THE OREGON PLAN *for Salmon and Watersheds*

Salmonid Life-Cycle Monitoring Project, 2000

REPORT NUMBER: OPSW-ODFW-2001-2

SALMONID LIFE-CYCLE MONITORING PROJECT 2000

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Mario F. Solazzi
Steven L. Johnson
Bruce Miller
Tim Dalton

Coastal Salmonid Inventory Project
Western Oregon Research and Monitoring Program
Oregon Department of Fish and Wildlife
28655 Highway 34
Corvallis, OR 97333

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PART I. SMOLT AND ADULT MONITORING

Introduction

In 1998, as part of the Oregon Plan for Salmon and Watersheds, the Oregon Department of Fish and Wildlife (ODFW) began monitoring survival and downstream migration of salmonid fishes (*Oncorhynchus spp*.) in coastal basins. As a part of this program the Salmonid Life-cycle Monitoring project developed three objectives; 1) estimate abundance of adult salmonids and downstream migrating juvenile salmonids, 2) estimate marine and freshwater survival rates for coho salmon (*Oncorhynchus kisutch)* and 3) evaluate effects of habitat modification on the abundance of juvenile salmonids in Cummins and Tenmile Creeks.

This report summarizes data collected on downstream migration of juvenile salmonids during the spring of 2000, as well as the adult return data from the winter of 1999-00. We also summarize the results from the Cummins and Tenmile Creeks habitat modification project, that began in 1991. We include a brief description of the preliminary results from sampling in Winchester Creek and South Slough (Coos Bay).

During 1999 we estimated abundance of adult salmonids at eight locations; N. Fork Scappoose Creek (Lower Columbia), North Fork Nehalem River, Mill Creek (Siletz Basin), Mill Creek (Yaquina Basin), Cascade Creek (Alsea Basin), West Fork Smith River, Fall Creek (Coos Basin) and Winchester Creek (South Slough, Coos Bay). At these locations, we were able to monitor both the downstream migrants (smolts) and returning adults. We also operated smolt traps at six other locations to monitor downstream migration. We were not able to monitor the numbers of returning adults at these additional sites due to the lack of adult capture facilities. These sites are the same as reported in Solazzi et al (2000) with the following exceptions; 1) an adult and juvenile trap site was added in the upper section of the North Fork Nehalem River above the trap site at Waterhouse Falls, 2) Fall Creek and Winchester Creek were added as adult and juvenile monitoring sites and 3) the juvenile trap on Bottom Creek (Coos Basin) was removed.

Methods for Estimating Abundance of Migrating Juvenile Salmonids

Rotary screw traps or rotating incline-plane traps were used to capture downstream-migrating juvenile salmonids. Traps generally began fishing in early March and fished continuously until catches diminished to low levels (or low streamflows precluded further operation of the traps), usually by mid June. The traps were normally checked and cleared of fish and debris once a day, although, to ensure fish safety, visits were more frequent during storm events and periods of high debris. Fish were anesthetized with MS-222 and enumerated by species, size class, age, and development (smoltification) class as indicated by visible brightness.

Each species was classified by age or size group. Coho salmon *(O. kisutch)* were identified as fry (age 0+) or smolts (age 1+). All chum salmon (*O. keta*) captured were fry (age 0+). Chinook salmon (*O. tshawytscha*), also age 0+, were identified as fry that migrated soon after emergence (<60 mm fork-length) and fingerlings that remained to rear until $\geq$60 mm. Trout species were classified into size classes that roughly correspond to age classes, the largest class for each species containing smolts, the smaller classes parr. Fry (<60 mm) were not differentiated to the species level. Additional size classes were 60-89, 90-119 and $\geq$120 mm for steelhead (*O. mykiss*), and 60-89, 90-119, 120-159 and $\geq$160 mm for cutthroat trout (*O. clarki*). Sea-run trout migrate to sea at various ages according to individual smoltification maturity, steelhead usually at ages 1+ or 2+, cutthroat at 2+, 3+, and 4+; however, both can migrate at any age.

To calibrate the efficiency of the traps and to estimate total outmigration, each day up to 25 fish of each species and size class were marked with a small clip on their caudal fin then released upstream of the traps for recapture. Marked fish were released at dusk from a floating timer-actuated release device (Miller et al. 2000). Recaptured marked fish were likewise enumerated by species and size class, and estimates of total outmigrants were made by expanding trap catches using the following equations:

$$N = n_i / E_i,$$

and

$$E_i = r_i / m_i,$$

where N = total estimated outmigrants, n_i = number of fish captured, E_i = estimated trap efficiency, r_i = number of recaptured marked fish, and m_i = number of marked fish released. Values used in these estimates were usually weekly totals. However, when recaptures were infrequent, weeks were pooled. Weekly estimates were summed to estimate total outmigrants for the season. Population estimates were not calculated if less than five marked fish of a particular species and size class were recaptured.

A bootstrap procedure was used to determine the variance and 95% confidence interval for each population estimate (Thedinga et al 1994). An estimate of the population bias was also obtained from the bootstrap procedure. A negative bias indicates that the true population size is likely to be underestimated, while a positive bias indicates that the true population size is likely to be overestimated. The percentage value referred to in the **Estimates of Population Size** section of this report is the percentage of times that the bootstrap procedure calculated a larger (or smaller) population size compared to the population estimate that we calculated. All variance estimates were based on 1000 iterations of the bootstrap procedure. The protocols described above were followed at each trap site.

The average length at the time of peak migration was calculated for each species. Peak migration was determined by selecting the week when the maximum numbers of migrants were estimated to have passed the trap. For coho salmon and steelhead trout smolts, the average lengths that we report are for fish >60mm and >120mm respectively. For cutthroat trout the average length that we report is for all cutthroat captured during the peak week and is not restricted by size class.

Results and Discussion

Estimates of Population Size

Populations of coho salmon smolts were generally higher during the spring of 2000 than in 1999, but not as high as in 1998 (Figure 1). For three years, the 95% confidence interval for coho salmon smolts averaged $\pm$18% of the population estimate and had an average bias of –0.9%. Coho salmon fry abundance during 2000 was higher than during 1999 at all sites except Yaquina Mill Creek (Figure 2). The confidence interval for three years averaged $\pm$39% of the population estimate and had an average bias of –3.5%. Chinook salmon fry abundance in 2000 was lower than during 1999 at most stations and considerably lower than in 1998 (Figure 3). The confidence intervals for chinook salmon fry averaged $\pm$12% of the population estimate and had an average bias of -0.53%. Steelhead populations tended to be higher in 2000 than in 1999, with Tenmile Creek, Cummins Creek and the North Fork Nehalem River having the highest numbers of migrants observed since 1998 (Figure 4). The steelhead smolt confidence intervals averaged $\pm$22% of the population estimate and had an average bias of –1.25%. Cutthroat trout smolt populations were higher in 2000 than in 1999 or 1998 at all stations except West Fork Smith River, Bales Creek, and the North Fork Scappoose Creek (Figure 5). The

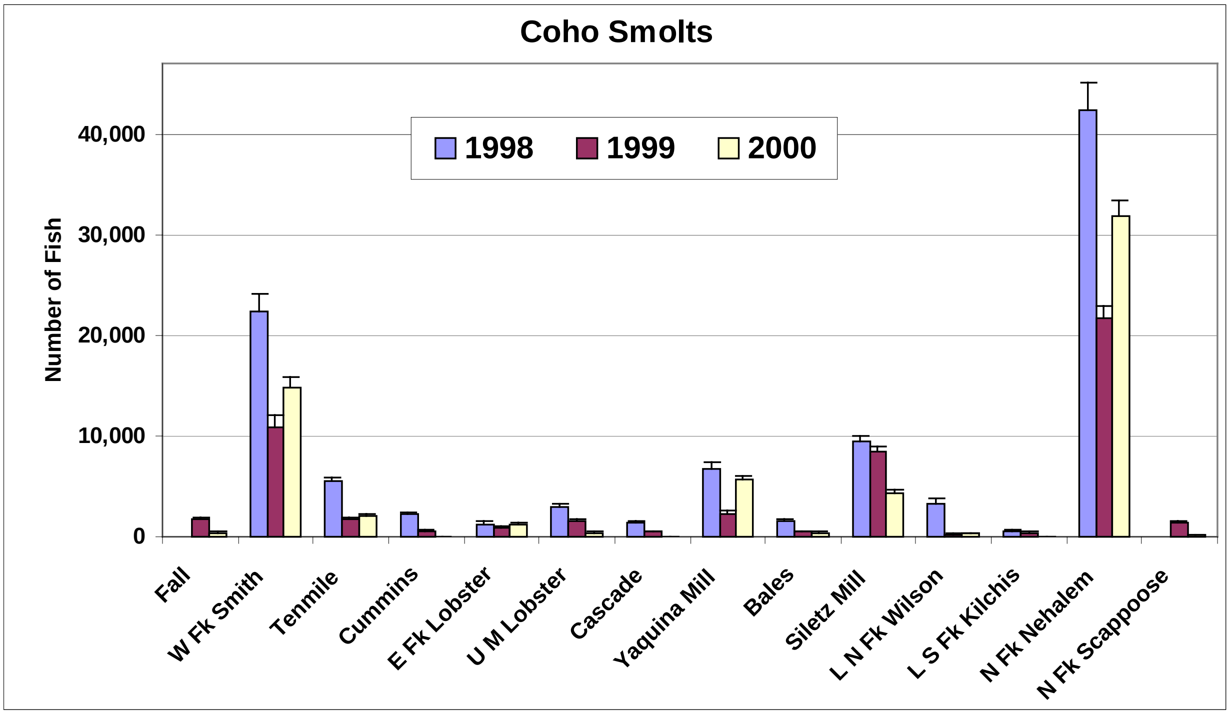

Figure 1. Population estimates and 95% confidence intervals for coho salmon smolts at 14 life cycle monitoring sites 1998–2000.

