Eagle Creek Ecological Interactions:
Distribution and migration of hatchery and wild steelhead and coho

Progress Report 2005

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Introduction

In 2003, the United States Fish and Wildlife Service - Columbia River Fisheries Program Office (USFWS- CRFPO) commenced a program to monitor and evaluate the effects of hatchery coho and steelhead released from Eagle Creek National Fish Hatchery (ECNFH) on wild populations of fish spawning and rearing in Eagle Creek and its tributaries. Initially, project efforts were focused on monitoring the distribution and outmigration timing of coho and steelhead smolts released from ECNFH using radio-telemetry techniques. The telemetry study conducted in 2003 and 2004 suggests that juvenile coho migrate at a significantly faster rate than steelhead, and hatchery steelhead may residualize in Eagle Creek following volitional release (Hoffman et al 2003, 2004).

In 2005, the Eagle Creek ecological interactions project was expanded, and the distribution, migration timing, and reproductive success of adult hatchery and natural origin steelhead and coho was monitored using trapping and radio-telemetry techniques. In addition to the telemetry study, a rearing density study is being conducted on winter steelhead released from ECNFH. The purpose of the project is to determine the effects of rearing density on growth and smolt to adult survival following volitional release from the hatchery. The project was initiated in 2004 and will continue through 2007. This report summarizes the progress made during the 2005 field investigation and outlines a work plan for the 2006 field season.

Objective 1: Assess the distribution and migration timing of hatchery and natural origin adult winter steelhead and coho in Eagle Creek and North Fork Eagle Creek using radio-telemetry.

Objective 2: Assess the distribution and outmigration timing of juvenile winter steelhead post volitional release from ECNFH using radio-telemetry.

Objective 3: Estimate the reproductive success of natural-origin winter steelhead in Eagle Creek and North Fork Eagle Creek using pedigree analyses.

Objective 4: Determine the effect of rearing density on growth and survival of winter steelhead, both on hatchery and post-release

Objective 5: Determine genetic structure of hatchery and natural origin steelhead in Eagle Creek and North Fork Eagle Creek

Background

Eagle Creek National Fish Hatchery (NFH) spawns and raises juvenile coho salmon (*Oncorhynchus kisutch*) and juvenile steelhead trout (*Oncorhynchus mykiss*) that are released into Eagle Creek within the Clackamas River basin, Oregon. The purpose of the program is to mitigate fish losses in the Columbia River Basin caused by federal dams, to provide commercial, sport, and tribal harvest, and to support tribal restoration programs upstream of Bonneville Dam. Eagle Creek NFH currently operates as part of the Columbia River Fisheries Development Program and is funded through the Mitchell Act - a program administered by NOAA Fisheries (formerly NMFS). This program is part of the mitigation for habitat loss resulting from flooding, siltation, and fluctuating water levels caused by Bonneville Dam. The Columbia River Fish Management Plan under U.S. v Oregon is currently under renegotiation, however, current production goals for release into Eagle Creek (150,000 steelhead and 500,000 coho) are generally consistent with the production goals in the expired plan. In addition, Eagle Creek NFH production is consistent with court adopted management agreements for Columbia River Chinook, steelhead, and coho that specifically identify coho production from Eagle Creek NFH for tribal restoration programs (Eagle Creek HGMP).

The majority of adult hatchery steelhead are present in Eagle Creek from December through March; whereas adult, wild, late-run winter steelhead are most present in Eagle Creek from February until June. While the run timing between the groups is a little different, there is an overlap and concerns have been raised about hatchery steelhead interacting with wild steelhead. The wild winter steelhead in Eagle Creek are considered a unique run, and the North Fork Eagle Creek is considered the major spawning area for the wild steelhead in the Eagle Creek watershed. Hatchery adults that stray into the North Fork Eagle Creek and spawn successfully can affect the wild population in four ways: 1) competition with wild fish for spawning areas, 2) displacement of wild fish due to presence alone, 3) competition between juveniles for rearing habitat, and 4) potential genetic introgression from the hatchery to the wild population.

Similar concerns regarding hatchery and wild fish interactions for coho salmon in Eagle Creek have also been raised. Broodstock used for hatchery production of coho salmon at Eagle Creek NFH are considered an early-run stock and are a mix of Sandy, Toutle, and Big Creek stocks. Adult hatchery coho salmon return to Eagle Creek between September and November and are spawned at the hatchery in October and November. Native coho salmon returning to the Clackamas River are considered a late run and migrate through the lower Willamette River between January and early March. The majority of spawning of native late-run coho is done in the Clackamas River above the North Fork Dam. Adult migration of late run coho in Eagle Creek is not well-known however, coho production in North Fork Eagle Creek has been documented (Appendix A);**(**Strobel 2004, pers. comm). If there is a difference between the hatchery fish and the natural origin fish in the North Fork Eagle Creek, it would have to be determined if they are early, late, or unknown stock.

Methods

Adult Trapping and Radio-Telemetry

Eagle Creek NFH owns and maintains three fish ladders on Eagle Creek. The lower ladder, located below the confluence of Eagle Creek and North Fork Eagle Creek, was closed periodically from January through June to trap adult winter steelhead and look for late returning coho; and then again from September through November to trap adult coho. A "V"-trap fish weir was placed in the ladder and used to trap adult fish migrating upstream to spawn. A sub-sample of hatchery and wild fish were gastrically implanted with coded radio-transmitters (Lotek Wireless; model MCFT-3A), weighing 16 grams and having an estimated operational life of 457 days. 100 radiotags were available for adult steelhead, and 50 radiotags were available for adult coho. A fish was considered "wild" if there were no obvious deformed or missing fins. Overall condition of fish trapped in the ladder was visually evaluated by fish handlers and only those fish determined to be "strong and healthy" were radiotagged. Selected fish were anestheized with clove oil, checked for marks (adipose clips, right ventricle clips, Coded Wire Tags) and measured for length. Scale and tissue samples were taken from wild fish to determine age structure and for genetic analyses by the USFWS Abernathy Fish Technology Center (Matala et al. 2005). Tagged fish were placed in a tub of fresh water to regain equilibrium and then released upstream of the ladder.

Three fixed telemetry stations were set up on Eagle Creek and North Fork Eagle Creek to monitor fish movement (Figure 1). Each fixed station consisted of a four element Yagi antenna, a Lotek SRX-400 continuous data logging receiver and a 12-volt battery used to power the receiver. Antennas were angled toward the stream and attached to 10 ft. long metal conduit pipes driven into the ground and secured with stake posts. Receivers were downloaded weekly with a Rugged laptop computer, and batteries were changed following downloads at each station. Fish were mobile tracked 2-3 times per week along North Fork and mainstem Eagle Creek. Eagle Creek flows downstream from the hatchery through a canyon making mobile tracking difficult in many areas. As a result, mobile tracking was concentrated in the stream area between the lower ladder and middle ladder.

