

Coos Watershed Tide Gate Replacement Project-Effectiveness Monitoring OWEB Grant 207-238 Project Completion Report

**Submitted by
Coos Watershed Association
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INTRODUCTION

The coho salmon Life Cycle Monitoring project in Palouse and Larson Creeks is a continuation of a long-term monitoring study initiated in 2004 to examine coho salmon survival, production and habitat use in tide gated coastal lowland streams. Tide gates are tidal flood control structures designed to open and close with each tidal cycle to limit tidal influence on upstream agricultural and residential areas. Basic tide gate function consists of diurnal gate opening and closing cycles that create a partial barrier to fish passage. Coastal lowland streams are critical for the sustainability of Oregon Coastal coho, but it is unclear how tide gates may affect coho movement, habitat use and survival. Oregon Watershed Enhancement Board (OWEB) Grant 207-238 supported Coos Watershed Association (CoosWA) efforts to implement the coho salmon Life Cycle Monitoring project in Palouse and Larson Creeks and to assist with research efforts led by Oregon State University (OSU) Fisheries researchers to monitor coho passage at the Palouse and Larson tide gates (see Bass 2010). This report summarizes results from the CoosWA Life Cycle Monitoring Project and associated efforts during 2004 through July 2010.

Beginning in 1997, coho salmon Life Cycle Monitoring efforts have been implemented as part of the Oregon Plan for Salmon and Watersheds by Oregon Department of Fish and Wildlife (ODFW) in seven coastal subbasins on the Oregon coast to monitor fish abundance and survival (Suring et al. 2009). Data from these sites provide valuable insight regarding salmon abundance and survival trends, and spatial and temporal variation in salmon production among Oregon coastal subbasins. The ODFW Life Cycle Monitoring sites are located primarily in upland settings in association with permanent or semi-permanent fish passage structures. Life Cycle Monitoring efforts conducted by the CoosWA in Palouse and Larson subbasins is intended to augment ODFW efforts by implementing long-term monitoring of coho salmon populations in tide gated lowland subbasins that represent an important component of coho production on the Oregon Coast.

Coastal lowland streams are often productive juvenile coho salmon nursery areas as a result of diverse low and moderate gradient stream habitats. Slow water habitats (i.e., pools, glides and ponded areas) provide critical nursery habitat for juvenile coho and lowland streams and estuaries can considerably increase juvenile coho salmon production (IMST 2002). Alteration of lowland areas is common throughout the range of coho salmon due to diking, tide gating and landfill (Giannico and Souder 2005). Tide gates are commonly installed in coastal dikes to control the in-

fluence of tidal fluctuations on lowland areas, and typically affect stream hydrology and water quality conditions upstream of the gate by impounding streamflow during closed gate periods (i.e., high tidal cycles). Impounded reservoir areas upstream of tide gates often experience increased temperature due to stagnant streamflow and highly varying levels of salinity resulting from tide gate leaks. The extent to which tide gate modifications of coastal lowland streams affect coho salmon movement and habitat use is not well understood.

Detection and monitoring of fish movement in freshwater habitats using passive integrated transponder (PIT) technology has been described previously (Zydlewski et al., 2003), but the use of this technology in brackish estuary habitats is less established. Passive integrated transponder tags are uniquely identifiable tags that provide researchers the ability to mark fish as small as 50 mm with minimal effects on growth and survival (Zydlewski et al., 2003). Recent advancements in the design and construction of stationary PIT antennae used to remotely detect PIT tagged fish have expanded the range of habitats in which tagged fish can be efficiently detected to brackish and saline environments (Adams et al., 2009; Bass 2010). In addition to monitoring fish movement and habitat use, PIT technology has been successfully used to measure freshwater and marine survival rates of juvenile salmonids (Brakensiek and Hankin, 2007, Knudsen et al., 2009), and may be a useful tool in addressing Life Cycle Monitoring project objectives in areas in which permanent instream fish trapping structures are not present.

The CoosWA initiated Life Cycle Monitoring efforts in the Palouse and Larson subbasins to augment the existing ODFW monitoring project by providing annual estimates of coho abundance and survival in lowland coastal streams. Passive integrated transponder technology used to tag and remotely track individual fish complemented standard ODFW Life Cycle Monitoring procedures to obtain juvenile and adult coho production estimates in each subbasin. Long-term monitoring of coho salmon abundance and survival in Oregon coastal subbasins is an integral part of maintaining sustainable coho populations.

OBJECTIVES

There were four objectives of the Life Cycle Monitoring project in the Palouse and Larson subbasins:

- 1) Estimate adult coho salmon spawner abundance in Palouse and Larson subbasins;
- 2) Estimate outmigrant juvenile coho smolt population size in each subbasin;
- 3) Estimate coho marine and freshwater survival rates;
- 4) Describe movement patterns of juvenile coho among lowland habitats within the Palouse subbasin; and
- 5) Evaluate whether juvenile coho size and growth are correlated with habitat usage in Palouse and Larson Creeks.

The CoosWA incorporated PIT tagging and tracking technology with ODFW Life Cycle Monitoring methods to achieve the project objectives in each subbasin. Efforts to study juvenile coho movement and growth among coastal lowland habitats was led by CoosWA staff in cooperation with OSU Fisheries researchers and was conducted concurrently with the Life Cycle Monitoring project.

METHODS

Project Area

Palouse and Larson Creeks are similarly sized third order lowland streams located in Coos Bay, Oregon (Figure 1). Each stream is tide gated at the interface with the Coos Bay estuary; Palouse Creek is regulated by a top-hinged gate and Larson Creek has a side-hinged gate. Palouse Creek is approximately 14.6 km long, with a 10-foot waterfall at River Kilometer (RKm) 12.1. The Larson Creek mainstem is approximately 12.9 km in length. The catchment area of each subbasin is approximately 28 km² and mean monthly streamflow in each subbasin ranges similarly from less than 0.1 m³/s during late summer to approximately 19 m³/s during winter bankfull flood events (CoosWA 2006).

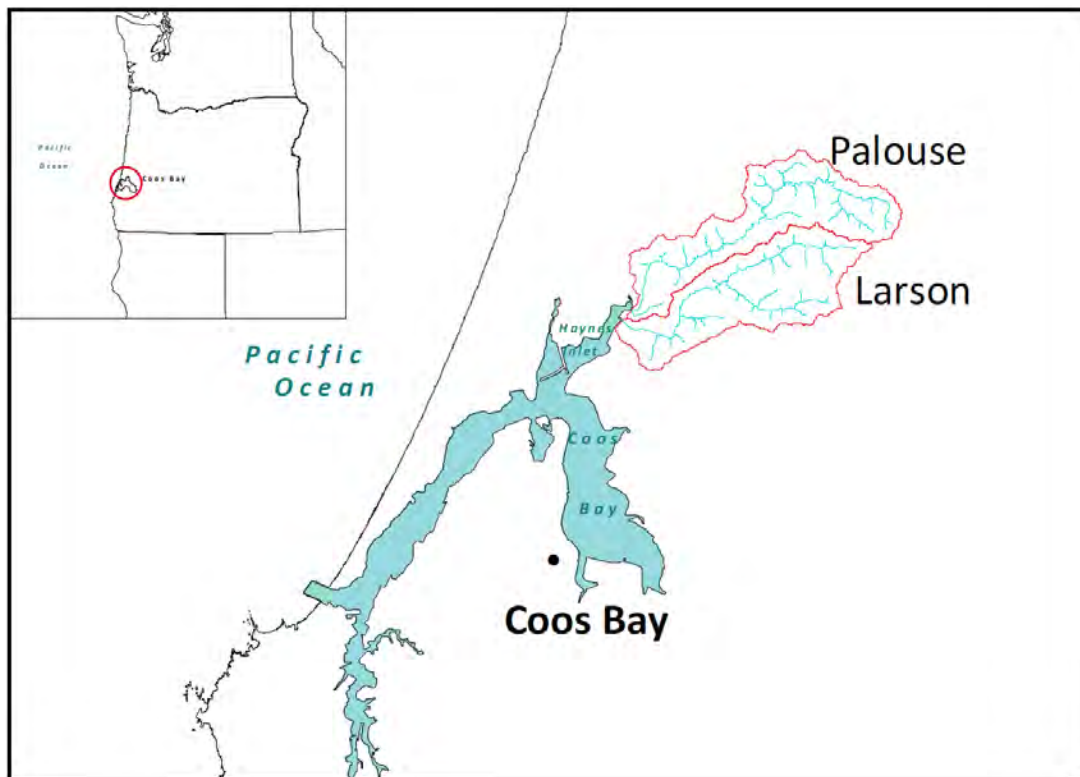


Figure 1. Location of Larson and Palouse Creek subbasins.

Palouse and Larson Creeks are tide gated at the confluence of each stream with Haynes Inlet (Rkm 0.0) in order to reduce tidal intrusion in the lower extent of each subbasin. Tide gates function to close during rising tides, temporarily impounding streamflow, and open during ebbing tides to release impounded water. The Palouse Creek gate consists of two rectangular wooden, top-hinged flap-doors (4.1 m high, 2.6 m high). The reservoir upstream of the Palouse tide gate is approximately 3.2 km in length, but fluctuates in size daily and seasonally in response to variable streamflow and tidal cycles. The Palouse tide gate was last refurbished in 1985, and since this time large scour holes have developed under the structure that allow substantial upstream intrusion of saline water from Haynes Inlet into the Palouse reservoir. The Larson Creek tide gate was reconstructed in 2001 with two side-hinged metal doors (3.2 m wide x 2.6 m high), which provide a more complete barrier to saline water than the Palouse tide gate. The Larson tide gate reservoir is approximately 2.0 km in length.

The Palouse and Larson tide gate reservoirs differ considerably in size and hydrologic characteristics. The Palouse reservoir is larger, has greater saline influence, and much of its area remains pooled throughout entire tidal cycles, whereas the Larson reservoir is smaller, less brackish and drains more completely in response to open tide gate cycle (i.e. low tides). The unique characteristics of each reservoir area are due primarily to differences in tide gate condition and design. The holes around the Palouse tide gate allow upstream leaking of saline water from Haynes Inlet during high tides, which augments impounded streamflow to form a larger reservoir and creates brackish conditions in the lower extent of the reservoir that varies in salinity with tidal cycles. The average salinity during the 2009 spring coho smolt outmigration (March – June) at Rkm 0.5 in the Palouse reservoir was 12.4 ppt, while average salinity at Rkm 0.5 in the Larson reservoir during the same period was 2.1 ppt (Bass 2010). Drainage of the tide gate reservoirs is in large part dictated by the elevation of the tide gate sill or invert. During the 2001 reconstruction of the Larson tide gate, the elevation of the tide gate invert was lowered approximately one meter, which has allowed the impounded reservoir area in Larson Creek to drain more completely than the Palouse reservoir.