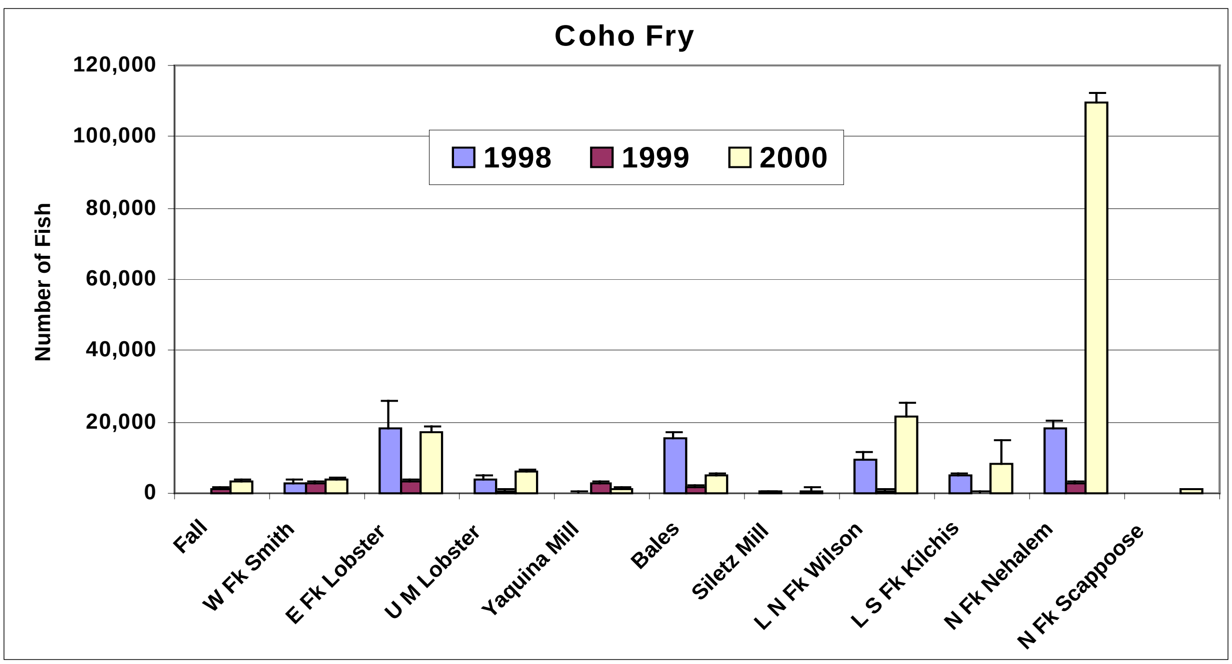

Figure 2. Population estimates and 95% confidence intervals for coho salmon fry at 11 life cycle monitoring sites 1998-2000.

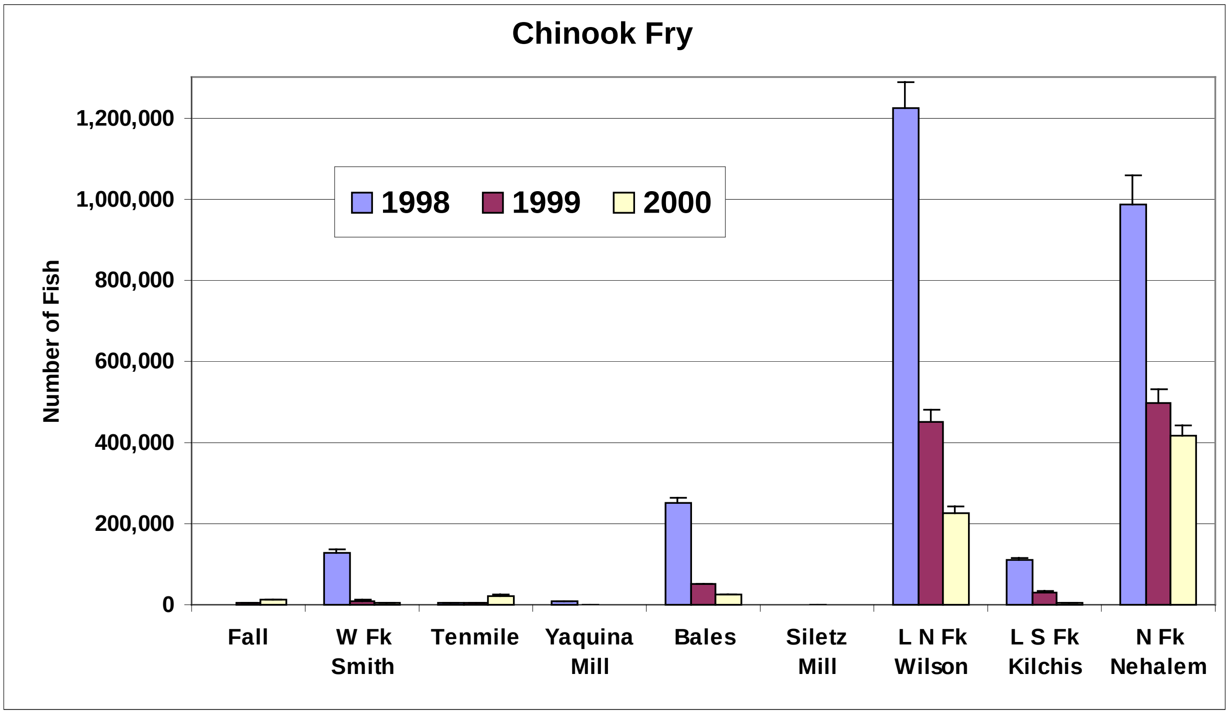

Figure 3. Population estimates and 95% confidence intervals for chinook salmon fry at 9 life cycle monitoring sites 1998-2000.

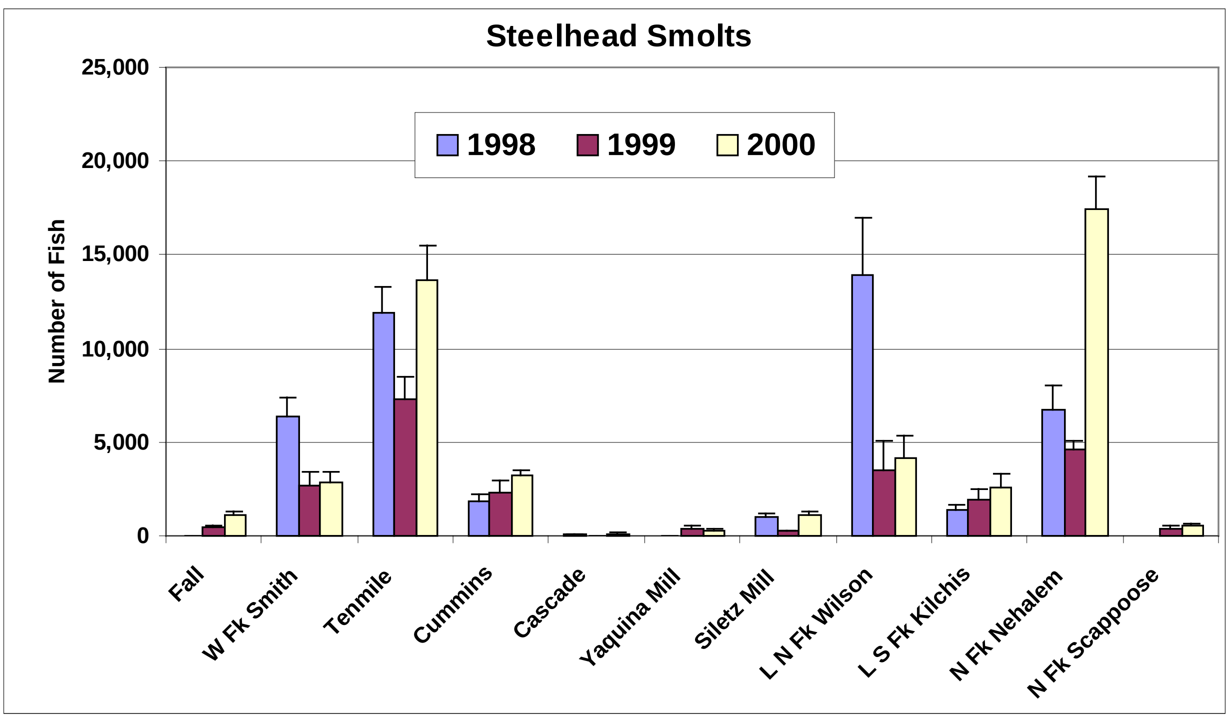

Figure 4. Population estimates and 95% confidence intervals for steelhead smolts at 11 life-cycle monitoring sites 1998-2000.

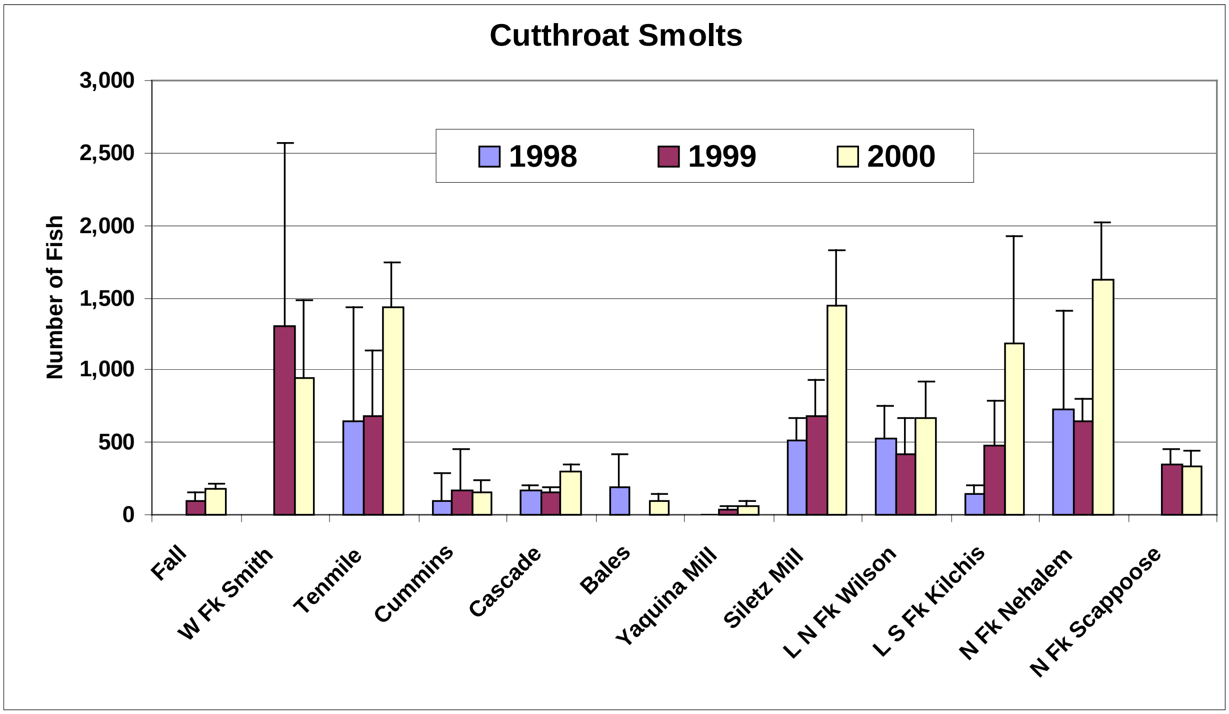

Figure 5. Population estimates and 95% confidence intervals for cutthroat smolts at 12 life-cycle monitoring sites 1998-2000.

