 pm	C3 – fyke net
February 20, 2009 10:36 am	February 20, 2009 1:30 pm	R1 – pole seine & block net
February 20, 2009 12:08 pm	February 20, 2009 12:30 pm	C1 – pole seine & block net
March 6, 2009 8:47 am	March 6, 2009 3:55 pm	R2 – pole seine & block net
March 6, 2009 9:17 am	March 6, 2009 3:30 am	C3 – fyke net & pole seine behind fyke net
March 6, 2009 9:35 am	March 6, 2009 2:34 pm	R1 –pole seine & block net
March 6, 2009 9:47 am	March 6, 2009 1:50 pm	C2 – pole seine & block net
March 20, 2009 9:00 am	March 20, 2009 3:10 pm	C3 – fyke net & pole seine behind fyke net
March 20, 2009 9:14 am	March 20, 2009 12:37 pm	R1 –pole seine & block net
March 20, 2009 9:20 am	March 20, 2009 1:37 pm	C2 – pole seine & block net
April 6, 2009 12:45 pm	April 6, 2009 5:57 pm	C3 – fyke net & pole seine behind fyke net
April 6, 2009 1:18 pm	April 6, 2009 4:36 pm	C2 – pole seine & block net
April 6, 2009 1:25 pm	April 6, 2009 5:19 pm	R1 –pole seine & block net
April 6, 2009 2:03 pm	April 6, 2009 6:55 pm	C1 –pole seine & block net
April 16, 2009 10:24 pm	April 17, 2009 11:50 am	R1 –pole seine & block net
April 16, 2009 11:30 pm	April 17, 2009 10:52 am	C2 – pole seine & block net
April 16, 2009 11:55 pm	April 17, 2009 1:57 pm	C3 – fyke net & pole seine behind fyke net
April 17, 2009 12:10 am	April 17, 2009 9:50 am	R2 – pole seine & block net
April 30, 2009 10:05 pm	May 1, 2009 12:10 pm	C2 – pole seine & block net
April 30, 2009 10:38 pm	May 1, 2009 11:00 am	R1 –pole seine & block net
April 30, 2009 10:48 pm	May 1, 2009 1:49 pm	C3 – fyke net & pole seine behind fyke net
April 30, 2009 11:05 pm	May 1, 2009 8:36 am	R2 – pole seine & block net
May 14, 2009 9:00 pm	May 15, 2009 9:42 am	C2 – pole seine & block net
May 14, 2009 9:10 pm	May 15, 2009 10:58 am	R1 –pole seine & block net
May 14, 2009 9:23 pm	May 15, 2009 11:52 am	C3 – fyke net & pole seine behind fyke net
May 28, 2009 9:02 pm	May 29, 2009 10:44 am	C2 – pole seine & block net
May 28, 2009 9:16 pm	May 29, 2009 12:30 pm	R1 –pole seine & block net
May 29, 2009 9:25 pm	May 29, 2009 9:36 am	C3 – fyke net & pole seine behind fyke net
June 11, 2009 7:22 pm	June 12, 2009 10:07 am	C2 – pole seine & block net
June 11, 2009 7:48 pm	June 12, 2009 11:17 am	R1 –pole seine & block net
June 11, 2009 8:35 pm	June 12, 2009 9:13 am	C3 – fyke net & pole seine behind fyke net

Figure 13.1. Constructed (C) and reference (R) sampling sites for 2009 tidal channel monitoring in the Jimmycomelately Creek Estuary (graphic by Dave Shreffler).

Figure 13.2. **Photos (view looking upstream from outlet) of constructed (C) and reference (R) sampling sites for 2009 tidal channel monitoring in the Jimmycomelately Creek Estuary (graphic by Dave Shreffler).**

Figure 13.3. Low tide view of the fyke net deployed at the outlet of the Eng tidal wetland complex (Constructed Site C2) (photo by Dave Shreffler).

Figure 13.4. Cheri Scalf and Victor Lebeus processing fish removed from the live box of the fyke net at the outlet of the Eng tidal wetland complex (Constructed Site C2) (photo by Dave Shreffler).

Figure 13.5. Victor Lebeus and Scott Sollars pole seining in a tidally-influenced freshwater tributary to Jimmycomelately Creek (Reference Site R1) (photo by Dave Shreffler).

Table 13.2. Jimmycomelately Creek summer chum salmon recovery project fry releases in 2009.