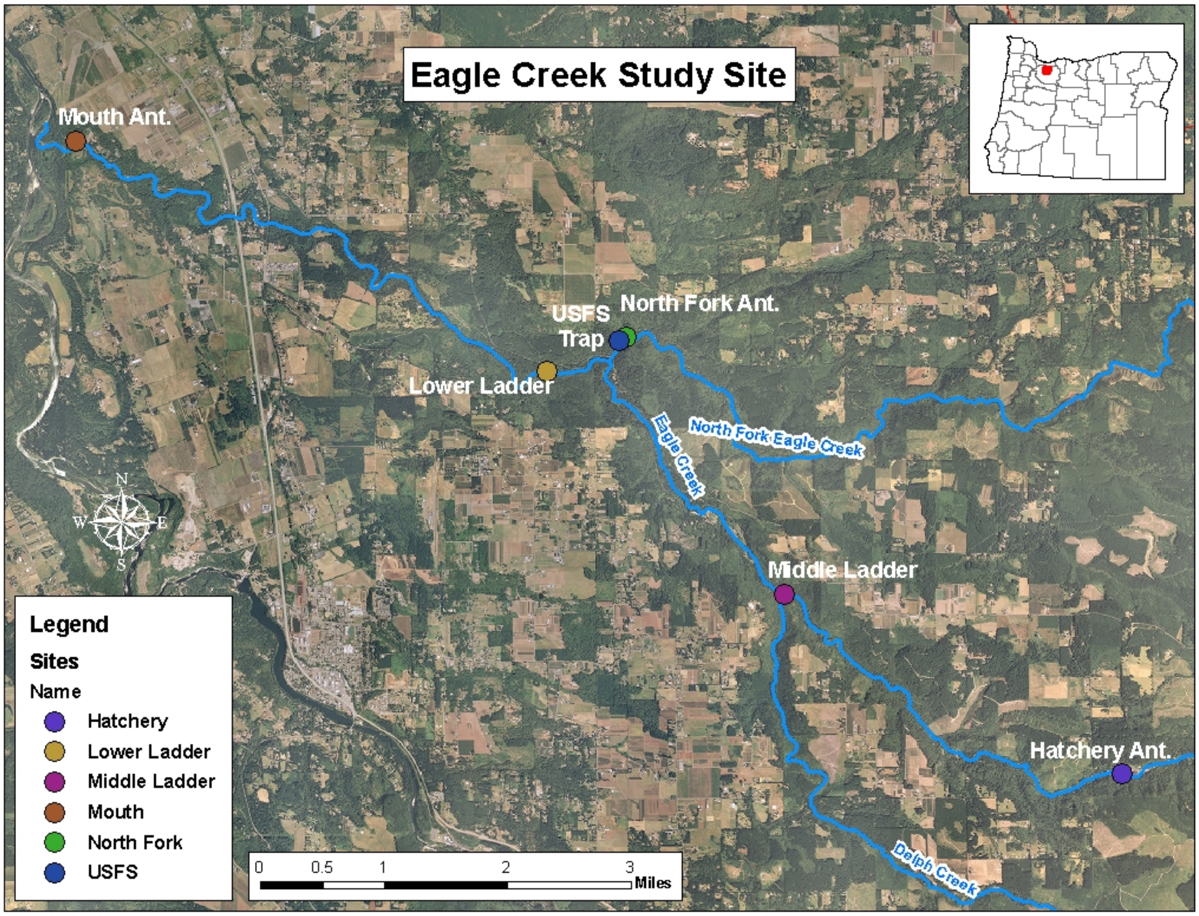

Figure 1: Stationary antennae sites on Eagle Creek and North Fork Eagle Creek

Juvenile Radio-Telemetry

In March 2005, 75 juvenile hatchery steelhead were surgically implanted with coded radio-transmitters (Lotek Wireless, model NTC-4-2L) weighing 2.1 grams and having an estimated operational life of 90 days. Eight to nine juvenile steelhead were randomly selected with a dip-net from 9 raceways representing three density groups (low, medium, high). Fish were anethesized with MS-222, measured for length and weight, radio-tagged, and allowed to recover before being placed in their respective raceway. Volitional release of juvenile steelhead from the hatchery began in April and coincided with radio-tagging of adult steelhead at the lower ladder. Mobile and stationary telemetry equipment used to monitor adult movement was simultaneously used to track juvenile fish.

Rearing Density

In 2004, a rearing density study was initiated for juvenile hatchery steelhead during broodyears 2004-2006. Growth, condition and survival of juvenile hatchery winter steelhead will be evaluated for three density groups (7500, 15,000, and 22,500 fish), and will be replicated three times for a total of nine raceways in the study group. All fish will be adipose fin clipped and right ventral clipped to identify them as hatchery fish for selective sports fisheries. Coded wire tags, unique for each raceway group, will be used to evaluate adult survival. Each broodyear of fish will be reared at the three densities for nine months before being volitionally released as yearling smolts. Adult return dates for each broodyear is outlined in Table1.

Table 1: Expected return dates of juvenile winter steelhead released for broodyears 2004-2006.

Brood Year	Tag Date	Smolt Release	Expected Return Year(s)
2004	July 2004	April 2005	Jan.-March 2007 & 2008
2005	July 2005	April 2006	Jan.-March 2008 & 2009
2006	July 2006	April 2007	Jan.-March 2009 & 2010

Within a release year, the following schedule will be used for sampling juvenile steelhead:

<u>July-</u>
Juvenile winter steelhead from each raceway will be fin clipped (Adipose-Right Ventral), and coded wire tags will be manually inserted into the snouts of each fish. During tagging, approximately 100 fish from each raceway will be sampled for fork length, weight, and dorsal fin height. Condition factor and density index for each group will be calculated using the equations developed by Piper et al (1982):

Condition factor

$$K = W/L^3$$

Where W= weight of fish
L= length of fish

Density Index

$$D = W/(VL)$$

Where W= weight of fish
V= volume of raceway
L= length of fish

November-
500 fish from each raceway will be sampled for tag retention. Fish will be crowded to the head of the raceway, randomly selected with a dipnet, and anethsized with MS-222. Juvenile steelhead will be visually inspected for mark (ADRV) retention and passed through coded wire tag detectors to determine tag retention rates.

March-
Prior to volitional release, 300 fish from each raceway will be sampled for fork length, weight, and dorsal fin height. Condition factor and density index will be calculated.

Preliminary analyses of treatment groups will compare the effect of rearing density on smolt length at time of release using a single factor ANOVA. If statistical differences are found between treatment groups, Tukey's t-test will be used to determine the statistically significant groups within each treatment. Subsequent analyses of treatment groups will be conducted in 2007 when adult steelhead from the 2004 brood return to the hatchery. Adult fish will be sampled for fork length, dorsal fin height, and to recover CWT. Adult survival between treatment groups will be tested at the 95% confidence level with a single factor ANOVA.

Genetics

The Eagle Creek watershed was divided into three sample reaches, and genetic samples were collected from juvenile steelhead in each reach (Figure 2). Reach 1 started at the confluence of Eagle Creek and the Clackamas River and extended to the confluence of North Fork Eagle Creek (Lower EC). Reach 2 began at the confluence of Eagle Creek and North Fork Eagle Creek and extended up to the Eagle Creek NFH (Upper EC) and reach 3 was comprised of North Fork Eagle Creek. Genetic samples from hatchery steelhead smolts were collected at Eagle Creek NFH and from wild adults at the lower ladder.

Samples were collected temporally and spatially to ensure steelhead from different family groups were being represented. Fork length, weight, and stream section were recorded for each fish sampled. Fin clips were placed in individually labeled and numbered vials filled with 100% EtOH and sent to Abernathy Fish Technology Center for analysis.

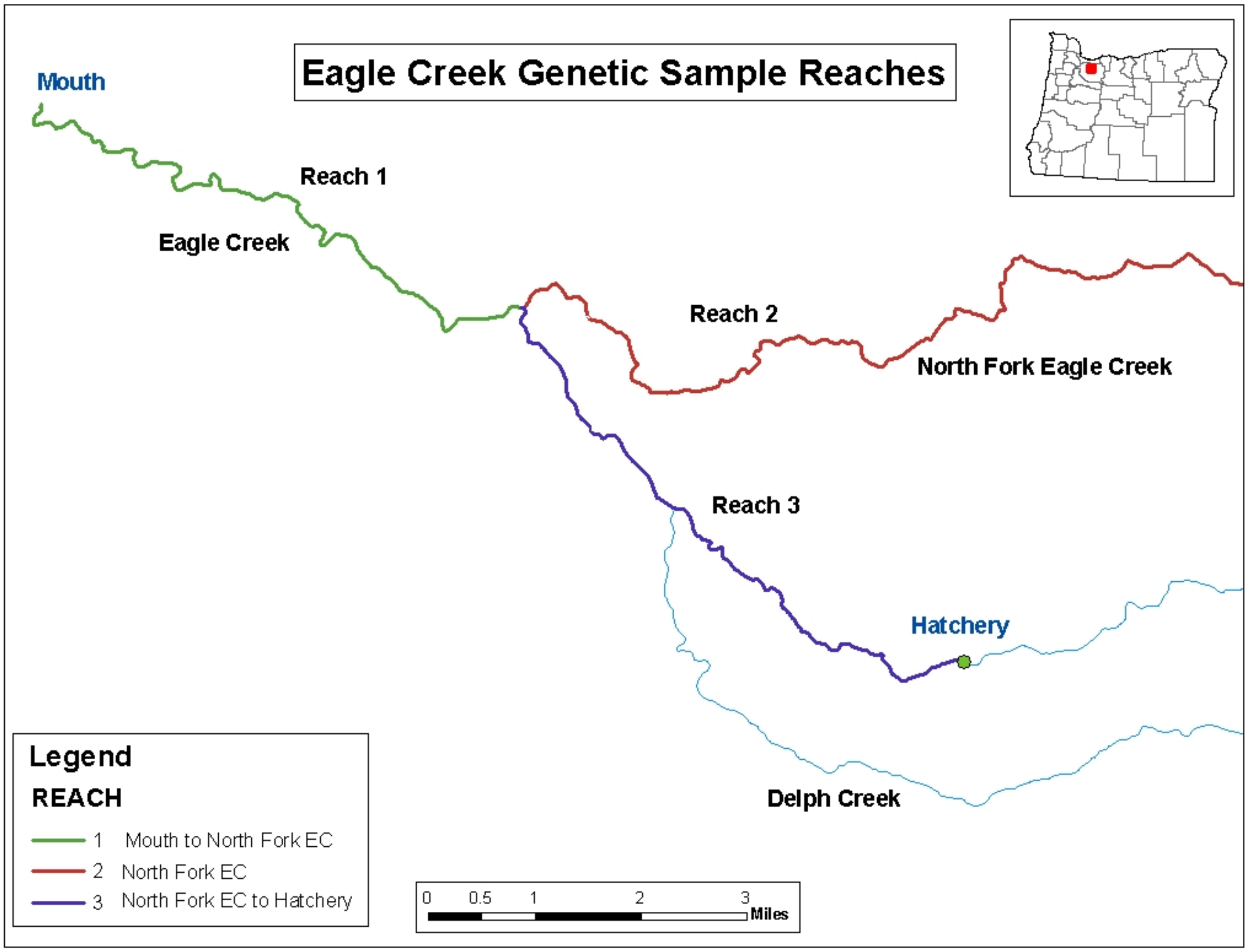

Figure 2: Reach locations for genetic sample collections on Eagle Creek and North Fork Eagle Creek.