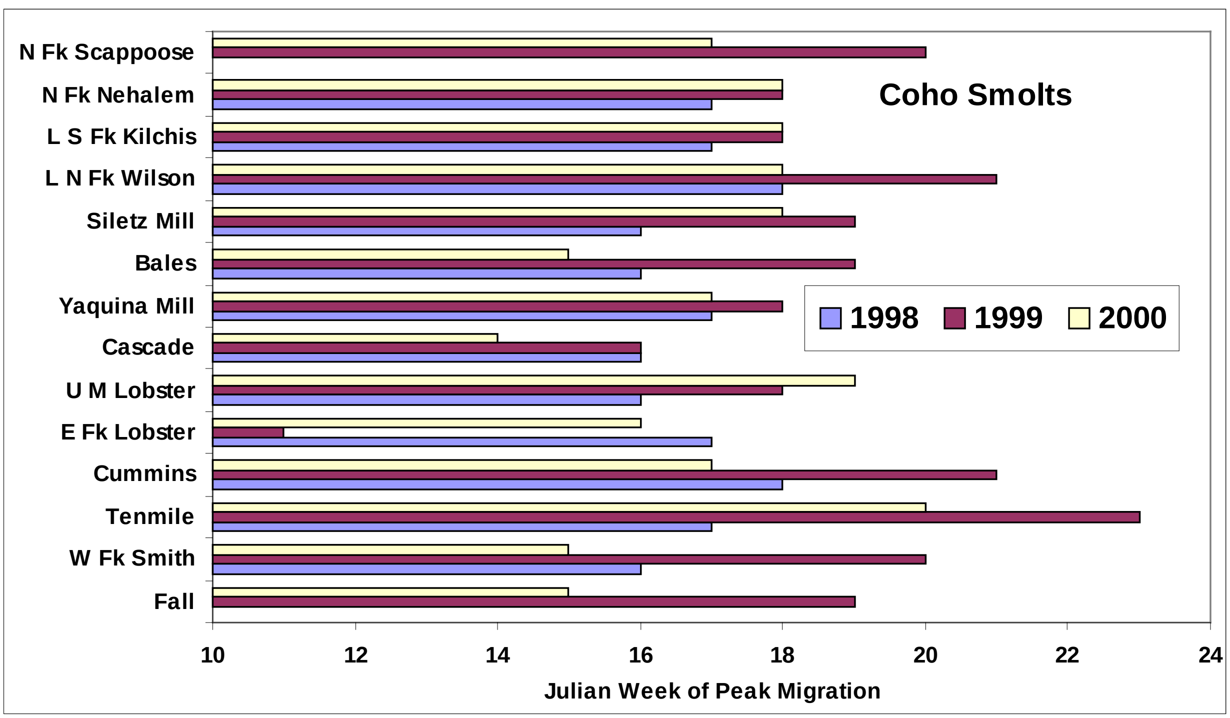

Figure 6. Julian week of peak migration of coho salmon smolts at 14 life-cycle monitoring sites 1998-2000.

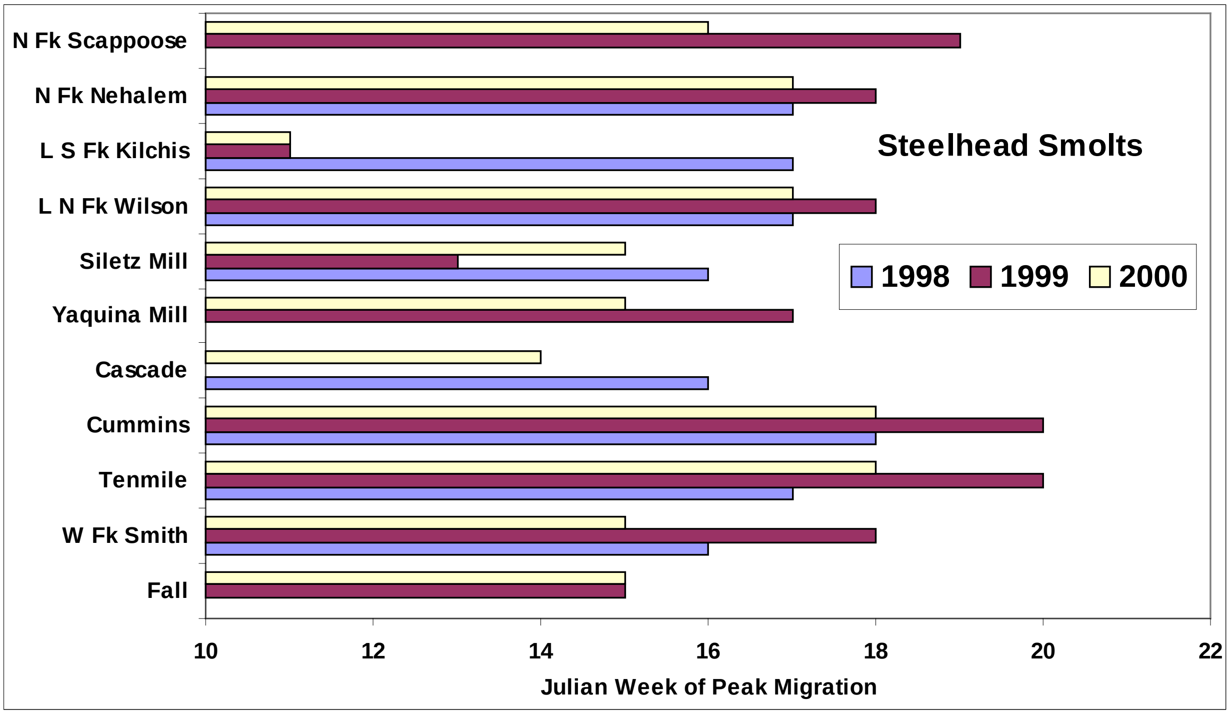

Figure 7. Julian week of peak migration of coho salmon smolts at 11 life-cycle monitoring sites 1998-2000.

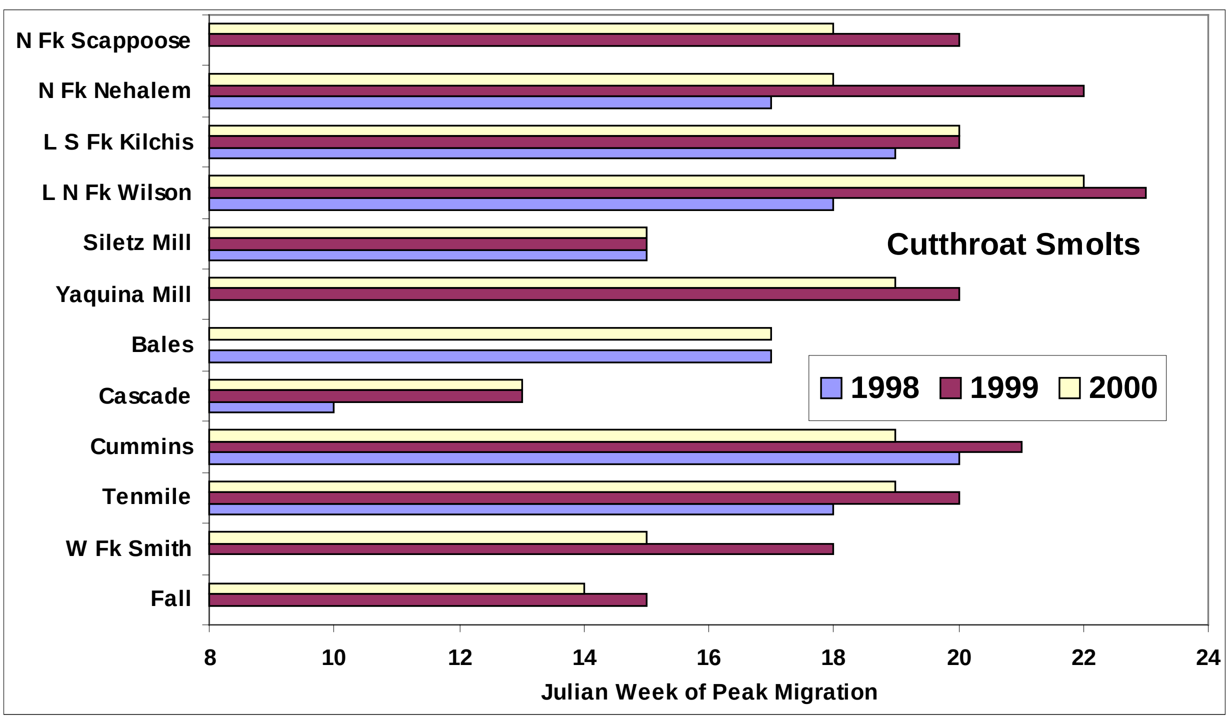

Figure 8. Julian week of peak migration of cutthroat smolts at 12 life-cycle monitoring sites 1998-2000.

average confidence interval was ±59.2% of the population estimate and the bias averaged –5.5%.

Timing of Downstream Migration

Peak migration timing for juvenile coho salmon, steelhead, and cutthroat trout smolts (1998-00) is summarized in Figures 6-8. The migration peak of coho salmon smolts in 2000 was similar to the migration timing we observed during 1998, these two years generally had earlier peaks than was found during 1999 (Figure 6). A similar pattern was evident with steelhead smolts, for which 1999 peak migration was generally later than was observed in 1998 or 2000 (Figure 7). The same pattern was evident for cutthroat trout (Figure 8), but was not as distinct as it was with coho salmon or steelhead.

Average Size of Downstream Migrants

Coho salmon smolts from Yaquina Mill Creek tended to be larger at the time of peak migration than smolts from the other sites monitored (Figure 9). This was due in part to their use of a reservoir (located above the trap site) for rearing, resulting in faster growth and a larger average length at peak migration. The increased length of coho salmon smolts from Cascade Creek during 2000 may have been a consequence of the extremely low rearing density during the previous summer. North Fork Scappoose Creek coho salmon tended to be larger than those found in coastal basins. The low abundance and rearing density of this population was probably also a significant factor contributing to their larger size at peak migration.

The coho salmon smolts in Lobster Creek, from both the East Fork and Upper Mainstem, tended to migrate at a smaller average size than was observed in other coastal streams. This may have been due in part to the location of the traps in the upper section of the drainage basin, where juvenile coho salmon smolts had further to migrate than those at the other sites that we monitored.

As observed with coho salmon smolts, the steelhead smolts from Yaquina Mill Creek also tended to be slightly larger than was observed at the other monitoring locations (Figure 10). Again, this was probably related to the fish's use of the reservoir for rearing before migrating downstream. The average lengths of steelhead smolts at the time of peak migration were similar between years within locations. Most of the steelhead populations that we monitor average about 150mm fork-length at the time of peak migration.

Cutthroat trout also tended to be larger at peak migration in Yaquina Mill Creek than in the other locations monitored, except for Tenmile Creek (Figure 11). The large average length of cutthroat trout smolts from Tenmile Creek may have been due to differences in life history and movement of this group of fish that we have not observed in other populations that we monitored. A lower proportion of the fluvial type cutthroat trout in lower Tenmile Creek than in the other streams, because of the proximity of the trap to the ocean, may have tended to shift the average length.

Density of Downstream Migrants

The numbers of smolts produced per meter of stream length in each year are summarized in Figures 12-14. The average density of coho salmon smolts ranged from a high of 0.33 smolts/meter in 1998 to a low of 0.13 smolts/meter in 2000. Average density of steelhead smolts ranged from 0.11 smolts/meter in 1999 to 0.24 smolts/meter in 1998. Density of cutthroat trout smolts averaged 0.02 smolts/meter during 1998 and 1999 and increased to 0.03 smolts/meter during 2000.