	3/16/09	3/24/09	3/30/09	4/6/09	4/18/09
Number released	17,458	19,733	17,395	6,881	27,299
From	Valhalla	Valhalla	Valhalla	Valhalla	Woods
Size - weight	1.0 grams	1.0 grams	1.2 grams	1.0 grams	1.1 -1.3 grams
Size - length	46 mm	46 mm	~51 mm	46 mm	~51 mm
Release site	101 Bridge	101 Bridge	101 Bridge	Downstream of Eng wetlands	Downstream of Eng wetlands

The fyke net proved to be practical at only one of the six sites; the deeper, wider channel at the mouth of the outlet of the Eng tidal channel network (Site C3). All of the other sites, except R3, were sampled using a pole seine behind a block net installed at the tidal channel outlet. Site R3 we abandoned, without ever sampling it, because there was a sill at the outlet of the tidal channel that limited fish access to this tidal channel system to a very short window of opportunity. We attempted sampling at Site R2 (outlet of JST west tidal channel) on March 6, April 16, and April 30. However, this site proved very difficult to sample because it was perched at a higher elevation than all the other tidal channels. This meant it was the last of our sampling sites to fill with water at high tide and the first to drain at low tide. We only attempted sampling at the outlet of the log yard lagoon (Site C1) on two dates (February 20 and April 6); this site was too shallow, soft, and muddy to effectively sample without inducing high fish mortality from dragging the seine through the mud.

After the first four sampling periods, we limited our sampling to just three sites (C2, R1, and C3) because these channels were similar in elevation and the timing of when they filled at high tide and drained at low tide, and because these sites consistently produced higher fish catches than R2 or C1. For the five sampling periods between April 16 and June 12, we developed a new standard monitoring protocol that consisted of installing the tidal channel block nets at C2 and R1 and the fyke net at C3 on an evening high tide, leaving the nets in place overnight, and returning the following morning at low tide to pole seine upstream from the block nets at C2 and R1 and the fyke net at C3.

Data Recording

On each sampling date, the data recorder made note of the time of day, air temperature, water temperature, weather conditions, and habitat characteristics on a standard, waterproof data form. We also took digital photos to document our sampling methods, gear types, and fish catches.

Catch Processing

Following each fyke net set or pole seine set, we made a quick visual estimate of the size of the catch, in order to determine whether we could process the entire catch or needed to process a subsample. We made every effort to process the catch quickly and efficiently to minimize handling and stress to the captured fish. We always processed ESA-listed species first. When possible, we released fish directly from the fyke live box or seine collection bag back into the water, rather than dip-netting them and transferring them into 5-gallon buckets. In instances where transfer of fish into buckets was necessary, we used battery-operated air stones and frequent water changes to keep the water as well oxygenated and cool as possible. When subsampling was necessary, we took several random (i.e., not species or size selective) dip nets out of the fyke live box or seine collection bag. We then transferred the subsample to buckets and processed the fish as outlined below.

We identified each individual fish to species and recorded fork lengths (mm) or total lengths (mm) for up to 30 individuals of each species. All fish (salmonids and non-salmonids) were released alive. There was no intentional lethal take of ESA-listed species as part of this study.

Strategy for Minimizing Potential Mortality of ESA-Listed Species

The following methods were used to minimize mortality of ESA-listed species (in particular, Hood Canal summer chum):

- No sampling took place within 3 days of releases of chum fry from the Jimmycomelately summer chum salmon recovery program.
- If the ―take" thresholds specified in our sampling permit (i.e., 0 chinook fry, 30 chum fry) were exceeded at any time, all sampling stopped.
- ESA-listed species were always processed first.
- Handling of all fish, and especially salmonids, was minimized. When possible, fish were counted in the water and released directly from the net without handling.
- When handling of fish was necessary, wet hands and/or small aquarium dip nets were used. Fish were not handled with bare, dry hands.
- To maximize fish survival if there was a particularly large catch, the catch was separated into oxygenated, 5-gallon buckets.
- If air temperature exceeded 70°F (21°C), fish were only observed and counted but not handled.

RESULTS

We caught a total of 682 summer chum salmon fry, 27 coho salmon fry, and 10 cutthroat trout fry (Table 13.3). No Chinook fry were captured. Nearly 70% of the chum (476/682) were caught in constructed channel C3, the outlet of the Eng tidal wetland complex (Table 13.4). More than 15% of the chum (104/682) were caught in reference channel R1, the outlet of a natural tributary to Jimmycomelately Creek. More than 14% of the chum (100/682) were caught in constructed channel C2, the outlet channel of the former RV Park tidal channel network. Only two (2) chum were caught in reference channel R2, the sinuous, natural tidal channel on Jamestown S'Klallam Tribe property to the east of the Howe house.

A total of 88,766 summer chum fry were released into Jimmycomelately Creek in 2009 from the WDFW summer chum salmon recovery program. Based on the timing and size at release (>46 mm) of these recovery program chum fry (Table 13.2), the chum fry we caught were likely from natural production rather than supplemented production. All of the chum fry we caught during tidal channel monitoring, except for one 56-mm chum at Site C3 on May 1, 2009, were less than 46 mm.

The three dominant non-salmonid fish species we caught were Pacific staghorn sculpins (4,340), three-spined sticklebacks (1,196), and shiner perch (74) (Table 13.5). The only other non-salmonid fish species we caught were arrow goby (6) and prickly sculpin (2).

Table 13.3. Summary of all salmonids caught during 2009 tidal channel monitoring.