Results

<u>Objective 1</u>: Assess the distribution and migration timing of hatchery and natural origin adult winter steelhead and coho in Eagle Creek and North Fork Eagle Creek.

<u>Winter Steelhead</u>

53 hatchery and 42 wild adult winter steelhead were trapped at the lower ladder on Eagle Creek from January through May 2005. Hatchery steelhead began migrating upstream through the lower ladder in January, and the peak of the hatchery run occurred between March 1-15. Natural origin steelhead began migrating through the lower ladder in late February, and the peak of the wild run was between March 16-31 (Figure 3).

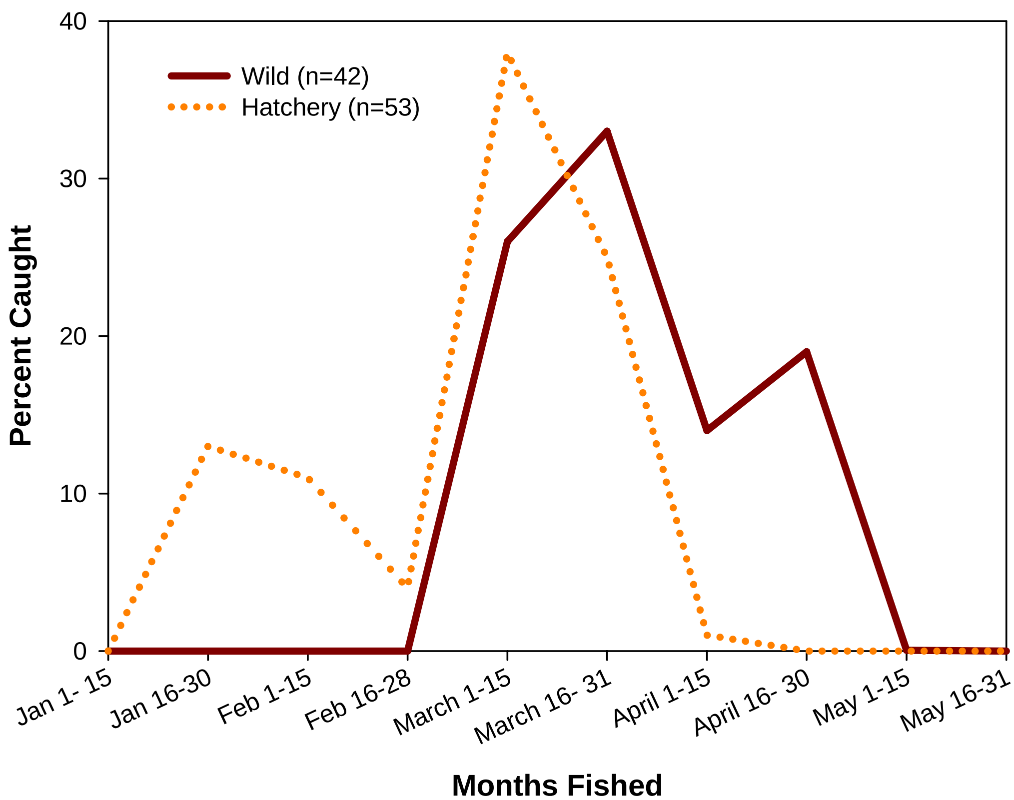

Figure 3: Biweekly catch of adult winter steelhead trapped in the lower ladder on Eagle Creek in 2005

A total of 149 hatchery steelhead were bio-sampled during spawning operations at Eagle Creek National Fish Hatchery in 2005. 74% (111 of 149) of returning hatchery adults were age 4 fish, and 26% (38 of 149) were age 3 fish. Mean length of age 3 and 4 hatchery steelhead was 62 and 75 cm (Table 2).

Scale samples collected from the 42 natural origin steelhead trapped at the lower ladder indicate twenty three fish were age 3, sixteen were age 4, and samples for three fish were from regenerated scales and unable to be read. Mean length of age 3 and 4 natural origin steelhead was 68 and 78 cm. Natural origin steelhead returning to Eagle Creek were significantly larger than hatchery steelhead for both year classes observed (Figures 4 and 5).

Table 2. Mean lengths of natural origin steelhead trapped at the lower ladder and hatchery steelhead bio-sampled at ECNFH.

Origin	Sex	Age 3	Mean Length	Std. dev	Age 4	Mean Length	Std. dev
Wild							
	Male[1]	10	68	2.22	2	73	4.94
	Female	4	69	2.87	11	79	4.66
	Unknown	9	66	5.55	3	77	5.50
Hatchery							
	Male	31	62	3.61	27	78	4.93
	Female	7	64	3.95	84	75	3.37

[1] Age was not determined for three wild male steelhead

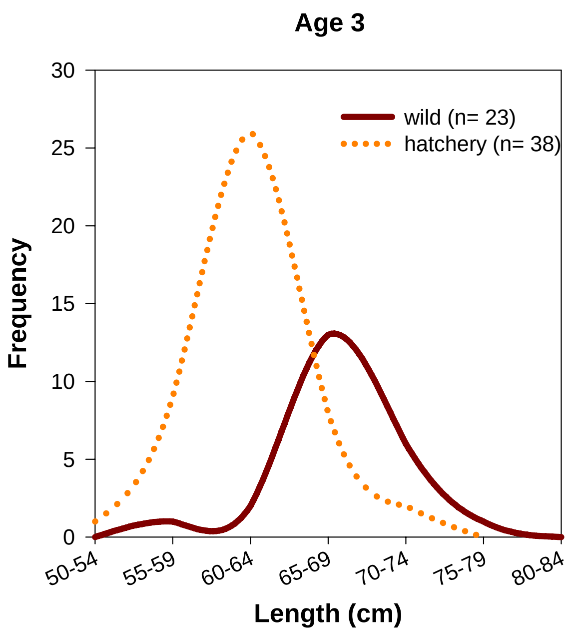

Figure 4: Length Frequency distribution of Age 3 adult winter steelhead. Scale samples were collected from wild steelhead trapped at the lower ladder on Eagle Creek and from hatchery steelhead during spawning operations at Eagle Creek NFH. Mean length of wild and hatchery steelhead was 68 and 62 cm. Wild steelhead were significantly larger than hatchery fish ($p < 0.05$).

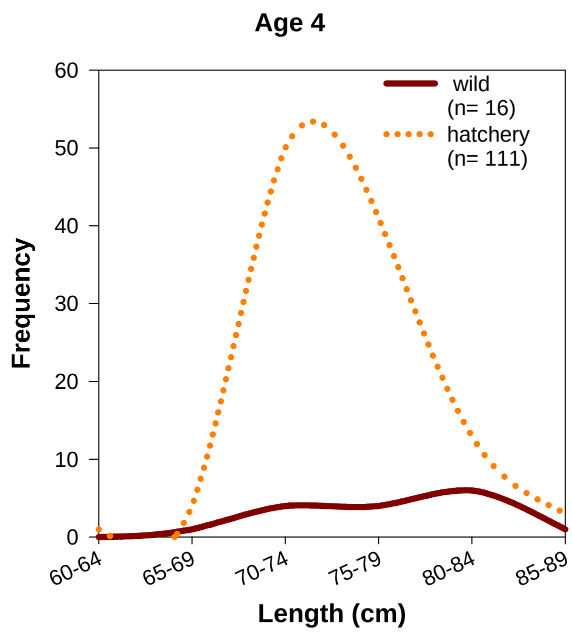

Figure 5: Length Frequency distribution of Age 4 adult winter steelhead. Scale samples were collected from wild steelhead trapped at the lower ladder on Eagle Creek and from hatchery steelhead during spawning operations at Eagle Creek NFH. Mean length of wild and hatchery steelhead was 78 and 75 cm. Wild steelhead were significantly larger than hatchery fish ($p < 0.03$).

