B O N N E V I L L E   P O W E R   A D M I N I S T R A T I O N

Mid-Columbia Coho Reintroduction Feasibility Study

Broodstock Development

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MID-COLUMBIA COHO REINTRODUCTION FEASIBILITY STUDY:

2002 Annual Monitoring and Evaluation Report

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YAKAMA NATION
FISHERIES RESOURCE MANAGEMENT

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EXECUTIVE SUMMARY

The long-term vision for the mid-Columbia coho reintroduction project is to reestablish naturally reproducing coho salmon populations in mid-Columbia river basins, with numbers at or near carrying capacity that provide opportunities for significant harvest for tribal and non-tribal fishers. The feasibility of re-establishing coho in mid-Columbia tributaries may initially rely upon the resolution of two central issues: the adaptability of a domesticated lower river coho stock used in the re-introduction efforts and associated survival rates, and the ecological risks to other species associated with coho re-introduction efforts. Research efforts in 2002 focused on addressing these two central issues.

• We evaluated travel time and migratory patterns of coho smolts emigrating through Lake Wenatchee using radio-telemetry. We determined the distribution of sockeye fry in Lake Wenatchee using three methods: littoral zone snorkeling, pelagic zone tow-netting, and hydroacoustics. Knowledge of the migratory behavior and distribution of sockeye fry enabled us to identify the time and space overlap within Lake Wenatchee and the opportunity for hatchery coho smolts to encounter and potentially prey upon sockeye fry. We found that hatchery coho may use the entire lake during their migration, and that sockeye fry, though distributed throughout the lake during the coho smolt emigration, display a vertical diel migration. The diel migration patterns of the sockeye fry likely evolved as a mechanism to reduce predation, and may significantly reduce the potential for predation by emigrating coho smolts.

• We investigated competition for space and food in sub-yearling coho salmon, sub- yearling chinook salmon and yearling steelhead in Nason Creek. We found that the juvenile coho, chinook, and steelhead select different microhabitats; and at densities tested, juvenile coho did not appear to displace juvenile chinook from preferred microhabitats.

• Through radio-telemetry, we attempted to examine stray rates and spawning locations for adult coho returning to the Wenatchee and Methow rivers. Adult coho used in the evaluation were trapped and tagged at Priest Rapids Dam. Due to low smolt-to-adult survival rates (SARs) in 2002, we were able to tag only 14 adult coho. Of the 14 tagged coho, one returned to the Wenatchee basin and one returned to the Methow River. The sample size was too small to draw conclusions regarding coho stray and/or drop-out rates in the mid-Columbia. The evaluation will be continued in 2003.

• During spawning ground surveys in Icicle Creek, we observed 21 coho redds and recovered 9 coho carcasses. Of the female carcasses recovered, egg voidance ranged from 90% to 100%. During spawning ground surveys in Nason Creek, we observed one coho redd and

recovered no carcasses. We located one coho redd in Peshastin Creek and five redds in the Wenatchee River downstream from Dryden Dam.

• Spring 2002 marked the first emigration of naturally produced coho smolts from the Wenatchee River in close to a century. Based on data collected from WDFW's rotary smolt trap located near Monitor on the Wenatchee River (RK 11.4) we estimate that 17,054 naturally produced yearling coho emigrated between March 5th and July 20th, 2002. From the population estimate we calculated an egg-to-emigrant survival rate of 10.35% (61 coho redds, 2700 eggs/female).

• The minimum smolt-to-adult survival rate for brood year 1999 hatchery coho smolt released in the Wenatchee River basin was 0.03% (255 adults and 66 jacks). The SAR observed for the 1999 brood was the lowest observed since this projects inception. A broodstock collection goal of 1400 fish (SAR ≈ 0.14%) is required for replacement in the hatchery environment. Higher smolt-adult survival rates will be necessary for a naturally reproducing run of coho to become established. Similarly, we observed a minimum smolt-to-adult survival rate for brood year 1999 hatchery coho smolts released in the Methow River of 0.03% (69 adults and 21 jacks).

• Based on PIT-tag detections, we estimate that 87.4% and 78.5% of lower Columbia River brood coho and mid Columbia River brood coho, respectively, survived from release in Icicle Creek to McNary Dam. We estimated that 39.3% of mid-Columbia River brood coho released from Nason Creek survived to McNary Dam.

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GENERAL INTRODUCTION

Wild stocks of coho salmon *Oncorhynchus kisutch* were once widely distributed within the Columbia River Basin (Fulton 1970; Chapman 1986). Since the early 1900s, the native stock of coho has been extirpated from the tributaries of the middle reach of the Columbia River (the Wenatchee and Methow rivers; Mullan 1983). Efforts to restore coho within the mid and upper Columbia Basin rely upon large releases of hatchery coho. The feasibility of re-establishing coho in the tributaries of the mid-Columbia River may initially depend upon the resolution of two central issues: the adaptability to natural selection by domesticated lower Columbia coho stocks used in the re-introduction efforts and their associated survival rates; and the ecological risk to other species of concern.

Continued downward trends in the abundance of wild spring chinook and steelhead above Priest Rapids Dam caused the National Marine Fisheries Service (NMFS) to list these species as endangered under the Endangered Species Act (ESA). The ecological risk associated with coho re-introduction efforts may be greatest for endangered species or those of critically low abundance. Many types of ecological interactions are theoretically possible between coho and other native fish species. Potential interactions could include predation, competition, or behavioral changes. Priorities can be assigned to different ecological interactions based on their effect on the productivity and viability of impacted populations. Although the impact of predation on an individual prey animal is unambiguous, the impact on a population of prey is not. Depending on the abundance and productivity of the prey population, the impact of predation on the persistence and productivity of the prey population may range from negligible to serious. Indeed, those ecological interactions that influence the survival, growth, or broad scale distribution of the impacted population would potentially be most serious in nature. Other potential interactions may include competition for space or food in the natal streams, or competition for spawning space and associated redd superimposition by the returning adults.

The mid-Columbia coho re-introduction feasibility study uses early-run stocks of hatchery coho smolts from state and federal facilities. Most of these facilities have a lengthy history of culture activities, which may have the potential to subject these stocks to genetic changes due to selective effects. This term is called domestication selection (Busack et al. 1997). The genetic composition of the endemic and extirpated coho of the mid-Columbia tributaries is unknown; however, it is likely that genotypic differences existed between the lower Columbia River hatchery coho salmon and original endemic mid-Columbia River stocks. It is possible that phenotypic differences between endemic mid-Columbia coho salmon populations and lower Columbia coho populations may have included maturation timing, run timing, stamina, or size of returning adults. Thus the reproductive potential of returning hatchery coho is a critical uncertainty which may ultimately determine if this project successfully re-establishes natural populations of coho.

If coho re-introduction efforts in the mid-Columbia tributaries are to succeed, parent stocks must possess sufficient genetic variability to allow phenotypic plasticity to respond to differing selective pressures between the environments of the lower Columbia River and mid-Columbia tributaries. The mid-Columbia Coho Hatchery and Genetic Management Plan (HGMP 2002) outlines strategies to track the local adaptation process.

We are optimistic that the project will observe positive trends in hatchery coho survival as the program transitions from the exclusive use of lower Columbia River hatchery coho to the exclusive use of in-basin locally adapted broodstock. Therefore it is important to measure hatchery fish performance not only to use as an indicator of project performance but to track potential short- and long-term program benefits from the outlined project strategies. Additionally, if the re-introduction effort is to be successful in the long term, when habitat and hydro impacts might be reduced, adult returns must be sufficient to meet stock replacement levels.

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CHAPTER 1: LAKE WENATCHEE SOCKEYE FRY AND COHO INTERACTION EVALUATION

INTRODUCTION

The research activities described in this chapter address the second of the two central issues to be resolved in the feasibility study: the ecological risk to sensitive species, in this case sockeye salmon (*Oncorhynchus nerka)* in Lake Wenatchee. In anticipation of proposed hatchery coho releases into the Little Wenatchee River from the Two Rivers acclimation site in 2003 (HGMP 2002), we present a two-part study to evaluate the potential for interaction and predation between hatchery coho and sockeye salmon fry in Lake Wenatchee, Washington.

Part one of the sockeye/coho interaction evaluation was aimed at determining coho run-timing and migratory patterns through Lake Wenatchee, while part two was to determine the emergence timing and subsequent distribution of sockeye fry into Lake Wenatchee. The study will identify the time and space overlap within the lake and the opportunity for hatchery coho smolts to encounter and potentially prey upon sockeye fry.

While juvenile coho salmon in freshwater habitats feed primarily on insects (Mason 1974; Mundie 1969; Sandercock 1998; Murdoch and Dunnigan 2002), they also have been shown to prey on several species of salmonids, including sockeye salmon fry *O. nerka* (Ricker 1941; Forester and Ricker 1953; Ruggerone and Rogers 1989), pink salmon fry *O. gorbuscha*, chum salmon fry *O. keta* (Hunter 1959), and fall chinook salmon (Thompson 1996). The results of this study will provide technical guidance to managers to decide how to proceed with further evaluation of juvenile coho and sockeye fry interaction in Lake Wenatchee.

Study area

Lake Wenatchee is the principal standing water feature of the Wenatchee River basin and serves as the sole nursery lake for sockeye salmon in the basin. The lake is approximately 8 km long, 1.6 km wide, and has a surface area of 989 hectares (ha). The mean depth is 55 meters. The water is relatively clear with low productivity (Allen and Meekin 1980). Mullan (1986) classifies Lake Wenatchee as classic sockeye rearing habitat: cold and well oxygenated, but infertile. The glacial-fed White and Little Wenatchee rivers are the principal source of inflow into the lake; the Wenatchee River is the outflow.

METHODS

Part 1. Hatchery coho migratory patterns through Lake Wenatchee – radio telemetry

The primary objective of the coho radio-telemetry study was to measure migration timing through Lake Wenatchee; the secondary objective was to determine coho smolt migratory routes through the lake. Both the primary and secondary objectives provided valuable information for evaluating the potential risks of coho reintroduction to the sockeye salmon population in Lake Wenatchee.

To determine the length of time and route required for coho smolts to migrate through the lake, we radio-tagged 149 coho smolts with Lotek nanotag model NTC-4-2S transmitters. Programmed with a 2.5-second burst rate, these radio-tags had a minimum tag life of 28 days. Coho smolts used in the evaluation were captured in a small net pen at night as they exited the Butcher Creek acclimation site on Nason Creek (RK 13.3). The coho were held in a live box overnight. The following day the smolts were transported in a large plastic trash can equipped with oxygen to the tagging site located at RK 2.7 on the Little Wenatchee River.

After anesthetizing the coho smolts with clove oil, fork length (FL) was measured to the nearest millimeter (mm) and the radio-tag was surgically implanted into the abdominal cavity. Smolts measuring less than 120 mm were excluded from the analysis because their small size deemed them unsuitable for implanting such a proportionally large radio-tag. After the tag was implanted, the coho smolts were held in a live box in the Little Wenatchee River for 24 to 48 hours. Prior to release, the live box was opened and any mortalities were removed. When released, the radio-tagged smolts exited the live box volitionally.

Tracking Locations: The radio-tagged smolts were tracked using a combination of six fixed monitoring stations and mobile tracking. All mobile tracking was done from a power boat with a hand-held or fixed antenna and often as time allowed, typically once a week. Fixed monitoring stations are illustrated in Figure 1.

Data were downloaded from all fixed receivers as frequently as required to prevent the loss of data, typically twice a week. We monitored the fixed stations beyond the maximum life of the last radio tags released (28 days). We supplemented the data collected from fixed stations with mobile tracking as time allowed.

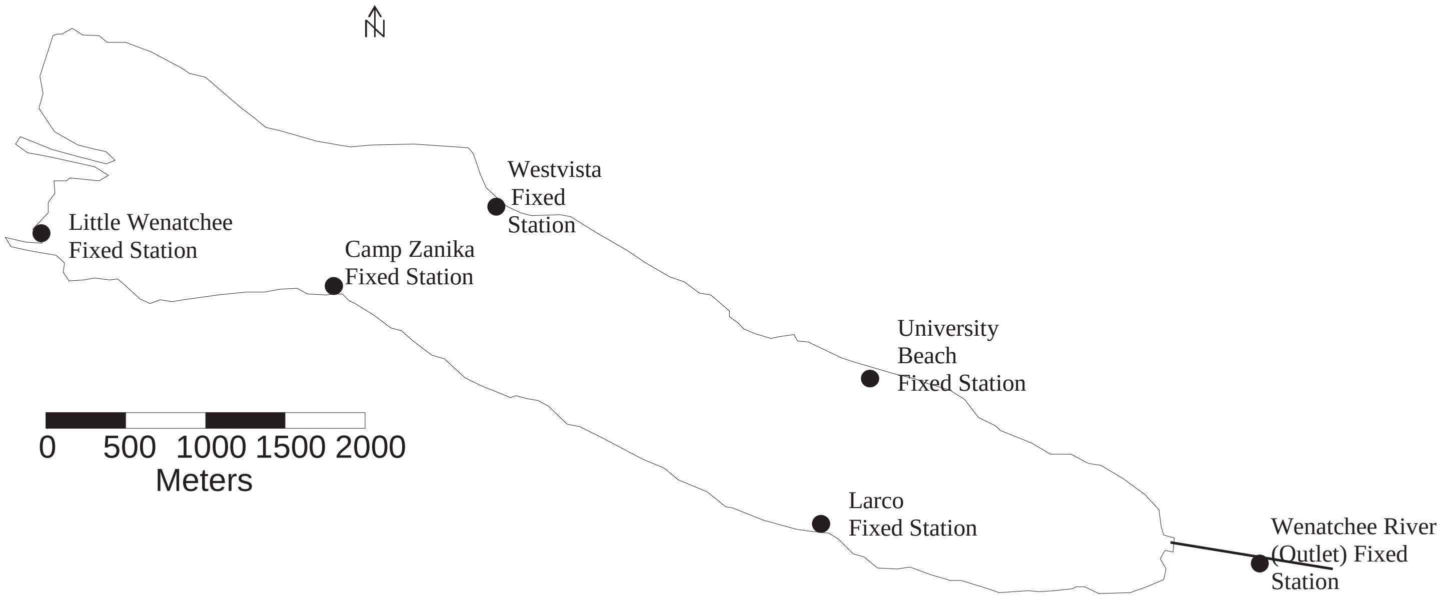

Figure 1. Map of Lake Wenatchee, fixed radio-telemetry monitoring sites.

Part II: Distribution of sockeye fry in Lake Wenatchee – pelagic zone tow-netting, littoral zone snorkeling and hydroacoustics

Knowledge of the emergence timing and distribution of sockeye salmon fry in Lake Wenatchee is important in evaluating the risks of releasing hatchery coho salmon in the Little Wenatchee River. This information will allow us to evaluate and identify possible temporal and spatial overlaps in the distribution of sockeye fry and hatchery coho salmon within the lake.

Sockeye Fry Emergence Timing

We monitored temperature units for sockeye eggs within the White River throughout the spawning, incubation and emergence periods. The temperature logger was placed approximately one mile upstream from the mouth of the White River. The placement of the temperature logger allowed us to track temperature units and calculate the emergence timing and subsequent fry emigration into Lake Wenatchee.

Sockeye Fry Distribution

Due to differences in depths and habitats, we used three techniques to determine the distribution of sockeye fry in Lake Wenatchee: 1) snorkeling in the littoral zone, 2) tow-netting in pelagic areas, and 3) hydroacoustics in nearshore and pelagic areas. During tow-netting and littoral zone snorkeling we stratified the lake into three sample areas, with each area containing a pelagic zone and a littoral zone (i.e., upper pelagic zone and upper littoral zone; Figure 2).

Littoral Zone Snorkeling

Teams snorkeled transects parallel to the shore to document the presence and observed densities of sockeye fry in the upper, middle, and lower littoral zones. Three observers moving in tandem held a ten-foot-long PVC pipe. The pipe allowed the observers to maintain an equal distance apart (five feet between each observer), and ensured that all observes move at the same speed. Observers focused on the area immediately beneath themselves and extending 5feet to their right for a total combined width of 15 feet (Figure 3). Using a pole of fixed length to maintain the appropriate distance between observers along a straight counting line allowed for efficient observations and fish counts in the transect (Thurow 1994) and the ability to calculate the density of fish observed in a given area. Fish density (fish/m^2) was calculated for each transect snorkeled. Underwater observations occurred only when visibility was good because water clarity can limit the ability to count fish reliably. Although sockeye were the target fish, other species observed also were recorded.

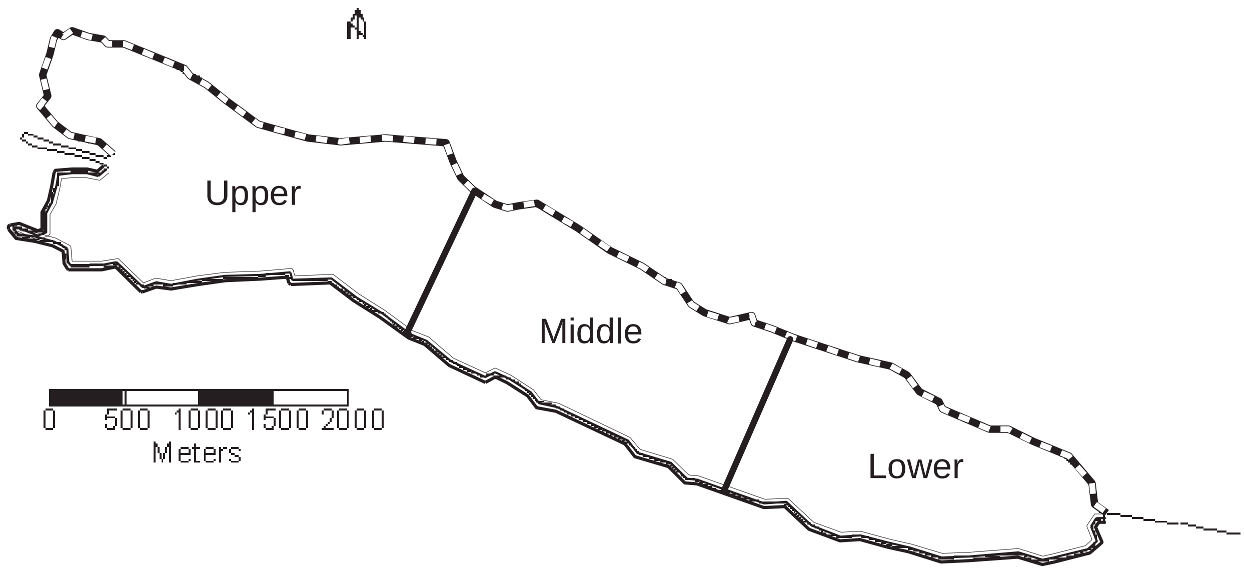

Figure 2. Lake Wenatchee divided into upper, middle, and lower zones.
Littoral zones are shown with dashed line (north shore) and double line (south shore).

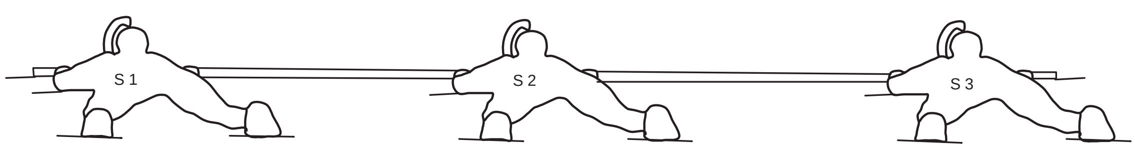

Figure 3. Observers snorkeling in tandem holding a 10-foot PVC pipe.

Observed densities (fish/m^2) were used to compare sockeye fry abundance in the littoral areas between the identified lake zones (i.e., upper, middle, lower) and shores (i.e., north and south) of Lake Wenatchee using a two-way ANOVA to test the following hypothesis:

H_o: There is no difference in sockeye fry density between zones and shores in Lake Wenatchee
H_a: There is a difference in sockeye fry density between zones and shores in Lake Wenatchee

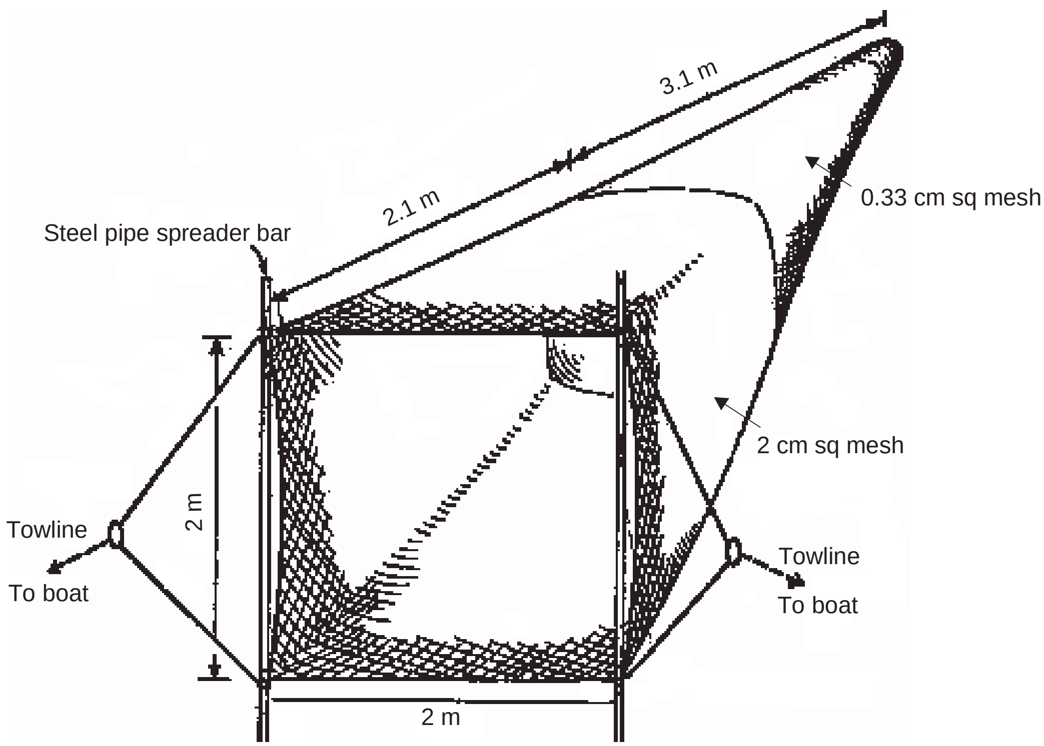

Figure 4. Diagram of tow net used in 2002.

Pelagic Zone Tow-Netting

Tow nets have been proven useful in collection of small and larval fishes in marine and freshwater environments (Rankin et al. 1999; Snyder 1983). For this study, surface water tows occurred on a weekly basis for three weeks in each pelagic zone. Surface tows were made along randomly selected transects within the upper, middle, and lower pelagic zones (Figure 2). Each transect took approximately 10 minutes to complete. Tow speeds ranged from 4.0-4.5 mph.

A conical tow net with a 2 m^2 opening and measuring 5.2 m in length (2 cm mesh at opening decreasing to 0.33 cm at the cod-end) was towed behind two parallel boats running approximately 100 feet apart (Figure 4).
The cod-end bucket created a safe reservoir for fish entrained in the net (Aquatic Research Instruments, pers. comm.) and allowed for quick removal of net contents. Upon removal, the cod-end maintains a reservoir of water and creates a sanctuary in which the fry are held and which allowed the fry to be transferred from the net while remaining immersed in water (Aquatic Research Instruments, pers. comm.). At the end of each tow period the net was lifted into the boat, and the cod end was removed immediately.

Each transect was located and documented with a handheld GPS unit. The time required for each transect was also recorded. At the end of each transect all fish captured were anesthetized with a standard stock solution of MS-222 (30mg/liter) using 5-10 ml of stock solution per gallon of water; then they were identified and enumerated. A sub-sample of 5-20 fry per transect was measured (FL). After enumeration and measurement, fry were allowed to fully recover before release into the lake. Catch-per-unit-effort (CPUE) was calculated for each transect using the number of fry captured per minute (one unit effort = 1 minute).

The CPUE for sockeye fry captured in the pelagic zones was compared using a two-way analysis of variance (ANOVA) to test the following hypothesis:

H_o: The CPUE for sockeye fry in each zone and week is equal.
H_a: The CPUE for sockeye fry in each zone and week is not equal.

Hydroacoustic Survey of Lake Wenatchee

To provided a more detailed picture of sockeye fry spatial distribution, we contracted Shuksan Fisheries Consulting to complete a hydroacoustic survey of Lake Wenatchee during mid-May (May 16-17, 2002; Stables 2002). Surveys were completed from a motorboat with a BioSonics 120 kHz, DT6000, spilt-beam echo sounder with a 7.4° transducer. The transducer was deployed from a pipe attached to the side of the boat and aimed vertically toward the lake bottom, effectively sampling fish that were at least 2 m beneath the lake surface. The echo sounder was operated by a computer, which allowed monitoring of data quality on echograms at the time of collection and served as a data logger. Latitude and longitude from a Furuno GP-35 GPS were added to acoustic data files as they were acquired. Additional data collection details and equipment settings can be found in Stables (2002). The full report is included in Appendix A.

Hydroacoustic sampling was performed along ten pre-determined transects between the hours of 9 p.m. and 1 a.m.; the transects were spaced about 650 m apart, perpendicular to the long axis of the lake (Figure 5). These transect lines were the same as those used on acoustic surveys in the 1970s (Dawson et al. 1973). During the May 2002 survey, half the segments between transect endpoints were also sampled while running between transects to increase coverage of near shore areas (Figure 5). Generally transects were terminated when the depth was less than 2 m, so littoral shallows were not sampled. A small amount of data was collected during daylight hours (2-3 p.m.) for comparison with the data collected during the night.

Shuksan Fisheries Consulting compiled and analyzed the hydroacoustic data to provide data regarding target strength, fish size, horizontal and vertical distribution, fish densities by size, and a population estimate. Details on hydroacoustic data analysis can be found in Stables 2002 (Appendix A).

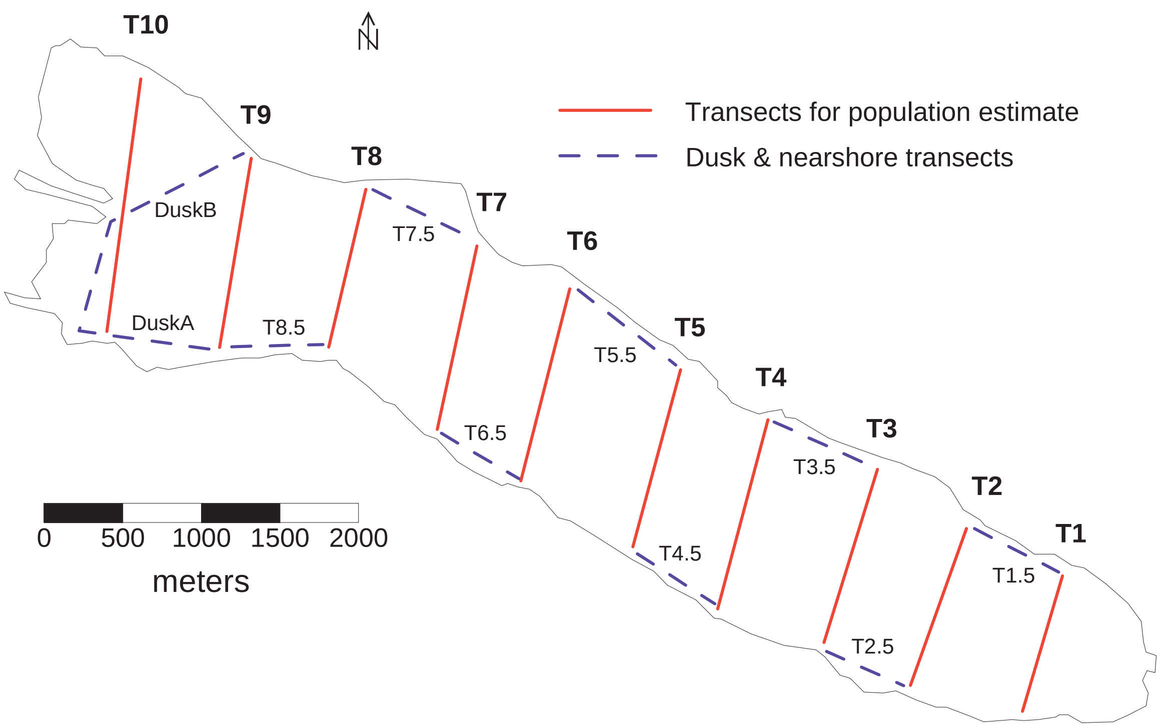

Figure 5. Map of Lake Wenatchee, showing transects for the May 16-17, 2002 acoustic survey.

RESULTS

Part I: Hatchery coho smolt migratory patterns through lake Wenatchee – Radio Telemetry

We radio-tagged and released 149 coho smolts between May 2nd and May 21st 2002, to determine the run timing and migratory route of hatchery coho smolts released in Little Wenatchee River (Table 1). We released radio-tagged coho smolts in seven tag groups ranging in size from 15 to 31 fish (Table 1).

Table 1. Release groups, dates and times of hatchery coho released into the Little Wenatchee River, 2002.

Release Date	Sample Size	No. to Enter Lake Wenatchee	% to Enter Lake Wenatchee	Mean Time to Enter Lake Wenatchee (days)	No. to Exit Lake Wenatchee	% to Exit	Mean Time to Exit Lake Wenatchee (days)
May 2	19	16	84.21	12.02	3	18.75	14.84
May 3	20	18	90.00	13.76	2	11.11	24.43
May 7	28	20	71.43	13.66	3	15.00	6.97
May 9	20	19	95.00	14.84	2	10.53	3.61
May 14	16	10	62.50	9.06	1	10.00	21.37
May 15	31	27	87.10	5.83	8	29.63	5.77
May 21	15	12	80.00	8.82	0	0.00	N/A
Total	**149**	**122**	**81.88**	**11.10**	**19**	**15.57**	**9.95**

Eighty-two percent (81.9%) of the radio tagged coho smolts were detected entering Lake Wenatchee (Table 1). The mean travel time from release to lake entry was 11.10 days (range: 0.02 days to 40.13 days). Four radio-tagged fish remained at the release site after release, and 23 were never detected entering the lake. Coho remaining at the release site and coho that never entered the lake were presumed dead. Of the 122 coho smolts known to have entered Lake Wenatchee, 19 were detected exiting the lake (Table 1). We believe that an additional 6 coho may have exited Lake Wenatchee during a two-week period when our receiver at the outlet of Lake Wenatchee was malfunctioning, bringing the percentage of coho exiting the lake up to 20.50% (25 fish). The mean travel time through the lake was 15.57 days (range: 0.98 to 31.28 days). Any radio-tagged coho entering or exiting Lake Wenatchee after the minimum tag life of 28 days were likely not detected. Individual tag histories can be found in Appendix B.

We classified the migration behavior of radio-tagged coho into 8 patterns. The migratory patterns and numbers of fish observing each type can be found in Table 2.

Table 2. Migratory patters of radio-tagged coho through Lake Wenatchee and the percentage of each pattern type exiting Lake Wenatchee.

Migratory Pattern	Sample Size	% of fish released	No. exiting Lake Wenatchee	% Exiting Lake Wenatchee	% of exiting fish from group
West End of Lake	36	24.16	2	5.56	10.5
Ping-Pong Entire Lake	30	20.13	12	40.00	63.2
Presumed Dead	27	18.12	0	0	0
Entered and Stayed at Little Wenatchee	21	14.09	0	0	0
Entered and Never Seen	19	12.75	0	0	0
Migrated South Shore/Center	12	8.05	3	25.00	15.8
Migrated North Shore/Center	2	1.34	1	50.00	5.3
Traveled Lake Center	2	1.34	1	50.00	5.3
Total	**149**	**100.00**	**19**	**12.75**	**N/A**

A coho which was categorized as staying at the west end of the lake was typically detected multiple times at more than one of the three west end fixed stations (Little Wenatchee, Camp Zanika, and Westvista). The "west end" behavior pattern was the most commonly observed migratory pattern. Of the 36 fish in the 'west end' category, only 2 exited the lake (10.5 % of all coho detected exiting). The second most common migratory pattern 'ping-ponged' the entire lake. As the name describes, fish in this category were repeatedly detected at all five stations within the lake, sometimes crossing the lake several times. Most of the coho detected exiting Lake Wenatchee displayed the 'ping-pong' behavior type (63%). Twelve radio-tagged coho migrated along the north shore, while only 2 coho migrated down the south shore and center of the lake (Table 2). Examples of each migratory behavior observed in the radio-tagged coho can be found in Appendix C.

The majority of radio-tagged coho (82%) were last detected at one of the three south shore fixed stations (Little Wenatchee, Camp Zanika, or Larco), with the most frequent last detections occurring at the Little Wenatchee River station (Figure 6). Very few fish (2%) were last seen at one of the two north shore fixed stations (Westvista or University Beach fixed stations; Figure 6).

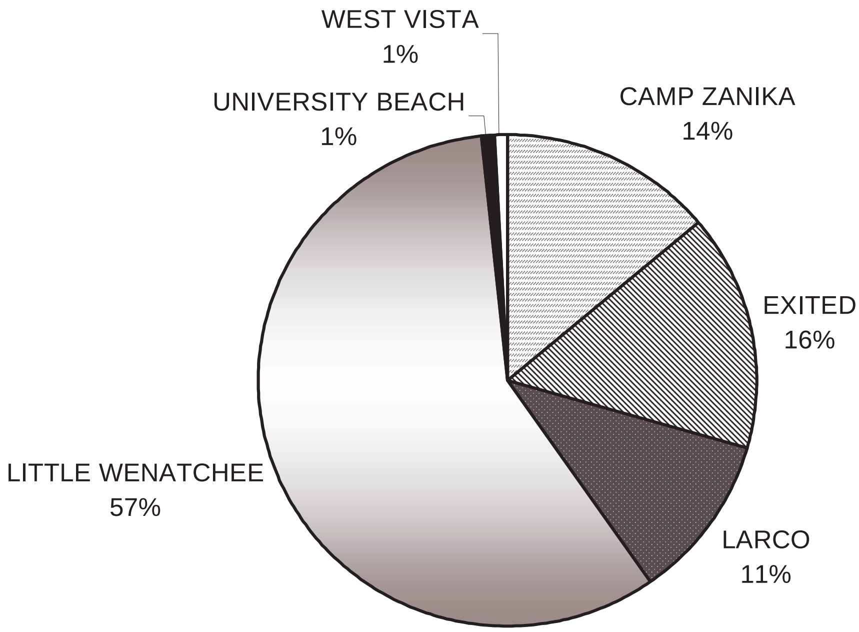

Figure 6. Last detection locations of radio-tagged coho smolts migrating through Lake Wenatchee.

Part II: Distribution of sockeye fry in Lake Wenatchee – Pelagic zone tow netting, littoral zone snorkeling, and hydroacoustics

Sockeye Fry Emergence Timing

During 2001, sockeye spawning activity occurred between September 1st and September 29th, with peak spawn in mid-September (A. Murdoch, WDFW, personal communication). Based on the mean daily temperature in the White River, we estimated that peak fry emergence was in mid-May and extended from the second week of April through mid-June, 2002 (Table 3).

Table 3. Estimated sockeye spawn and fry emergence timing, 2002.

Spawn	Date	Emergence*
Early	9/1/01	4/9/02
Peak	9/15/01	5/16/02
Last	9/29/01	6/19/02

* Sockeye fry emerge at 1700 temperature units (Piper et. al. 1998).

Sockeye Fry Distribution in Lake Wenatchee

Littoral Zone

We surveyed a total of 18 snorkel transects between May 6th and May 25th, 2002 (Figure 7). Sockeye fry were observed in 7 of 18 transects (Table 4; Figure 7). Transect lengths ranged from 95 to 137 m ($\overline{X}$ = 107 ± 11 SD) with transect areas ranging from 434 m^2 to 626 m^2 ($\overline{X}$ = 490 ± 50 SD). We observed a total of 176 sockeye fry during our littoral zone transects. We also observed sculpin *Cottus spp.*, mountain whitefish *Prosopium williamsoni*, bull trout *Salvelinus confluentus*, and suckers *Catostomus spp.*

Table 4. Lake Wenatchee littoral zone snorkel transects, fry observations and observed fry densities.

Date	Littoral Zone*	Shore	Distance (m)	Width (m)	Area (m^2)	Sockeye Fry Observed	Sockeye Fry Density (#/m^2)
5/6/02	Upper	South	137	4.57	626	0	0
5/6/02	Upper	South	102	4.57	466	0	0
5/10/02	Lower	South	95	4.57	434	0	0
5/10/02	Middle	North	98	4.57	448	0	0
5/10/02	Lower	South	97	4.57	443	9	0.020
5/17/02	Upper	North	103	4.57	471	53	0.113
5/17/02	Upper	South	122	4.57	558	0	0
5/17/02	Middle	South	118	4.57	539	103	0.191
5/23/02	Lower	North	101	4.57	462	6	0.013
5/23/02	Lower	North	101	4.57	462	0	0
5/23/02	Middle	North	110	4.57	503	0	0
5/23/02	Middle	North	105	4.57	480	2	0.004
5/24/02	Upper	North	95	4.57	434	0	0
5/24/02	Upper	North	99	4.57	453	0	0
5/24/02	Middle	South	105	4.57	480	0	0
5/31/02	Middle	South	115	4.57	526	0	0
5/31/02	Lower	South	110	4.57	503	1	0.002
5/31/02	Lower	North	117	4.57	535	2	0.004

Note: littoral zone designations can be found in Figure 2.

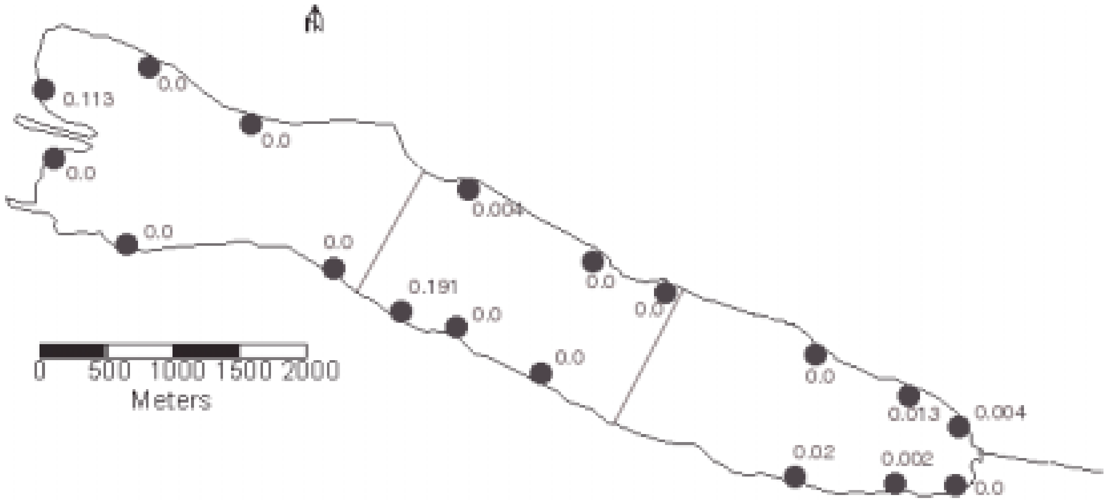

Figure 7. Observed sockeye fry densities and locations of snorkel transects in Lake Wenatchee littoral zones.

While most of the snorkel transects in which we found sockeye fry were in the lower zone, the results of the ANOVA indicated no significant differences in sockeye fry densities between lake zones or shores (Table 5).

Table 5. Analysis of variance results for sockeye fry distribution among littoral zones/shores.

H_o: The densities of sockeye fry in the littoral zone of Lake Wenatchee are the same in all zones and on both shores (sockeye fry are evenly distributed throughout the littoral zone of Lake Wenatchee)							
H_a: The densities of sockeye fry in the littoral zone of Lake Wenatchee are not the same in all zones or shores (sockeye fry are not evenly distributed throughout the littoral zone).							
Source	**SS**	**df**	**MS**	**F**	**P-value**	**Ho**	**Ha**
Shore (A)	0.000347	1	0.00347	0.125414	0.729	do not reject	reject
Zone (B)	0.00203	2	0.001015	0.3671	0.7	do not reject	reject
Interaction (A*B)	0.007614	2	0.003807	1.377007	0.289	do not reject	reject
Within	0.03318	12	0.0027				
Total	0.0437	17					

$\alpha = 0.05$

Pelagic Zone

A total of 10 surface tow-net transects were completed between May 8 and May 20, 2002 (Table 6). We attempted to sample each zone (upper, middle, and lower) during each week of the study. However, due to weather conditions on the lake, some transects were missed. Two samples were incomplete due to equipment failure. Sockeye fry were collected in all tow-net samples, including the incomplete samples. Sockeye smolts were captured on three of the ten transects. Smolts were captured only during weeks one and two, and were never captured in the upper zone of the lake. Sockeye fry FL averaged 27 mm ± 1 SD (n = 47), while wild yearling sockeye FL averaged 82 mm ± 7.8 SD (n = 3). One yearling hatchery sockeye was captured. The hatchery sockeye smolt measured 121 mm and was identified as hatchery origin by a clipped adipose fin.

Table 6. Summary of tow net transect locations, frequency and fry counts in Lake Wenatchee, 2002.

Zone	Week	Fry Counts	Fry CPUE
Upper	1	1	0.07
Upper	2	22	1.83
Upper	3	26	2.00
Middle	1	43 + 1 smolt	3.91
Middle	2	Incomplete (1)	Not calculated*
Middle	3	1	0.07
Middle	3	41	3.15
Middle	3	Incomplete (3)	Not calculated**
Lower	2	5 + 2 smolts	0.50
Lower	2	2 + 1 smolt	0.29

Note: pelagic zone designations can be found in Figure 2.
* One tow-line broke approximately 30-45 seconds into the transect.
** Cod end bucket tore partially off, allowing fry to escape.

One minute of tow netting was designated as one unit of effort. CPUE was calculated by dividing the total catch by the total number of minutes it took to complete a transect. We compared CPUE between pelagic zones and weeks with a two-way ANOVA (Table 7).

Table 7. Two-way analysis of variance results for sockeye fry CPUE in pelagic zones.

H_o: The CPUE for sockeye fry in each zone of Lake Wenatchee is equal. H_a: The CPUE for sockeye fry in each zone of Lake Wenatchee is not equal							
Source	**SS**	**df**	**MS**	**F**	**P**	**Ho**	**Ha**
Week	3.24	2	11.6	0.33	0.75	do not reject	reject
Zone	22.74	2	11.4	2.31	0.30	do not reject	reject

Hydroacoustic Survey

During the limited daylight sampling in the west end of Lake Wenatchee on the afternoon of May 16, nearly all fish were observed offshore and below 45 m in the water column (Figure 8). At night fish were abundant both near shore and off shore throughout the lake and nearly all fish occurred in the upper 40 m of the water column (Figure 9). For fish of all sizes combined, densities within individual transect depth layers ranged from 0.0 to 0.09 fish/m^3. Fish densities were consistently highest in the upper 15 m of the water column. The horizontal fish distribution indicated that densities (fish m^2) were relatively high along the southern shore, particularly toward the eastern end of the lake. High densities also occurred in some mid-lake areas. Fish densities tended to be low along the northern shoreline except at the ends of the lake. Fish were similarly distributed during dusk and night transects in the west end of the lake. Data collected at dusk were included with night data for analysis.

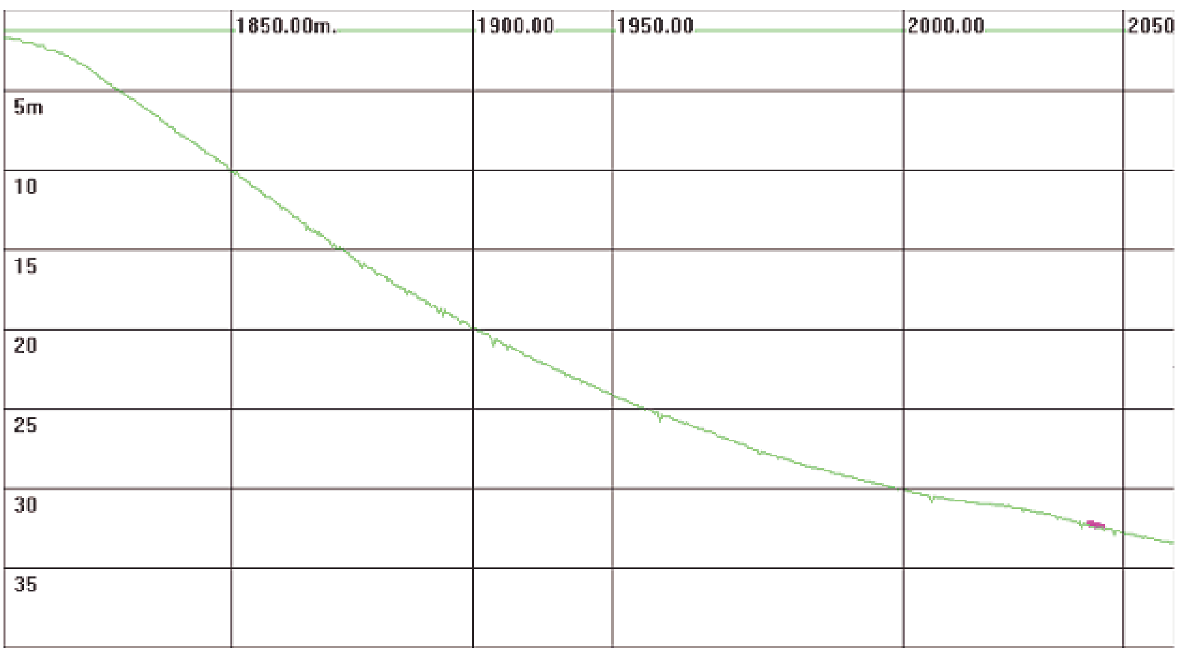

Figure 8. Near-shore distribution of fish during daylight hours, May 16, west end of Lake Wenatchee. (Source: Stables 2002)

Note: Bottom of the lake is represented by the green line. Only one fish is visible along the bottom at a depth >30m.

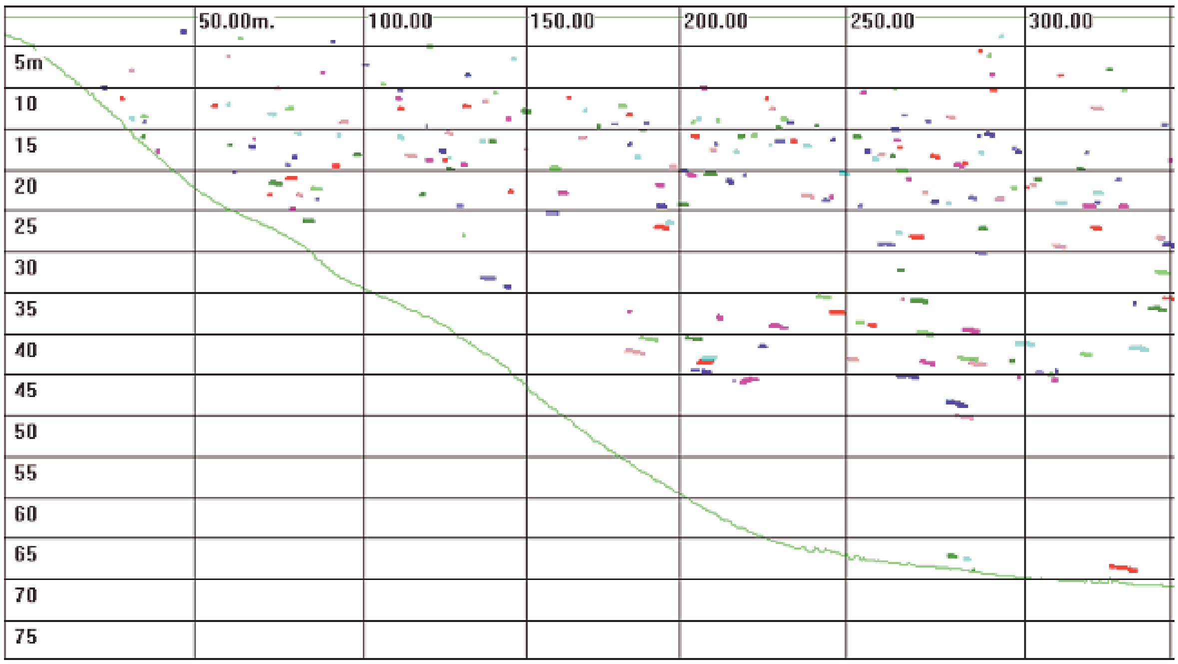

Figure 9. Typical nighttime echogram showing fish traces on Transect 5 in Lake Wenatchee, May 16, 2002.
The transect is from the north shore to about 300 m out into the lake. Different colors serve no purpose except to distinguish individual fish traces (Stables 2002).

Spatial Distribution Relative to Fish Size
Frequency distribution of target strength (TS (dB)) by transect indicated the presence of two size groups. Based on our tow-netting results, we believe the two size groups represented sockeye fry and yearling sockeye. The small size group (fry) was found on all transects. The large size group (yearlings) were found on most transects that crossed deep water, and was nearly absent from Transect 1 (lake outlet) and from several of the near-shore transects that did not extend to deep water.

The small size group had a mode of 25 mm while the larger group had a mode of 75mm. Mean length of fish by 5-meter depth layer and transect intervals can be found in Stables 2002 (Appendix A). At night, fry-sized fish were found throughout the water column, both near shore and offshore, but tended to predominate in the upper 30 m of the lake. Plots of fish density for fry-size and for larger fish can be found in Stables 2002 (Appendix A). Fry densities were somewhat patchy, often changing radically in a short distance. High densities of fry were seen both near and off shore (Figure 10). Fry densities tended to be high along the south shore and very low along the north shore, except for the southeast quadrant of the lake. Larger fish were less abundant than fry.

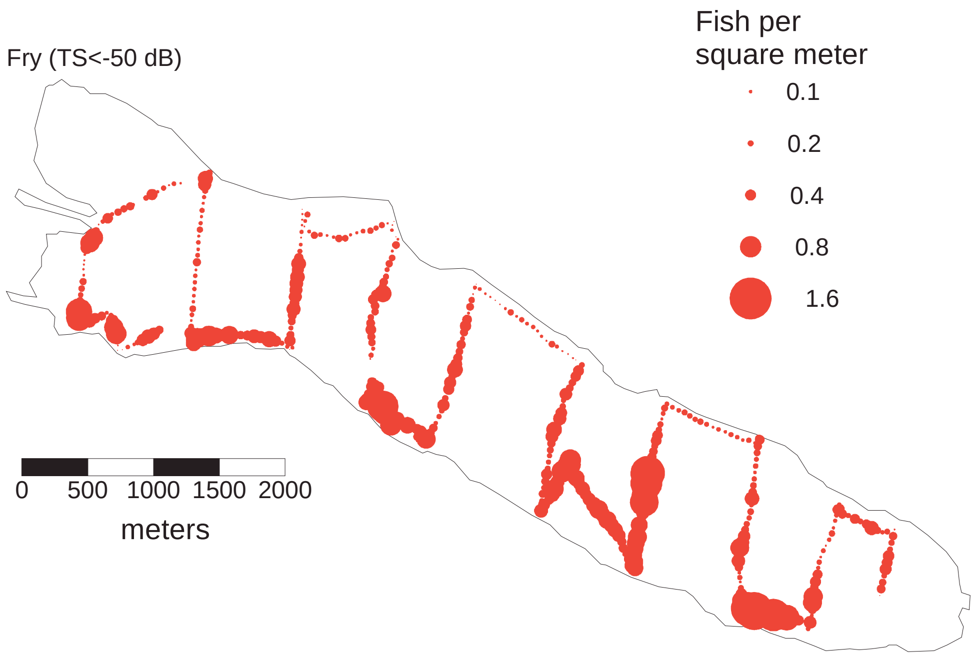

Figure 10. Density (fish/m^2) of sockeye fry along acoustic transects in Lake Wenatchee, May 16-17, 2002, from 2130-0100 hours.
(Source: Stables 2002).

Population Estimate
The population estimate for sockeye fry (assuming that all fish with TS less than –50 dB were fry), was 3.9 million (+/- 24%); 71% of the fry were in the upper 15 m of the water column (Table 8).

Table 8. Sockeye fry density (fish/m3) by transect and depth layer from May 16-17, 2002 acoustic survey of Lake Wenatchee*.

Depth	Upper	Lower								Fish density by transect			Total	
interval	limit (m)	limit (m)	1	2	3	4	5	6	7	8	9	n	Mean	Var
1	0	5	0.013	0.016	0.013	0.028	0.018	0.019	0.015	0.018	0.009	9	0.01660	0.000029
2	5	10	0.045	0.012	0.016	0.021	0.011	0.011	0.015	0.014	0.009	9	0.01715	0.000123
3	10	15	0.090	0.018	0.020	0.019	0.012	0.012	0.009	0.009	0.010	9	0.02214	0.000679
4	15	20		0.009	0.015	0.015	0.010	0.008	0.007	0.007	0.006	8	0.00951	0.000013
5	20	25		0.002	0.006	0.010	0.006	0.005	0.005	0.005	0.004	8	0.00528	0.000005
6	25	30		0.001	0.004	0.006	0.004	0.005	0.003	0.004	0.002	8	0.00382	0.000002
7	30	35		0.002	0.003	0.004	0.003	0.004	0.002	0.003	0.002	8	0.00284	0.000001
8	35	40		0.003	0.002	0.003	0.003	0.002	0.002	0.002	0.001	8	0.00211	0.000000
9	40	45		0.003	0.002	0.002	0.001	0.002	0.001	0.001	0.000	8	0.00130	0.000001
10	45	50			0.001	0.001	0.001	0.000	0.001	0.000	0.000	7	0.00050	0.000000
11	50	55			0.000	0.000	0.000	0.000	0.001	0.000	0.000	7	0.00024	0.000000
12	55	60			0.000	0.000	0.000	0.000	0.000	0.000	0.000	7	0.00008	0.000000
13	60	65			0.000	0.000	0.000	0.000	0.000	0.000	0.000	7	0.00004	0.000000
14	65	70				0.000	0.000	0.000	0.000			4	0.00011	0.000000
15	70	75					0.000	0.000	0.000			3	0.00000	0.000000
		Mean	0.0496	0.0074	0.0063	0.0078	0.0044	0.0045	0.0041	0.0049	0.0034			

* This assumes that all fish with TS <-50 dB were sockeye fry. Shoreline areas with depth <2 m and the upper-most 2 m of the water column were not sampled (Stables 2002).