Site Name	Date	Sum of Total	Common Name	Scientific Name
TCM_R1	2/20/2009	2	Chum salmon	*Oncorhynchus keta*
TCM_R1	3/6/2009	14	Chum salmon	*Oncorhynchus keta*
TCM_C3	3/6/2009	104	Chum salmon	*Oncorhynchus keta*
TCM_C2	3/6/2009	42	Chum salmon	*Oncorhynchus keta*
TCM_C3	3/6/2009	1	Coho salmon	*Oncorhynchus kisutch*
TCM_C3	3/20/2009	33	Chum salmon	*Oncorhynchus keta*
TCM_R1	3/20/2009	39	Chum salmon	*Oncorhynchus keta*
TCM_R1	3/20/2009	2	Coho salmon	*Oncorhynchus kisutch*
TCM_C2	3/20/2009	20	Chum salmon	*Oncorhynchus keta*
TCM_C3	4/6/2009	50	Chum salmon	*Oncorhynchus keta*
TCM_C2	4/6/2009	16	Chum salmon	*Oncorhynchus keta*
TCM_R1	4/6/2009	34	Chum salmon	*Oncorhynchus keta*
TCM_R1	4/6/2009	8	Coho salmon	*Oncorhynchus kisutch*
TCM_R1	4/16/2009	5	Coho salmon	*Oncorhynchus kisutch*
TCM_C2	4/16/2009	22	Chum salmon	*Oncorhynchus keta*
TCM_R1	4/16/2009	12	Chum salmon	*Oncorhynchus keta*
TCM_C3	4/16/2009	2	Coho salmon	*Oncorhynchus kisutch*
TCM_C3	4/16/2009	117	Chum salmon	*Oncorhynchus keta*
TCM_R2	4/17/2009	1	Chum salmon	*Oncorhynchus keta*
TCM_R1	5/1/2009	2	Coho salmon	*Oncorhynchus kisutch*
TCM_R2	5/1/2009	1	Chum salmon	*Oncorhynchus keta*
TCM_C3	5/1/2009	1	Coho salmon	*Oncorhynchus kisutch*
TCM_C3	5/1/2009	146	Chum salmon	*Oncorhynchus keta*
TCM_R1	5/15/2009	3	Chum salmon	*Oncorhynchus keta*
TCM_R1	5/15/2009	3	Coho salmon	*Oncorhynchus kisutch*
TCM_C3	5/15/2009	26	Chum salmon	*Oncorhynchus keta*
TCM_C3	5/29/2009	2	Coho salmon	*Oncorhynchus kisutch*
TCM_C3	5/29/2009	7	Cutthroat trout	*Oncorhynchus clarki*
TCM_R1	5/29/2009	2	Cutthroat trout	*Oncorhynchus clarki*
TCM_R1	6/12/2009	1	Coho salmon	*Oncorhynchus kisutch*
TCM_C3	6/12/2009	1	Cutthroat trout	*Oncorhynchus clarki*
Total Chum		**682**		
Total Coho		**27**		
Total Cutthroat		**10**		
Total All Salmonids		**719**		

Table 13.4. 2009 tidal channel monitoring summer chum salmon catch summary by site and date.

	SAMPLING DATE									
Site Name	20-Feb	6-Mar	20-Mar	6-Apr	17-Apr	1-May	15-May	29-May	12-Jun	Total
Constructed Channels										
C1	n/a	n/a	n/a	0	n/a	n/a	n/a	n/a	n/a	0
C2	n/a	42	20	16	22	0	0	0	0	100
C3	0	104	33	50	117	146	26	0	0	476
Reference Channels										
R1	2	14	39	34	12	0	3	0	0	104
R2	n/a	n/a	n/a	n/a	1	1	n/a	n/a	n/a	2
TOTAL	2	160	92	100	152	147	29	0	0	682

Table 13.5. Summary of all non-salmonids caught during 2009 tidal channel monitoring.

Site Name	Date	Sum of Count	Common Name	Scientific Name
TCM_R1	2/20/2009	79	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_R1	2/20/2009	24	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_R1	3/6/2009	4	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_C3	3/6/2009	68	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_C3	3/6/2009	24	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_C2	3/6/2009	284	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_R1	3/6/2009	27	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_C2	3/6/2009	30	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_R2	3/6/2009	2	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_C3	3/20/2009	10	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_R1	3/20/2009	30	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_C2	3/20/2009	7	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_C3	3/20/2009	2	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_C2	3/20/2009	465	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_R1	3/20/2009	148	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_C2	4/6/2009	1	arrow goby	*Clevelandia ios*
TCM_R1	4/6/2009	4	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_C3	4/6/2009	53	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_C2	4/6/2009	109	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_C2	4/6/2009	545	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_R1	4/6/2009	50	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_C3	4/6/2009	41	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_C3	4/17/2009	6	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_R1	4/17/2009	21	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_C3	4/17/2009	57	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_C2	4/17/2009	95	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_C2	4/17/2009	21	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_R1	4/17/2009	47	Pacific staghorn sculpin	*Leptocottus armatus*