Radio-telemetry

During the trapping period, 76 steelhead (52 hatchery and 24 wild) were radio-tagged and released back into Eagle Creek. Average migration time from the lower ladder to the hatchery receiver for radio-tagged fish was 202 hours or approximately 8.5 days. Adult steelhead movement was distributed throughout upper (above the North Fork), and lower (below the North Fork) Eagle Creek and North Fork Eagle Creek (Table 3).

For radio-tagged wild steelhead, 33% (8 of 24) were last detected in upper Eagle Creek, 17% (4 of 24) in North Fork Eagle Creek, and 29% (7 of 24) at the mouth of Eagle Creek (Table 4). Two wild steelhead were not detected at any of the fixed station receivers or through mobile tracking efforts. Radio-tags from three wild steelhead were detected only at the lower ladder after tagging; indicating these fish regurgitated the tags after release. Two of these radio-tags were later recovered near the lower ladder through snorkeling.

For hatchery steelhead, 18 were detected near the hatchery receiver, but only 13% (7 of 52) entered the fish ladder at the hatchery and were recovered during spawning (Table 4). 31% (16 of 52) of hatchery steelhead were last detected in upper Eagle Creek, and 25% (13 of 52) were last detected at the mouth (Figure 6). 23% (12 of 52) of radio-tagged hatchery steelhead were detected only at the lower ladder, and it is assumed these tags were regurgitated by the fish post tagging. Several attempts were made to recover these tags through snorkeling but they were not located. 2 radio-tags were recovered by anglers approximately 1 mile downstream from the hatchery, and one tag was recovered by an angler just below the lower ladder. One hatchery steelhead was not detected at any of the fixed station receivers or through mobile tracking. Straying of hatchery steelhead into North Fork Eagle Creek in 2005 was minimal; only one hatchery male was detected at the North Fork receiver on March 19th and again on April 11th. His last known location was at the mouth receiver on April 12th.

Two hatchery steelhead died during trapping operations at the lower ladder. One fish was in poor condition when removed from the ladder during trapping and was immediately placed in the recovery tub without attempting to radio-tag or sample. The fish died in the recovery tub and was placed back in Eagle Creek. A second fish died after being radio-tagged and placed back into the stream. No unmarked wild fish mortalities were observed.

Table 3: The number of radio-tagged adult winter steelhead detected at the hatchery, North Fork, and mouth receivers from January through June 2005.

	Number tagged at lower ladder	Passed hatchery receiver	Passed North Fork receiver	Passed mouth receiver
Hatchery origin	52	32	1	16
Natural origin	24	10	5	9

Table 4: The number of radio-tagged adult winter steelhead last detected at the hatchery, North Fork, and mouth receivers from January through June 2005. Tag recoveries include tags collected from fish during spawning, by anglers, and through snorkeling efforts. Steelhead not detected at a fixed telemetry station or through mobile tracking were classified as not detected.

	Last detection Hatchery receiver *	Last detection North Fork receiver	Last detection Mouth receiver	Last detection Lower Ladder	Last detection above Lower Ladder **	Tags Not Detected
Hatchery	18	0	13	12	5	1
Natural	6	4	7	3	2	2

* Hatchery receiver is located approximately 100' downstream of hatchery fish ladder
** Mobile tracking events that occurred between lower ladder and middle ladder of Eagle Creek

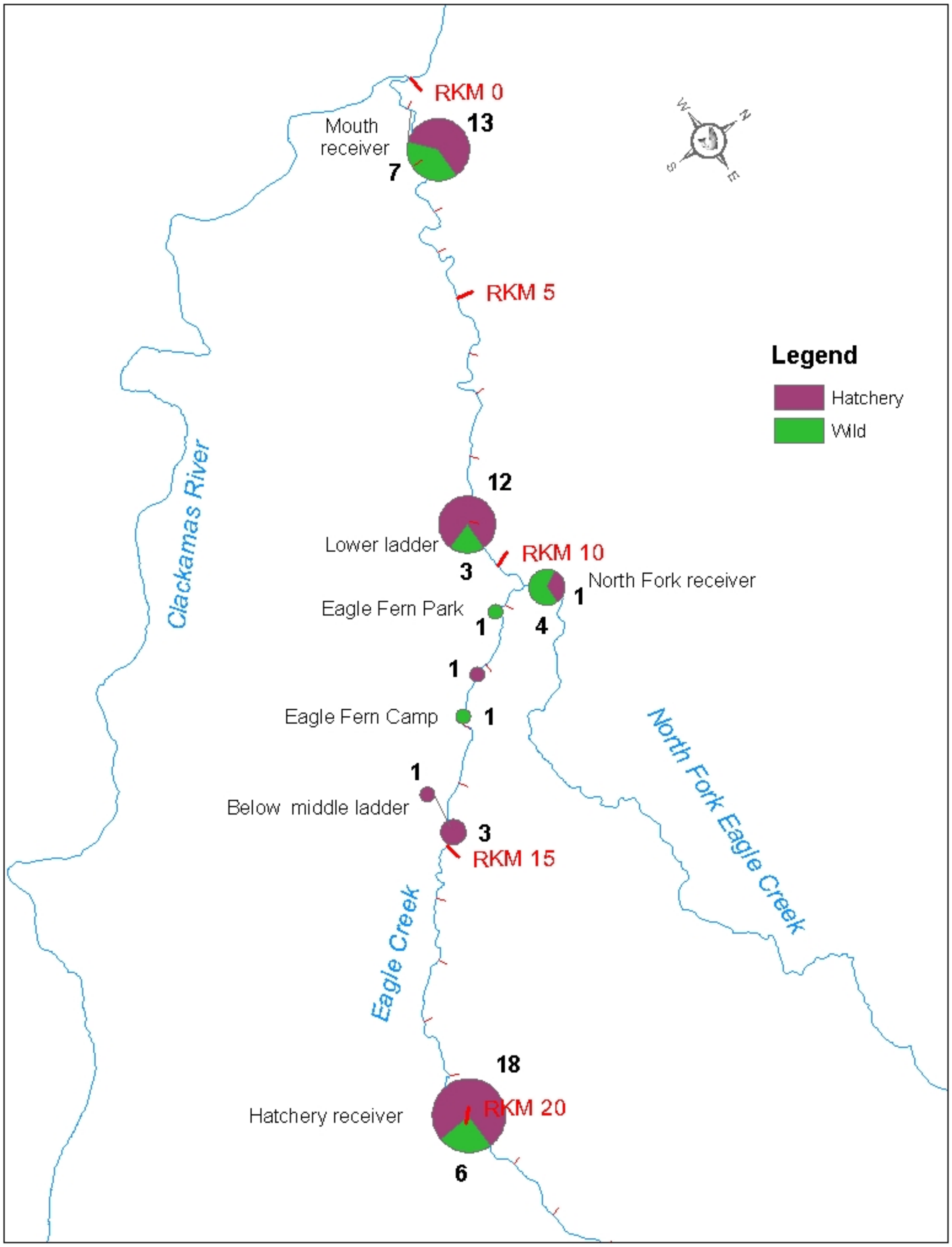

Figure 6: Last mobile and/or fixed station detections for radio-tagged adult winter steelhead. The number of hatchery and wild steelhead detected at each site is indicated in bold text next to the pie chart. Tag recoveries by anglers are not included on the map. Two wild steelhead and one hatchery steelhead were not detected post tagging.

Coho

171 hatchery coho were trapped at the lower ladder on Eagle Creek from September through November 2005. Trapping effort at the ladder ranged from one to 48 hours with a mean effort of 12 hours. The majority of hatchery coho passed through the ladder in early October with two smaller pulses of fish moving through in mid-October and early November (Figure 6). The presence of natural origin coho at the ladder in 2005 was minimal. A total of 5 unmarked adults, (no CWT and intact adipose fins), were trapped at the ladder. Capture dates for the natural origin coho were 10/3, 10/26, and 11/2. No coho were observed during the Jan 1st through May 31st sampling period.