Winchester Creek

Methods

The West Fork of Winchester Creek, 5.5 km above the migrant trap, was sampled by electro-fishing at one-month intervals from April 1999 to May 2000 to measure growth of juvenile coho residing in the upper watershed. The downstream migration of juvenile coho in Winchester Creek was monitored daily using a rotary screw trap. All fish were dye-marked on the ventral surface from just anterior to the pectoral fins to just posterior of the ventral fins. Recaptured fish were also given a unique mark each time they were recaptured. From March 19 to May 23, 1999, fish were dye-marked with a subcutaneous injection of black India ink using a syringe. During this period, marks were changed at one-week intervals. Beginning fall 1999, all fish were dye-marked using a needle-less dental injector with either alcian blue or India ink. During this period, new marks were applied at three-day intervals, permitting finer resolution of residence time for fish subsequently recaptured. The number of days since initial capture for fish subsequently recaptured was calculated from the mid-point of the three day period assigned to each dye-mark.

Growth rates of juvenile coho in upper estuarine habitats were determined from recaptured dye-marked fish by calculating a linear regression between fork length and number of days since initial capture. Growth rates of coho caught in West Fork Winchester Creek were calculated for specific time periods by taking the difference in mean fork length of the population and dividing by the number of days between sampling events.

Results and Discussion

Dye-marked coho were resident in the uppermost reaches of South Slough for at least four months and utilized the tidal channel, recently restored salt marshes, and off-channel beaver ponds. Age-0 coho were present for at least three months and individually marked fish were resident for at least 52 days. We estimated a total of 5,547 migrants for the 1998 brood year. At least three different life-history types were identified: 13.2% of migrants entered the estuary in the spring as age-0 fry, 34.1% entered tidewater in the fall and winter as pre-smolts, and 53.7% migrated to the estuary in the spring as age-1 smolts. Dye-marked coho recaptured in the tidal channel indicated 50% of migrants spent up to 23 days in upper estuarine and associated habitats, 25% resided from 24 to 43 days, and 25% resided from 44 to at least 114 days. Longest residence times were accrued by age-0 spring migrants and age-1 fall and winter migrants, while age-1 spring migrants tended to reside less than one month.

A non-normal distribution in fork length of fish sampled in the upper estuary during the fall suggests fish originated from more than one population; some fish most likely resided over summer in upper tidewater while others moved downstream from the upper watershed. Populations of age-0 fry in upper estuarine habitats had growth rates as high as 0.44mm day^{-1}, almost double the 0.25mm day^{-1} for fish sampled in the upper watershed during the same period. Fish that reared in a beaver pond near head of tide had growth rates of 0.30mm day^{-1}. Fish that foraged in a restored salt marsh for only a few hours at high tide had higher condition factor than fish sampled in the adjacent tidal channel, indicating better forage opportunities in fringing marsh.

Abundance of Returning Adult Salmonids

North Fork Scappoose Creek

Adult salmonids were trapped in a fish ladder located at Bonnie Falls. The fish ladder provides passage around a waterfall that is considered a complete barrier to upstream migration of adult salmon and steelhead. The trap began operation in mid September 1999 and was fished continuously through June 2000. All fish entering the trap were examined for marks, identified as male or female, measured for fork length, given a lower caudal mark, then released

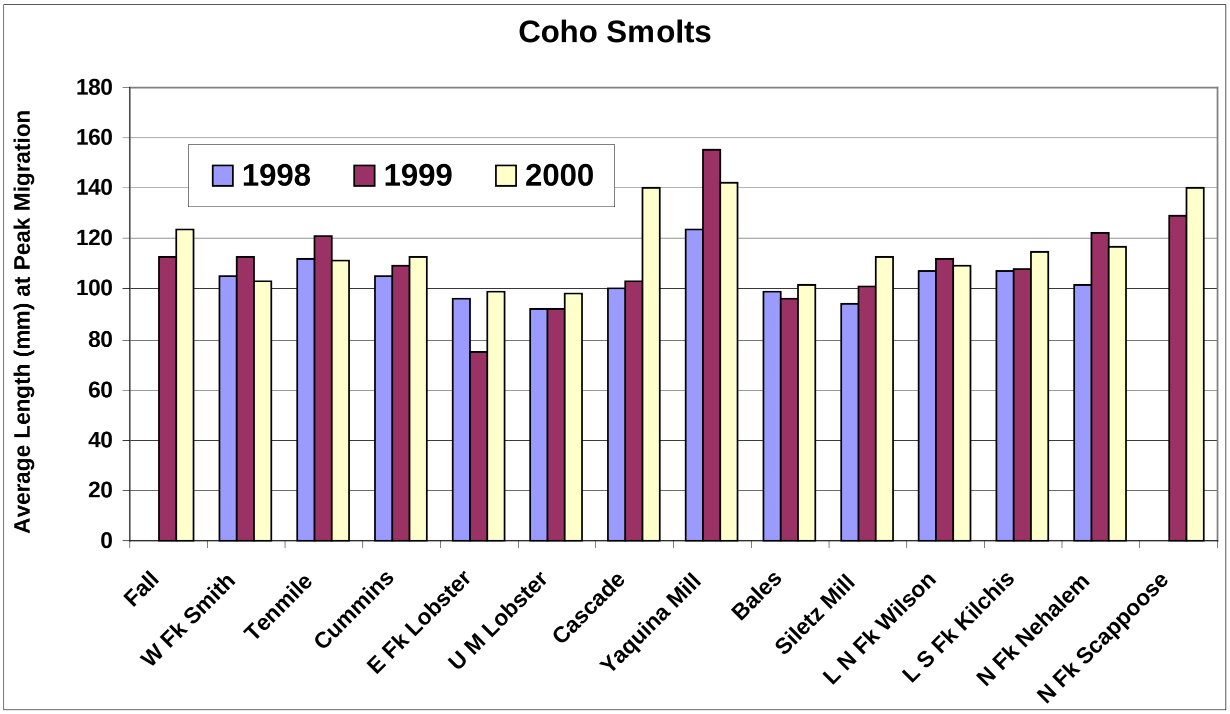

Figure 9. Average length at peak migration of coho salmon smolts at 14 life-cycle monitoring sites 1998-2000.

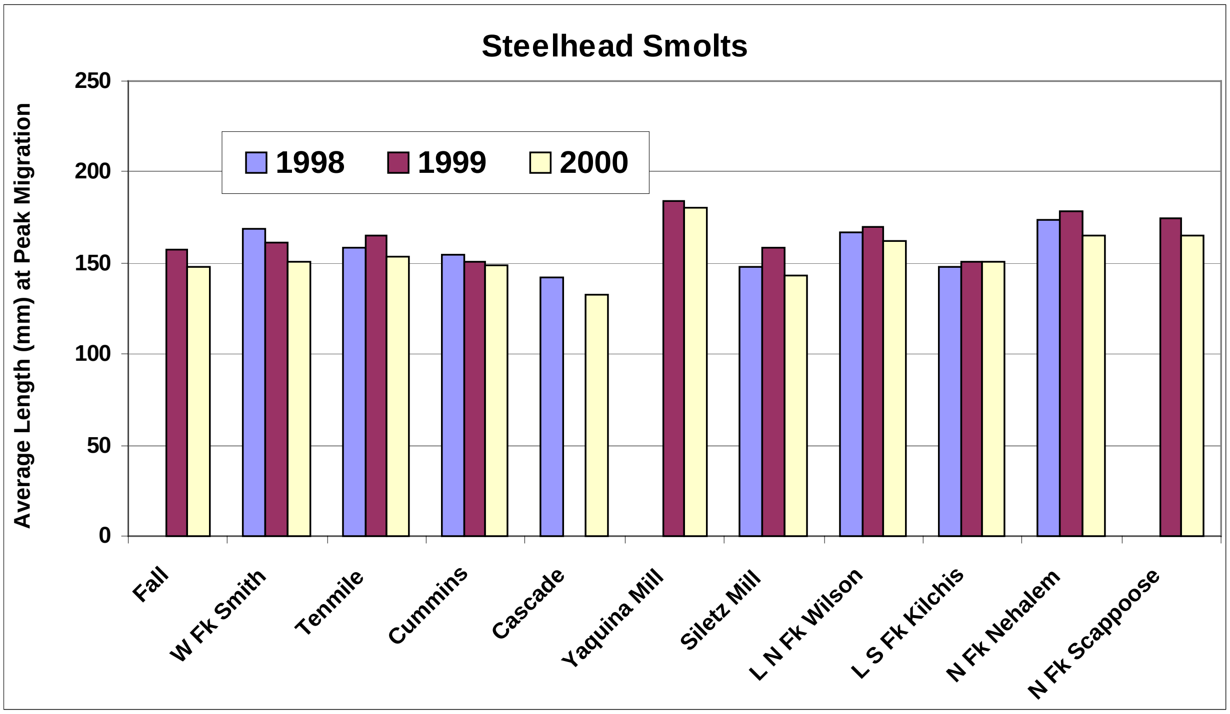

Figure 10. Average length at peak migration of steelhead smolts at 11 life-cycle monitoring sites 1998-2000.

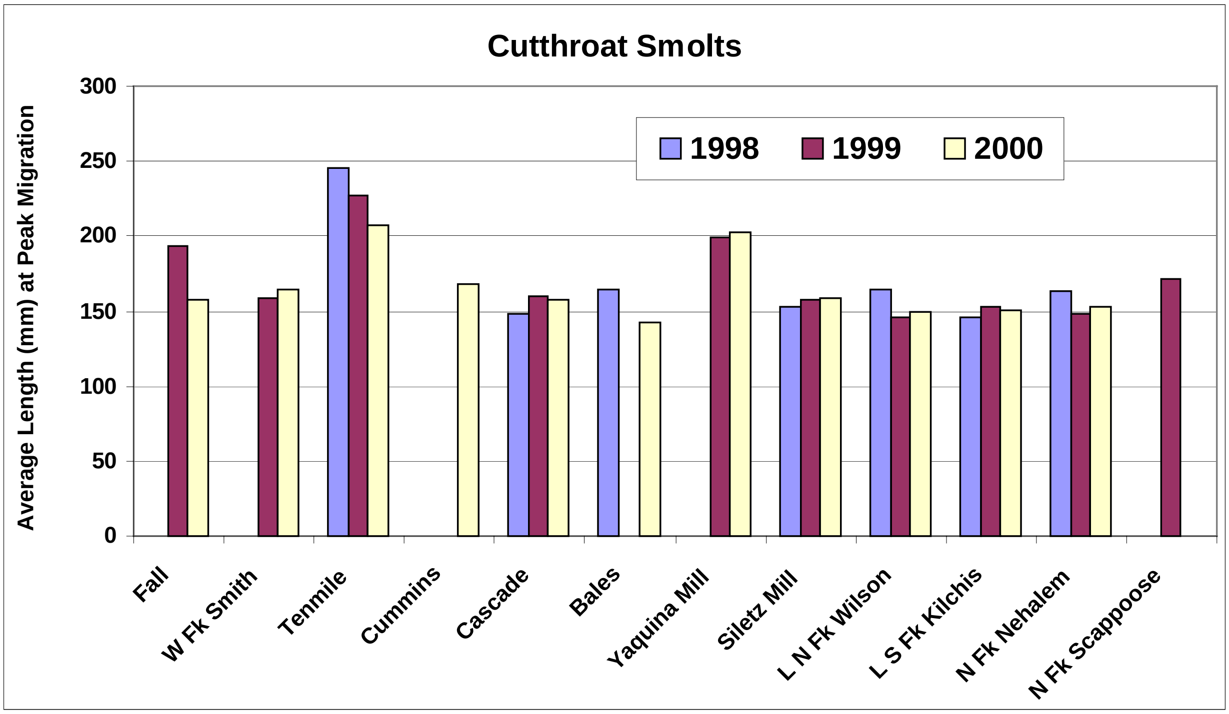

Figure 11. Average length at peak migration of cutthroat migrants at 12 life-cycle monitoring sites 1998-2000.