Salmonid Life Cycle Monitoring

Adult Spawner Estimates. Methods used in association with the coho Life Cycle Monitoring Project in Palouse and Larson Creeks follow the ODFW protocols utilized at seven ODFW Life Cycle Monitoring sites on the Oregon Coast (Suring et al. 2007). Adult coho spawner populations in Palouse and Larson Creeks were sampled and monitored during spawning periods in late fall and winter using temporary fish weirs and systematic spawner surveys. Adult coho salmon were captured in picket fence weir traps at the lower extent of spawning areas in each subbasin to measure and Floy® tag a portion of the adult spawner population. Floy-tagged adult coho were resighted or recovered as carcasses during spawner surveys conducted on foot every 7-10 days in each subbasin. Spawning surveys in each subbasin covered all known spawning areas; however, short sec-

tions of the Larson Creek mainstem and tributaries were not surveyed due to lack of landowner permission (Figure 2). Adult coho population sizes in the Palouse and Larson subbasins were calculated using mark-recapture and area-under-the-curve (AUC) calculations based on the number of fish tagged and recaptured and calibrated using total weekly spawner counts within each subbasin (Jacobs and Nickelson 1998).

Smolt and Juvenile Population Estimation. The abundance of coho smolt populations was estimated based on capture of downstream migrant fish at rotary screw traps operated on Palouse and Larson Creeks. The rotary screw traps were located downstream of all spawning and most rearing areas in each stream in order to maximize the ability to capture downstream migrant smolts (Figure 2). The screw trap sampling effort targeted coho smolts, however, coho fry, steelhead and cutthroat trout and lamprey were also sampled based on ODFW Life Cycle Monitoring protocols. Fish captured each day at the Palouse and Larson screw traps were enumerated and a subsample of captured salmonids were measured for length and marked. A maximum of 25 individuals of each salmonid species and age-class were measured and marked with a small fin clip and released upstream of the screw trap into a box equipped with a trap door and a light sensitive trigger switch.

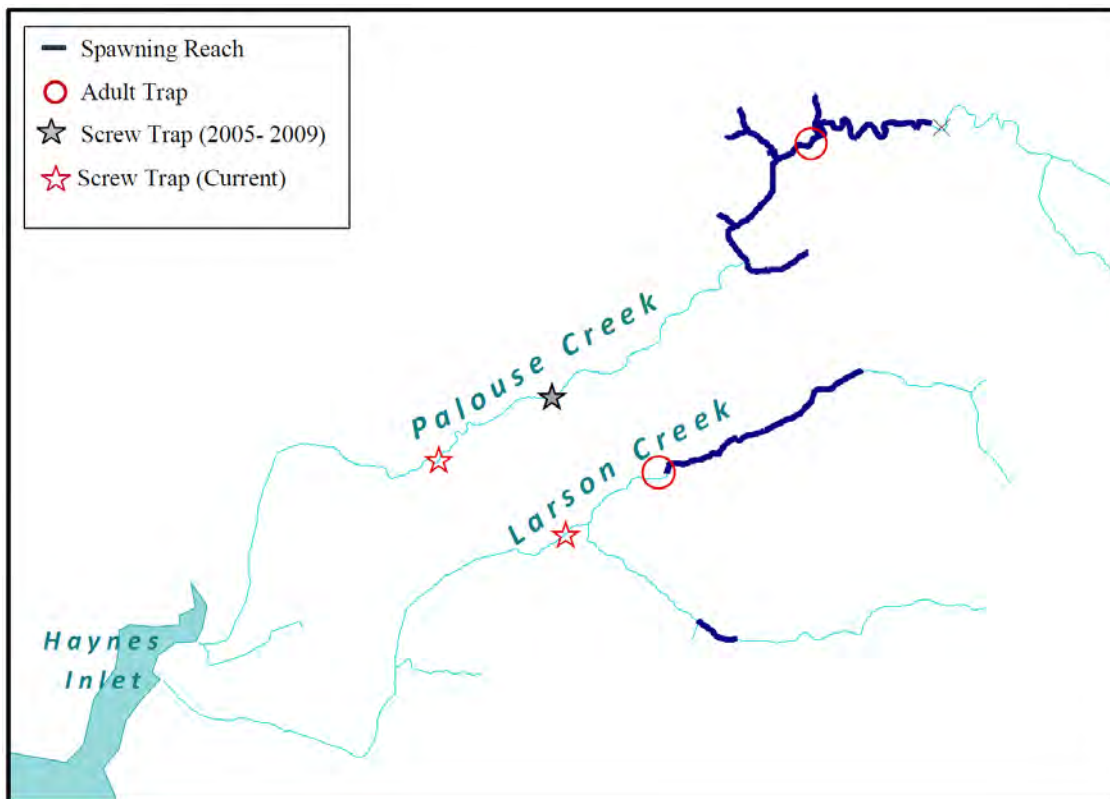


Figure 2. Coho adult trap, spawning survey segment, and juvenile screw trap locations within the Palouse and Larson subbasins.

The switch automatically released fish at dusk in order to reduce risk of potential predation. Screw trap efficiency was calculated for each trap on a weekly basis and outmigrant smolt population es-

imates were calculated by extrapolating weekly capture totals based on weekly trap efficiency estimates. Variance and confidence intervals were calculated for yearly smolt population estimates using a bootstrap procedure with 1,000 iterations per calculation (Thedinga et al. 1994).

Adult and Juvenile Survival Estimates. Freshwater and marine coho survival rates were calculated for each brood year based on estimates of egg deposition, outmigrant smolt population size, and the total number of adult coho spawners. Total egg deposition for each brood year was estimated based on coho spawner counts and total abundance estimates. The number and average fork length of female spawners was derived from sampled carcasses, or if few carcasses were observed it was assumed that the male: female ratio was 1:1 and an average length obtained from cumulative years was used. An average female coho fecundity rate was applied to the estimated number of female coho to predict the total egg deposition in each stream. The coho freshwater survival rate was calculated as the number of smolts having survived to outmigration divided by the estimated total number of eggs deposited. Marine survival was calculated as the proportion of coho adults that returned to each stream from the estimated total number of outmigrant smolts. A coho brood year represents the first year eggs are deposited during the winter spawning period by adult fish (e.g., 2007 brood year coho were derived from adult coho spawning during winter 2007-08, hatched in winter/spring 2008, and emigrated as age-1 smolts in spring 2009).

PIT Tagging For Life Cycle Monitoring. Coho salmon Life Cycle Monitoring in the Palouse and Larson subbasins began in 2004, while efforts to incorporate PIT technology with coho abundance estimation in both subbasins were initiated in the spring of 2008. PIT tagging efforts were conducted in both Palouse and Larson subbasins; however, the bulk of PIT tagging efforts took place in the Palouse subbasin. Beginning with age-1 coho smolts during spring 2008 (brood year 2006), age-0 coho fry and parr and age-1 coho smolts of the 2006-2008 brood years were individually marked with uniquely identifiable PIT tags and tracked within and upon outmigration from each subbasin. Table 5 (page 16) displays the number of PIT tagged fish by life stage and year).

Monitoring of PIT tagged coho through the freshwater and marine life history periods provides a means to complement estimates of survival developed in association with the Life Cycle Monitoring project. Juvenile coho PIT tagged as age-0 fry and parr were monitored through their freshwater residence until outmigration as age-1 smolts; the proportion of coho PIT tagged as age-0 fry detected as outmigrant age-1 smolts represented summer and over-winter survival within each subbasin. This estimate of freshwater survival differed from the Life Cycle Monitoring freshwater estimate of egg-to-smolt survival, but provided useful insight into coho life cycle trends. Similarly, the proportion of PIT tagged yearling coho smolts recorded outmigrating from each subbasin that returned as subadult jack (2-years old) and adult (3-years old) coho to spawn in each subbasin provided an estimate of marine survival rates for each returning age class. These estimates of marine survival were directly comparable to survival rates calculated as part of Life Cycle Monitoring activities.

Juvenile Coho Residence Times and Movement Sampling

Sample Reach Delineation. Mainstem areas upstream of the tide gates on Palouse and Larson Creeks were classified into separate reaches based on existing hydrology, instream habitat, and channel geomorphology data. In Palouse Creek, a total of six mainstem were identified: tide gate reservoir (Reach 1), tidally affected stream areas upstream of the reservoir (Reach 2), low gradient riverine reaches (Reaches 3, 4, and 5) and moderate gradient upland reaches in which adult coho salmon spawn (Reach 6). Two low gradient and two upland tributaries, and three off-channel ponds were sampled in addition to mainstem areas in the Palouse subbasin (Figure 3). Sampling in the Larson Creek subbasin occurred in three mainstem reaches. Sampling of juvenile coho also occurred in Haynes Inlet downstream of the Palouse and Larson tide gates, although physical habitat in this area was not characterized. Larson Creek Reach 2 was not sampled during PIT tagging efforts due to denied access by local landowners, with the exception of age-1 coho smolts tagged in association with spring smolt trapping activities.

