THE OREGON PLAN *for Salmon and Watersheds*

Recovery of Wild Coho Salmon in Salmon River Basin, 2008

Report Number: OPSW-ODFW-2009-10

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Annual Monitoring Report No. OPSW-ODFW-2009-10

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CONTENTS

FIGURES

TABLES

INTRODUCTION

Recovery and conservation of naturally self-sustaining salmon populations is a central goal of the Oregon Plan for Salmon and Watersheds. In 1998, the Oregon Department of Fish and Wildlife (ODFW) initiated a comprehensive program to monitor the status of coho salmon (*Oncorhynchus kisutch*) populations and aquatic habitat in coastal drainages of Oregon (OWEB 2003). A 2005 assessment by ODFW concluded that Oregon coastal coho were viable at the scale of the Evolutionary Significant Unit (ESU) and demonstrated resilience in response to improving ocean conditions. Yet 7 of 21 (33%) individual populations within the ESU failed one or more of five criteria used to assess viability (Chilcote et al. 2005), and it is uncertain whether productivity levels across the ESU will recover sufficiently to withstand future periods of poor ocean conditions. The coho population in Salmon River was the only population in the ESU to fail all five viability criteria. Uncertainty remains about the response of Oregon coastal coho salmon to different combinations of freshwater and marine limiting factors, complicating recovery efforts (Lawson 1993; Lawson et al. 2004; IMST 2006). Such uncertainty cannot be resolved entirely by existing Oregon Plan monitoring programs, which target only a portion of the habitats and coho salmon life stages in large river basins, and with few exceptions (e.g., Johnson et al. 2005), were not designed to test population responses to individual management manipulations.

In 2007, in response to the failure of viability criteria, ODFW managers discontinued releases of hatchery coho salmon into Salmon River as one of the primary management actions under the Oregon Conservation Plan for the Oregon Coast Coho Evolutionarily Significant Unit (hereafter “coho plan,” Nicholas 2006). This change affords the first opportunity in Oregon to monitor the results of a large scale experiment in removing hatchery coho salmon from a basin for at least four generations (twelve years). Hatchery production has been a centerpiece of salmon management for decades, but rarely has full recovery from hatchery influence been given a chance to succeed. Salmon River offers a test basin to explore whether an independent population of coho salmon can recover from a prolonged period of very low abundance following removal of the primary factor limiting productivity.

Here we describe the first year of a study to monitor the dynamics of the coho salmon population in the Salmon River basin on the central Oregon coast and to determine whether management changes targeting both hatchery influence and stream habitat complexity improve population viability. This research will validate assumptions about factors limiting coho recovery and determine whether recovery measures proposed by the Coho Plan have been effective.

Our research is designed to document changes in population abundance, distribution, and life history structure of coho salmon following the removal of hatchery coho salmon from the watershed. It integrates adult, juvenile, and habitat components to establish links and describe variability between juvenile performance and adult recovery. It also monitors the coho salmon population across habitat types and life history stages to identify population responses at a landscape scale. We will establish the link between productivity and survival at each salmon life stage and recovery of the adult population. From these indicators, we will determine the potential resiliency of coho salmon, detail the biological benefits/tradeoffs of returning the ecosystem to natural salmon production, and assess whether supplementation should remain an option in Salmon River.

As a conceptual framework, our research design and analyses are guided by the "viable salmonid population" criteria identified by McElhany (2000) and modified by Chilcote et al. (2005) and Nicholas (2006), including abundance, productivity, distribution, diversity, and habitat quality. The results of our new research will be integrated with habitat survey and adult population data collected under the existing Oregon Plan monitoring program and coho salmon population and life history data available from previous Salmon River surveys (Mullen 1978, 1979; Cornwell et al. 2001; Bottom et al 2005; Volk et al. in review). Together these data will address four prinicipal objectives:

1. Quantify viability of the coho salmon population before and after hatchery coho salmon are removed from Salmon River.

2. Assess whether viability of the Salmon River coho population is limited by quantity and complexity of stream habitat.

3. Describe the diversity of juvenile and adult life histories of coho salmon in the Salmon River basin and estimate the relative contributions of alternate juvenile life history to adult returns.

4. Determine salmonid use and benefits of restored tidal wetlands before and after hatchery coho salmon are removed from Salmon River.

By synthesizing historic data with new information for the Salmon River basin, we will compare population structure during three distinct periods – pre-hatchery (1974-77), hatchery (1990-2008), and post-hatchery (2009-2013). This annual report discusses the activities and findings from 2008, the first year of the multi-year project, including coho salmon distribution and abundance on the Salmon River spawning grounds, juvenile abundance and distribution in the watershed and estuary, migration timing, and life history diversity.