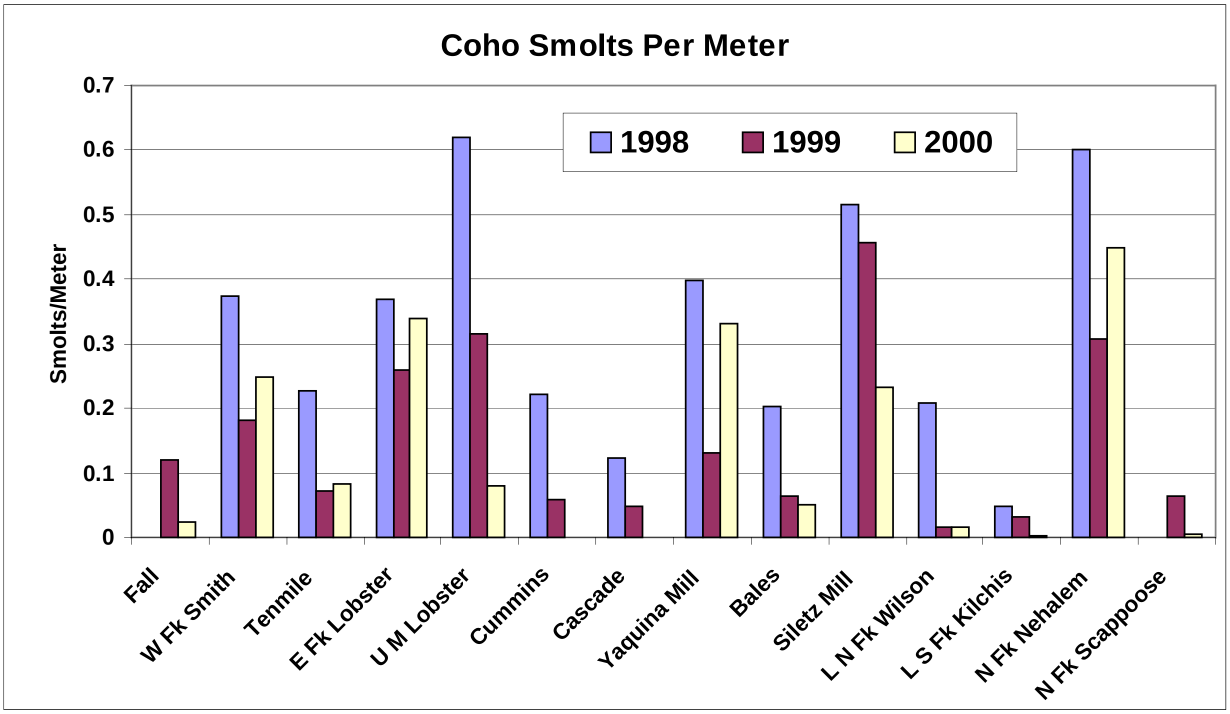

Figure 12. Coho salmon smolts produce per meter of stream length at 14 life-cycle monitoring sites 1998-2000.

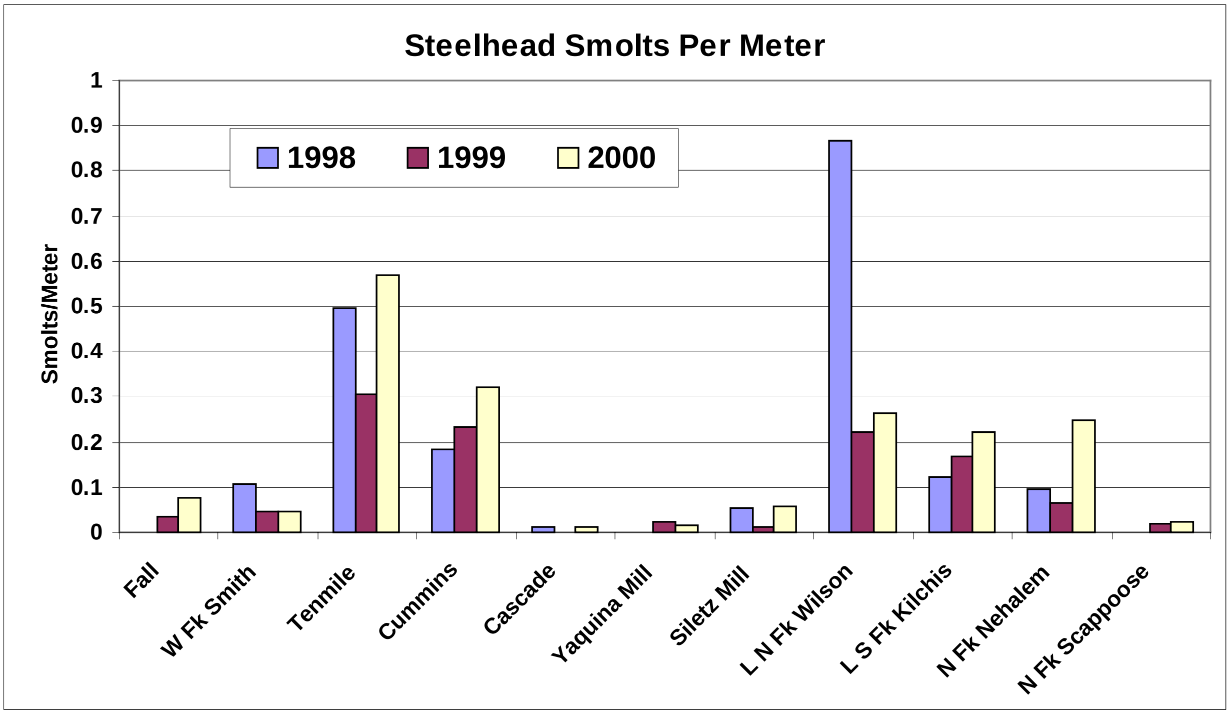

Figure 13. Steelhead smolts produced per meter of stream length at 11 life-cycle monitoring sites 1998-2000.

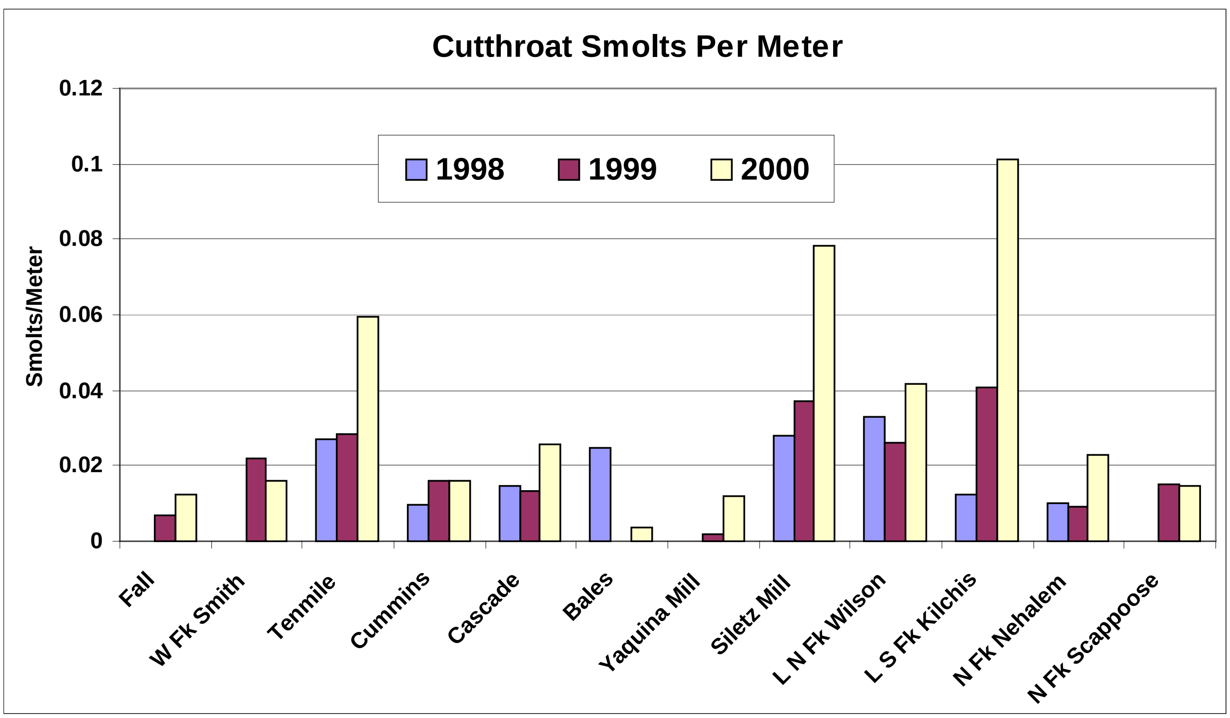

Figure 14. Cutthroat smolts produced per meter of stream length at 12 life-cycle monitoring 1998-2000.

upstream from the trap. The caudal mark was used to determine if any fish had fallen back over the falls and re-entered the trap. The numbers of each species captured at this facility are summarized in Tables 1-3.

Table 1. Number of coho salmon captured at eight life-cycle monitoring sites.

	At Trap					
	Wild			Hatchery		
Location	Males	Females	Jacks	Males	Females	Jacks
Scappoose	4	6	14	1	0	1
N. Nehalem	234	227	4	307	345	13
Siletz Mill	40	52	10	18	6	2
Yaquina Mill	49	43	49	0	0	0
Cascade	4	5	0	7	0	0
W. Smith	58	38	1	0	0	0
Fall	24	11	15	0	0	0
Winchester	10	5	5	3	2	1

Table 2. Population estimates for coho salmon at eight life-cycle monitoring sites.