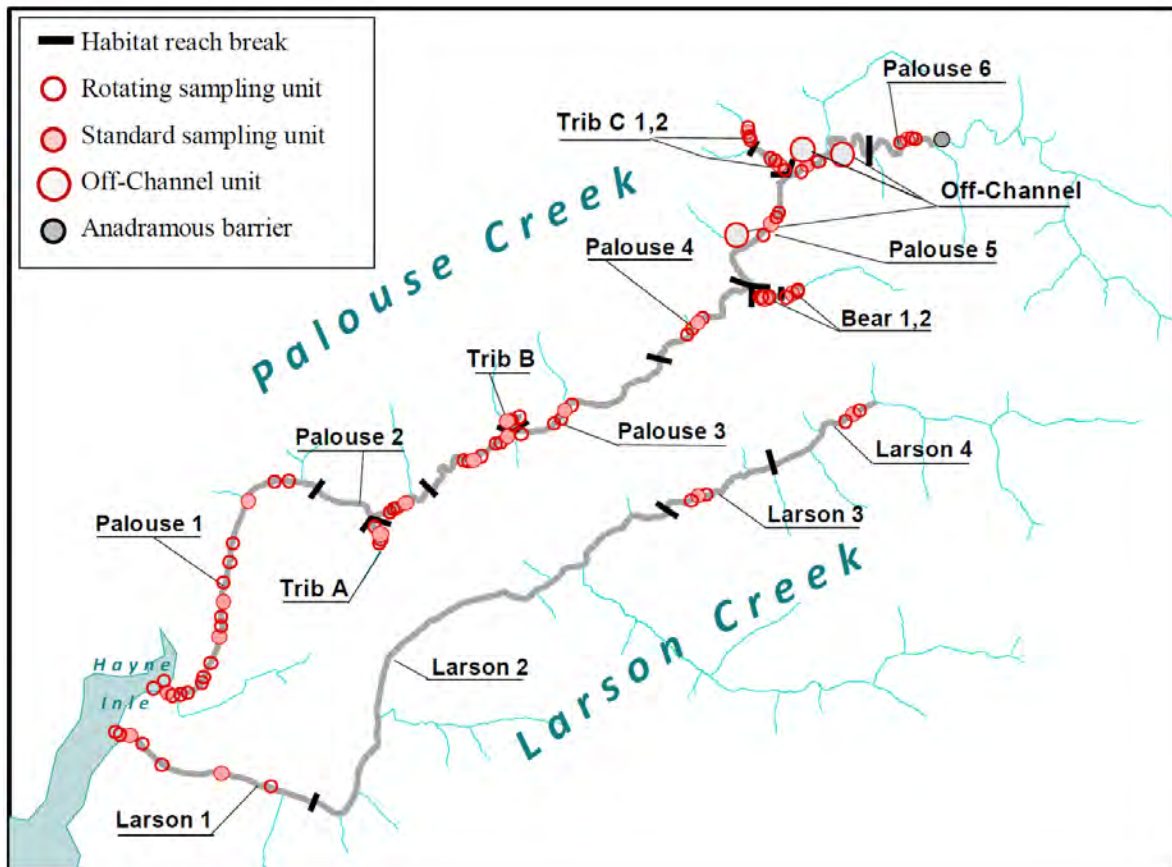


Figure 3. Habitat reaches in the Palouse and Larson subbasins with sampling segments and standard and random units sampled during 2008-2010.

Sample Site Selection. Randomly selected stream segments within each mainstem and tributary reach were utilized for fish capture and tagging. Palouse and Larson mainstem stream segments

were approximately 300 m in length, and tributary segments were approximately 150 m in length. The upstream and downstream endpoints for each segment corresponded with habitat unit structure. Within each stream segment, two pool and/or glide habitat units were randomly selected for sampling based on a rotating panel sampling design with replacement. Of the two selected habitat units, the standard unit was sampled during each visit, while the random habitat unit was a rotating unit that was sampled two consecutive visits prior to being replaced with a new habitat unit selected at random (Figure 4). The Palouse and Larson tide gate reservoirs are characterized by a single continuous habitat type and were consequently sampled differently. Sampling in reservoir areas was conducted based on randomly selected point locations, with approximately half of selected locations designated as standard sites and half as rotating random sites that were replaced after two consecutive visits. The number of sampling segments or point locations in each reach corresponded approximately with reach length (Palouse $n=14$ segments, Larson $n=2$ segments). A total of 115 and 13 habitat units and reservoir locations were sampled in the Palouse and Larson subbasins during 2008-2010, respectively.

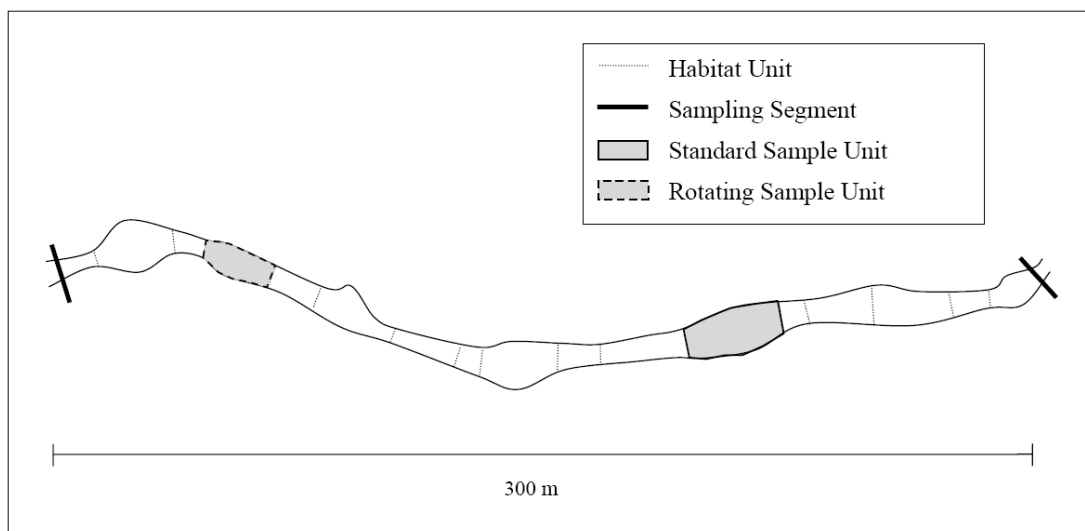


Figure 4. Conceptual diagram representing sampling segment format with standard and rotating habitat units.

Habitat Characterization. Physical habitat in the Palouse and Larson subbasins was measured during aquatic habitat surveys conducted by the CoosWA during 2002-2005. Habitat data collected during this period characterize the transition in each subbasin from low gradient estuarine and lowland riverine habitats to moderate gradient upland headwater areas. In the Palouse subbasin, lowland areas that were historically estuarine are now tide gate reservoir or low gradient stream reaches that are affected by tidal and tide gate reservoir flux and are characterized by dune-ripple channel morphology (Table 1) (Montgomery and Buffington 1997). Upstream of tidally affected areas, Palouse Creek is primarily low gradient and dominated by fine substrates and transitions to moderate gradient channel near the headwater areas with gravel substrate utilized

for spawning by adult salmonids (Table 1). Pool spacing, a common metric used to describe stream channel complexity calculated by dividing reach length by the number of pools and average channel width (Montgomery et al. 1995), was determined for each stream reach to quantify differences in stream channel complexity among tidally affected lowland areas and riverine reaches (Table 1).

Physical habitat within individual sample segments was measured again in 2010 to characterize conditions in which juvenile coho salmon were captured and PIT tagged. Stream segments were measured for channel and unit type and dimensions (length, width, and depth), slope, cover, substrate, vegetation, and volume of large wood based on ODFW survey methods (Moore et al. 2010). Water quality variables (temperature, dissolved oxygen, conductivity/salinity) were recorded as spot measurements in association with fish capture and sampling events, and temperature was recorded in each subbasin using arrays of temperature loggers that recorded ambient water temperature at 30-minute intervals. Analyses of these data are incomplete and are thus not reported here.

Table 1. Physical habitat metrics in the Palouse Creek mainstem, by stream reach.

Palouse Reach	Length (km)	Active Channel Width (m)	Slope (%)	Pool Spacing ¹	Shade (%)	Substrate Type (% Composition)		Channel Type ²
						Dominant	Subdominant	
1	3.3	21	0	-	20	Silt (60)	Sand (40)	Reservoir
2	1.4	5	0	90	25	Sand (80)	Silt (20)	Dune-Ripple
3	2.8	4	1	16	35	Sand (70)	Silt (20)	Pool-Riffle
4	1.2	7	1	4	55	Sand (50)	Gravel (30)	Pool-Riffle
5	2.8	9	1	4	55	Gravel (40)	Sand (40)	Pool-Riffle
6	1.2	10	2	3	80	Bedrock (30)	Gravel (30)	Pool-Riffle

¹ Pool spacing is pool-to-pool spacing in units of channel width and was calculated as follows:

Pool spacing = (Reach length) / [(Number of pools) • (Reach average active channel width)] (Montgomery et al. 1995).

² Channel types are based on classifications in Montgomery and Buffington 1997.

Fish capture and sampling in each stream was conducted using beach seine, pole seine, and electrofishing techniques based on stream channel characteristics. Fish were captured and sampled using a beach seine (1.8 m x 21.3 m, 3.2 mm mesh bag) in the lower tide gate reservoirs of each subbasin where channel width and depth precluded other capture methods. Pole seining was used in the upper reservoir and riverine channels characterized by narrow width (less than 20 m wetted width), predominantly sand substrate, and minimal instream wood. Riverine seining was conducted using fine mesh block nets (4.8 mm) to block fish movement at the upstream and downstream extents of the sampled unit, and a pole seine was used to herd fish downstream into a separate channel-spanning seine equipped with a large bag of fine mesh (3.2 mm). Electrofishing methods were utilized in riverine areas characterized by complex physical habitat, such as woody

debris accumulations and coarse substrate where seines were generally less effective. Habitat units were blocked with nets at the upstream and downstream extents prior to electrofishing, and units were sampled in an upstream direction. Riverine seining and electrofishing efforts were conducted using multiple-pass removal to estimate juvenile coho abundance within the sampled habitat unit. A fourth removal was made if less than 50% reduction in juvenile coho capture was recorded between any two passes.

All fish captured during seine and electrofish sampling were enumerated by species and salmonids were measured for fork length to the nearest 1 mm, and weighed to the nearest 0.1 g. Captured juvenile coho were electronically scanned for the presence of a PIT tag with a hand-held PIT antenna and a subsample of captured fish were PIT tagged, measured for length (FL, mm) and weight (g), and visually scanned to identify and enumerate externally visible parasites. Coho salmon fry 48-60 mm (FL) were tagged with 8.5 mm PIT tags, while coho parr and smolts 61 mm and larger were tagged with 12.5 mm tags. Salmonids sampled for biological data were anesthetized prior to handling with buffered MS-222 solution and were allowed to recover completely prior to release at the location of capture.