METHODS

Salmon River watershed is located on the north-central Oregon coast immediately north of Lincoln City (Figure 1). The basin is 195 km^2 in size, with an 800 hectare estuary that extends to river kilometer (rkm) 6.5. The estuary has extensive wetlands, some of which were restored in 1978, 1987, and 1996 (Figure 2). The basin has a diverse ownership and management: US Forest Service (USFS) Cascade Head Scenic Research Area in the estuary, USFS and private industrial forest in the uplands, Oregon State Parks in 3.2 km of stream corridor, and rural residential along the lower reaches of the mainstem. ODFW operates a hatchery at rkm 8 (Figure 1) that was established in 1978 to supplement coho and chinook salmon populations. The last release of juvenile coho occurred in May 2007.

Abundance & distribution of coho at each life stage

We estimated the abundance of coho salmon at the adult, age-0 juvenile, and outmigrant (age-0 and age-1) life stages. ODFW's Oregon Adult Salmonid Inventory and Sampling project (OASIS; ODFW 2007) conducts annual surveys of adult coho salmon in Salmon River. Since the 2006-2007 spawning season, spawning surveys have encompassed approximately 30 percent of the potential coho spawning habitat annually within a spatially-balanced random sample. Sites are selected using the generalized random-tessellation stratified (GRTS) sampling methodology (Stevens and Olsen 2004), and surveys are designed to estimate abundance with precision of ±30 percent using a local neighborhood (NBH) variance estimator (Stevens and Olsen 2003). Twelve sites were surveyed in 2007 and in 2008, and we collaborated with OASIS to estimate escapement of hatchery and naturally produced adult coho. In addition to the standard OASIS protocol (Jacobs et al. 2002), we collected scales and otoliths from all wild coho salmon carcasses handled on spawning ground surveys. Distribution was assessed as a function of site occupancy and density.

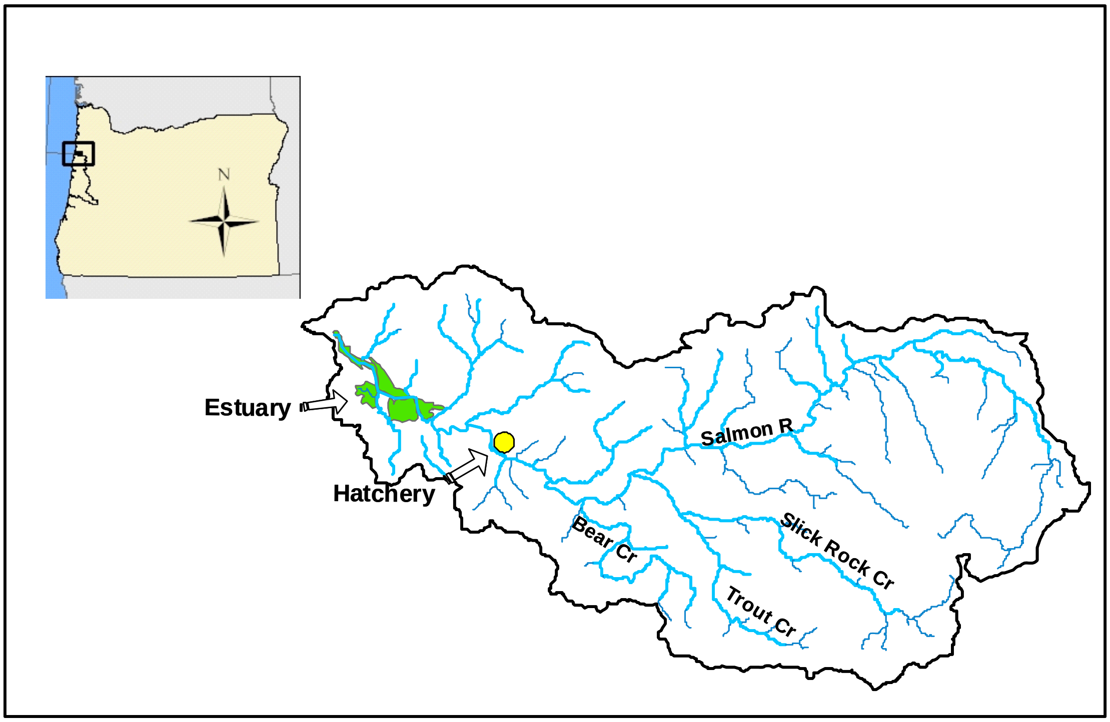

Figure 1. Salmon River basin on the north-central Oregon Coast.