DISCUSSION

Radio-tagged coho smolt performance

The mean travel time for radio-tagged coho smolts migrating through Lake Wenatchee was 9.95 days. While some fish migrated through the lake rapidly (minimum travel time 0.69 days), others took close to a month (maximum travel time 26.92 days). Travel times through Lake Wenatchee in 2002 were almost double the run timing results observed in 2001 (mean 2001 travel time = 5.7 days). It is probable that the calculated difference in run timing was the result of the longer tag life of the transmitters used during the 2002 evaluation (28 days) compared to the short tag life of transmitters used during the 2001 evaluation (9 days). The short tag life of the 2001 transmitters biased our 2001 results by only recording travel time for fish that left quickly (Murdoch and LaRue 2002). A fish that exited the lake after the tag had died would not have been recorded or used in travel time calculations.

The observed travel times for radio-tagged hatchery coho migrating through Lake Wenatchee were longer than migration rates observed for non-radio-tagged coho released from acclimation ponds in the Yakima and Wenatchee rivers (Dunnigan 1999; Murdoch and Dunnigan 2002). The increased travel time may be the result of several factors including lack of flow velocities in Lake Wenatchee, difficulty navigating through the lake, or impaired swimming ability due to the radio-tag, surgical implant procedures, or transplanting the fish from Nason Creek to the Little Wenatchee River.

The smolt migration rate in salmonids slows with a decrease in flow velocities (Fried et al. 1978; Raymond 1979; Moser et al. 1991; Berggren and Filardo 1993; Venditti et. al. 2000). Berggren and Filardo (1993) reported that river flow explained most of the variation in travel time for juvenile steelhead, yearling chinook and sub-yearling chinook migrating in the Columbia and Snake Rivers. Moser et al. (1991) found the migration rates of coho salmon smolts to be "comparable with ambient current velocities". Coho salmon were documented moving rapidly downstream in areas of swift unidirectional current but swimming back and forth in low-velocity currents (Moser et al 1991). Similarly, the migration rate of juvenile fall chinook salmon in the Little Goose Reservoir mirrored reservoir water velocity: both migration rates and flow velocity slowed as the smolts approached the dam (Venditti et al. 2000).

In addition to slower water velocities, navigational difficulties may have played a role in the travel time and migratory patterns documented for radio-tagged coho smolts. Similar to the 'ping-pong' type behavior we observed in Lake Wenatchee, Vendetti et al. (2000) reported two behavior types in radio-tagged juvenile fall chinook salmon when entering the forebay of Little Goose Dam: repeated crosses of the forebay (up to 21 times) and upstream excursions (up to 14.4 km up river). The forebay crossing and upstream excursions in the radio-tagged chinook were thought to be caused by reduced water velocities encountered in the forebay (Vendetti et al. 2000). These researchers suggested that a "search pattern" was manifesting itself in the observed forebay crossing behavior, and after a period of searching, if the fish was still unable to locate the current to pass through the forebay, then an upstream excursion would allow the migrant to relocate to an area of higher velocity and make another attempt at passing. The behavior described by Vendetti et al. (2000) in the forebay of Little Goose Dam is remarkably similar to the behavior of radio-tagged coho upon entering Lake Wenatchee: repeated crossings of Lake Wenatchee and multiple return trips to the mouth of the Little Wenatchee River (an area of increased flow velocity where the current may be relocated).

Swimming tests have been used to examine the effects of surgical and gastric implantation of radio-tags on fish performance (McCleave and Stred 1975; Adams et. al. 1998). Adams et al. (1998) reported that surgically implanted transmitters did not cause significant long-term effects on the swimming performance of fish >120 mm but did show impaired swimming performance one day after tagging. Similarly, the swimming capacity of juvenile Atlantic salmon with surgical implants was not affected during a 7 to 14 day period (Moore et al. 1990).

Predation by bull trout or northern pike minnow may have reduced the number of radio-tagged fish tracked through Lake Wenatchee, or coho consumed may have been inadvertently tracked within the Lake. Bull trout in Lake Wenatchee have been reported to consume significant numbers of hatchery sockeye smolts (Thompson and Tufts 1967). Radio-tagged bull trout were regularly detected at most of our fixed detection stations. Bull trout were also observed at the tagging and release site. Unintentionally tracked bull trout or northern pike minnow, due to predation, may could account for the high numbers of coho observed and last detected in the 'West End' of Lake Wenatchee.

A relationship between swimming performance and vulnerability to predation has been well documented (Bams 1967; Adams et al. 1998). Adams et al. (1998) reported that both gastric and surgically tagged chinook smolts were eaten by predators in greater numbers than control fish. Factors other than swimming performance, such as failure to detect predators, decreased fast-start performance, the inability to school effectively and increased conspicuousness (Mesa et al. 1994) due to the presence of the antenna, could have influenced the vulnerability of radio-tagged coho smolts to predation. Any one of these factors may have worked in concert to increase vulnerability to predation; for example, swimming performance may have been affected by the transmitter, and the transmitter antenna could have made it easier for predators to target and capture the radio-tagged smolts (Adams et. al. 1998).

Distribution of radio-tagged coho and sockeye fry in Lake Wenatchee

Despite the limitations discussed above, radio-tags provided valuable information on coho smolt navigation and distribution in Lake Wenatchee. The data we collected indicated that the coho spent more time along the south side of Lake Wenatchee than along the north shore. Results of the hydroacoustic survey showed higher densities of sockeye fry just off the south shore than off the north shore. While we are unsure of the reasons for the observed fish distributions, observations indicate that the south shore of Lake Wenatchee tends to be more protected, and less windy than the north shore. The south shore also is frequently shaded from the moonlight and tends to be darker than the north shore. The Little Wenatchee River enters Lake Wenatchee near the west end of the south shore; therefore, there may be more attraction flow along the south side of the lake. Any one of the above reasons could explain the greater densities of sockeye fry and frequency of detections of radio-tagged coho smolts along the south shore.

Sockeye fry emerged from the gravel from mid-April through early June. Peak emergence occurred in mid-May. It appears that upon entering Lake Wenatchee, sockeye fry rapidly assume a pelagic existence. While a few sockeye fry were observed in littoral areas, most were found in the pelagic areas of the Lake Wenatchee. The results of the hydroacoustic survey indicated that sockeye fry were primarily located below 45 meters during daylight hours, moving upward and shoreward after dark. This vertical movement of juvenile sockeye salmon in rearing lakes has been well documented (Johnson 1956; Foerster 1968; Narver 1969; Nikoayev 1990; Burgner 1998). We were unable to track the vertical movement of radio-tagged coho through the water column to ascertain exactly where the coho smolts spent greatest amount of time. However, Ruggerone and Rogers (1989) reported that in Chignik Lake, AK, 50% of juvenile coho were found in the upper 2 m of the water column, with the remaining coho found in the upper 15 m of the water column. Juvenile coho were typically located within 25 m of the shore (Ruggerone and Roger 1989). For this reason, we conclude that nighttime, when sockeye fry move upward and shoreward, would be the most probable time hatchery coho smolts could encounter, and possibly prey upon, sockeye fry. Coho juveniles are highly dependent on visual cues for locating and capturing food (Hoar 1958). During daylight hours and crepuscular periods, coho can often be seen jumping clear of the water surface to capture insects (Sandercock 1998; C. Kamphaus, YN, personnel communication). During darkness, juvenile coho feeding activity ceases (Sandercock 1998). Because coho salmon do not feed at night, and the greatest opportunity for a juvenile coho to encounter a sockeye fry is at night, we believe the predation risk for sockeye fry by reintroduced juvenile coho salmon is minimal.

Ruggerone (1992) reported that sockeye fry in Chignik Lake, AK, were vulnerable to predation by coho immediately after emerging from shoreline spawning areas, but the fry quickly migrated off-shore where coho were less abundant. In offshore areas, the sockeye fry were less vulnerable to predation (Ruggerone 1992). Predation by coho on sockeye fry in Black Lake, AK, is low, apparently because sockeye are not predictably concentrated in one area of the lake (Ruggerone 1992). Lake Wenatchee sockeye fry densities were patchy and inconsistent (Stables 2002); therefore, predation rates (coho/sockeye fry) in Lake Wenatchee may be similar to the low rates observed by Ruggerone in Black Lake, AK.

Based on the results of the 2002 Lake Wenatchee sockeye and coho interaction evaluation, we believe that the predation risk for sockeye salmon fry by hatchery coho smolts is low. The densities of sockeye fry are patchy, and the fry are not predictably concentrated in one area of the lake. Because of the diel vertical movements of the fry, the greatest opportunity for hatchery coho to encounter a sockeye fry is at night, when coho feeding ceases (Sandercock 1998).

A continuation of this evaluation is necessary to actually document predation rates by hatchery coho salmon on sockeye fry. In 2003, we will volitionally release 100,000 acclimated hatchery coho smolts into the Little Wenatchee River, upstream of Lake Wenatchee. Approximately 9000 of the smolts will be marked with PIT tags. A detection system will detect the PIT-tagged coho leaving the acclimation pond. All coho recaptured in a rotary smolt trap located at the Lake Wenatchee outlet will be rescanned for PIT tags, providing another measure of migration timing through the lake.

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CHAPTER 2: MICROHABITAT USE – COMPETITION FOR SPACE AND FOOD

INTRODUCTION

The long-term vision of the mid-Columbia coho reintroduction program is to re-establish naturally reproducing coho salmon populations in mid-Columbia river basins, with numbers at or near carrying capacity. Interactions between hatchery releases of coho and ESA-listed spring chinook and steelhead in the Wenatchee River Basin are ongoing (Dunnigan 2000, Murdoch and Dunnigan 2002, Murdoch and LaRue 2002). In 2002 we evaluated the potential for naturally produced coho salmon to negatively impact steelhead and spring chinook salmon through competition for space and food.

Coho salmon, chinook salmon, and rainbow/steelhead trout are reported to be sympatric along the western coast of North America from California to British Columbia (Hartman 1965; Johnston 1967; Frasier 1969; Burns1971; Lister and Genoe 1972; Stein 1972; Shirvell 1994). While, habitat requirements of newly emerged chinook and coho salmon are similar during the first three months of stream life, differences in spawn timing, emergence timing, and size result in a high degree of spatial segregation (Lister and Genoe 1970). Chinook fry emerge about a month earlier than coho fry, are larger upon emergence, and grow at a faster rate (Lister and Genoe 1970). Coho were shown not to affect chinook or steelhead habitat use and growth in the Wenatchee River (Spaulding et al. 1989). Hartman (1965) concluded that strong habitat selection occurred in the spring and summer as a result of agnostic behaviors that were differentially directed by coho against steelhead in pools and by steelhead against coho in riffle habitats. Shirvell (1994) evaluated the effect of stream flow on microhabitat use by juvenile coho and chinook salmon in a natural stream. Comparisons between species showed that juvenile coho and chinook salmon chose different microhabitats for each of three stream flows tested in Kloiya Creek, British Columbia (Shirvell 1994).

The purpose of this evaluation was to investigate habitat use and growth of spring chinook, steelhead and coho salmon in Nason Creek, Washington, with the specific objective to determine the potential for naturally produced juvenile coho salmon to negatively impact spring chinook salmon and steelhead parr through competition for space and food. In 2001, only three coho redds were identified in Nason Creek during weekly spawning ground surveys (Murdoch and LaRue 2002). Due to the low number of coho redds observed, we out-planted hatchery coho parr in Nason Creek for this evaluation. While the scatter-planted coho salmon are of hatchery origin, they served as a surrogate for naturally produced coho, providing valuable information regarding interaction between juvenile coho, chinook and steelhead.

METHODS

Study Area and Scatter Plants

Distribution, macrohabitat preference, microhabitat use, and growth of 0+ spring chinook salmon, yearling steelhead and 0+ coho salmon were examined in Nason Creek in July, August, and September, 2002. Due to the low number of coho redds in Nason Creek in 2001, hatchery coho parr from mid-Columbia River broodstock origin were scatter-planted on July 25, 2002 into two of four study reaches (Table 1). A total of 33,204 coho parr were released into Nason Creek (Table 2). All scatter-planted coho were adipose clipped and coded wire tagged (CWT) for future identification.

Table 1. Nason Creek study reaches.

Reach Number	Location	Coho Scatter Plants	River Kilometer
1	Mouth to Kahler Creek Bridge	Yes	0.0 to 6.3
2	Kahler Creek Bridge to Butcher Creek	Yes	6.3 to 13.3
3	Butcher Creek to Merritt Bridge	No	13.3 to 17.9
4	Merritt Bridge to Whitepine Creek	No	17.9 to 24.8

Table 2. Coho scatter-plant release locations.

River Kilometer	Location	Number Released	Pounds
1.6	Nason Creek Campground	3648	28.5
5.0	Fishing pond	7968	62.3
6.3	Kahler Creek Bridge	2426	19.0
9.5	High voltage power lines	8435	65.9
11.4	Butcher Creek Rd bridge	5082	39.7
12.1	Rest area	2061	16.1
13.3	Wood bridge @ Butcher Creek	3584	28.0
	Total	**33,204**	**259.5**

We determined the number of coho scatter plants based on an estimate of spring chinook salmon carrying capacity in Nason Creek. The spring chinook carrying capacity in Nason Creek was determined by the National Marine Fisheries Service (NMFS) at 917 spawners (memo from Tim Tynan, NMFS-SFD and Laurie Weitkamp-NWFSC, June 29, 2001). This estimate was provided by Tom Cooney (NMFS-UCR TRT), and was back-calculated from the estimated proportion of the total number of spring chinook salmon late summer parr produced in the Wenatchee River basin attributable to Nason Creek (~21%). In this same memo it was recommended that the annual adult coho salmon escapement in 2001 and 2002 be limited to no greater than half the estimated spring chinook salmon carrying capacity in Nason Creek (917 spawners), or no greater than the total number of spring chinook salmon adults estimated in-season to have escaped to Nason Creek, whichever is the smaller figure.

The above guidelines allow for a maximum of 459 adult coho spawners. Using a figure of 2.2 fish per redd, 459 spawners could result in a maximum of 209 coho redds in Nason Creek (Table 3). The maximum egg seeding level could reach 564,300 (mean fecundity: 2700). Mean egg-to-late-summer-parr survival for spring chinook salmon during an eight-year study in the Chiwawa River was 10.6% (Hillman and Miller 2000).

Table 3. Determination of Nason Creek coho parr densities and scatter plant numbers.

Chinook Carrying Capacity[1]	Temp. Coho Escapement Cap (max)[2]	Maximum Possible Coho Redds[3]	Mean Fecundity	Max. Egg Seeding Level	Egg to Parr Survival Rate[4]	Est. Coho Parr Population
917 spawners	459 spawners	209	2700	564,300	10.6%	59,816

Nason Creek Available Habitat[5]	Estimated coho parr density	Study Reach Available Habitat[6]	Coho Scatter Planting Numbers[7]
336,102 m^3	0.178coho/m^3	180,248 m^3	32,084

[1]Nason Creek spring chinook carrying capacity as determined by Tom Cooney (NMFS-UCR TRT).
[2]Nason Creek coho salmon suggested temporary escapement limit as recommended by Tim Tynan (NMFS-SFD) and Laurie Weitkamp (NMFS-NWFSC). In 2001 and 2002, the annual adult coho salmon escapement will be limited to no greater than half of the estimated spring chinook salmon carry capacity in Nason Creek, or no greater than the total number of spring chinook salmon adults estimated in-season to have escaped to Nason Creek, whichever is the smaller figure.
[3] Assumes 2.2 adults/redd and a 50:50 male/female ratio. Actual male/female ratios may increase the number of adults/redd and decrease the maximum number of redds.
[4]Hillman T.W., and M.D. Miller Abundance and Total numbers of Chinook Salmon and Trout in the Chiwawa River Basin, Washington, 1999.
[5]Available habitat: river kilometer 24.8 – 0.0, mean depth 0.975 m, mean width 13.9 m. Mean depth and width data provided by Pierre Dawson, USFS.
[6]Study reach extends from the Butcher Creek acclimation site to the confluence (RK 13.3-0.0). Mean depth and width data provided by Pierre Dawson, USFS.
[7]Scatter-planting numbers were calculated by multiplying the estimated density of coho parr (fish/m^3) to the available habitat within the study reach.

Since no data are available for coho salmon in tributaries to the Wenatchee River; the spring chinook egg-to-parr survival rate of 10.6% was used to project coho parr numbers in Nason Creek. An egg-to-parr survival rate of 10.6% and an egg seeding level of 564,300 predicts 57,240 late summer coho parr. Based on the mean width and depth of Nason Creek (data provided by Pierre Dawson, USFS), 57,240 coho parr result in a mean density of 0.1715 fish/m^3. By applying this density to the treatment reaches (RK 13.3 to 0.0), we determined that 32,084 coho parr were required for scatter-planting between the Butcher Creek acclimation site (RK 13.3) and the confluence of Nason Creek (RK 0.0). The actual number scatter-planted was slightly higher: 33,204 juvenile coho. The larger number was intended to accommodate any mortality that may have occurred during transportation or during the scatter-planting process.

Selection of Sampling Units

Each reach (Table 1) was divided into 500-meter sections. From each section we randomly selected a 100-meter unit for distribution and macrohabitat use analysis (20% sample rate). Every second selected unit was included in the micro-habitat analysis (10% sample rate).

Classification of Habitat Units

Each selected unit was classified as pool, riffle or glide, or a combination. Habitat units were defined as described in USFS (1996). If a combination of habitat units existed in a selected 100-meter section, we measured the length and width of each habitat type and recorded the observation, count, and microhabitat data separately for each habitat unit in the combination.

Underwater Observation Methods

We snorkeled on clear days between 0900 and 1800 hours, following techniques described by Thurow (1994). Three observers snorkeled in a downstream direction; depth typically did not permit snorkeling in an upstream direction. Observers maintained a prescribed spacing from one another by snorkeling through a predetermined counting lane.

For each species, we grouped fish according their age or size. We divided juvenile chinook into age 0 (<4 inches) and age 1+ or residual chinook (>4 inches). Coho salmon were grouped into the same size categories as spring chinook. Steelhead/rainbow trout were divided into three size/age classes: age 0 (0-3 inches), age 1 (3-6 inches) and those measuring greater than 6 inches. Residual hatchery steelhead were recorded separately and were easily distinguishable from wild steelhead based on their large size, the presence of an elastomer tag, and by eroded fins. Bull trout were grouped into two size classes, juvenile (2-8 inches) and adult (>8 inches).

Controls and survey replication

The study was designed with both spatial and temporal controls to detect and evaluate changes in habitat use. Reaches three and four served as a spatial control. The spatial control reaches contained approximately half the spring chinook redds in Nason Creek and no coho salmon. The spatial control allowed us to evaluate differences in habitat use between the control and treatment reaches. The first survey, completed prior to scatter-planting (see "Survey and Sampling Timeline" section), served as a temporal control, providing a baseline of fish distribution and habitat use in both the treatment and control reaches. Survey 2 occurred one week after scatter-planting and was essentially a "check-in" to observe how the coho were distributing themselves (see "Survey and Sampling Timeline"). Survey 3 occurred a month after scatter planning and provided the final comparison of habitat use.

Microhabitat Use

During the surveys, each observer carried a selection of large washers. The washers were color coded for identification. For example, a red washer was used to identify the location of a 0+ chinook, a yellow washer identified the location of yearling steelhead, and a ½ red ½ yellow washer identified the location of 0+ coho. Each washer was placed in the location the observer first saw a fish. If more than one fish was seen in a given location, the observer wrote the number of fish counted on the appropriate washer with a grease pencil. Microhabitat variables were measured after the 100-meter unit was completed and fish locations identified. Water velocity was measured with a Marsh-McBirney flow meter (0.01 ft/s). Depth was measured to the nearest 10^{th} of a foot. Dominant and sub-dominant substrate classes were estimated using a modified Wentworth particle scale (Table 4). The presence of cover and cover type was recorded.

Table 1. Modified Wentworth particle scale.

Code	Classification	Particle Size
1	Detritus	-----
2	Silt	0.09-0.625 mm
3	Sand	0.625-2.0 mm
4	Gravel	2 – 16 mm
5	Pebble	17 – 64 mm
6	Cobble	65 – 255 mm
7	Boulder	> 256 mm

Data Analysis

<u>Macrohabitat availability and selection</u>

The available macrohabitat was measured in terms of the proportion of pools, riffles and glides sampled. The proportion of each habitat type in the control and treatment reaches was compared with a Chi-Square Goodness-of-Fit test to test the null hypothesis that the proportion of pools, riffles and glides were the same in the treatment and control reaches.

To evaluate macrohabitat selection, we used a Chi-Square Goodness-of-Fit test to compare the proportions of chinook, coho, and steelhead found in each of the habitat types to the proportions in which those habitat types were sampled.

Microhabitat use and displacement

A MANOVA was used to examine microhabitat use and overlap in reaches where chinook, steelhead, and coho were sympatric (treatment reaches, surveys 2 & 3 only). The dependant variables used in the model were flow velocity (ft/sec), depth (ft), dominant substrate type, and cover use. Independent variables used in the model were species and survey. If the null hypothesis was rejected, we used a Fisher's Least Significant Differences (Fisher's LSD) test to determine where the differences in habitat use occurred (α=0.05).

In order to detect a habitat shift, or displacement of chinook from preferred habitat in reaches where coho were planted, we used a MANOVA to compare microhabitat use by chinook in the control and treatment reaches. The dependant variables in the model were flow velocity, depth, cover use, and dominant substrate. The independent variables were survey and treatment. Due to small sample sizes, steelhead were excluded from this analysis. If the null hypothesis was rejected, we used a Fisher's LSD test to determine where the differences in habitat use occurred (α=0.05).

Growth and Condition Factors

We measured fish growth and condition factors to indirectly assess competition for space and food. Similar to the microhabitat evaluation, growth and condition factor surveys were conducted prior to scatter-planting (temporal control) and twice after scatter-planting coho parr in both the treatment and control reaches (spatial control) (Table 4; Figure 1). A Fulton-type condition factor was calculated for each fish examined:

$$\text{Kfactor} = (w/fl^3)*10^5$$

Where Kfactor = condition factor, w = fish weight (g), and fl = fork length (mm).

We believe that if competition for food exists to the extent that the population of juvenile chinook is negatively affected, then condition factors and/or growth should be depressed in areas where all three species occur together (treatment) when compared to reaches where coho are absent (control). Condition factors may also decline if a species is using less suitable habitat where all three species coexist as compared to areas where coho are not present (i.e. habitat displacement).

A temperature probe was placed in the treatment and control reaches, allowing us to evaluate if any differences in Kfactor were the result of temperature.

Fish were collected with a backpack electro-fisher. We attempted to collect 25 fish of each species (coho, chinook, steelhead) during each of three sample periods. The first sample period occurred prior to scatter planting coho. The remaining two sample periods occurred one and two months after scatter planting coho parr into the treatment reaches.

Survey and sampling timeline

Table 2. Timeline of microhabitat surveys, growth and condition factor sampling and juvenile coho scatter planting in Nason Creek, 2002.

Date	Survey/Sample Number	Activity
July 11-15, 2002	Baseline	Growth and Kfactor
July 17-19 & 22, 2002	Baseline	Microhabitat Use
July 25	Scatter Plant Coho	Scatter Plant Coho
August 2, 5-8	Survey 2	Microhabitat Use
August 15, 16, 19-22	Survey 3	Microhabitat Use
August 26-30	Sample 2	Growth and Kfactor
September 23-27	Sample 3	Growth and Kfactor

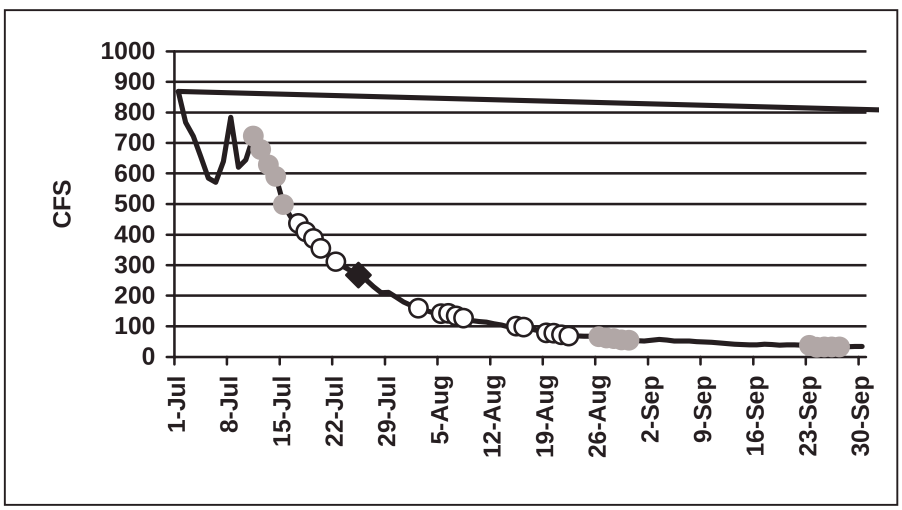

Figure 1. Plot of microhabitat survey, growth and condition factor, and scatter planning timeline vs. CFS in Nason Creek, 2002.
Grey dots = growth and Kfactor samples, white dots = microhabitat surveys, black diamond = scatter-planting.

Data Analysis
To compare the fork length (mm) and Kfactors of chinook, coho and steelhead (fry and yearlings) where all three species coexisted (treatment reaches), we used a MANOVA. Species and survey were the independent variables in the model; fork length and Kfactor were the dependant variables.

We used MANOVA to compare fork length (dependant variable) and Kfactor (dependant variable) between juvenile chinook salmon in the control and treatment reaches (independent variable), before and after planting coho (independent variable). Due to low numbers of steelhead yearlings collected in both the control and treatment reaches, steelhead were eliminated from this part of the analysis.

RESULTS

Distribution of chinook, steelhead and coho in Nason Creek

<u>Baseline Distribution</u>
Prior to scatter-planting coho salmon parr into the treatment reaches (reaches 1 & 2,) we completed a baseline distribution survey of Nason Creek (reaches 1-4). During the baseline survey we observed 13 naturally produced coho parr, 729 juvenile spring chinook salmon, 36 yearling steelhead, 4 steelhead fry, and 15 residual hatchery steelhead (Figure 2). All naturally produced coho were observed in reach 1. Seventy percent of the juvenile chinook were observed in reach 1. Reaches 2, 3, and 4 contained 17%, 13% and 0% of the observed chinook parr, respectively (Figure 2). Steelhead fry were observed only in reach 2. We believe most steelhead fry had not yet emerged from the gravel. Increasing numbers of steelhead fry were seen in subsequent surveys. Residual hatchery steelhead were observed in reaches 1 and 2. During the baseline survey, 80% of the residual steelhead were counted in reach 2 (Figure 2). Complete species counts can be found in Appendix D.

<u>Second Survey</u>
The second survey was completed 1-2 weeks after scatter-planting coho parr into the Nason Creek treatment reaches. The second survey served as a “check-in” to observe how the scatter-planted fish were distributing within the treatment reach. We used the second survey as a training opportunity for new observers and, as a result, the total number of fish observed during the second survey decreased. During the second survey we observed no naturally produced coho. We counted 183 scatter-planted coho. Scatter-planted coho were observed only in the treatment reaches, with 39% in reach 1and 61% in reach 2. We counted 541 juvenile chinook salmon. Most of the chinook (58%) were observed in reach 1. Reaches 2, 3, and 4r contained 27%, 15%, and 1% of the observed juvenile chinook.

Yearling steelhead were observed only in reaches 1 and 2, with 37.5% and 62.5% respectively (Figure 3). Complete species counts can be found in Appendix D.

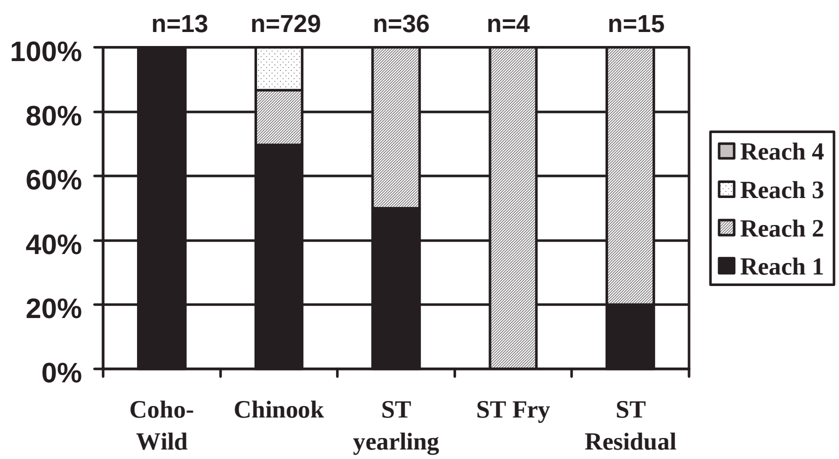

Figure 2. Distribution of juvenile coho salmon, chinook salmon and steelhead trout during the baseline survey (before scatter-planting) in Nason Creek, July 17-23, 2002.

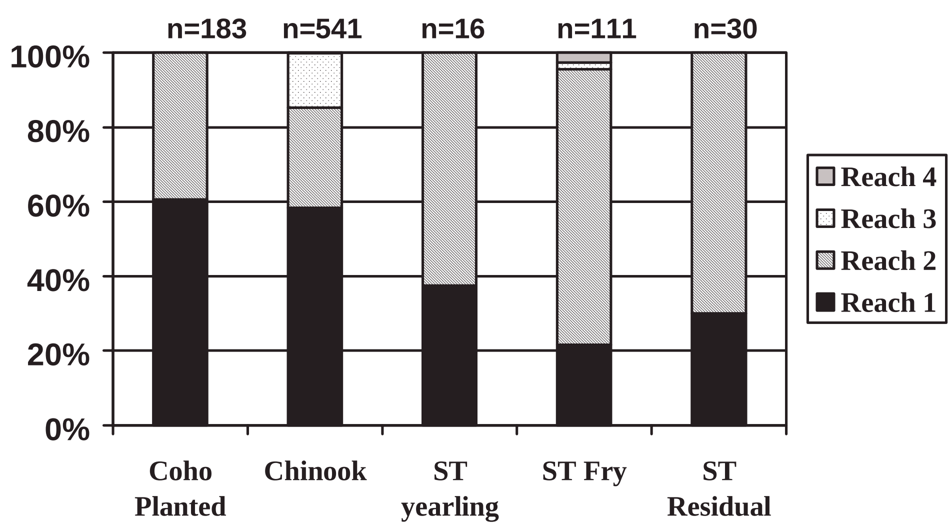

Figure 3. Distribution of coho, chinook and steelhead during the second survey (1-2 weeks after scatter-planting coho), Nason Creek August 1-7, 2002.

Third Survey
The third survey was completed one month after scatter-planting. This survey provided the final comparison of habitat use and distribution of juvenile chinook, coho and steelhead. During the third survey, two naturally produced coho parr were seen in reach 1. The scatter-planted coho were found only in reaches 1 and 2, which contained 44% and 56% of the observed coho (Figure 4). We counted 1472 juvenile chinook. This is nearly twice as many juvenile chinook as we observed during the baseline survey, and close to three times the number of chinook observed on the second survey. We continued to find the greatest portion of chinook (44%) in reach 1. Reaches 2, 3, and 4 contained 19%, 33%, and 3% of the observed chinook. Yearling steelhead were found in all four reaches during the final survey, with half (54%) of the steelhead counted in reach 1 (Figure 4). We observed 19% of the yearling steelhead in reaches 2 and 3. Reach 4 contained 8% of the observed yearling steelhead. Steelhead fry were observed in all four reaches, with the highest counts in reaches 1, 2, and 3. Residual hatchery steelhead were observered in reaches 1, 2, and 3 during the final survey (Figure 4). Complete species counts can be found in Appendix D.

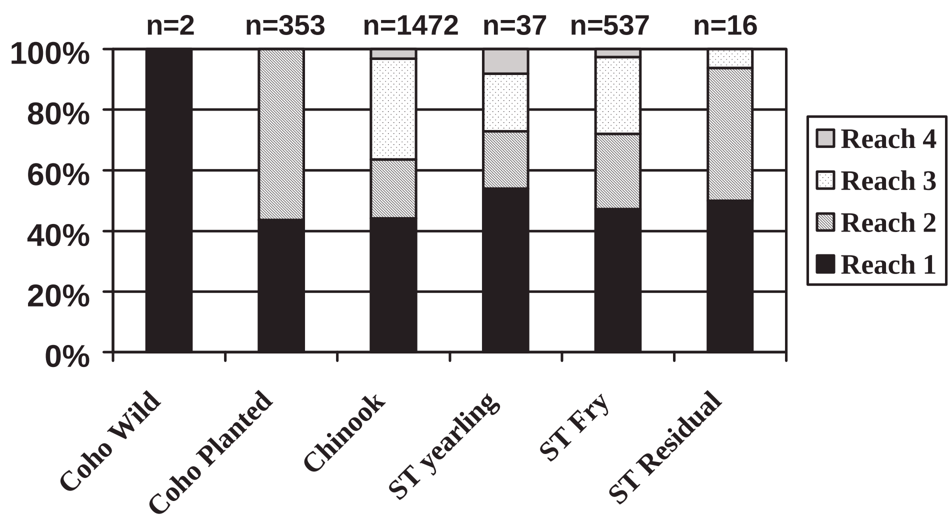

Figure 4. Distribution of coho, chinook and steelhead during the final survey (3-4 weeks after scatter-planting coho) in Nason Creek, August 15-21, 2002.

Observed fish densities
We observed the highest fish counts and calculated the highest fish densities during the third (final) survey. It is likely that more fish were observed during this survey because river flows and habitat area were the lowest during the evaluation period. The low flows and reduced habitat area increased our snorkel efficiencies. The densities reported below are calculated from actual fish counts; counts were not expanded for observer efficiency

and should be considered a minimum value. Coho densities were similar in reaches 1 (0.17 fish/m^2) and 2 (0.22 fish/m^2; Figure 5). During the third survey, chinook densities were the same in reaches 1 (0.070 fish/$m^{2)}$ and 3 (0.074 fish/m^2). Steelhead densities were highest in reach 1 (0.002 fish/m^2), decreasing in reach 2 (0.0008 fish/m^2), 3 (0.001 fish/m^2), and 4 (0.0005 fish/m^2) (Figure 5).

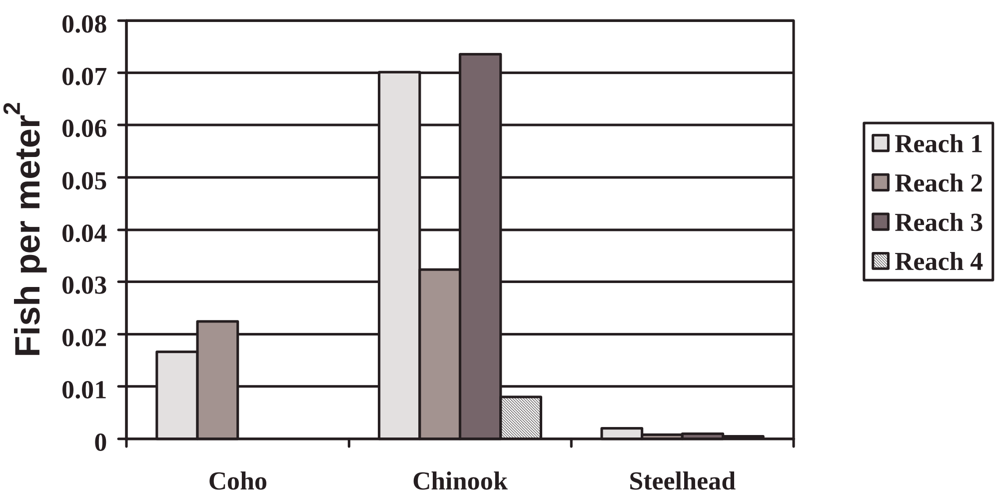

Figure 5. Densities of fish observed during the third survey of Nason Creek, 2002.

Available macro-habitat

We used a Chi-Square Goodness-of-Fit test to compare the available macrohabitat in the control and treatment reaches. Results of the Chi-Square Goodness-of-Fit test can be found in Table 3.

Table 3. Results of Chi-Square Goodness of Fit test to evaluate the proportion of macrohabitat types in the treatment and control reaches, Nason Creek, 2002.

H_o: The proportion of pools, riffles, and glides was the same in the treatment and control reaches				
H_a: The proportion of pools, riffles and glides was not the same in treatment and control reaches				
Statistic	Critical Value	P	H_o	H_a
$\chi^2 = 4680$	$\chi^2 > 5.991$	P=0.000	Reject	Do not reject
Conclude: The proportion of pools, riffles, and glides in the treatment reach was not the same as the control reach. There were more riffles and less pools and glides in the treatment reach than in the control reach.				

We rejected the null hypothesis and concluded that the proportion of pools, riffles, and glides in the treatment reach was not the same as the proportion of each habitat type in the control reach. There were a greater proportion of riffles, and less pools and glides in the treatment reach than in the control reach.

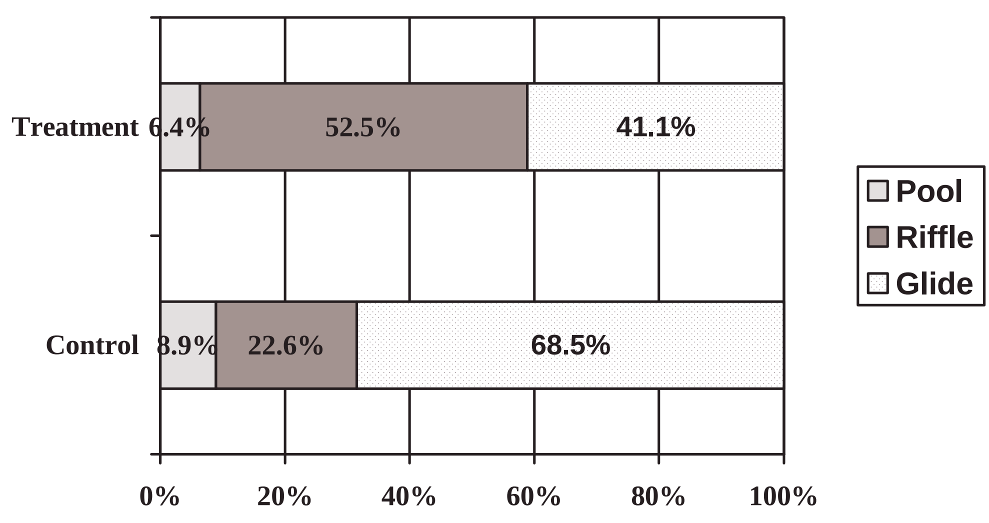

Figure 6. Available macrohabitat in treatment and control reaches, Nason Creek 2002.
Note: USFS 1996 habitat survey of Nason Creek (USFS 1996) reported the proportion of pool habitat to be substantially higher than we observed in our sampled units; however, USFS noted that the pool quality was impaired, lacking depth, cover, surface turbulence, and complexity. It is likely that much of what we referred

to as glides during this survey may have been classified as pools in the USFS surveys. During the 1996 USFS survey, glides were not considered a habitat unit. All units were classified as pool or riffle.

Macrohabitat use

Most juvenile coho and chinook salmon were observed in glides. We observed 73.1% of coho in glides and 62.5% of chinook in glides (Figure 7). Juvenile coho and chinook were observed least often in pools with 12% and 8.4% respectively (Figure 7). Juvenile steelhead were observed most often in riffles, with 52.7% of the steelhead observations (Figure 7).

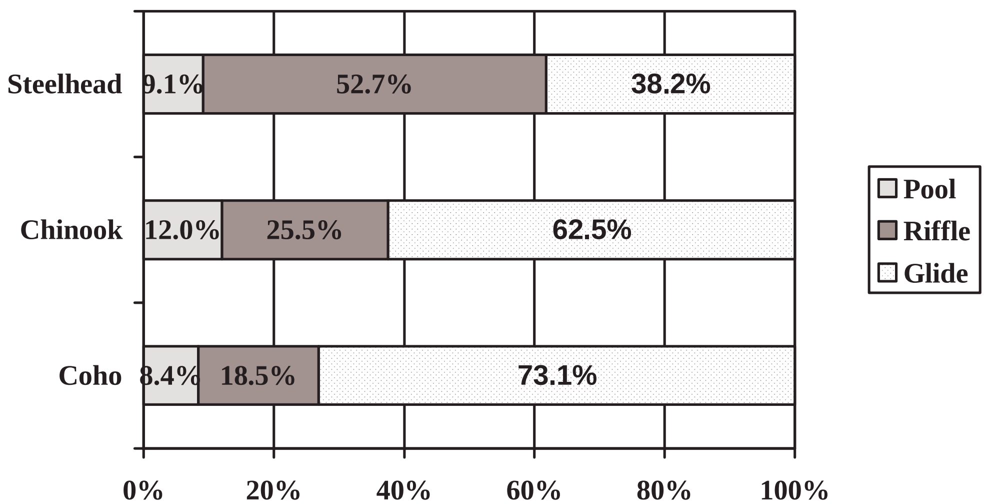

Figure 7. The proportion of juvenile coho, chinook, and steelhead observed in pools, riffles and glides, Nason Creek, 2002.

Macrohabitat selection

We compared the proportion of juvenile coho, chinook, and steelhead counted in pools, riffles and glides, with the proportion of pools, riffles, and glides sampled with a Chi-Square Goodness-of-Fit test, providing a measure of habitat selection. If no habitat selection occurred, we would expect to find the proportion of juvenile coho, chinook, and steelhead found in each habitat type in the same proportions as each habitat type was sampled. For chinook and steelhead, we used data collected from all four reaches of Nason Creek in the analysis (Table 4). Microhabitat selection data for coho was analyzed for treatment reaches only (no coho were observed in control reaches) (Table 5).

Table 4. Results of Chi-Square Goodness of Fit test to evaluate macrohabitat selection by juvenile chinook and steelhead (all surveys pooled), Nason Creek, 2002.

H_o: The proportion of chinook and steelhead found in pools, riffles, and glides was the same as the proportion in which pools, riffles and glides were sampled (no selection).				
H_a: The proportion of chinook and steelhead found in pools, riffles, and glides was not the same as the proportion of pools, riffles, and glides sampled (macrohabitat selection).				
Statistic	Critical Value	P	H_o	H_a
$\chi^2 = 293.6$	$\chi^2 > 5.991$	P<0.001	Reject	Do not reject
Conclude: Juvenile chinook and steelhead were not found in habitat types in the proportions in which they were sampled. Chinook were found less frequently in riffles and were selecting pools and glides. Steelhead were found less frequently in pools and glides and were selecting for riffles.				

Table 5. Results of Chi-Square Goodness-of-Fit test to evaluate macrohabitat selection by juvenile coho salmon (surveys 2 & 3, treatment reaches only), Nason Creek, 2002.

H_o: The proportion of juvenile coho found in pools, riffles, and glides was the same as the proportion in which pools, riffles and glides were sampled (no selection).				
H_a: The proportion of juvenile coho found in pools, riffles, and glides was not the same as the proportion of pools, riffles, and glides sampled (macrohabitat selection).				
Statistic	Critical Value	P	H_o	H_a
$\chi^2 = 256.8$	$\chi^2 > 5.991$	P<0.001	Reject	Do not reject
Conclude: Juvenile coho salmon were not found in habitat types in the proportions in which they were sampled. Coho were found less frequently in riffles and were selecting pools and glides.				

The results of the Chi-Square analysis indicated that juvenile chinook and coho were selecting pools and glides, and were found less frequently in riffles. Yearling steelhead were selecting riffles and were found less frequently in pools and glides.

Microhabitat sample sizes

Sample sizes used in microhabitat analyses can be found in Table 6. Sample sizes of chinook and coho in the treatment reach were large, providing a valid comparison of habitat use. With the exception of survey 2, sample sizes of chinook in the control reach were large, enabling a comparison of results between the control and treatment reaches. In general, sample sizes of steelhead were small, resulting in large confidence intervals which make it difficult to draw conclusions regarding microhabitat use by steelhead (Table 6).

Table 6. Sample sizes of coho, chinook, and steelhead used in microhabitat use and displacement analyses.

Reach	**Survey**	**Coho (N)**	**Chinook (N)**	**Steelhead (N)**
Treatment	**1**	0	235	18
Control	**1**	0	62	0
Treatment	**2**	94	307	14
Control	**2**	0	3	0
Treatment	**3**	145	482	32
Control	**3**	0	202	8
Total		**239**	**1291**	**72**

Microhabitat use

We used MANOVA to examine microhabitat use in reaches where chinook, steelhead, and coho were sympatric. To meet these criteria, we used data collected in treatment reaches during surveys 2 and 3 only. The dependant variables in the MANOVA model were flow velocity (ft/sec), depth (ft), dominant substrate type, and cover use. Species and survey were the independent variables. The hypotheses tested and the results of the MANOVA are presented in Table 7.

Table 7. Results of MANOVA comparing microhabitat use between chinook, steelhead, and coho.

H_o: Spring chinook, steelhead, and coho use the same microhabitat when all three species occur together					
H_a: Spring chinook, steelhead, and coho do not use the same microhabitat when all three species occur together					
Effect	Test	Value	F	Df effect/error	P
Intercept	Wilks	0.0008	306294	4 / 1065	0.000
Survey	Wilks	0.9572	11.9	4 / 1065	0.000
Species	Wilks	0.8744	18.5	8 /2130	0.000
Survey*species	Wilks	0.9632	5.0	8 / 2130	0.0003
H_o: Reject H_a: Do not reject					
Conclude: Spring chinook, steelhead, and coho do not use the same microhabitat when all three species coexist.					

We rejected the null hypothesis between surveys, between species, and between the interaction of survey and species indicating that spring chinook, steelhead, and coho did not use the same microhabitat in reaches and surveys where all three species coexisted.

Descriptions and comparison of habitat variables, and results of Fisher's LSD to determine where differences in microhabitat use existed are described below.

Flow Velocity

In reaches where juvenile spring chinook, steelhead and coho were sympatric (surveys 2 & 3, treatment reaches), coho used the slowest velocities while steelhead were found in the fastest velocities (Figure 8). Juvenile coho and chinook were both found in areas of higher velocity during the third survey than during the second survey (Figure 8). We observed yearling steelhead in faster currents that chinook or coho, steelhead flow velocities decreased during the third survey.

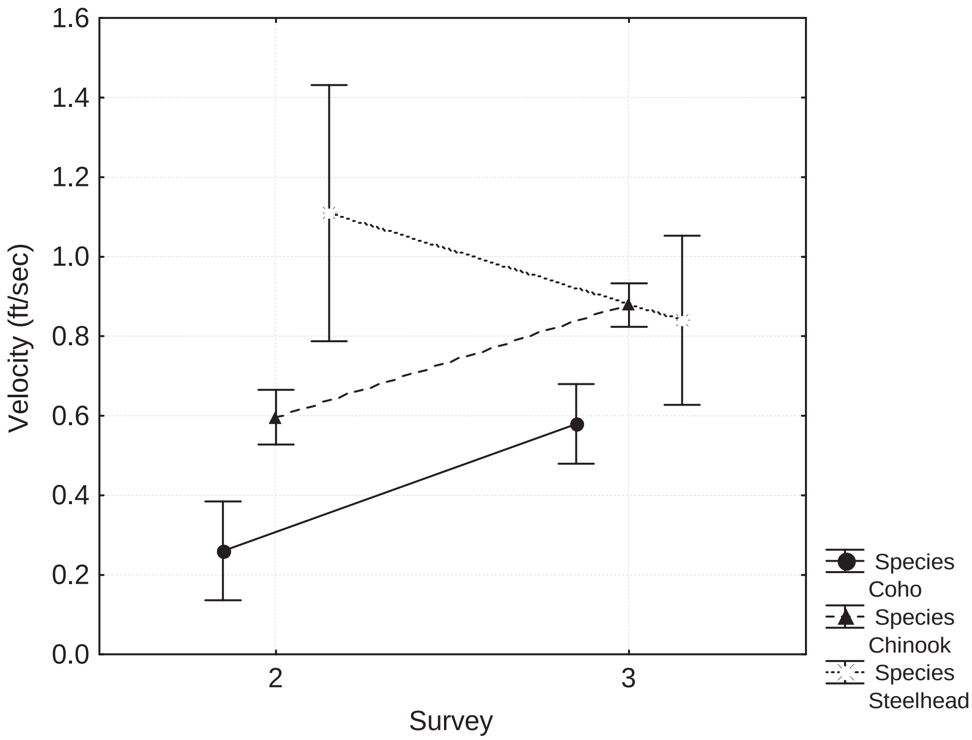

Figure 8. Mean flow velocities used by chinook, coho, and steelhead where they co-occurred (surveys 2 & 3, treatment reaches).
Error bars represent a 95% confidence interval.

Results of Fisher's LSD (Table 8) indicated that during survey 2, coho used significantly slower velocities than chinook or steelhead. Chinook used significantly slower velocities than steelhead, but faster velocities than coho. During survey 3, coho used significantly slower velocities than chinook and steelhead (Table 8).

Table 8. Fisher's LSD matrix of results for differences in observed velocities used by coho, chinook, and steelhead in Nason Creek, 2002.

Cell No.	Survey	Species	**(1)** **coho survey 2**	**(2)** **chinook survey 2**	**(3)** **steelhead survey 2**	**(4)** **coho survey 3**	**(5)** **chinook survey 3**	**(6)** **steelhead survey 3**
(1)	2	Coho		S	S	S	S	S
(2)	2	Chinook	S		S	N	S	S
(3)	2	Steelhead	S	S		S	N	N
(4)	3	Coho	S	N	S		S	S
(5)	3	Chinook	S	S	N	S		N
(6)	3	Steelhead	S	S	N	S	N	

S = significant differences in mean velocities, N = no statistical difference in observed velocities.

<u>Depth</u>

During survey 2, depths in which juvenile chinook, coho, and steelhead were found were similar (Figure 9). Depths where chinook and steelhead were found were similar during both surveys. Coho were observed at greater depths during survey 2 than survey 3 (Figure 9). During survey 3 we observed greater depth separation between the three species. Coho were found in shallower depths than chinook and steelhead (Figure 9).

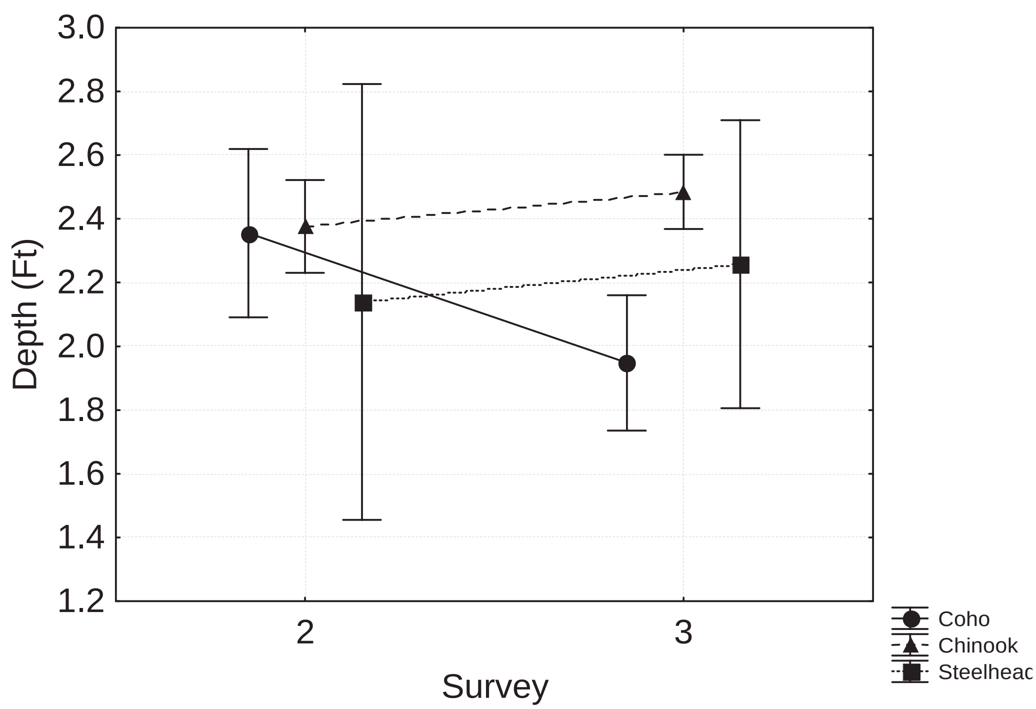

Figure 9. Mean observed depths for juvenile chinook, steelhead, and coho in Nason Creek, 2002.

Error bars represent 95% confidence intervals.

Results of Fisher's LSD test (Table 9) indicated that there was no statistical difference in depths used by juvenile coho, chinook, and steelhead during survey 2. During survey 3, coho used significantly shallower depths than chinook (Table 9).

Table 9. Fisher's LSD matrix of results for differences in observed depths (ft) used by coho, chinook, and steelhead in Nason Creek, 2002.

Cell No.	Survey	Species	**(1) coho survey 2**	**(2) chinook survey 2**	**(3) steelhead survey 2**	**(4) coho survey 3**	**(5) chinook survey 3**	**(6) steelhead survey 3**
(1)	2	Coho		N	N	S	N	N
(2)	2	Chinook	N		N	S	N	N
(3)	2	Steelhead	N	N		N	N	N
(4)	3	Coho	S	S	N		S	N
(5)	3	Chinook	N	N	N	S		N
(6)	3	Steelhead	N	N	N	N	N	

S = significant differences in mean depth (ft), N = no statistical difference in mean depths (ft).

<u>Cover Use</u>

Coho used cover statistically more often than chinook and steelhead during both surveys 2 and 3. The proportion of chinook and steelhead using cover remained the same during surveys 2 and 3, while the proportion of coho observed using cover increased during survey 3 (Figures 10 & 11).

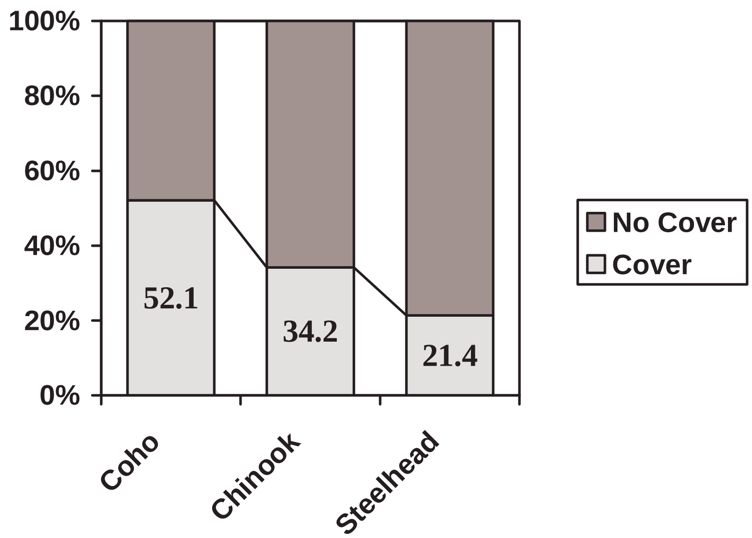

Figure 10. Cover use by juvenile coho, chinook, and steelhead during survey two treatment reaches, Nason Creek, 2002.