Juvenile Coho Movement Analysis Using PIT Tags. Movement of PIT tagged juvenile coho salmon in each subbasin was assessed based on physical recapture and detection of PIT tagged fish during repeat sampling events using hand-held PIT antennae and at stationary PIT antennas located at several locations in both subbasins. Stationary PIT antenna arrays, consisting of at least two antennas each (height: 1.2 m, width: 3.3 m), were installed at four locations in Palouse Creek between habitat reach breaks and in Larson Creek at the tide gate opening (Figure 5). Each antenna array was configured in parallel such that the date, time, and directional movement of tagged fish could be ascertained. Antenna arrays in each subbasin were operational for varying periods and durations during 2008-2010 (Figure 5). However, for the purposes of monitoring outmigration of PIT tagged coho smolts and upstream migration of PIT tagged jack and adult coho, the Palouse tide gate PIT antenna array was operational for each spring coho smolt outmigration period and the PIT antenna array located between Palouse Reaches 1 and 2 was operational during each fall and winter period since PIT tagging was initiated in 2008. The Larson tide gate antenna array has been operational since spring 2009. PIT antenna arrays located at each tide gate during smolt outmigration periods and PIT antenna arrays at any location within each basin during adult spawner upstream migrations provide the necessary data for estimating the numbers of outmigrant PIT tagged smolts and freshwater and marine survival.

Patterns of reach-scale habitat use and movement in the Palouse subbasin were monitored between spring 2009 and fall 2010 using stationary PIT antenna arrays installed at four locations on Palouse Creek and at the Larson Creek tide gate (Figure 5). Age-0 coho of the 2008 brood year were captured and tagged in habitat units in each Palouse mainstem and tributary reach during summer 2009 and winter 2009-10 and residence and movement patterns of PIT tagged fish were identified

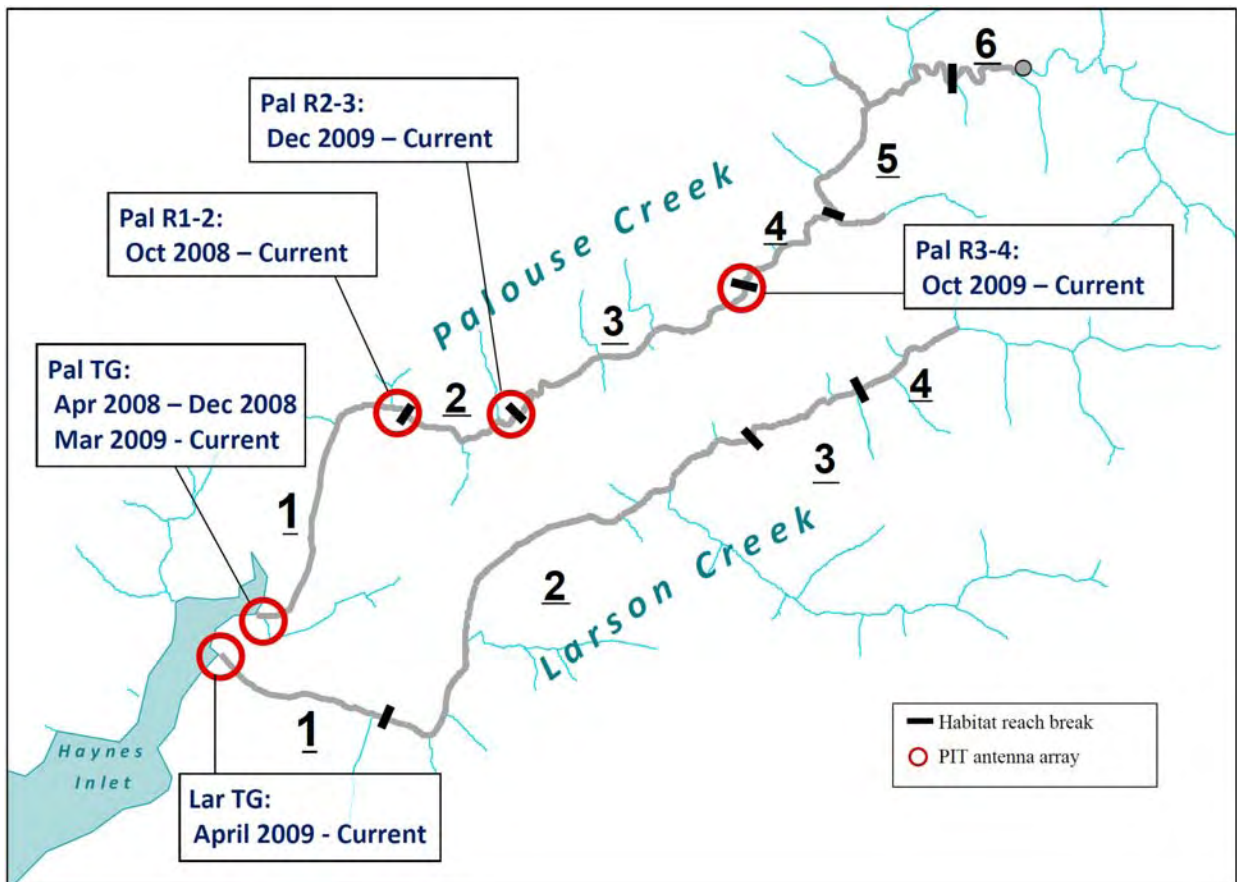


Figure 5. Location and operational periods of PIT antenna arrays located in the Palouse and Larson subbasins during spring 2008 – fall 2010 (i.e., current).

during repeat capture efforts and using stationary PIT antenna arrays. Age-0 coho of the 2009 brood year were PIT tagged during spring and summer 2010 and tagged individuals were similarly monitored. Residence and movement among habitats in the Palouse subbasin were summarized on a reach scale and over seasonal periods (summer, winter). Summer was characterized as the period of low streamflow and warm stream temperatures, and the winter period of high flow and cold stream temperatures was considered to begin as of the first substantial rain event. Data relating to winter movement and the 2009 brood year coho is currently being analyzed and consequently was not summarized for this report.

Analysis of Juvenile Movement and Growth Rates. Comparisons of juvenile coho movement within the Palouse subbasin were based upon range and frequency of large-scale reach movements recorded at PIT antenna arrays and during repeat sampling events in each stream reach. Movement was defined as a detected change in reach residence from the time of tagging through the summer 2009 season (June – October 2009). Movement range was described as the maximum extent of movement, in terms of stream reaches, from the reach of initial capture and PIT tagging. Frequency of movement was considered to be the number of movements (i.e. changes in reach residence) a tagged fish was observed to complete during the summer season.

Multiple captures of individual juvenile coho during stream and estuary residence allowed for calculation of specific growth rates within each sampled habitat. Instantaneous growth rates for PIT tagged juvenile coho captured on multiple occasions were calculated using the equation:

$$G = \left(\frac{\log_e W_{t_2} - \log_e W_{t_1}}{t_2 - t_1} \right) 100$$

where W_{t_1} is weight at tagging, W_{t_2} is weight at recapture, and $t_2 - t_1$ represents the days between tagging and recapture. A minimum span of 21 days between capture events was used for growth calculations to minimize capture and handling effects. Comparisons of growth among habitat reaches in the Palouse subbasin were made over semi-seasonal summer and winter periods based on timing of capture events.

RESULTS

Life History Monitoring

Adult Spawner Estimates. Adult coho salmon spawning has been monitored in the Palouse and Larson subbasins since 2003 and 2002, respectively. Since the initiation of coho salmon spawner monitoring, AUC estimates of coho spawner population abundance has trended downward, but has rebounded during the last two spawning seasons (Table 2, Figure 6a). The CoosWA was denied survey access to portions of the Larson Creek spawning reach in 2008 and 2009; escapement in these areas was estimated based on regression of escapement and peak spawning survey counts from previous years. Estimates of adult coho spawner abundance based on adult trap capture, mark and recapture procedures have not been possible due to low, variable capture rates at fence weir traps in Palouse and Larson Creeks. A total of 12 fish were marked with external Floy tags in the Palouse subbasin in both 2008 and 2009, while 8 fish were Floy tagged in the Larson subbasin during those years.

Smolt Outmigrant Estimates. Juvenile coho salmon smolt outmigrant abundance in Palouse and Larson Creeks during the period of Life Cycle Monitoring efforts (2006-2010) did not reflect the declining trend in adult spawner abundance. Estimates of adult coho salmon spawner abundance declined from 2005-2007 in both subbasins, but estimated abundance of the smolt offspring from these cohorts during 2007-2009 indicated an opposite trend (Table 3, Figure 6c). Large confidence intervals for the 2009 and 2010 coho smolt abundance estimates are an indication, however, that the apparent increasing trend may be more likely a reflection of low screw trap capture efficiency during this period.

Table 2. Estimated adult and jack coho spawning population abundance by brood and return year in Palouse and Larson subbasins.

Brood Year	Return Year	Larson Subbasin		Palouse Subbasin	
		Adult	Jack	Adult	Jack
2000	2003	481 ¹	117 ¹	1,763	243
2001	2004	624	158	1,484	164
2002	2005	269	38	429	52
2003	2006	197	30	245	23
2004	2007	67	22	43	14
2005	2008	272 ²	n/a	422	39
2006	2009	366 ²	n/a	491	69

¹ Spawning survey coverage in Larson subbasin in 2003 did not include Sullivan Creek.

² Spawning survey frequency and coverage in the Larson subbasin during 2008-09 was incomplete; adult population size was estimated based on regression of previous AUC abundance estimates.