TCM_R2	4/17/2009	12	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_R2	5/1/2009	200	shore crab	
TCM_C3	5/1/2009	45	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_C3	5/1/2009	1	prickly sculpin	*Cottus asper*
TCM_R2	5/1/2009	1	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_C3	5/1/2009	16	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_R1	5/1/2009	1	prickly sculpin	*Cottus asper*
TCM_R1	5/1/2009	63	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_C2	5/1/2009	96	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_R1	5/1/2009	6	Shiner perch	*Cymatogaster aggregata*
TCM_C2	5/1/2009	38	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_R1	5/1/2009	67	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_C2	5/1/2009	5	arrow goby	*Clevelandia ios*
TCM_C2	5/1/2009	12	shore crab	
TCM_R1	5/1/2009	20	shore crab	
TCM_C3	5/15/2009	168	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_C3	5/15/2009	69	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_C2	5/15/2009	59	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_R1	5/15/2009	160	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_R1	5/15/2009	2	Shiner perch	*Cymatogaster aggregata*
TCM_R1	5/15/2009	98	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_C2	5/15/2009	6	shore crab	
TCM_C2	5/15/2009	32	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_C2	5/29/2009	3	Shiner perch	*Cymatogaster aggregata*
TCM_C2	5/29/2009	255	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_R1	5/29/2009	255	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_R1	5/29/2009	50	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_C3	5/29/2009	500	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_R1	5/29/2009	27	Shiner perch	*Cymatogaster aggregata*
TCM_C2	5/29/2009	12	shore crab	
TCM_C3	5/29/2009	86	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_C3	5/29/2009	31	Shiner perch	*Cymatogaster aggregata*
TCM_C2	5/29/2009	150	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_C3	6/12/2009	621	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_C3	6/12/2009	4	Shiner perch	*Cymatogaster aggregata*
TCM_C2	6/12/2009	8	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_C2	6/12/2009	283	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_R1	6/12/2009	100	Pacific staghorn sculpin	*Leptocottus armatus*
TCM_R1	6/12/2009	1	Shiner perch	*Cymatogaster aggregata*
TCM_R1	6/12/2009	100	shore crab	
TCM_R1	6/12/2009	41	Three-spine stickleback	*Gasterosteus aculeatus*
TCM_R1	6/12/2009	1	unidentifiedjuvenile flatfish	
TCM_C3	6/12/2009	37	Three-spine stickleback	*Gasterosteus aculeatus*
Total Staghorns		**4,340**		
Total Sticklebacks		**1,196**		
Total Shiners		**74**		

DISCUSSION

> The juvenile life stages of chum and Chinook salmon are often considered the most estuarine dependent because of their prolonged use of estuarine habitats.

Tidal channels are documented to be important habitats for juvenile salmonid feeding, refuge from predators, and physiological transition during their seaward migration (see review in Fresh 2006). The juvenile life stages of chum and Chinook salmon are often considered the most estuarine dependent because of their prolonged use of estuarine habitats (see review in Sather 2008). We conducted a pilot study in 2009 to assess juvenile fish use of constructed tidal channels and natural (reference) tidal channels in the Jimmycomelately Creek Estuary. We documented that significant numbers of chum salmon (682) and lower numbers of coho salmon (27) and cutthroat trout (10) used both the constructed and natural tidal channels in 2009. We caught the highest percentage of chum salmon in constructed channel C3 (69.8%), followed by natural channel R1 (15.2%), constructed channel C2 (14.7%), and natural channel R2 (0.3%). These same tidal channels were also used by non-salmonids; in particular, Pacific staghorn sculpins (4,340), three-spined sticklebacks (1,196), and shiner perch (74).

Our null hypothesis for this pilot study was that there is no significant difference in fish abundance or fish species composition between the constructed tidal channels and the natural (reference) tidal channels. On the basis of our monitoring results we are unable to either accept or reject the null hypothesis. A paired comparison of constructed and reference tidal channels was not possible due to the limitations of gear availability and manpower. In addition, two of the intended reference channels (R2 and R3) proved to be infeasible to effectively sample and of limited use to fish because of the brief window of opportunity during which fish could access these tidal channels.

Our pre-sampling expectation was that we would catch the highest numbers of juvenile salmonids in the mature, vegetated, sinuous, natural channels R2 and R3. However, we only caught a total of two chum in channel R2 and no salmonids in channel R3, which we eliminated as a sampling site because it was perched too high to be accessible to fish except at the highest possible tides (>7.6 ft. MLLW). It is likely that channel R2 is not used much by juvenile salmonids because: a) it is too high in elevation to be of much use as fish habitat (it requires a tide higher than ~7.2 ft. MLLW to fill, and it drains very quickly, and thus fish have limited opportunity to use it); and b) it is potentially too far from the JCL main channel to be chosen by fish over other tidal channels that are much closer to the main channel. The highest fish catches recorded were at constructed channel C3, natural channel R1, and construction channel C2, all of which have a direct connection to the Jimmycomelately channel. This is also the order in which fish migrating downstream would encounter these tidal channels (i.e., C3 first, then R1, then C2).