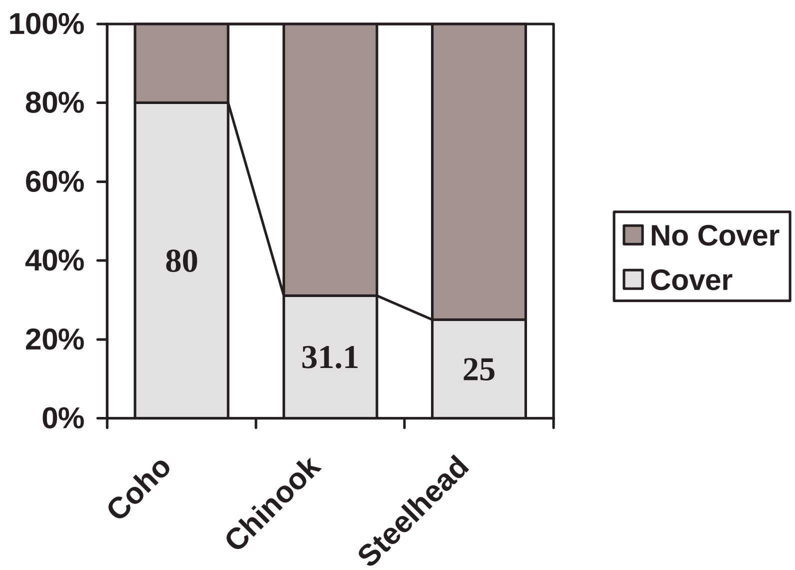

Figure 11. Cover use by juvenile coho, chinook, and steelhead during survey three treatment reaches, Nason Creek, 2002.

Dominant substrate types
The dominant substrate type over which juvenile chinook, coho, and steelhead were found is illustrated in Figure 12. Coho were found most frequently over silt or sand, while chinook and steelhead were more frequently found over larger substrate types (Figure 12).

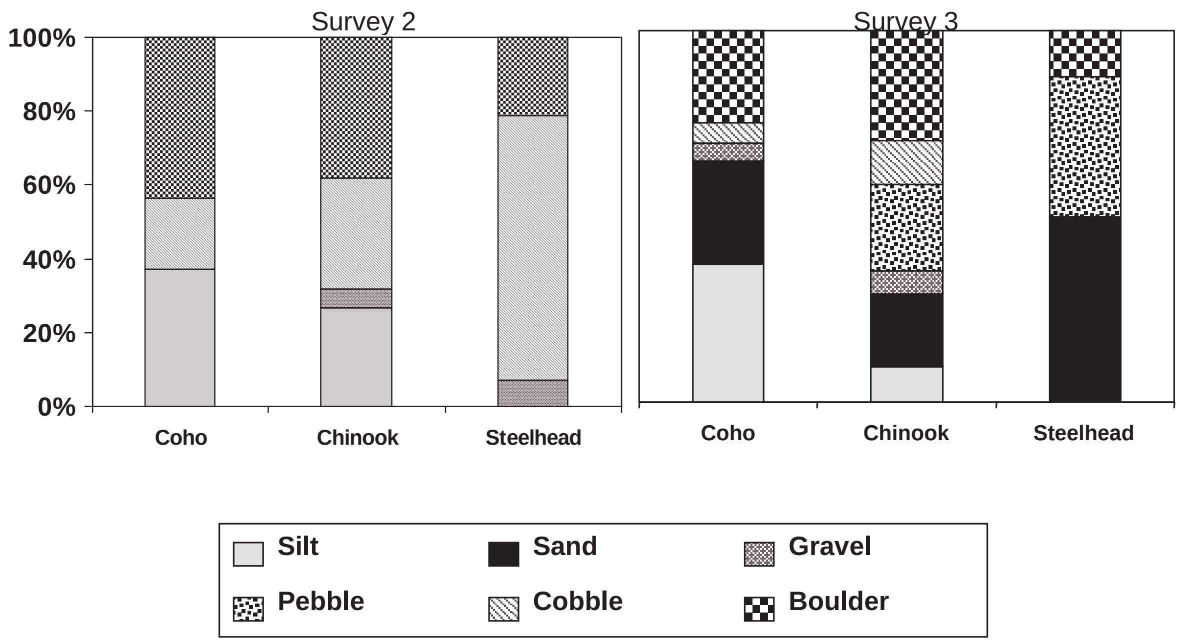

Figure 12. Dominant substrate types where juvenile coho, chinook, and steelhead were observed, Nason Creek., 2002.

Microhabitat displacement

To determine if spring chinook microhabitat use changed after the introduction of juvenile coho salmon, we use MANOVA (Table 10) to compare microhabitat use by juvenile spring chinook in the control and treatment reaches. The first survey served as a temporal control in all reaches.

We rejected the null hypothesis between reaches (treatment & control), between surveys (1, 2, & 3), and between the interaction of reach and survey. Therefore, we conclude that spring chinook did not use the same microhabitat in the treatment and control reaches. Descriptions and comparison of microhabitat variables, and results of Fisher's LSD to determine where differences in microhabitat use occurred are described below.

Table 10. Results of MANOVA comparing microhabitat use by sub-yearling chinook salmon in treatment and control reaches of Nason Creek, 2002.

H_o: Spring chinook used the same microhabitat in treatment and control reaches.					
H_a: Spring chinook did not use the same microhabitat in treatment and control reaches.					
Effect	Test	Value	F	Df effect/error	P
Intercept	Wilks	0.00254	126133	4 / 1282	0.000
Reach (T,C)	Wilks	0.99253	2.4	4 / 1282	0.047
Survey	Wilks	0.80675	36.3	8 / 2564	0.000
Reach*survey	Wilks	0.87593	21.9	8 / 2564	0.000
H_o: Reject H_a: Do not reject					
Conclude: Spring chinook did not use the same microhabitat in the control and treatment reaches.					

Flow Velocities

Within the treatment reach we found no difference in flow velocities used by juvenile chinook before coho were planted (first survey) and after coho were planted (third survey) (Table 11; Figure 13). The sample size in the control reach during the second survey was too small to make the results of the second survey meaningful.

Before coho were scatter-planted (survey 1), flow velocities used by juvenile chinook were significantly faster in the treatment reach than in the control reach. This discrepancy between flow velocities used by juvenile spring chinook maintained itself throughout the evaluation (Table 11; Figure 13). Because of the discrepancy in flow velocities used by juvenile chinook in the control and treatment reaches prior to coho scatter-planting, the temporal control (first survey) may be a better means of evaluating changes in habitat use after coho introduction.

Table 11. Fisher's LSD matrix of results for differences in observed velocities used by subyearling chinook in Nason Creek, 2002.

Cell No.	Treatment	Survey	**(1)* Treat. Survey 1**	**(2) Treat. Survey 2**	**(3) Treat. Survey 3**	**(4) Control Survey 1**	**(5) Control Survey 2**	**(6) Control Survey 3**
(1)*	Treatment*	1		S	N	S	N	S
(2)	Treatment	2	S		S	N	N	S
(3)	Treatment	3	N	S		S	N	S
(4)	Control	1	S	N	S		N	S
(5)	Control	2	N	N	N	N		N
(6)	Control	3	S	S	S	S	N	

S = significant differences in flow velocity (ft/s), N = no statistical difference in mean flow velocities (ft/s).
*The first survey in the treatment reach was pre-coho planting and served as a temporal control.

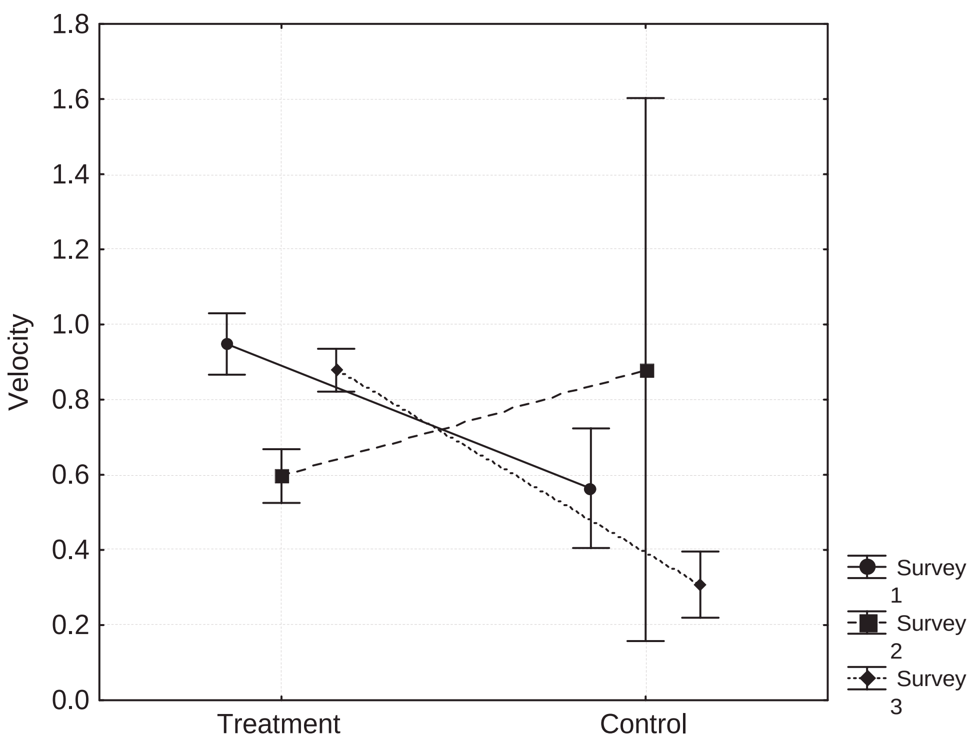

Figure 13. Flow velocities used by juvenile chinook salmon in treatment and control reaches, Nason Creek, 2002.
Note: Survey 1, treatment reach, was surveyed prior to planting coho in the reach and served as a temporal control (not a treatment).

Depth

Within the treatment reach we found a significant difference in depth used by juvenile chinook before coho were planted (temporal control, first survey) and after coho were planted (third survey) (Table 12; Figure 14). After coho were planted, there was no difference in depths used by chinook in the treatment and control reaches (surveys 1 & 3) (Table 12; Figure 14). It is likely that the differences in depth within the treatment reach relate to the declining river flow between the surveys (Figure 1).

Table 12. Fisher's LSD matrix of results for differences in observed depths used by sub-yearling chinook in Nason Creek, 2002.

Cell No.	Treatment	Survey	**(1)* Treat. Survey 1**	**(2) Treat. Survey 2**	**(3) Treat. Survey 3**	**(4) Control Survey 1**	**(5) Control Survey 2**	**(6) Control Survey 3**
(1)*	Treatment*	1		S	S	S	N	S
(2)	Treatment	2	S		N	S	N	S
(3)	Treatment	3	S	N		S	N	N
(4)	Control	1	S	S	S		S	S
(5)	Control	2	N	N	N	S		N
(6)	Control	3	S	S	N	S	N	

S = significant differences in mean depth (ft), N = no statistical difference in mean depths (ft).
* The first survey in the treatment reach was pre-coho planting and surveyed as a temporal control.

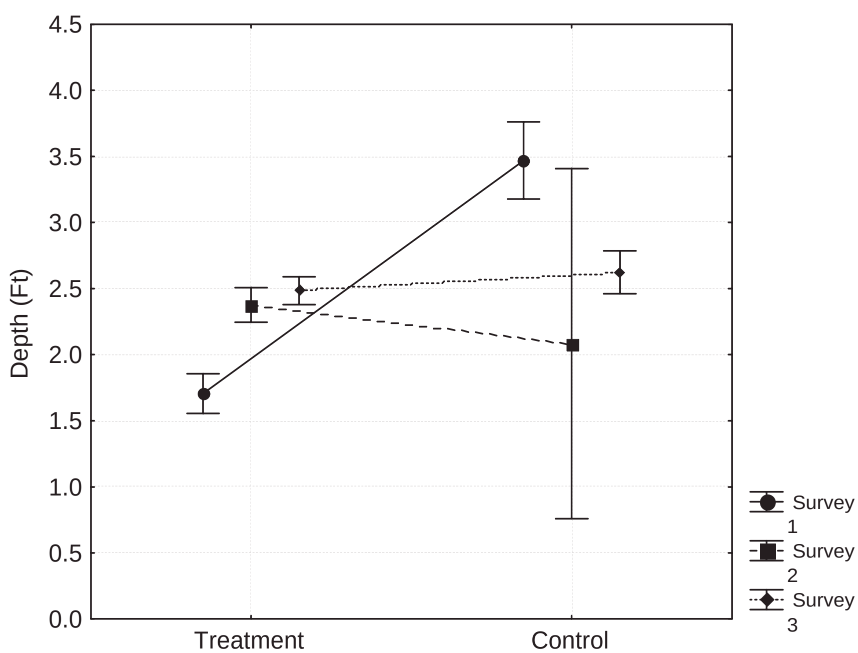

Figure 14. Depths used by juvenile chinook salmon in treatment and control reaches during Surveys 1 through 3, Nason Creek, 2002.

Cover Use

The proportion of juvenile chinook found under cover (woody debris, overhanging vegetation, or undercut bank) was measured in the treatment and control reaches. Cover use in both the control and treatment reaches was the same (Figure 15). Cover use was high in both the control and treatment during survey one, declining during subsequent surveys (Figure 15).

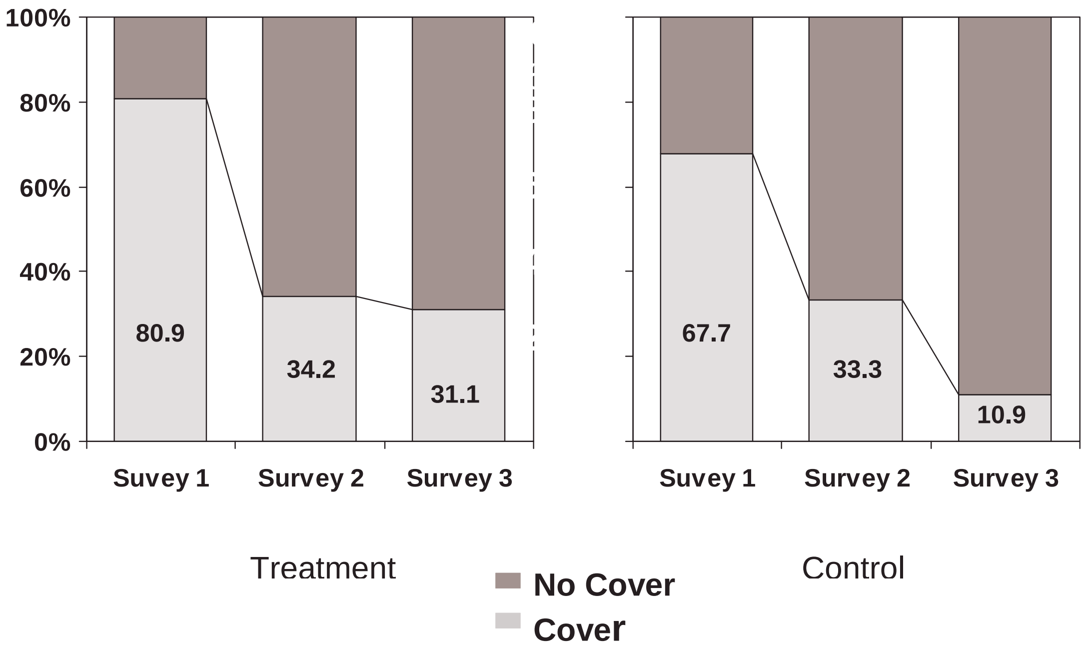

Figure 15. Proportion of juvenile chinook found under cover (woody debris, undercut bank, overhanging vegetation) in the control and treatment reaches, all three surveys, in Nason Creek, 2002.

Dominant substrate

The most common substrate types over which juvenile chinook were observed in the treatment reach were sand, cobble, and boulder (Figure 16). These three substrate types were also common in the control reach. Juvenile coho were observed over gravel more frequently in the control than in the treatment reach (Figure 16).

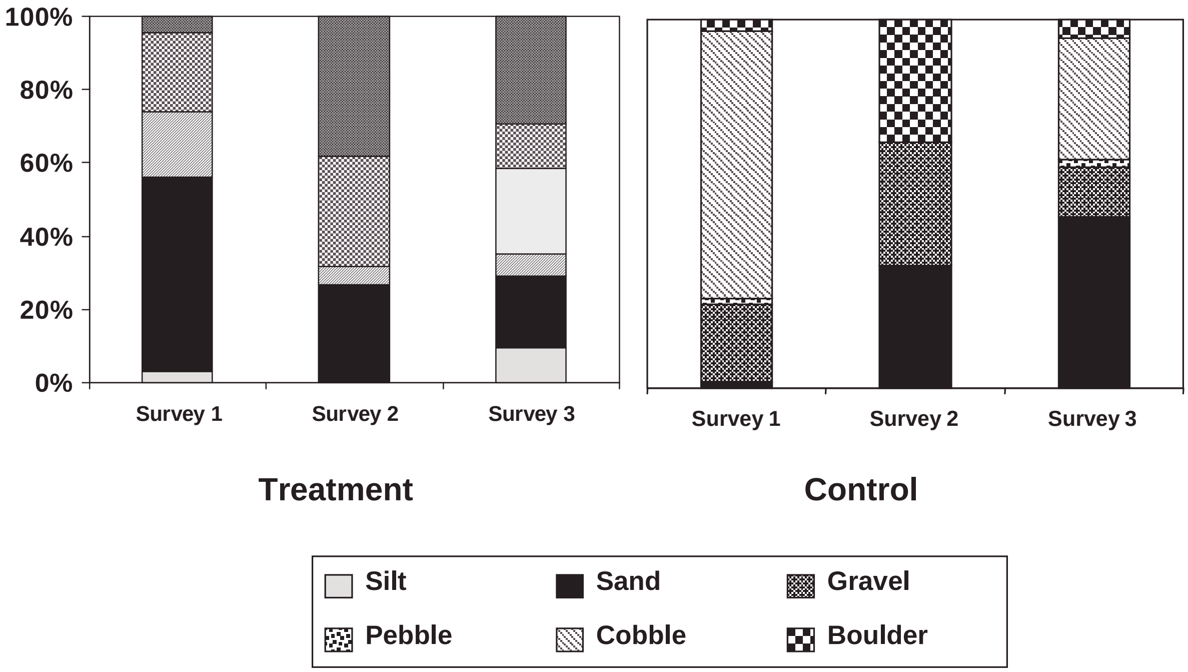

Figure 16. Dominant substrate types over which juvenile chinook were observed in the control and treatment reaches of Nason Creek, 2002.

Growth and condition factors of sympatric spring chinook and coho salmon

We attempted to collect 25 fish of each species from each of the four identified Nason Creek reaches in July, August, and September. The first survey (July) was conducted prior to coho planting and served a baseline or temporal control. We were able to collect the desired sample size of juvenile chinook (Table 13). The number of coho sampled was below the desired sample size, but sufficient for analysis (Table 13). Our steelhead sample fell short of the desired sample size of 25 fish per reach (Table 13). We had little success collecting enough steelhead for the analysis without collecting more chinook than permitting allowed.

For analysis purposes, we pooled data from reaches one and two to form a larger ‘treatment reach’, and we pooled data from reaches three and four to form a larger “control” reach. Pooling the data effectively increased sample sizes in the MANOVA models used in the analysis. Pooling the reaches did not result in steelhead samples sizes large enough to make a valid comparison between surveys and reaches; we therefore eliminated steelhead from the analysis.

Table 13. Sample sizes of juvenile spring chinook, scatter planted coho, steelhead yearlings, and steelhead fry used in growth and condition factor analysis, Nason Creek, 2002.

Reach	Baseline (C)				Sample 2				Sample 3			
	Sp Ch	Coho Plant	Sthd Year	Sthd Fry	Sp Ch	Coho Plant	Sthd Year	Sthd Fry	Sp Ch	Coho Plant	Sthd Year	Sthd Fry
1 (T)	24	0	0	0	34	9	2	9	30	23	2	6
2 (T)	25	0	0	0	28	20	4	8	28	16	3	6
3 (C)	49	0	1	4	31	0	0	14	30	0	5	14
4 (C)	27	0	2	0	28	0	2	9	27	0	0	6

We use MANOVA to compare fork length and fish condition (Kfactor) of chinook and coho where both species coexisted (surveys 2 & 3 treatment reach). To test the null hypothesis that sub-yearling spring chinook, and scatter-planted coho were the same size and condition in August and September, we used FL and Kfactor as the dependant variable in the MANOVA model, and species and survey the independent variable (Table 14).

Table 14. Results of MANOVA comparing spring chinook and coho size and condition where they co-occurred in Nason Creek, 2002.

H_o: Sub-yearling spring chinook, and scatter-planted coho were the same size and condition in August and September.							
H_a: Sub-yearling chinook, and scatter-planted coho were not the same size and condition during August and September.							
Effect	Test	Value	F	Df effect/error	P	H_o	H_a
Intercept	Wilks	0.00593	11315.5	2 / 135	0.000		
Species	Wilks	0.89769	7.69	2 / 135	0.001	Reject	Accept
Survey	Wilks	0.87968	9.23	2 / 135	0.000	Reject	Accept
Species x survey	Wilks	0.99520	0.33	2 / 135	0.723	Do not Reject	Reject
Conclude: There was a statistical difference in FL and Kfactor between juvenile spring chinook and scatter planted coho (both surveys combined). There was a statistical difference in FL and Kfactor between surveys (both species combined). We did not detect a statistical difference in both FL and Kfactor when the interaction of species and survey was considered.							

We rejected the null hypothesis between species (coho, chinook), and between surveys (August, September). We did not reject the null hypothesis for the interaction of species and survey. To further understand and evaluate these results, we used Fisher's LSD test to determine where the differences in size and fish condition existed.

Fork length - sympatric

During both August and September, the FL (mm) of spring chinook was significantly smaller than the FL (mm) of scatter-planted coho (Table 15; Figure 17). The FL of spring chinook in September was statistically longer than the FL of spring chinook in August. There was no significant difference in coho FL (mm) between August and September (Table 15; Figure17).

Table 15. Fisher's LSD matrix of results for differences in fork length (mm) between sub-yearling chinook, and scatter-planted coho where they co-occurred in Nason Creek, 2002. (Treatment reach after scatter planting) S = significant difference in FL, N = no statistical difference in FL.

Cell No.	Species	Survey	**(1) Chinook Aug**	**(2) Chinook Sept**	**(3) Coho Aug**	**(4) Coho Sept**
(1)	Chinook	Aug		S	S	S
(2)	Chinook	Sept	S		N	S
(3)	Coho	Aug	S	N		N
(4)	Coho	Sept	S	S	N	

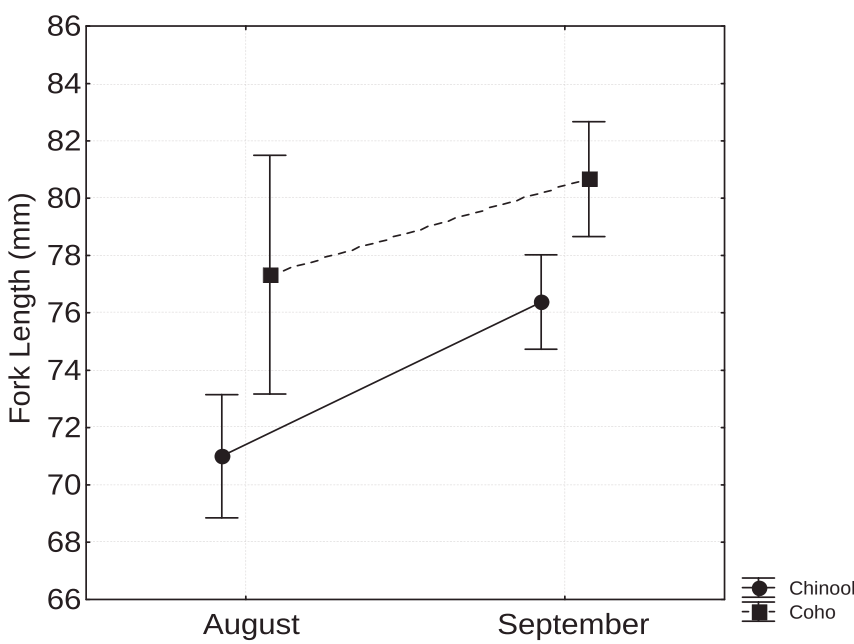

Figure 17. Mean fork length (mm) of sub-yearling spring chinook, and scatter-planted coho in the treatment reach, Nason Creek, 2002.

Fish Condition – sympatric

There was no statistical difference in fish condition (Kfactor) between sub-yearling chinook and scatter-planted coho during August or September (Table 16; Figure 18). However, chinook Kfactors increased significantly between the August survey and the September survey, while the mean Kfactor for coho remained the same (Table 16; Figure 18).

Table 16. Fisher's LSD matrix of results for differences in condition factor (Kfactor) (between sub-yearling chinook, scatter planted coho, yearling steelhead and steelhead fry where they co-occurred in Nason Creek, 2002.

(Treatment reach after scatter planting) S = significant difference in FL, N = no statistical difference in FL.

Cell No.	Species	Survey	(1)	(2)	(3)	(4)
(1)	Chinook	Aug		S	N	N
(2)	Chinook	Sept	S		N	N
(3)	Coho	Aug	N	N		N
(4)	Coho	Sept	N	N	N	

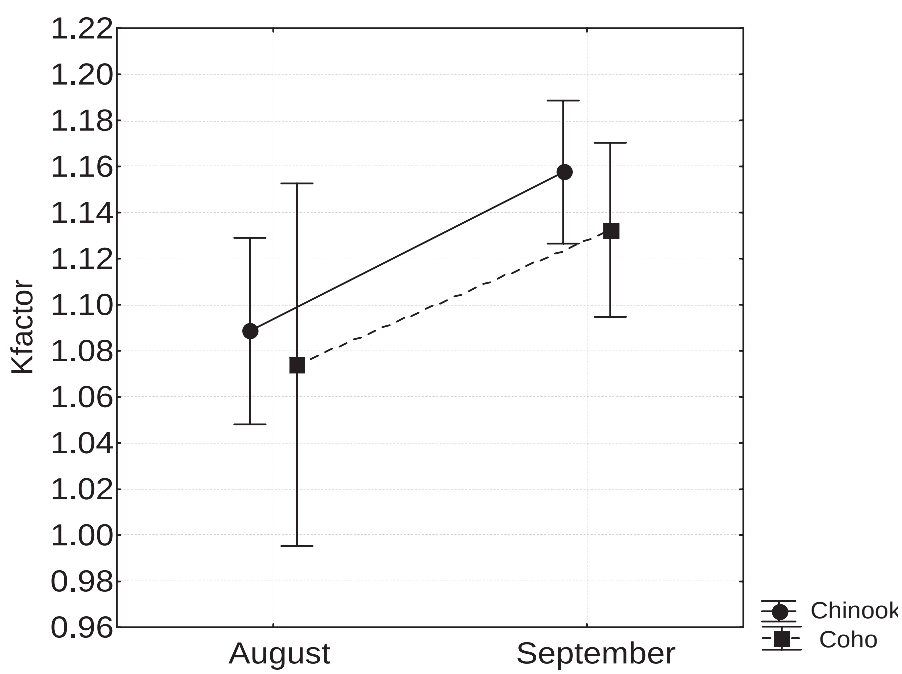

Figure 18. Mean Kfactor of subyearling spring chinook, and scatter planted coho in the treatment reach, Nason Creek, 2002.

Growth and condition factors of juvenile spring chinook in control and treatment reaches

We used growth and condition factors of spring chinook in control and treatment reaches, before and after scatter-planting juvenile coho salmon to evaluate competition for resources (food and/or space). Theoretically, if competition for resources exists, at coho scatter-planting densities, to such an extent as to negatively affect the population of juvenile chinook salmon, we should be able to measure a decline in growth rates and/or fish condition in areas where both species occurred when compared to reaches without coho salmon.

We used MANOVA to compare spring chinook FL (mm) and Kfactors in the treatment and control reaches, before and after scatter-planting coho salmon (Table 17). Dependant variables in the model were reach (treatment or control) and survey (July, August, and September). The July survey occurred prior to scatter-planting juvenile coho and served as a baseline for comparison, or temporal control.

Table 17. Results of MANOVA comparing spring chinook size and condition in the control and treatment reach, Nason Creek 2002.

H_o: Spring chinook were the same size and condition in control and treatment reaches during each survey.							
H_a: Spring chinook were not the same size and condition in control and treatment reaches during each survey							
Effect	Test	Value	F	Df effect/error	P	H_o	H_a
Intercept	Wilks	0.00939	17301.5	2 / 327	0.000		
Reach (T,C)	Wilks	0.98530	2.44	2 / 327	0.089	Accept	Reject
Survey	Wilks	0.26197	155.9	4 / 654	0.000	Reject	Accept
Reach x survey	Wilks	0.99104	0.74	4 / 654	0.566	Accept	Reject
Conclude: There was no significant difference in FL or fish condition (Kfactor) in the treatment and control reaches, before and after scatter-planting coho.							

The results of the MANOVA indicated no significant difference in spring chinook FL and Kfactor between the treatment and control reaches, or between the interaction of reaches and surveys (Table 17). There was a significant difference in spring chinook FL and Kfactor between surveys (July, August, and September) (Table 17).

Fork Length

The mean fork length and the change in mean fork length (growth) between surveys in the treatment reach mirrored the control reach (Figure 19). During the evaluation, growth rates increased the most between the first and second surveys in both the control and treatment reaches. In the control reach, the mean FL of chinook increased 22.6 mm between the July survey and the August survey, and increased 21.1 mm between July and August in the treatment reach (Figure 19). Fork length continued to increase into September; however, the rate of increase declined. Between August and September, the mean FL of chinook increased 3.2 mm and 4.7 mm in the control and treatment reaches respectively. The total increase in the mean FL of spring chinook from the beginning of the evaluation through the last survey was exactly 25.8 mm in both the treatment and the control reaches (Figure 19).

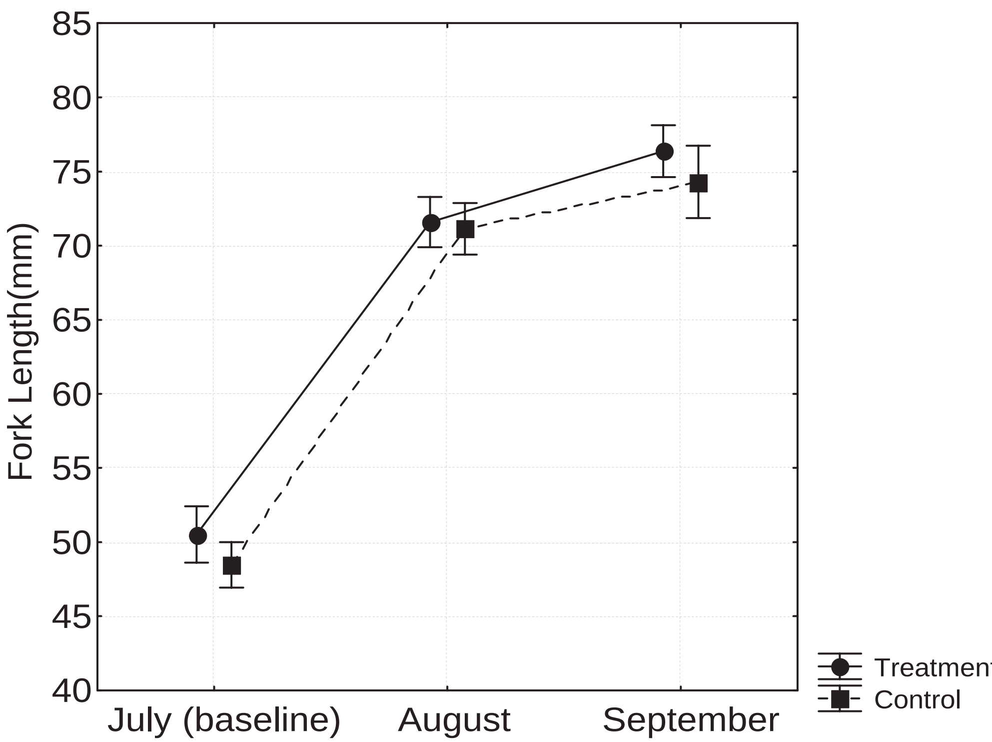

Figure 19. Fork length (mm) and growth of spring chinook in treatment and control reaches, Nason Creek, 2002.

Fish Condition

There was no significant difference in the mean Kfactor of juvenile spring chinook in the treatment and control reaches during any of the surveys (July, August, or September). Within the control reach, mean Kfactor did not change significantly between any of the surveys (no difference in July, August, or September). Within the treatment reach, there was no change in Kfactor between the July and August surveys, but spring chinook Kfactors increased significantly in the treatment reach during the third survey (September; Figure 20). During the evaluation, growth rates increased the most between the first and second surveys in both control and treatment reaches. In the control reach, the mean FL of chinook increased 22.6 mm between the July survey and the August survey, and increased 21.1 mm between July and August in the treatment reach (Figure 18). Fork length continued to increase into September; however, the rate of increase declined. Between August and September, the mean FL of chinook increased 3.2 mm and 4.7 mm in the control and treatment reaches respectively. The total increase in the mean FL of spring chinook from the beginning of the evaluation through the last survey was exactly 25.8 mm in both the treatment and the control reaches (Figure 20).

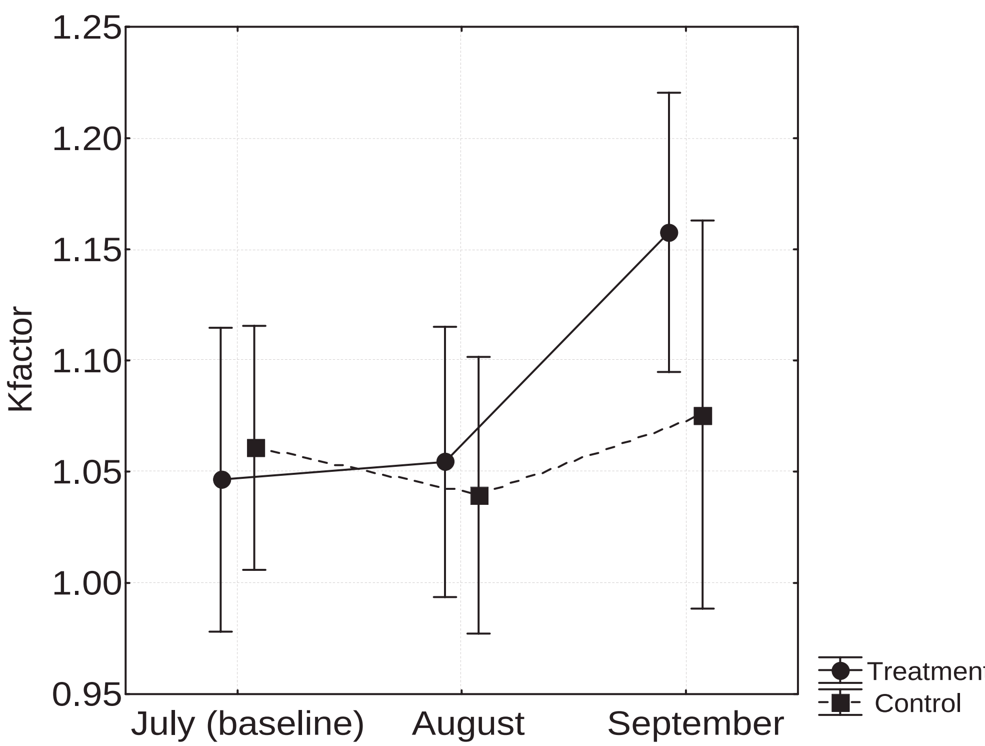

Figure 20. Fish condition (Kfactor) of juvenile spring chinook in treatment and control reaches, Nason Creek, 2002.

DISCUSSION

The results of this evaluation indicated that yearling steelhead, sub-yearling coho, and sub-yearling chinook selected different macrohabitats. Yearling steelhead were selecting riffles, while juvenile coho and chinook both selected pools and glides. The macrohabitat selection we observed in Nason Creek comports well with previously reported habitat use for coho, chinook, and steelhead (Hartman 1965; Lister and Genoe 1970; Allee 1981; Glova 1987; Bisson et al. 1988; Spaulding et al. 1988; Murphy et al. 1989; Bugert and Bjornn 1991; Taylor 1991; Nichelson et al. 1992; Beecher et al. 2002; Hicks and Hall 2003).

Each species is best adapted to only a subset of all the conditions within a stream. The total microhabitat used by a species can be divided into preferred microhabitat and non-preferred microhabitat (Hearn 1987). Two mechanisms contribute to the segregation of salmonid species: interactive segregation is produced by competition-related behavioral interactions, while selective segregation results from the process of natural selection and implies innate differences which lead to species-specific habitat use regardless of whether the other species is present. Innate differences between salmonid species contribute to habitat segregation through such mechanisms as differences in habitat preference and timing of fry emergence and body morphology; these differences have been well documented. Stream dwelling salmonids which have evolved in sympatry have developed mechanisms to promote coexistence and partition the available habitat. Studies with coho salmon and steelhead trout (Hartman 1965; Johnson 1967; Frasier 1969; Allee 1974), chinook salmon and steelhead trout (Everest and Chapman 1972), chinook salmon and coho salmon (Lister and Genoe 1970; Stein et al. 1972; Murphy et al. 1989), coho salmon and cutthroat trout (Bjornn 1971; Bustard and Narver 1975; Sabo and Pauley 1997) and coho salmon and dolly varden (Dolloff and Reeves 1990) all support this statement.

Based on observed macro- and microhabitat use, juvenile chinook, steelhead and introduced coho salmon did not use the same set of habitat conditions. Coho used significantly slower velocities than both chinook and steelhead. Initially, mean depths where all species were found were similar, but as the river flows decreased, depths used by coho decreased, while depths used by chinook stayed the same (surveys 2 & 3). Similarly, Taylor (1991) reported that coho and chinook used different microhabitats in two streams where both coho and chinook were sympatric. Coho used slow water, deep pool areas while chinook were found in faster water (Taylor 1991). Taylor (1991) inferred that the differences in habitat use were the result of species-specific differences in habitat preference and not behavioral interaction because chinook made greater use of faster water and riffle habitats when they were introduced alone or with coho. In an experimental stream, coho were more abundant than steelhead in pools (Allee 1981), but when the stream channel habitat was all riffle, or divided equally into pools and riffles, spatial overlap by coho and steelhead occurred in the stream channel, but simple competitive exclusion in either habitat type was not evidenced (Allee 1981). Within pools, vertical stratification was observed. Coho were distributed near the surface, while steelhead were found near the bottom of pools (Allee 1981).

Juvenile chinook and coho respond differently to a decrease in water flow, and generally move in different directions in response to the change (Shirvell 1994). As stream flow decreases, juvenile coho typically move upstream and parallel to the shore, while juvenile chinook moved offshore and downstream (Shirvell 1994). Movement patterns in response to flow change, as described by Shirvell (1994), may have resulted in the decreasing water depths used by coho and the maintenance of water depth observed for juvenile chinook in Nason Creek. It is also an example of the innate differences in habitat selection, which may result in selective segregation between juvenile chinook and coho salmon in Nason Creek.

We found coho under cover (in-stream and/or overhead) more often than chinook or steelhead. There was no difference in cover use by chinook in reaches stocked with coho and the reaches without coho. Cover use by coho comports well with previously reported research; Giannco and Healy (1999) reported that juvenile coho preferred pools with in-stream cover and coho abundance increased as cover complexity increased (McMahon and Hartman 1989).

We found no evidence of chinook habitat displacement with the introduction of coho into the treatment reach. The mean flow velocity used by spring chinook in the treatment reach was the same prior to scatter-planting coho as it was one month after planting coho. While spring chinook used significantly faster velocities in the treatment reach than in the control reach, this trend in flow velocity used by juvenile chinook remained consistent throughout the evaluation. It is likely that the increased flow velocities used by chinook in the treatment reach resulted from the increased proportion of riffles within the treatment reach.

Habitat differences observed by coho and chinook in Nason Creek did not appear to be size related. Due to the use of hatchery coho in this evaluation, the mean coho salmon length was consistently larger than that the mean length of chinook salmon, yet the chinook selected faster water than the coho salmon. Spaulding et al. (1989) used hatchery coho to investigate microhabitat use and competition with chinook (ocean-type) and steelhead in the Wenatchee River and reported this same trend. This differs from Lister and Genoe (1970), who investigated chinook and coho salmon in a British Columbia river, and who document that segregation was maintained by inter-specific size differences, with larger fish occupying faster water. While Lister and Genoe (1970) stated that segregation was based on size, rather than on innate differences in habitat selection, it was still chinook that occupied faster water rather than naturally produced coho, the smaller of the two species.

Spring chinook reached record escapement to the Wenatchee basin and Nason Creek in 2001 (Mosey and Murphy 2002). Three hundred eighty-four spring chinook redds were counted in Nason Creek (Mosey and Murphy 2002). This record number of redds produced the juvenile chinook present in Nason Creek during this evaluation and would account for the high densities of fish observed in the treatment reach. While lower densities of chinook were seen in the control reaches, 46% of the spring chinook redds were located in the control reaches (reaches 3 & 4). It is likely that downstream movements of fish after emergence and during spring runoff contributed to the higher observed chinook and steelhead densities in the treatment reach (reaches 1 & 2). Although spring chinook parr density information is not available for previous years, we assume, based upon the record spring chinook redd counts in Nason Creek (2001), that the number of parr occupying the available habitat during this evaluation was higher than in previous years. The higher chinook densities made 2002 an ideal year to evaluate interactions between chinook and coho.

At stocking densities evaluated in 2002, we believe that juvenile chinook, coho, and steelhead in Nason Creek are segregating based on habitat preferences (selective segregation) rather than on competitive segregation. In a similar evaluation of microhabitat use, growth and competition between coho, chinook (ocean-type) and steelhead in the Wenatchee River, inter-specific aggression between salmon species did not intensify with increased numbers of coho salmon (Spaulding et al 1989), implying that habitat segregation was innate, rather than the result of competitive interactions. In faster water, few chinook salmon were found with coho salmon; in pools, no inter-specific clustering was observed (Spaulding et al. 1989). Steelhead did not aggregate with salmon in pool or riffle habitat (Spaulding et al 1989).

It is possible that with increased densities of coho and/or chinook we could measure a negative interaction to either of the species. However, it is unlikely that the current or proposed release numbers for coho smolts reintroduced into Nason Creek (Kamphaus 2003; Yakama Nation et al. 2001) would result in densities of naturally produced coho as high as during this evaluation. We are unlikely to see another record return of chinook during the time period for the coho reintroduction feasibility study.

Results of the growth and condition factor analysis support the conclusions of our microhabitat evaluation. While growth rates were identical in the control and treatment reaches, chinook had a higher condition factor when they co-occurred with coho than when alone in the control reach. If competition for food or space occurred to such an extent as to have a negative effect on the spring chinook population, we would expect condition factors and/or growth rates to decline in reaches where coho were introduced. Similarly, the introduction of coho to a chinook/steelhead community in the Wenatchee River did not affect the growth rates, densities, or emigration rate of juvenile chinook or steelhead fry (Spaulding et al. 1989).

The use of a hatchery coho parr as a surrogate for naturally produced coho may not have provided exactly the same results as if the evaluation were conducted with naturally produced coho; however, we believe that any negative or competitive interactions were maximized by using hatchery coho. Hatchery coho are larger than naturally produced coho and spring chinook. Much existing literature on competition among salmonids suggests that larger fish generally dominate smaller fish in both inter- and intra-specific competition (Griffith 1972; Abbot et al. 1985; Hearn 1987; Chandler and Bjornn 1988; Hughes 1992; Sabo and Pauley 1997). In addition to the possible size advantage, hatchery experience may contribute to aggressive dominance of coho salmon (Spaulding et al 1989). Hatchery experience provided juvenile Atlantic salmon an aggressive advantage over other wild fish (Fenderson et al. 1968; Dickson and MacCrimmon 1982). Similarly, residual hatchery steelhead have been shown to dominate over wild rainbow trout (McMichael et. al. 1997). Any negative effects of competition to spring chinook should have been exacerbated by the use of hatchery coho as a surrogate for naturally produced coho.

While the coho were introduced to Nason Creek, the juvenile chinook and steelhead were naturally produced, establishing prior residence in the creek. It is possible that prior residence and resulting established territories gave the spring chinook and steelhead a competitive advantage over scatter-planted coho parr. There is limited data specifically pertaining to potential effects of prior residence among salmonids in inter-specific competition evaluations. Allee (1974; 1981) reported that prior residence did not provide either coho or steelhead with exclusive habitat occupancy. Coexistence was always the outcome (Allee 1981). Innate species-specific habitat selection seemed to be the more important determinant of final population structure than prior residence (Allee 1981).

Spring chinook salmon in Nason Creek evolved with coho. On an evolutionary time scale, the extirpation of coho in the Wenatchee basin has been very recent. Introductions that produce sympatry between populations of species that have evolved together elsewhere are less likely to result in intense competition than introductions that bring together species that are not naturally sympatric (Hearn 1987).

Based on the results of this evaluation, we believe that, at the sub-yearling coho parr densities that may result from the temporary maximum recommended coho spawning escapement numbers (memo from NMFS 6/29/01), coho do not negatively affect sub-yearling chinook and yearling steelhead through the mechanism of competition. Juvenile coho, chinook, and steelhead appear to have innate differences in habitat selection. At the fish densities evaluated, Nason Creek can support the observed differences in habitat selection, resulting in increased biomass and salmonid production.

We propose to repeat this evaluation in 2003 with a few minor changes to the study design. We will use a habitat-based approach as described in Hankin (1984), and will take microhabitat measurements from 20% of the available habitat. We will reduce the treatment and control reaches to reaches one and three respectively.

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CHAPTER 3: COHO RADIO-TELEMTRY: COLUMBIA, WENATCHEE, ENTIAT AND METHOW RIVERS

INTRODUCTION

Coho salmon, reintroduced to mid-Columbia tributaries, have a significantly longer spawning migration (500 - 600 miles) then the stocks from which they originated (150-200 miles). A goal of the mid-Columbia coho reintroduction feasibility study is to determine whether a local brood can be developed from lower Columbia River stocks. The increased migratory distance will likely result in strong selective pressures during the first generations of broodstock development. With divergence from the founding stocks, we may see a change in migration timing, spawn timing, egg size, or other phenotypic traits as a result of the selective pressures associated with the increased migration length.

Anadromous salmon migrations are energetically expensive (Hinch and Rand 2000). The duration of a migration or travel time is often a critical variable in determining the cost of migration (Zable 2002). Natural selection for greater energy reserves prior to migration is perhaps the most likely mechanism by which migratory costs are ameliorated (Kinneson et al. 2001). Wild salmon with longer freshwater migrations, such as Yukon River chum salmon, can have nearly four times the energy reserves (primarily fat content) found in salmon from coastal populations (Brett 1995).

In addition to greater energy reserves, long-distance migrants should be efficient in their use of energy, minimizing swimming costs wherever possible (Hinch and Rand 2000). Bernatchez and Dodson (1987) compared energetic costs of migration for short- and long-distance upriver migrating anadromous fish and concluded that only the long-distance migrants swam at energetically optimal speeds. Hinch and Bratty (2000) used electromyogram telemetry to estimate swimming speeds of sockeye salmon migrating through Hells Gate in the Fraser River, British Columbia. This 150-meter reach is energetically costly for migrating sockeye because of its fast and turbulent currents (Hinch and Rand 1998). Migrants that successfully ascended this reach swam at "optimal" speeds, while those of the unsuccessful group swam at faster than optimal speeds. All of the unsuccessful migrants descended downstream, never passing Hells Gate, and died prior to spawning. Hinch and Bratty (2000) suggested that the ability to swim at energetically optimal speeds may be under strong natural selection pressures.

The trade-off between reproductive investment and migration should be an important factor shaping the evolution of life history traits among populations following their radiation, or introduction, into habitats with different migratory costs (Kinneson et al.

2001). Long-migrating salmon need to conserve energy during their migration to ensure that they can reach the spawning ground and still have enough energy to mature and successfully spawn. However, they may have a limited amount of time to reach spawning areas; migrational delays could have a negative effect on fitness (Hinch and Rand 2000). Salmon that migrate long distances are under strong selective pressure to complete spawning early enough to ensure sufficient degree-days for eggs and alevin development, and to reduce chances of over-winter mortality cause by spawning ground freeze-up (MacDonald and Williams 1998). Kinneson et al. (2001) examined the effects of altered migration distance on reproductive investment in chinook salmon and found that the cost of a longer migration appears to come not only as a cost to tissue energy reserves, but also as a cost to ovarian investment, primarily egg size.

The selective pressures described by Bernatchez and Dodson (1987), Brett (1995), Hinch and Bratty (2000), Hinch and Rand (2000), and Kinneson et al. (2001) are similar to the selective pressures that may face reintroduced coho salmon returning to mid-Columbia tributaries. Returning coho that do not have enough energy reserves to migrate 500 – 600 miles will drop out and die, or will stray to closer spawning locations.

Through the broodstock development process, we expect to see selection for traits that support the increased migration distance. These traits may include altered run-timing, egg size, or energy reserves. The expression of these phenotypic traits should result in increased SARs for reintroduced coho and a reduction in dropout and stray rates along the migratory route.

High dropout or stray rates of returning reintroduced coho salmon may be a potential factor that could limit project success. Sufficient numbers of adults must return to mid-Columbia tributaries to be collected for the broodstock development process. Observations made during the first coho returns to the Wenatchee River basin in 2000 and 2001 indicated that some coho are spawning in the mainstem of the Wenatchee and Methow rivers as well as on other tributaries along the migratory route, such as the Entiat River (C. Hamstreet, USFWS, personal communication) and Chelan Falls (C. Snow, WDFW, personal communication). The numbers of coho spawning in lower mainstem tributaries of release and other locations is unknown.

In 2002 we initiated a radio-telemetry evaluation to examine stray and dropout rates in adult coho salmon returning to the Wenatchee and Methow rivers to answer questions related to energetics and reintroduction, and to meet the following objectives:

- Objective 1 – To determine the stray rates of coho salmon returning to the Wenatchee and Methow river basins

- Objective 2 – To determine if the development of a local broodstock decreases stray rates of coho salmon returning to mid-Columbia tributaries

- Objective 3- To determine if there is a correlation between run-timing, size, or gender with the ability to return to streams of acclimation

- Objective 4 – To determine the spawning distribution of reintroduced coho salmon.

METHODS

Priest Rapids Dam

We attempted to radio-tag up to 200 coho at Priest Rapids Dam between September 1st and November 15th, 2002. We divided the tags into 3 equally sized tag groups to better evaluate the effect of run timing on return, stray, and drop-out rates (Table 1).

The Priest Rapids Dam fish trap (CWT trap) is located at the upstream end of the east fish ladder. Trapping at the dam was done in conjunction with WDFW's steelhead stock assessment sampling. During the radio-tag evaluation, the CWT trap was operated twice a week between August 27th and November 17th, typically between 8AM and 4PM. At the end of the trapping period, the denil fishway was turned off and passage through the fish ladder resumed.

During the trapping operations at Priest Rapids Dam, all coho greater than 50 cm were radio-tagged by YN personnel. Steelhead were sampled by WDFW, and all adult chinook and coho jacks were counted, recorded, and returned to the river.

Radio-tagged coho were held in a fish transport tank with a constant supply of freshwater for a minimum of one hour, but up to 8 hours for recovery. Radio-tagged coho were transported 1.5 miles upstream and released at the Desert Aire boat ramp. The upstream transport was intended to minimize fallbacks over Priest Rapids Dam.

Table 1. Tag group timing, dates, and tag goal, Priest Rapids Dam 2002.

Timing	Dates	Tag Goal
Early Run	Aug. 27 – Oct. 6	13 fish/week
Middle Run	Oct. 7 – Oct. 25	22 fish/week
Late Run	Oct. 25 – Nov. 15	22 fish/week

Tumwater Dam
We attempted to tag an additional 30 coho at Tumwater Dam in the Wenatchee River basin. By increasing the number of radio-tags implanted into coho with a known destination (Nason Creek), the radio-tags used at Tumwater Dam allowed for a more detailed evaluation of spawning areas in the upper Wenatchee basin.

We passively operated the Tumwater Dam fish trap three days per week from October 9th through November 29th, 2002. We typically set the trap at 7:30 a.m. by gating off the fish ladder and turning on the denil fishway, which shunted upstream migrants into a holding area. We checked the trap at 3:30 p.m., turned the denil fishway off, and resumed passage in the fish ladder.

Any coho larger than 50 cm were radio-tagged. Radio-tagged coho were held in a fish tote for a one-hour recovery period, and then transported ¼ mile upstream to "The Alps" for release. The upstream transport was intended to prevent fallbacks over Tumwater Dam. All incidentally trapped fish were counted, recorded, and released into the Wenatchee River.

Tagging Procedures
All trapped coho were anesthetized in a solution of MS-222. After the fish was sedated, FL was measured to the nearest millimeter. The coho was placed on its back in a trough designed to support the fish, and was either tagged in the water (at Priest Rapids Dam) or was kept wet with sprinklers (Tumwater Dam). The radio-tag was activated and checked with a receiver to ensure that it was functioning prior to use. A small rubber O-ring was placed around the radio-tag to prevent regurgitation. The radio-tag was then inserted gastrically using a plastic pipette as a push-rod. Proper placement of the tag was determined by feel as the tag was inserted. While still anesthetized, the tagged coho was placed in a rubber sock filled with water and either hoisted up (Priest Rapids Dam) or carried (Tumwater Dam) to the recovery/transport tank.