Juvenile (age-0) coho salmon abundance was estimated in tributary and mainstem habitats in 93 kilometers of wadeable stream in the basin. Within this sampling frame, 25 GRTS-selected survey sites were identified. Sites overlapped with the 2007 adult survey sites but also included sites within the rearing only distribution. Abundance was estimated by removal (Zippin 1958) using backpack electroshockers. Each site was 20 active channel widths in length. Blocknets were placed at the upstream and downstream end of each site, and we made multiple passes through the site until a sufficient reduction in catch was achieved between subsequent passes. In two large water sites, we made estimates using mark-recapture technique (Rodgers et al 1992). The total number of summer coho parr rearing in the basin was estimated using the LNB estimator and expanded to all stream kilometers in the basin. All handled fish were PIT tagged with full duplex 12.5 mm tags.

The abundance, size, and migration timing of downstream-migrant coho salmon was quantified at a screw trap located above the head of tide, close to Salmon River Hatchery. The trap was operated continuously from March 18 through June 20. Trap efficiency was calculated on a weekly basis, and abundance was estimated following the techniques of Solazzi et al. (2000). Juvenile coho collected in the screw trap were marked individually with PIT-tags to allow estimates of estuarine residence time from seine samples at the mouth of the estuary and future identification on the spawning grounds.

Life history diversity: size, migration time, growth, age, and habitat use

We collected measures of life history diversity including size and age at migration to estuary and ocean, growth, and habitat use. Size and age at migration to the estuary was sampled at the screw trap (described above). The main channel and wetland habitats of the lower river and upper estuary (i.e. the stream-estuary ecotone, Miller and Sadro 2003) were sampled at least twice monthly using a 38m beach seine. Site selection was representative of available habitat throughout the ecotone from the 96 marsh to ocean entrance. We sampled main channel (tidal) and wetland habitats in Salmon River estuary (Figure 2) to evaluate habitat use through the year. The wetland habitats (natural and restored) are located along a salinity gradient from tidal-fresh to marine zones (Bottom et al 2005).

Beach seining is an effective means of capturing juvenile salmonids in the Salmon River estuary (Mullen 1979, Cornwell et al. 2001, Bottom et al. 2005), and catch-per-unit-effort seining is a reliable index of salmonid abundance in small Oregon estuaries (Reimers 1973, Pearcy et al. 1989). Juvenile coho were sampled in the 96 marsh through the summer and fall. The reference, 78, and 87 marshes were used very sparingly by coho so we concentrated the marsh sampling in the 96 marsh. We estimated absolute abundance of juvenile coho in the 96 wetland through short-term mark-recapture sampling (e.g. Reimers 1973). We also seined regularly at the mouth of the estuary to estimate size, time, and abundance of juvenile coho at ocean entrance. Juvenile coho were scanned for PIT tags to estimate timing from estuary entrance to ocean entrance and growth.

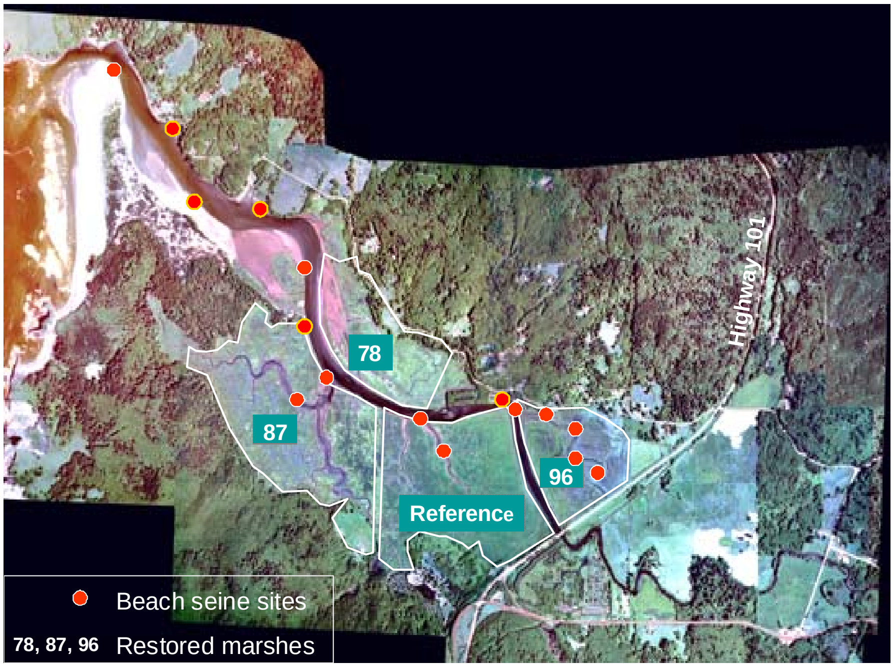

Figure 2. Salmon River estuary. Restored marshes are identified by date.