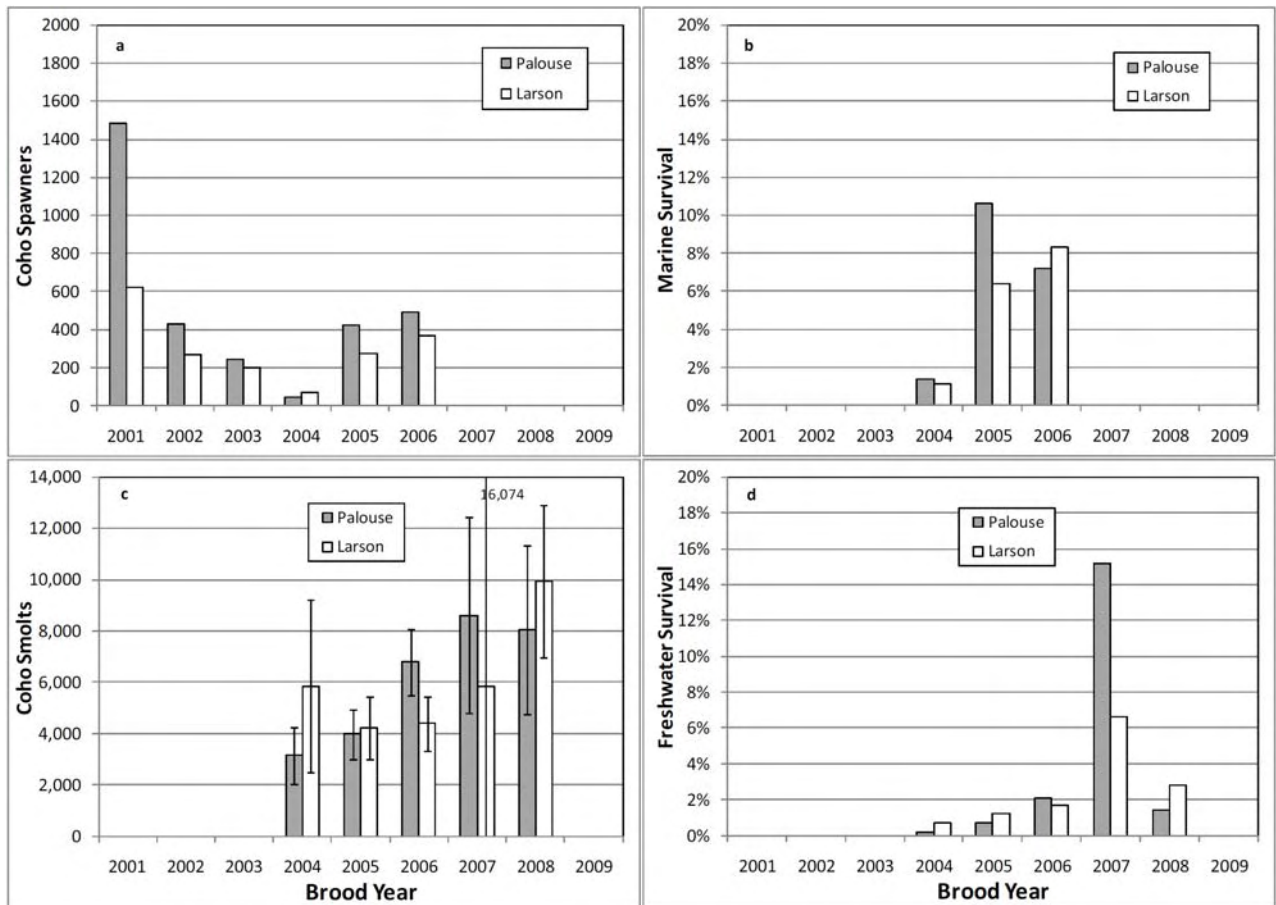


Figure 6. Annual estimates of coho salmon a) adult spawner abundance, b) marine survival, c) outmigrant smolt abundance, and d) freshwater survival in Palouse and Larson subbasins during Life Cycle Monitoring efforts 2004-2010.

Table 3. Estimated outmigrant coho smolt population abundance by brood and outmigrant year in Palouse and Larson subbasins.

Brood Year	Outmigrant Year	Larson (95% CI)	Palouse (95% CI)
2004	2006	5,856 ($\pm 3,347$)	3,139 ($\pm 1,106$)
2005	2007	4,233 ($\pm 1,227$)	3,200 (± 776)
2006	2008	4,386 ($\pm 1,061$)	6,783 ($\pm 1,286$)
2007	2009	5,828 ($\pm 10,246$)	9,947 ($\pm 3,919$)
2008	2010	9,941 ($\pm 2,959$)	8,042 ($\pm 3,293$)

Freshwater and Marine Survival. Freshwater and marine survival rates in Palouse and Larson subbasins varied similarly among the years of study. Freshwater survival of juvenile coho in each subbasin was generally less than 3%, with the exception of brood year 2007 in which estimated survival peaked in each subbasin (Table 4). Marine survival was estimated to be less than 2% for brood year 2004, the first year in which it was calculated, but has risen during each of the two subsequent years (Table 4).

The total number of age-0 juvenile coho fry tagged during 2008-2010 (coho brood years 2007-2009) in the Palouse subbasin ranged from 967 to 2,846, and from 75 to 282 fry in Larson Creek, with the largest tagging effort occurring in 2009 (Table 5). The number of age-1 coho smolts tagged during the same period (coho brood years 2006-2008) ranged from 487 to 742 in Palouse Creek and 125 to 375 smolts in Larson Creek (Table 5). The freshwater survival rate of PIT tagged age-0 coho from the time of tagging to outmigration was approximately 30% in the Palouse subbasin for each of coho brood years 2007 and 2008, and was 20% and 9% in the Larson subbasin for each respective brood year. The proportion of smolts that returned as 2-year old jacks was consistently 2% or less in both subbasins (Table 5). The estimated marine survival rate for coho in the Palouse subbasin was 5% for the only year in where data were available, which is similar to the marine survival rate estimated based on Life Cycle Monitoring efforts (Tables 4, 5).

Table 4. Coho Life Cycle Monitoring parameters for Larson and Palouse Creek Basins, including estimates of adult spawner escapement, egg deposition, outmigrant smolt population size, and freshwater and marine survival rates by brood year.

Basin	Brood Year ¹	Egg Deposition ²	Smolt Population Size	Adult Spawner Escapement	Adult Female Coho	Freshwater Survival ³	Marine Survival ⁴
Palouse	2000	-	-	1,763	882	-	-
	2001	-	-	1,484	742	-	-
	2002	-	-	429	215	-	-
	2003	2,321,249	-	245	123	-	-
	2004	1,953,904	3,139	43	22	0.2%	1.4%
	2005	564,935	3,977	422	211	0.7%	10.6%
	2006	323,161	6,783	491	245	2.1%	7.2%
	2007	56,861	8,623			15.2%	
	2008	556,196	8,042			1.4%	
	2009	646,031					
Larson	2001	-	-	624	312	-	-
	2002	-	-	269	135	-	-
	2003	-	-	197	99	-	-
	2004	821,588	5,856	67	34	0.7%	1.1%
	2005	354,178	4,233	272	136	1.2%	6.4%
	2006	259,379	4,386	366	183	1.7%	8.3%
	2007	88,215	5,828			6.6%	
	2008	358,128	9,941			2.8%	
	2009	481,893					

¹ Brood year is defined as the first year that eggs are deposited during the fall/winter spawn period (e.g. coho of the 2006 brood year were derived from coho spawning during the 2006-07 spawn period. This brood will return to spawn as adults during the 2009-10 spawn season).

² Egg deposition values correspond to the first year in which the eggs were deposited by adult female coho during the spawn period (e.g. eggs deposited by 2004 brood year adult coho during the 2007-08 spawn period correspond with 2007 brood year data).

³ Freshwater survival was calculated as the proportion of the estimated number of eggs deposited that produce outmigrant coho smolts.

⁴ Marine survival is the proportion of coho smolts that return to spawn as adults.

Table 5. The number of coho salmon fry and smolt PIT tagged in the Palouse and Larson sub-basins during 2008-2010, by brood year, and estimated number of PIT tagged coho detected as outmigrant smolts, and returning jacks and adults, with corresponding freshwater and marine survival rates.

Subbasin	Brood Year ¹	PIT Tagged Juvenile Coho		Estimated Number of PIT Tagged Coho and Percent Survival ²					
		Fry (age-0)	Smolt (age-1)	Smolt Pop.	Freshwater Survival ³	Jack Pop.	Marine Survival (1-year) ⁴	Adult Pop.	Marine Survival (2-year)
Palouse	2006	0	487	380	na	2	1.0%	19	5%
	2007	1,191	742	754	29.8%	9	1.0%	na	na
	2008	2,846	542	1,376	31.2%	na	na	na	na
	2009	967	na	na	na	na	na	na	na
Larson	2007	282	375	302	19.9%	6	2.1%	na	na
	2008	495	125	90	9.1%	na	na	na	na
	2009	75	na	na	na	na	na	na	na

¹ Coho brood year is defined as the first year that eggs are deposited during the fall/winter spawn period (e.g. the 2006 brood year of coho were derived from adult coho spawning during the 2006-07 winter spawn period. This brood will outmigrate as yearling smolts during the spring 2008).

² Number of PIT tagged coho smolt populations based on tide gate PIT antenna detections; jack and adult coho estimates based on detections at all antennas.

³ Freshwater survival represents the proportion of coho PIT tagged as age-0 fry or parr within a subbasin that were recorded at the subbasin tide gate PIT antenna array during the following spring, adjusted for antenna efficiency.

⁴ The proportion of outmigrant age-1 coho smolts that return as age-2 jacks to spawn.

⁵ The proportion of outmigrant age-1 coho smolts that return as age-3 adults to spawn.

na Data are not applicable or not yet available.

Juvenile Coho Movement and Growth

A total of 18,353 brood year 2008 and 3,284 brood year 2009 juvenile coho salmon were captured in the Palouse subbasin during 2009 and 2010 to monitor movement and habitat-specific growth rates (Table 6). During 2009 and 2010, 3,388 brood year 2008 coho were PIT tagged in the Palouse subbasin, of which total 832 were recaptured during repeat sampling efforts and 1,369 were detected at PIT antenna array in either the Palouse or Larson subbasins (Table 6). As of July 2010, 967 juvenile coho were PIT tagged and 79 PIT tagged fish were recaptured and 113 were detected at PIT antenna arrays in both subbasins (Table 6).

Table 6. The number of coho salmon fry and smolt captured and PIT tagged in the Palouse subbasin during May 2009-July 2010, with the number of PIT tagged coho recaptured during repeat sampling events and detected at PIT antenna arrays in the Palouse and Larson subbasins.

Subbasin	Brood Year ¹	PIT Tagged Coho			
		Captured	Tagged	Recaptured ²	Detected ³
Palouse	2008	18,353	3,388	832	1,369
	2009	3,284	967	79	113

¹ Coho brood year is defined as the first year that eggs are deposited during the fall/winter spawn period (e.g. the 2006 brood year of coho were derived from adult coho spawning during the 2006-07 winter spawn period and will outmigrate as yearling smolts during the spring 2008).

² Recaptured coho represent PIT tagged fish that were captured at least once after initial tagging; this figure does not include individual fish that were recaptured more than once.

³ The number of detected coho represents PIT tagged coho that were identified at least once at any PIT antenna array located in the Palouse or Larson subbasins and does not reflect the number that were detected more than once.