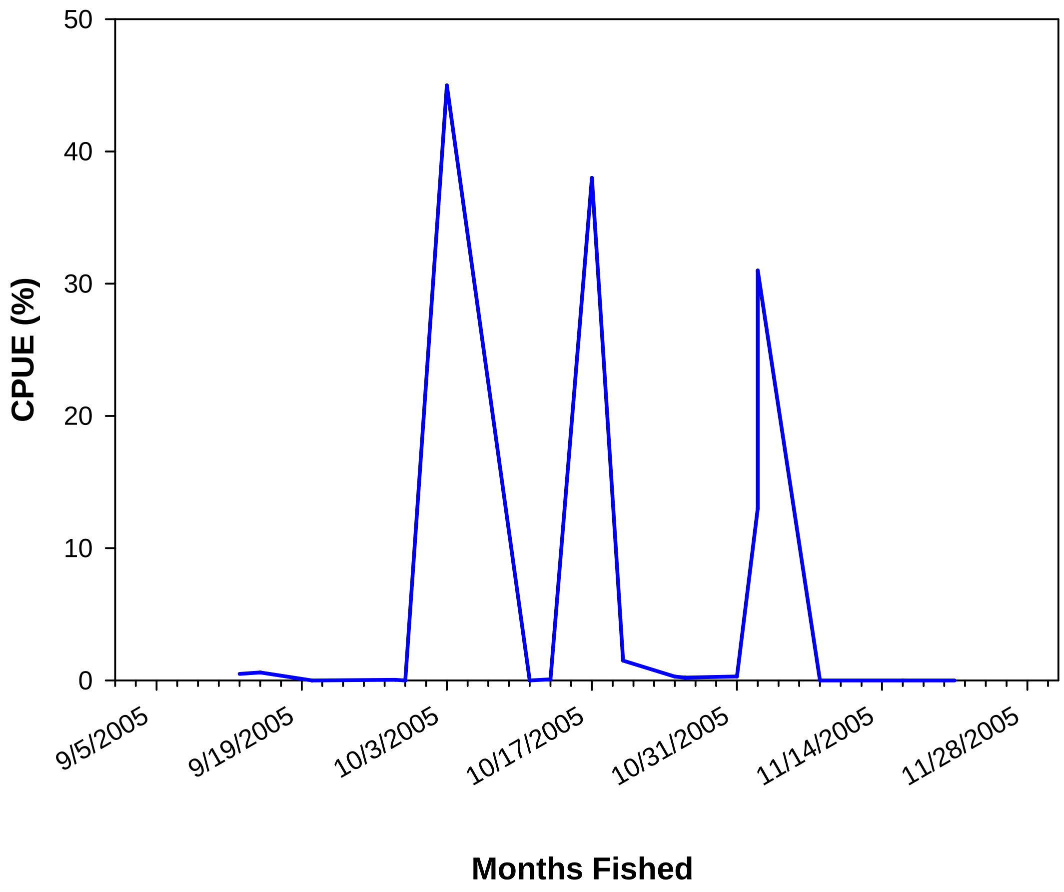

Figure 7: Catch per unit effort of adult hatchery coho through the lower ladder on Eagle Creek. Effort during the trapping period ranged from one hour to 48 hours.

Fork length was measured for 44 hatchery and 5 natural origin coho trapped in the ladder. Scale samples collected from natural origin coho at the lower ladder were used to age natural origin fish and data collected from hatchery coho during bio-sampling at ECNFH was used to age hatchery coho. Mean fork length by age for hatchery coho bio-sampled at ECNFH was 40 cm (age 2) and 71 cm (age 3). Mean fork length by age for natural origin coho was 42 cm (age 2) and 69 cm (age 3) (Figure 7).

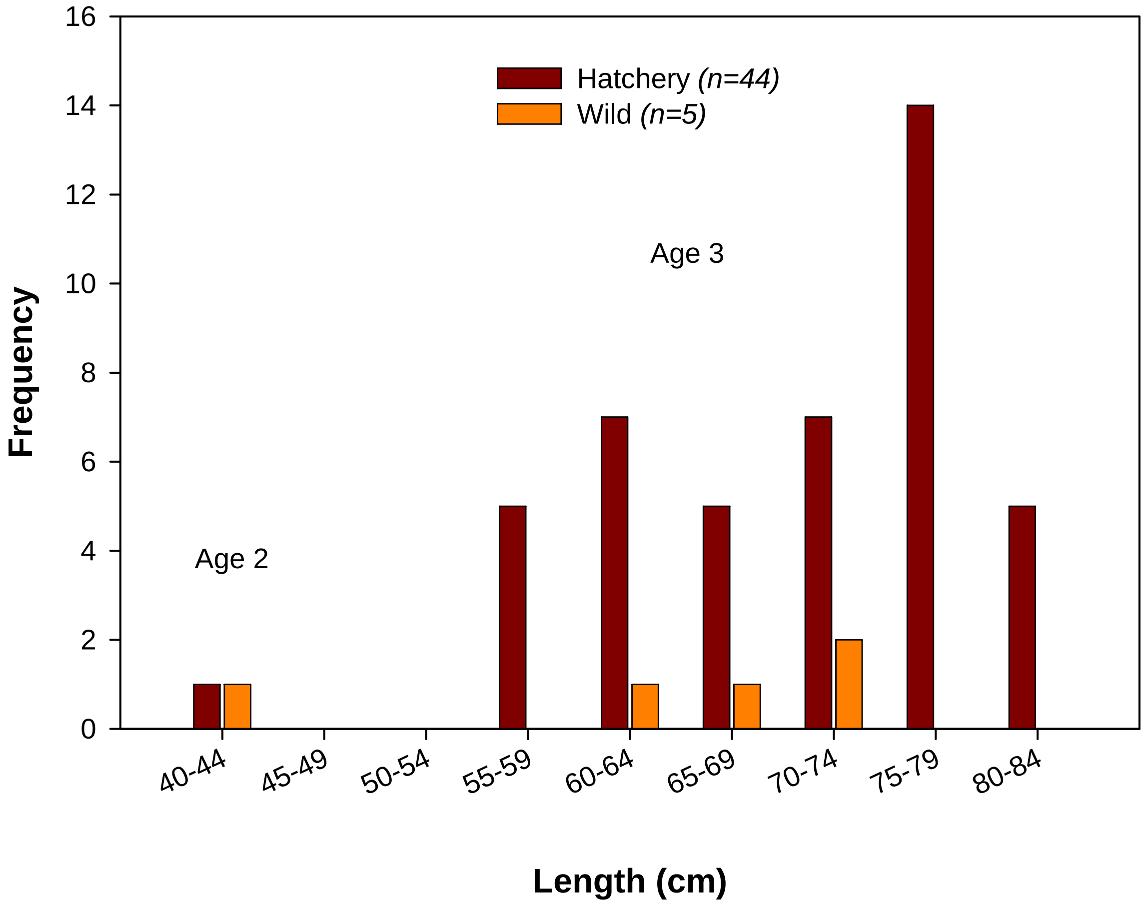

Figure 8: Length-Frequency distribution of adult coho trapped at the lower ladder on Eagle Creek.

Radio-telemetry

30 hatchery, 4 natural origin, and 2 “unknown” origin coho were radio-tagged from September through November at the lower ladder. The two unknown origin coho had intact adipose fins; however the presence of coded wire tags in the fish was unable to be determined.

Radio-tags from three hatchery and one natural origin coho were recovered at the lower ladder indicating these tags were regurgitated by the fish after release into the stream. 20 radio-tagged coho were recorded at the hatchery receiver and 3 were recorded at the North Fork receiver (Table 5). During spawning at the hatchery 15 radio-tags were recovered.

Table 5: The number of radio-tagged adult coho recorded at the hatchery and North Fork receivers from September through November 2005.

	Number tagged at lower ladder	Passed Hatchery receiver	Passed North Fork receiver	Recovered at Hatchery
Hatchery origin	30	20	3	15
Natural origin	4	1	1	0
Unknown Origin	2	1	1	0

Juvenile Steelhead

Objective 2: Assess the distribution and outmigration timing of juvenile winter steelhead post volitional release from ECNFH using radio-telemetry.

In March 2005, 75 hatchery steelhead smolts were surgically implanted with coded radio- transmitters prior to volitional release. Following surgery, 12 fish shed their tags in the hatchery raceways and were excluded from all analyses. Mean length, weight, and condition factor of radio-tagged hatchery smolts is given in Table 6. Condition factor of smolts from the high density group was significantly less than those of the low and medium density groups ($p<0.001$) (Figure 8).

Table 6. Mean length, weight, and condition factor for radio-tagged hatchery steelhead smolts from low, medium, and high density groups. Steelhead smolts that shed their tags in the hatchery raceways post surgery were excluded from analysis. Condition factor of smolts from the high density group was significantly less than smolts from the low and medium density groups (p<0.001).