RESULTS

Adult Population

The spawning escapement of adult coho salmon was estimated at 993 ± 54% (95% confidence interval) in 2007 and 3,853 ± 38% (95% confidence interval) in 2008. Of the adult coho observed, approximately 5% and 20% were from naturally spawned parents in 2007 and 2008 respectively. Adult coho were present in all sites, but distribution of spawning was concentrated in upper mainstem Salmon River and in Bear Creek (Figure 3).

Juvenile Population (age-0) in the watershed

Juvenile coho were collected at 16 of 25 randomly selected sites (Figure 4). The population was estimated at 19,412 ± 57% (95% confidence interval). The density of juvenile coho averaged 0.18 fish per linear meter of stream, or 0.04 per m^2. Distribution was uneven, not unlike that depicted by the adult surveys. High abundances occurred in upper Salmon River and Salmon Creek. We handled 474 coho and PIT-tagged 373 of them during the sampling. The proportion of the population handled was less than 2.5%. Handling and tagging stress resulted in 31 mortalities which represented approximately 0.16% of the population of age-0 coho.

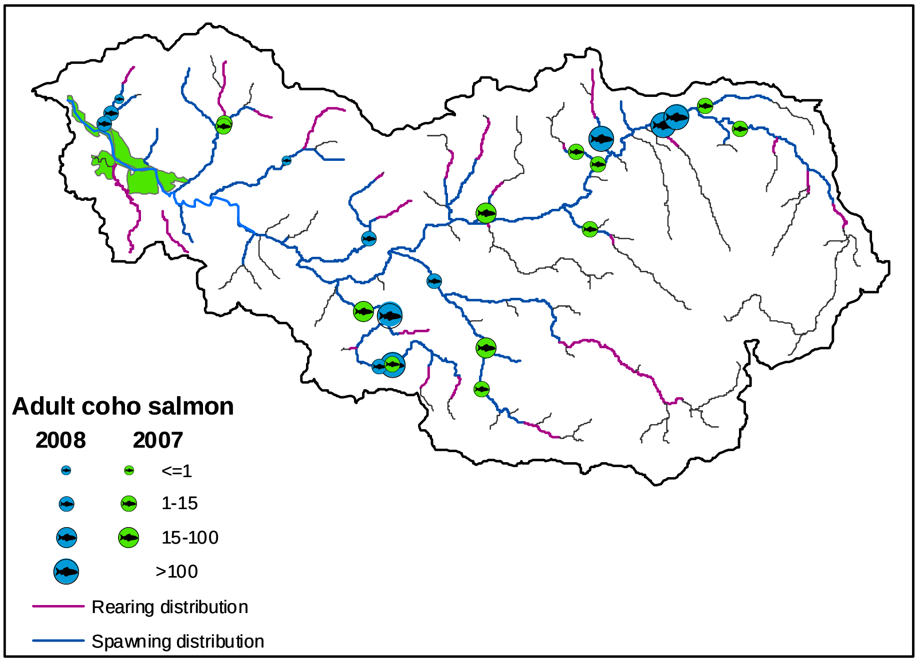

Figure 3. Abundance of adult coho during 2007 and 2008 in Salmon River

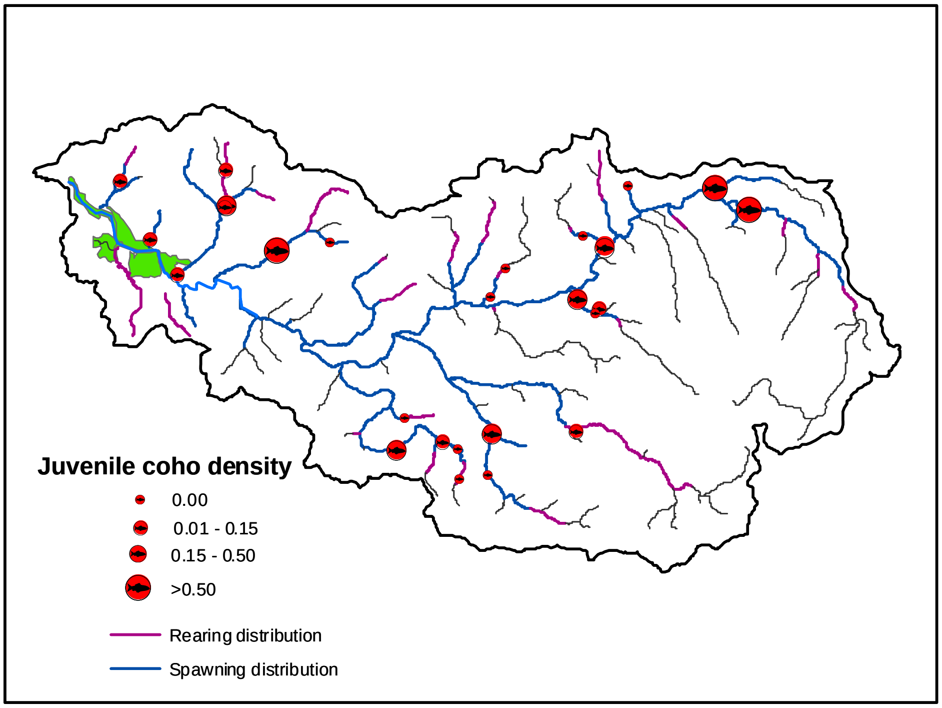

Figure 4. Abundance of juvenile coho per linear meter in August and September 2008 in Salmon River.