Equipment
We used Lotek MCFT-CA coded transmitters in the evaluation. The transmitters used at Priest Rapid Dam were compatible with the digital spectrum processors (DSPs) used at the mainstem fixed stations (Wanapum Dam, Rock Island Dam, Rocky Reach Dam, and Wells Dam). The transmitters used at Priest Rapids Dam were also equipped with a 6-month "kill" switch, ensuring that the tags were deactivated after the evaluation was complete, and reducing the chance of interfering with future evaluations in the Columbia River. The same Lotek MCFT-CA coded transmitter was used at Tumwater Dam; however, the Tumwater Dam radio-tags were not DSP compatible (could not be detected at mainstem fixed stations) and had a tag life of 685 days (1.9 years). The tag life on the Tumwater tags allowed us to locate and recover the transmitters, manually turn them off, and re-use the

tag in future evaluations. Lotek SRX_400 receivers were used during mobile tracking and at the fixed stations.

Fixed Detection Sites

We monitored the upstream migration of radio-tagged coho through a series of fixed detection sites. Several of the fixed detection sites were owned by the mid-Columbia PUDs and operated by Bioanalysts and/or LGL Limited. The location of each fixed detection site can be found in Table 2.

Table 2. Locations of fixed stations in the mid-Columbia River, 2002.

Fixed Detection Site	Location	Site Owner/Operator
Wanapum Dam	Fish Ladder Exits (2)	Grant PUD/LGL Ltd.
Rock Island Dam	Fish Ladder Exits (3)	Chelan PUD/Bioanalysts
Wenatchee River	Monitor	Chelan PUD/Bioanalysts
Wenatchee River	Tumwater Dam	USFWS/ YN&USFWS
Wenatchee River	Upper Wenatchee R. Bridge	USFWS/ YN&USFWS
Nason Creek	Campground	YN/YN
Nason Creek	Butcher Creek Acc. Site	YN/YN
Entiat River	Mouth	Chelan PUD/Bioanalysts
Entiat River	Entiat NFH	YN/YN
Wells Dam	Fish Ladder Exits (2)	Douglas PUD/LGL Ltd.
Methow River	Mouth (RKM 3)	Douglas PUD/LGL Ltd.
Methow River	Carlton Acclimation Ponds	YN/YN
Okanogan River	Mouth	Douglas PUD/LGL Ltd.

Fixed stations owned by the Yakama Nation or the USFWS were downloaded and operated by YN. The YN sorted and processed the raw data files from these stations. Fixed stations owned by Chelan PUD were operated and downloaded by Bioanalysts; the data were then sent to LGL for sorting and summarizing. LGL Ltd. then provided the coho data to the YN. Stations owned by Grant and Douglas PUDs were operated and downloaded by LGL Ltd. LGL Ltd. sorted and summarized the data and then provided the coho data to the YN.

Mobile Tracking

Mobile tracking in the Wenatchee River was usually conducted with a truck-mounted antenna once or twice a week. We also mobile tracked by raft in Icicle Creek and in the Wenatchee River during spawning ground surveys.

We mobile tracked by truck along the Columbia River between the Wenatchee River and Priest Rapids Dam twice a week while driving to the tagging site. Mobile tracking on the Columbia River between the Wenatchee River and Methow River was typically done once per week en-route to download receivers in the Methow River.

We mobile tracked the entire distance of the Columbia River from Priest Rapids Dam to the mouth of the Methow River by powerboat once after tagging was completed. During this survey we searched for coho unaccounted for at the fixed sites.

RESULTS

We tagged 14 coho at Priest Rapids Dam during the 12 weeks that we assisted in trap operation and were present to tag coho. The mean FL of tagged coho measured 57 cm (SD = 8.7 cm). All adult coho trapped and tagged passed Priest Rapids Dam between October 8th and October 31st (Table 3). A total of 27 jacks and 15 adults were trapped during this time period (Figure 1). The jacks were too small to tag and one adult regurgitated its tag in the transport tank and was eliminated from the sample.

Table 3. Dates, coho fork length, and transmitters used, Priest Rapids Dam 2002.

Date	Time Tagged	Fork Length (mm)	Gender	Frequency	Code
Oct. 8	16:42	502	F	148.500	187
Oct. 10	10:15	500	F	148.560	183
Oct. 10	11:05	505	M	148.560	202
Oct. 10	15:30	535	M	148.560	180
Oct. 10	15:35	500	F	148.560	199
Oct. 10	15:40	550	F	148.500	183
Oct. 10	15:45	560	F	148.560	198
Oct. 15	11:10	530	F	148.520	192
Oct. 15	16:00	500	F	148.540	156
Oct. 22	12:00	645	M	148.560	170
Oct. 22	14:27	723	M	148.540	163
Oct. 22	14:35	750	M	148.520	188
Oct. 24	14:27	520	F	148.540	164
Oct. 31	14:05	660	M	148.540	162

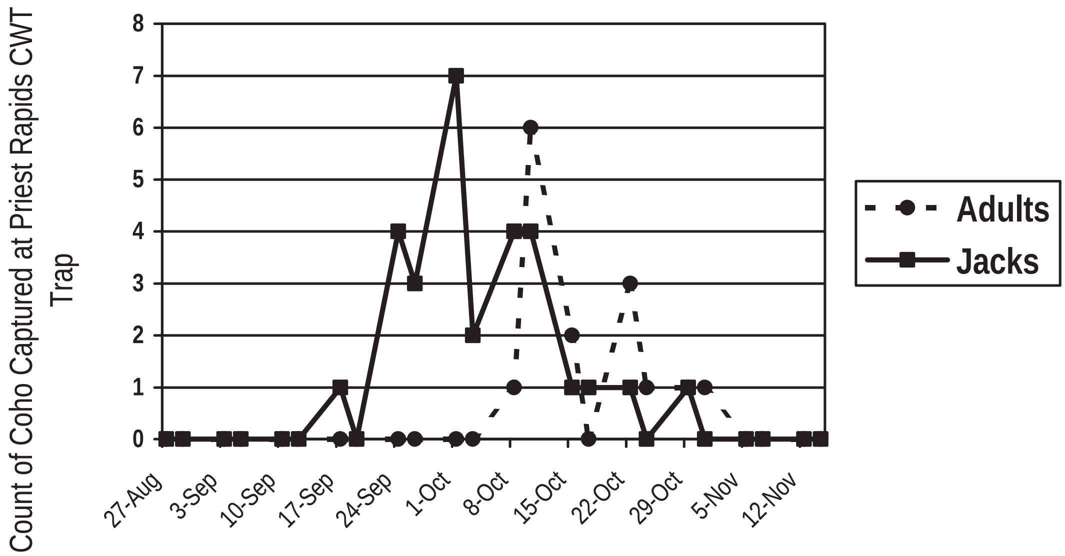

Figure 1. Distribution of adult and jack coho trapped at Priest Rapids Dam, 2003.

Of the 14 fish tagged, only two were tracked back to their tributary of release (Table 4). The other twelve were never detected passing Wanapum Dam or further upstream. One fish was discovered dead on Buckskin Peninsula, and two other fish were detected between Priest Rapids and Wanapum Dam while mobile tracking; it is unknown whether these fish were alive or dead at the time of detection. Both coho tracked to tributaries were tagged the same week (1^{st} & 3^{rd} fish tagged) and were among the smallest fish tagged (50.2 cm and 50.5 cm).

Table 4. Detection histories for radio-tagged fish returning to tributaries of release, 2002.

Channel and Code	Gender	Size (mm)	Location	Date/Time
Ch 210 Cd 187	Female	502	Release @ Desert Aire	Oct. 8 @ 17:20
			Wanapum Exit	Oct. 20 @ 9:32
			Rock Island Exit	Oct. 26 @ 15:59
			Wells Dam Exit	Oct. 28 @ 10:22
			Methow Mouth – Mobile Track	Nov. 21 @ 10:46
			Methow Mouth Fixed Station	Nov. 21 @ 18:37
			Methow R. RM 18.2 - Mobile	Dec. 4 @ 10:30
			Methow R. RM 18.2 - Mobile	Dec. 19 @ 10:15
Ch 213 Cd 202	Male	505	Release @ Desert Aire	Oct. 10 @ 17:15
			Wanapum Exit	Oct. 15 @ 16:18
			Rock Island Exit	Oct. 18 @ 8:46
			Wenatchee River above Cashmere - Mobile	Oct. 22 @ 7:17
			Icicle River near bridge – Mobile	Nov. 21 @ 14:30
			Wenatchee River downstream of Cashmere – Mobile	Dec. 26 @ 12:00

DISCUSSION

Low SARs (see Chapter 6) in 2002 (brood year 1999) resulted in an inability to trap and tag enough adult coho to meet the objectives outlined in the chapter ‘Introduction’ or to draw any meaningful conclusions. During a year with larger coho returns, this evaluation has the potential to provide meaningful information regarding the broodstock development process, run timing, straying, and the survival of coho returning to mid-Columbia tributaries.

During this evaluation, 1529 coho (adults and jacks) passed over Priest Rapids Dam (based on dam counts). The CWT trap was operated twice a week for eight hours a day; under this operational plan, the estimated efficiency for adult steelhead passing over Priest Rapids Dam is 10% (A. Viola personal communication). A 10% trap efficiency should have resulted in trapping approximately 153 coho. Either the CWT trap was not as efficient in 2002 as in previous years, the dam counts are not correct, or the trap efficiency for coho is markedly different than the efficiencies for steelhead.

While we were unable to meet the objectives of this evaluations and answer key questions regarding drop-out and stray rates during the 2002 coho return, some interesting information was gathered. Both fish that returned to tributaries of release were among first tagged fish (1^{st} and 3^{rd}), and were also among the smallest of the radio-tagged coho. However, insufficient data was gathered to correlate run timing or fish size with drop-out rates. The coho that returned to the Methow River held between Wells Dam and the mouth of the Methow River for 21 days. This same fish passed a between Wanapum Dam and Wells Dam in 11 days. This three-week delay between Wells Dam and the mouth of the Methow River may indicate a holding period prior to entering the Methow River. Conversely, the coho tracked to the Wenatchee basin did not delay entering the Wenatchee River. The radio-tagged fish entering the Wenatchee River passed between Wanapum Dam and Rock Island Dam in 3 days and was first detected in the Wenatchee 4 days later.

We plan to repeat this evaluation in 2003. Adult coho returning in 2003 were released as yearling smolts in 2002. During the 2002 smolt emigration, we observed higher downstream survival rates from the Wenatchee basin than in 1999, 2000, or 2001 (Chapter 6). Smolt survival rates from release in Icicle Creek to detection at McNary Dam were 2.5 times higher in 2002 than in 2001 (Chapter 6). We are optimistic that the increased downstream smolt survival rate in 2002 will result in increased SARs and the ability to trap and tag coho at Priest Rapids Dam.

We propose to radio-tag up to 275 adult coho at Priest Rapids Dam, 30 coho at Tumwater Dam, and an additional 25 coho at Wells Dam in 2003. The supplemental tagging efforts at Tumwater and Wells dams will enable us to increase the sample size of coho returning to the upper Wenatchee River and the Methow River, providing valuable in-basin spawning distribution data in addition to information regarding mainstem dropout and stray rates.

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CHAPTER 4: COHO SPAWNING GROUND SURVEYS

INTRODUCTION

The long-term vision of the mid-Columbia coho reintroduction project is to reestablish a naturally reproducing coho salmon population in mid-Columbia tributaries, with numbers at or near carrying capacity (HGMP 2002). A short-term goal for the project’s feasibility phase is to initiate natural production in areas of low risk to listed species and in areas where interactions between naturally reproducing coho salmon and ESA-listed species can be evaluated. The amount of natural production in the Wenatchee River basin is an important project performance indicator.

The information presented in this chapter represents the third year of adult returns to the Wenatchee and Methow river basins. Our efforts described below are fundamental to addressing spawn timing and associated success in the natural environment for the coho returns to the Wenatchee River under the mid-Columbia Coho Reintroduction Feasibility Study. The HGMP (2002) outlines the future monitoring plan to assess the reproductive success of returning coho.

METHODS

In 2002 we surveyed Nason Creek for coho redds weekly or as often as visibility and weather conditions permitted. Spawning ground surveys in Icicle Creek were conducted once every 10 days. In 2002 we expanded our survey area to include the Wenatchee River, Beaver Creek, Chiwakum Creek, Chumstick Creek, Peshastin Creek and Mission Creek. All surveys were completed between mid-October and the end of December. Survey reaches are identified in Table 1. Nason Creek surveys were conducted by foot and extended from Whitepine Creek to the mouth of Nason Creek (RK 25.4 – 0.0). We surveyed Icicle Creek by raft from Dam 5 behind the LNFH to the mouth (RK 4.7 – 0.0). The Wenatchee River was surveyed by raft, with the exception of Tumwater Canyon, at 10-day intervals. The Wenatchee River surveys extended from Lake Wenatchee to the mouth (RK 86.7-0.0). All surveys were completed by one- or two-person teams. Individual redds were marked and cataloged to get precise redd counts and timing. Coho redds were flagged with surveyor's tape tied to nearby shrubbery. Each flag was marked with the date, approximate redd location, and redd number. The number of new redds, live and dead fish, time required to complete the survey and the stream temperature were recorded. Surveyors checked all flags from previous surveys as they searched for new redds. Global positioning (GPS) was used to record the exact location of individual redds on all surveys.

From coho carcasses recovered during the surveys, fork length (FL) and post-orbital hypural length (POH) were measured to the nearest centimeter. Snouts were collected from all carcasses. The snouts were scanned for the presence of coded wire tags (CWT) in the laboratory; all snouts containing CWTs were dissected for tag recovery. Carcass gender was recorded, and female carcasses were checked for egg retention by visual estimation of the percent of eggs voided. We removed the caudal fin from sampled carcasses to prevent re-sampling during later surveys.

Table 1. Spawning ground reaches for Icicle Creek, Nason Creek, and the Wenatchee River used in 2002.

Reach Designation	Reach Description	Reach Location (RK)
	Icicle Creek	
I1	Mouth to E. Leavenworth Br.	0.0-3.7
I2	E. Leavenworth Br. to Hatchery	3.7-4.5
I3	Hatchery to Dam 5	4.5-4.7
	Nason Creek	
N1	Mouth to Kahler Cr. Br.	0.0-6.3
N2	Kahler Cr. Br. to High Voltage Lines	6.3-10.3
N3	High Voltage Lines to Old Wood Br.	10.3-13.3
N4	Old Wood Br. to Rayrock	13.3-20.9
N5	Rayrock to Whitepine Cr.	20.9-25.4
	Chiwakum Creek	
C1	Highway 2 Bridge to Mouth	0.8-0.0
	Chumstick Creek	
CS1	North Rd culvert to Mouth	1.6-0.0
	Peshastin Creek	
P1	River Mile 4 to Mouth	6.4-0.0
	Mission Creek	
M1	Brender Creek to Mouth	3.2-0.0
	Beaver Creek	
B1	Acclimation Pond to Mouth	2.4-0.0
	Wenatchee River	
W1	Mouth to Sleepy Hollow Br.	0.0-5.6
W2	Sleepy Hollow Br. to Monitor Br.	5.6-9.3
W3	Monitor Br. to lower Cashmere Br.	9.3-15.3
W4	Lower Cashmere Br. to Dryden Dam	15.3-28.2
W5	Dryden Dam to Leavenworth Br.	28.2-38.5
W6	Leavenworth Br. to Icicle Rd. Br.	38.5-42.5
W7	Icicle Rd. Br. to Tumwater Br.	42.5-57.3
W8	Tumwater Br. to Lake Wenatchee	57.3-86.3
	Methow River	
M1	Mouth to Carlton Bridge	0.0-43.8
M2	Carlton Bridge to Twisp Bridge	43.8-63.3
M3	Twisp Bridge to Winthrop Bridge	63.3-80.1
M4	Winthrop Bridge to WNFH	80.1-81.0
M5	WNFH to Wolf Creek	81.0-84.9

RESULTS

Icicle Creek

We conducted spawning ground surveys in Icicle Creek between October 18th and December 19th. Twenty-one coho redds were counted and recorded in 2002 (Figure 1; Table 2). The first redd was documented on November 7th, which coincided with the first observations of live coho. Peak spawning occurred during the first week of December, two to four weeks later than peak spawn timing observed in 2000 and 2001 (Figure 2). Nine coho carcasses were recovered—five females and four males. Mean POH for both male and female coho was 46.3 cm (SD =14.1) and 47.2 cm (SD = 5.4), respectively. All females were examined for the presence of eggs within the body cavity. Mean egg voidance was 97.5% and ranged between 90% and 100%. One coded-wire tag was recovered. Most of the redds (62%) were located between the East Leavenworth Road bridge and the mouth of Icicle Creek (Reach 1; I1). Seventy-five percent of the coho redds found in the Wenatchee River basin were located in Icicle Creek (Table 2). Complete survey records can be found in Appendix E.

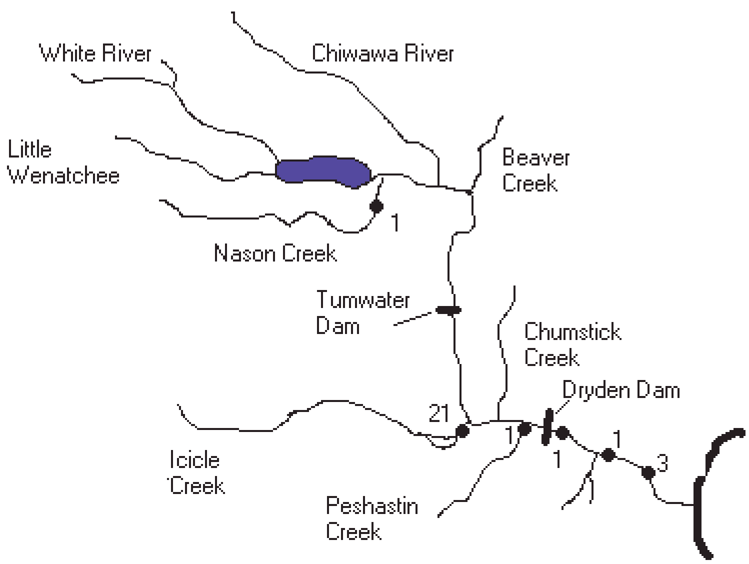

Figure 1. Spatial distribution and number of coho redds in the Wenatchee River basin, 2002.

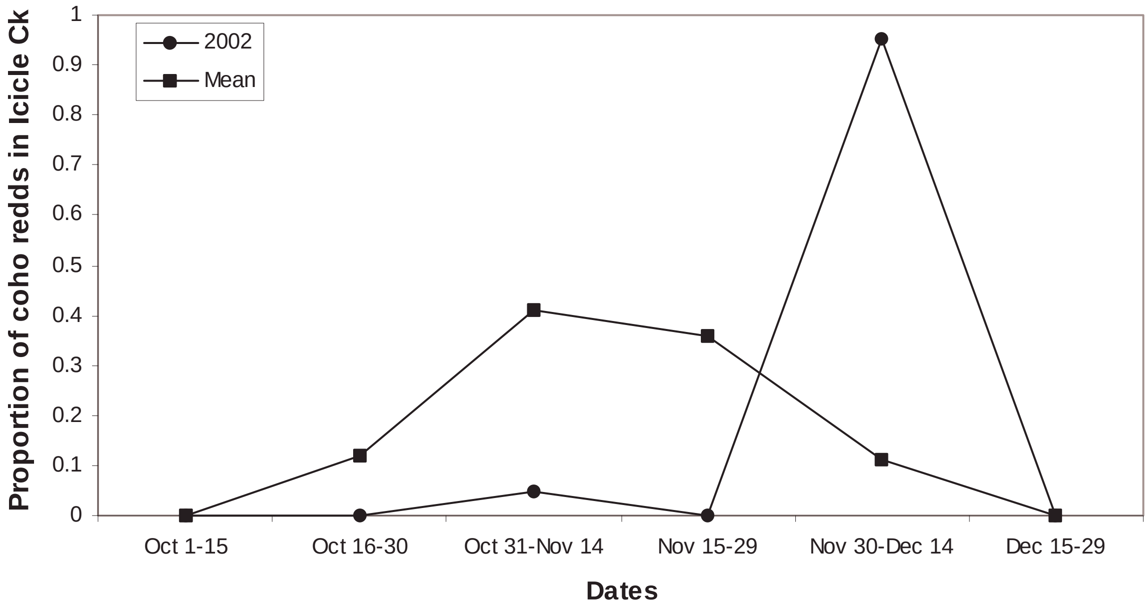

Figure 2. Coho spawn timing in Icicle Creek, 2002.
Note: mean spawn time represents years 2000 and 2001.

Table 2. Summary of coho redds counted in the Wenatchee River basin and the percentage of redds within each river, 2002.

River	No. of Redds	% Of Redds
Icicle Creek	21	75%
Nason Creek	1	3.6%
Peshastin Creek	1	3.6%
Wenatchee River upstream of Dryden Dam	0	0.0%
Wenatchee River downstream of Dryden Dam	5	17.8%
Total	28	100%

Nason Creek
Spawning ground surveys were conducted on Nason Creek between October 16th and December 23rd (Appendix E). Nason Creek was divided into five reaches for spawning ground surveys (Table 1). One redd was identified in Nason Creek on December 5th (Table 2). This redd was located approximately ½ mile upstream from the Nason Creek campground (Figure 2). No live coho or carcasses were observed in Nason Creek. The redd located on Nason Creek represented 3.6% of the coho redds in the Wenatchee River basin. Based on fish way video counts, 11 adult coho (2 F and 9 M) had passed Tumwater Dam in 2002 (WDFW unpublished data).

Wenatchee River
Surveys were expanded in 2002 to include the Wenatchee River. Wenatchee River surveys were divided into eight reaches (Table 1). A total of five redds were identified in the Wenatchee River in 2002 (Table 2). One redd was observed below the right bank of Dryden Dam, another redd was located below Cashmere, and three redds were identified below Monitor (Figure 2). YN personnel found no live coho or carcasses on the Wenatchee River. One male coho carcass was recovered in the Wenatchee River by WDFW personnel during summer chinook spawning ground/carcass surveys. Coho redds located on the Wenatchee River accounted for 17.8% of the observed redds in the Wenatchee Basin (Table 2).

Other Tributaries
Spawning ground surveys were expanded in 2002 to include several small tributaries to the Wenatchee River. These small tributary surveys were single surveys completed at or just after peak spawn. Survey areas included the lower reach of Beaver Creek, Chiwakum Creek, Peshastin Creek, Chumstick Creek, and Mission Creek (Table 2). One coho redd was located in Peshastin Creek approximately 50 meters upstream from the mouth with one live female observed (Appendix E). The Peshastin Creek redd represents 3.6% of the coho redds found in the Wenatchee River basin.

Methow River
Surveys were conducted on the Methow River just after peak spawn to examine the coho spawning distribution. Methow River survey reaches can be found in Table 1. During the week of December 16-20th, a total of 41 redds were found by YN personnel. Thirty-four of these redds were identified upstream of the confluence with the Chewuch River (Figure 3). These redds may have been misidentified chinook redds due to the near record chinook escapement to the Methow basin and the low number of coho females ($N=7$) which were able to return to the Winthrop NFH (Kamphaus 2003). It seems unlikely that this many coho would have traveled past the hatchery to spawn naturally. Three redds were located below the town of Winthrop with live fish present, three redds at the mouth of Gold Creek,

and a single redd was located at RM 5.0 on the Methow River (Table 3; Figure 3). No carcasses were recovered in the Methow River in 2002.

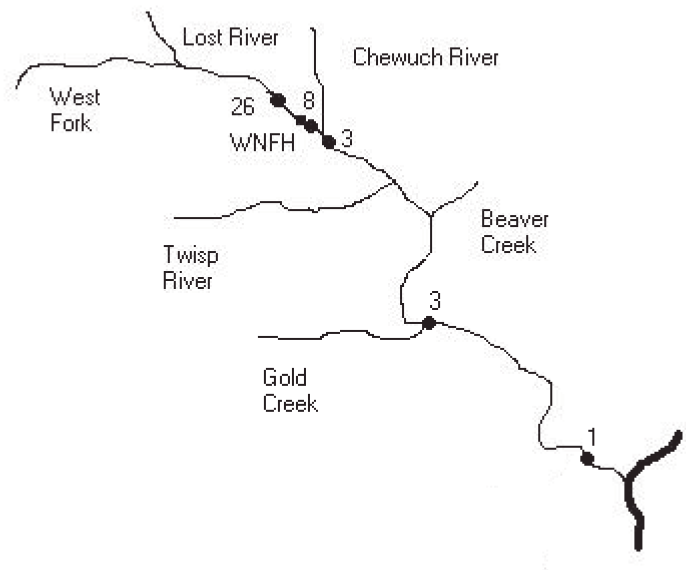

Figure 3. Spatial distribution and number of coho redds in the Methow River basin, 2002.

Table 3. Summary of coho redds counted in the Methow River and the percentage of coho redds within each surveyed reach, 2002.

River Reach	No. of Redds	% Of Redds
Mouth to Carlton Bridge	4	9.8%
Carlton Bridge to Twisp Bridge	0	0.0%
Twisp Bridge to Winthrop Bridge	3	7.3%
Winthrop Bridge to WNFH	8	19.5%
WNFH to Wolf Creek	26*	63.4%
Total	41	100%

* Redds located just above and below the hatchery diversion dam are suspect and could possibly be summer chinook redds due to the large 2002 escapement of summer chinook and the low proportion of coho females that returned to the Methow basin, based on collections at Wells Dam and swim-ins to the WNFH.

DISCUSSION

The 2002 adult coho returns to the Wenatchee River were the lowest observed under the mid-Columbia coho reintroduction project; however, they were somewhat expected due to poor emigrant survival in 2001 (19% survival from release to McNary Dam) (Murdoch and LaRue 2002). We estimate that 343 coho returned to the Wenatchee River basin, as measured by Dryden Dam trap counts expanded for non-trapping days (Chapter 6). This figure may underestimate the actual number of coho that returned to the basin because the trap is not 100% effective and this method of enumeration does not account for coho spawning downstream of Dryden Dam (Chapter 6). Of the returning coho we trapped, 213 were collected for broodstock (Kamphaus 2003), leaving a minimum spawning escapement of 130 coho. From the 130 coho estimated to have escaped to Icicle Creek, to Nason Creek, and to reaches of the Wenatchee River, we found 28 redds or 4.6 fish per redd. The sex ratio observed at Dryden Dam predicts 3.4 fish per redd. A discrepancy in fish per redd estimates could result if not all redds were found. Locating coho redds on the Wenatchee River can be difficult. Coho spawn timing overlaps with summer chinook. Coho redds in heavily used summer chinook spawning areas cannot be positively identified without seeing the fish on the redd.

Most of the coho passing over Tumwater Dam did not actually spawn in Nason Creek. Only two of the 11 coho counted at Tumwater Dam were females, one of which built a redd in Nason Creek. Based on sex ratios seen at Tumwater Dam, we would expect to find 5.5 fish per redd. It is possible that females are dropping out earlier than males or otherwise are unable to navigate though Tumwater Canyon. Several coho returning to Icicle Creek and/or Nason Creek spawned in the lower reaches of the Wenatchee River. Our observations at Dryden Dam indicate that some coho may be ascending the Wenatchee River in a ripe condition and must spawn prior to reaching their tributary of release or suitable habitat.

We are optimistic that the development of a local broodstock will result in increased returns and natural production in coho habitat. Through the broodstock development process, natural selection should eliminate some of the deleterious traits that could affect successful reproduction (run timing, spawn timing etc). By adding more acclimation sites in the upper reaches of the Wenatchee River basin, we hope to see an increased number of naturally spawning coho in upper basin reaches. Historically, Nason Creek may have been the largest producer of coho in the Wenatchee basin (Mullan et al. 1992). We plan to continue spawning ground surveys, supplemented by radio-telemetry evaluations, to track the distribution of coho spawners throughout the broodstock development process.

SUMMARY

• During spawning ground surveys in Icicle Creek, we observed 21 coho redds and recovered 9 coho carcasses. The mean egg voidance was of 98%.

• During spawning ground surveys in Nason Creek, we counted one coho redd and did not recover any carcasses.

• We found five coho redds in the mainstem and one redd in Peshastin Creek. No carcasses were recovered.

• Forty-one redds were identified on the Methow River, with a high proportion found above the hatchery. These redds were most likely mistaken chinook redds due to the record escapement of chinook in the Methow basin in 2002, and low coho escapement.

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CHAPTER 5: POPULATION ESTIMATE OF NATURALLY PRODUCED COHO SALMON SMOLTS *ONCORHYNCHUS KISUTCH* IN THE WENATCHEE RIVER BASIN

INTRODUCTION

Efforts to restore naturally producing coho to tributaries of the mid-Columbia River depend largely upon the ability of adult coho to spawn successfully in the natural environment. Estimating natural production in terms of smolt emigration is intrinsic for measuring smolt-to-adult survival rates, establishing recovery goals, and for the development of coho stock-recruitment curves in the mid-Columbia (Symons 1979; Chadwick 1982; Gardiner and Shackley, 1991; Kennedy and Crozier 1993; Ward and Slaney 1993).

The Washington Department of Fish and Wildlife (WDFW) currently operates a rotary smolt trap in the lower Wenatchee River above the town of Monitor (RK 10.9). This smolt trap is designed to collect data from all emigrating salmonids in the basin, including data from coho emigrants.

The 2002 smolt emigration included the first naturally produced coho smolts in the Wenatchee River in close to a century. Our efforts described below mark an important step in evaluating the potential for reintroduced hatchery coho salmon to reproduce successfully in mid-Columbia tributaries.

METHODS

To collect data on the emigration of naturally produced and hatchery coho in the Wenatchee River, YN personnel worked with WDFW personnel on the Monitor rotary smolt trap between April 25th and May 25th. The trap crews operated the smolt trap each night from dusk until dawn. The trap was not operated during daylight hours because salmon smolts migrate primarily at night (Sandercock 1991; Roper and Scarnecchia 1999). Biological information recorded nightly on both hatchery and natural coho emigrants helped define length-at-migration and run timing. On nights when the trap was inoperable due to high river discharge or mechanical problems, the number of trapped coho was estimated from the mean number of coho salmon smolts captured two days before and two days after the break in operation. WDFW personnel conducted mark/recapture trap efficiency trials. Trap efficiency was used to calculate population estimates for naturally produced coho salmon. The efficiency trial and emigration estimate methods described below were provided by T. Miller, WDFW.

Efficiency Trials

Hatchery coho smolts were collected for mark/recapture efficiency trials throughout the smolt emigration. A minimum of 100 fish were used in each mark group. Fish used in the efficiency trials were held in floating live boxes located at the rear of the trap. The holding time required to collect a sufficient sample typically did not exceed 24-hours. A fin clip was applied to either the top or the bottom lobe of the caudal fin to mark fish used in the efficiency trials. A small caudal clip, whether performed on the upper or lower lobe, has no significant effects on capture efficiency (Petersen et al. 1995). Marked fish were then transported upstream to Dryden Dam (RK 28.2) and released in equal proportions on both sides of the river.

Data Analysis and Emigration Estimate

Trap efficiency trials were conducted at various river discharges and three trap operation positions. Efficiency trials from multiple years (2001-2003) were used to calculate trap efficiency. The efficiency estimates were stratified by flow and three trap positions. Data analysis details can be found in Miller (In Prep).

RESULTS

Coho Run Timing

Naturally produced coho smolts were seen emigrating between March 5th and July 20th. Peak migration occurred between April 27th and May 25th (Figure 1). Hatchery coho were observed emigrating between April 25th and July 8th (volitional releases began on April 24th), with a peak emigration between April 30th and May 27th (Figure 1). The emigration of naturally produced coho was prolonged over the run timing of volitionally released hatchery coho. Emigration trends of both hatchery and natural coho appeared to be correlated with river discharge (Figure 1).

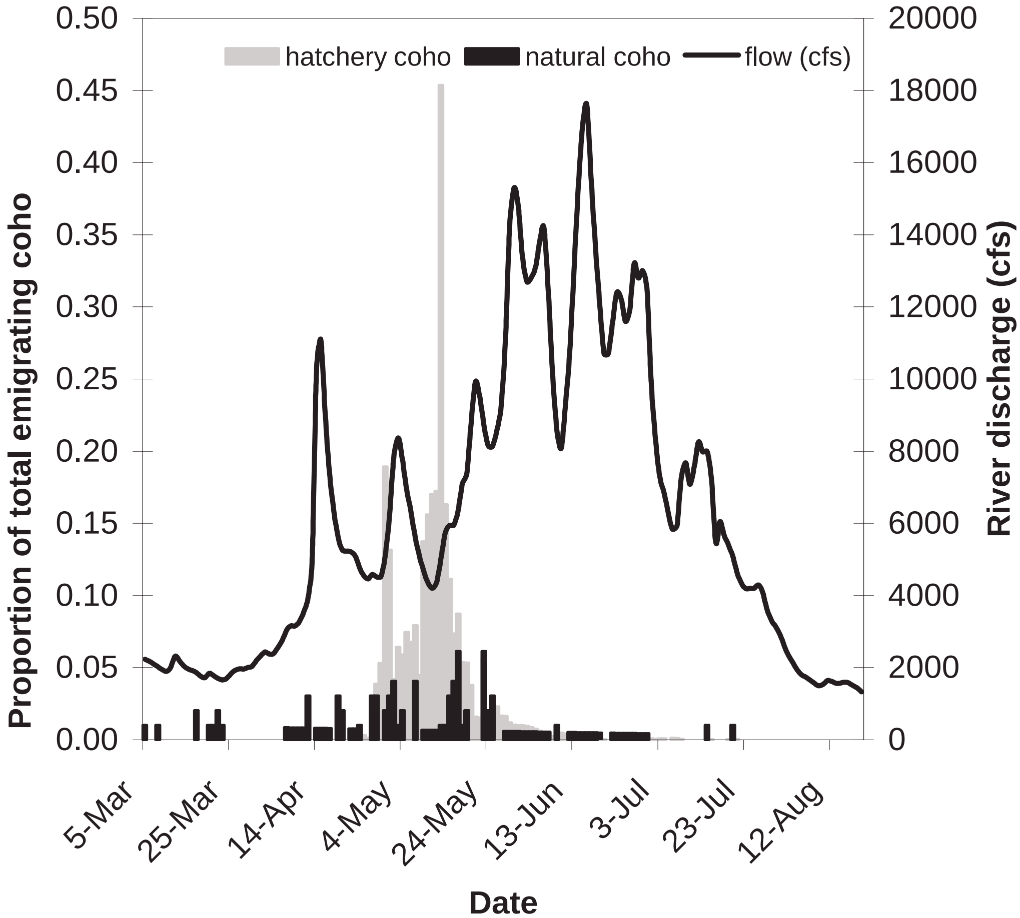

Figure 1. Run timing of natural and hatchery coho emigrating from the Wenatchee River, 2002.

Emigration Expansion

A total of 72 naturally produced coho smolts (brood year 2000) were trapped during 2002. We estimate that a total of 98 naturally produced coho would have been trapped when the known value (72) is expanded for days when the trap was inoperable. During trapping operations, an additional 1430 naturally produced coho fry (brood year 2001) were captured. Trap efficiencies used to produce an estimate of naturally produced coho emigrating from the Wenatchee River ranged between 0.28% and 1.8%. Wenatchee River flows used to stratify the efficiency trials ranged from 3450 cfs to 8300 cfs.

Based on the efficiency estimates, river flow, and trap position, we estimate that approximately 17,054 naturally produced coho smolts emigrated from the Wenatchee River in 2002 (T. Miller unpublished data).

Egg-to-Emigrant Survival

We assume the Wenatchee River basin was seeded with 164,700 coho salmon eggs in 2000 (61 redds times 2700 eggs/female) (Murdoch and Dunnigan 2002). Using naturally produced coho emigration point estimates provided by T. Miller (WDFW unpublished data), we calculate an egg-to-emigrant survival rate of 10.35%. It is possible that not all coho redds were located in the Wenatchee basin because surveys in the mainstem Wenatchee River were not conducted in 2000. Unaccounted for redds would artificially inflate the egg-to-emigrant survival rate.

DISCUSSION

Trap efficiencies at WDFW’s rotary smolt trap located near Monitor on the Wenatchee River are extremely low due to the large size of the Wenatchee River during spring run-off. Because of the low trap efficiency, efficiency trials from multiple years were used in the development of a population estimate model (T. Miller, WDFW, pers comm.). Due to the high variability in trap efficiencies, even when stratified for river discharge and trap operation position, only a point estimate could be calculated. As more efficiency trials are conducted in future years, a reanalysis of 2002 data may provide a population estimate with a 95% confidence interval.

The egg-to-emigrant survival rate (10.35%) observed for the first generation of naturally produced coho provides an optimistic future for the reintroduction of naturally producing coho salmon in the Wenatchee basin. The observed egg-to-emigrant survival rate comports well with egg-to-emigrant survival rates observed for spring chinook in the Chiwawa River between 1994 and 2002 (4.7% to 18.1%) (Murdoch et al. 2001; Miller 2003).

The first migration of naturally produced coho smolts demonstrates that successful natural production of reintroduced hatchery coho occurred. Successful reproduction, even on a small scale, can provide valuable insight on the feasibility of introduction. With each generation of coho returns to the Wenatchee River, a locally-adapted coho stock should evolve in mid-Columbia tributaries. We expect local adaptation to result in increased natural production and improved survival rates.

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CHAPTER 6: SURVIVAL OF HATCHERY COHO

INTRODUCTION

Project success requires sufficient numbers of adult coho to return to the basin from which they were released in order to spawn naturally or to be spawned in a hatchery. The mid-Columbia Hatchery and Genetics Management Plan (HGMP 2002) identifies several project performance indicators. The performance indicator of highest interest in the short term may be smolt-to-adult survival. The HGMP speculates that to develop a local broodstock, sufficient adults must return to the Wenatchee and Methow rivers in order to meet broodstock requirements. Thus, a monitoring program that tracks smolt-to-adult survival rates through time is essential to track the project's long-term performance.

The project is also interested in juvenile survival in order to parse out that portion of the smolt-to-adult mortality that is occurring in the freshwater life stages. Juvenile coho released in the Wenatchee and Methow rivers must migrate past 7 and 9 hydropower dams on the mainstem Columbia River respectively before reaching the Pacific Ocean. These dams have increased the total cross-sectional area of the Columbia River, resulting in decreased water velocity and turbidity, which in turn has increased smolt travel time and generally subjected smolts to greater exposure to predators and other factors influencing survival (Raymond 1979, 1988; Williams 1989). Physical changes in the Columbia River environment attributable to hydro-projects may require salmonids to migrate under a different set of environmental conditions than the conditions in which they evolved.

Juvenile and adult coho survival in the Columbia River mainstem may be further depressed by the source of hatchery broodstock. Lower Columbia River stocks of coho may not be well adapted to migrate the long distances required for them to reach the ocean and return. A baseline monitoring program that tracks both juvenile survival and smolt-to-adult survival rates will be important to determine if survival benefits are achieved through the development of a locally adapted broodstock.

METHODS

Wenatchee River Basin: Downstream Smolt Survival

The YN acclimated and released an estimated 1,002,323 yearling coho smolts into Wenatchee River tributaries in 2002. Release sites and the estimated numbers of fish released from each site (after attributing for known mortalities), and the number of PIT tags in each release group can be found in Table 1.

Table 1. Number of coho released from Wenatchee basin acclimation sites, 2002.

Basin	Tributary	Acc. Site	Broodstock Origin	Est. No. Released[1]	No. of PIT tags	CWT
Wenatchee	Icicle Ck.	Dam 5	Lower Col.	418,779	8000	100%
			Mid. Col.	348,553	8907	100%
	Nason Ck.	Butcher Ck. Pd.	Mid. Col.	143,314	7876	100%
		Early Pd.	Mid. Col.	19,001	N/A	100%[2]
	Beaver Ck.	Beaver Ck. Pd.	Mid. Col.	72,676	N/A	100%
Methow	Methow R.	WNFH	Lower. Col.	185,507	N/A	100%

[1]Estimated number of smolts released is based on the number of fish transported minus the estimated number of mortalities. Estimated mortality numbers are 2 x the known mortality (Kamphaus 2003).
[2]Coho released from Early Pond shared a PIT code with one of five tag groups released in from Dam 5.

PIT-tagged fish released from the Dam 5 and Butcher Creek acclimation sites were detected at McNary, John Day and Bonneville dams and allowed estimates of release-to-McNary survival to be calculated.

Statistical Analysis
To obtain a McNary passage index of PIT-tagged fish released into the Wenatchee and Methow basins, the number of McNary Dam PIT tag detections were expanded by dividing by an estimate of the McNary detection-rate (efficiency). McNary's detection rate is the proportion of total PIT-tagged fish passing the dam that are detected by the dam's PIT tag detectors. McNary's detection rate is calculated by summing the number of PIT-tagged fish detected at McNary and at a downstream dam and dividing by the total number detected at the downstream dam. An index of survival to McNary is the McNary passage index divided by the number of PIT-tagged fish released.

For the 2002 survival rates, detection-rate estimates were calculated for the Leavenworth and Winthrop releases separately, based on John Day Dam and Bonneville Dam Powerhouse 2 detections. All detection-rate estimates were statistically tested for comparison using a z-test for binomial proportions, and if the detection-rate estimates were not different, the estimates were pooled. Neeley 2003 (Appendix F) describes the methods used to estimate coho smolt survival to McNary Dam in detail.

Methow and Wenatchee River Basin Smolt-Adult Survival
The year 2002 represented the third year for adult coho returns to the Wenatchee and the third year of trapping adult coho in the Methow River. The Yakama Nation acclimated and released 260,319 coho smolts into the Methow River Basin in 2001 (Murdoch and

Kamphaus 2003). Smolt-to-adult survival was calculated based on two methods of enumerating adult coho in the Methow River: 1) broodstock (WNFH swim-ins and Wells trapping) and redd counts, and 2) Wells Dam fish counts.

The Yakama Nation acclimated and released 997,458 coho smolts into the Wenatchee River basin in 2001 (Murdoch and Kamphaus 2002). The smolts were released from two acclimation sites within the Wenatchee River basin: 142,291 coho smolts were released from the Butcher Creek acclimation site at RK 13.2 on Nason Creek, and 855,167 acclimated coho smolts were released from the Dam 5 acclimation site behind the LNFH on Icicle Creek. We calculated smolt-to-adult survival for 2002 adult returns using three equations to estimate the number of adults that returned:

1) Dryden Dam counts expanded by linear regression for non-trapping days,
2) Dryden Dam counts plus redd counts, and
3) mainstem dam counts (Rock Island Dam – Rocky Reach Dam).

Method one may underestimate the total number of coho returning to the basin, as the efficiency of the Dryden Dam fish trap is not 100%. The actual efficiency is unknown, but during low flows observed when coho are returning to the basin, the efficiency should be high. Method two is also an underestimate because it relies on Dryden Dam counts as well as redd counts. If not all redds are located, we may underestimate the spawning escapement to the Wenatchee River. Method three is an overestimate, as it assumes no fallbacks or dropouts occurred between Rock Island and Rocky Reach Dams. Due to low flows and warm river temperatures in 2001, it is possible that the dropout rate was high.

RESULTS

Wenatchee River: Smolt Survival, Release to McNary Dam

A pooled McNary detection-rate estimate over releases and downstream dams was used to calculate the survival index for Wenatchee basin releases. The number of PIT-tagged coho smolts actually detected at McNary Dam was 511 each for both Icicle Creek mid-Columbia brood and Icicle Creek lower Columbia brood. From Nason Creek (Butcher Creek acclimation site), 226 PIT-tagged coho smolts were detected at McNary Dam. The calculated survival index for the 2002 Icicle Creek mid-Columbia and lower Columbia River brood was 0.7848 and 0.8738 respectively (Table 2). The calculated survival index for the 2002 Nason Creek release was 0.3926 (Table 2).

Table 2. Number of McNary PIT-tagged detections of Icicle Creek (Leavenworth) and Nason Creek releases, estimated McNary detection rate, associated expanded passages, release numbers, and survival indices as proportions of number released.

	Icicle Creek (mid-Col. brood)	**Icicle Creek (lower Col. brood)**	**Nason Creek (mid-Col. brood)**
Number of McNary Detections (McN Det)	511	511	226
Estimated McN Detection Rate (McN DR)	0.073098	0.073098	0.073098
Expanded McN Passage (McN Pass =[McN Det]/[McN DR])	6990.6	6990.6	3091.7
PIT-tagged Number Released (Num Rel)	8907	8000	7876
Survival Index (Surv Ind = [McN Pass]/[Num Rel])	**0.7848**	**0.8738**	**0.3926**

Source: Neeley 2003 (Appendix F).

The passage of PIT-tagged lower Columbia River (LCR) brood coho released on April 24th, 2002 from the acclimation site behind the LNFH peaked at McNary Dam on May 31st, with 56 PIT-tagged fish per day (Figure 1). Mid-Columbia River (MCR) brood coho released from the Dam 5 acclimation site on the same date reached peak detection at McNary Dam three days later with 74 fish per day. The mean detection date for LCR and MCR brood coho released from Dam 5 was May 29th and June 2nd, respectively. We estimated that a total of 6991 (87.4%) of LCR PIT-tagged coho and 6991 (78.5%) of MCR PIT-tagged coho released from the Icicle Creek passed McNary Dam between April 24th and July 31st.

Detection at McNary Dam of PIT-tagged mid-Columbia brood coho released from Nason Creek peaked on June 8th with 21 detections per day. The mean detection date for PIT-tagged MCR brood coho from Nason Creek was June 11th, 2002. We estimate that a total of 3092 (39.3%) PIT-tagged coho released from the Butcher Creek acclimation site passed McNary Dam between May 1st and July 31st.

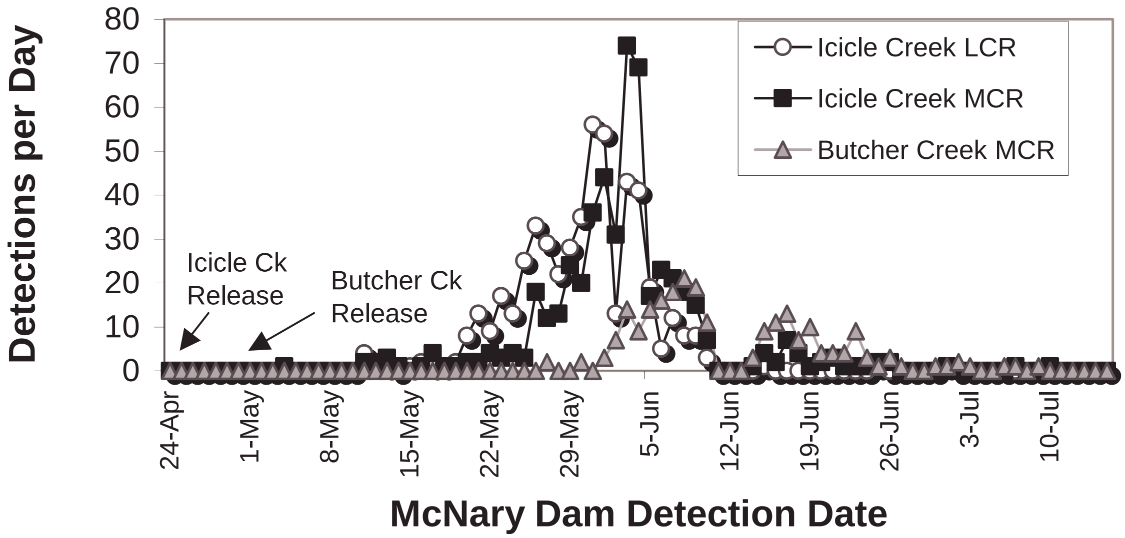

Figure 1. Daily PIT-tag detections at McNary Dam for hatchery coho released into Icicle and Nason Creeks, Wenatchee River Basin, 2002.
LCR = Lower Columbia River Brood; MCR = Mid-Columbia River Brood.

Methow River Basin Smolt-to-Adult Survival

Based on coho enumeration method one (broodstock and redd counts), we estimate that 63 adults (BY 1999) and 23 (BY 2000) coho jacks returned to the Methow River in 2002. An additional 21 jacks (BY 1999) were estimated to have returned in 2001. Using method one for BY 1999 returns (eliminating BY 2000 returns), we estimate the SAR for coho returning to the Methow River to be 0.03% (Table 3). Based on Wells Dam counts (method two), an estimated 104 coho adults (BY 1999) and 36 coho jacks (BY 2000) returned to the Methow River, with an additional 35 jack coho in 2001 (BY 1999). For the 1999 brood year (BY), we estimate a SAR of .053% (Table 3).

Table 3. Smolt-to-Adult survival rates for brood year 1999 returns to the Methow River, 2002.

Method	2002 return estimate (BY 1999 & 2000)	2001 Jack Estimate (BY 1999)	SAR
1) BROODSTOCK AND REDD COUNTS	69 adult & 23 jack	21 jack	0.03%
1) WELLS DAM COUNTS	104 adult & 36 jack	35 jack	0.053%

Wenatchee River Smolt-to-Adult Survival

Coho counts at Dryden Dam, expanded with linear regression for non-trapping days (method one), predict that 255 coho adults and 88 coho jacks returned to the Wenatchee basin in 2002. An additional 66 jacks from BY 1999 were estimated to have passed Dryden Dam in 2001. Using coho enumeration method one, the smolt-to-adult survival rate (BY 1999) for the Wenatchee River basin was 0.03%. Using coho enumeration method two (trapped broodstock and redd counts), we estimate that 234 adults and 74 jacks returned to the Wenatchee River in 2002. An additional 64 jacks (BY 1999) returned in 2001, resulting in an SAR of 0.03%. Based on the difference in counts of coho at Rock Island Dam and Rocky Reach Dam (method 3), 1267 adult coho and 323 jacks returned to the Wenatchee River in 2002; an additional 316 jack coho returned in 1999, resulting in an SAR for 0.13% for BY 1999 (Table 4). Mainstem dam counts used in calculations of SARs for Wenatchee and Methow river returning coho can be found in Figure 2. Fish counters at Rock Island, Rocky Reach and Wells dams did not differentiate between adult and jack coho. Counts from Priest Rapids and McNary dams included both adults and jacks. We estimated the number of jacks passing over Rock Island, Rocky Reach, and Wells dams based upon the proportion of jacks observed in-basin (Kamphaus 2003).

Table 4. Brood year 1999 hatchery coho smolt-to-adult survival in the Wenatchee River basin.

Method	2002 return estimate (BY 1999 & 2000)	2001 Jack Estimate (BY 1999)	Smolt-to-Adult Survival
1) Dryden Dam counts expanded for non-trapping days.	255 adult & 88 jack	66 jack	0.03%
2) Broodstock collected at Dryden Dam and redd counts	234 adult & 74 jack	64 jack	0.03%
3) Rock Island Dam Count minus Rocky Reach Dam counts	1267 & 323 jack	316 jack	0.13%

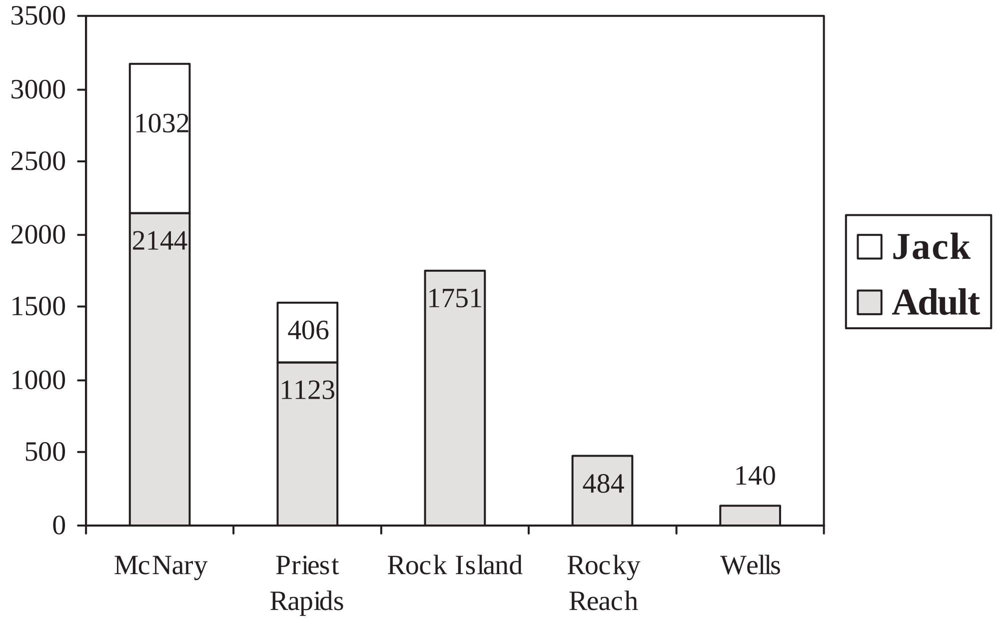

Figure 2. Mid-Columbia River dam counts of adult and jack coho, 2002.

In addition to calculating SARs for the sum of all hatchery coho returning to the Wenatchee River, we calculated SARs for each release site based on the recovery of CWTs. The SARs for the Butcher Creek release site, Dam 5 CWT release, and non-tagged recoveries (assumed to be from the non-tagged group released from Dam 5 in 2001) can be found in Figure 3. Butcher Creek had the highest SAR of the three groups (0.031%). The 2001 Butcher Creek release was the first release of mid-Columbia brood coho (spawned at WNFH in 1999). The CWT group released from LNFH had an SAR of 0.023% while the non-CWT group released from LNFH had an SAR of 0.028% (Figure 3). A breakdown of each CWT group and associated SARs can be found in Table 5.

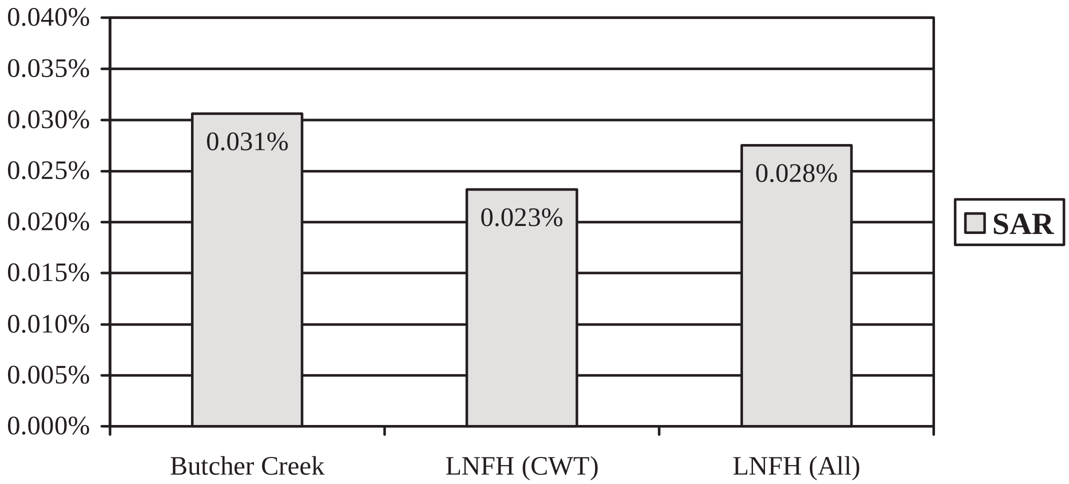

Figure 3. Coho SARs for each acclimation /release site in the Wenatchee River Basin, 2002.