	Estimated coho salmon spawners above trap site					
	Wild			Hatchery		
Location	Males	Females	Jacks	Males	Females	Jacks
Scappoose	4	6	14	1	0	1
N. Nehalem	374	363	--	175	205	--
Siletz Mill	64	83	--	20	8	--
Yaquina Mill	49	43	49	0	0	0
Cascade	4	5	--	0	0	0
W. Fk. Smith	166	109	--	0	0	0
Fall	24	11	15	0	0	0
Winchester	20	10	--	6	4	1

Table 3. Population estimates of chinook, steelhead and cutthroat at eight monitoring sites for the 1999-2000 run year. Estimates do not include jacks.

Location	Chinook	Steelhead	Cutthroat[a]
N. Fk. Scappoose	0	22	62
N. Fk. Nehalem	484	395	0
Siletz Mill	--	--	--
Yaquina Mill	35	63	8
Cascade	2	14	15
W. Fk. Smith	--	453	--
Fall	--	60	--
Winchester	--	--	--

[a]The cutthroat trout number represents the number of fish captured and is incomplete because the bar spacing in the traps allows cutthroat trout to pass.

North Fork Nehalem River

Adult salmonids were trapped and tagged in the fish ladder that provides passage around Waterhouse Falls, a partial barrier to adult salmonid upstream migration. The trap began operation on October 11, 1999 and was operated through June 11, 2000. Fish were inspected for marks, identified to species, sex and origin (hatchery or wild), and fork-length was measured. Coho salmon <51 cm and chinook salmon <61 cm were designated jacks. Wild coho, chinook and steelhead were implanted with one or, usually, two Floy tags (tag color varying by species) and passed upstream. Hatchery reared coho salmon were killed, whereas hatchery reared steelhead were tagged and then transported downstream to provide additional fishery opportunities.

A second trap operated from October 27, 1999 to June 3, 2000 above the confluence of Fall Creek, approximately 6.5 kilometers upstream from Waterhouse Falls. Tagged adults captured in this trap, found as carcasses on spawner surveys, or caught in juvenile traps operated in the spring, were pooled as mark recoveries. Their proportion among all adults captured by these methods was used to estimate trapping and tagging efficiency at the Waterhouse Falls trap.

The number of coho salmon captured and the population estimates at Waterhouse Falls are summarized in Tables 1 and 2. Wild and hatchery reared coho salmon were trapped at Waterhouse Falls from October 12 to December 2, but only two, both wild, entered the trap before or after October 25 to November 15. Of the 170 wild coho salmon adults captured in the upstream trap or found as carcasses on spawning surveys, 105 had been marked with Floy tags. An estimate of wild coho salmon spawners was made using an adjusted Petersen Mark-Recapture methodology:

$$N = ((M + 1)(C + 1)) / (R + 1)$$

where:

M = 456, the number of wild adult coho salmon marked with Floy tag(s).

C = 170, the number of wild adult coho salmon captured in the upstream trap or found as carcasses on spawning surveys.

R = 105, the number of tagged wild adult coho salmon captured in the upstream trap or found as carcasses on spawning surveys.

Using this methodology[1], the spawning escapement of wild adult coho salmon in the North Fork Nehalem watershed upstream of Waterhouse Falls was estimated to be 737 adults (95% CI=±163). The ratio between wild males and females caught in the Waterhouse Falls trap was used to estimate that 374 of these were males and 363 were females (Table 2). The ratios between hatchery males and females and between wild and hatchery adults (Table 1) caught in this trap were used to estimate the number of hatchery males and females that jumped Waterhouse Falls or swam into the ladder. After subtraction of the hatchery fish that were killed and removed from the two ladder traps, we estimated that 175 hatchery males and 205 hatchery females spawned upstream of Waterhouse Falls (Table 2).

Chinook salmon (all wild) were trapped at Waterhouse Falls from October 25 until December 9, all but three were caught by November 15. An estimate of adult chinook salmon spawners was made using the same methodology, where:

M = 335, the number of chinook salmon marked with Floy tag(s).

C = 94, the number of chinook salmon captured in the upstream trap or found as carcasses on spawning surveys.

[1] This methodology differed from that of 1998 in which we first estimated the total number of adults, both wild and hatchery reared, and then allocated these as wild or hatchery and then male or female. As discussed in a later section, we changed methodology because of our discovery that wild coho salmon spawner distribution differs from that of hatchery spawners. Application of the revised methodology to the 1998 data yielded estimates for 1998 spawning escapement above Waterhouse Falls of 224 and 189 for wild males and females, and of 147 and 140 for hatchery males and females.

R = 65, the number of tagged chinook salmon captured in the upstream trap or found as carcasses on spawning surveys.

The estimate for the spawning escapement of adult chinook salmon in the North Fork Nehalem watershed above Waterhouse Falls (Table 3) was 484 fish (95% CI=±145). Using the sex ratio between males and females observed at the upper ladder and carcass recoveries, we estimated there were 260 males and 224 females.

Both wild and hatchery steelhead were first caught at Waterhouse Falls on December 19. Hatchery fish comprised most of the trap catch through mid February. No hatchery fish were caught after March 21 but wild steelhead continued to enter the trap until May 18. An estimate of adult steelhead spawners was made using the same mark-recapture methodology, where:

M = 224, the number of steelhead marked with Floy tag(s).
C = 71, the number of steelhead captured in the upstream trap or in juvenile traps.
R = 40, The number of tagged steelhead captured in the upstream trap or juvenile traps.

Using this methodology, the spawning escapement of wild adult steelhead in the North Fork Nehalem River watershed upstream of Waterhouse Falls (Table 3) was estimated to be 395 adults (95% CI=±145). The ratio between wild males and females in the catches of the upper ladder and juvenile traps (i.e., fish caught in or exiting the watershed above Waterhouse Falls) was used to estimate that 197 of these were males and 198 were females. We estimated the numbers of male (157) and female (71) hatchery adults that jumped Waterhouse Falls (those that entered the ladder were recycled downstream and thus subtracted) by assuming that the same proportion of both hatchery and wild steelhead jumped the falls, and that they occurred at the same male to female ratio.

Siletz Mill Creek

Adult salmonids were trapped in a fish ladder near the mouth of Siletz Mill Creek (River Kilometer 0.4). The fish ladder provides passage around a small waterfall that is a partial barrier to adult salmon and steelhead upstream migration. The trap was fished continuously from mid-September 1999 through June 2000 All adult salmon, steelhead and cutthroat trout entering the trap were examined for marks, identified as male or female, and measured for fork length. All wild salmon and wild steelhead were given a Floy-tag on each side of the dorsal fin and released upstream. All hatchery coho were killed. If these fish were bright and in good condition, they were taken to local food share organizations, if dark, they were deposited below the trap in the stream. All hatchery steelhead captured in the trap from October through January were given a hole punch in the operculum and released below the falls. Hatchery steelhead caught between February and March were either trucked to Ollala Reservoir to provide fishery opportunities or used as broodstock for future hatchery releases in the Siletz River.

The waterfall at Siletz Mill Creek is not a complete barrier to upstream migration at all river levels. Therefore, some fish may jump the falls rather than move through the fish ladder and into the trap where they can be counted. In order to estimate the total number of spawners, we conducted spawning fish surveys above the trap site to determine the proportion of tagged and untagged fish.

Eight adult coho salmon spawning surveys in the Siletz Mill Creek watershed were completed weekly from November 1,1999 through January 31, 2000. The total length for all surveys combined was 12 km, and encompassed the best spawning areas within the watershed. Surveyors counted live and dead adult salmonids in each survey area to determine the tagged to untagged ratio of adult salmonids above the trap site.

Four steelhead spawning surveys in the Siletz Mill Creek watershed were completed biweekly from February 1, 2000 through April 15, 2000. The total length of these surveys combined was 7.5 km. Surveyors kept similar information on all dead and live steelhead as described above for coho salmon spawning surveys.

Table 1 summarizes the trap catch and Table 2 summarizes the population estimates at Siletz Mill Creek between October 1999 and June 2000. Ninety-two wild adult coho and 10 wild jack coho entered the trap during the winter of 1999-2000 (Table 1). Twenty-four hatchery adult coho and 2 hatchery jack coho were collected in the trap during the winter (Table 1). Ninety-two adult coho (40 males and 52 females) and 10 jacks were released above the trap. All of these fish were double Floy-tagged.

Five wild steelhead adults (2 males and 3 females) and 1 steelhead jack were double-Floy-tagged and released above the trap. Seventeen hatchery adult steelhead also entered the trap during the winter of 1999-00. Hatchery fish accounted for 74% of the steelhead entering the watershed. Most of the hatchery fish entered the trap in November and December. These were adipose-clipped fish and were generally dark, indicating they had been in the river for some time. Presumably, these were mostly Siletz summer steelhead. The hatchery fish entering the trap in the late winter and spring were almost all adipose-left maxillary marked. These were Siletz winter steelhead originally released from the Palmer Creek acclimation ponds near Moonshine Park.

Sixty-seven live coho salmon were observed on spawning surveys. Fifty-nine of these fish were observed well enough to determine if the fish was tagged. No coho salmon carcasses were found. Sixty-three percent of the adult coho salmon observed were Floy-tagged, indicating they had been counted at the trap. Fifty live steelhead were observed on the spawning surveys. Forty of these fish were observed well enough to detect a tag. However, no tags were observed on any of the steelhead.

An estimate of the adult coho spawners was made using the adjusted Petersen Mark-Recapture methodology where:

M = 92, the number of adult coho marked with Floy-tags
C = 59, the number of adult coho observed for presence of Floy-tags on spawning surveys. This includes live and dead fish. Live fish that could not be observed well enough to determine if a Floy-tag was attached were excluded from this analysis.
R = 37, the number of marked live or dead fish observed during the spawning surveys.

The spawning escapement of adult coho in Siletz Mill Creek was estimated to be 147 fish (95% CI=$\pm$51) which included 64 males and 83 females (Table 2). Because few steelhead were Floy-tagged at the trap, and no tagged fish were observed on steelhead spawning surveys, no population estimate for steelhead spawners could be made for the winter of 1999-2000.

Yaquina Mill Creek

The adult trap was installed in the fish ladder late September 1999, and fished through May 2000. All adult salmonids entering the trap were examined for marks, identified as male or female, and measured for fork length. All fish were given a hole punch in the left operculum to determine if fish were falling back down through the reservoir spillway and re-entering the ladder and trap. After processing, wild coho and steelhead were placed in the reservoir and allowed to proceed upstream (Table 3). Hatchery coho (fin clipped fish) were killed. Bright fish in good condition were taken to a local food-share organization. Dark fish were placed in the stream below the fish ladder. Hatchery steelhead were given a right operculum mark and released below the reservoir. Most of the chinook salmon that entered the trap were retained for ODFW district personnel for the Yaquina River chinook broodstock program.

A total of 92 wild coho adults and 49 wild coho jacks were captured in the Yaquina Mill Creek trap (Table 1). No hatchery coho were observed at the trap site in the winter of 1999-2000. A total of 91 wild coho adults (43 females and 48 males) and 43 coho jacks were placed above the trap and into the reservoir. Because the ladder is the only possible route into reservoir, this represents the total number of spawners (Table 2).