Other researchers have found that the distance of tidal channel habitats to the main channel from which juvenile salmonids are outmigrating can be a primary determinant in their level of use of a particular tidal channel (Simenstad and Cordell 2000, Gray et al. 2002, Beamer et al. 2005, Sather 2008). In particular, Sather (2008) found that although *habitat complexity* (e.g., prey availability, structure) and *opportunity* (e.g., water depth, velocity, water quality) partially governed the distribution of juvenile salmonids within tidal marshes near the Dungeness River, salmonid distribution was most strongly influenced by the *degree of habitat connectivity* (i.e., distance) between the tidal marshes and the mouth of the Dungeness River.

The performance criterion established for juvenile salmonid use of the estuary was: *at the end of 10 years, juvenile salmonid abundance within the estuary should be higher than the pre-project abundance within* *the former estuary* (Shreffler 2004). We are unable to assess this criterion because there are no pre-project, juvenile salmonid abundance data available. What we do know, based on pre- and post-restoration adult returns to Jimmycomelately Creek is that a significantly higher number of summer chum salmon are returning to spawn since the restoration work occurred (see Chapter 10 Adult Salmonid Use: Chum and Coho Escapement). Thus, we would hypothesize that there has been a corresponding increase in post-project abundance of juvenile salmonids in the estuary, but we have no data to support or refute that hypothesis.

This pilot study raised more questions than it answered. Unfortunately, funding was not available to continue the tidal channel monitoring in additional years. Intriguing questions to pursue further include:

1. Why did we always catch coho salmon in the natural tidal channel with freshwater input (R1), and rarely in any of the constructed channels with no freshwater input?
2. Pacific staghorn sculpins were the most ubiquitous and numerically dominant species. What is their role in the ecosystem?
3. Researchers refer to the window of time in which fish can access and use tidal channels as "opportunity." What is the estimated opportunity for fish use of each of the different tidal channels? (i.e., during how much of the tidal cycle is there enough water in R1, R2, C1, C2, and C3 for fish to access these channels?) What would the installation of HOBO water level data loggers conclude about the frequency of tidal inundation?
4. Why did we not catch many fish in the most mature natural channel (R2)? Is this a function of distance of the tidal channel from the mainstem JCL channel? Is this due to limited opportunity for fish to access this tidal channel because it is higher in elevation than other nearby tidal channels? Is it due to other factors?
5. Why did we catch chum fry that were predominantly in the 25 mm to 45 mm range, and only one larger than 50mm? Are smaller, wild production fry more likely to use tidal channel habitats and larger, broodstock production fry more likely to migrate straight to Sequim Bay? Are larger fry better able to avoid capture?
6. Did the smolt trap (installed April 6, 2009), which is above all of our tidal channel sampling locations, affect our fish catches in the tidal channels?
7. Quinn (2005) reported that juvenile salmonids, in general, trade off the need to acquire food against the cost of acquiring it. Would adding diet analysis of fish captured in tidal channels help explain patterns of distribution and abundance?

On the basis of this pilot study, we hypothesize that tidal channel elevation (i.e., window of opportunity for fish use), and proximity to the source (i.e., JCL main channel) are the two main factors that have the greatest influence on fish use of the tidal channels in the JCL Estuary. This hypothesis merits further investigation.

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CHAPTER 14. BIRD USE: WATERBIRD ABUNDANCE IN JIMMYCOMELATELY CREEK AND ESTUARY

– KAREN HOLTROP (VOLUNTEER)

BACKGROUND

Restoration Objective – JCL Channel (Shreffler 2001) and Estuary (Shreffler 2004)
The restoration objective relative to bird use was to increase the amount of habitat available for birds and their prey resources in the JCL Channel and estuary.

Restoration Rationale – JCL Channel (Shreffler 2001) and Estuary (Shreffler 2004)
By increasing the amount of floodplain, mudflat, emergent marsh, and eelgrass habitat, the Estuary Design Group (EDG) expected to see a corresponding increase in the total number of waterbird species (i.e., species richness) and the total number of individuals of each species (i.e., abundance).

METHODS

Ground-based bird counts were conducted at Lower Sequim Bay from November 1996 to September 2011. Bird survey visits were distributed throughout the year. During each visit the birds in the water and along the shore from the Jamestown S'Klallam Tribe buildings to the trees west of Dean Creek were counted using a spotting scope and binoculars. Birds were usually counted at medium tides (between high and low tides) to increase the likelihood of obtaining accurate shorebird counts. All water bird species were counted, including shorebirds, waterfowl, alcids (auklets, murres, guillemots, puffins), larids (gulls and terns), loons, grebes, cormorants, herons, and kingfishers. Raptors were also counted, if observed on or near the shore. Notes were taken on location, such as the east end (near Tribal buildings), Dean Creek, or Jimmycomelately Creek, behavior, plumage, and age. A total of 265 visits were conducted. Surveys were done by biologists who volunteered time for this project.

Bird abundance (average number of individuals per visit) and bird richness (average number of species per visit) were calculated. Abundance was also calculated by month. Month comparisons were done for all birds, waterfowl, shorebirds, and select species.