Spring Migration

Juvenile coho migrate out of the freshwater streams throughout the year but the peak migration period for the age-1 juveniles is from March through June. Many age-0 coho migrate during this time period as well, but few of these fish are expected to enter the ocean until later in the year. We operated a screw trap at Rkm 8 (adjacent to the hatchery) to enumerate, measure, and PIT-tag juvenile coho. We PIT-tagged 1,149 age-1 juveniles at the screw trap. The 0-age fish were too small to tag.

Figure 5 displays the migration timing and number of migrants during spring 2000-2002 (Bottom et al 2005) and spring 2008. Estimates of abundance, extrapolated by weekly trap efficiencies are reported in Table 1.

Table 1. Annual abundance of spring outmigrant age-1 and age-0 coho salmon during four years in which a smolttrap was operated between 2000 and 2008

Year	Age-1	Age-0
2000	8,268	979
2001	6,982	11,621
2002	16,387	5,367
2008	25,806	55,201

Peak migration time for the age-1 (yearling) coho was in May for 3 of the 4 years. Subyearlings migrated in late March as newly hatched fry (some still had the egg sac attached) in 2008, but then slowly left the river through the spring. However, sampling in the estuary (discussed below) indicated that subyearlings entered the estuary continuously through the summer and fall.

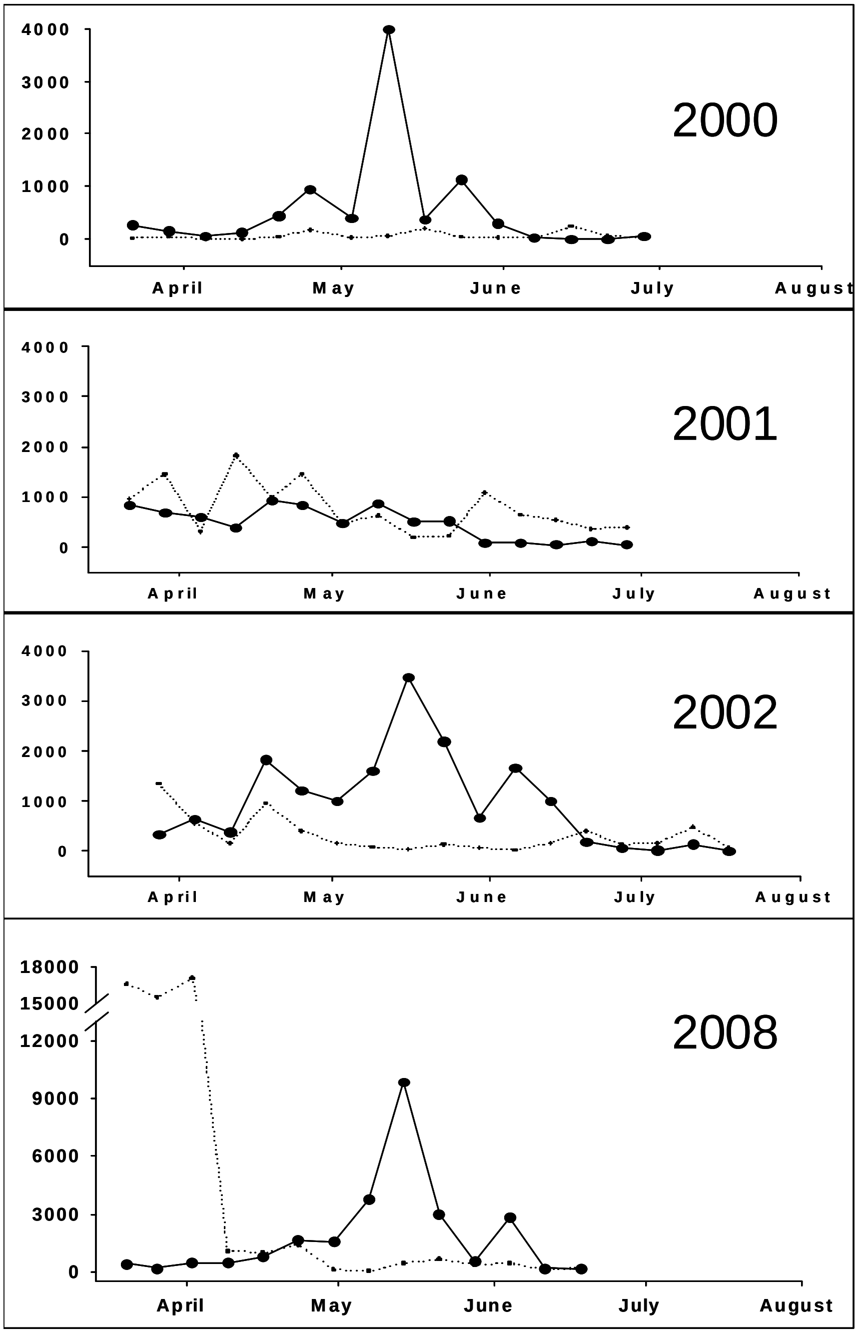

Figure 5. Abundance and timing of yearling (solid lines) and subyearling (dashed lines) juvenile coho at the screw trap in Salmon River in 2000-2002 (from Bottom et al. 2005) and 2008.

Abundance, Timing, and Habitat Use in the Estuary

Yearling coho traveled quickly through the main estuarine channel to the ocean and were rarely sampled after June. However, some did linger and were sampled in the 96 marsh (Figure 2) in April and May (Figure 6). Yearling coho marked at the screw trap (head of tide) and recaptured in the estuary had a median residence time of 14 days, and a range up to 28 days. The yearlings (considered smolts) grew quickly at a rate of 0.85 mm per day, an average of 2.2% of their body weight per day (N=5) (Figure 7).

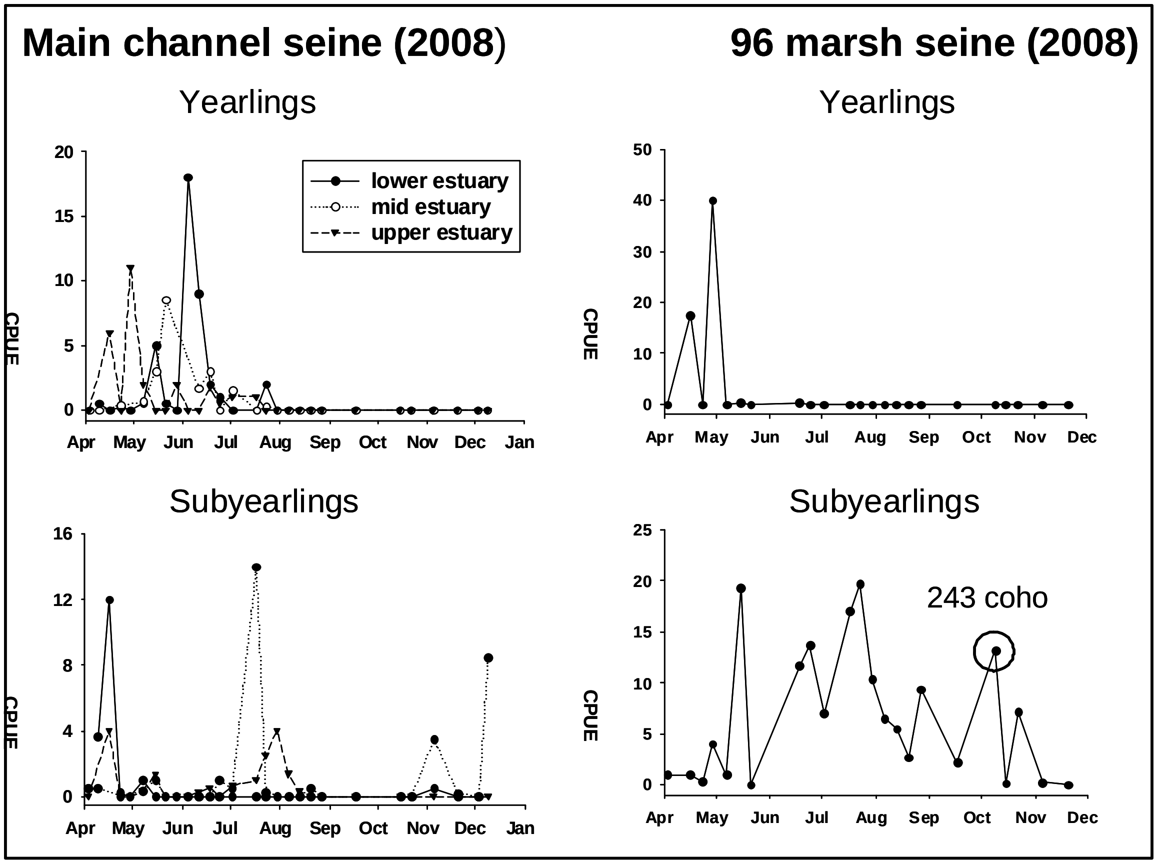

Figure 6. Abundance (catch per unit effort) of yearling and subyearling coho in the Salmon River estuary from April through December in 2008.