Cascade Creek

The adult trap was installed in the fish ladder in late September 1999, and fished through May 2000. All adult salmonids entering the trap were examined for marks, identified as male or female, and measured for fork length. All fish were given a hole punch in the left operculum to determine if fish were falling back down the waterfall and re-entering the ladder and trap. All hatchery coho were killed. If these fish were bright and in good condition, they were taken to food share, if dark, they were deposited below the trap in the stream. All hatchery steelhead were given a hole-punch in the operculum and released below the falls to provide additional fishery opportunities.

Adult salmonids were trapped as they moved through a fish ladder near the mouth of Cascade Creek. The fish ladder provides passage for adult salmon and steelhead around a waterfall at river kilometer 0.15. The falls are believed to be a complete barrier to upstream migration, so the trap catch should represents the total spawners in the basin. A total of 9 wild coho adults and 7 hatchery coho adults were captured in the Cascade Creek trap (Table 1). No jack coho were captured. Nine wild adult coho (5 females and 4 males) were placed above the trap (Table 2).

West Fork Smith River

The adult trap was operated from November 6, 1999 to May 3, 2000. The trap operated continuously during the trapping period but there were periods when the floating weir was submerged and did not function as a complete barrier to fish passage. During November and December, accumulation of suspended leaves on the weir pickets caused the weir to periodically submerge during increased stream flows. High stream flow events after December also depressed the weir for short periods. The weir was submerged for four days in November, seven days in December, and six days in January. The floating weir functioned continuously after January, but a short section was deliberately submerged beginning February 9 to allow downstream passage of spawned-out steelhead (kelts). The floating weir was removed from the river on May 3 and sections of the head dam and attachment sill were opened to allow downstream passage of kelts and eliminate these barriers to passage of small fish.

Chinook salmon were trapped between November 10, 1999, and December 13, 1999. Chinook salmon run timing coincided with periods when the floating weir was submerged due to leaf accumulation, thus some portion of the returning adults may have bypassed the trap. A total of three observations of chinook spawners was made, suggesting total run size was low in 1999. No estimate of chinook spawner escapement was made.

Coho salmon were trapped between November 6, 1999, and January 20, 2000, but most fish (63.4%) were trapped during the three-day period November 18 to 20. Spawning surveys were conducted at weekly intervals on 22 kilometers of tributaries and the main stem to determine percentage of adult coho that were tagged. Coho spawners were found in all tributaries and main stem reaches surveyed, but highest live-counts were found in Beaver Creek and in the mainstem above Gold Creek.

Presence of yellow Floy-tags was recorded on live fish and spawned-out carcasses. During November and December, high stream flows and turbidity made it difficult to observe live fish well enough to determine whether tagged fish had one or two tags, therefore, these data were collected only from spawned-out carcasses.

The adult salmonid population estimates for the West Fork Smith River are shown in Table 2. An estimate of adult coho spawners was made using the adjusted Peterson Mark-Recapture methodology where:

M = 95, the number of adult coho marked with Floy-tags
C = 165, the number of adult coho observed for presence of Floy-tags on spawning surveys (live fish plus carcass recoveries), excluding fish for which presence of tag could not be determined.
R = 54, the number of tagged fish observed (live fish plus carcass recoveries).

Using this methodology and adjusting for tag loss, the total spawning escapement of adult coho in the West Fork Smith River was estimated to be 275 fish (95% CI=$\pm$60) during the 1999-2000 run year. This estimate includes 109 females, based on the sex ratio of fish in the adult trap.

Steelhead were trapped between December 21, 1999, and May 2, 2000. Peak catch occurred during February, but steelhead entered the trap in relatively high numbers through mid-April. Highest numbers of steelhead spawners were found in main-stem reaches, primarily from Moore Creek to 1.5 kilometer above Gold Creek. Presence of yellow Floy-tags was recorded on live fish and spawned-out carcasses. Relatively good water clarity and moderate streamflows allowed us to discern number of tags present on most live fish observed on spawning surveys. We were also able to make close observation of post-spawned steelhead (kelts) that tended to pause for several days in the pool created by the head dam at the adult trap. An estimate of steelhead spawners was made using the adjusted Peterson Mark-Recapture methodology where:

M = 404, the number of steelhead marked with Floy-tags
C = 234, the number of steelhead observed for presence of Floy-tags on spawning surveys (live fish plus carcass recoveries), excluding fish for which presence of tag could not be determined, and from kelts holding in the pool above the adult trap
R = 209, the number of tagged fish observed (live fish plus carcass recoveries)

Using this methodology, the total spawning escapement of steelhead in the West Fork Smith River was 453 (95% CI=$\pm$61) during the 1999-2000 run year (Table 3). This estimate includes 274 females, based on the sex ratio of fish in the adult trap.

Fall Creek

The Fall Creek fish ladder was modified during summer 2000 to trap adult fish that ascend the ladder. The adult trap was operated continuously from October 1999 through April 2000. Coho were trapped between November 12, 1999, and December 19, 2000. Coho entered the trap from November 12 to December 19, with peak catch found during the second half of November. Population estimates for each species are summarized in Tables 2 and 3. A total of 11 female and 24 adult male coho were trapped and passed above the falls. Additionally, 15 coho jacks were trapped and passed (Table 1). We had one recapture of a fish that was passed above the falls and subsequently fell back and re-entered the trap. Because the falls are a total barrier, the estimate of adult coho spawners is the same as the number trapped and passed. We do not know if all coho jacks were retained in the trap due to picket spacing.

We had difficulty retaining coho in the trap raceway. After entering the trap some fish would find the opening in the V-fyke and exit back down the fishway. This problem occurred primarily during the period of heavy leaf-fall; as the blocking weir became plugged with leaves, flow through the trap raceway would diminish, making it easier for trapped fish to mill around and locate the exit. Some fish that fell back through the raceway may not have re-ascended the fishway, thus the occurrence of fallbacks probably reduced the number of fish trapped and passed above the falls. This problem was eliminated by modifications to the V-fyke during the trapping period for steelhead.

Steelhead entered the trap from January 7 to March 18, 2000. A total of 31 females and 29 males were passed above the falls (Table 3). We had two recaptures of fish that fell back and subsequently re-entered the trap. Thirty percent of the catch (18 fish) were AD-LV marked. These fish were probably strays from the group of steelhead that had been acclimated at Big Creek (19 km below Fall Creek) as smolts and contributed as adults to the South Coos River steelhead fishery. Peak catch occurred during late January but continued steadily through February. During March, low precipitation and streamflows made it difficult for late-returning steelhead to reach the raceway in Fall Creek. We observed nine different adult steelhead on redds just below the fish ladder, between March 9 and April 10. Some of these fish may have ascended the ladder if streamflows had been favorable.

Winchester Creek

The Winchester Creek adult trap was constructed during summer 2000 and first operated beginning in October. Adult coho were trapped between November 10, 1999, and January 10, 2000. Population estimates for each species are summarized in Tables 2 and 3. Peak catch occurred during the last week of November. All fish trapped were tagged with two Floy tags just below the dorsal fin. The adult trap was not a complete barrier to migration. The trap is located near the head of tide in Winchester Creek and is normally exposed to approximately one meter tidal exchange. During the last week of November, high stream flows occurred during a high spring-tide series and fish were able to by-pass the trap as water flowed around the weir at high tide.

Spawning surveys were conducted on the Middle Fork and West Fork Winchester Creek to determine the percentage of adult coho that were tagged. Surveys were also conducted on Anderson Creek and Cox Canyon Creek, two tributaries that join Winchester Creek near head of tide. Spawners were only found in West Fork Winchester Creek.
An estimate of adult coho spawners (Table 2) was made using the adjusted Peterson Mark-Recapture methodology where:

M = 20, the number of adult coho marked with Floy-tags
C = 18, the number of adult coho observed for presence of Floy-tags on spawning surveys (live fish plus carcass recoveries), excluding fish for which presence of tag could not be determined.
R = 8, the number of tagged fish observed (live fish plus carcass recoveries)

Using this methodology, and an adjustment for tag loss, the spawning escapement of adult coho in Winchester Creek in 1999 was 40 fish (95% CI=$\pm$36), including 14 females based on the sex ratio of adults in the trap (Table 2). None of the jacks observed on spawning surveys were tagged. This suggests some jacks either bypassed the trap at high water, or that picket spacing on the weir was not sufficient to block passage of all jacks. Therefore, no estimate of coho jack escapement was made.

PART II. DETERMINE FRESHWATER AND MARINE SURVIVAL RATES FOR COHO SALMON

Introduction

The purpose of estimating the freshwater and marine survival rates for coho salmon in Oregon coastal streams is to develop a database of survival information that can be used to monitor the status and trends in population abundance. In addition, this type of information will be useful to determine if any future changes in the status of coho salmon populations are being affected by freshwater or marine environmental conditions. When we refer to freshwater survival rate we include only that part of the life history between egg deposition and arrival at the trap site. This often does not include subsequent residence time in freshwater during migration. Marine survival rate therefore, includes the remaining time in freshwater and estuarine survival.

Methods

To calculate the freshwater survival rate for coho salmon, we estimated the number of eggs placed in redds by the females that spawned in 1998-99. We estimated the fecundity of each female above the N. Fk. Nehalem, Siletz Mill Creek, Yaquina Mill Creek, Cascade Creek, and W. Fk. Smith traps using the following equation where:

Number of eggs = 7.9556 (fork length in mm) -2854.07.

This relationship between length of female coho salmon and fecundity was developed from hatchery fish returning to Fall Creek Hatchery in the Alsea basin (Johnson 1983). Freshwater survival rate for each brood was calculated by dividing the estimated number of smolts produced by the number of eggs that were estimated to be deposited by their parents. To calculate the marine survival rate for coho salmon, the estimated number of adults returning in year t is divided by the estimated smolt abundance in year t-2.

Results and Discussion

Summary statistics used to calculate marine and freshwater survival for coho salmon are shown in Table 4. Freshwater survival rate has ranged from a high of 8.8% for the 1997 brood coho salmon in Siletz Mill Creek to a low of 0.1% for the 1998 brood in Cascade Creek. Marine survival rate has ranged from a high of 10% for the 1995 brood in Yaquina Mill Creek to a low of 0.6% for the 1996 brood in Cascade Creek.

Table 4. The freshwater and marine survival rate for coho salmon at seven life-cycle monitoring sites.