Movement Patterns. Movement by PIT tagged juvenile coho in the Palouse subbasin was observed to be variable among mainstem and tributary stream reaches during the 2009 summer season. Juvenile coho tagged in the lower, tidally affected extent of the Palouse Creek mainstem and in Haynes Inlet downstream of the Palouse tide gate were observed to move more extensively and frequently than coho tagged in areas characterized by riverine habitat (Figure 7). Approximately 80% of coho PIT tagged in Haynes Inlet and in Palouse Creek Reach 1 exhibited highly variable patterns of movement, while a smaller proportion (23%) of coho originally captured in Reach 2, located at the upstream extent of tidal influence, demonstrated similar movement patterns (Figure 7a-c). Recaptures and detections of juvenile coho originally captured and PIT tagged in Palouse mainstem areas upstream of tidal influence were almost entirely sedentary during the summer 2009 period (Figure 7d-f). Observed patterns of movement and residence in one lowland tributary and two upland tributaries closely resembled the general trend observed in the mainstem areas, with a large proportion of highly mobile fish in the lowland tributary and predominantly sedentary individuals in the moderate gradient upland tributaries (Figure 7g,h).

Growth Rates. Instantaneous growth rates were estimated for juvenile coho during three separate periods during summer 2010: early summer (April-June), mid-summer (June-August), and late summer (August-October). Growth among all Palouse subbasin stream reaches appeared to decrease through the three summer periods, with the highest growth occurring during April to June (Figure 8). While no distinct differences in growth among individual reaches were discernable, growth in the lower extent of the Palouse Creek mainstem appeared to decline relative to other mainstem reaches as the summer progressed. Growth rates among juvenile coho captured in more

than one reach, and thus classified as mobile, were highly variable but did not differ from sedentary coho (Figure 8).

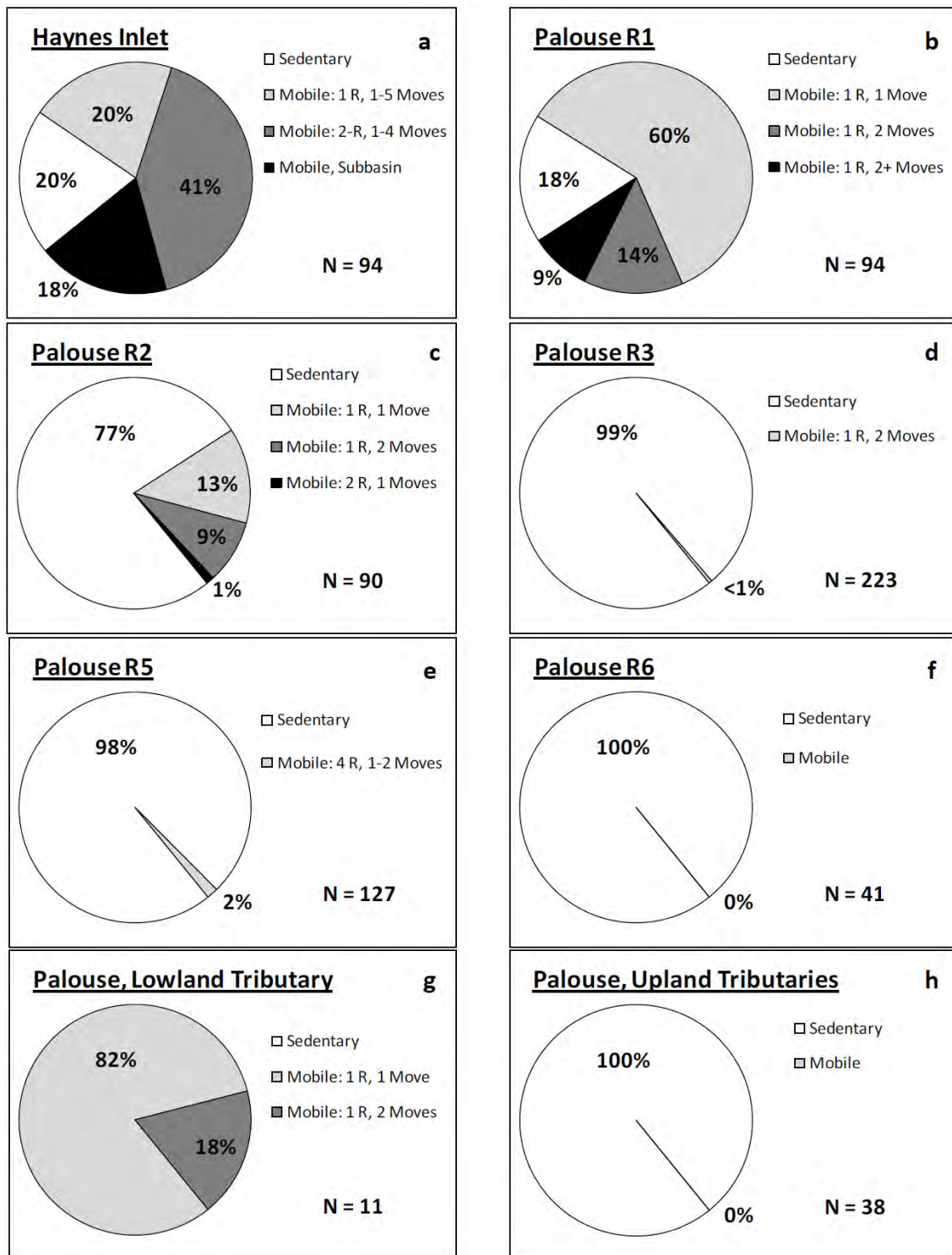


Figure 7. Movement patterns of PIT tagged juvenile coho in the Palouse subbasin by stream reach. Movement is described in terms of range (i.e. maximum distance moved) and frequency (i.e. number of movements during the summer season).

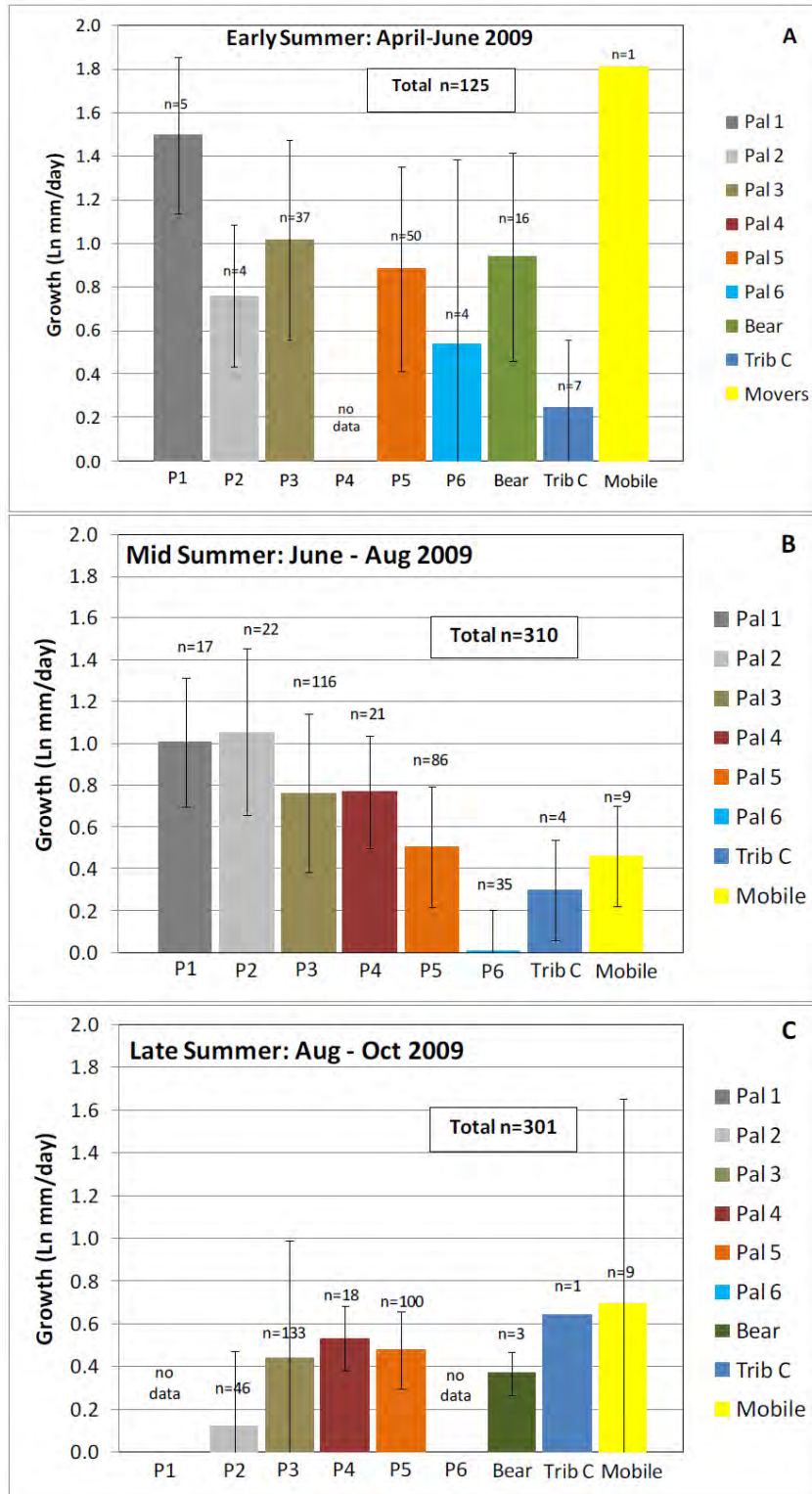


Figure 8. Average instantaneous growth rates among sedentary (i.e. remained within original capture reach) juvenile coho captured more than once within Palouse mainstem and tributary reaches and coho exhibiting mobile strategies (i.e. moved from original capture reach) during early (A), mid- (B), and late summer (C) 2009.

DISCUSSION

Coho salmon Life Cycle Monitoring efforts have been conducted in Palouse and Larson subbasins since 2004 and more recent efforts to monitor and describe juvenile coho movement and growth in lowland habitats were initiated in 2008. Life Cycle Monitoring efforts in Palouse and Larson subbasins have yielded estimates of freshwater survival that will augment ODFW monitoring efforts in other coastal Oregon subbasins. Recent incorporation of PIT technology with Life Cycle Monitoring protocols will provide an additional means to corroborate estimated freshwater and marine survival in each subbasin. In addition, juvenile coho PIT tagged among the range of available lowland habitats will provide unique insight into differential use and value of habitats to juvenile coho.