Subyearling coho were observed all year in the estuary, with highest numbers sampled in the 96 marsh channel (Figure 6). In October, we estimated 243 (95% confidence interval = 201-311) subyearling coho were present based on a one day mark-recapture experiment. The subyearling coho grew more slowly than yearlings at an average of 0.34 mm/day, or 1.3% body weight per day (n=91) (Figure 7). Subyearling coho tagged and recaptured in the 96 marsh (n=32) were at large between captures for a mean and median residence time of 26 days and a maximum of 56 days.

Few subyearling coho were caught in the estuary main channel from late August through October. However, in November and December, groups of coho were caught at a beach seine site at rkm 1.6 (average fork length 111mm and 104mm, respectively) that may suggest a later outmigration coinciding with higher river flows. Seining near the mouth of the estuary on January of 2009 also resulted in 23 coho with an average length of 94mm.

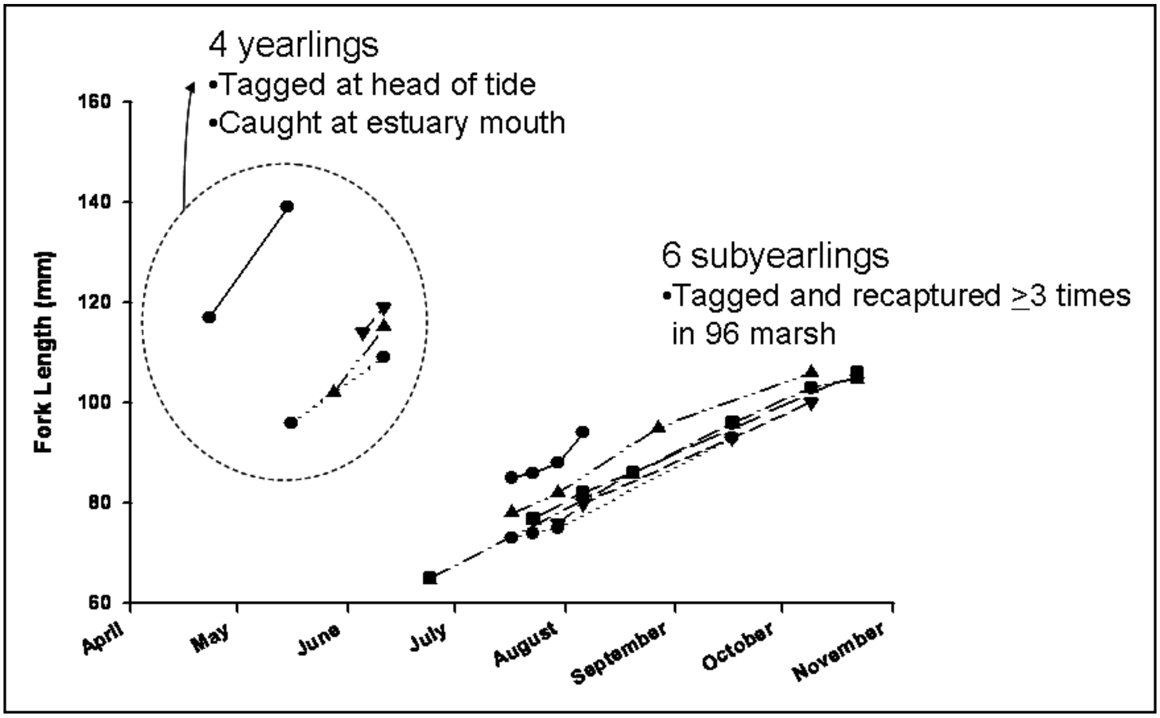

Figure 7. Growth and residence of yearling (smolts) and subyearling coho recaptured in the Salmon River estuary.

DISCUSSION

The majority of adult coho spawning in the Salmon River watershed were hatchery-origin fish in 2007 and 2008, as in past years. The spawning population was limited in distribution (concentrated in two areas of the basin) and the spawning period was short and early relative to other coho populations. Adults in Salmon River spawned from late October through mid-November, peaking in early November and ending by early December (ODFW 2007; OASIS Project, ODFW, Corvallis, unpublished data). In contrast to Salmon River, other coho populations on the coast started spawning in early October, but extended through early February with peak spawning occurring in mid-December.

An increased number of surveys coupled with the GRTS survey design have led to increases in precision of population abundance estimates. The confidence interval around the estimates of the spawning populations in 2007 and 2008 (54 -38% respectively) were lower than previous years because the number of surveys were increased to cover more than 20% of the habitat available to spawning coho. The increased precision will provide an accurate baseline for detecting trends in numbers and spawn timing of the Salmon River population. Fall 2008 was the last year that hatchery coho salmon will return to Salmon River; only adult progeny of naturally spawned adults will return to the basin in 2009.