Stream	Brood Year	Female Spawners	Egg Deposition	Smolts Produced	Returning Adults Male	Returning Adults Female	FW Survival (%)	Marine Survival (%)
NF Nehalem	1996			42,427	374	363		1.7
	1997			21,702				
	1998	447	1,176,634	31,628			2.7	
	1999	568	1,623,341					
Siletz Mill	1995			8,110	30	25		0.7
	1996			9,547	64	83		1.5
	1997	48	95,945	8,409			8.8	
	1998	25	52,716	4,049			8.2	
	1999	83	204,416					
Yaquina Mill	1995			1,381	58	80		10.0
	1996			6,698	49	43		1.4
	1997	42	101,674	2,225			2.2	
	1998	77	206,935	5,599			2.7	
	1999	43	116,500					
Cascade Cr.	1996			1,404	4	5		0.6
	1997	17	37,321	557			1.5	
	1998	5	10,104	13			0.1	
	1999	5	14,927					
WF Smith	1996			22,412	160	104		1.2
	1997			10,866				
	1998			14,663				
	1999	104	291,955					
Fall Cr.	1997			1,681				
	1998			333				
	1999	11	28,556					
Winchester	1997			2,208				
	1998			3,129				
	1999	15	36,121					

PART III. TENMILE CREEK WATERSHED RESTORATION STUDY

Introduction

This objective initially involved two separate studies. Both studies combined a treatment and reference stream approach with a pre- and post-project evaluation. The first study (Alsea/Nestucca Winter Habitat Study) involved two treatment streams and two reference streams and was designed to examine the effects of increasing winter habitat on the production of downstream migrant salmonids, particularly coho salmon. This study involved two streams in the Alsea basin, East Fork Lobster Creek and Upper Mainstem Lobster Creek, and two streams in the Nestucca basin, East Creek and Moon Creek, as paired study sites. This study began in 1988 and continued for 8 years. Results are summarized in (Solazzi et al. 1998 and Solazzi et al. 2000).

A second study (Tenmile Watershed Restoration Study) was initiated in 1991 on Tenmile Creek and Cummins Creek, both ocean tributary streams on the central Oregon coast. This study was designed to examine the effects of watershed restoration activities (including the addition of large wood into the stream channel) on the production of downstream migrant salmonids, particularly steelhead and cutthroat trout. Most of the restoration activities in the Tenmile Creek study took place in 1996, and the post-restoration sampling is ongoing. An update of data collected in 1999-2000 is presented here.

Study Area Description

Tenmile Creek was chosen as the treatment stream in the Tenmile Creek Watershed Restoration Study with Cummins Creek as its reference. While these streams have populations of coho salmon, they also produce significant numbers of steelhead and cutthroat trout. Tenmile Creek also has a viable population of chinook salmon. Physical characteristics of the study streams are given in Table 5.

Table 5. Physical characteristics of the two study streams.

Stream	Basin area (km2)	Stream length (km)	Mean summer wetted width (m)	Average gradient (%)
Tenmile Cr.	60.7	24.0	8.5	1.7
Cummins Cr.	24.6	10.0	6.6	2.9

Description of Habitat Modification

Watershed restoration work in the Tenmile basin began in the summer of 1996 as a cooperative project with the US Forest Service (Siuslaw Forest) and local landowners. The U.S. Forest Service decommissioned approximately 12 miles of roads in the watershed, removing culverts and fill to decrease future landslides. Riparian areas were planted with approximately two thousand young conifer trees along approximately 1.6 km of stream. Other streamside riparian areas dominated by hardwood were thinned to increase the growth of existing conifers in the understory. In October of 1996, 240 large conifer trees were transported to the stream channel by helicopter. About 200 of the trees (length of 30 – 35 m, 75 cm butt diameter) were felled on adjacent ridges and placed within the stream channel with limbs attached. The remaining trees were removed from two debris torrent deposits on the road running adjacent to Tenmile Creek. These trees often had rootwads attached, but were generally shorter in length (15 – 20 m) than the felled trees. The trees were placed at 35 different sites throughout reach 3

(133 trees) and the upper portion of reach 2 in the mainstem of Tenmile Creek. Most sites consisted of 3 to 8 large trees placed together to produce accumulations of large wood. Most sites were located in areas near the upper or lower entrances of old side channels, or in natural bends in the stream where large debris would logically accumulate. Trees were not cabled or attached, and no attempt was made to create specific types of habitat (i.e. dam pools) as in the Alsea/Nestucca Winter Habitat Study.

Methods

Summer and Winter Habitat Surveys

In both study streams during August and September of each year, we complete physical habitat surveys. We use the methods described by Hankin and Reeves (1988) to estimate the amount of available habitat (Nickelson et al. 1992). Surface area for each habitat unit in each stream is visually estimated, and every tenth unit is measured to calibrate the visual estimates. In addition, we classify the substrate in each habitat unit by visually estimating the percentage of each category of substrate present. Substrate composition is separated into the following categories: clay (extremely fine sediment that is tightly packed), silt (fine sediment often containing a large proportion of organic material that when disturbed will become suspended in the water column); sand (<0.2 cm); gravel (particles between 0.2 and 6 cm. in diameter); cobble (6 to 25 cm.); small boulders (26 to 100 cm.); large boulders (>100 cm); and bedrock. We also measure the maximum depth of each pool, and estimate the surface area of undercut bank, the percent canopy, and the wood complexity for each habitat unit.

Twice during the pre-restoration period (1991-92, and 1993-94) and once during the post- restoration period (1996-97), we completed winter habitat surveys to determine the amount of winter habitat available for rearing in each stream. These surveys were completed in December and January during moderate winter flow conditions. Another winter habitat survey is planned for the winter of 2000-01.

Estimating Population Size

Estimates are made of the number of young-of-the-year coho salmon, young-of-the-year trout (steelhead and cutthroat combined), age 1+ steelhead trout, and age 1+ cutthroat trout rearing in each stream above the trap sites each year. To estimate the number of fish rearing in the pools, we (1) estimate the mean number of fish per pool by snorkeling every third pool, (2) adjust the mean fish per pool estimate by a calibration factor derived from electrofishing population estimates in a subset of the snorkeled pools, and then (3) multiply this adjusted mean by the total number of pools in the stream (Hankin and Reeves 1988). Snorkel estimates are impractical in habitat with shallow depths. Therefore, we estimate the mean density of fish for a subset of glide, riffle, and rapid habitats by electrofishing. For each habitat type, we then multiplied this mean density by the surface area of this habitat type in the entire stream reach above the trap (Hankin 1984).

We estimate the population size for each species and size group of juvenile salmonid in each sample unit by using either a mark-recapture estimate (Chapman 1951) or a removal estimate with two or more passes (Seber and LeCren 1967). Mark-recapture estimates are generally used in pool habitat that was characterized by high levels of wood complexity or presented special sampling problems where removal estimation methods have been shown to be less accurate (Rodgers et al. 1992). Every habitat unit is blocked by seines on both ends and sampled for juvenile salmonids using 1000-volt D.C. backpack electrofishers. Specific criteria for sampling intensity were established to control the size of the confidence interval derived from the population estimate and to prevent exposing the fish to unnecessary repeated electrofishing. When using the removal method, we continue to sample until we achieved a 50% reduction in the number of fish captured on the previous pass, if the catch on the first pass was fewer than

10 fish. If the catch on the first pass was greater than or equal to 10 fish, then a 66% reduction is required before discontinuing the sampling effort. For the mark-recapture estimates, we attempt to retrieve 50% of the marked fish released.

We divided the Tenmile Creek basin into 6 stream reaches, and the Cummins Creek basin into 3 stream reaches. We make separate estimates of the number of juvenile salmonids rearing in each reach during the summer. We generally sample 5 pools, 10 glides, and 10 riffles in each stream reach.

Estimating the Number of Downstream Migrants

We estimate the number of downstream-migrating juvenile coho salmon, steelhead, cutthroat trout, and chinook salmon in Tenmile and Cummins Creeks each spring using the methods described in the "**Methods for Estimating Abundance of Migrating Juvenile Salmonids**" section of this report.

Results and Discussion

Habitat Modification

In the Tenmile Creek Watershed Restoration Study, the number of key pieces of large wood increased from 21 pieces in reach 3 in pre-restoration surveys to over 150 in the initial post-restoration survey. As a result, the percent of summer pool surface area in reach 3 with high wood complexity increased from an average of 6% in pre-restoration surveys to 12%, 18%, 15%, and 12% in post-restoration surveys completed during the summers of 1997-2000. To date, the total number of pools, the surface area of pools, and the substrate composition have not changed significantly in reach 3 as a whole.

Observations of habitat immediately in the vicinity of selected sites does suggest substrate changes are occurring near the wood accumulations. More detailed analysis of the physical habitat changes that resulted from the restoration work will be completed as more years of post restoration data are collected.

Estimating Fish Populations

Estimates of fish populations in the post- restoration phase of this project are not complete. Results of summer population estimates and spring migrant estimates observed to date are given for both Tenmile and Cummins Creeks in Tables 6 and 7. Estimates of spring migrants in Table 7 often differ from estimates previously reported. These changes have occurred because we recalculated trap efficiency estimates for weeks with few marked fish recaptured.

Table 6. Summer population estimates of juvenile salmonids in Tenmile and Cummins Creeks during the Tenmile Creek Restoration Study, 1991-2000.

Stream	Year of summer Sampling	Coho Salmon	Cutthroat Trout ≥90mm	Steelhead ≥90mm	0+ trout
Cummins Cr.	1991	1,292	1,177	2,306	6,467
	1992	1,316	1,591	3,010	8,104
	1993	1,079	1,274	2,946	4,646
	1994	1,015	1,281	2,255	7,998
	1995	913	1,502	3,689	9,383
	1996	1,074	1,545	5,002	8,625
	1997	1,646	2,417	4,798	17,927
	1998	863	2,524	7,171	11,132
	1999	0	2,702	5,472	16,717
	2000	209	1,890	6.272	14,156
Tenmile Cr.	1991	8,003	4,023	16,613	79,958
	1992	7,799	3,503	16,324	66,226
	1993	30,663	3,231	18,417	70,664
	1994	3,294	2,540	12,180	54,865
	1995	4,369	2,822	12,818	69,391
	1996	3,783	4,256	19,784	63,193
	1997	4,410	2,412	13,491	59,710
	1998	2,105	2,957	12,204	60,903
	1999	1,198	4,203	11,258	74,337
	2000	4,580	4,409	16,179	72,430

Table 7. Estimates of salmonid smolt production in Tenmile and Cummins Creeks during the Tenmile Creek Restoration Study, 1992-2000.

Stream	Year of spring sampling	Coho salmon smolts	Cutthroat Trout smolts ≥160mm	Steelhead Smolts ≥120mm	Chinook
Cummins Cr.	1992	1,024	36	766	--
	1993	741	35	1,375	--
	1994	1,336	64	1,287	--
	1995	1,065	30	1,274	--
	1996	424	88	2,300	--
	1997	730	127	2,438	--
	1998	2,215	94	1,816	--
	1999	584	162	2,311	--
	2000	7	160	3,206	3,353
Tenmile Cr.	1992	5,338	244	5,686	587[a]
	1993	5,229	187	7,876	386[a]
	1994	9,266	123	4,953	583[a]
	1995	1,679	182	2,200	1,013[a]
	1996	2,182	117	4,538	2,821[b]
	1997	2,975	523	7,184	4,120[b]
	1998	5,462	644	11,869	4,841[b]
	1999	1,739	687	7,315	5,667[b]
	2000	1,998	1,434	13,641	21,777[b]

[a] Trapping period March 1 - June 30
[b] Trapping period March 1 - August 15

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