Table 5. Coho SARs for individual CWT release groups, Wenatchee River, 2002.

Code	Release Site	Broodstock Origin	No. Released	SAR (%)	AD Clip
093011	LNFH	LCRB	26,083	0.0309	Yes
054529	Butcher Ck.	MCRB	142,291	0.0306	No
No Tag	LNFH	LCRB	556,727	0.0298	No
054432	LNFH	LCRB	48,995	0.0296	No
054433	LNFH	LCRB	49,165	0.0262	No
093202	LNFH	LCRB	26,363	0.0183	No
054524	LNFH	LCRB	147,360	0.0122	No

DISCUSSION

The downstream hatchery coho smolt survival indices from release in Icicle Creek to McNary Dam (87.4% & 78.5%) were twice as high as the downstream smolt survival estimate for hatchery coho released into Nason Creek from the Butcher Creek acclimation site (39.3%). Differences in the survival indices could be the result of differing predation rates in the two acclimation sites; however, PIT-tag detections at the outlet of the Butcher Creek acclimation site indicate that 92.5% of the coho acclimated in Butcher Creek survived and left the pond (Kamphaus 2003). The difference in downstream survival rates could be the result of later migration timing. The peak detection date at McNary was 5-8 days longer for the coho released in Nason Creek. While peak and mean detection dates at McNary Dam were approximately one week apart, the volitional release at the Butcher Creek acclimation site was prolonged: the last PIT-tagged coho left the Butcher Creek acclimation pond on June 12th 2002, while all fish appeared to have left Dam 5 by May 17th (Kamphaus 2003). The Icicle Creek fish were released 8 days before those in Butcher Creek. Other reasons for a difference in survival from release to McNary Dam might include the migratory route. Smolts migrating from Nason Creek must migrate over Tumwater Dam and through Tumwater Canyon, an area of fast and turbulent currents.

We observed the highest downstream survival rate from release in Icicle Creek to detection at McNary Dam since the YN began releasing coho in the mid-Columbia. The 2002 downstream survival rate was 4 times higher than survival rates in 2001 (Table 6).

Table 6. Comparison of smolt-smolt survival, smolt travel time, and smolt-adult survival rates for mid-Columbia coho releases, 1999-2001.

Release Year	Methow River Smolt Travel Time (km/day)*	Methow R. Smolt Survival *	Methow R. Smolt-Adult Survival	Icicle Creek Smolt Travel Time (km/day)*	Nason Creek Smolt Travel Time (km/day)	Icicle Creek Smolt Survival*	Nason Creek Smolt Survival*	Wenatchee R. Smolt-Adult Survival
1999	N/A	N/A	N/A	11.4	N/A	53.9%	N/A	0.21% - 0.38%
2000	9.8	33.3%	0.17% - 0.27%	8.1	N/A	63.0%	N/A	0.17% - 0.86%
2001	9.6	9.9%	N/A	7.9	N/A	21.6%	N/A	0.03%
2002	N/A	N/A	0.03%	15.4**- 14.0***	14.7***	87.4%** 78.5%***	39.3%***	N/A

*Release to McNary Dam based on PIT tag detections
** Lower-Columbia brood smolts
***Mid-Columbia brood smolts

The 2002 smolt-to-adult survival rates in the Methow and Wenatchee rivers were the lowest observed since the reintroduction project began trapping broodstock and monitoring survival rates in 1999 (Table 6).

The smolt-to-adult survival rate in the Wenatchee and Methow basins were similar in 2002. There was variability in the three estimates of smolt-to-adult survival in the Wenatchee River. The discrepancy between the three smolt-to-adult survival rates may be due to high dropout rates, or to stray rates in the Columbia River and lower Wenatchee River.

The smolt-to-adult survival rate calculated from Wenatchee River counts (i.e., trapped broodstock, Icicle Creek redd counts, and Nason Creek redd counts) was very close to the smolt-to-adult survival rate calculated from Dryden Dam passage counts. Both of these methods may underestimate of the total number of returning adults. Both in-basin estimates were lower than the SAR calculated from the difference between Rock Island Dam counts and Rocky Reach counts.

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APPENDIX A: HYDROACOUSTIC SURVEY OF LAKE WENATCHEE, WASHINGTON

HYDROACOUSTIC SURVEY OF LAKE WENATCHEE, WASHINGTON
MAY 16 & 17, 2002
WITH EMPHASIS ON SOCKEYE FRY SPATIAL DISTRIBUTION

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INTRODUCTION

A recent initiative to re-introduce coho salmon to the Wenatchee River watershed requires consideration of the ecological risk posed by this action to cohabiting sockeye salmon (Murdoch 2001). To this end, the Yakama Nation conducted studies in spring 2001 and 2002 to assess the interaction between out-migrant coho and sockeye fry in the lake and to develop effective sampling methods for this task. A small, 1 m conical tow-net, a larger 2x2 m tow-net, and snorkeling were each used at times to sample juvenile salmonids in pelagic and littoral areas in 2001 and 2002 (K. Murdoch, Yakama Tribal Fisheries, personal communication). Radio telemetry was also used to determine the distribution and movements of tagged coho smolts in the lake. In May 2002, a one-night mobile hydroacoustic survey was conducted to estimate the abundance and distribution of fish in the lake and to examine how this method might complement other sampling activities. Findings of this acoustic survey are the subject of this report.

Acoustic survey objectives were:
1) to measure the spatial distribution of fish in the lake, mainly during hours of darkness, including both pelagic and near shore areas;
2) to examine in detail the horizontal and vertical distribution of sockeye fry in the lake; and
3) to estimate the number of fish in the lake and its 95% confidence interval.

METHODS

Data Collection

The acoustic survey was conducted on May 16-17, 2002. Most sampling was during the night between the hours of 9 PM and 1 AM. A small amount of daytime data was also collected from 2-3 PM the afternoon of May 16 in the west end of the lake. A BioSonics 120 kHz, DT6000, split-beam echo sounder with a 7.4º transducer was used to collect data from a powerboat. The transducer was deployed from a pipe attached to the side of the boat, aimed vertically toward the lake bottom, effectively sampling fish that were at least 2 m beneath the lake surface. The echo sounder was operated by a computer, which allowed monitoring of data quality on echograms at the time of collection and served as a data logger. Latitude and longitude from a Furuno GP-35 GPS were added to acoustic data files as they were acquired. Additional data collection details and equipment settings appear in Table 1.

Sampling was performed along ten pre-determined transects spaced about 650 m apart, perpendicular to the long axis of the lake (Figure 1). These transect lines were the same as those used on acoustic surveys in the 1970s (Dawson et al. 1973). In the May 2002 survey, half the segments between transect endpoints were also sampled while running between transects to increase coverage of near shore areas (Figure 1). Generally, transects were terminated when the depth was less than 2 m, so littoral shallows were not sample.

Data Analysis

Fish density (fish per m^3 or per m^2) was determined according to standard echo-trace counting methods (Thorne 1983, MacLennan and Simmonds 1992). Computer files were processed in the office using Echoview© v2.25 software to extract fish traces, to measure target strength (TS), and to determine sampling volumes. Fish traces were recognized by their shape, cohesiveness, and number of echoes. Traces from occasional columns of bubbles were recognized by their pattern of association and slope and excluded from fish counts. TS was determined by the split-beam method. The echo sounder was calibrated at BioSonics prior to the survey, and in-situ TS measurements of a standard sphere were within 0.1 dB of the expected value (-41.1 dB) on average. Lengths of individual fish were estimated from TS using Love's (1977) equation for fish insonified dorsally:

$$\text{length (mm)} = 10 * 10^{((TS + 0.9 \log (kHz) + 62) / 19.1)}$$

This equation was developed from several species, and TS is affected by factors other than fish size (MacLennan and Simmonds 1992), so this relationship provides an estimate of fish length less precise than hands-on physical measurements.

Depth intervals for data analysis were 0-5 m, 5-10m, 10-15 m, and so forth to the lake bottom. Fish densities were summarized as fish per m^3 within depth intervals of transects for the population estimate, and as fish per hectare in approximately 50m long segments along transects for spatial analysis. For each spatial cell of interest, fish density was calculated as the total number of fish counted divided by the volume sampled. The volume sampled in each spatial cell was calculated from the acoustic beam angle and distance transected corrected for bottom intrusion, using the wedge model (Kieser and Mulligan 1984) for all depth intervals. Processing settings were a -65 dB counting threshold and an 8º full beam angle. A complete list of data analysis settings appears in Table 1.

For the population estimate, each transect provided one replicate of each depth interval that it included (shallow transects did not contain all intervals). For each depth stratum, mean fish density was expanded in proportion to stratum volume, and these values were in turn summed to obtain the total population estimate. Volumes of 5 m thick depth strata from 0 m to 75 m were derived from values for 10 m thick depth intervals from 10 m to 70 m in Dawson et al. (1973) using the equations:

area = volume / interval thickness
where area = surface area (million m^2) of a slice at the depth interval midpoint

$$\text{area} = (-0.0412 * \text{depth}^{1.69} + 50.9180)^{1/1.69} \qquad R^2 = 0.9979$$

Variance and 95% confidence intervals of the population estimate were calculated as for a stratified random sample with depth intervals the only stratification (Cochran 1977).

Net sampling was not conducted concurrently with acoustic sampling, so acoustic results were not apportioned by fish species. Spatial patterns of small fish, estimated from TS, were used as an estimate of the sockeye fry distribution. This analysis makes the assumption that other species, such as sticklebacks or peamouth chub, were not present in the lake in significant numbers. This assumption is supported by tow-net and snorkeling results (K. Murdoch, Yakama Tribal Fisheries, personal communication).

RESULTS

General Spatial Patterns of Fish in the Lake

During limited sampling in the west end of the lake on the afternoon of May 16, nearly all fish were observed off shore and below 45 m in the water column (Figure 2). At night, fish were abundant both near shore and off shore throughout the lake and nearly all fish occurred in the upper 40 m of the water column (Figure 3, Table 2). For fish of all sizes combined, densities within individual transect depth layers ranged from 0.0 to 0.09 fish/m^3, with densities consistently highest in the upper 15 m of the water column. Considering the horizontal distribution of fish, densities (fish/m^2) were relatively high along the southern shore, particularly toward the eastern end of the lake (Figure 4). High densities also occurred in some mid-lake areas, whereas densities tended to be low along the northern shoreline, except at the ends of the lake. Fish were similarly distributed during dusk (2130-2200 hours) and night (2200-0130 hours) transects in the west end of the lake, so dusk data were included in the results below for hours of darkness. All of the following results are for hours of darkness unless stated otherwise.

Spatial Distribution Relative to Fish Size

Frequency distributions of target strength (TS) by transect indicated the presence of two size groups of fish, probably fry and yearling sockeye, in many parts of the lake (Figure 5). The small size group was found on all transects. The large size group was present on most transects that crossed deep water, and was nearly absent from transect 1 (lake outlet) and from several of the near shore transects that did not extend to deep water. Modes of the small and large size groups were typically about –55 dB and –48 dB, with a minimum between the two peaks at about –50 dB (Figures 5&6). TS measurements of fish in deep water during daytime sampling showed a similar size distribution.

Fish length computed from TS ranged from 8-302 mm, with modes of about 25 mm and 75 mm for the two size groups and by far the largest proportion of fish in the smaller size group (Figure 7). Mean length of fish by 5 meter depth layer and 50 m transect interval were examined on cross-lake transects 2, 4, 6, and 8. Average fish size tended to be larger below about 30 m, except in mid-lake on transect 2 where some larger fish also occurred in the upper water column (Figure 8). In general, fry-sized fish occurred throughout the water column, both near shore and offshore, but tended to predominate in the upper 30 m of the lake.

Plots of fish density (fish/m^2) were drawn for fry-size and larger fish along cross-lake and near shore transects using TS <-50 dB for fry and TS >-48 dB for larger fish. A minimum TS of –48 dB rather than –50 dB was used for plots of larger fish to avoid including fry. Fry densities approached 1.6 fish/m^2 in places and were somewhat patchy, often changing radically in a short distance, and high densities were seen both near and off shore (Figure 9). Some spatial patterns were consistent. Fry densities tended to be high along the south shore and very low along the north shore, except for moderate densities in the northeast and northwest corners of the lake. Highest fry densities occurred in the southeast quadrant of the lake. Larger fish were much less abundant than fry, with densities approaching only 0.2 fish/m^2 (Figure 9). Larger fish were most numerous in the west half of the lake, away from shore where the water was deep, and their densities were very low near shore.

Population Estimate

The population estimate for all species and sizes in the lake combined was 4.2 million fish +/- 22% with 95% confidence (Table 3). Fish densities were highest by far in the upper 15 m of the water column, which accounted for about 67% of the total population estimate. Based on fish length estimates from acoustics and on capture sampling results, most of these fish were sockeye fry. Assuming that all fish with TS less than –50 dB were fry, there were 3.9 million sockeye fry in the lake (+/- 24%), 71% of which were in the upper 15 m of the water column (Tables 4&5).

DISCUSSION

This survey indicates that by mid May 2002, sockeye fry in Lake Wenatchee were mainly pelagic during the day, and both pelagic and littoral at night. Limited daytime sampling in the west end of the lake showed that both fry and larger fish occurred almost exclusively in deep water (depth > 45 m) at that time. Fry moved into the upper water column and shoreward during hours of darkness, with maximum densities for that period occurring in those areas. This movement appeared fairly complete shortly after dusk at 2130 hours. This depth distribution differs markedly from that observed in the 1970s, when peak night time densities occurred at 20-30 m with very few fish in the upper water column (Dawson et al. 1973, Dawson and Thorne 1974, Dawson and Thorne 1975). Fish larger than fry also moved upward at night, but mainly inhabited deep water away from shore both day and night. These patterns are generally consistent with behavior described in published literature. Sockeye fry are typically littoral and bottom oriented both day and night in the spring, becoming more pelagic as the season progresses (Burgner 1991). By late spring and summer when they have become mainly pelagic, fry usually remain below the level of light penetration during the day in lakes with significant predation risk (Levy 1989). Older age groups are typically highly pelagic and (except larger kokanee) also migrate vertically where there is predation risk.

Several potential sources of error in this survey deserve mention. Transect 10 (west end of the lake) was missed due to a navigation error, but with little consequence. The general area was still covered by “dusk” transects for the description of fry distribution, and the 95%CI of the population estimate was good (+/-22%) with the 9 cross-lake transects that were surveyed. Rough weather on many transects caused more movement of the transducer than is desirable. This did not appear to degrade the data significantly, however, as fish traces were clearly recognizable and modes in the TS data were appropriate for fry and yearling sockeye. The sound frequency used for this survey (120 kHz) is robust with respect to changes in angle of insonification for TS of small fish (Horne and Clay 1998). Layer volumes used for the population estimate were approximated from available data and should be more accurately estimated in the future, if possible. As dictated by the survey plan, the 0-2 m depth range of the water column was not sampled. The shallow depth distribution we observed in this survey suggests that attention to these depths be merited in the future work. This layer could be sampled efficiently with an upward looking transducer. Also in accordance with the survey plan, littoral areas shallower than 2 m were not sampled with acoustics. These areas are problematic for mobile acoustic surveys and are usually best sampled by other methods such as snorkeling or beach seining, as was done at Lake Wenatchee in spring 2002. Hydroacoustics using fixed location transducers is another sampling option for littoral areas that can be used to describe patterns of fish movement between shallow and deep water on a daily or hourly time scale (Stables and Thomas 1992).

While the spring 2002 acoustic survey provided much information that is pertinent to the potential interaction between juvenile sockeye and coho salmon in Lake Wenatchee, it leaves some important questions unanswered. These include: describing timing of the onshore and offshore fry migrations at dusk and dawn; determining whether fry are abundant near shore anywhere in the lake during the day; determining whether the spatial patterns seen in this survey remain the same earlier and later in the season. It would be desirable to address these questions if future acoustic surveys are conducted in the lake.

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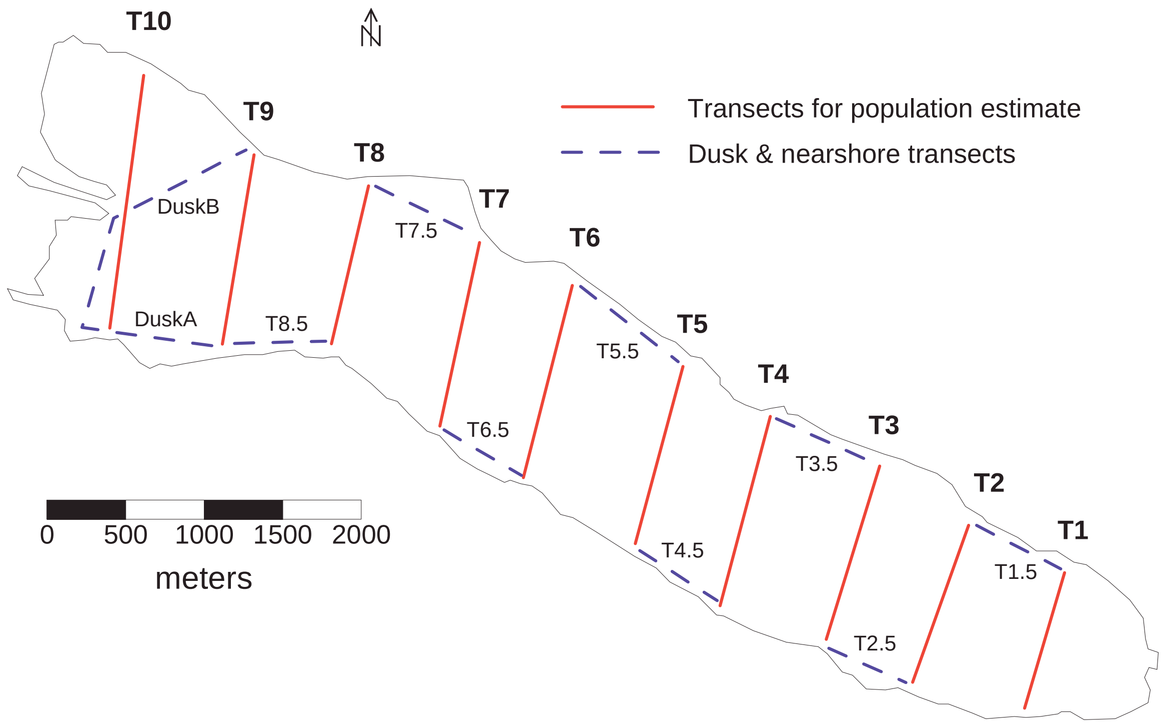
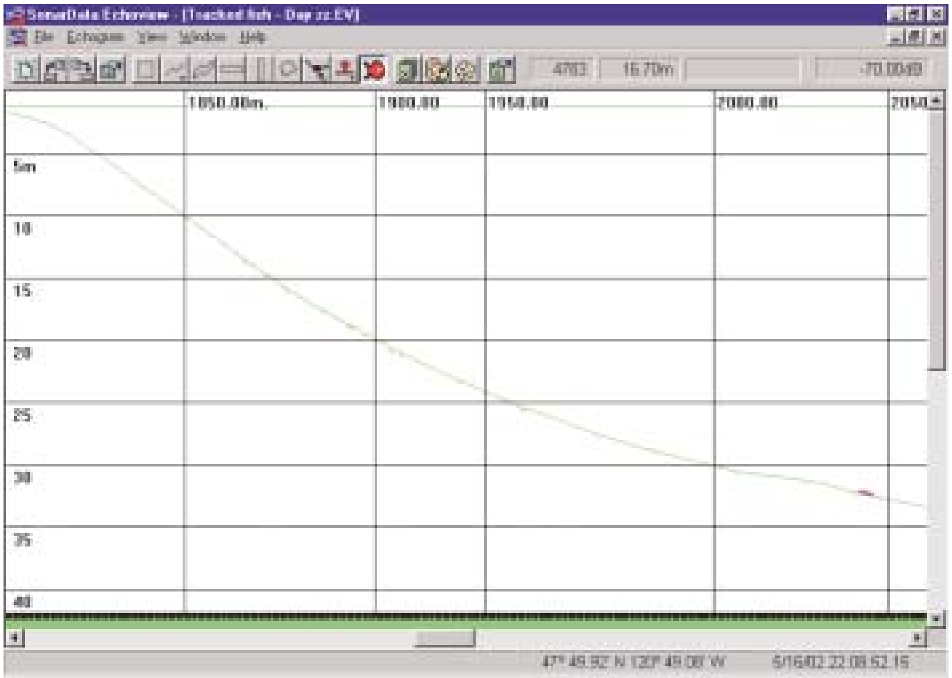


Figure 1. Map of Lake Wenatchee, showing transects for May 16-17, 2002 acoustic survey.

(a)



(b)

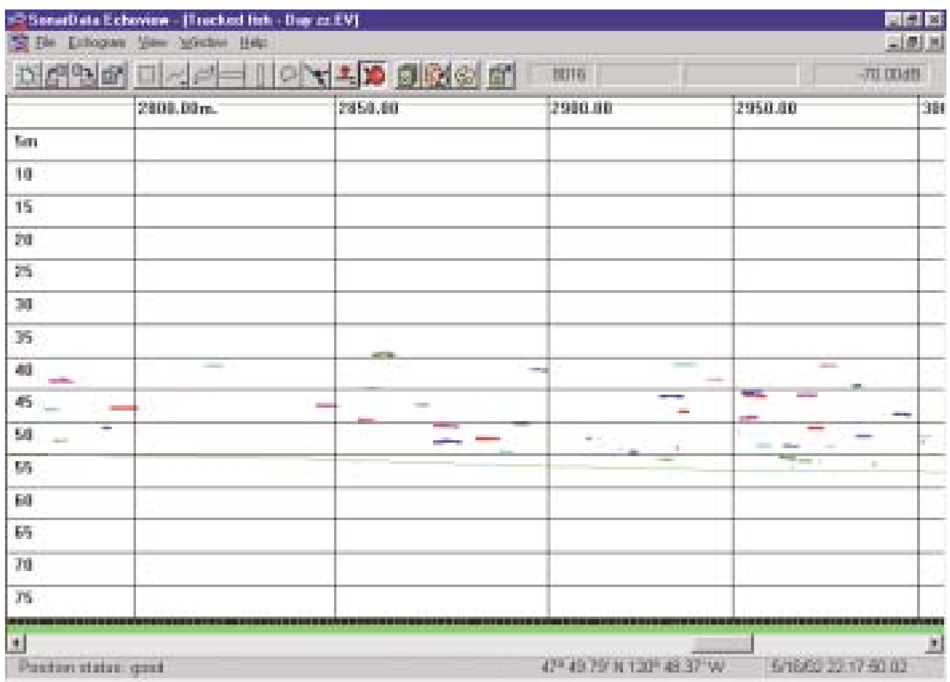


Figure 2. Distribution of fish during the day (1400-1500 hours) of May 16, 2002 in the west end of Lake Wenatchee a) near shore, and b) off shore.

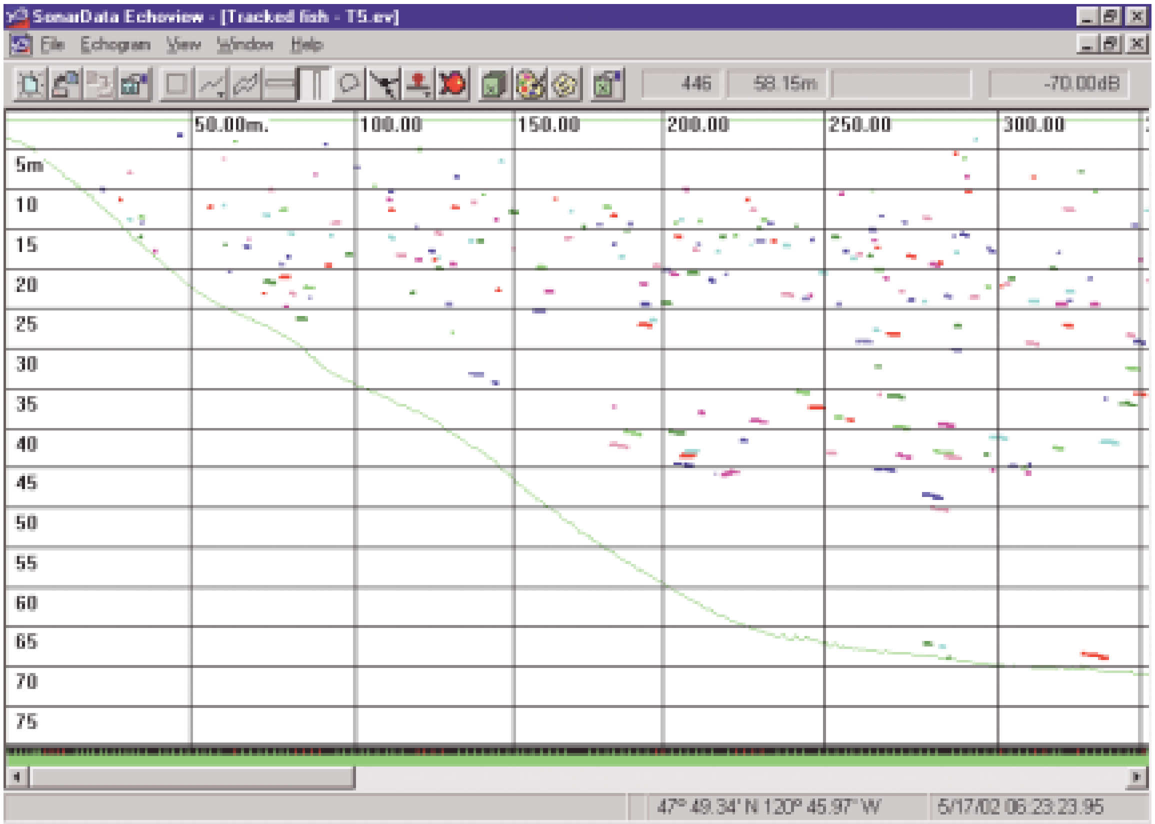


Figure 3. Typical nighttime echogram showing fish traces on Transect 5 from the north shore to about 300 m out in Lake Wenatchee, May 16, 2002. Different colors serve no purpose than to distinguish individual fish traces.

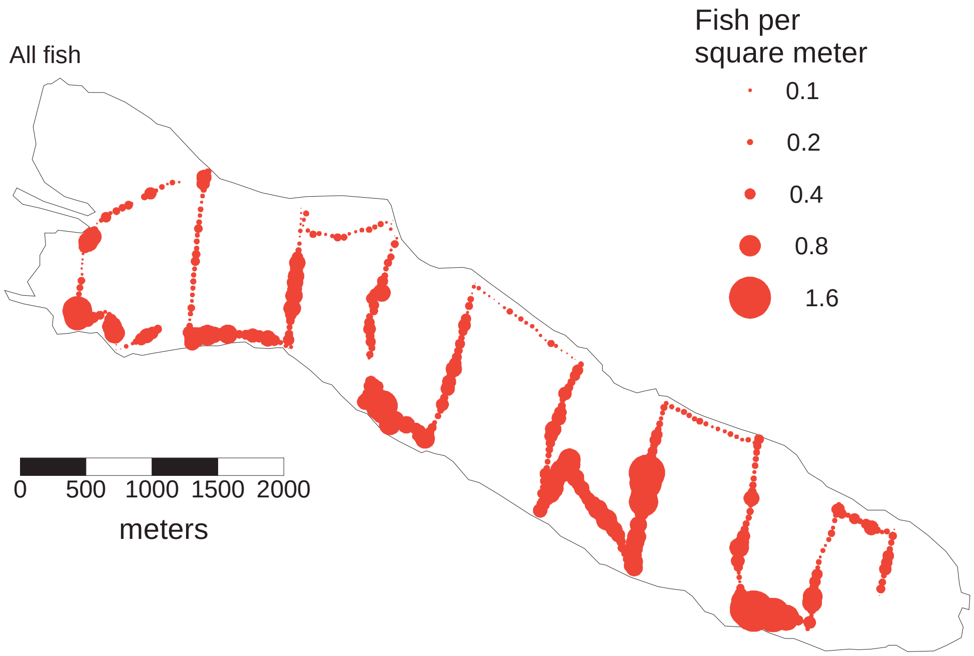


Figure 4. Fish density (fish/m^2) for fish of all sizes along acoustic transects in Lake Wenatchee on the night of May 16-17, 2002, 2130-0100 hours.

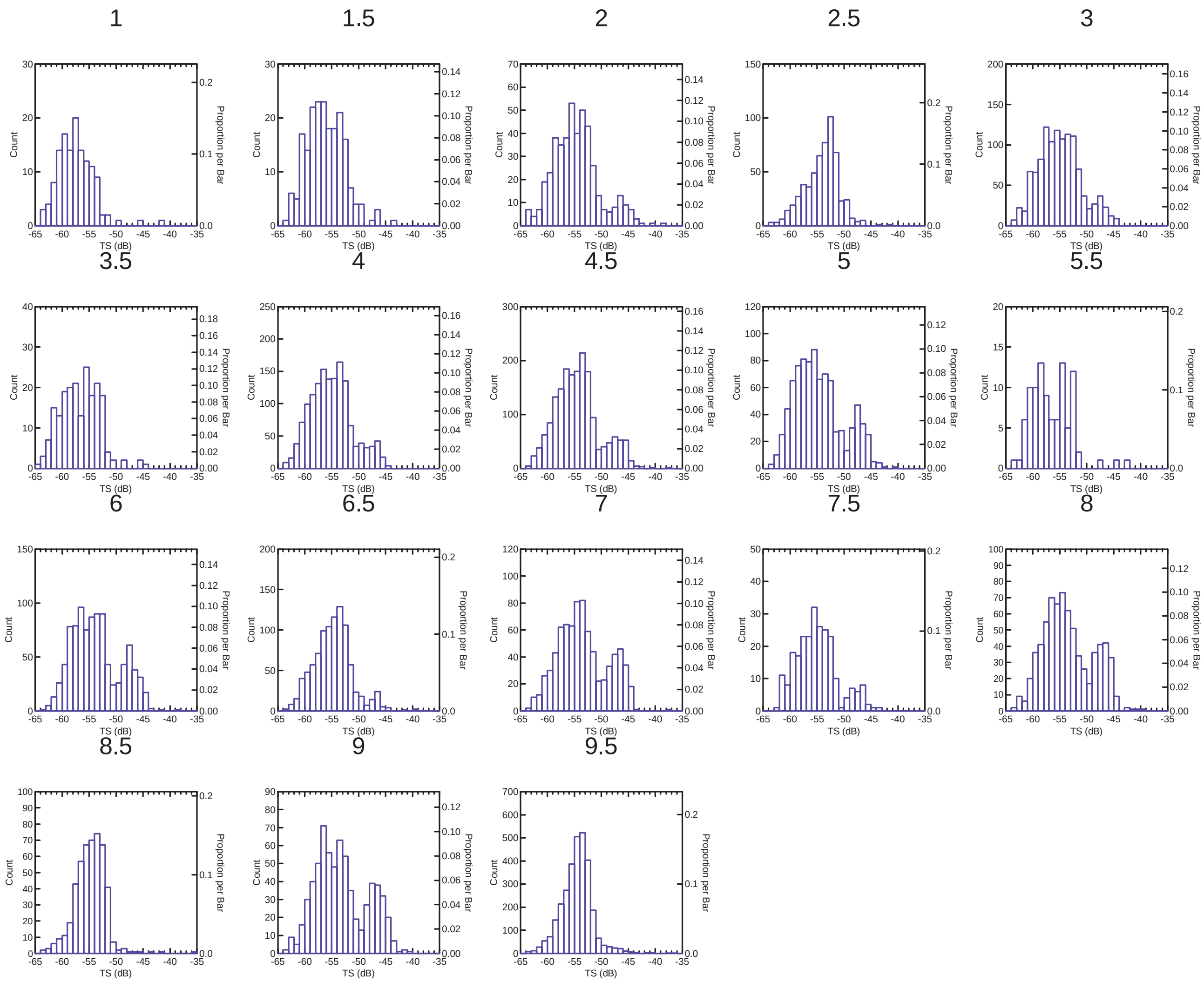


Figure 5. Frequency distribution of TS by transect, all depths combined, Lake Wenatchee, May 16-17, 2002. Dusk transects at the lake's west end were combined as transect 9.5.

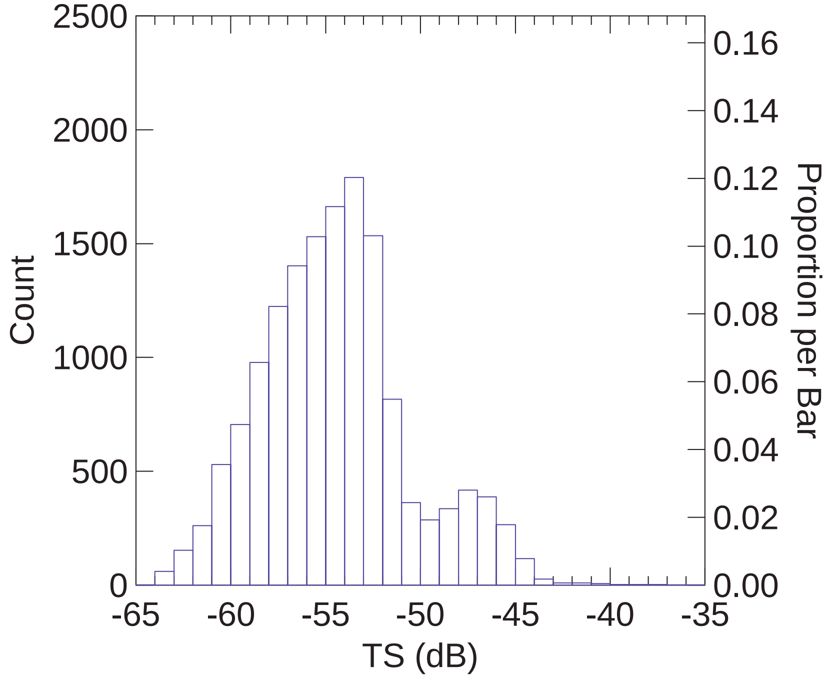


Figure 6. Frequency distribution of TS for all transects and depths combined, Lake Wenatchee, May 16-17, 2002.

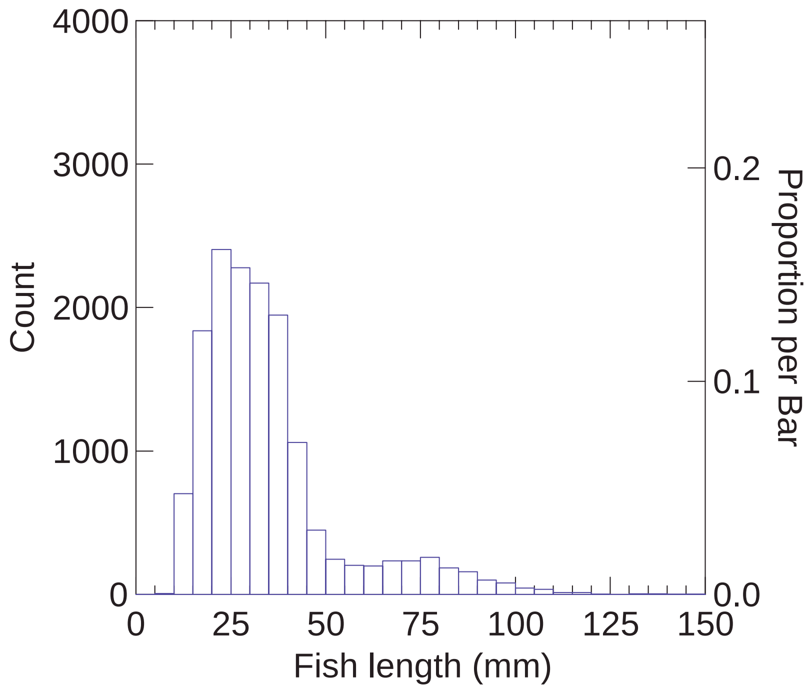


Figure 7. Frequency distribution of fish length (mm) estimated from TS using Love's (1977) relationship for fish insonified dorsally, Lake Wenatchee, May 16-17, 2002. Data are for all transects and depths combined.

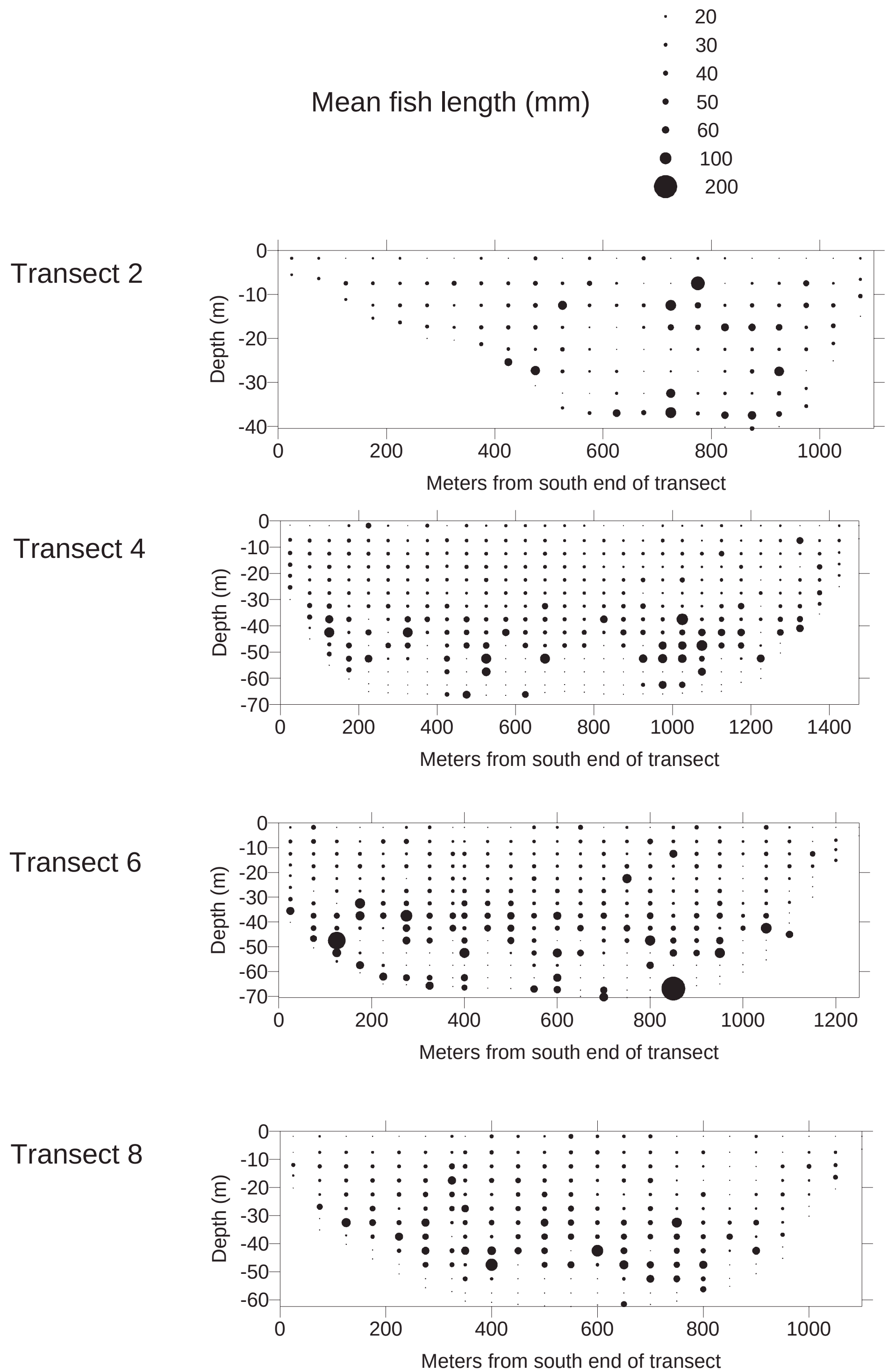
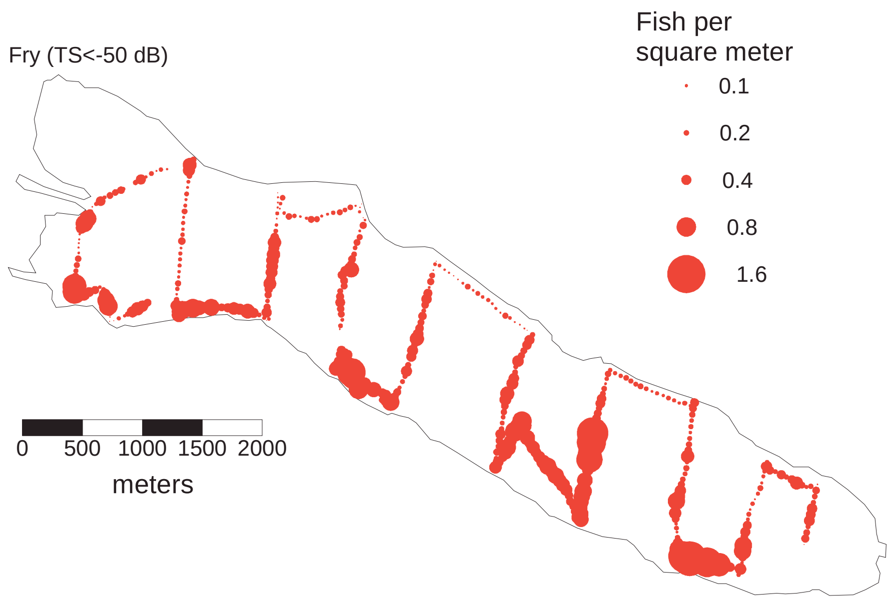


Figure 8. Mean fish length (mm) by depth and distance from south end of transect, transects 2, 4, 6, and 8, Lake Wenatchee, May 16-17, 2002. Lengths were estimated from TS using Love's (1977) dorsal aspect relationship. Smallest dots represent cells that were sampled where no fish were detected (e.g., transect 8, 400 m from south end and 61 m deep).



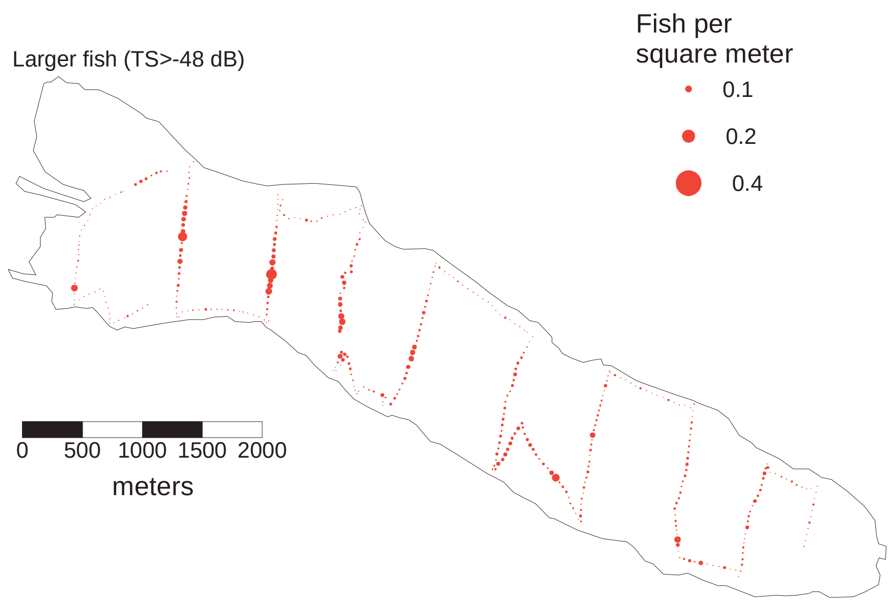


Figure 9. Density (fish/m^2) of sockeye fry and yearling sized fish along acoustic transects in Lake Wenatchee, May 16-17, 2002, from 2130-0100 hours.

Table 1. Sampling details and equipment settings for May 16-17, 2002 acoustic survey of Lake Wenatchee.

Project Phase	Category	Parameter	All transects
Data collection	transducer	type	split beam
		sound frequency	120 kHz
		nominal beam angle	7.4 x 17 deg
		pulse width	0.4 msec
		data collection threshold	-65 dB
		Time Varied Threshold	40 log R
		Transecting speed	2.0-2.5 m/sec
		ping rate (pps)	6
	GPS	type	Furuno GP-35
		coordinate system	NAD83
Data Analysis		Time Varied Gain	40 log R
		processing threshold (dB)	-65
		beam full angle (deg)	8
		Single target filters:	0.8-1.5 @ -6dB
		Fish tracking parameters:	
		minimum hits	1
		max change in range (m)	0.2
		max ping gap	3

Table 2. Total fish density (fish/m^3) by transect and depth layer from May 16-17, 2002 acoustic survey of Lake Wenatchee. Shoreline areas with depth < 2 m and the upper most 2 m of the water column were not sampled.

Depth	Upper	Lower					Fish density by transect		t				Total	
interval	limit (m)	limit (m)	1	2	3	4	5	6	7	8	9	n	Mean	Var
1	0	5	0.0131	0.0161	0.0133	0.0283	0.0180	0.0192	0.0160	0.0190	0.0099	9	0.0170	0.000027
2	5	10	0.0467	0.0137	0.0165	0.0211	0.0108	0.0109	0.0159	0.0146	0.0091	9	0.0177	0.000131
3	10	15	0.0907	0.0195	0.0211	0.0191	0.0122	0.0121	0.0101	0.0101	0.0101	9	0.0228	0.000668
4	15	20		0.0104	0.0160	0.0154	0.0081	0.0082	0.0082	0.0080	0.0069	8	0.0102	0.000013
5	20	25		0.0024	0.0059	0.0098	0.0062	0.0052	0.0057	0.0057	0.0041	8	0.0056	0.000004
6	25	30		0.0018	0.0044	0.0064	0.0045	0.0055	0.0042	0.0057	0.0027	8	0.0044	0.000002
7	30	35		0.0017	0.0034	0.0047	0.0040	0.0048	0.0040	0.0064	0.0035	8	0.0041	0.000002
8	35	40		0.0048	0.0027	0.0041	0.0046	0.0043	0.0035	0.0028	0.0031	8	0.0037	0.000001
9	40	45		0.0025	0.0027	0.0028	0.0027	0.0031	0.0025	0.0014	0.0016	8	0.0024	0.000000
10	45	50			0.0015	0.0012	0.0009	0.0010	0.0010	0.0007	0.0010	7	0.0010	0.000000
11	50	55			0.0006	0.0007	0.0003	0.0004	0.0005	0.0004	0.0003	7	0.0005	0.000000
12	55	60			0.0003	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	7	0.0002	0.000000
13	60	65			0.0001	0.0002	0.0001	0.0002	0.0001	0.0001	0.0000	7	0.0001	0.000000
14	65	70				0.0003	0.0002	0.0004	0.0002			4	0.0003	0.000000
15	70	75					0.0005	0.0008	0.0000			3	0.0004	0.000000
		Mean	0.0501	0.0081	0.0068	0.0082	0.0049	0.0051	0.0048	0.0058	0.0040			

Table 3. Population estimate for fish of all sizes in Lake Wenatchee, from May 16-17, 2002 acoustic survey. Shoreline areas with depth < 2 m and the upper most 2 m of the water column were not sampled.

Depth interval	Upper limit (m)	Lower limit (m)	Mean no. per cubic m	Variance	Sample size *	Stratum Volume (cubic m)	Pop est	SE of pop est	Lower 95% CL	Upper 95% CL
1	0	5	0.01699	2.72E-05	9	5.04E+07	855,389	87,502	653,608	1,057,170
2	5	10	0.01770	1.31E-04	9	4.97E+07	880,305	189,805	442,613	1,317,997
3	10	15	0.02277	6.68E-04	9	4.87E+07	1,109,734	419,758	141,770	2,077,697
4	15	20	0.01016	1.27E-05	8	4.74E+07	481,480	59,639	340,457	622,504
5	20	25	0.00561	4.43E-06	8	4.57E+07	256,291	33,988	175,923	336,659
6	25	30	0.00441	2.40E-06	8	4.36E+07	192,345	23,883	135,870	248,820
7	30	35	0.00407	1.83E-06	8	4.12E+07	167,688	19,731	121,032	214,344
8	35	40	0.00374	6.56E-07	8	3.85E+07	143,927	11,013	117,885	169,969
9	40	45	0.00241	3.63E-07	8	3.52E+07	84,829	7,501	67,091	102,567
10	45	50	0.00104	6.63E-08	7	3.15E+07	32,597	3,065	25,097	40,096
11	50	55	0.00046	2.22E-08	7	2.71E+07	12,320	1,526	8,587	16,053
12	55	60	0.00016	8.23E-09	7	2.17E+07	3,459	744	1,638	5,279
13	60	65	0.00010	4.82E-09	7	1.47E+07	1,514	386	569	2,458
14	65	70	0.00027	8.37E-09	4	8.86E+05	237	41	108	366
15	70	75	0.00042	1.54E-07	3	8.86E+03	4	2	-5	12
Total					155	4.96E+08	4,222,117	475,122	3,282,775	5,161,459
								95% CI is the population estimate	+/-	22%

* Number of transects with corresponding depth interval.

Table 4. Sockeye fry density (fish/m^3) by transect and depth layer from May 16-17, 2002 acoustic survey of Lake Wenatchee assuming that all fish with TS <-50 dB were sockeye fry. Shoreline areas with depth < 2 m and the upper most 2 m of the water column were not sampled.

Depth	Upper	Lower								Fish density by transect			Total	
interval	limit (m)	limit (m)	1	2	3	4	5	6	7	8	9	n	Mean	Var
1	0	5	0.0131	0.0161	0.0125	0.0283	0.0180	0.0192	0.0151	0.0180	0.0091	9	0.01660	0.000029
2	5	10	0.0451	0.0122	0.0161	0.0208	0.0108	0.0108	0.0154	0.0142	0.0090	9	0.01715	0.000123
3	10	15	0.0907	0.0183	0.0200	0.0189	0.0118	0.0118	0.0090	0.0091	0.0096	9	0.02214	0.000679
4	15	20		0.0094	0.0151	0.0153	0.0080	0.0081	0.0072	0.0068	0.0062	8	0.00951	0.000013
5	20	25		0.0023	0.0056	0.0098	0.0060	0.0048	0.0052	0.0049	0.0036	8	0.00528	0.000005
6	25	30		0.0012	0.0044	0.0063	0.0040	0.0049	0.0034	0.0042	0.0022	8	0.00382	0.000002
7	30	35		0.0016	0.0030	0.0039	0.0033	0.0035	0.0023	0.0034	0.0019	8	0.00284	0.000001
8	35	40		0.0027	0.0022	0.0026	0.0029	0.0017	0.0016	0.0017	0.0014	8	0.00211	0.000000
9	40	45		0.0025	0.0017	0.0016	0.0010	0.0017	0.0009	0.0006	0.0004	8	0.00130	0.000001
10	45	50			0.0008	0.0007	0.0005	0.0004	0.0005	0.0003	0.0003	7	0.00050	0.000000
11	50	55			0.0003	0.0003	0.0001	0.0002	0.0005	0.0002	0.0001	7	0.00024	0.000000
12	55	60			0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	7	0.00008	0.000000
13	60	65			0.0000	0.0001	0.0000	0.0001	0.0001	0.0001	0.0000	7	0.00004	0.000000
14	65	70				0.0001	0.0001	0.0001	0.0001			4	0.00011	0.000000
15	70	75					0.0000	0.0000	0.0000			3	0.00000	0.000000
		Mean	0.0496	0.0074	0.0063	0.0078	0.0044	0.0045	0.0041	0.0049	0.0034			

Table 5. Population estimate for sockeye fry in Lake Wenatchee, from May 16-17, 2002 acoustic survey assuming that all fish with TS <-50 dB were sockeye fry. Shoreline areas with depth < 2 m and the upper most 2 m of the water column were not sampled.