Bird abundances before, during, or after estuary restoration were calculated. ―Before restoration" included survey visits before July 2003, and ―after restoration" included surveys after November 20, 2005. This between-year analysis used a subset of the survey visits (225 surveys) to standardize the number of visits by month or season; (The survey visits were irregular, especially in the early years, and some years and months had many more visits than others). In addition to total birds, the abundances of groups of birds were calculated, including shorebirds, waterfowl, larids, and of select species (the most abundant species with sufficient data). Further, abundance was calculated for a subset of waterfowl, including only dabbling ducks and excluding diving ducks. The supposition was that birds on or close to the shore would be particularly affected by restoration, such as shorebirds and dabbling ducks.

RESULTS

Overall Bird Richness and Abundance

A total of eighty-one species were detected (Table 14.1). The three most abundant species were dunlin (*Calidris alpina*), American wigeon (*Anas Americana*), and Western sandpiper (*Calidris mauri*) (Figure 14.1). Glaucous-winged gull hybrids, black-bellied plovers, green-winged teal, ring-billed gull, mallards, and mew gull were also abundant on the shore. Out in the water, bufflehead and white-winged scoters were commonly observed. The mean number of birds per visit was 587, and ranged from 14 to 6610 birds. The mean number of species per visit was 14, and ranged from 4 to 30 species. The mean number of species per visit did not change before vs. after restoration.

Bird Abundance by Time of the Year

Bird abundance fluctuated through the year. Total bird abundance (number of all birds observed per visit) was highest in November, December, January, and April, and lowest in June. Waterfowl, primarily American wigeon, were most abundant in the winter months: November, December, and January. Mallards were most abundant late winter (January – February), and green-winged teal early spring (March – April). Shorebirds were most abundant in April (spring migration) and in winter, November – January. Both dunlins and western sandpipers were most abundant in April. Dunlins were commonly observed in winter, and Western sandpipers in July - September (fall migration).

Several species were observed every month of the year, including bald eagle, great blue heron, belted kingfisher, double-crested cormorant, killdeer, mallard, gulls and scoters; many other species were observed almost all year. American wigeons were observed all year except the summer (June-Aug).

Table 14.1. Water bird species detected at Jimmycomelately Creek and Estuary during 265 survey visits 1996 – 2011. Species are listed from most to least abundant.

Common Name	Scientific Name	Total #	Max Count	Species Status
Dunlin	*Calidris alpina*	42868	3900	
American Wigeon	*Anas americana*	20409	1700	
Western Sandpiper	*Calidris mauri*	18803	2400	
Glaucous-winged Gull or hybrid	*Larus glaucescens*	9655	230	
Black-bellied Plover	*Pluvialis squatarola*	9313	575	
Green-winged Teal	*Anas crecca*	8180	225	
Bufflehead	*Bucephala albeola*	7549	310	
White-winged Scoter	*Melanitta fusca*	7172	270	
Ring-billed Gull	*Larus delawarensis*	4081	185	
Mallard	*Anas platyrhynchos*	3846	270	
Mew Gull	*Larus canus*	3624	270	
Bonaparte's Gull	*Larus philadelphia*	2768	390	
Common Tern	*Sterna hirundo*	1963	270	
Northern Pintail	*Anas acuta*	1556	68	
Horned Grebe	*Podiceps auritus*	1539	140	State Monitor
Canada Goose	*Branta canadensis*	1358	265	
Greater Scaup	*Aythya marila*	1348	75	
Short-billed Dowitcher	*Limnodromus griseus*	1339	163	
Common Goldeneye	*Bucephala clangula*	1198	55	
Red-breasted Merganser	*Mergus serrator*	1140	86	
Great Blue Heron	*Ardea herodias*	655	16	State Monitor

Common Name	Scientific Name	Total #	Max Count	Species Status
Double-crested Cormorant	*Phalacrocorax auritus*	572	42	
Surf Scoter	*Melanitta perspicillata*	509	59	
Killdeer	*Charadrius vociferus*	471	12	
Whimbrel	*Numenius phaeopus*	453	190	
Caspian Tern	*Sterna caspia*	433	49	State Monitor
Long-billed Dowitcher	*Limnodromus scolopaceus*	373	91	
Belted Kingfisher	*Ceryle alcyon*	291	20	
Hooded Merganser	*Lophodytes cucullatus*	284	17	
Least Sandpiper	*Calidris minutilla*	258	60	
Common Loon	*Gavia immer*	241	10	State Sensitive
California Gull	*Larus californicus*	222	40	
Greater White-fronted Goose	*Anser albifrons*	210	209	
Western Grebe	*Aechmophorus occidentalis*	193	64	State Candidate
Long-tailed Duck	*Clangula hyemalis*	139	45	
Red-necked Grebe	*Podiceps grisegena*	130	58	State Monitor
Bald Eagle	*Haliaeetus leucocephalus*	120	4	Fed Species Concern, State Sensitive
Eurasian Wigeon	*Anas penelope*	84	60	
Northern Shoveler	*Anas clypeata*	65	31	
Heermann's Gull	*Larus heermanni*	62	42	
Greater Yellowlegs	*Tringa melanoleuca*	61	9	
Barrow's Goldeneye	*Bucephala islandica*	51	12	
Pacific Loon	*Gavia pacifica*	46	9	
Rhinoceros Auklet	*Cerorhinca monocerata*	43	24	
Black Turnstone	*Arenaria melanocephala*	38	8	
Brant	*Branta bernicla*	35	28	
Spotted Sandpiper	*Tringa macularia*	31	8	
Common Merganser	*Mergus merganser*	30	8	
Common Murre	*Uria aalge*	25	21	State Candidate
Sanderling	*Calidris alba*	21	18	
Western Gull	*Larus occidentalis*	21	12	
Pelagic Cormorant	*Phalacrocorax pelagicus*	20	7	
Semipalmated Plover	*Charadrius semipalmatus*	19	10	
Marbled Godwit	*Limosa fedoa*	18	7	
Black Scoter	*Melanitta nigra*	15	10	
Gadwall	*Anas strepera*	15	7	
Turkey Vulture	*Cathartes aura*	13	6	State Monitor