Density Group	*n*	Mean Length (mm)	Mean Weight (g)	Condition Factor	95% Confidence Interval
Low	20	196	79.9	1.05	0.043
Medium	21	199	78.6	0.99	0.037
High	22	192	53.5	0.75*	0.081

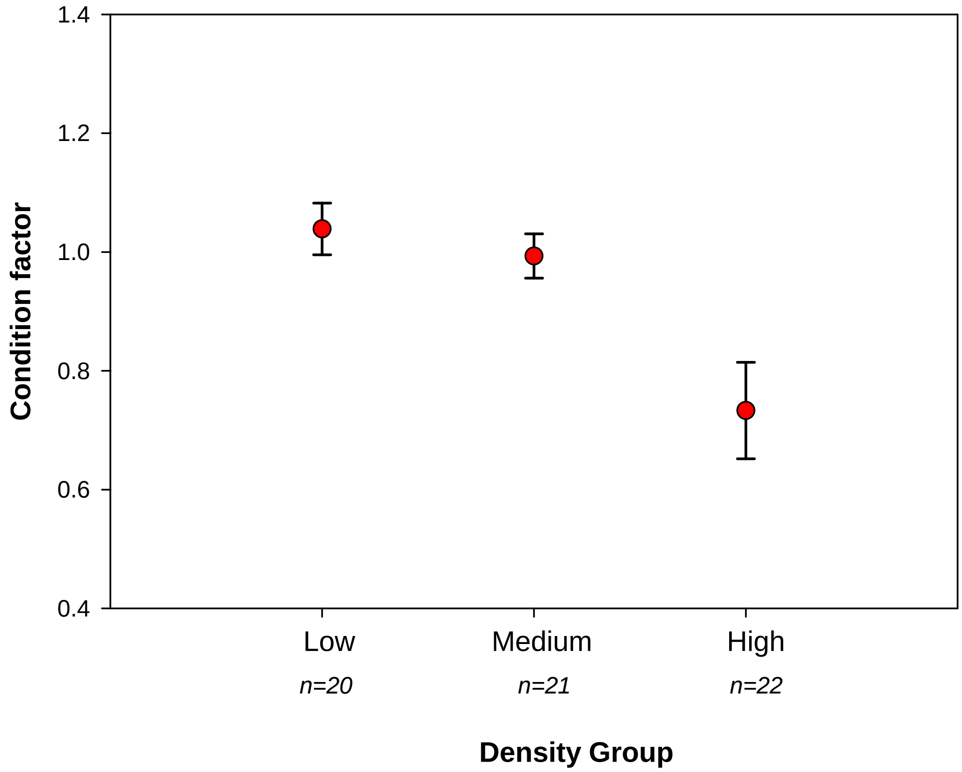

Figure 9: Condition factor of radio-tagged hatchery steelhead smolts from low, medium, and high density groups. Condition factor of smolts from the high denstiy group was significantly less than those from the low and medium density groups (p<0.001). Error bars represent 95% confidence intervals.

A data logging receiver was set up on Eagle Creek just below the volitional release pond to detect smolts as they left the hatchery. 29 radio-tagged steelhead smolts were detected at the fixed station receiver located at the hatchery. Three smolts were detected at Eagle Fern Camp (Rkm 12.8), 3 were detected at the lower ladder (Rkm 9.7), 1 smolt was detected just downstream from the middle ladder (Rkm 14.66), and 14 were detected upstream of the hatchery and below the upper falls (Rkm21) (Figure 9). Five smolts were not detected at the fixed station receivers or through mobile tracking.

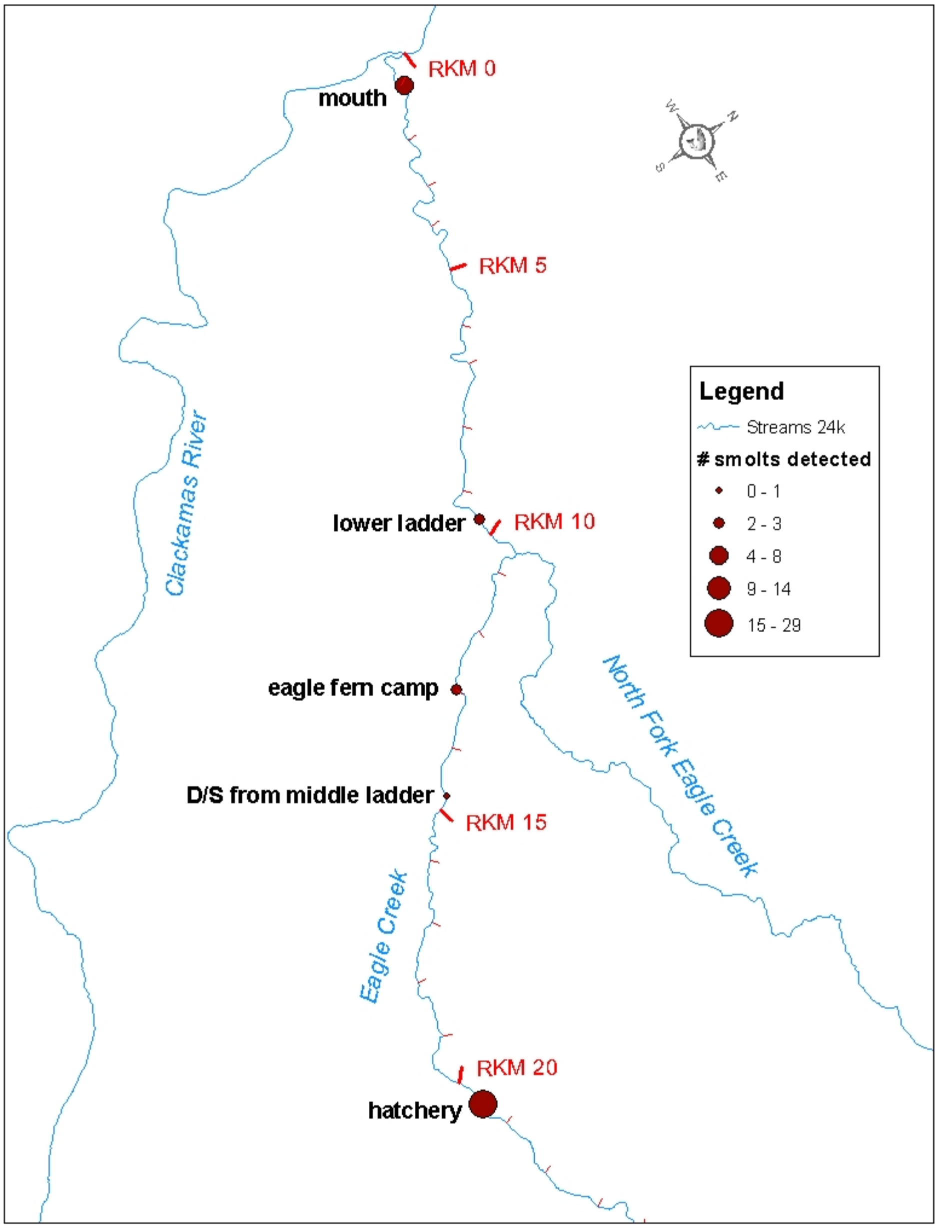

Figure 10: Last mobile and fixed telemetry detections for hatchery steelhead smolts following volitional release from Eagle Creek National Fish Hatchery.

8 radio-tagged hatchery steelhead smolts were detected at the fixed telemetry station located near the mouth of Eagle Creek. Average migration time from the hatchery to the mouth was 223 hours or approximately 9 days. A linear regression showed no significant relationship between smolt size at release and migration time from the hatchery (RKM 20) to the fixed station at the mouth of Eagle Creek (RKM 1.1) (Figure 10).