Depth interval	Upper limit (m)	Lower limit (m)	Mean no. per cubic m	Variance	Sample size *	Stratum Volume (cubic m)	Pop est	SE of pop est	Lower 95% CL	Upper 95% CL
1	0	5	0.01660	2.93E-05	9	5.04E+07	835,779	90,817	626,353	1,045,204
2	5	10	0.01715	1.23E-04	9	4.97E+07	853,289	183,792	429,465	1,277,114
3	10	15	0.02214	6.79E-04	9	4.87E+07	1,078,831	423,420	102,422	2,055,241
4	15	20	0.00951	1.32E-05	8	4.74E+07	450,273	60,758	306,602	593,944
5	20	25	0.00528	4.71E-06	8	4.57E+07	241,148	35,032	158,309	323,986
6	25	30	0.00382	2.44E-06	8	4.36E+07	166,788	24,097	109,808	223,769
7	30	35	0.00284	6.76E-07	8	4.12E+07	117,320	11,989	88,971	145,669
8	35	40	0.00211	3.44E-07	8	3.85E+07	81,216	7,977	62,353	100,078
9	40	45	0.00130	5.01E-07	8	3.52E+07	45,701	8,814	24,859	66,543
10	45	50	0.00050	3.51E-08	7	3.15E+07	15,872	2,230	10,415	21,328
11	50	55	0.00024	1.73E-08	7	2.71E+07	6,442	1,347	3,146	9,738
12	55	60	0.00008	1.95E-09	7	2.17E+07	1,722	362	835	2,609
13	60	65	0.00004	1.72E-09	7	1.47E+07	614	230	50	1,178
14	65	70	0.00011	9.45E-10	4	8.86E+05	102	14	59	145
15	70	75	0.00000	0.00E+00	3	8.86E+03	0	0	0	0
Total					155	4.96E+08	3,895,096	476,554	2,952,923	4,837,269
								95% CI is the population estimate	+/-	24%

APPENDIX B: COHO SMOLT RADIO-TAG HISTORIES

APPENDIX B: COHO SMOLT RAIDO-TAG HISTORIES
2002 SOCKEYE AND COHO INTERACTION EVALUATION

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
5	1	5/9/02 0:00	Two Rivers Tagging Site		148	13.50		
5	1	5/10/02 10:15	Release Date					
5	1	5/23/02 22:19	Entered Lake Wenatchee					
5	1	6/3/02 15:12	West Vista					
5	1	6/4/02 23:19	Little Wenatchee Station 1					
5	1	6/8/02 7:27	West Vista					
		6/6/02 0:00	Tag Kill Date					West end
5	2	5/9/02 0:00	Two Rivers Tagging Site		124	13.55		
5	2	5/10/02 10:15	Release Date					
5	2	5/23/02 23:26	Entered Lake Wenatchee					
5	2	6/4/02 22:38	Little Wenatchee Station 1					
5	2	6/5/02 1:09	Camp Zanika					
5	2	6/5/02 4:51	West Vista					
5	2	6/6/02 23:03	West Vista					
		6/6/02 0:00	Tag Kill Date					West end
5	3	5/9/02 0:00	Two Rivers Tagging Site		140	26.30		
5	3	5/10/02 20:15	Release Date					
5	3	6/6/02 3:31	Entered Lake Wenatchee					
		6/6/02 0:00	Tag Kill Date					Entered and disappeared
5	4	5/9/02 0:00	Two Rivers Tagging Site		130	26.72		
5	4	5/10/02 10:15	Release Date					
5	4	6/6/02 3:24	Entered Lake Wenatchee					
		6/6/02 0:00	Tag Kill Date					Entered and disappeared
5	5	5/21/02 0:00	Two Rivers Tagging Site			15.15		
5	5	5/22/02 0:00	Release Date					
5	5	6/6/02 3:41	Entered Lake Wenatchee					
5	5	6/24/02 22:51	Little Wenatchee Station 1					
		6/18/02 0:00	Tag Kill Date					Little Wenatchee
5	6	5/3/02 0:00	Two Rivers Tagging Site		127	6.61		

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
5	6	5/4/02 9:20	Release Date					
5	6	Not Detected	Entered Lake Wenatchee					Entered but not detected
5	6	5/11/02 0:02	Larco					
		5/31/02 0:00	Tag Kill Date	South shore				
5	7	5/7/02 0:00	Two Rivers Tagging Site		134	16.71		
5	7	5/8/02 13:30	Release Date					
5	7	5/25/02 6:31	Entered Lake Wenatchee					
		6/4/02 0:00	Tag Kill Date	Entered and disappeared				
5	8	5/7/02 0:00	Two Rivers Tagging Site		128	20.14		
5	8	5/8/02 13:30	Release Date					
5	8	Not Detected	Entered Lake Wenatchee					Entered but not detected
5	8	5/28/02 16:48	Camp Zanika					
5	8	5/29/02 1:02	West Vista					
5	8	5/29/02 3:51	Camp Zanika					
5	8	5/29/02 20:16	Camp Zanika					
5	8	6/4/02 23:06	Little Wenatchee Station 1					
		6/4/02 0:00	Tag Kill Date	West end				
5	9	5/15/02 0:00	Two Rivers Tagging Site		138	0.82		
5	9	5/15/02 12:00	Release Date					
5	9	5/16/02 7:43	Entered Lake Wenatchee					
5	9	5/24/02 8:49	Little Wenatchee Station 1					
5	9	5/24/02 15:16	Little Wenatchee Station 1					
5	9	5/25/02 2:16	Little Wenatchee Station 1					
5	9	5/31/02 19:28	Little Wenatchee Station 1					
		6/12/02 0:00	Tag Kill Date	Little Wenatchee				
5	10	5/15/02 0:00	Two Rivers Tagging Site		139	11.51	1.17	
5	10	5/16/02 12:15	Release Date					
5	10	Not Detected	Entered Lake Wenatchee					
5	10	5/28/02 0:27	Camp Zanika					
5	10	5/28/02 3:10	West Vista					
5	10	5/28/02 6:09	University Beach					
5	10	5/28/02 9:45	Larco					
5	10	5/29/02 4:37	Exited Lake Wenatchee					
		6/12/02 0:00	Tag Kill Date	Ping pong / exited				
5	11	5/3/02 0:00	Two Rivers Tagging Site		129	11.73		
5	11	5/4/02 9:20	Release Date					

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
5	11	5/16/02 2:47	Entered Lake Wenatchee					
		5/31/02 0:00	Tag Kill Date	Entered and disappeared				
5	12	5/7/02 0:00	Two Rivers Tagging Site		126	N/A		
5	12	5/8/02 13:30	Release Date					
5	13	5/7/02 0:00	Two Rivers Tagging Site		140	1.63		
5	13	5/8/02 13:30	Release Date					
5	13	Not Detected	Entered Lake Wenatchee					Entered but not detected
5	13	5/10/02 4:31	Camp Zanika					
5	13	5/11/02 1:58	Larco					
5	13	6/1/02 17:02	Larco					
5	13	6/2/02 21:42	Larco					
5	13	6/4/02 4:14	Larco					
5	13	6/5/02 6:01	Larco					
5	13	6/5/02 21:22	Larco					
		6/4/02 0:00	Tag Kill Date	South shore				
5	14	5/21/02 0:00	Two Rivers Tagging Site			N/A		
5	14	5/22/02 0:00	Release Date					
5	15	5/3/02 0:00	Two Rivers Tagging Site		121	9.61		
5	15	5/4/02 9:20	Release Date					
5	15	5/14/02 0:01	Entered Lake Wenatchee					
5	15	5/14/02 13:01	Larco					
5	15	5/23/02 23:05	Little Wenatchee Station 1					
5	15	5/24/02 3:22	Little Wenatchee Station 1					
5	15	6/4/02 23:13	Little Wenatchee Station 1					
5	15	6/5/02 19:08	Little Wenatchee Station 1					
		5/31/02 0:00	Tag Kill Date	Little Wenatchee				
5	16	5/15/02 0:00	Two Rivers Tagging Site		136	0.68		
5	16	5/16/02 12:15	Release Date					
5	16	5/17/02 4:32	Entered Lake Wenatchee					
5	16	5/20/02 22:48	Camp Zanika					
5	16	5/21/02 11:16	Camp Zanika					
5	16	5/21/02 11:46	West Vista					
5	16	6/1/02 1:17	Little Wenatchee Station 1					
5	16	5/4/02 16:37	Little Wenatchee Station 1					
5	16	6/5/02 0:38	Little Wenatchee Station 1					

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION / COMMENTS	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)
		6/12/02 0:00	Tag Kill Date	West end			
5	17	5/15/02 0:00	Two Rivers Tagging Site		135	2.39	9.31
5	17	5/16/02 12:15	Release Date				
5	17	5/18/02 21:38	Entered Lake Wenatchee				
5	17	5/18/02 23:30	Camp Zanika				
5	17	5/19/02 22:54	Camp Zanika				
5	17	5/19/02 23:45	West Vista				
5	17	5/20/02 2:42	University Beach				
5	17	5/20/02 4:51	Larco				
5	17	5/20/02 12:24	Larco				
5	17	5/20/02 17:00	University Beach				
5	17	5/21/02 2:22	West Vista				
5	17	5/21/02 8:40	Camp Zanika				
5	17	5/21/02 20:10	Camp Zanika				
5	17	5/22/02 2:56	West Vista				
5	17	5/22/02 8:45	Camp Zanika				
5	17	5/22/02 15:55	Camp Zanika				
5	17	5/22/02 17:27	West Vista				
5	17	5/22/02 19:48	University Beach				
5	17	5/22/02 21:07	Larco				
5	17	5/23/02 11:04	West Vista				
5	17	5/23/02 18:28	Camp Zanika				
5	17	5/23/02 21:35	Camp Zanika				
5	17	5/24/02 0:35	Little Wenatchee Station 1				
5	17	5/24/02 23:59	West Vista				
5	17	5/25/02 1:17	University Beach				
5	17	5/25/02 13:30	Larco				
5	17	5/25/02 17:26	Camp Zanika				
5	17	5/25/02 19:01	Little Wenatchee Station 1				
5	17	5/26/02 3:02	Camp Zanika				
5	17	5/26/02 4:10	West Vista				
5	17	5/26/02 18:28	Camp Zanika				
5	17	5/26/02 21:25	West Vista				
5	17	5/27/02 0:01	University Beach				
5	17	5/27/02 6:14	University Beach				
5	17	5/27/02 13:40	West Vista				

APPENDIX B CONTINUED

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION / COMMENTS	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE / TRAVEL TIME (LAKE)
5	17	5/27/02 15:17	Camp Zanika			
5	17	5/27/02 22:02	Larco			
5	17	5/28/02 4:58	Exited Lake Wenatchee			
		6/12/02 0:00	Tag Kill Date	Ping pong / Exit		
5	18	5/15/02 0:00	Two Rivers Tagging Site		138	2.37
5	18	5/16/02 12:15	Release Date			
5	18	5/18/02 21:06	Entered Lake Wenatchee			
5	18	5/18/02 23:33	Camp Zanika			
5	18	5/19/02 1:19	West Vista			
5	18	5/19/02 18:33	Larco			
5	18	5/23/02 22:53	Little Wenatchee Station 1			
5	18	5/24/02 3:21	Little Wenatchee Station 1			
5	18	5/31/02 19:47	Little Wenatchee Station 1			
5	18	6/3/02 16:23	University Beach			
5	18	6/3/02 23:04	Larco			
5	18	6/4/02 10:51	University Beach			
		6/12/02 0:00	Tag Kill Date	Ping pong		
5	19	5/15/02 0:00	Two Rivers Tagging Site		142	15.17
5	19	5/16/02 12:15	Release Date			
5	19	5/31/02 16:17	Entered Lake Wenatchee			
5	19	6/5/02 1:35	Little Wenatchee Station 1			
		6/12/02 0:00	Tag Kill Date	Little Wenatchee		
5	20	5/21/02 0:00	Two Rivers Tagging Site			15.18
5	20	5/22/02 0:00	Release Date			
5	20	6/6/02 4:26	Entered Lake Wenatchee			
		6/18/02 0:00	Tag Kill Date	Entered and disappeared		
5	21	5/3/02 0:00	Two Rivers Tagging Site			27.27
5	21	5/4/02 9:20	Release Date			
5	21	5/31/02 15:41	Entered Lake Wenatchee			
		5/31/02 0:00	Tag Kill Date	Entered and disappeared		
5	22	5/3/02 0:00	Two Rivers Tagging Site		123	N/A
5	22	5/4/02 9:20	Release Date			
5	23	5/2/02 0:00	Two Rivers Tagging Site		129	N/A
5	23	5/3/02 11:30	Release Date			
5	24	5/2/02 0:00	Two Rivers Tagging Site		135	20.79
5	24	5/3/02 11:30	Release Date			

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
5	24	5/24/02 6:26	Entered Lake Wenatchee					
		5/30/02 0:00	Tag Kill Date	Entered and disappeared				
5	25	5/2/02 0:00	Two Rivers Tagging Site		139	2.40		Descaled
5	25	5/3/02 11:30	Release Date					
5	25	5/5/02 20:59	Entered Lake Wenatchee					
5	25	5/7/02 20:36	Little Wenatchee Station 1					
5	25	5/8/02 16:41	Little Wenatchee Station 1					
5	25	5/13/02 0:00	Little Wenatchee Station 1					
5	25	5/13/02 23:48	Camp Zanika					
5	25	5/19/02 0:37	Camp Zanika					
		5/30/02 0:00	Tag Kill Date	West end				
5	26	5/3/02 0:00	Two Rivers Tagging Site		132	1.11		
5	26	5/4/02 9:20	Release Date					
5	26	5/5/02 12:03	Entered Lake Wenatchee					
5	26	5/7/02 14:02	Little Wenatchee Station 1					
5	26	5/13/02 12:47	Little Wenatchee Station 1					
5	26	5/23/02 16:23	Little Wenatchee Station 1					
5	26	5/25/02 1:19	Little Wenatchee Station 1					
5	26	5/30/02 11:25	Little Wenatchee Station 1					
5	26	6/4/02 14:30	Little Wenatchee Station 1					
		5/31/02 0:00	Tag Kill Date	Little Wenatchee				
5	27	5/3/02 0:00	Two Rivers Tagging Site		126	24.63		
5	27	5/4/02 9:20	Release Date					
5	27	5/21/02 0:00	Mobile: Two Rivers Tagging Site					
5	27	Not Detected	Enterd					Entered but not detected
5	27	5/29/02 0:26	Camp Zanika					
5	27	5/29/02 4:09	Camp Zanika					
5	27	5/29/02 9:15	Camp Zanika					
5	27	5/29/02 18:47	West Vista					
5	27	5/29/02 22:48	University Beach					
5	27	5/30/02 4:56	University Beach					
5	27	5/31/02 3:33	University Beach					
5	27	5/31/02 6:01	Camp Zanika					
5	27	6/1/02 3:45	Little Wenatchee Station 1					
5	27	6/4/02 2:21	Camp Zanika					
5	27	6/4/02 17:55	Camp Zanika					

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
5	27	6/4/02 23:55	Little Wenatchee Station 1					
5	27	6/5/02 2:06	Camp Zanika					
5	27	6/5/02 19:55	Camp Zanika					
5	27	6/7/02 7:46	Camp Zanika					
5	27	6/7/02 17:47	Camp Zanika					
5	27	6/7/02 23:27	Larco					
5	27	6/8/02 23:54	Larco					
5	27	6/9/02 0:07	Larco					
5	27	6/9/02 4:53	Larco					
5	27	6/9/02 20:30	Camp Zanika					
5	27	6/11/02 22:30	West Vista					
5	27	6/12/02 4:49	Camp Zanika					
		5/31/02 0:00	Tag Kill Date	Ping pong				
5	28	5/2/02 0:00	Two Rivers Tagging Site		131	20.64		
5	28	5/3/02 9:20	Release Date					
5	28	5/24/02 0:35	Entered Lake Wenatchee					
5	28	5/31/02 0:17	Little Wenatchee Station 1					
5	28	6/2/02 1:32	Camp Zanika					
		5/30/02 0:00	Tag Kill Date	West end				
5	29	5/2/02 0:00	Two Rivers Tagging Site		140	0.42		
5	29	5/3/02 11:30	Release Date					
5	29	5/3/02 21:36	Entered Lake Wenatchee					
5	29	5/3/02 23:07	Camp Zanika					
5	29	5/7/02 15:48	Little Wenatchee Station 1					
5	29	5/8/02 23:35	Little Wenatchee Station 1					
5	29	5/8/02 22:34	Camp Zanika					
5	29	5/10/02 0:48	Camp Zanika					
5	29	5/11/02 0:50	Camp Zanika					
5	29	5/11/02 5:48	Camp Zanika					
5	29	5/12/02 18:59	Camp Zanika					
5	29	5/13/02 6:08	Camp Zanika					
5	29	5/13/02 14:14	Camp Zanika					
5	29	5/13/02 21:07	Camp Zanika					
5	29	5/13/02 23:38	Little Wenatchee Station 1					
5	29	5/14/02 1:12	West Vista					
5	29	5/14/02 19:01	Larco					

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
5	29	5/15/02 3:28	Camp Zanika					
5	29	5/15/02 8:52	Little Wenatchee Station 1					
5	29	5/15/02 20:51	Camp Zanika					
5	29	5/16/02 2:11	Little Wenatchee Station 1					
5	29	5/16/02 8:33	Camp Zanika					
5	29	5/16/02 19:06	Little Wenatchee Station 1					
5	29	5/17/02 5:51	Camp Zanika					
5	29	5/17/02 17:36	Larco					
5	29	5/17/02 19:30	Larco					
5	29	5/17/02 23:47	Camp Zanika					
5	29	5/18/02 1:05	Little Wenatchee Station 1					
5	29	5/18/02 9:20	Little Wenatchee Station 1					
5	29	5/19/02 2:33	Little Wenatchee Station 1					
5	29	5/19/02 4:46	Camp Zanika					
5	29	5/23/02 16:23	Little Wenatchee Station 1					
5	29	5/24/02 0:24	Little Wenatchee Station 1					
5	29	5/25/02 16:45	Camp Zanika					
5	29	5/25/02 21:29	Little Wenatchee Station 1					
5	29	5/26/02 5:49	Camp Zanika					
5	29	5/26/02 11:55	Camp Zanika					
5	29	5/26/02 15:12	Camp Zanika					
5	29	5/26/02 19:48	Camp Zanika					
5	29	5/28/02 16:00	West Vista					
5	29	5/28/02 19:58	Camp Zanika					
5	29	5/30/02 20:33	Little Wenatchee Station 1					
5	29	5/31/02 12:05	Camp Zanika					
5	29	6/4/02 14:28	Little Wenatchee Station 1					
		5/30/02 0:00	Tag Kill Date	Ping pong/South shore				
5	30	5/2/02 0:00	Two Rivers Tagging Site		128	27.55		
5	30	5/3/02 9:20	Release Date					
5	30	5/21/02 0:00	Mobile: Two Rivers Tagging Site					
5	30	5/30/02 22:33	Entered Lake Wenatchee					
5	30	6/6/02 3:53	Little Wenatchee Station 1					
		5/30/02 0:00	Tag Kill Date	Little Wenatchee				
5	31	5/9/02 0:00	Two Rivers Tagging Site		137	6.59		
5	31	5/10/02 10:15	Release Date					

APPENDIX B CONTINUED

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
5	31	Not Detected	Entered Lake Wenatchee					Entered but not detected
5	31	5/17/02 0:20	Camp Zanika					
5	31	5/18/02 4:38	West Vista					
5	31	5/19/02 1:39	Camp Zanika					
5	31	5/19/02 21:25	Camp Zanika					
5	31	5/20/02 21:12	Camp Zanika					
5	31	5/21/02 0:19	Camp Zanika					
5	31	5/21/02 2:14	Camp Zanika					
5	31	5/21/02 14:11	Camp Zanika					
5	31	5/21/02 18:06	Camp Zanika					
5	31	5/21/02 23:59	Camp Zanika					
		6/6/02 0:00	Tag Kill Date	West end				
5	32	5/7/02 0:00	Two Rivers Tagging Site		130	8.44		
5	32	5/8/02 13:30	Release Date					
5	32	5/17/02 0:00	Entered Lake Wenatchee					
5	32	5/28/02 6:50	Camp Zanika					
5	32	5/28/02 21:49	Camp Zanika					
5	32	5/29/02 12:23	West Vista					
5	32	5/29/02 12:30	Camp Zanika					
5	32	5/29/02 23:04	West Vista					
5	32	5/30/02 1:52	University Beach					
5	32	5/30/02 5:44	University Beach					
5	32	5/30/02 7:39	West Vista					
5	32	5/31/02 1:02	University Beach					
5	32	5/31/02 7:18	Camp Zanika					
5	32	6/1/02 5:12	Camp Zanika					
5	32	6/3/02 5:05	Camp Zanika					
		6/4/02 0:00	Tag Kill Date	Ping pong				
5	53	5/9/02 0:00	Two Rivers Tagging Site		129	20.62		
5	53	5/10/02 10:15	Release Date					
5	53	5/31/02 1:12	Entered Lake Wenatchee					
		6/6/02 0:00	Tag Kill Date	Entered and disappeared				
5	54	5/7/02 0:00	Two Rivers Tagging Site		132	16.47		
5	54	5/8/02 13:30	Release Date					
5	54	5/25/02 0:45	Entered Lake Wenatchee					

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE
	TRAVEL TIME (LAKE)		COMMENTS			
5	54	6/5/02 22:03	Little Wenatchee Station 1			
		6/4/02 0:00	Tag Kill Date	Little Wenatchee		
5	155	5/7/02 0:00	Two Rivers Tagging Site		140	6.39
5	155	5/8/02 13:30	Release Date			
5	155	5/14/02 22:47	Entered Lake Wenatchee			
5	155	5/15/02 2:00	Camp Zanika			
5	155	5/15/02 8:02	Camp Zanika			
5	155	5/15/02 20:02	Little Wenatchee Station 1			
5	155	5/15/02 21:52	Camp Zanika			
5	155	5/16/02 19:29	Camp Zanika			
5	155	5/16/02 23:48	Little Wenatchee Station 1			
5	155	5/17/02 4:15	Camp Zanika			
5	155	5/17/02 7:09	Little Wenatchee Station 1			
5	155	5/17/02 19:33	Camp Zanika			
5	155	5/17/02 20:22	West Vista			
5	155	5/18/02 2:45	University Beach			
5	155	5/18/02 7:05	Camp Zanika			
5	155	5/19/02 6:04	University Beach			
5	155	5/19/02 10:39	University Beach			
5	155	5/20/02 19:25	Larco			
5	155	5/21/02 12:03	Camp Zanika			
5	155	5/21/02 22:30	Larco			
5	155	5/22/02 1:45	University Beach			
5	155	5/22/02 11:25	Larco			
5	155	5/22/02 20:59	Larco			
5	155	5/23/02 3:32	University Beach			
5	155	5/23/02 21:01	Camp Zanika			
5	155	5/23/02 22:14	Little Wenatchee Station 1			
5	155	5/24/02 0:06	Little Wenatchee Station 1			
5	155	5/24/02 0:27	Camp Zanika			
5	155	5/24/02 3:29	Little Wenatchee Station 1			
5	155	5/24/02 6:11	Little Wenatchee Station 1			
5	155	5/24/02 7:13	Camp Zanika			
5	155	5/24/02 11:59	Camp Zanika			
5	155	5/25/02 4:28	Little Wenatchee Station 1			
5	155	5/25/02 11:54	Little Wenatchee Station 1			

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE
	TRAVEL TIME (LAKE)		COMMENTS			
5	155	5/27/02 7:47	Camp Zanika			
5	155	5/31/02 1:56	Little Wenatchee Station 1			
5	155	6/5/02 1:12	Little Wenatchee Station 1			
5	155	6/14/02 16:03	Little Wenatchee Station 1			
5	155	6/16/02 5:33	Little Wenatchee Station 1			
5	155	6/16/02 7:34	Little Wenatchee Station 1			
		6/4/02 0:00	Tag Kill Date	Ping pong		
5	156	5/7/02 0:00	Two Rivers Tagging Site		133	N/A
5	156	5/8/02 13:30	Release Date			
5	157	5/7/02 0:00	Two Rivers Tagging Site		130	N/A
5	157	5/8/02 13:30	Release Date			
5	158	5/2/02 0:00	Two Rivers Tagging Site		150	N/A
5	158	5/2/02 11:30	Release Date			
5	159	5/9/02 0:00	Two Rivers Tagging Site		133	7.56
5	159	5/10/02 10:15	Release Date			
5	159	5/17/02 23:43	Entered Lake Wenatchee			
5	159	5/18/02 2:06	Camp Zanika			
5	159	5/18/02 11:45	West Vista			
5	159	5/18/02 12:14	Camp Zanika			
5	159	5/18/02 22:16	University Beach			
5	159	5/19/02 14:00	University Beach			
5	159	5/19/02 18:24	West Vista			
5	159	5/20/02 0:57	University Beach			
5	159	5/20/02 10:06	West Vista			
5	159	5/20/02 13:29	West Vista			
5	159	5/20/02 15:10	Camp Zanika			
5	159	5/20/02 19:02	West Vista			
5	159	5/21/02 21:24	Camp Zanika			
5	159	5/23/02 20:18	Little Wenatchee Station 1			
5	159	5/24/02 2:02	Camp Zanika			
5	159	5/24/02 20:24	Little Wenatchee Station 1			
5	159	5/25/02 20:37	Little Wenatchee Station 1			
5	159	5/31/02 7:24	Little Wenatchee Station 1			
5	159	6/4/02 14:37	Little Wenatchee Station 1			
		6/6/02 0:00	Tag Kill Date	Ping pong		
5	160	5/14/02 0:00	Two Rivers Tagging Site		126	N/A

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
5	160	5/15/02 0:00	Release Date					
5	160	5/21/02 0:00	Mobile: Two Rivers Tagging Site					
5	161	5/15/02 0:00	Two Rivers Tagging Site		143	3.44		
5	161	5/15/02 12:00	Release Date					
5	161	5/18/02 22:29	Entered Lake Wenatchee					
5	161	5/24/02 1:00	Camp Zanika					
5	161	5/24/02 19:02	West Vista					
5	161	5/24/02 23:23	Camp Zanika					
5	161	5/25/02 8:02	Camp Zanika					
5	161	5/25/02 14:06	Camp Zanika					
5	161	5/25/02 20:41	Camp Zanika					
5	161	5/28/02 22:50	Camp Zanika					
5	161	5/29/02 5:58	Larco					
5	161	6/3/02 18:42	University Beach					
5	161	6/3/02 22:36	Larco					
5	161	6/4/02 11:05	Camp Zanika					
5	161	6/6/02 1:34	Camp Zanika					
5	161	6/6/02 3:20	Little Wenatchee Station 1					
5	161	6/18/02 9:01	Little Wenatchee Station 1					
5	161	6/19/02 6:20	Little Wenatchee Station 1					
5	161	6/20/02 6:02	Little Wenatchee Station 1					
		6/12/02 0:00	Tag Kill Date	Ping pong				
5	162	5/14/02 0:00	Two Rivers Tagging Site		140	0.59		
5	162	5/15/02 10:15	Release Date					
5	162	5/16/02 0:23	Entered Lake Wenatchee					
5	162	5/16/02 2:48	Camp Zanika					
5	162	5/16/02 15:18	West Vista					
5	162	5/16/02 21:35	Little Wenatchee Station 1					
5	162	5/18/02 2:35	Camp Zanika					
5	162	5/18/02 19:37	Camp Zanika					
5	162	5/22/02 0:37	Camp Zanika					
5	162	5/22/02 0:00	Camp Zanika					
5	162	5/23/02 18:30	Camp Zanika					
5	162	5/25/02 1:28	Little Wenatchee Station 1					
5	162	6/4/02 20:20	Little Wenatchee Station 1					
5	162	6/5/02 14:35	Little Wenatchee Station 1					

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
		6/11/02 0:00	Tag Kill Date	West end				
5	163	5/14/02 0:00	Two Rivers Tagging Site		139	22.05		
5	163	5/15/02 12:00	Release Date					
5	163	6/6/02 13:07	West Vista					
5	163	6/6/02 18:40	West Vista					
		6/11/02 0:00	Tag Kill Date	North shore				
5	164	5/14/02 0:00	Two Rivers Tagging Site		150	0.46		
5	164	5/15/02 12:00	Release Date					
5	164	5/15/02 22:55	Entered Lake Wenatchee					
5	164	5/16/02 1:41	Camp Zanika					
5	164	5/16/02 23:07	Little Wenatchee Station 1					
5	164	5/17/02 0:36	Camp Zanika					
5	164	5/17/02 9:50	Little Wenatchee Station 1					
5	164	5/18/02 3:32	Camp Zanika					
5	164	5/18/02 12:10	Little Wenatchee Station 1					
5	164	5/21/02 5:08	Camp Zanika					
5	164	5/21/02 9:26	Camp Zanika					
5	164	5/23/02 5:25	Camp Zanika					
5	164	5/23/02 9:07	West Vista					
5	164	5/23/02 20:40	Camp Zanika					
5	164	5/24/02 1:17	Camp Zanika					
5	164	5/24/02 14:17	West Vista					
5	164	5/25/02 9:25	Camp Zanika					
5	164	5/25/02 19:05	Camp Zanika					
5	164	5/25/02 20:07	Little Wenatchee Station 1					
5	164	5/26/02 20:56	Camp Zanika					
5	164	5/30/02 17:35	Little Wenatchee Station 1					
5	164	6/4/02 14:29	Little Wenatchee Station 1					
5	164	6/6/02 6:25	Little Wenatchee Station 1					
5	164	6/14/02 12:58	Little Wenatchee Station 1					
5	164	6/17/02 13:45	Little Wenatchee Station 1					
5	164	6/20/02 12:20	Little Wenatchee Station 1					
		6/11/02 0:00	Tag Kill Date	West end				
5	165	5/15/02 0:00	Two Rivers Tagging Site		148	2.39		
5	165	5/16/02 12:15	Release Date					
5	165	5/18/02 21:43	Entered Lake Wenatchee					

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
5	165	5/18/02 23:33	Camp Zanika					
5	165	5/19/02 2:28	West Vista					
5	165	5/19/02 5:32	University Beach					
5	165	5/20/02 21:46	University Beach					
5	165	5/21/02 0:12	Larco					
5	165	5/21/02 11:44	University Beach					
5	165	5/21/02 21:39	University Beach					
5	165	5/22/02 2:46	West Vista					
5	165	5/22/02 10:33	Larco					
5	165	5/23/02 1:00	Larco					
5	165	5/23/02 5:07	University Beach					
5	165	5/23/02 23:18	University Beach					
5	165	5/24/02 0:41	Larco					
5	165	5/24/02 4:18	University Beach					
5	165	5/24/02 16:32	West Vista					
5	165	5/24/02 18:28	Camp Zanika					
5	165	5/24/02 20:18	West Vista					
5	165	5/25/02 0:19	West Vista					
5	165	5/25/02 3:58	Larco					
5	165	5/26/02 23:56	Larco					
5	165	5/27/02 0:11	Larco					
5	165	5/27/02 2:52	University Beach					
5	165	5/27/02 21:35	Larco					
5	165	5/28/02 6:28	University Beach					
5	165	5/28/02 11:14	University Beach					
5	165	5/28/02 21:24	University Beach					
5	165	5/29/02 2:01	West Vista					
5	165	5/29/02 3:43	Camp Zanika					
5	165	5/30/02 22:26	University Beach					
5	165	5/31/02 21:55	University Beach					
5	165	6/1/02 3:48	University Beach					
5	165	6/2/02 1:47	Larco					
5	165	6/6/02 13:42	Camp Zanika					
5	165	6/6/02 22:43	West Vista					
5	165	6/7/02 2:51	West Vista					
5	165	6/8/02 21:55	West Vista					

APPENDIX B CONTINUED

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
5	165	6/11/02 5:00	West Vista					
5	165	6/11/02 20:58	Camp Zanika					
5	165	6/11/02 22:00	West Vista					
5	165	6/13/02 10:14	University Beach					
5	165	6/15/02 10:43	Larco					
5	165	6/18/02 12:54	Larco					
5	165	6/18/02 22:58	Larco					
5	165	6/19/02 14:13	West Vista					
5	165	6/20/02 5:13	Larco					
5	165	6/20/02 8:30	West Vista					
		6/12/02 0:00	Tag Kill Date	Ping pong				
5	166	5/3/02 0:00	Two Rivers Tagging Site		136	0.59	21.95	
5	166	5/4/02 9:20	Release Date					
5	166	5/4/02 23:35	Entered Lake Wenatchee					
5	166	5/5/02 2:21	camp zanika					
5	166	5/5/02 5:47	West Vista					
5	166	5/5/02 23:47	West Vista					
5	166	5/8/02 1:46	West Vista					
5	166	5/9/02 2:46	Camp Zanika					
5	166	5/10/02 2:14	Camp Zanika					
5	166	5/10/02 4:11	West Vista					
5	166	5/11/02 20:39	Larco					
5	166	5/11/02 22:42	University Beach					
5	166	5/12/02 5:02	Larco					
5	166	5/12/02 22:02	West Vista					
5	166	5/13/02 0:03	Camp Zanika					
5	166	5/13/02 4:17	West Vista					
5	166	5/15/02 3:36	Camp Zanika					
5	166	5/16/02 0:34	West Vista					
5	166	5/16/02 3:27	Camp Zanika					
5	166	5/16/02 20:56	University Beach					
5	166	5/16/02 23:05	West Vista					
5	166	5/17/02 4:28	West Vista					
5	166	5/18/02 0:53	West Vista					
5	166	5/18/02 23:32	West Vista					
5	166	5/19/02 21:01	University Beach					

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
5	166	5/20/02 3:49	University Beach					
5	166	5/20/02 6:23	Larco					
5	166	5/21/02 0:32	West Vista					
5	166	5/24/02 22:08	University Beach					
5	166	5/25/02 4:35	University Beach					
5	166	5/25/02 15:16	University Beach					
5	166	5/25/02 18:08	University Beach					
5	166	5/26/02 0:30	Larco					
5	166	5/26/02 22:29	Exited Lake Wenatchee					
		5/31/02 0:00	Tag Kill Date	Ping pong / Exit				
5	167	5/3/02 0:00	Two Rivers Tagging Site		130	19.30		
5	167	5/4/02 9:20	Release Date					
5	167	5/23/02 16:26	Entered Lake Wenatchee					
5	167	5/23/02 21:51	Camp Zanika					
5	167	5/25/02 9:27	Little Wenatchee Station 1					
5	167	5/25/02 19:55	Little Wenatchee Station 1					
5	167	5/31/02 6:36	Little Wenatchee Station 1					
5	167	6/2/02 6:07	Camp Zanika					
5	167	6/2/02 22:51	University Beach					
5	167	6/3/02 11:39	Camp Zanika					
5	167	6/3/02 14:03	Camp Zanika					
5	167	6/4/02 7:37	Camp Zanika					
5	167	6/5/02 6:05	Camp Zanika					
5	167	6/5/02 19:42	Larco					
5	167	6/6/02 5:37	Camp Zanika					
5	167	6/6/02 4:26	West Vista					
5	167	6/6/02 13:16	Camp Zanika					
5	167	6/7/02 1:45	West Vista					
5	167	6/7/02 13:15	Camp Zanika					
5	167	6/7/02 18:22	Larco					
5	167	6/7/02 22:52	West Vista					
5	167	6/8/02 12:54	Camp Zanika					
5	167	6/8/02 17:43	West Vista					
5	167	6/9/02 10:25	Camp Zanika					
5	167	6/9/02 17:52	Larco					
5	167	6/10/02 4:00	Larco					

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE
	TRAVEL TIME (LAKE)		COMMENTS			
5	167	6/10/02 6:52	West Vista			
5	167	6/10/02 12:29	Camp Zanika			
5	167	6/11/02 2:36	West Vista			
5	167	6/11/02 5:55	Camp Zanika			
5	167	6/11/02 13:47	Camp Zanika			
5	167	6/12/02 5:55	Camp Zanika			
5	167	6/12/02 17:08	West Vista			
5	167	6/13/02 4:29	Camp Zanika			
5	167	6/13/02 11:53	Camp Zanika			
		5/31/02 0:00	Tag Kill Date	Ping pong		
5	168	5/21/02 0:00	Two Rivers Tagging Site		11.88	
5	168	5/22/02 0:00	Release Date			
5	168	Not Detected	Entered Lake Wenatchee			Entered but not detected
5	168	6/2/02 21:01	Camp Zanika			
5	168	6/3/02 4:44	Camp Zanika			
5	168	6/3/02 19:02	Camp Zanika			
5	168	6/3/02 22:13	West Vista			
5	168	6/4/02 1:23	Camp Zanika			
5	168	6/4/02 15:15	West Vista			
5	168	6/5/02 2:37	Camp Zanika			
5	168	6/5/02 20:48	Little Wenatchee Station 1			
5	168	6/5/02 22:32	Camp Zanika			
5	168	6/5/02 23:37	West Vista			
		6/18/02 0:00	Tag Kill Date	West end		
5	169	5/21/02 0:00	Two Rivers Tagging Site		1.46	
5	169	5/22/02 12:00	Release Date			
5	169	5/23/02 23:07	Entered Lake Wenatchee			
5	169	5/24/02 4:26	Camp Zanika			
5	169	5/25/02 1:14	Camp Zanika			
5	169	5/29/02 5:11	Camp Zanika			
5	169	5/30/02 18:31	Camp Zanika			
5	169	5/31/02 5:14	Camp Zanika			
5	169	6/1/02 4:26	Camp Zanika			
5	169	6/5/02 10:15	Camp Zanika			
5	169	6/6/02 5:11	Camp Zanika			

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
5	169	6/8/02 4:09	Camp Zanika					
5	169	6/9/02 9:07	Camp Zanika					
5	169	6/12/02 13:08	Camp Zanika					
		6/18/02 0:00	Tag Kill Date	West end				
5	170	5/14/02 0:00	Two Rivers Tagging Site		122	N/A		
5	170	5/15/02 12:00	Release Date					
6	21	5/21/02 0:00	Two Rivers Tagging Site		130	N/A		
6	21	5/22/02 0:00	Release Date					
6	22	5/15/02 0:00	Two Rivers Tagging Site		127	1.39	13.29	
6	22	5/16/02 12:15	Release Date					
6	22	5/17/02 21:33	Entered Lake Wenatchee					
6	22	5/17/02 23:55	Camp Zanika					
6	22	5/18/02 19:47	West Vista					
6	22	5/18/02 20:13	University Beach					
6	22	5/19/02 1:15	Camp Zanika					
6	22	5/19/02 23:48	Camp Zanika					
6	22	5/21/02 0:37	Camp Zanika					
6	22	5/23/02 17:15	Little Wenatchee Station 1					
6	22	5/24/02 17:27	Little Wenatchee Station 1					
6	22	5/26/02 4:37	Camp Zanika					
6	22	5/28/02 22:02	Camp Zanika					
6	22	5/29/02 3:16	Camp Zanika					
6	22	5/30/02 20:15	Camp Zanika					
6	22	5/31/02 4:32	Exited Lake Wenatchee					
		6/12/02 0:00	Tag Kill Date	Ping pong				
6	23	5/15/02 0:00	Two Rivers Tagging Site		142	0.44	0.98	
6	23	5/16/02 12:00	Release Date					
6	23	5/16/02 22:36	Entered Lake Wenatchee					
6	23	5/17/02 5:38	University Beach					
6	23	5/17/02 22:07	Exited Lake Wenatchee					
		6/12/02 0:00	Tag Kill Date	Center/ North shore/ Exit				
6	24	5/7/02 0:00	Two Rivers Tagging Site		126	N/A		
6	24	5/8/02 13:30	Release Date					
6	25	5/14/02 0:00	Two Rivers Tagging Site		143	5.68		
6	25	5/15/02 10:15	Release Date					

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
6	25	Not Detected	Entered Lake Wenatchee			Entered but not detected		
6	25	5/21/02 2:30	Camp Zanika					
6	25	5/23/02 16:23	Little Wenatchee Station 1					
6	25	5/24/02 0:43	Little Wenatchee Station 1					
6	25	5/24/02 15:41	Camp Zanika					
6	25	5/25/02 0:28	Little Wenatchee Station 1					
6	25	5/25/02 4:50	Camp Zanika					
6	25	5/31/02 9:40	Little Wenatchee Station 1					
6	25	5/31/02 20:59	Little Wenatchee Station 1					
6	25	5/31/02 23:37	Camp Zanika					
6	25	6/4/02 20:46	Little Wenatchee Station 1					
6	25	6/5/02 19:30	Little Wenatchee Station 1					
6	25	6/5/02 22:23	Camp Zanika					
6	25	6/6/02 2:50	West Vista					
6	25	6/6/02 20:26	West Vista					
6	25	6/7/02 18:17	West Vista					
6	25	6/8/02 18:50	University Beach					
6	25	6/9/02 0:42	Larco					
		6/11/02 0:00	Tag Kill Date	West end				
6	26	5/2/02 0:00	Two Rivers Tagging Site		136	5.79		
6	26	5/3/02 11:30	Release Date					
6	26	5/9/02 6:34	camp zanika					
6	26	6/6/02 3:49	West Vista					
		5/30/02 0:00	Tag Kill Date	West end				
6	27	5/2/02 0:00	Two Rivers Tagging Site		134	7.63		
6	27	5/3/02 9:20	Release Date					
6	27	Not Detected	Entered Lake Wenatchee			Entered but not detected		
6	27	5/11/02 0:24	Larco					
		5/31/02 0:00	Tag Kill Date	Center				
6	28	5/2/02 0:00	Two Rivers Tagging Site		141	N/A		
6	28	5/3/02 9:20	Release Date					
6	33	5/2/02 0:00	Two Rivers Tagging Site		134	9.71	1.79	
6	33	5/3/02 9:20	Release Date					

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
6	33	Not Detected	Entered Lake Wenatchee			Entered but not detected		
6	33	5/13/02 2:26	camp zanika					
6	33	5/13/02 0:00	Mobile Tracking					
6	33	5/14/02 0:08	University Beach					
6	33	5/14/02 4:40	Larco					
6	33	5/14/02 21:17	Exited Lake Wenatchee					
		5/30/02 0:00	Tag Kill Date	Ping pong / Exit				
6	34	5/2/02 0:00	Two Rivers Tagging Site		123	1.49		
6	34	5/3/02 11:30	Release Date					
6	34	5/4/02 23:18	Entered Lake Wenatchee					
		5/31/02 0:00	Tag Kill Date	Enter and disappear				
6	35	5/7/02 0:00	Two Rivers Tagging Site		138	15.59		
6	35	5/8/02 13:30	Release Date					
6	35	5/21/02 0:00	Mobile: Two Rivers Tagging Site					
6	35	5/24/02 3:33	Entered Lake Wenatchee					
		6/4/02 0:00	Tag Kill Date	Enter and disappear				
6	36	5/7/02 0:00	Two Rivers Tagging Site		126	25.74		
6	36	5/8/02 13:30	Release Date					
6	36	Not Detected	Entered Lake Wenatchee			Entered but not detected		
6	36	6/3/02 7:13	Camp Zanika					
6	36	6/5/02 17:57	Larco					
6	36	6/6/02 10:37	Larco					
		6/4/02 0:00	Tag Kill Date	South shore				
6	37	5/7/02 0:00	Two Rivers Tagging Site		132	16.44		
6	37	5/8/02 13:30	Release Date					
6	37	5/24/02 23:59	Entered Lake Wenatchee					
6	37	5/25/02 2:37	Little Wenatchee Station 1					
		6/4/02 0:00	Tag Kill Date	Little Wenatchee				
6	38	5/7/02 0:00	Two Rivers Tagging Site		139	15.12		
6	38	5/8/02 13:30	Release Date					
6	38	5/23/02 16:26	Entered Lake Wenatchee					
6	38	5/24/02 22:08	Little Wenatchee Station 1					
6	38	6/4/02 15:23	Little Wenatchee Station 1					
		6/4/02 0:00	Tag Kill Date	Little Wenatchee				

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
6	39	5/3/02 0:00	Two Rivers Tagging Site		134	20.56		
6	39	5/4/02 9:20	Release Date					
6	39	5/24/02 22:53	Entered Lake Wenatchee					
6	39	5/31/02 22:59	Little Wenatchee Station 1					
6	39	6/3/02 0:32	camp zanika					
6	39	6/3/02 22:27	Larco					
6	39	6/4/02 4:28	Larco					
6	39	6/6/02 16:33	Larco					
		5/31/02 0:00	Tag Kill Date	South shore				
6	40	5/7/02 0:00	Two Rivers Tagging Site		139	13.63	6.75	
6	40	5/8/02 13:30	Release Date					
6	40	Not Detected	Entered Lake Wenatchee					Entered but not detected
6	40	5/22/02 4:40	Camp Zanika					
6	40	5/23/02 9:32	Camp Zanika					
6	40	5/23/02 16:23	Little Wenatchee Station 1					
6	40	5/23/02 21:14	Little Wenatchee Station 1					
6	40	5/24/02 4:52	Camp Zanika					
6	40	5/24/02 9:14	Camp Zanika					
6	40	5/24/02 13:06	Little Wenatchee Station 1					
6	40	5/24/02 22:07	Little Wenatchee Station 1					
6	40	5/25/02 1:50	Little Wenatchee Station 1					
6	40	5/25/02 5:26	Camp Zanika					
6	40	5/25/02 12:44	Camp Zanika					
6	40	5/25/02 19:58	Little Wenatchee Station 1					
6	40	5/26/02 4:06	Camp Zanika					
6	40	5/26/02 16:04	Camp Zanika					
6	40	5/27/02 21:43	Camp Zanika					
6	40	5/28/02 0:50	West Vista					
6	40	5/28/02 4:37	University Beach					
6	40	5/28/02 22:40	Exited Lake Wenatchee					
		6/4/02 0:00	Tag Kill Date	West end / Exit				
6	41	5/7/02 0:00	Two Rivers Tagging Site		129	N\A		
6	41	5/8/02 13:30	Release Date					
6	42	5/7/02 0:00	Two Rivers Tagging Site		131	N\A		

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
6	42	5/8/02 13:30	Release Date					
6	43	5/9/02 0:00	Two Rivers Tagging Site		130	15.01		
6	43	5/10/02 10:15	Release Date					
6	43	5/25/02 10:34	Entered Lake Wenatchee					
6	43	5/28/02 6:25	Camp Zanika					
6	43	5/29/02 8:38	Camp Zanika					
6	43	5/30/02 3:56	West Vista					
6	43	5/30/02 9:17	University Beach					
6	43	5/30/02 22:46	Camp Zanika					
6	43	5/31/02 3:12	Little Wenatchee Station 1					
6	43	5/31/02 10:10	Camp Zanika					
6	43	5/31/02 21:35	Camp Zanika					
6	43	6/2/02 5:50	Camp Zanika					
6	43	6/6/02 2:03	Little Wenatchee Station 1					
6	43	6/12/02 4:13	camp zanika					
		6/6/02 0:00	Tag Kill Date	Ping pong				
6	44	5/7/02 0:00	Two Rivers Tagging Site		128	N\A		
6	44	5/8/02 13:30	Release Date					
6	45	5/9/02 0:00	Two Rivers Tagging Site		132	15.11		
6	45	5/10/02 10:15	Release Date					
6	45	5/25/02 12:52	Entered Lake Wenatchee					
6	45	5/26/02 5:25	West Vista					
6	45	5/26/02 5:30	Camp Zanika					
		6/6/02 0:00	Tag Kill Date	West end				
6	46	5/9/02 0:00	Two Rivers Tagging Site		139	6.54	1.97	
6	46	5/10/02 10:15	Release Date					
6	46	5/16/02 23:06	Entered Lake Wenatchee					
6	46	5/17/02 2:27	Camp Zanika					
6	46	5/17/02 3:37	West Vista					
6	46	5/17/02 22:44	University Beach					
6	46	5/18/02 4:47	Larco					
6	46	5/18/02 19:32	Larco					
6	46	5/18/02 22:26	Exited Lake Wenatchee					
		6/6/02 0:00	Tag Kill Date	Ping pong / Exit				
6	47	5/15/02 0:00	Two Rivers Tagging Site		147	4.21	9.17	
6	47	5/16/02 12:15	Release Date					

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE) COMMENTS
6	47	Not Detected	Entered Lake Wenatchee				Entered but not detected
6	47	5/20/02 17:24	Camp Zanika				
6	47	5/20/02 18:15	West Vista				
6	47	5/20/02 23:48	University Beach				
6	47	5/21/02 1:02	Larco				
6	47	5/22/02 5:56	Camp Zanika				
6	47	5/23/02 4:54	Camp Zanika				
6	47	5/28/02 4:12	Camp Zanika				
6	47	5/28/02 20:28	Camp Zanika				
6	47	5/28/02 23:49	University Beach				
6	47	5/29/02 21:26	Exited Lake Wenatchee				
		6/12/02 0:00	Tag Kill Date	Ping pong / Exit			
6	48	5/15/02 0:00	Two Rivers Tagging Site		125	N/A	
6	48	5/16/02 12:15	Release Date				
6	49	5/14/02 0:00	Two Rivers Tagging Site		139	N/A	
6	49	5/14/02 0:00	Release Date				
6	50	5/2/02 0:00	Two Rivers Tagging Site		134	25.60	
6	50	5/3/02 9:20	Release Date				
6	50	Not Detected	Entered Lake Wenatchee				Entered but not detected
6	50	5/28/02 23:43	Camp Zanika				
6	50	5/29/02 18:39	Larco				
6	50	5/30/02 0:12	Larco				
6	50	5/30/02 14:43	University Beach				
6	50	5/30/02 20:23	Larco				
6	50	5/31/02 10:18	Larco				
6	50	6/1/02 17:28	Camp Zanika				
6	50	6/3/02 0:07	Camp Zanika				
6	50	6/3/02 5:57	Camp Zanika				
6	50	6/3/02 22:30	Camp Zanika				
6	50	6/4/02 3:02	West Vista				
		5/30/02 0:00	Tag Kill Date	Ping pong			
6	51	5/3/02 0:00	Two Rivers Tagging Site		126	1.61	
6	51	5/4/02 9:20	Release Date				
6	51	5/6/02 0:00	Entered Lake Wenatchee				

COHO SMOLT RADIO-TAG HISTORIES

6	51	5/11/02 0:07	Larco				
		5/31/02 0:00	Tag Kill Date	South shore			
6	52	5/3/02 0:00	Two Rivers Tagging Site		147	1.67	
6	52	5/4/02 9:20	Release Date				
6	52	5/6/02 1:19	Entered Lake Wenatchee				
6	52	5/17/02 21:22	Little Wenatchee Station 1				
		5/31/02 0:00	Tag Kill Date	Little Wenatchee			
6	53	5/9/02 0:00	Two Rivers Tagging Site		127	18.83	
6	53	5/10/02 10:15	Release Date				
6	53	Not Detected	Entered Lake Wenatchee				Entered but not detected
6	53	5/29/02 6:10	Camp Zanika				
6	53	5/31/02 1:51	Camp Zanika				
6	53	5/31/02 22:25	Larco				
6	53	6/2/02 13:22	Camp Zanika				
6	53	6/4/02 15:19	Little Wenatchee Station 1				
6	53	6/5/02 5:09	Camp Zanika				
6	53	6/5/02 7:09	Little Wenatchee Station 1				
6	53	6/5/02 19:25	Little Wenatchee Station 1				
6	53	6/6/02 7:12	West Vista				
6	53	6/7/02 23:29	Camp Zanika				
6	53	6/8/02 5:38	Camp Zanika				
6	53	6/8/02 6:16	West Vista				
6	53	6/8/02 13:10	Larco				
6	53	6/8/02 22:50	Larco				
6	53	6/12/02 5:35	West Vista				
6	53	6/12/02 8:31	West Vista				
6	53	6/12/02 20:51	Camp Zanika				
6	53	6/13/02 4:33	Camp Zanika				
6	53	6/13/02 17:46	Camp Zanika				
6	53	6/14/02 7:18	Camp Zanika				
6	53	6/14/02 12:44	Little Wenatchee Station 1				
6	53	6/15/02 5:31	Little Wenatchee Station 1				
6	53	6/16/02 7:51	Camp Zanika				
6	53	6/16/02 11:37	Camp Zanika				
6	53	6/17/02 4:44	Little Wenatchee Station 1				
		6/6/02 0:00	Tag Kill Date	Ping pong			

APPENDIX B CONTINUED

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
6	54	5/9/02 0:00	Two Rivers Tagging Site		132	3.38	1.86	
6	54	5/10/02 10:15	Release Date					
6	54	5/13/02 19:23	Entered Lake Wenatchee					
6	54	5/13/02 4:27	Camp Zanika					
6	54	5/13/02 19:38	Camp Zanika					
6	54	5/15/02 16:05	Exited Lake Wenatchee					
6	54	5/22/02 20:14	Camp Zanika					
6	54	5/25/02 8:38	Little Wenatchee Station 1					
6	54	5/25/02 17:06	Little Wenatchee Station 1					
		6/6/02 0:00	Tag Kill Date	South shore / Exit				
6	55	5/14/02 0:00	Two Rivers Tagging Site		127	N\A		
6	55	5/15/02 0:00	Release Date					
6	56	5/9/02 0:00	Two Rivers Tagging Site		136	0.58		
6	56	5/10/02 10:15	Release Date					
6	56	Not Detected	Entered Lake Wenatchee					Entered but not detected
6	56	5/11/02 0:06	Larco					
6	56	5/17/02 2:53	Larco					
6	56	6/25/02 5:43	Larco					
		6/6/02 0:00	Tag Kill Date	South shore				
6	57	5/14/02 0:00	Two Rivers Tagging Site		139	0.41		
6	57	5/15/02 12:00	Release Date					
6	57	5/15/02 21:55	Entered Lake Wenatchee					
6	57	5/16/02 0:43	Camp Zanika					
6	57	5/16/02 23:38	Camp Zanika					
6	57	5/17/02 1:39	West Vista					
6	57	5/17/02 5:35	Camp Zanika					
6	57	5/17/02 8:14	West Vista					
6	57	5/18/02 0:20	West Vista					
6	57	5/19/02 9:29	West Vista					
6	57	5/19/02 14:48	Camp Zanika					
6	57	5/19/02 23:09	Camp Zanika					
6	57	5/20/02 0:02	West Vista					
6	57	5/20/02 2:46	Camp Zanika					
6	57	5/22/02 2:37	Camp Zanika					
6	57	5/22/02 17:42	Camp Zanika					
6	57	5/23/02 16:42	Little Wenatchee Station 1					

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
6	57	5/25/02 4:52	Little Wenatchee Station 1					
6	57	5/30/02 21:57	Little Wenatchee Station 1					
6	57	6/4/02 14:33	Little Wenatchee Station 1					
6	57	6/5/02 5:16	Little Wenatchee Station 1					
6	57	6/5/02 14:37	Little Wenatchee Station 1					
6	57	6/6/02 4:39	Little Wenatchee Station 1					
6	57	6/6/02 8:57	Little Wenatchee Station 1					
6	57	6/14/02 19:36	Little Wenatchee Station 1					
6	57	6/15/02 4:45	Little Wenatchee Station 1					
6	57	6/15/02 9:26	Little Wenatchee Station 1					
6	57	6/15/02 21:57	Little Wenatchee Station 1					
6	57	6/16/02 12:26	Little Wenatchee Station 1					
6	57	6/17/02 13:50	Little Wenatchee Station 1					
6	57	6/18/02 21:39	Little Wenatchee Station 1					
6	57	6/19/02 3:59	Little Wenatchee Station 1					
6	57	6/20/02 18:24	Little Wenatchee Station 1					
		6/11/02 0:00	Tag Kill Date	West end				
6	58	5/14/02 0:00	Two Rivers Tagging Site		130	9.98		
6	58	5/15/02 12:00	Release Date					
6	58	5/25/02 11:34	Entered Lake Wenatchee					
		6/11/02 0:00	Tag Kill Date	Enter and disappear				
6	71	5/14/02 0:00	Two Rivers Tagging Site		140	N/A		
6	71	5/15/02 12:00	Release Date					
6	72	5/15/02 0:00	Two Rivers Tagging Site		145	N/A		
6	72	5/16/02 12:15	Release Date					
6	73	5/15/02 0:00	Two Rivers Tagging Site		148	2.43		
6	73	5/16/02 12:15	Release Date					
6	73	5/18/02 22:34	Entered Lake Wenatchee					
6	73	5/19/02 3:30	Little Wenatchee Station 1					
6	73	5/19/02 4:33	Camp Zanika					
6	73	5/19/02 14:45	Camp Zanika					
6	73	5/19/02 15:47	West Vista					
6	73	5/20/02 13:26	West Vista					
6	73	5/22/02 4:29	West Vista					
6	73	5/22/02 22:59	West Vista					
6	73	5/23/02 7:18	West Vista					