Results From the Current Project

Adult coho salmon abundance in each subbasin was estimated based on comprehensive spawner surveys in each subbasin in conjunction with trapping of upstream migrant adult coho in temporary fence weir traps. Although capture efficiency at adult weir traps has been variable due to the flashy nature of winter discharge in both subbasins and lack of permanent fish capture structures, comprehensive spawner surveys have provided reliable AUC estimates of adult abundance since the project was initiated. PIT tagged adult coho salmon returning to each stream may serve as an additional means to estimate adult abundance using mark-recapture methods. Tagged adults recorded at PIT antenna arrays will serve as the marked population and the proportion of individuals with tags recovered during spawning surveys will provide a subset of recaptured individuals.

Freshwater and marine survival of coho salmon in the Palouse and Larson subbasins have been estimated for 5 and 3 brood years, respectively. Although the period in which data are available is limited, survival estimates in each subbasin reflect trends in survival apparent from ODFW monitoring sites (Suring et al. 2009). Coastal lowland streams represent productive and integral components of coastal Oregon coho salmon production and characterization of life cycle trends will greatly augment ODFW Life Cycle Monitoring efforts.

Efforts to PIT tag juvenile coho fry and smolts will provide an opportunity to corroborate Life Cycle Monitoring survival estimates and individually marked coho have added value in terms of monitoring individual movement, habitat use, and growth patterns. Estimates of freshwater survival derived from recovery of PIT tagged coho fry as outmigrant smolts are a measure of summer and over-winter freshwater survival, whereas freshwater survival estimates developed in association with Life Cycle Monitoring efforts are a measure of egg-to-smolt survival. For this reason, these estimates are not directly comparable, however each figure provides valuable insight regarding the freshwater life history of coho salmon. The survival or return rate of PIT tagged juvenile coho as 2-year old jacks and 3-year old adult was measured in both subbasins and will con-

tinue to provide marine survival estimates that are directly comparable to Life Cycle Monitoring marine survival estimates useful for understanding spatial and temporal variation in coho production.

Juvenile coho salmon movement patterns inferred from recaptured PIT tagged coho and detection of tagged fish at stationary PIT antenna arrays indicate that coho in the lower, tidally influenced extent of the Palouse subbasin exhibit a greater degree of mobility than those in riverine areas. Juvenile coho tagged in Haynes Inlet and lower Palouse Creek moved greater distances and with higher frequency than coho elsewhere in the subbasin. Operational periods of PIT antenna arrays located at the upstream extent of Palouse Reach 3 was limited for much of the summer 2009 period and the antenna array at upstream of Reach 2 was not operational, so movement patterns apparent from 2009 data must be evaluated with operational periods of antennas in mind (Figure 5). Additional movement data collected in 2010 will supplement existing data and will likely provide a better understanding of juvenile coho movement and habitat use.

Growth rates of juvenile coho salmon were not distinctly different among the Palouse subbasin reaches. Growth rates appeared to decline among all reaches through the summer 2009 period, but particularly so in the downstream extent of the Palouse mainstem (Figure 8). During the late summer in the tidally affected portion of Palouse Creek, water temperatures typically warm substantially and dissolved oxygen levels can drop to the extent that these factors may affect juvenile coho growth. These factors will be analyzed with the 2008 and 2009 coho brood years to better understand impacts of changing habitat conditions on juvenile coho growth and condition.

Next Steps

Our work to understand coho salmon in tide gated Oregon coastal lowland streams, which began in 2004, will continue until at least 2012 under a new Oregon Watershed Enhancement Board grant (210-2071). Our future studies will emphasize leveraging the investments we've made by inserting over 8,000 PIT tags in coho fry and smolts from 2006 to 2009 (see Table 5). Some of these fish have already returned, and we are expecting significant numbers during the 2010 and 2011 brood years.

Life Cycle Monitoring. We will collaborate with ODFW Corvallis Research Laboratory to make operational improvements during the 2010 and 2011 spawning seasons to refine the antenna capacity to detect returning adult (and jack) coho that were PIT tagged as parr or smolts. We will initially retain at least one PIT tag antenna array in Larson and Palouse Creeks during the 2010 spawning season, with the location depending on whether a tide gate or an upstream location is most likely to survive winter freshets. A known sample of adults will be trapped in Haynes Inlet and the tide gate reservoir pools and PIT tagged; afterwards they will be released downstream from the antenna arrays to evaluate their tag detection efficiency. PIT tagged spawners will also be

identified with a hand held tag reader when fish are handled at the picket weir traps and the carcasses found during spawning surveys.

The population estimates derived from the PIT tagging will be compared with those from the traditional trap and AUC surveys. By the end of this project we will have three years to demonstrate and evaluate whether PIT tagging can provide a substitute for adult picket weir traps and spawning surveys in salmon life cycle monitoring. By continuing both the traditional adult weir traps as well as the PIT tag antenna arrays, we will attempt to answer, first, our standard coastal lowlands life cycle monitoring question, and second, see whether there are techniques that will improve the operation of these sites:

1. How does coho survival (both freshwater and marine) estimated for the populations of the Coos Bay Lowlands consistently differ, and to what extent, from those estimated at the other seven life cycle monitoring sites operated by ODFW?
2. Can PIT tags and stationary antenna arrays be as, or more, effective than picket fence weir traps in the process of estimating spawner returns at salmon life cycle monitoring sites?

Evaluate Fish Passage At Different Types of Tide Gates. The infrastructure and techniques developed during the existing project—as well as the companion O.S.U. research project—shows that there is movement of coho parr across tide gates and among the various tributary streams (for this study these consist of Larson, Palouse, and Winchester Creeks)(Bass, 2010). There are indications that differences in the amount and timing of pre-smolt use of the estuarine ecotone that reflect differences among various types of tide gates (and between tide gated and non-tide gated streams).

We will expand our network of antenna array to include Willanch Creek, which had its tide gated replaced in the summer, 2010 with a new set of doors (one side-hinged and one top-hinged) that have a Muted Tide Regulator (MTR). An MTR allows some tidal flow into the reservoir pool and as a result gate doors are open for a greater time period compared to the other two styles of gates in the present study. The question to be answered in this monitoring:

3. Is there a difference in fish passage timing, movement frequency and type among the Palouse (traditional top-hinged), Larson (side-hinged), and Willanch (MTR) tide gates?

We are anticipating that two articles will be submitted to peer-reviewed journals as a result of Art Bass's thesis work. One entitled "Juvenile Coho Salmon Passage Through Two Tide Gates and a Non-Gated Stream" will be submitted to *Ecology of Freshwater Fish*, while the other entitled, "Environmental Variables Influenced by Tide Gates and Their Effects on Coho Salmon Smolt Likelihood of Emigration" will be submitted to the *Environmental Biology of Fishes*.

Juvenile Coho Salmon Seasonal Habitat Use in Lowland Streams. Field data collected during this project will continue to be analyzed by Adam Weybright as part of his thesis research at O.S.U. We expect that this analysis will be conducted during the fall, 2010 through the spring,

2011. The thesis is scheduled to be completed by June, 2011. We expect that two articles will likely be submitted to peer-reviewed journals as a result of his work describing 1) seasonal movement patterns of juvenile coho salmon and 2) seasonal habitat use and growth of juvenile coho in a tide gated lowland coastal stream.

For this project we conducted one year's worth of seasonal sampling to indentify regional life histories of juvenile coho within lowland streams. In the new grant, we will conduct a second year of this sampling, then transition to evaluating juvenile coho use in relation to various habitat-types and in relation to restoration projects in the Coos Bay lowlands. Fish and habitat sampling efforts will be initiated in summer 2011 and repeated in 2012, following spring fry emergence, and will continue through smolt outmigration into spring 2013. The sampling period will be divided into spring, summer and winter, with season beginnings and ends determined by streamflow, rainfall and fish behavior patterns rather than the calendar exclusively.

This sampling will be designed to address the following monitoring questions:

4. Do juvenile coho salmon use habitats in the freshwater-upper estuary zone during their first summer?
5. How many habitat use strategies can be identified among juvenile coho salmon in spring, summer and winter?
6. Are there differences in terms of final body size or growth rate among fish with different strategies?
7. Is there a difference in fish habitat use strategy, body size and abundance between restored and un-restored habitats?

Concluding Observations

Starting in 2002 with our first monitoring of tide gated streams, we have endeavored to increase knowledge about why these streams are so productive for coho salmon. Our initial work began by focusing on the physical operation of different types of tide gates because we thought that adult fish passage might have the greatest effect on coho salmon populations. While adult passage availability in both traditional top-hinged and side-hinged gates is relatively short—and predation may be an important factor while adults are waiting to pass—the comparatively high numbers of adults reaching spawning grounds indicates that seeding levels are probably not the limiting factor in these coastal lowland streams. Research by Bruce Miller and Steve Sadro (2003) showed that there are likely remnant coho life histories that involve pre-smolt use of the freshwater-estuarine ecotone if this habitat is available to them. If this life history trait was previously widespread—but presently largely extirpated due to tide gates—then there could be an opportunity to improve the resilience of coastal coho salmon populations if this alternate life history could be restored. The results that Art Bass (2010) found by PIT tagging juveniles and watching their inter-

actions with the Larson and Palouse tide gates—particularly their wide-ranging roaming behavior—demonstrates that juvenile fish passage may be the most important effect of tide gates. A second finding from Bass (2010) furthered our concern about the effects on water quality (temperature and salinity) in the reservoir pool upstream from tide gates and how different designs affect these parameters. Once the importance of the reservoir pool was understood, we focused one area of this project to evaluate survival and growth rates in different regions of the stream systems, with a special interest in the differences between juveniles who remained in the vicinity of their natal reach (i.e., sedentary) versus those that moved (i.e., nomads). Our initial results support further investigation into this question—investigations which will be done during our next project phase.

The results of our work to date have not been just theoretical. Throughout our effectiveness monitoring program we have developed techniques and analytical tools to help understand how tide gates effect a plethora of variables. Initially, we devised a process to use water surface elevation transducers to determine opening periods; subsequently, we expanded this to develop and test devices to measure and log the angles when the doors are open. Our PIT tagging studies first had to demonstrate that antennas can work in brackish water, something that had not previously been widely applied. This advancement of technology will continue as we have begun to see PIT tagged smolts return as spawners. If antenna arrays can operate effectively during high winter flows to adequately enumerate these spawners a whole new field of investigation will be opened up. Life cycle monitoring will become easier, required staffing and maintenance of fish weirs can be reduced, and tagged spawners—especially if otoliths are recovered from their carcasses—have the potential to be tracked as individuals from their parr stage throughout the remainder of their lives.