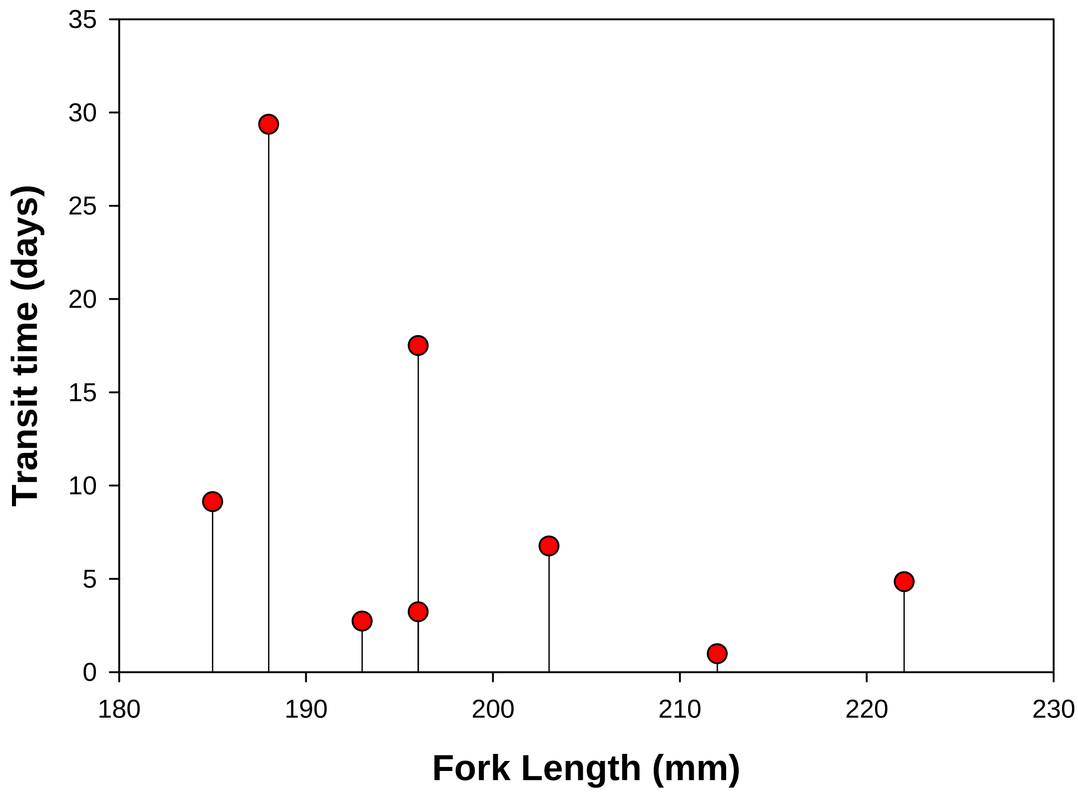

Figure 11: Fork length of winter steelhead smolts volitionally released from Eagle Creek National Fish Hatchery (Rkm 20) and detected at the fixed telemetry station at the mouth of Eagle Creek (Rkm 1.1). No relationship between smolt length at release and emmigration time from the hatchery to the mouth of Eagle Creek was detected.

Objective 4: Determine the effect of rearing density on growth and survival of winter steelhead, both on-hatchery and post-release

In July 2004, juvenile steelhead were transferred from rearing units in the hatchery to outside raceways designated as low, medium, or high density. Fork length, condition factor, and biomass were calculated during initial ponding (Table 7) and prior to release (Table 8).

Table 7: Mean fork length, condition factor, biomass, and density for brood year 2004 hatchery juvenile steelhead in the rearing density study. Fish were sampled in July 2004 during coded wire tagging.

Sample Date	**Pond Concentration**	**# Sampled**	**Mean fork length (mm)**	***S.D.***	**Condition factor**	**Fish bio-mass (kg)**	**Density (kg/m^3)**	**Density Index**
July 2004	Low *(7,471)*	100	67	5.74	1.09	25.02	0.68	0.02
	Low *(7,481)*	100	65	5.72	1.09	22.32	0.60	0.02
	Low *(7,464)*	100	59	4.47	1.06	16.03	0.43	0.01
	Medium *(14,980)*	100	68	4.59	1.05	49.13	1.33	0.03
	Medium *(14,980)*	100	66	5.64	1.10	46.57	1.26	0.03
	Medium *(15,032)*	100	60	5.01	1.08	35.28	0.95	0.03
	High *(22,426)*	100	68	5.59	1.05	73.13	1.98	0.05
	High *(22,246)*	100	66	5.55	1.05	67.69	1.83	0.05
	High *(22,514)*	100	60	4.66	1.06	50.32	1.36	0.04

Table 8: Mean fork length, condition factor, biomass, and density for brood year 2004 hatchery juvenile steelhead in the rearing density study. Fish were sampled in March 2005 and volitionally released in April 2005. The number of fish released from each raceway is in parentheses.

Sample Date	**Pond Concentration**	**# Sampled**	**Mean fork length (mm)**	***S.D.***	**Condition factor**	**Fish bio-mass (kg)**	**Density (kg/m^3)**	**Density Index**
March 2005	Low *(7,471)*	117	194	22.4	1.00	550.3	14.9	0.13
	Low *(7,481)*	142	186	20.4	1.00	477.9	12.9	0.12
	Low *(7,464)*	141	189	18.8	0.96	485.0	13.7	0.12
	Medium *(14,980)*	128	183	20.2	1.07	987.4	26.7	0.25
	Medium *(14,980)*	125	186	17.8	1.01	976.1	26.4	0.24
	Medium *(15,032)*	129	184	19.8	1.07	993.7	26.9	0.25
	High *(22,426)*	125	181	20.2	1.00	1334.6	36.1	0.34
	High *(22,246)*	130	179	16.6	1.04	1327.3	35.9	0.34
	High *(22,514)*	132	181	16.6	1.08	1431.3	38.7	0.36

Fork lengths from smolts in the low, medium, and high density raceway groups were pooled together, and a one way ANOVA was used to compare lengths between density groups.   No significant difference in fork length between density groups was detected during tagging or at release in 2005 (Figures 11 and 12).

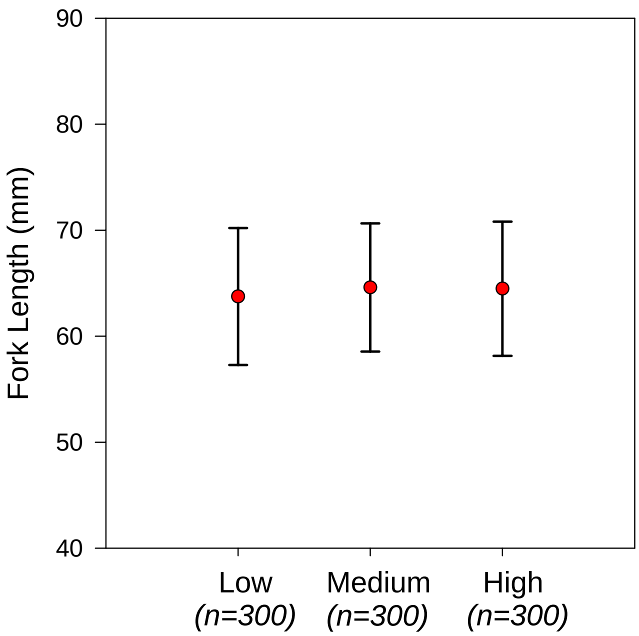

Figure 12: Mean fork lengths of juvenile winter steelhead, (brood year 2004), sampled in July 2004 during coded wire tagging at Eagle Creek National Fish Hatchery. Lengths were taken from fish prior to initial ponding at the hatchery. No significant difference in fork lengths between density groups was detected. Error bars represent standard devaition.

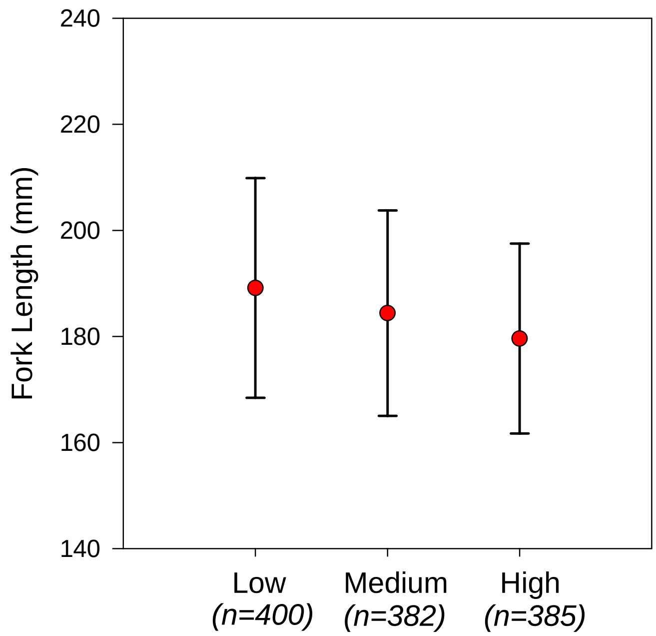

Figure 13: Mean fork lengths of juvenile winter steelhead, (brood year 2004), sampled in March 2005 prior to volitional release from Eagle Creek National Fish Hatchery. No significant difference in fork lengths between density groups was detected. Error bars represent standard deviation.

Genetics

Objective 5: Determine genetic structure of hatchery and natural origin steelhead in Eagle Creek and North Fork Eagle Creek

Genetic samples collected from adult and juvenile steelhead in Eagle Creek and North Fork Eagle Creek were analyzed at USFWS Abernathy Fish Technology Center. A summary of the results from the FY2005 report (Matala et al. 2005) are described in the following section. The FY2005 report was a collaborative effort with the Columbia River Fisheries Program Office and Abernathy Fish Technology Center.

Genetic sample collections for lower Eagle Creek were concentrated around the lower ladder, and collections for upper Eagle Creek near the middle ladder (Figure 13). Several attempts were made to sample other sections of the stream within a sample reach; however we had difficulty collecting fish in many of the locations that were sampled. Samples were collected from steelhead in the North Fork during smolt trap operations from March –June.