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
6	73	5/23/02 8:31	Camp Zanika					
6	73	5/23/02 21:57	Camp Zanika					
6	73	5/23/02 22:48	West Vista					
6	73	5/24/02 4:58	Camp Zanika					
6	73	5/24/02 19:42	Camp Zanika					
6	73	5/25/02 11:17	Little Wenatchee Station 1					
6	73	5/25/02 17:11	Little Wenatchee Station 1					
6	73	5/25/02 19:14	Camp Zanika					
6	73	5/25/02 21:57	Larco					
6	73	5/26/02 8:21	Camp Zanika					
6	73	5/26/02 15:32	Camp Zanika					
6	73	5/26/02 17:30	West Vista					
6	73	5/26/02 19:42	Larco					
6	73	5/26/02 21:40	University Beach					
6	73	5/27/02 9:03	Camp Zanika					
6	73	5/30/02 21:46	Little Wenatchee Station 1					
		6/12/02 0:00	Tag Kill Date	Ping pong				
6	74	5/15/02 0:00	Two Rivers Tagging Site		150	1.48		
6	74	5/16/02 12:15	Release Date					
6	74	5/17/02 23:42	Entered Lake Wenatchee					
6	74	5/18/02 1:36	Camp Zanika					
6	74	5/18/02 2:37	West Vista					
6	74	5/18/02 18:44	University Beach					
6	74	5/19/02 22:10	West Vista					
6	74	5/20/02 4:45	West Vista					
6	74	5/20/02 14:57	West Vista					
6	74	5/22/02 6:54	West Vista					
6	74	5/22/02 23:57	West Vista					
		6/12/02 0:00	Tag Kill Date	Ping pong				
6	75	5/15/02 0:00	Two Rivers Tagging Site		145	7.40		
6	75	5/16/02 12:15	Release Date					
6	75	5/23/02 21:47	Entered Lake Wenatchee					
6	75	5/24/02 21:03	Little Wenatchee Station 1					
6	75	5/25/02 5:20	Camp Zanika					
6	75	5/25/02 9:20	Little Wenatchee Station 1					
6	75	5/25/02 23:28	Camp Zanika					

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
6	75	5/26/02 1:40	West Vista					
6	75	5/26/02 9:07	Camp Zanika					
6	75	5/27/02 4:12	Camp Zanika					
6	75	5/28/02 13:38	Camp Zanika					
6	75	5/29/02 6:38	Camp Zanika					
6	75	5/29/02 16:30	Camp Zanika					
6	75	5/30/02 16:17	Camp Zanika					
6	75	5/31/02 2:45	Camp Zanika					
6	75	5/31/02 16:12	Little Wenatchee Station 1					
6	75	6/1/02 6:30	Camp Zanika					
6	75	6/2/02 5:07	Camp Zanika					
6	75	6/3/02 10:26	Camp Zanika					
		6/12/02 0:00	Tag Kill Date	West end				
6	76	5/15/02 0:00	Two Rivers Tagging Site		150	1.21		
6	76	5/16/02 12:00	Release Date					
6	76	5/17/02 16:59	Entered Lake Wenatchee					
6	76	5/18/02 23:48	Camp Zanika					
6	76	5/19/02 10:12	Camp Zanika					
6	76	5/22/02 1:39	Camp Zanika					
6	76	5/25/02 2:25	Little Wenatchee Station 1					
		6/12/02 0:00	Tag Kill Date	West end				
6	77	5/15/02 0:00	Two Rivers Tagging Site		152	28.50		
6	77	5/16/02 12:15	Release Date					
6	77	Not Detected	Entered Lake Wenatchee					Entered but not detected
6	77	6/14/02 0:19	Camp Zanika					
		6/12/02 0:00	Tag Kill Date	West end				
6	78	5/21/02 0:00	Two Rivers Tagging Site		135	6.77		
6	78	5/22/02 0:00	Release Date					
6	78	Not Detected	Entered Lake Wenatchee					Enterd but not detected
6	78	5/28/02 18:28	Camp Zanika					
6	78	5/28/02 21:13	West Vista					
6	78	5/29/02 2:05	Camp Zanika					
6	78	5/30/02 3:43	West Vista					
6	78	5/30/02 23:04	Camp Zanika					
6	78	5/31/02 11:23	Little Wenatchee Station 1					

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
6	78	5/31/02 17:40	Camp Zanika					
6	78	6/1/02 4:47	Camp Zanika					
6	78	6/3/02 11:22	Camp Zanika					
6	78	6/4/02 1:03	Camp Zanika					
6	78	6/4/02 23:24	Camp Zanika					
6	78	6/12/02 4:09	Camp Zanika					
6	78	6/16/02 0:09	Camp Zanika					
6	78	6/17/02 0:34	Camp Zanika					
		6/18/02 0:00	Tag Kill Date	West end				
6	79	5/15/02 0:00	Two Rivers Tagging Site		134	4.51	4.81	
6	79	5/16/02 12:00	Release Date					
6	79	Not Detected	Entered Lake Wenatchee					Entered but not detected
6	79	5/21/02 0:18	West Vista					
6	79	5/21/02 3:27	Larco					
6	79	5/21/02 7:23	Exited Lake Wenatchee					
		6/12/02 0:00	Tag Kill Date	North shore / Center/ Exit				
6	80	5/21/02 0:00	Two Rivers Tagging Site		137	15.21		
6	80	5/22/02 0:00	Release Date					
6	80	Not Detected	Entered Lake Wenatchee					Entered but not detected
6	80	6/6/02 4:57	Larco					
6	80	6/6/02 20:59	Larco					
		6/18/02 0:00	Tag Kill Date	South shore / Center				
6	81	5/15/02 0:00	Two Rivers Tagging Site		148	N\A		
6	81	5/15/02 12:15	Release Date					
6	81	5/21/02 0:00	Mobile: Two Rivers Tagging Site					
6	92	5/15/02 0:00	Two Rivers Tagging Site		143	9.47		
6	92	5/16/02 12:15	Release Date					
6	92	5/25/02 23:29	Entered Lake Wenatchee					
6	92	5/26/02 2:01	Camp Zanika					
		6/12/02 0:00	Tag Kill Date	West end				
6	94	5/21/02 0:00	Two Rivers Tagging Site		138	3.44		
6	94	5/22/02 12:00	Release Date					
6	94	5/25/02 22:36	Entered Lake Wenatchee					
6	94	5/26/02 0:20	Camp Zanika					

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
6	94	5/26/02 4:49	West Vista					
6	94	5/27/02 9:44	Camp Zanika					
6	94	5/27/02 12:50	Camp Zanika					
6	94	5/28/02 18:53	Camp Zanika					
6	94	5/29/02 9:37	Camp Zanika					
6	94	5/31/02 1:44	Camp Zanika					
6	94	5/31/02 7:11	Camp Zanika					
6	94	6/2/02 3:38	Camp Zanika					
6	94	6/2/02 8:51	Camp Zanika					
6	94	6/4/02 16:28	Little Wenatchee Station 1					
6	94	6/5/02 18:42	Little Wenatchee Station 1					
6	94	6/6/02 5:35	Camp Zanika					
6	94	6/6/02 8:54	Little Wenatchee Station 1					
		6/18/02 0:00	Tag Kill Date	West end				
6	95	5/21/02 0:00	Two Rivers Tagging Site		131	N\A		
6	95	5/22/02 0:00	Release Date					
6	96	5/15/02 0:00	Two Rivers Tagging Site		134	7.18	5.83	
6	96	5/16/02 12:15	Release Date					
6	96	5/23/02 16:33	Entered Lake Wenatchee					
6	96	5/25/02 14:28	Little Wenatchee Station 1					
6	96	5/28/02 20:43	Camp Zanika					
6	96	5/29/02 5:45	Larco					
6	96	5/29/02 12:29	Exited Lake Wenatchee					
		6/12/02 0:00	Tag Kill Date	South shore / Exit				
9	33	5/3/02 0:00	Two Rivers Tagging Site		132	26.13		
9	33	5/4/02 12:00	Release Date					
9	33	5/30/02 15:10	Entered Lake Wenatchee					
9	33	6/5/02 17:36	Little Wenatchee Station 1					
		5/31/02 0:00	Tag Kill Date	Little Wenatchee				
9	34	5/2/02 0:00	Two Rivers Tagging Site		125	1.58		
9	34	5/3/02 9:20	Release Date					
9	34	5/4/02 23:19	Entered Lake Wenatchee					
9	34	5/5/02 23:58	Camp Zanika					
9	34	5/6/02 5:29	Camp Zanika					
9	34	5/7/02 19:45	Little Wenatchee Station 1					
9	34	5/7/02 21:02	Camp Zanika					

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
9	34	5/8/02 5:26	camp zanika					
9	34	5/9/02 0:06	Camp Zanika					
9	34	5/9/02 1:25	Little Wenatchee Station 1					
9	34	5/9/02 23:56	Camp Zanika					
9	34	5/10/02 14:52	Camp Zanika					
9	34	5/11/02 14:19	Camp Zanika					
9	34	5/12/02 22:59	Camp Zanika					
9	34	5/13/02 11:39	Camp Zanika					
9	34	5/13/02 19:06	Camp Zanika					
9	34	5/14/02 6:46	Little Wenatchee Station 1					
9	34	5/14/02 13:29	Camp Zanika					
9	34	5/14/02 14:58	Camp Zanika					
9	34	5/14/02 20:38	Little Wenatchee Station 1					
9	34	5/15/02 2:24	Little Wenatchee Station 1					
9	34	5/15/02 21:39	Camp Zanika					
9	34	5/16/02 22:37	Little Wenatchee Station 1					
9	34	5/17/02 4:37	Camp Zanika					
9	34	5/17/02 7:34	Camp Zanika					
9	34	5/17/02 18:58	Larco					
9	34	5/18/02 1:09	Camp Zanika					
9	34	5/19/02 3:40	West Vista					
9	34	5/19/02 5:21	Camp Zanika					
9	34	5/20/02 2:18	Camp Zanika					
9	34	5/20/02 22:08	Camp Zanika					
9	34	5/21/02 22:05	Camp Zanika					
9	34	5/22/02 0:43	Camp Zanika					
9	34	5/23/02 23:02	Little Wenatchee Station 1					
9	34	5/24/02 22:09	Camp Zanika					
9	34	5/25/02 1:34	Camp Zanika					
9	34	5/25/02 13:22	Camp Zanika					
9	34	5/25/02 23:14	Camp Zanika					
9	34	5/27/02 3:42	Camp Zanika					
9	34	5/27/02 17:15	Camp Zanika					
9	34	5/28/02 1:11	Camp Zanika					
9	34	5/28/02 7:12	Camp Zanika					
9	34	6/18/02 22:17	Little Wenatchee Station 1					

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

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CHANNEL     CODE  DATE AND TIME     LOCATION    MIGRATORY PATTERN FISH LENGTH (mm)  TIME TO ENTER LAKE
      TRAVEL TIME (LAKE)      COMMENTS
            5/30/02 0:00      Tag Kill Date     West end
9     35    5/2/02 0:00 Two Rivers Tagging Site       134   21.28
9     35    5/3/02 11:30      Release Date
9     35    5/24/02 18:14     Entered Lake Wenatchee
9     35    5/25/02 0:18      Little Wenatchee Station 1
9     35    5/25/02 4:59      Little Wenatchee Station 1
9     35    5/25/02 11:39     Little Wenatchee Station 1
9     35    5/30/02 12:30     Little Wenatchee Station 1
            5/30/02 0:00      Tag Kill Date     Little Wenatchee
9     36    5/2/02 0:00 Two Rivers Tagging Site       142   2.84  31.28
9     36    5/3/02 11:30      Release Date
9     36    Not Detected      Entered Lake Wenatchee                            Entered but not detected
9     36    5/6/02 7:36 camp zanika
9     36    5/20/02 23:57     Camp Zanika
9     36    5/21/02 9:11      Camp Zanika
9     36    5/22/02 5:28      Camp Zanika
9     36    5/23/02 4:47      Camp Zanika
9     36    5/23/02 5:51      West Vista
9     36    5/24/02 4:22      West Vista
9     36    5/24/02 8:51      West Vista
9     36    5/25/02 4:35      West Vista
9     36    5/25/02 5:45      camp zanika
9     36    5/26/02 2:16      West Vista
9     36    5/26/02 4:34      West Vista
9     36    5/27/02 4:22      West Vista
9     36    5/27/02 4:57      camp zanika
9     36    5/28/02 4:13      West Vista
9     36    5/28/02 21:21     West Vista
9     36    5/29/02 1:13      West Vista
9     36    5/29/02 4:46      West Vista
9     36    5/30/02 1:35      West Vista
9     36    5/30/02 4:16      West Vista
9     36    6/4/02 2:37 West Vista
9     36    6/5/02 17:05      Larco
9     36    6/6/02 3:30 West Vista
9     36    6/6/02 10:11      Larco
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COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE
	TRAVEL TIME (LAKE)		COMMENTS			
9	36	6/6/02 14:13	exited Lake Wenatchee-USFWS			
9	36	6/7/02 4:13	Dryden-USFWS			
		5/30/02 0:00	Tag Kill Date	West end / Center / Exit		
9	37	5/2/02 0:00	Two Rivers Tagging Site		130	2.40
9	37	5/3/02 11:30	Release Date			
9	37	5/5/02 20:59	Entered Lake Wenatchee			
9	37	5/8/02 16:40	Little Wenatchee Station 1			
9	37	5/13/02 18:05	Little Wenatchee Station 1			
9	37	5/13/02 23:32	camp zanika			
9	37	6/5/02 1:39	Little Wenatchee Station 1			
9	37	6/18/02 13:20	Little Wenatchee Station 1			
		5/30/02 0:00	Tag Kill Date	West end		
9	38	5/3/02 0:00	Two Rivers Tagging Site		128	1.51
9	38	5/4/02 9:20	Release Date			
9	38	5/5/02 21:28	Entered Lake Wenatchee			
9	38	5/23/02 21:27	Little Wenatchee Station 1			
		5/31/02 0:00	Tag Kill Date	Little Wenatchee		
9	39	5/7/02 0:00	Two Rivers Tagging Site		124	0.43
9	39	5/8/02 13:30	Release Date			
9	39	5/8/02 23:53	Entered Lake Wenatchee			
9	39	5/24/02 13:05	Little Wenatchee Station 1			
9	39	6/4/02 17:47	Little Wenatchee Station 1			
9	39	6/9/02 17:48	Larco			
9	39	6/9/02 20:51	Larco			
9	39	6/10/02 8:13	Larco			
		6/4/02 0:00	Tag Kill Date	South shore		
9	40	5/3/02 0:00	Two Rivers Tagging Site		129	19.58
9	40	5/4/02 9:20	Release Date			
9	40	5/23/02 23:15	Entered Lake Wenatchee			
9	40	5/24/02 17:44	Little Wenatchee Station 1			
9	40	5/25/02 0:15	Little Wenatchee Station 1			
		5/31/02 0:00	Tag Kill Date	Little Wenatchee		
9	41	5/3/02 0:00	Two Rivers Tagging Site		135	26.97
9	41	5/4/02 9:20	Release Date			
9	41	5/31/02 8:29	Entered Lake Wenatchee			
9	41	6/12/02 14:33	West Vista			

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
9	41	6/18/02 0:07	Little Wenatchee Station 1					
		5/31/02 0:00	Tag Kill Date					West end
9	42	5/3/02 0:00	Two Rivers Tagging Site		128	26.71		
9	42	5/4/02 9:20	Release Date					
9	42	5/31/02 2:16	Entered Lake Wenatchee					
9	42	6/5/02 15:23	Little Wenatchee Station 1					
9	42	6/18/02 8:08	Little Wenatchee Station 1					
9	42	6/18/02 23:02	Little Wenatchee Station 1					
		5/31/02 0:00	Tag Kill Date					Little Wenatchee
9	43	5/7/02 0:00	Two Rivers Tagging Site		126	27.46		
9	43	5/8/02 13:30	Release Date					
9	43	6/5/02 0:29	Entered Lake Wenatchee					
9	43	6/28/02 19:28	Little Wenatchee Station 1					
9	43	6/29/02 8:34	Little Wenatchee Station 1					
		6/4/02 0:00	Tag Kill Date					Little Wenatchee
9	44	5/7/02 0:00	Two Rivers Tagging Site		136	16.24		
9	44	5/8/02 13:30	Release Date					
9	44	5/24/02 19:09	Entered Lake Wenatchee					
		6/4/02 0:00	Tag Kill Date					Entered and dissapeared
9	45	5/7/02 0:00	Two Rivers Tagging Site		135	0.40		
9	45	5/8/02 13:30	Release Date					
9	45	5/8/02 23:07	Entered Lake Wenatchee					
9	45	5/9/02 7:46	camp zanika					
9	45	5/9/02 19:17	camp zanika					
9	45	5/9/02 21:00	West Vista					
9	45	5/10/02 6:13	camp zanika					
9	45	5/10/02 9:49	West Vista					
9	45	5/16/02 7:31	West Vista					
		6/4/02 0:00	Tag Kill Date					West end
9	46	5/9/02 0:00	Two Rivers Tagging Site		144	2.74		
9	46	5/10/02 10:15	Release Date					
9	46	Not Detected	Entered Lake Wenatchee					Entered but not detected
9	46	5/13/02 3:59	Camp Zanika					
9	46	5/13/02 16:34	Camp Zanika					
9	46	5/15/02 3:34	West Vista					

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
9	46	5/17/02 3:59	West Vista					
9	46	5/24/02 21:34	Little Wenatchee Station 1					
		6/6/02 0:00	Tag Kill Date	West end				
9	47	5/2/02 0:00	Two Rivers Tagging Site		129	20.20	11.46	
9	47	5/3/02 11:30	Release Date					
9	47	5/23/02 16:24	Entered Lake Wenatchee					
9	47	5/23/02 19:14	Little Wenatchee Station 1					
9	47	5/24/02 4:32	Little Wenatchee Station 1					
9	47	5/24/02 10:34	Camp Zanika					
9	47	5/25/02 1:55	Camp Zanika					
9	47	5/25/02 14:24	Little Wenatchee Station 1					
9	47	5/27/02 2:32	Camp Zanika					
9	47	5/30/02 11:28	Little Wenatchee Station 1					
9	47	5/30/02 14:50	camp zanika					
9	47	5/30/02 21:21	University Beach					
9	47	5/31/02 23:32	University Beach					
9	47	6/1/02 23:53	camp zanika					
9	47	6/2/02 21:17	camp zanika					
9	47	6/3/02 21:20	University Beach					
9	47	6/4/02 3:25	Exited Lake Wenatchee					
9	47	6/5/02 3:04	Dryden					
		5/30/02 0:00	Tag Kill Date	Ping pong / Exit				
9	48	5/7/02 0:00	Two Rivers Tagging Site		139	1.79	2.76	
9	48	5/8/02 13:30	Release Date					
9	48	5/10/02 8:22	Entered Lake Wenatchee					
9	48	5/11/02 1:03	West Vista					
9	48	5/11/02 4:34	Larco					
9	48	5/11/02 14:16	University Beach					
9	48	5/11/02 17:01	Camp Zanika					
9	48	5/11/02 22:16	Camp Zanika					
9	48	5/12/02 8:30	Camp Zanika					
9	48	5/12/02 21:41	Larco					
9	48	5/13/02 2:31	Exited Lake Wenatchee					
		6/4/02 0:00	Tag Kill Date	Ping pong / Exit				
9	49	5/7/02 0:00	Two Rivers Tagging Site		135	N/A		
9	49	5/8/02 13:30	Release Date					

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE
	TRAVEL TIME (LAKE)		COMMENTS			
9	50	5/7/02 0:00	Two Rivers Tagging Site		129	10.67
9	50	5/8/02 13:30	Release Date			
9	50	5/19/02 5:36	Entered Lake Wenatchee			
9	50	6/16/02 15:57	Little Wenatchee Station 1			
9	50	6/28/02 13:29	Little Wenatchee Station 1			
		6/4/02 0:00	Tag Kill Date	Little Wenatchee		
9	51	5/7/02 0:00	Two Rivers Tagging Site		134	36.97
9	51	5/8/02 13:30	Release Date			
9	51	6/14/02 12:42	Entered Lake Wenatchee			
9	51	6/15/02 4:13	Camp Zanika			
9	51	6/15/02 9:31	West Vista			
		6/4/02 0:00	Tag Kill Date	West end		
9	52	5/7/02 0:00	Two Rivers Tagging Site		128	0.02
9	52	5/8/02 13:30	Release Date			
9	52	5/8/02 14:04	Entered Lake Wenatchee			
9	52	5/9/02 2:56	camp zanika			
9	52	5/13/02 5:12	Larco			
9	52	5/17/02 21:23	Little Wenatchee Station 1			
9	52	5/18/02 9:24	West Vista			
9	52	5/19/02 14:14	West Vista			
9	52	5/19/02 20:33	West Vista			
9	52	5/20/02 7:00	West Vista			
9	52	5/20/02 13:41	West Vista			
9	52	5/20/02 17:38	camp zanika			
9	52	5/20/02 20:04	camp zanika			
9	52	5/21/02 5:34	camp zanika			
9	52	5/21/02 7:18	West Vista			
9	52	5/21/02 20:07	University Beach			
9	52	5/22/02 1:32	West Vista			
9	52	5/22/02 3:30	camp zanika			
9	52	5/23/02 1:27	camp zanika			
9	52	5/23/02 10:50	West Vista			
9	52	5/23/02 20:54	West Vista			
9	52	5/23/02 21:41	camp zanika			
9	52	5/23/02 22:47	Little Wenatchee Station 1			
9	52	5/24/02 5:21	camp zanika			

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE
	TRAVEL TIME (LAKE)		COMMENTS			
9	52	5/24/02 6:29	West Vista			
9	52	6/18/02 7:07	Little Wenatchee Station 1			
9	52	6/30/02 7:03	Little Wenatchee Station 1			
9	52	6/30/02 20:44	Little Wenatchee Station 1			
		6/4/02 0:00	Tag Kill Date	Ping pong		
9	53	5/9/02 0:00	Two Rivers Tagging Site	0.64		
9	53	5/10/02 10:15	Release Date			
9	53	Not Detected	Entered Lake Wenatchee			Entered but not detected
9	53	5/11/02 1:39	camp zanika			
9	53	5/11/02 2:33	West Vista			
9	53	5/11/02 20:37	Larco			
9	53	5/12/02 4:29	University Beach			
9	53	5/12/02 7:41	West Vista			
9	53	5/12/02 15:41	camp zanika			
9	53	5/12/02 20:31	Larco			
9	53	5/13/02 20:07	Larco			
9	53	5/14/02 20:17	Larco			
9	53	5/15/02 17:52	Larco			
9	53	5/16/02 5:49	Larco			
9	53	5/16/02 22:52	Larco			
9	53	5/17/02 15:38	Larco			
9	53	5/18/02 6:11	Larco			
9	53	5/18/02 11:56	University Beach			
9	53	5/19/02 20:46	Larco			
9	53	5/20/02 8:21	Larco			
9	53	5/21/02 10:26	University Beach			
9	53	5/21/02 17:06	Larco			
9	53	5/21/02 21:12	University Beach			
9	53	5/22/02 4:56	Larco			
9	53	5/22/02 14:45	Larco			
9	53	5/22/02 23:03	Larco			
9	53	5/23/02 8:50	University Beach			
9	53	5/23/02 15:35	West Vista			
9	53	5/23/02 20:52	Larco			

APPENDIX B CONTINUED

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL CODE DATE AND TIME LOCATION MIGRATORY PATTERN FISH LENGTH (mm) TIME TO ENTER LAKE
TRAVEL TIME (LAKE) COMMENTS

9	53	5/24/02 0:53	University Beach
9	53	5/24/02 13:08	West Vista
9	53	5/24/02 15:23	University Beach
9	53	5/24/02 19:09	Larco
9	53	5/25/02 2:56	University Beach
9	53	5/25/02 5:53	Larco
9	53	5/25/02 9:57	University Beach
9	53	5/25/02 20:44	Larco
9	53	5/26/02 6:35	West Vista
9	53	5/26/02 10:35	West Vista
9	53	5/26/02 13:43	University Beach
9	53	5/26/02 15:51	Larco
9	53	5/27/02 1:30	Larco
9	53	5/27/02 8:09	University Beach
9	53	5/27/02 11:48	University Beach
9	53	5/27/02 19:21	University Beach
9	53	5/28/02 3:06	University Beach
9	53	5/28/02 15:56	Larco
9	53	5/28/02 19:36	University Beach
9	53	5/29/02 3:25	Larco
9	53	5/29/02 4:13	University Beach
9	53	5/29/02 7:52	West Vista
9	53	5/29/02 19:13	Larco
9	53	5/30/02 4:01	University Beach
9	53	5/30/02 5:35	Larco
9	53	5/30/02 12:39	University Beach
9	53	5/30/02 20:53	Larco
9	53	5/31/02 1:43	Larco
9	53	5/31/02 4:24	University Beach
9	53	5/31/02 15:25	Larco
9	53	6/1/02 4:01	University Beach
9	53	6/1/02 11:29	Camp Zanika
9	53	6/1/02 20:35	University Beach
9	53	6/2/02 10:35	University Beach
9	53	6/2/02 17:00	Larco

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL CODE DATE AND TIME LOCATION MIGRATORY PATTERN FISH LENGTH (mm) TIME TO ENTER LAKE
TRAVEL TIME (LAKE) COMMENTS
9 53 6/3/02 0:51 Larco
9 53 6/3/02 18:27 Camp Zanika
9 53 6/3/02 21:15 West Vista
9 53 6/4/02 1:00 University Beach
9 53 6/4/02 3:41 Larco
9 53 6/4/02 18:06 Larco
9 53 6/4/02 22:46 University Beach
9 53 6/5/02 15:44 Larco
9 53 6/6/02 1:45 Larco
9 53 6/6/02 12:42 Larco
9 53 6/19/02 14:31 Little Wenatchee Station 1
9 53 6/29/02 7:41 Little Wenatchee Station 1
6/6/02 0:00 Tag Kill Date Ping pong
9 54 5/7/02 0:00 Two Rivers Tagging Site 127 22.96 11.40
9 54 5/8/02 13:30 Release Date
9 54 5/31/02 12:31 Entered Lake Wenatchee
9 54 6/6/02 1:03 Little Wenatchee Station 1
9 54 6/10/02 14:03 Camp Zanika
9 54 6/11/02 22:03 exited Lake wenatchee-USFWS
6/4/02 0:00 Tag Kill Date South shore / Exit
9 55 5/15/02 0:00 Two Rivers Tagging Site 139 5.36
9 55 5/16/02 12:15 Release Date
9 55 5/21/02 20:56 West Vista
9 55 6/5/02 14:45 Little Wenatchee Station 1
9 55 6/16/02 22:35 Little Wenatchee Station 1
9 55 6/17/02 0:35 Little Wenatchee Station 1 West end
9 56 5/9/02 0:00 Two Rivers Tagging Site 132 35.81
9 56 5/10/02 10:15 Release Date
9 56 5/21/02 0:00 Mobile: Two Rivers Tagging Site
9 56 6/15/02 5:37 Entered Lake Wenatchee
6/6/02 0:00 Tag Kill Date Entered and dissapeared
9 57 5/9/02 0:00 Two Rivers Tagging Site 140 20.67
9 57 5/10/02 10:15 Release Date
9 57 5/31/02 2:13 Entered Lake Wenatchee
6/6/02 0:00 Tag Kill Date Entered and dissapeared
9 58 5/3/02 0:00 Two Rivers Tagging Site 128 N/A

COHO SMOLT RADIO-TAG HISTORIES

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CHANNEL     CODE  DATE AND TIME     LOCATION    MIGRATORY PATTERN FISH LENGTH (mm)  TIME TO ENTER LAKE
      TRAVEL TIME (LAKE)      COMMENTS
9     58    5/4/02 9:20 Release Date
9     58    5/21/02 0:00      Mobile: Two Rivers Tagging Site
9     59    5/9/02 0:00 Two Rivers Tagging Site       130   N/A
9     59    5/10/02 0:00      Release Date
9     60    5/14/02 0:00      Two Rivers Tagging Site             13.61
9     60    5/15/02 12:00     Release Date
9     60    Not Detected      Entered Lake Wenatchee
9     60    5/29/02 2:38      West Vista
9     60    5/29/02 4:49      Camp Zanika
9     60    5/29/02 9:56      West Vista
9     60    5/31/02 11:13     Camp Zanika
9     60    6/1/02 11:22      Camp Zanika
9     60    6/14/02 18:38     Little Wenatchee Station 1
9     60    6/17/02 14:06     Little Wenatchee Station 1
9     60    6/19/02 17:06     Little Wenatchee Station 1
9     60    6/20/02 21:40     Little Wenatchee Station 1
            6/11/02 0:00      Tag Kill Date     West end
9     61    5/14/02 0:00      Two Rivers Tagging Site             34.68
9     61    5/15/02 12:00     Release Date
9     61    6/19/02 4:23      Entered Lake Wenatchee
            6/11/02 0:00      Tag Kill Date     Entered and dissapeared
9     62    5/14/02 0:00      Two Rivers Tagging Site             0.67  21.37
9     62    5/15/02 12:00     Release Date
9     62    5/16/02 4:02      Entered Lake Wenatchee
9     62    5/16/02 21:19     camp zanika
9     62    5/17/02 1:51      Little Wenatchee Station 1
9     62    5/23/02 16:31     Little Wenatchee Station 1
9     62    5/23/02 18:28     Little Wenatchee Station 1
9     62    5/23/02 20:35     Little Wenatchee Station 1
9     62    5/24/02 4:28      Little Wenatchee Station 1
9     62    5/24/02 9:38      Little Wenatchee Station 1
9     62    5/24/02 13:38     Little Wenatchee Station 1
9     62    5/24/02 17:10     Little Wenatchee Station 1
9     62    5/25/02 1:14      Little Wenatchee Station 1
9     62    5/30/02 14:29     Little Wenatchee Station 1
9     62    5/31/02 0:02      Camp Zanika
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APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
9	62	6/2/02 23:53	Camp Zanika					
9	62	6/3/02 22:31	Larco					
9	62	6/4/02 9:41	University Beach					
9	62	6/4/02 14:43	west vista					
9	62	6/5/02 3:03	West Vista					
9	62	6/5/02 5:23	Camp Zanika					
9	62	6/5/02 8:20	Little Wenatchee Station 1					
9	62	6/5/02 18:13	Camp Zanika					
9	62	6/6/02 12:54	exited Lake wenatchee-USFWS					
9	62	6/7/02 5:29	Dryden					
		6/11/02 0:00	Tag Kill Date	Ping pong / Exit				
9	63	5/9/02 0:00	Two Rivers Tagging Site		132	7.63		
9	63	5/10/02 10:15	Release Date					
9	63	5/18/02 1:16	Entered Lake Wenatchee					
9	63	5/23/02 16:25	Little Wenatchee Station 1					
9	63	5/24/02 4:58	Little Wenatchee Station 1					
9	63	5/24/02 7:17	Little Wenatchee Station 1					
9	63	5/25/02 4:39	Little Wenatchee Station 1					
9	63	5/25/02 21:36	Little Wenatchee Station 1					
9	63	6/1/02 0:16	Little Wenatchee Station 1					
		6/6/02 0:00	Tag Kill Date	Little Wenatchee				
9	64	5/9/02 0:00	Two Rivers Tagging Site		120	40.13		
9	64	5/10/02 10:15	Release Date					
9	64	6/19/02 13:16	Entered Lake Wenatchee					
9	64	6/22/02 17:04	Little Wenatchee Station 1					
		6/6/02 0:00	Tag Kill Date	Little Wenatchee				
9	65	5/21/02 0:00	Two Rivers Tagging Site		139	2.74		
9	65	5/22/02 0:00	Release Date					
9	65	5/24/02 17:42	Entered Lake Wenatchee					
		6/18/02 0:00	Tag Kill Date	Entered and dissapeared				
9	66	5/14/02 0:00	Two Rivers Tagging Site			N/A		
9	66	5/15/02 12:00	Release Date					
9	66	5/21/02 0:00	Mobile: Two Rivers Tagging Site					
9	67	5/14/02 0:00	Two Rivers Tagging Site			2.52		
9	67	5/15/02 12:00	Release Date					
9	67	5/18/02 0:22	Entered Lake Wenatchee					

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
9	67	5/27/02 9:42	Westvista					
9	67	5/27/02 9:44	camp zanika					
		6/11/02 0:00	Tag Kill Date	West end				
9	68	5/3/02 0:00	Two Rivers Tagging Site		124	21.52		
9	68	5/4/02 9:20	Release Date					
9	68	5/25/02 21:46	Entered Lake Wenatchee					
9	68	5/26/02 4:58	camp zanika					
9	68	5/26/02 22:12	camp zanika					
9	68	5/27/02 5:12	camp zanika					
9	68	5/27/02 11:27	camp zanika					
9	68	5/28/02 5:28	camp zanika					
9	68	5/28/02 15:58	camp zanika					
9	68	5/28/02 21:25	camp zanika					
9	68	5/30/02 12:09	Little Wenatchee Station 1					
9	68	5/31/02 8:16	Camp Zanika					
9	68	5/31/02 22:04	Camp Zanika					
9	68	6/1/02 5:31	Camp Zanika					
9	68	6/3/02 12:28	Camp Zanika					
9	68	6/4/02 14:36	Little Wenatchee Station 1					
9	68	6/5/02 11:33	Camp Zanika					
9	68	6/5/02 23:23	Camp Zanika					
9	68	6/6/02 4:56	Camp Zanika					
9	68	6/6/02 7:59	West Vista					
9	68	6/6/02 23:46	West Vista					
9	68	6/7/02 23:44	West Vista					
9	68	6/9/02 14:07	West Vista					
9	68	6/9/02 20:49	West Vista					
9	68	6/10/02 17:26	West Vista					
9	68	6/11/02 19:50	West Vista					
9	68	6/12/02 2:58	West Vista					
		5/31/02 0:00	Tag Kill Date	West end				
9	69	5/3/02 0:00	Two Rivers Tagging Site		143	0.60	26.92	
9	69	5/4/02 9:20	Release Date					
9	69	5/4/02 23:50	Entered Lake Wenatchee					
9	69	5/5/02 0:00	camp zanika					
9	69	5/5/02 6:50	Westvista					

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
9	69	5/5/02 21:14	Westvista					
9	69	5/5/02 23:48	camp zanika					
9	69	5/6/02 10:06	Westvista					
9	69	5/6/02 22:30	camp zanika					
9	69	5/7/02 6:58	Westvista					
9	69	5/7/02 23:50	Westvista					
9	69	5/8/02 2:02	camp zanika					
9	69	5/8/02 10:23	Westvista					
9	69	5/8/02 23:44	camp zanika					
9	69	5/9/02 7:22	camp zanika					
9	69	5/9/02 11:16	Westvista					
9	69	5/9/02 15:07	Larco					
9	69	5/9/02 19:49	Larco					
9	69	5/9/02 23:42	Westvista					
9	69	5/10/02 1:17	camp zanika					
9	69	5/10/02 4:30	Little Wenatchee Station 1					
9	69	5/10/02 6:45	Westvista					
9	69	5/10/02 15:19	Larco					
9	69	5/11/02 0:05	camp zanika					
9	69	5/11/02 7:18	Westvista					
9	69	5/11/02 23:13	camp zanika					
9	69	5/12/02 5:07	Westvista					
9	69	5/12/02 15:58	University Beach					
9	69	5/12/02 21:32	Westvista					
9	69	5/13/02 0:19	camp zanika					
9	69	5/13/02 4:39	Westvista					
9	69	5/13/02 6:32	University Beach					
9	69	5/13/02 13:41	Larco					
9	69	5/13/02 21:20	Westvista					
9	69	5/13/02 22:54	camp zanika					
9	69	5/14/02 5:06	Westvista					
9	69	5/14/02 7:13	University Beach					
9	69	5/14/02 16:49	Larco					
9	69	5/14/02 23:34	Westvista					
9	69	5/15/02 1:44	camp zanika					
9	69	5/15/02 19:46	Larco					

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
9	69	5/15/02 23:57	Westvista					
9	69	5/16/02 1:14	camp zanika					
9	69	5/16/02 5:33	Westvista					
9	69	5/16/02 19:20	Westvista					
9	69	5/16/02 23:27	camp zanika					
9	69	5/17/02 2:41	camp zanika					
9	69	5/17/02 4:55	Westvista					
9	69	5/17/02 15:16	Larco					
9	69	5/18/02 1:48	Westvista					
9	69	5/18/02 15:24	Westvista					
9	69	5/19/02 1:48	camp zanika					
9	69	5/19/02 4:47	camp zanika					
9	69	5/19/02 5:43	Westvista					
9	69	5/20/02 0:29	Westvista					
9	69	5/20/02 17:59	Larco					
9	69	5/21/02 1:56	Westvista					
9	69	5/21/02 3:37	camp zanika					
9	69	5/21/02 5:17	camp zanika					
9	69	5/21/02 23:14	Westvista					
9	69	5/22/02 3:02	camp zanika					
9	69	5/22/02 5:04	Westvista					
9	69	5/23/02 4:11	Westvista					
9	69	5/23/02 16:36	camp zanika					
9	69	5/23/02 21:23	camp zanika					
9	69	5/24/02 6:42	Westvista					
9	69	5/24/02 10:01	University Beach					
9	69	5/24/02 22:56	University Beach					
9	69	5/28/02 21:49	camp zanika					
9	69	5/29/02 10:31	camp zanika					
9	69	5/30/02 0:29	Westvista					
9	69	5/30/02 16:11	camp zanika					
9	69	5/30/02 17:27	Little Wenatchee Station 1					
9	69	5/30/02 22:15	camp zanika					
9	69	5/31/02 5:11	Larco					
9	69	5/31/02 21:49	exited Lake wenatchee					
		5/31/02 0:00	Tag Kill Date	Ping pong / Exit				

COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
9	85	5/21/02 0:00	Two Rivers Tagging Site		142	28.08		
9	85	5/22/02 12:00	Release Date					
9	85	6/19/02 13:54	Entered Lake Wenatchee					
		6/18/02 0:00	Tag Kill Date	Entered and dissapeared				
9	86	5/21/02 0:00	Two Rivers Tagging Site		136	4.53		
9	86	5/22/02 12:00	Release Date					
9	86	Not Detected	Entered Lake Wenatchee					Entered but not detected
9	86	5/27/02 0:41	camp zanika					
9	86	5/27/02 4:49	Westvista					
9	86	5/27/02 15:04	camp zanika					
9	86	6/19/02 4:31	Little Wenatchee Station 1					
9	86	6/19/02 20:42	Little Wenatchee Station 1					
		6/18/02 0:00	Tag Kill Date	West end				
9	87	5/2/02 0:00	Two Rivers Tagging Site		123	22.03		
9	87	5/3/02 11:30	Release Date					
9	87	5/25/02 12:17	Entered Lake Wenatchee					
		5/30/02 0:00	Tag Kill Date	Entered and dissapeared				
9	88	5/15/02 0:00	Two Rivers Tagging Site		140	1.42		
9	88	5/16/02 12:15	Release Date					
9	88	5/17/02 22:24	Entered Lake Wenatchee					
9	88	5/18/02 4:03	camp zanika					
9	88	6/19/02 20:49	Little Wenatchee Station 1					
		6/12/02 0:00	Tag Kill Date	West end				
9	89	5/21/02 0:00	Two Rivers Tagging Site		153	1.42		
9	89	5/22/02 12:00	Release Date					
9	89	5/23/02 22:07	Entered Lake Wenatchee					
9	89	6/19/02 17:17	Little Wenatchee Station 1					
		6/18/02 0:00	Tag Kill Date	Little Wenatchee				
9	90	5/15/02 0:00	Two Rivers Tagging Site		141	0.61		
9	90	5/16/02 12:15	Release Date					
9	90	5/17/02 2:49	Entered Lake Wenatchee					
9	90	5/17/02 17:51	University Beach					
9	90	5/18/02 4:57	University Beach					
9	90	5/18/02 17:01	Larco					
9	90	5/19/02 7:40	University Beach					
9	90	5/19/02 14:43	Westvista					

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE	TRAVEL TIME (LAKE)	COMMENTS
9	90	5/20/02 3:13	camp zanika					
9	90	5/20/02 6:16	camp zanika					MAX STRENGTH 204 @7:47
9	90	5/20/02 14:55	Westvista					
		6/12/02 0:00	Tag Kill Date	Ping pong				
9	91	5/21/02 0:00	Two Rivers Tagging Site		141	3.01		
9	91	5/22/02 0:00	Release Date					
9	91	5/25/02 0:11	Entered Lake Wenatchee					
9	91	6/20/02 0:16	Little Wenatchee Station 1					
		6/18/02 0:00	Tag Kill Date	Little Wenatchee				
9	92	5/15/02 0:00	Two Rivers Tagging Site		131	11.75		
9	92	5/16/02 12:15	Release Date					
9	92	5/21/02 0:00	Mobile: Two Rivers Tagging Site					
9	92	Not Detected	Entered Lake Wenatchee					Entered but not detected
9	92	5/28/02 6:11	camp zanika					
9	92	5/28/02 21:57	Westvista					
9	92	5/29/02 6:50	University Beach					
9	92	5/29/02 15:05	camp zanika					
9	92	5/29/02 20:59	Westvista					
9	92	5/30/02 12:32	Little Wenatchee Station 1					
9	92	5/30/02 23:54	camp zanika					
9	92	5/31/02 13:52	Larco					
9	92	6/1/02 6:40	Larco					
9	92	6/2/02 3:38	camp zanika					
9	92	6/2/02 12:11	University Beach					
9	92	6/3/02 10:59	camp zanika					
9	92	6/4/02 0:13	west vista					
9	92	6/4/02 4:53	Larco					
9	92	6/4/02 11:21	camp zanika					
9	92	6/4/02 21:43	Little Wenatchee Station 1					
9	92	6/5/02 15:47	Larco					
9	92	6/5/02 23:56	Larco					
9	92	6/6/02 14:17	Larco					
		6/12/02 0:00	Tag Kill Date	Ping pong				
9	93	5/15/02 0:00	Two Rivers Tagging Site		142	12.94	6.07	
9	93	5/16/02 12:15	Release Date					
9	93	5/20/02 0:00	Mobile: Two Rivers Tagging Site					

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE
	TRAVEL TIME (LAKE)		COMMENTS			
9	93	Not Detected	Entered Lake Wenatchee			Entered but not detected
9	93	5/29/02 10:44	camp zanika			
9	93	5/29/02 21:16	Westvista			
9	93	5/30/02 12:31	Little Wenatchee Station 1			
9	93	5/30/02 20:35	camp zanika			
9	93	5/30/02 23:21	University Beach			
9	93	5/30/02 23:57	Larco			
9	93	5/31/02 4:16	University Beach			
9	93	5/31/02 7:23	Larco			
9	93	5/31/02 11:03	University Beach			
9	93	6/1/02 15:34	camp zanika			
9	93	6/1/02 22:02	Larco			
9	93	6/2/02 12:47	University Beach			
9	93	6/3/02 2:54 camp zanika				
9	93	6/3/02 15:24	camp zanika			
9	93	6/3/02 21:32	camp zanika			
9	93	6/3/02 21:55	west vista			
9	93	6/3/02 23:36	University Beach			
9	93	6/4/02 0:46 University Beach				
9	93	6/4/02 2:56 west vista				
9	93	6/4/02 4:59 Larco				
9	93	6/4/02 12:24	exited Lake wenatchee			
		6/12/02 0:00	Tag Kill Date	Ping pong / Exit		
9	94	5/15/02 0:00	Two Rivers Tagging Site	136	0.46	
9	94	5/16/02 12:15	Release Date			
9	94	5/16/02 23:13	Entered Lake Wenatchee			
		6/12/02 0:00	Tag Kill Date	Entered and dissapeared		
9	95	5/15/02 0:00	Two Rivers Tagging Site		N\A	
9	95	5/16/02 12:15	Release Date			
9	96	5/15/02 0:00	Two Rivers Tagging Site	135	13.97	
9	96	5/16/02 12:15	Release Date			
9	96	5/30/02 11:33	Entered Lake Wenatchee			
9	96	6/3/02 18:29	west vista			
9	96	6/3/02 20:54	camp zanika			
		6/12/02 0:00	Tag Kill Date	West end		
9	97	5/15/02 0:00	Two Rivers Tagging Site	130	3.55	

APPENDIX B CONTINUED
COHO SMOLT RADIO-TAG HISTORIES

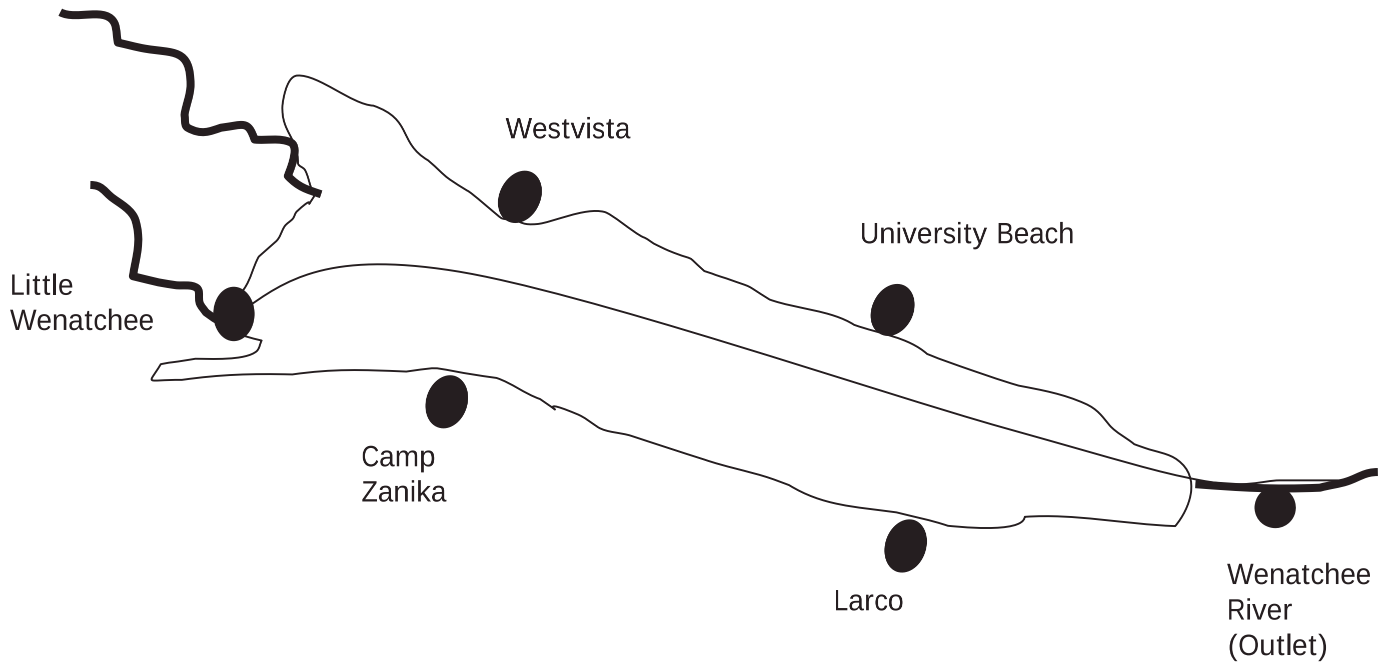
CHANNEL	CODE	DATE AND TIME	LOCATION	MIGRATORY PATTERN	FISH LENGTH (mm)	TIME TO ENTER LAKE
	TRAVEL TIME (LAKE)		COMMENTS			
9	97	5/16/02 12:15	Release Date			
9	97	Not Detected	Entered Lake Wenatchee			Entered but not detected
9	97	5/20/02 1:24	Camp Zanika			
9	97	5/20/02 21:32	west vista			
9	97	5/20/02 23:22	University Beach			
9	97	5/21/02 10:26	Larco			
9	97	5/22/02 14:32	Larco			
9	97	5/23/02 1:10	Larco			
9	97	5/24/02 20:31	University Beach			
9	97	5/26/02 5:55	University Beach			
9	97	5/26/02 12:13	Larco			
9	97	5/26/02 18:00	University Beach			
9	97	5/28/02 4:20	University Beach			
9	97	5/28/02 15:59	University Beach			
9	97	5/28/02 18:51	University Beach			
9	97	5/29/02 4:02	Larco			
9	97	6/3/02 21:51	University Beach			
9	97	6/4/02 6:19 Larco				
9	97	6/10/02 4:16	Larco			
9	97	6/11/02 4:37	west vista			
9	97	6/12/02 4:12	west vista			
9	97	6/13/02 21:36	west vista			
9	97	6/14/02 13:56	University Beach			
9	97	6/15/02 23:37	camp zanika			
9	97	6/16/02 12:17	University Beach			
9	97	6/17/02 19:52	camp zanika			
9	97	6/18/02 5:06	Little Wenatchee Station 1			
9	97	6/18/02 8:15	west vista			
9	97	6/18/02 20:00	west vista			
9	97	6/18/02 23:11	Little Wenatchee Station 1			
9	97	6/19/02 13:42	Little Wenatchee Station 1			
9	97	6/20/02 0:51	camp zanika			
9	97	6/20/02 2:15	Little Wenatchee Station 1			
9	97	6/25/02 6:17	Larco			
		6/18/02 0:00	Tag Kill Date	Ping pong		

APPENDIX C: LAKE WENATCHEE SOCKEYE AND COHO INTERACTION EVALUATION - EXAMPLES OF COHO SMOLT MIGRATORY BEHAVIOR PATTERNS

LAKE WENATCHEE SOCKEYE AND COHO INTERACTION EVALUATION
EXAMPLES OF COHO MIGRATORY BEHAVIOR PATTERNS

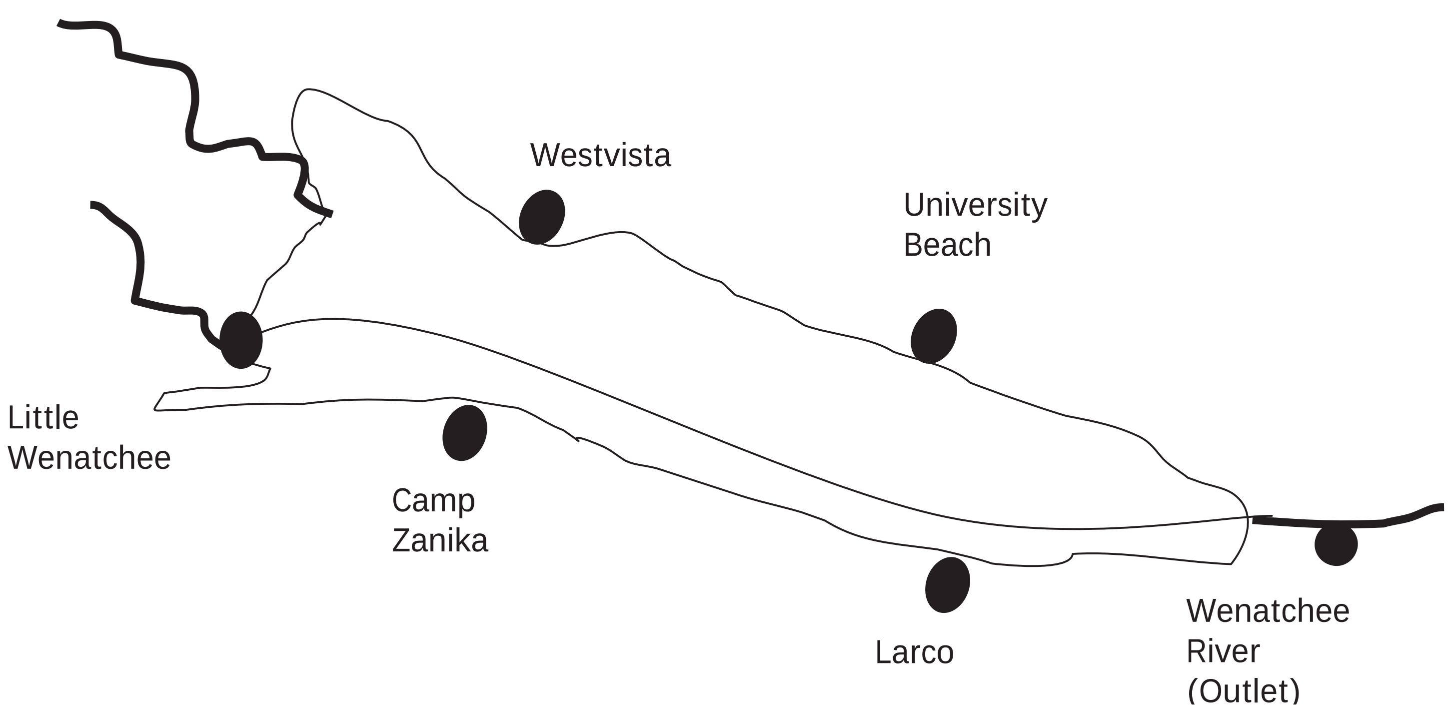
BEHAVIOR PATTERN:
CENTER

6-23 Release Date 5/16
Entered Lake: 5/16 22:36
University Beach: 5/17 05:38
Exited Lake: 5/17 22:07