Common Name	Scientific Name	Total #	Max Count	Species Status
Harlequin Duck	*Histrionicus histrionicus*	9	3	
Pigeon Guillemot	*Ceppus columba*	8	3	
Red-throated Loon	*Gavia stellata*	8	1	
Elegant Tern	*Sterna elegans*	7	4	
Pectoral Sandpiper	*Calidris melanotos*	6	3	
Osprey	*Pandion haliaetus*	6	2	State Monitor
Red-tailed Hawk	*Buteo jamaicensis*	6	1	
Blue-winged Teal	*Anas discors*	5	3	
Black Oystercatcher	*Haematopus bachmani*	5	3	State Monitor
Red Knot	*Calidris canutus*	5	2	
Pied-billed Grebe	*Podilymbus podiceps*	5	2	
Rock Sandpiper	*Calidris ptilocnemis*	4	3	
Green Heron	*Butorides virescens*	4	2	State Monitor
Semipalmated Sandpiper	*Calidris pusilla*	4	2	
Marbled Murrelet	*Brachyramphus marmoratus*	3	2	Fed Threatened, State Threatened
Redhead	*Aythya americana*	2	2	
Ruddy Turnstone	*Arenaria interpres*	2	2	
Ring-necked Duck	*Aythya collaris*	2	2	
Ancient Murrelet	*Synthliboramphus antiquus*	2	2	
Eared Grebe	*Podiceps nigricollis*	2	1	
Bar-tailed Godwit	*Limosa lapponica*	2	1	
Yellow-billed Loon	*Gavia adamsii*	1	1	
Lesser Scaup	*Aythya affinis*	1	1	
Northern Harrier	*Circus cyaneus*	1	1	

(A)

(B)

(C)

Figure 14.1. Photos of the three most abundant waterbird species: (A) dunlin; (B) American wigeon; and (C) Western sandpiper (photos by Dave Shreffler).

Dunlins were observed all year except June and July. Black-bellied plovers were observed all year except June. Caspian terns were detected only in spring and summer (April to September).

Bird Abundance Before and After Restoration
Total bird abundance was higher before restoration, but some species or groups had higher abundances after restoration (Table 14.2). Waterfowl as a group were more abundant before restoration, but dabbling ducks were more abundant after. Specifically, mallards and green-winged teal were more abundant after restoration. Abundance of shorebirds as a group was lower after restoration. This was mainly due to lower dunlin abundance. Western sandpiper abundance was higher after restoration. The abundance of gulls and terns was almost the same before and after restoration, although Caspian tern abundance was higher after restoration. The abundance of waterfowl, including American wigeon, mallard, green-winged teal, decreased during the restoration work. The average number of species per visit did not change before vs. after restoration, for all water birds or species groups (e.g., shorebirds, waterfowl).

Table 14.2. The average number of birds per survey before, during and after restoration of Jimmycomelately Creek and Estuary, using data from 225 survey visits.

Species or Group	Average # Per Visit			Change
	Before	During	After	
All Water Birds	607	561	476	decrease
All Waterfowl	235	197	222	decrease
Dabbling Ducks	145	104	155	increase
Mallard	13	9	25	increase
Green-winged Teal	21	33	52	increase
American Wigeon	103	58	71	decrease
Geese	3	3	3	same
Shorebirds	287	259	168	decrease
Dunlin	206	196	87	decrease
Western Sandpiper	28	31	69	increase
Black-bellied Plover	43	26	8	decrease
Herons	2	3	4	increase
all Gulls & Terns	73	83	72	same
Caspian Tern	<1	2	4	increase

DISCUSSION

The Estuary Design Group (EDG) established the following performance criterion for bird use of JCL Creek and Estuary (Shreffler 2004): *Within 10 years post-restoration, species richness and abundance of breeding, wintering, and migrating birds using the estuary shall equal or exceed pre-restoration species richness and abundance*. Five years post-restoration, there has been no change in species richness, but a decline in overall waterbird abundance, with some groups of waterbirds (e.g., shorebirds) more abundant pre-restoration and some groups (e.g., dabbling ducks) more abundant post-restoration.