The juvenile 0-age (subyearling) coho we sampled in the watershed in 2008 were the progeny of the 2007 brood adults. The confidence interval of the juvenile population is larger than desired because 36% of the sites did not have coho present even though the sites were within the potential rearing distribution. The average density of juvenile coho, 180 fish per kilometer of stream, was very low, well below the average of 5,000 parr per kilometer the habitat can support (Rodgers et al 2005). In addition to providing precise baseline abundance, the estimate of the juvenile population provides an indicator of the survival from egg to summer parr life stage. Assuming 2,500 eggs per female (Nickelson 1998) the survival from egg to parr of the 2007 brood was less than 2%, a value much lower than that estimated in other basins (Life Cycle Project, ODFW, unpublished data). Because we will not sample the yearling migrants of the 2007 brood until spring 2009, we cannot report on the overwinter survival rate of the summer parr. Hatchery influences on the genetic structure of the population (Nickelson 2003) or on the temporal distribution of spawners could influence survival of coho salmon eggs. If such changes have occurred in Salmon River, we may expect a shift in the peak time of spawning or an increase in egg to parr survival since the hatchery has terminated all releases of coho salmon. Only the progeny of naturally spawned adults will contribute to adult returns to the basin starting in 2009. The distribution of returning adults and juveniles may expand as well if salmon survival varies among streams in the basin.

Measures of life history diversity include growth rates, age and timing of migration, and habitat use. Subyearling coho were observed in all habitats in the basin, from freshwater tributaries to freshwater and brackish portions of the upper estuary. The distribution and abundance of fry were influenced by location along the tidal gradient, salinity, and temperature. The fry in the estuary were observed most often in the least saline of the wetlands, the 96 marsh. However, even this wetland had salinity levels over 20 PSU in September and October. In other years, juvenile salmon were sampled in the 96 marsh in late July even though the water temperature was close to 20 degrees (Cornwell et al 2001). We did not observe subyearling coho in the reference marsh, located 0.5 kilometers downstream, which had a slightly higher salinity but lower temperature, suggesting that a salinity threshold may limit the suitability of estuarine rearing habitats earlier in the summer. Subyearling coho grew well in the 96 marsh, comparable to rates in freshwater streams, and spent considerable time in the estuary. It was notable that the yearling smolts grew rapidly in the estuary, twice as fast as the subyearlings. The estuary may provide a very productive and important environment for the relatively short time that smolts spend as they transition to the ocean environment. One individual smolt doubled in size during its 28 day residence.

In coastal basins and in the Salmon River, complex overwinter habitat is considered potentially limiting to coho salmon populations (Nickelson et al. 1992, Solazzi et al. 2000, Rodgers et al 2005). Survival from summer parr to migrant smolt the following spring requires the availability of complex slow water habitat such as pools with wood jams, beaver ponds, and off-channel alcoves to provide refuge during winter freshets. In the Salmon River, complex habitat exists through the Van Duzer State Park corridor, and tidal-fresh wetlands in the estuary may play an important role in maintaining juvenile populations over the winter. We observed movement of juvenile coho into the estuary during late fall and winter, and into the lower estuary during November through January. One PIT-tagged fish moved from a site in the upper basin (Slick Rock Creek) to a small channel in the 78 marsh in February.

Even though the number of coho subyearlings that entered and resided in the estuary was high, we do not know if and when these fish move into the ocean and whether they survive to contribute back to the adult population. Scale analyses from adult spawners sampled in 1999-2004 provided evidence that subyearling migrants to the ocean could account for significant proportions of the spawning population in Salmon River in some years (Lisa Borgerson, ODFW, unpublished data). Seventeen percent of the spawning coho were two-year old adults in 1999. However, the validity of this interpretation remains uncertain because we have no independent verification of the scale-pattern analysis used to infer a subyearling, ocean-migrant life history. Regardless, the estuary clearly serves as winter habitat for a portion of the juvenile population. To verify whether subyearling migrants enter the ocean and contribute to the returning spawning population we will (1) recover adult spawners that were PIT-tagged as juveniles in the watershed, screw trap, or estuary, and (2) analyze the SR/CA ratios and age patterns on the otoliths of the adults (Zimmerman 2005, Volk in review). By comparing otolith chemistry and scale patterns of individual spawners, we can also validate whether scale analysis offers a reliable, low-cost tool for interpreting juvenile life histories. Because large dike removal projects have restored fish access to most tidal wetlands in Salmon River, coho salmon now have the opportunity to more fully use the estuary and may display a subyearling life history pattern that is not widely recognized on the Pacific coast (Koski 2009).

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