BEHAVIOR PATTERN:
MIGRATE SOUTH SHORE/CENTER

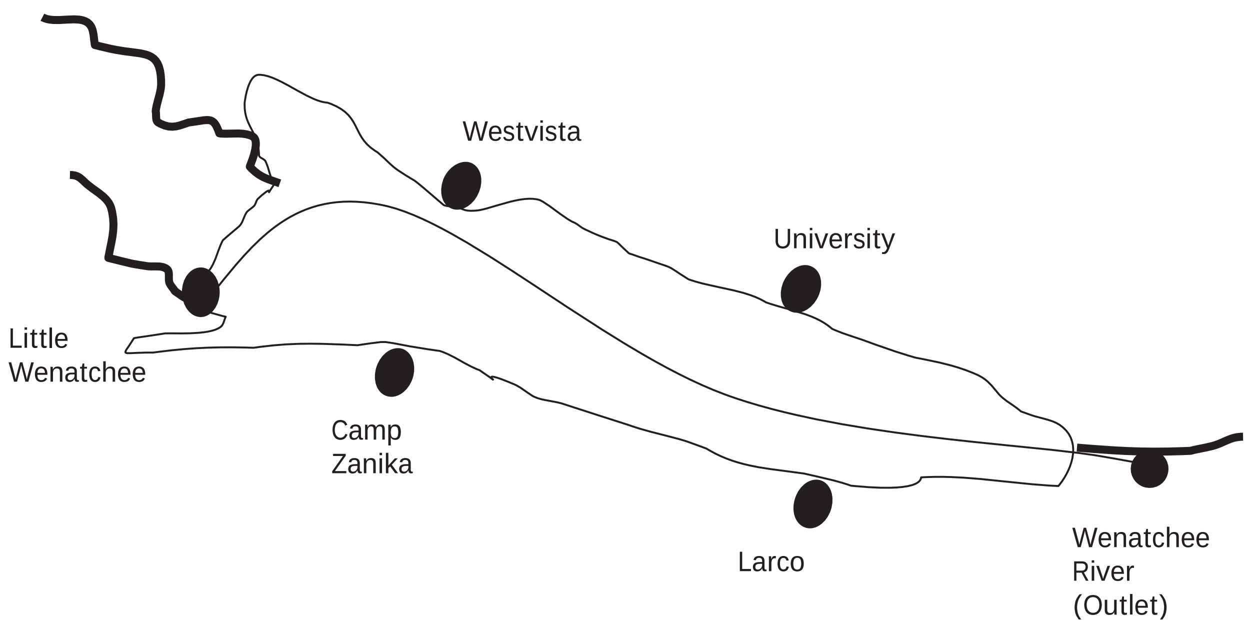
6-96 Release Date 5/16
Entered Lake: 5/23 16:33
Little Wenatchee: 5/25 14:28
Camp Zanika: 5/28 20:43
Larco: 5/29 05:45
Exit Lake: 5/29 12:29



APPENDIX C CONTINUED
LAKE WENATCHEE SOCKEYE AND COHO INTERACTION EVALUATION
EXAMPLES OF COHO MIGRATORY BEHAVIOR PATTERNS

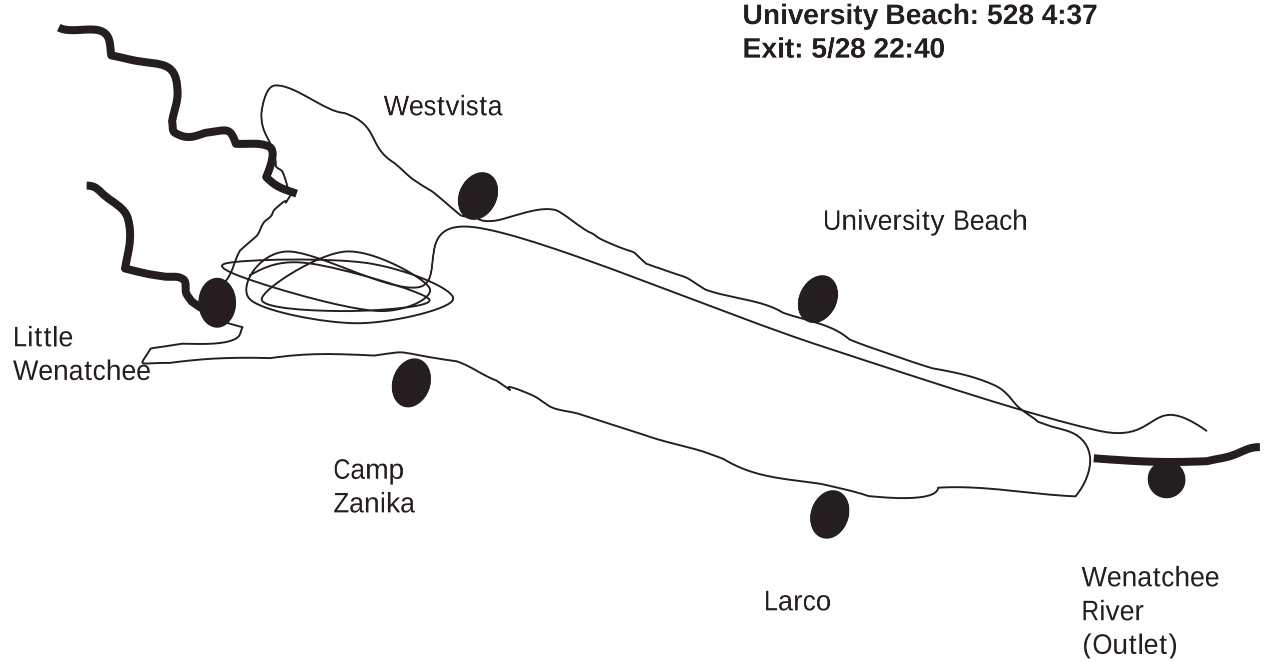
BEHAVIOR PATTERN:
MIGRATE NORTH SHORE/CENTER

6-79 Release Date
5/16
Entered Lake:
West Vista: 5/21 00:18
Larco: 5/21 3:27
Exited Lake: 5/21 7:23



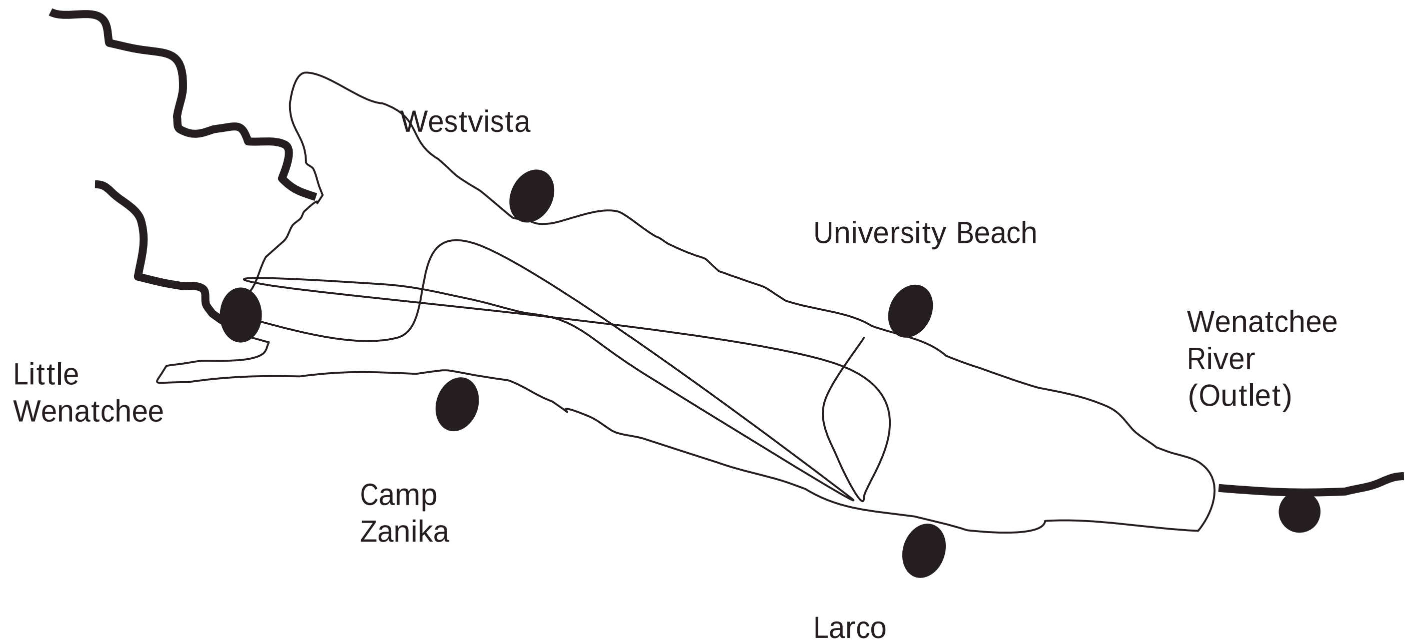
BEHAVIOR PATTERN:
WEST END / EXIT

6-40 Release Date 5/8
Camp Zanika: 5/22 4:40
Little Wenatchee: 5/23 16:23
Camp Zanika: 5/24 4:52
Little Wenatchee: 5/24 13:06
Camp Zanika: 5/25 5:26
Little Wenatchee: 5/25 19:58
Camp Zanika: 5/26 4:06
West Vista: 5/28 00:50
University Beach: 528 4:37
Exit: 5/28 22:40



BEHAVIOR PATTERN:
PING PONG ENTIRE LAKE

5-18 Release Date 5/16
Entered Lake: 5/18 21:06
Camp Zanika: 5/18 23:33
West Vista: 5/19 1:19
Larco: 5/19 18:33
Little Wenatchee: 5/23 22:53
Little Wenatchee: 5/24 3:21
Little Wenatchee: 5/31 19:47
University Beach: 6/3 16:23
Larco: 6/3 23:04
University Beach: 6/7 10:51



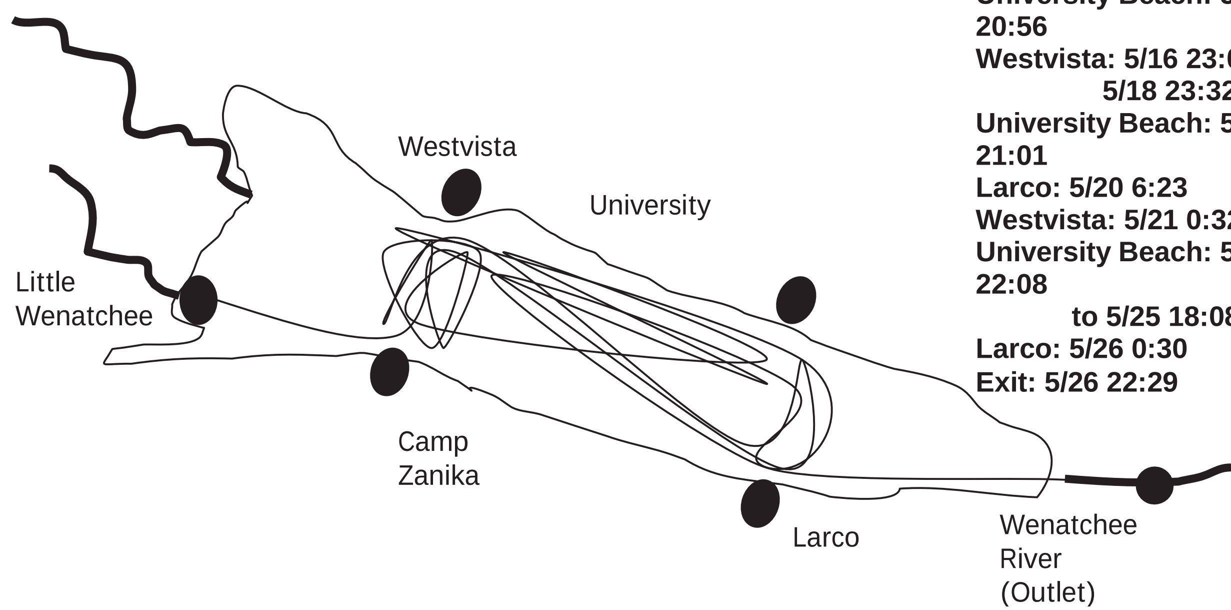
APPENDIX C CONTINUED
LAKE WENATCHEE SOCKEYE AND COHO INTERACTION EVALUATION
EXAMPLES OF COHO MIGRATORY BEHAVIOR PATTERNS

BEHAVIOR PATTERN:
PING PONG ENTIRE LAKE

5-166 Release Date 5/4
Entered Lake:5/4 23:35
Camp Zanika: 5/5 2:21
Westvista: 5/5 5:47
to 5/8 1:46

Camp Zanika: 5/9 2:46
Westvista: 5/10 4:11
Larco: 5/11 20:39
University Beach: 5/11 20:56
Larco: 5/12 5:02
Westvista: 5/12 22:02
Camp Zanika: 5/13 0:03
Westvista: 5/13 4:17
Camp Zanika: 5/15 3:36
Westvista: 5/16 0:34
Camp Zanika: 5/16 3:27

University Beach: 5/16 20:56
Westvista: 5/16 23:05 to 5/18 23:32
University Beach: 5/19 21:01
Larco: 5/20 6:23
Westvista: 5/21 0:32
University Beach: 5/24 22:08
to 5/25 18:08
Larco: 5/26 0:30
Exit: 5/26 22:29



APPENDIX D: NASON CREEK 2002 SNORKEL COUNTS

Appendix D

Nason Creek 2002 Snorkel Counts

Reach 1 Kahler Creek to Mouth

						Coho		Chinook			RBT/STHD				Bull Trout		Cutthroat		Brk Trt
Reach	Date	Unit	Hab Type	Length	Width	Wild	Plants	Subyear	Yearling	Adult	Fry	Yearling	>6"	Hat. Res.	<6 "	>6"	<6"	>6"	
1	07/18/2002	1	R	100	24	0	0	0	0	1	0	0	0	2	0	1	0	1	0
1	07/18/2002	2	R	100	19	0	0	0	0	0	0	0	0	1	0	0	0	0	0
1	07/18/2002	3	G	100	17	0	0	1	0	0	0	0	0	0	0	0	0	0	0
1	07/18/2002	4	G	100	30	3	0	91	0	0	0	0	0	0	0	0	0	0	0
1	07/18/2002	5	G	100	27	10	0	246	0	0	0	6	0	0	0	0	0	0	0
1	07/18/2002	6	P	100	19	0	0	17	0	1	0	1	0	0	0	0	0	0	0
1	07/18/2002	7	P	10	17	0	0	13	0	0	0	0	0	0	0	0	0	0	0
1	07/18/2002	7	R	90	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	07/18/2002	8	P	10	22	0	0	7	0	0	0	0	0	0	0	0	0	0	0
1	07/18/2002	8	R	90	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	07/18/2002	9	P	10	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	07/18/2002	9	R	90	24	0	0	19	0	0	0	3	0	0	0	0	0	0	0
1	07/18/2002	10	G	100	41	0	0	17	0	0	0	0	0	0	0	0	0	0	0
1	07/18/2002	11	R	100	30	0	0	2	0	0	0	0	0	0	0	0	0	0	0
1	07/18/2002	12	R	100	17	0	0	3	0	0	0	0	0	0	0	0	0	0	0
1	07/18/2002	13	R	100	26	0	0	76	1	0	0	2	1	0	0	1	0	0	1
1	07/18/2002	14	R	100	28	0	0	0	0	0	0	6	0	0	0	0	0	0	0
1	07/18/2002	15	G	100	24	0	0	14	0	0	0	0	0	0	0	0	0	0	0
1	07/18/2002	16	G	100	23	0	0	2	0	0	0	0	0	0	0	0	0	0	0
	Total					13	0	508	1	2	0	18	1	3	0	2	0	1	1

Note: Hab Type = Pool (P), Riffle (R), Glide (G)
Brk Trt = Brook Trout

Appendix D Cont'

Nason Creek 2002 Snorkel Counts

Reach 1 Kahler Creek to Mouth

						Coho		Chinook			RBT/STHD				Bull Trout		Cutthroat		Brk Trt
Reach	Date	Unit	Hab Type	Length	Width	Wild	Plants	Subyear	Yearling	Adult	Fry	Yearling	>6"	Hat. Res.	<6 "	>6"	<6"	>6"	
1	08/02/2002	1	G	50	27	0	3	14	0	0	0	0	0	5	0	0	0	0	0
1	08/02/2002	1	R	50	27	0	3	12	0	3	0	0	0	0	0	0	0	0	0
1	08/02/2002	2	R	100	15	0	1	0	0	0	0	0	1	1	0	0	0	0	0
1	08/02/2002	12	R	100	15	0	0	8	0	0	13	0	0	0	0	0	0	0	0
1	08/02/2002	13	G	100	24	0	59	70	0	0	0	2	0	0	0	0	0	0	0
1	08/02/2002	14	G	100	22	0	32	130	0	0	0	4	0	1	0	0	0	0	0
1	08/02/2002	15	G	100	29	0	9	33	0	0	0	0	0	2	0	0	0	0	0
1	08/06/2002	3	R	100	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	08/06/2002	4	G	100	30	0	4	20	0	0	0	0	0	0	0	0	0	0	0
1	08/06/2002	5	G	100	24	0	0	14	0	1	0	0	0	0	0	0	0	0	0
1	08/06/2002	6	G	50	19	0	0	5	0	0	5	0	0	0	0	0	0	0	0
1	08/06/2002	6	P	50	19	0	0	5	0	0	3	0	0	0	0	0	0	0	0
1	08/06/2002	7	P	70	18	0	0	0	0	0	3	0	0	0	0	0	0	0	0
1	08/06/2002	7	R	30	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	08/06/2002	8	G	100	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	08/06/2002	9	R	100	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	08/06/2002	10	G	100	23	0	0	5	0	0	0	0	0	0	0	0	0	0	0
1	08/06/2002	11	R	100	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total					0	111	316	0	4	24	6	1	9	0	0	0	0	0

Appendix D Cont'

Nason Creek 2002 Snorkel Counts

Reach 1 Kahler Creek to Mouth

						Coho		Chinook			RBT/STHD				Bull Trout		Cutthroat		Brk Trt
Reach	Date	Unit	Hab Type	Length	Width	Wild	Plants	Subyear	Yearling	Adult	Fry	Yearling	>6"	Hat. Res.	<6 "	>6"	<6"	>6"	
1	08/16/2002	1	G	50	16	0	14	5	0	1	12	0	0	4	0	0	0	0	0
1	08/16/2002	1	R	50	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	08/16/2002	2	R	100	15	0	0	2	0	0	0	0	0	0	0	0	0	0	0
1	08/16/2002	12	G	70	21	0	8	39	0	0	16	0	0	0	0	0	0	0	0
1	08/16/2002	12	P	10	21	0	1	4	0	0	0	0	0	0	0	0	0	0	0
1	08/16/2002	12	R	20	21	0	0	15	0	0	0	0	0	0	0	0	0	0	0
1	08/16/2002	13	G	100	16	0	94	122	0	0	4	1	2	0	0	0	0	0	0
1	08/16/2002	14	G	10	14	0	0	34	0	0	0	0	0	0	0	0	0	0	0
1	08/16/2002	14	P	40	14	0	4	63	0	0	0	9	0	0	0	0	0	0	0
1	08/16/2002	14	R	50	14	0	6	27	0	0	0	6	0	0	0	0	0	0	0
1	08/16/2002	15	G	100	21	0	0	12	0	0	21	1	0	0	0	0	0	0	0
1	08/20/2002	3	R	100	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	08/20/2002	4	R	100	29	0	20	30	0	0	24	0	0	0	0	0	0	0	0
1	08/20/2002	5	G	100	18	2	7	263	0	0	68	2	0	0	0	0	0	0	0
1	08/20/2002	6	G	70	18	0	57	106	0	1	42	12	0	0	0	0	0	0	0
1	08/20/2002	6	P	30	18	0	12	53	0	0	18	1	0	0	3	0	0	0	0
1	08/20/2002	7	G	100	18	0	0	19	0	0	28	0	0	0	0	0	0	0	0
1	08/20/2002	8	G	100	15	0	0	0	0	0	10	0	0	0	0	0	0	0	0
1	08/20/2002	9	G	80	15	0	0	15	0	0	4	1	0	1	0	0	0	0	0
1	08/20/2002	9	P	20	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	08/20/2002	10	G	50	18	0	0	0	0	0	4	0	0	0	0	0	0	0	0
1	08/20/2002	10	P	50	18	0	0	5	0	0	0	0	0	0	0	0	0	0	0
1	08/20/2002	11	R	100	19	0	0	0	0	0	2	0	0	0	0	0	0	0	0
						2	223	814	0	2	253	33	2	5	3	0	0	0	0

Appendix D Cont'

Nason Creek 2002 Snorkel Counts

Reach 2 Wood Bridge to Kahler Ck. Bridge

						Coho		Chinook			RBT/STHD				Bull Trout		Cutthroat		BrK Trt
Reach	Date	Unit	Hab Type	Length	Width	Wild	Plants	Subyear	Yearling	Adult	Fry	Yearling	>6"	Hat. Res.	<6"	>6"	<6"	>6"	
2	07/19/2002	1	G	100	22	0	0	3	0	0	0	0	0	0	0	0	0	0	0
2	07/19/2002	2	R	100	24	0	0	0	0	0	4	0	1	0	0	0	0	0	0
2	07/19/2002	3	G	100	22	0	0	2	0	0	0	0	0	0	0	0	0	0	0
2	07/19/2002	4	G	100	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	07/19/2002	5	G	100	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	07/19/2002	6	R	100	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	07/19/2002	7	G	100	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	07/19/2002	8	P	10	29	0	0	0	0	0	0	1	0	0	0	0	0	0	0
2	07/19/2002	8	R	90	29	0	0	1	0	0	0	0	0	3	0	0	0	0	0
2	07/22/2002	9	R	100	19	0	0	0	0	0	0	0	0	0	0	0	1	0	0
2	07/22/2002	10	R	100	19	0	0	0	0	1	0	2	0	0	2	0	1	0	0
2	07/22/2002	11	G	90	23	0	0	0	0	0	0	1	0	1	0	0	0	0	0
2	07/22/2002	11	R	10	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	07/22/2002	12	R	100	19	0	0	14	0	1	0	6	0	0	3	0	0	0	0
2	07/22/2002	13	R	100	18	0	0	0	0	0	0	5	1	0	1	0	0	0	0
2	07/22/2002	14	R	100	30	0	0	100	0	0	0	2	0	0	3	0	0	0	0
2	07/22/2002	15	R	100	26	0	0	4	0	0	0	1	0	0	0	0	0	0	0
						0	0	124	0	2	4	18	2	4	9	0	2	0	0

Note: Hab Type = Pool (P), Riffle (R), Glide (G)
Brk Trt = Brook Trout

Appendix D Cont'

Nason Creek 2002 Snorkel Counts

Reach 2 Wood Bridge to Kahler Ck. Bridge

						Coho		Chinook			RBT/STHD				Bull Trout		Cutthroat		BrK Trt
Reach	Date	Unit	Hab Type	Length	Width	Wild	Plants	Subyear	Yearling	Adult	Fry	Yearling	>6"	Hat. Res.	<6"	>6"	<6"	>6"	
2	08/08/2002	1	G	100	17	0	0	0	0	0	0	0	2	0	0	0	0	0	0
2	08/08/2002	2	G	100	23	0	0	0	0	0	35	0	0	0	0	0	0	0	0
2	08/08/2002	3	G	100	16	0	7	0	0	0	0	0	0	0	0	1	0	1	0
2	08/08/2002	4	G	40	20	0	14	22	0	0	31	0	0	0	0	0	0	0	0
2	08/08/2002	4	P	40	20	0	6	5	0	3	1	0	0	2	0	0	0	2	0
2	08/08/2002	4	R	20	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	08/08/2002	5	R	100	17	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2	08/08/2002	6	R	100	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	08/08/2002	7	R	100	21	0	0	2	0	0	1	0	0	0	0	0	0	0	0
2	08/08/2002	8	R	100	18	0	4	52	0	0	10	0	11	1	0	1	0	0	0
2	08/05/2002	9	R	100	15	0	3	0	0	0	2	0	0	1	0	0	0	0	0
2	08/05/2002	10	R	100	17	0	31	15	0	1	0	3	0	1	3	0	0	0	0
2	08/05/2002	11	G	20	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	08/05/2002	11	R	80	18	0	0	0	0	0	1	0	0	1	6	0	0	0	0
2	08/05/2002	12	R	100	17	0	0	1	0	2	0	6	0	0	0	0	0	0	0
2	08/05/2002	13	R	100	20	0	0	0	0	0	0	0	0	0	2	0	0	0	0
2	08/05/2002	14	R	100	16	0	7	48	0	0	0	1	0	0	1	0	0	0	0
2	08/05/2002	15	R	100	19	0	0	0	0	0	0	0	0	1	6	0	0	0	0
						0	72	145	0	6	82	10	13	7	18	2	0	3	0

Note: Hab Type = Pool (P), Riffle (R), Glide (G)
Brk Trt = Brook Trout

Appendix D Cont'

Nason Creek 2002 Snorkel Counts

Reach 2 Wood Bridge to Kahler Ck. Bridge

						Coho		Chinook			RBT/STHD				Bull Trout		Cutthroat		BrK Trt
Reach	Date	Unit	Hab Type	Length	Width	Wild	Plants	Subyear	Yearling	Adult	Fry	Yearling	>6"	Hat. Res.	<6"	>6"	<6"	>6"	
2	08/19/2002	1	R	90	14	0	0	4	0	1	3	0	0	0	0	0	0	0	0
2	08/19/2002	2	R	100	19	0	0	6	0	0	0	0	0	0	0	0	0	0	0
2	08/19/2002	3	P	50	10	0	32	70	0	0	29	0	0	0	0	0	0	0	0
2	08/19/2002	3	R	50	5	0	28	55	0	1	28	0	1	0	0	0	0	0	0
2	08/19/2002	4	G	90	17	0	9	31	0	0	41	0	0	0	0	0	0	0	0
2	08/19/2002	4	P	10	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	08/19/2002	5	G	50	18	0	70	42	0	1	19	0	0	3	0	0	0	0	0
2	08/19/2002	5	P	50	17	0	35	10	0	0	0	0	0	0	0	0	0	0	0
2	08/19/2002	6	r	100	19	0	2	12	0	0	3	0	0	0	0	0	0	0	0
2	08/19/2002	7	R	100	20	0	0	0	0	0	5	0	0	0	0	0	0	0	0
2	08/19/2002	8	R	100	18	0	0	39	0	0	0	2	0	2	0	0	0	0	0
2	08/22/2002	9	R	100	18	0	3	0	0	0	0	0	0	0	0	0	0	0	0
2	08/22/2002	10	G	100	18	0	29	5	0	0	1	2	1	1	0	0	0	0	0
2	08/22/2002	11	G	90	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	08/22/2002	11	P	10	15	0	1	0	0	0	0	0	0	0	1	0	0	0	0
2	08/22/2002	12	G	10	16	0	0	0	0	0	0	2	0	0	0	0	0	0	0
2	08/22/2002	12	R	90	16	0	0	0	0	0	0	0	0	0	1	0	0	0	0
2	08/22/2002	13	G	80	17	0	0	0	0	0	4	0	0	0	0	0	0	0	0
2	08/22/2002	13	R	20	17	0	0	1	0	0	0	1	0	0	0	0	0	0	0
2	08/22/2002	14	G	80	15	0	0	3	0	1	0	0	0	0	0	0	0	0	0
2	08/22/2002	14	R	20	15	0	0	7	0	0	0	0	0	0	0	0	0	0	0
2	08/22/2002	15	G	60	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	08/22/2002	15	R	40	17	0	0	0	0	0	0	0	1	1	0	0	0	0	0
						0	209	285	0	4	101	7	3	7	2	0	0	0	0

Appendix D Cont'

Nason Creek 2002 Snorkel Counts

Reach 3 Rayrock to Wood Bridge

						Coho		Chinook			RBT/STHD				Bull Trout		Cutthroat		Brk Trt
Reach	Date	Unit	Hab Type	Length	Width	Wild	Plants	Subyear	Yearling	Adult	Fry	Yearling	>6"	Hat. Res.	<6 "	>6"	<6"	>6"	
3	07/17/2002	1	G	60	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	07/17/2002	1	P	40	22	0	0	0	0	0	0	0	0	0	0	0	0	0	1
3	07/17/2002	2	G	100	25	0	0	8	0	0	0	0	0	0	0	0	0	0	0
3	07/17/2002	3	P	80	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	07/17/2002	3	R	20	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	07/17/2002	4	G	50	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	07/17/2002	4	P	50	24	0	0	37	0	0	0	0	0	0	0	0	0	0	0
3	07/17/2002	5	R	100	22	0	0	4	0	0	0	0	0	0	0	0	0	0	0
3	07/17/2002	6	G	100	22	0	0	15	0	0	0	0	0	0	0	0	0	0	0
3	07/17/2002	7	G	100	29	0	0	25	0	0	0	0	0	0	0	0	0	0	0
3	07/17/2002	8	G	100	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	07/17/2002	9	G	100	23	0	0	6	0	0	0	0	0	0	0	0	0	0	0
3	07/17/2002	10	G	100	21	0	0	2	0	0	0	0	0	0	0	0	0	0	0
3	07/17/2002	11	G	100	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total					0	0	97	0	0	0	0	0	0	0	0	0	0	1

Note: Hab Type = Pool (P), Riffle (R), Glide (G)
Brk Trt = Brook Trout

Appendix D Cont'

Nason Creek 2002 Snorkel Counts

Reach 3 Rayrock to Wood Bridge

						Coho		Chinook			RBT/STHD				Bull Trout		Cutthroat		Brk Trt.
Reach	Date	Unit	Hab Type	Length	Width	Wild	Plants	Subyear	Yearling	Adult	Fry	Yearling	>6"	Hat. Res.	<6 "	>6"	<6"	>6"	
3	08/01/2002	1	P	40	27	0	0	0	0	0	0	0	0	0	0	2	0	0	0
3	08/01/2002	1	R	60	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	08/01/2002	2	G	100	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	08/01/2002	3	P	20	16	0	0	7	0	1	0	0	0	0	0	0	0	0	0
3	08/01/2002	3	R	80	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	08/01/2002	4	P	50	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	08/01/2002	4	R	50	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	08/01/2002	5	G	50	17	0	0	5	0	0	0	0	0	0	0	0	0	0	0
3	08/01/2002	5	R	50	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	08/01/2002	6	G	100	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	08/01/2002	7	G	100	21	0	0	62	1	0	0	0	0	0	0	0	0	0	0
3	08/01/2002	8	G	100	18	0	0	0	0	1	0	0	0	0	0	0	0	0	0
3	08/01/2002	9	G	100	18	0	0	1	0	0	0	0	0	0	0	0	0	0	0
3	08/01/2002	10	G	100	18	0	0	2	0	0	2	0	0	0	0	0	0	0	0
3	08/01/2002	11	G	100	19	0	0	2	0	1	0	0	0	0	0	0	0	0	0
	Total					0	0	79	1	3	2	0	0	0	0	2	0	0	0

Note: Hab Type = Pool (P), Riffle (R), Glide (G)
Brk Trt = Brook Trout

Appendix D Cont'

Nason Creek 2002 Snorkel Counts

Reach 3 Rayrock to Wood Bridge

						Coho		Chinook			RBT/STHD				Bull Trout		Cutthroat		Brk Trt.
Reach	Date	Unit	Hab Type	Length	Width	Wild	Plants	Subyear	Yearling	Adult	Fry	Yearling	>6"	Hat. Res.	<6 "	>6"	<6"	>6"	
3	08/15/2002	1	P	20	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	08/15/2002	1	R	80	15	0	0	1	0	3	8	0	0	0	0	0	0	0	0
3	08/15/2002	2	G	90	18	0	0	3	0	0	9	0	0	0	0	0	0	0	0
3	08/15/2002	2	R	10	18	0	0	17	0	0	0	0	0	0	0	0	0	0	0
3	08/15/2002	3	P	30	21	0	0	192	0	2	11	1	0	0	0	0	0	0	0
3	08/15/2002	3	R	70	21	0	0	15	0	0	0	0	0	0	0	0	0	0	0
3	08/15/2002	4	G	80	21	0	0	163	0	0	26	6	0	0	0	0	0	0	0
3	08/15/2002	4	R	20	21	0	0	2	0	0	0	0	0	1	0	0	0	0	0
3	08/15/2002	5	G	100	16	0	0	6	0	0	10	0	0	0	0	0	0	0	0
3	08/15/2002	6	G	100	18	0	0	2	0	0	7	0	0	0	0	0	0	0	0
3	08/15/2002	7	G	100	22	0	0	60	0	2	34	0	0	0	0	0	0	0	0
3	08/15/2002	8	G	100	18	0	0	11	0	0	6	0	0	0	0	0	0	0	0
3	08/15/2002	9	G	100	19	0	0	0	0	1	25	0	0	0	0	0	0	0	0
3	08/15/2002	10	G	100	18	0	0	1	0	0	0	0	0	0	0	0	0	0	0
3	08/15/2002	11	G	100	18	0	0	17	0	1	0	0	0	0	0	0	0	0	0
	Total					0	0	490	0	9	136	7	0	1	0	0	0	0	0

Note: Hab Type = Pool (P), Riffle (R), Glide (G)
Brk Trt = Brook Trout

Appendix D Cont'

Nason Creek 2002 Snorkel Counts

Reach 4 Whitepine to Rayrock

						Coho		Chinook			RBT/STHD				Bull Trout		Cutthroat		Brk Trt.
Reach	Date	Unit	Hab Type	Length	Width	Wild	Plants	Subyear	Yearling	Adult	Fry	Yearling	>6"	Hat. Res.	<6 "	>6"	<6"	>6"	
4	07/23/2002	1	R	100	17	0	0	0	0	0	0	0	1	0	0	0	0	0	0
4	07/23/2002	2	G	100	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	07/23/2002	3	G	50	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	07/23/2002	3	R	50	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	07/23/2002	4	G	50	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	07/23/2002	4	R	50	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	07/23/2002	5	G	80	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	07/23/2002	5	R	20	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	07/23/2002	6	G	40	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	07/23/2002	6	P	60	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	07/23/2002	7	G	50	15	0	0	0	0	1	0	0	0	0	0	0	0	0	0
4	07/23/2002	7	R	50	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	07/23/2002	8	R	100	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	07/23/2002	9	R	100	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	07/23/2002	10	R	100	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	07/23/2002	11	P	70	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	07/23/2002	11	R	30	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
						0	0	0	0	1	0	0	1	0	0	0	0	0	0

Note: Hab Type = Pool (P), Riffle (R), Glide (G)
Brk Trt = Brook Trout

Appendix D Cont'

Nason Creek 2002 Snorkel Counts

Reach 4 Whitepine to Rayrock

						Coho		Chinook			RBT/STHD				Bull Trout		Cutthroat		Brk Trt
Reach	Date	Unit	Hab Type	Length	Width	Wild	Plants	Subyear	Yearling	Adult	Fry	Yearling	>6"	Hat. Res.	<6 "	>6"	<6"	>6"	
4	08/07/2002	1	G	60	14	0	0	0	0	0	0	0	3	0	0	0	0	0	0
4	08/07/2002	1	R	40	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	08/07/2002	2	G	100	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	08/07/2002	3	G	100	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	08/07/2002	4	R	100	24	0	0	0	0	0	3	0	0	0	0	0	0	0	0
4	08/07/2002	5	G	100	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	08/07/2002	6	G	50	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	08/07/2002	6	P	50	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	08/07/2002	7	G	100	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	08/07/2002	8	R	100	19	0	0	1	0	0	0	0	0	0	0	0	0	0	0
4	08/07/2002	9	G	50	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	08/07/2002	9	R	50	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	08/07/2002	10	G	70	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	08/07/2002	10	R	30	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	08/07/2002	11	P	80	19	0	0	0	0	3	0	0	0	0	0	0	0	0	0
4	08/07/2002	11	R	20	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
						0	0	1	0	3	3	0	3	0	0	0	0	0	0

Note: Hab Type = Pool (P), Riffle (R), Glide (G)
Brk Trt = Brook Trout

Appendix D Cont'

Nason Creek 2002 Snorkel Counts

Reach 4 Whitepine to Rayrock

						Coho		Chinook			RBT/STHD				Bull Trout		Cutthroat		Brk Trt
Reach	Date	Unit	Hab Type	Length	Width	Wild	Plants	Subyear	Yearling	Adult	Fry	Yearling	>6"	Hat. Res.	<6 "	>6"	<6"	>6"	
4	08/21/2002	1	G	90	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	08/21/2002	1	R	10	17	0	0	0	0	0	0	1	0	0	0	0	0	0	0
4	08/21/2002	2	G	100	15	0	0	0	0	7	0	0	0	0	0	0	0	0	0
4	08/21/2002	3	G	100	15	0	0	0	0	2	1	0	0	0	0	0	0	0	0
4	08/21/2002	4	G	100	15	0	0	0	0	3	0	0	0	0	0	0	0	0	0
4	08/21/2002	5	G	100	15	0	0	3	0	0	0	0	0	0	0	0	0	0	0
4	08/21/2002	6	G	100	22	0	0	1	0	1	4	2	0	0	0	0	0	0	0
4	08/21/2002	7	G	100	17	0	0	38	0	0	4	0	0	0	0	0	0	0	0
4	08/21/2002	8	G	100	15	0	0	1	0	0	0	0	0	0	0	0	0	0	0
4	08/21/2002	9	G	100	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	08/21/2002	10	G	100	16	0	0	0	0	1	0	0	0	0	0	0	0	0	0
4	08/21/2002	11	G	100	17	0	0	3	0	2	5	0	0	0	0	0	0	0	0
						0	0	46	0	16	14	3	0	0	0	0	0	0	0

Note: Hab Type = Pool (P), Riffle (R), Glide (G)
Brk Trt = Brook Trout

APPENDIX E: 2002 COHO SPAWNING GROUND SURVEYS

APPENDIX E: 2002 COHO SPAWINING GROUND SURVEYS

River	Section	River Kilometer	Date	New Redds	Live Fish	Dead Fish	Temp (C)
Icicle	**I3**						
	Dam 5 to Hatchery	4.7 – 4.5	18-Oct	0	0	0	
			24-Oct	0	0	0	
			31-Oct	0	0	0	
			7-Nov	1	2	0	3.0
			20-Nov	0	0	0	
			3-Dec	5	2	0	2.0
			10-Dec	0	4	1	2.0
			19-Dec	0	1	0	2.0
	I2						
	Hatchery to Bridge	4.5 – 3.7	18-Oct	0	0	0	
			24-Oct	0	0	0	
			31-Oct	0	0	0	
			7-Nov	0	1	0	3.0
			20-Nov	0	0	0	
			3-Dec	1	19	0	2.0
			10-Dec	1	3	0	2.0
			19-Dec	0	1	0	2.5
	I1						
	Bridge to Mouth	3.7 - 0.0	18-Oct	0	0	0	
			24-Oct	0	0	0	
			31-Oct	0	0	0	
			7-Nov	0	0	0	
			20-Nov	0	0	0	
			3-Dec	7	26	3	2.0
			10-Dec	6	19	3	2.0
			19-Dec	0	1	2	3.0
	Total			**21**	**79**	**9**	**2.4**

APPENDIX E: 2002 COHO SPAWINING GROUND SURVEYS CONT'

River	Section	River Kilometer	Date	New Redds	Live Fish	Dead Fish	Temp (C)
Nason Creek	**N5**						
	Upper RR. Bridge to	25.4-24.8	NA	NA	NA	NA	NA
	Whitepine Creek						
	Whitepine Creek to	24.8-22.8	NA	NA	NA	NA	NA
	Camp						
	Camp to	22.8-21.2	NA	NA	NA	NA	NA
	Lower RR Bridge						
	Lower RR Bridge to	21.2-20.9	NA	NA	NA	NA	NA
	Rayrock						
	N4						
	Rayrock to	20.9-18.3	Nov-22	0	0	0	6
	Merrit Bridge		Dec-5	0	0	0	4
			Dec-11	0	0	0	2.5
	Merrit Bridge to	18.3-16.4	Nov-22	0	0	0	6
	Powerlines		Dec-5	0	0	0	2.5
			Dec-11	0	0	0	2.5
	Powerlines to	16.4-13.3	Nov-22	0	0	0	6
	Wood bridge		Dec-5	1	0	0	2.5
			Dec-11	0	0	0	2.5
	N3						
	Wood bridge to	13.3-12.6	Oct-16	0	0	0	6
	1st Powerline		Oct-23	0	0	0	6
	1st Powerline to	12.6-11.4	Oct-16	0	0	0	4
	Butcher Ck Rd. Bridge		Oct-23	0	0	0	4.5
	Butcher Ck Rd. Bridge	11.4-10.3	Oct-16	0	0	0	6
	to High Volt. Line 1		Oct-23	0	0	0	5
	N2						
	High Volt. Line 1 to	10.3-9.5	Oct-16	0	0	0	6
	High Volt. Line 2		Oct-23	0	0	0	6
	High Volt Line 2 to	9.5-6.3		NA	NA	NA	NA
	Kahler Ck. Bridge			NA	NA	NA	NA
	N1						
	Kahler Ck. Bridge	6.3-5.5	Oct-17	0	0	0	
	to Fishing Pond		Oct. 24	0	0	0	3
			Oct 29	0	0	0	5

APPENDIX E: 2002 COHO SPAWINING GROUND SURVEYS CONT'

Nason Creek			Nov. 6	0	0	0	1.5
			Nov. 22	0	0	0	
			Dec. 5	0	0	0	
			Dec. 17	0	0	0	
			Dec. 23	0	0	0	
	Fishing Pond to Campground	5.5-1.3	Oct-17	0	0	0	
			Oct. 24	0	0	0	4
			Oct 29	0	0	0	5
			Nov. 6	0	0	0	1.5
			Nov. 22	0	0	0	
			Dec. 5	1	0	0	
			Dec. 17	0	0	0	
			Dec. 23	0	0	0	
	Campground to Mouth	1.3-0.0	Oct-17	0	0	0	
			Oct. 24	0	0	0	4
			Oct 29	0	0	0	4.5
			Nov. 6	0	0	0	1.5
			Nov. 22	0	0	0	
			Dec. 5	0	0	0	
			Dec. 17	0	0	0	
			Dec. 23	0	0	0	
	Total			**1**	**0**	**0**	

APPENDIX E: 2002 COHO SPAWINING GROUND SURVEYS CONT’

River	Section	River Kilometer	Date	New Redds	Live Fish	Dead Fish
Wenatchee River	**W8**					
	Lake Wenatchee to Plain Bridge	86.3-xx	Dec-4	0	0	0
	Plain Bridge to Tumwater Bridge	xx-57.3	Dec-4	0	0	0
			Dec-18	0	2	0
	W7					
	Tumwater Bridge to Icicle Road Bridge	57.3-42.5	NA	NA	NA	NA
	W6					
	Icicle Road Bridge to Leavenworth Bridge	42.5-38.5	Dec-9	0	0	0
	W5					
	Leavenworth Bridge to Dryden Dam	38.5-28.2	Dec-9	0	1	0
	W4					
	Dryden Dam to Lower Cashmere Br.	28.2-15.3	Nov-1	0	0	0
			Nov-20	1	0	0
			Dec-4	0	0	0
	W3					
	Lower Cashmere Br. to Monitor Bridge	15.3-9.3	Oct-18	0	0	0
			Nov-1	0	0	0
			Nov-20	0	0	0
			Dec-4	1	1	0
	W2					
	Monitor Bridge to Sleepy Hollow Bridge	9.3-5.6	Oct-25	0	0	0
			Nov-1	0	0	0
			Nov-22	0	0	0
			Dec-4	3	0	0
	W1					
	Sleepy Hollow Bridge to Mouth	5.6-0.0	Oct-25	0	7	0
			Nov-1	0	0	0
			Nov-22	0	0	0
			Dec-4	0	2	0

APPENDIX E: 2002 COHO SPAWINING GROUND SURVEYS CONT'

Chumstick Creek	North Rd. culvert to Mouth	1.6-0.0	Nov-23	0	0	0
Peshastin Creek	Mile 4 to Mouth	6.4-0.0	Nov-21	1	1	0
Mission Creek	Brender Creek to Mouth	3.2-0.0	Nov-21	0	0	0
Chiwaukum Creek	Highway 2 Bridge to Mouth	0.8-0.0	Nov-23	0	0	0
Beaver Creek	Beaver Creek Acc. Pd. to Mouth	2.4-0.0	Nov-23	0	0	0
	Total			**6**	**14**	**0**

APPENDIX F: RELEASE-TO-MCNARY SURVIVAL INDICES FOR YEAR 2002 RELEASES MADE INTO THE WENATCHEE RIVER

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Date: April 1, 2003

To: Keely Murdoch

From: Doug Neeley

Subject: Release-to-McNary Survival Indices for Year 2002 Releases made into the Wenatchee River

I have performed an analysis of survivals to McNary Dam of 2002 releases into the Wenatchee Basin. There were three different release sets:

Icicle Creek Site, Lower Columbia Broodstock
Icicle Creek Site, Middle Columbia Broodstock
Nason Creek Site, Middle Columbia Broodstock

For these release sets, the smolt-survival estimates, as an estimated proportion surviving, are given in Table 1.

Table 1. Release-to-McNary Survival Index for 2002 Outmigrant Coho Releases into the Wenatchee River

Release Set	McNary Detections (McN Det)	McNary Detection Efficiency (Det Eff)	Expanded Detections { Exp Det = [(McN Det)/ (Det Eff)] }	Release Number (Rel Num)	Survival Index [(Exp Det)/ (Rel Num)]
Icicle Creek; Lower Columbia Brood	511	0.073098	6990.6	8000	0.8738
Icicle Creek; Mid-Columbia Brood	511	0.073098	6990.6	8907	0.7848
Nason Creek; Mid-Columbia Brood	226	0.073098	3091.7	7876	0.3926

There were two tagged groups for each of the last two release sets. Apparently these tag groups do not constitute independent releases or replicates. Even so, survival indices were estimated separately for each tagged group, and a pseudo-analysis was performed. Discussion of the estimation and analysis procedures follows.

The release-to-McNary smolt-to-smolt survival index in this study is estimated as follows:

$$\text{Release - to - McNary Survival Index} = \frac{\left[\dfrac{\text{Number of Fish Detected at McNary}}{\text{McNary Detection Efficiency}}\right]}{\text{Number of PIT - Tagged Fish Released}}$$

The McNary Detection Efficiency given in the above equation is

$$\text{McNary Detection Efficiency} = \frac{\text{number of joint detections at McNary and downstream dam}}{\text{estimated total number of detections at downstream dam}}$$

The number of detections actually represents a pooling of counts from John Day and Bonneville dams[1].

A major reason for referring to the survival measure as a survival index instead of survival is that there are known biases associated with the estimate. Assumptions behind the detection efficiency estimation procedures are as follows:

1. Survivals from McNary to downstream detectors are the same for all routes of McNary passage (e.g., survival is the same for fish whether they pass through the bypass, the turbines, or the spillway);

2. Detection efficiencies do not vary over the outmigration period.

3. The pooled detection rate estimates from John Dam and Bonneville Dams are accurate.

Assumption 1 is unlikely to hold. Assumption 2 is also unlikely to hold; however, no attempt has been made here to stratify the detection rates over the passage period to address failure of this assumption. For Assumption 3 to hold for the methods used in

[1] In recent years experiments were conducted at John Day and Bonneville that varied the proportion of flow spilled in the daytime relative to the proportion spilled at night. To offset the electric power lost at one dam during a given period, contravening action was often taken at the other dam (Personal Communication, Rock Peters, U.S. Army Corps of Engineers, Portland, Oregon). Given this situation, it was deemed more appropriate to pool John Day and Bonneville Dam-based estimates of the McNary detection rate. This means that the fish detected at both John Day and Bonneville dams were used twice to estimate the McNary detection efficiency (an effective "sampling with replacement").

this report, the probability of a fish being entrained into the bypass at Bonneville would have to be independent of whether or not that fish was entrained into a bypass at John Day or McNary and the probability of a fish being entrained into the bypass at John Day would have to be independent of whether or not that fish was entrained into the bypass at McNary. If some fish are more likely to swim under the traveling screens to the bypass than others or if some fish are more likely to use spillways than others, then Assumption 3 will fail.

To partially test against failures of Assumptions 2 and 3 that would result in relative biases among the different release sets' survival-index estimates, a logistic analysis of variation was conducted on estimated detection efficiencies to determine whether there were detection efficiency differences among the releases or among Bonneville Dam-based and John Day Dam-based detection efficiencies. For each downstream dam and release combination, Tables 2.a., 2.b., and 2.c. respectively give the total downstream dam detections, the total joint McNary and downstream dam detections, and the estimated detection efficiencies.

Table 2.d. gives a weighted[2] two-way logistic analysis of variation. The reason for using a logistic analysis of variation instead of the more traditional least-squares-based analysis of variance is discussed at the end of this report. The Among Downstream Dam source is based on John Day's and the two Bonneville powerhouses' estimates (2 degrees of freedom), and the Releases source is based on the 5 release estimates (4 degrees of freedom). Since neither of the sources was significant at the 20% level[3], I made the decision to use the pooled[4] estimate of McNary detection efficiency (detection efficiency of 0.073098 from Table 2.c. under column and row headers "Total").

Estimated survival indices using the pooled detection efficiency are given in Table 3.a. A logistic pseudo-analysis of variation is given in Table 3.b. Again, the reason for using a logistic analysis of variation instead of the more traditional least-squares-based analysis of variance is discussed at the end of this report. This analysis is not truly appropriate for making comparisons among release sets because the individual releases with release sets are not independent replicated releases. The pseudo-Type 1 error probability for comparisons among release sets is P = .0.009 (Table 3.b.). Table 3.c. gives pairwise-comparison pseudo-Type-1-error probabilities among the three release sets. I suggest that these statistical comparisons not be formally used.

[2] The weighting variable is the number downstream dam detections from Table 2.a.

[3] P = 0.820 for Among Down Stream Dams source and P = 0.482 for Among Releases source (Table 2.d.).

[4] Pooled over releases and downstream dams.

Table 2. Total Downstream Dam Detections, Total Joint McNary and Downstream Detections, and Detection Efficiency Estimates for all Combinations of Releases and Downstream Dams

a. Number of Downstream Detections

Release Set	Release File Extender	John Day	Bonneville Dam Power House 1	Bonneville Dam Power House 1	Bonneville Dam Pooled	Total
Icicle Creek; Lower Col. Brood	LES	511	38	734	772	1283
Icicle Creek; Mid Col. Brood	LC1	335	38	389	427	762
	LC2	271	25	321	346	617
Nason Creek; Mid Col. Brood	NC1	251	12	283	295	546
	NC2	223	20	229	249	472
	Total	1591	133	1956	2089	3680

b. Number of Joint McNary, Downstream Detections

Release Set	Release File Extender	John Day	Bonneville Dam Power House 1	Bonneville Dam Power House 1	Bonneville Dam Pooled	Total
Icicle Creek; Lower Col. Brood	LES	47	4	75	79	126
Icicle Creek; Mid Col. Brood	LC1	38	11	31	42	80
	LC2	27	1	42	43	70
Nason Creek; Mid Col. Brood	NC1	25	0	16	16	41
	NC2	16	0	15	15	31
	Total	153	12	104	116	269

c. Detection Efficiencies = (Joint McNary, Downstream Detections)/(Downstream Detections)

Release Set	Releases File Extender	John Day	Bonneville Dam Power House 1	Bonneville Dam Power House 1	Bonneville Dam Pooled	Total
Icicle Creek; Lower Col. Brood	LES	0.091977	0.105263	0.102180	0.102332	0.098207
Icicle Creek; Mid Col. Brood	LC1	0.113433	0.289474	0.079692	0.098361	0.104987
	LC2	0.099631	0.040000	0.130841	0.124277	0.113452
Nason Creek; Mid Col. Brood	NC1	0.099602	0.000000	0.056537	0.054237	0.075092
	NC2	0.071749	0.000000	0.065502	0.060241	0.065678
	Total	0.096166	0.090226	0.053170	0.055529	0.073098

d. Weighted* Analysis of Variation of Detection Efficiencies

Source	Deviance (Dev)	Degrees of Freedom (DF)	Mean Dev (Dev/DF)	F-Ratio	Type 1 Error P
Among Down Stream Dams	1.2	2	0.6	0.20	0.8198
Among Releases	11.23	4	2.8075	0.95	0.4819
Error	23.56	8	2.945		

* Weighting variable = number of downstream detections

Table 3.a. Release-to-McNary Estimated Survival Indices
= [Expanded Detections]/(Release Number)
= [(McNary Detections)/(McNary Efficiency)]/(Release Number)
for Year-2002 Outmigrant Coho Released into the Wenatchee River

Release Set	Release/ Mean	McNary Detections	Detection Efficiency	Expanded Detections	Release Number	Survival Index
Icicle Creek; Lower Columbia Brood	**Mean**	511	0.0731	6990.6	8000	**0.8738**
Icicle Creek; Mid-Columbia Brood	Tag Group 1	265	0.0731	3625.3	4765	0.7608
	Tag Group 2	246	0.0731	3365.4	4142	0.8125
	Mean			6990.6	8907	**0.7848**
Nason Creek; Mid-Columbia Brood	Tag Group 1	113	0.0731	1545.9	4136	0.3738
	Tag Group 2	113	0.0731	1545.9	3740	0.4133
	Mean			3091.7	7876	**0.3926**

Table 3.b. Weighted[5] Logistic Pseudo-Analysis of Variation of Year-2002 Outmigrant Wenatchee Release-to-McNary Survival Indices over Release Sets

Source	Dev	DF	Mean Dev	F-Ratio	Type 1 P
Treatment	2560.83	2	1280.42	108.83	0.0091
Error	23.53	2	11.77		

Table 3.c. Pseudo-Type 1 Error Probabilities for Survival-Index Differences Among Release Sets based on Logistic Comparisons for Year-2002 Outmigrant Wenatchee Release-to-McNary Survival Indices

	Icicle Creek Lower Columbia Brood	Icicle Creek Mid-Columbia Brood
Icicle Creek Mid-Columbia Brood	0.1136	
Nason Creek Mid-Columbia Brood	0.0056	0.0078

[5] Weighting Variable is Number of Fish Released

Logistic Analysis of Variation

Instead of a traditional least-squares-based analyses of variance, weighted logistic analyses of variation were undertaken for 1) detection efficiencies as proportions using number of downstream dam detections as a weighting variable and 2) release-to-McNary survival-index estimates as proportions using release number as the weighting variable[6]. Least squares analysis assumes that the variance of the estimates is constant over releases. In the case of proportions, this is not expected to be true. The assumption behind the logistic analysis of variation used is that the variance of the estimated proportion is proportional to what would be expected in the case of a binomially distributed estimate:

$$\text{Variance of estimates proportional to } \frac{P*(1-P)}{n}$$

wherein P is a proportion that represents either the expected detection efficiency or the expected proportion surviving to McNary. The variance would change as P changed, making the traditional analysis of variance inappropriate. Further, n in the above equation also changes. In the case of detection efficiency, n the number of downstream dam detections, which varied over releases and downstream sites. In the case of survival to McNary, n is the number of fish released, which also varied over releases. This variation in n would also contribute to the variance of the proportion estimate changing. For this reason, n was used as a weighting variable.

In the logistic analysis of variation, the comparison is effectively made among the estimated logit transforms of the estimated proportions, the logit transform being

$$y = \text{logit}(p) = \text{natural log}\left(\frac{p}{1-p}\right)$$

p being the estimated proportion. The reverse transform, the proportion as a function of the logit, is

$$p = \frac{1}{1+\exp(-y)}$$

wherein exp(-y) is the exponential constant raised to the power given within the parentheses.

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[6] Recommended reading on logistic regression: McCullagh, P. and Nelder, J.A. (1989) Generalized Linear Models (2nd edition), Chapman and Hall, London.