Our work has also changed the perspective that simply focused on the gates themselves to instead one that evaluates how the gates exist in a larger stream landscape. Fish passage is important, but so is water quality in the reservoir and the ability of coho to access a diversity of high quality habitats, both freshwater and estuarine. This emphasis on looking holistically at systems is important when decisions are being made—both for regulation as well as restoration. From a regulatory perspective, ODFW has used the results of our studies to design fish passage criteria at tide gates, and NMFS has used its authority under the Endangered Species Act to specify acceptable gate designs in the permitting process. From a restoration perspective, we—as well as others—are using our results to design and prioritize where and how a variety of projects are implemented. These insights allow us to better target our work with landowners to more effectively use limited resources as well as help them meet their land management objectives.

LITERATURE CITED

- Adams, A. J., R. K. Wolfe, W. E. Pine and B. L. Thornton. 2009. Efficacy of PIT tags and an autonomous antenna system to study the juvenile life stage of an estuarine-dependent fish. *Estuaries and Coasts* 29(2): 311-317.
- Bass, A. L. 2010. Juvenile coho movement and migration through tide gates. Master's Thesis. Oregon State University, Corvallis, Oregon, USA.
- Brakensiek, K. E. and D. G. Hankin. 2007. Estimating overwinter survival of juvenile coho salmon in a northern California stream: accounting for effects of passive integrated transponder tagging mortality and size-dependent survival. *Transactions of the American Fisheries Society* 136:1423–1437.
- Coos Watershed Association (CoosWA). 2006. Coos Bay Lowland Assessment and Restoration Plan. Coos Watershed Association, Charleston, OR. 212 pages.
- Giannico, G., and J. A. Souder. 2005. Tide gates in the Pacific Northwest: operation, types, and environmental effects. Rep. No. ORESU-T-05-001, Oregon Sea Grant, Oregon State University.
- IMST (Independent Multi-disciplinary Science Team). 2002. Recovery of wild salmonids in western Oregon lowlands. Technical report 2002-1 to the Oregon Plan for Salmon and Watersheds, Governor's Natural Resources Office, Salem, OR.
- Jacobs, S.E. and T.E. Nickelson. 1998. Use of stratified random sampling to estimated the abundance of coastal coho salmon. Oregon Dept. of Fish and Wildlife, Report F-145-R-09.
- Knudsen, C. M., M. V. Johnston, S. L. Schroder, W. J. Bosch, D. E. Fast, and C. R. Strom. 2009. Effects of passive integrated transponder tags on smolt-to-adult recruit survival, growth, and behavior of hatchery spring Chinook salmon. *North American Journal of Fisheries Management* 29:658–669.
- Miller, B. and S. Sadro. 2003. Residence Time and Seasonal Movements of Juvenile Coho Salmon in the Ecotone and Lower Estuary of Winchester Creek Sough Slough, Oregon. *Transactions of the American Fisheries Society* 132: 546-559.
- Montgomery, D.R., and Buffington, J.M. 1997. Channel reach morphology in mountain drainage basins. *Geol. Soc. Am. Bull.* 109: 596–611.
- Montgomery, D.R., J.M. Buffington, R.D. Smith, K.M. Schmidt, and G. Pess. 1995. Pool spacing in forest channels. *Water Resources Research* 31: 1097–1105.
- Moore, K.M.S, K.K. Jones, and J.M. Dambacher. 2010. Methods for Stream Habitat Surveys: Aquatic Inventories Project. Information Report 2007-01, version 3, Oregon Department of Fish & Wildlife, Corvallis. 67p.
- Suring, E., K.A. Leader, C.M. Lorion, B.A. Miller, D.J. Wiley. 2009. Salmonid Life Cycle Monitoring in Western Oregon Streams, 2006-2008. Monitoring Program Report Number OPSW-ODFW-2009-2, Oregon Department of Fish and Wildlife, Salem.
- Thedinga, J.F., M.L. Murphy, S.W. Johnson, J.M. Lorenz, and K.V. Koski. 1994. Determination of Salmonid Smolt Yield with Rotary-Screw Traps in the Situk River, Alaska, to Predict Effects of Glacial Flooding. *North American Journal of Fisheries Management* 14:837-851.
- Zydlewski, G. B., C. Winter, D. McClanahan, J. Johnson, J. Zydlewski, and S. Casey. 2003. Evaluation of fish movements, migration patterns, and population abundance with streamwidth PIT tag interrogation systems. Project No. 2001-01200, BPA Report DOE/BPOOOO5464-1.

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A project as extensive and complicated as this could not be done without the support of a team that includes personnel from CoosWA and our partner agencies, other volunteers, cooperative land-owners, and regulatory authorities. We acknowledge these contributions here while reserving to ourselves the responsibility for any errors of omission or commission in the conduct of this project.

Personnel

Coos Watershed Association. Adam Weybright, Monitoring Fish Biologist, carried out this grant project from start to finish both as an employee and as a graduate student at O.S.U. Jon Souder, Executive Director, provided continuity and coordination with our partners. Aimee Peters, Bookkeeper and Office Manager, kept us all out of jail. Other CoosWA staff who provided field assistance included Dan Draper and Freelin Reasor.

Displaced Salmon Fishermen. Technician support for this project was provided by OWEB Grant 208-2098 to hire displaced commercial salmon fishermen and charter boat operators under the 2008 Salmon Season State of Emergency program. These folks, who provided almost 1,400 hours of labor for the project, included Jay Blodgette, Brad Blodgette, Scott Howard, and particularly Dave Nelson. We could not have carried out the project without their enthusiasm and dedication; we were so impressed with Dave Nelson that we hired him permanently to lead CoosWA's riparian stewardship crew.

Oregon State University. This project was conducted in partnership with Dr. Guillermo Giannico of the Department of Fisheries and Wildlife. Guillermo has worked with us over the last ten years as we've evaluated the effects of tide gates on Oregon coastal lowland streams. He's served as graduate advisor for three students who have worked on the overall project, and has assisted in proposal preparation, research design, and data evaluation. Art Bass completed his Master's thesis research under a companion OWEB Research Grant, and he and Adam were responsible for the installation of the PIT Tag arrays and much of the smolt trapping.

Oregon Department of Fish & Wildlife. Overall coordination with ODFW's Life Cycle Monitoring Program was provided by Jeff Rodgers, Conservation and Recovery Monitoring Coordinator and Erik Suring, Salmonid Life Cycle Monitoring Project Leader, both at the Corvallis Research Laboratory. Assistance in implementing the Life Cycle Monitoring in Larson and Palouse Creeks was provided by Bruce Miller and Katherine Nordholm, ODFW Research staff in Charleston. Jennifer Feola, Habitat Biologist with ODFW in Charleston provided one day per week of field time throughout the study. Mike Gray, District Fish Biologist assisted with obtaining and managing the Scientific Take Permits needed for the project.

Voluntary Contributions

Graduate Study Committee. The juvenile coho movement and growth study design and analyses were overseen by Adam Weybright's graduate committee in the Fisheries and Wildlife Department at Oregon State University: Joe Ebersole, U.S. Environmental Protection Agency; Gordon Reeves, U.S. Forest Service Pacific Northwest Research Station; and Don Stevens, Department of Statistics. Guillermo Giannico ably chaired the committee.

Field Studies. Reese Bender, retired ODFW District Fish Biologist and CoosWA Board member conducted salmon spawning surveys on Palouse Creek, as he has done for the last 20 years. His surveys provide one of the most consistent sources of data on coho and steelhead spawning on the Oregon coast. We appreciate the ability to use these surveys as match for this grant. Additional on-call volunteer field assistance was provided by Morgan Bancroft and his help was also greatly appreciated.

Equipment. We are particularly grateful to Gabriel Brooks of the NOAA-Northwest Fisheries Science Center for teaching us how to build and maintain PIT tag antennas. The U.S. Forest Service, Pacific Northwest Research Station provided one of the rotary screw traps and a PIT tag transceiver. Bruce Hansen was instrumental in facilitating the use of this equipment. The second rotary screw trap was loaned by ODFW. Chris Jordan, NOAA Northwest Fisheries Science Center provided a loaner PIT tag transceiver while one of ours was being repaired. The U.S.E.P.A. (through a donation to the South Slough National Estuarine Research Reserve) provided another of the PIT tag transceivers used for the project. The Coos Bay District of the Bureau of Land Management loaned an electroshocker for the duration of the project.

Landowner Access

Almost all the property within the project area is privately owned. We have received remarkable cooperation from dozens of landowners during the course of our life cycle monitoring program. Without this cooperation this project could not have been conducted.

Adult and Screw Traps and PIT Tag Antennas. We appreciate the landowners and managers who have suffered the presence of our traps, permanent antennas and staff on their property. The Palouse adult trap is located on the Elliott State Forest on lands owned by the Oregon Board of Forestry. The Palouse rotary screw trap was located on the property of the late Walt Granum and Joann Granum for several years and currently resides on the property of Jeffrey and Lonna Coleman. The Larson adult trap was initially on the property of Mark Debrito and Faith Taylor, and was moved downstream to Judy Wergeland's in 2008. The rotary screw trap on Larson Creek is located on property owned by the Brelage Pacific Dairy; Dan Brelage, CoosWA Board member, has allowed this even as he's pastured his dairy herd on adjacent fields. PIT tag antennas are located on tide gates owned by the Larson Drainage District and the Haynes Drainage Districts. Ad-

ditional PIT antenna arrays on Palouse Creek were installed on property owned by Iris Jackson, Jeff and Lonna Coleman, and Gary Haga.

Fish Sampling. On Palouse Creek, fish sampling was conducted on properties owned by Mike and Cathryn Roberts, Nancy Peterson (Greg Stone), Fred Messerle & Sons, Ken and Patricia Fredrickson, Sue Cahill, Iris Jackson, Jeff and Lonna Coleman, Clarence and Ron Nelson, Walt and Joann Granum, King and Yvonne Frey, Steve and Linda Gross, Gary Haga, Keith and Kathleen Hawley, James Jordan, and Lauri Rettalick. On Larson Creek, fish sampling was conducted on property owned by Scott and Michelle Roberts, Jim and Karleen Bailey, Tom and Deanna Prather, Erik and Star Wolfgang, Helen Curley, Judith Wergeland, and Faith Taylor and Mark Debrito.

Scientific Take Permits

Fish surveys, fish sampling, and aquatic inventories were conducted under the following ODFW and NMFS Scientific Take Permits:

- 2007: NMFS #OR2007-3669
- 2008: NMFS #OR2008-4160
- 2009: ODFW #13617
- 2010: ODFW #14699