Jimmycomelately Creek Estuary has high bird species richness and abundance, especially during the migratory seasons and the winter. The estuary is a particularly important area for wintering and migratory shorebirds and waterfowl. The fall migratory season stretches from July, when shorebirds start to arrive, until November. Since there are also high bird numbers in the spring and the winter, almost every month of the year is important for migrant and wintering birds.

Some water birds breed in the vicinity of Jimmycomelately. Young birds observed in the vicinity included spotted sandpipers, Canada goose, killdeer, mallards, great blue heron, and bald eagles.

Sequim Bay is considered an important shorebird site in western Washington according to the Northern Pacific Coast Regional Management Plan (Drut and Buchanan 2000). Dunlins, western sandpipers, and black-bellied plovers were given the regional conservation score of 4 (“high concern”) in that plan. Sequim Bay, including Jimmycomelately Creek Estuary, supports thousands of these birds in the winter and during the spring migration.

As the restored Jimmycomelately tide flats evolve and the abundance and diversity of benthic macroinvertebrates increases, we anticipate shorebird abundance may in turn reach or exceed the pre-project levels documented in Table 14.2

Buchanan (2006) documented the habitat requirements of nearshore birds in Puget Sound, with detailed species profiles for surf scoters, black oystercatchers, and dunlins. Dunlins typically return from their Arctic breeding grounds in mid- to late October, and from that time through mid-April, they generally make up more than 90 % of the estuarine shorebird community throughout Puget Sound. The peak of spring migration occurs in late April or very early May, and essentially all migrants have departed by about mid-May.

Dunlins’ preferred foraging areas are characterized by the presence of fine silts, where they forage on a wide variety of benthic invertebrates by probing with their long bills in tidal mudflats. Unfortunately, as mentioned in Chapter 3 Water Quality Monitoring, the benthic macroinvertebrate sampling proposed in the estuary monitoring plan (Shreffler 2004) was dropped due to lack of funding. Fresh et al. (2011) documented more than 30 species of shorebirds in Puget Sound that are dependent on tidal mudflats, which they referred to as “food factories” for shorebirds. Of particular relevance to the restored Jimmycomelately tidal mudflats, dunlin and other shorebirds exhibit fidelity to particular foraging areas, returning to the same tidal flats repeatedly over years. As the restored Jimmycomelately tide flats evolve and the abundance and diversity of benthic macroinvertebrates increases, we anticipate shorebird abundance may in turn reach or exceed the pre-project levels documented in Table 14.2.

While Sequim Bay provides essential habitat for large concentrations of migratory and wintering water birds, the area is also important for many uncommon species. Thirteen state or federally listed, candidate, monitor, or species of concern were detected in Jimmycomelately Creek Estuary (Table14.1). Vagrant species have been observed including ruff and Eurasian wigeon (ruff detections were not included in this survey data, but there have been incidental sightings).

The Washington Department of Fish and Wildlife maintains a catalog of habitats and species considered to be priorities for conservation and management (WDFW 2008). Puget Sound Nearshore (estuary fjord), which would include the vicinity of Jimmycomelately Creek, is considered a priority habitat. Priority species in Jimmycomelately Creek and Estuary include regular non-breeding concentrations of Charadriidae (plovers) and Scolopacidae (sandpipers) and regular waterfowl concentrations in winter.

It is apparent that the realigned Jimmycomelately Creek channel and realigned Dean Creek channel provide vast benefits for waterbirds.

Roosting sites are important for shorebirds where they preen and rest during high tides. The decrease in shorebird numbers after restoration may be partly due to fewer roosting sites, particularly the old log yard pier and pilings. Before restoration, shorebirds were observed roosting on the log yard pier, which has been removed. However, shorebird numbers tend to fluctuate annually (Buchanan and Evenson 1997, Buchanan 1988), and monitoring should continue to obtain more post-restoration data to document a decrease of shorebirds. Other species that used the before-restoration pier and pilings for perching included cormorants, bald eagles, great blue heron, and various gulls.

It is apparent that the realigned Jimmycomelately Creek channel and realigned Dean Creek channel provide vast benefits for waterbirds. Dean Creek area provides native vegetation in place of an old log yard and a small lagoon where shorebirds and waterfowl have been observed, including a pair of gadwall and spotted sandpipers. Jimmycomelately Creek provides a new meandering channel and wetland vegetation. A variety of species have been observed in the new Jimmycomelately channel, including dunlin, western sandpiper, least sandpiper, and spotted sandpiper, black-bellied plover, killdeer, American and Eurasian wigeons, mallard, common and Barrow's goldeneyes, northern pintail, bufflehead, red-breasted and hooded mergansers, Canada goose, great blue and green herons, belted kingfisher, osprey, bald eagle, and various gulls. Many birds concentrate in Jimmycomelately Estuary at the mouth of the realigned JCL channel, including terns, gulls and various shorebirds and waterfowl. The new JCL channel and estuary are providing good quality habitat, especially for dabbling ducks as indicated by their increase in abundance post-project.

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