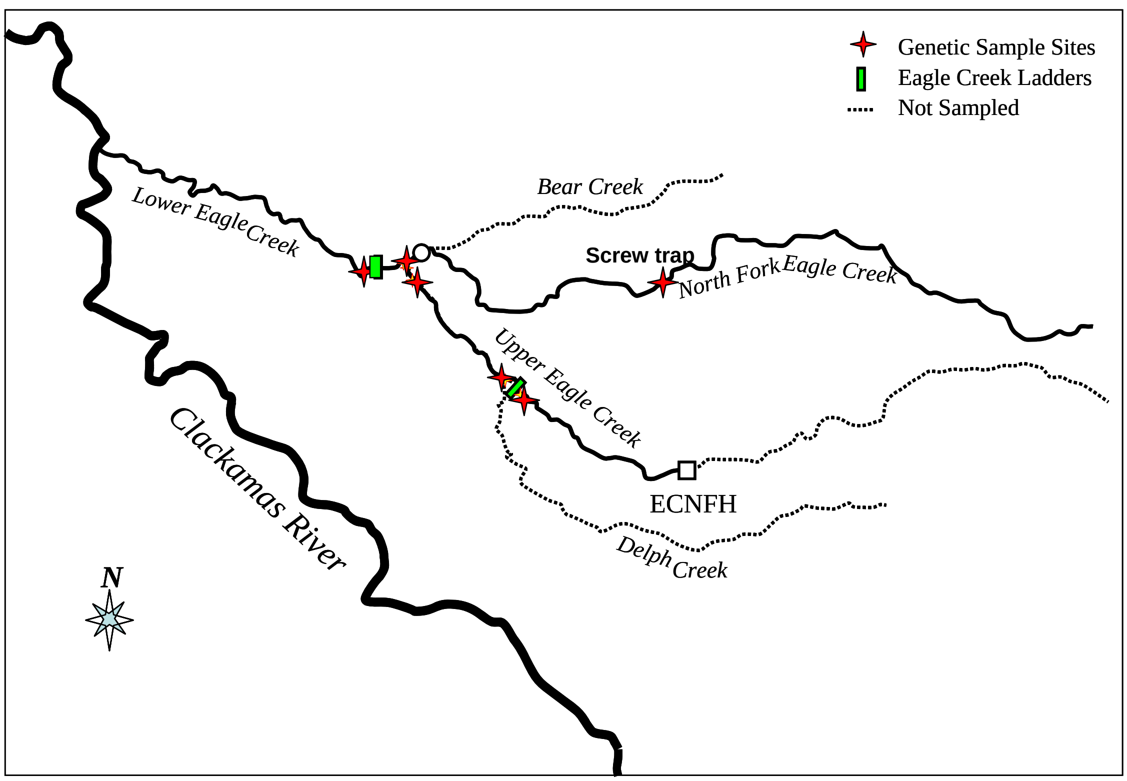

Figure 14: Map of genetic sample sites on Eagle Creek

For detailed information on genetic techniques and results see Matala et al (2005). We provide the following snapshot of information from that report. ECNFH smolts (hatchery origin) and adult wild fish collected at the lower ladder (natural origin) were used as baseline groups to compare with unknown sample groups collected from upper and lower Eagle Creek and North Fork Eagle Creek (Table 9). Matala et al (2005) calculated the probability of and individual belonging to either the natural origin or hatchery origin group using genotypic similarity assignments (Figure 14), and an assignemnet test assessment was used to determine the power of a particular assignemnent . 76% of samples from lower Eagle Creek assigned to the natural origin group with 95% confidence and 4% assigned to the hatchery origin group. 39.2% of North Fork Eagle creek fish assigned to the natural origin population and 21.6% assigned to the hatchery population with 95% confidence.

Table 9. The number of genetic samples collected for each sample reach in 2005. Unknown sample groups included juveniles from the North Fork and upper and lower Eagle Creek. Natural origin adults collected at the lower ladder and juveniles collected from ECNFH were used as baseline groups.

Location	Life History Stage	Target #	Actual # sampled
North Fork	Smolt (NOR)	50	37(juv.) 5(smolt)
North Fork to Hatchery (Upper EC)	Juvenile (NOR)	50	104
Mouth to North Fork (Lower EC)	Juvenile (NOR)	50	46
Lower Ladder	Adults (NOR)	50	42
Eagle Creek NFH	Juvenile (HOR)	50	56

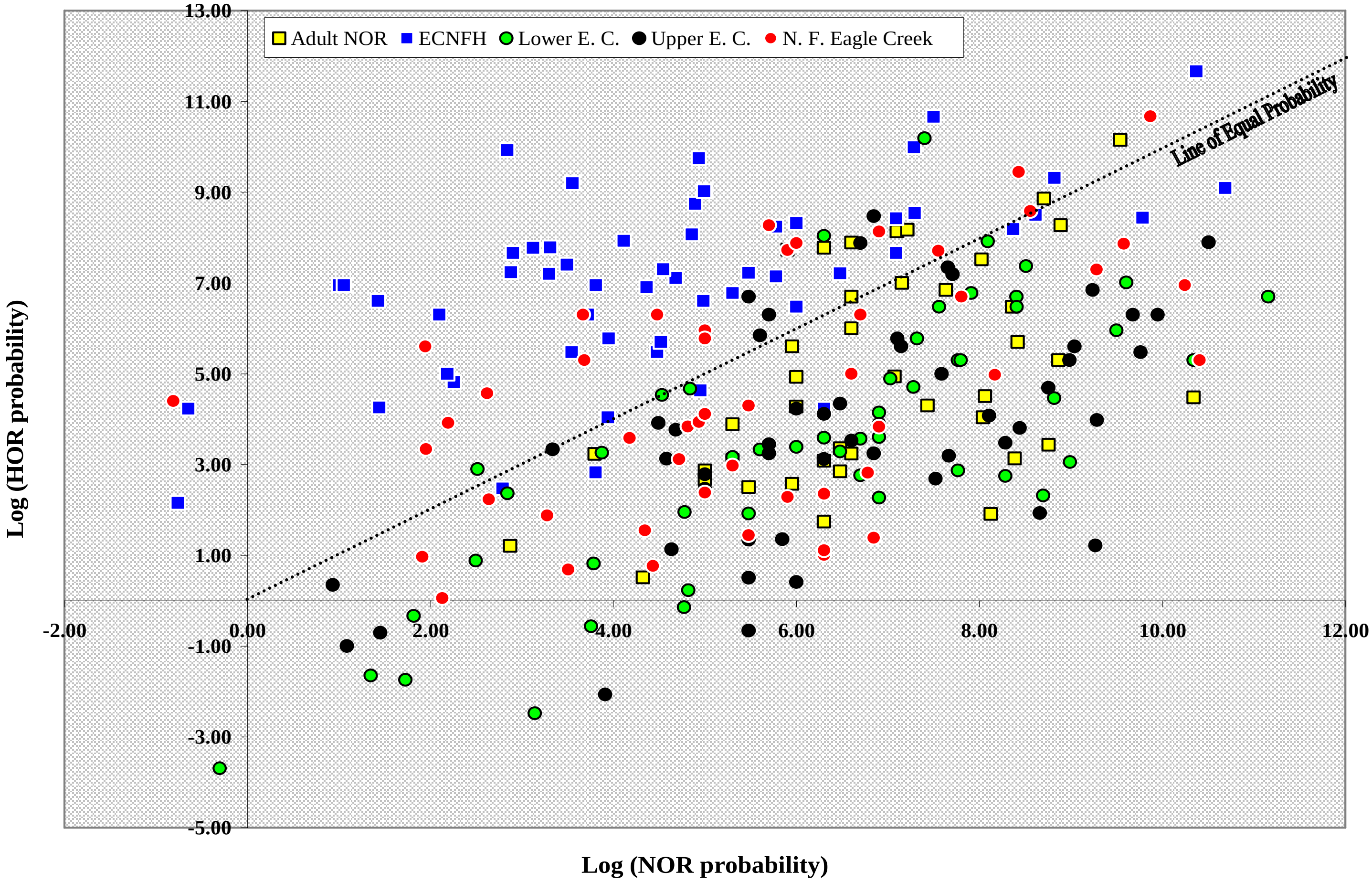

Figure 15. Plot of population assignment probabilities for individuals of each group. The trend-line delineates where an individual is equally likely to be of NOR origin as HOR origin (Figure taken from Matala et al 2005).

Acknowledgements

We would like to thank the field and office staff at Eagle Creek National Fish Hatchery especially Doug Dysart and Steve Turner for their help in field support during this study. We would also like to thank Bill Ardren and Andrew Matala at Abernathy Fish Technology Center Ken Lujan with USFWS Fish Health Center, and USFS field staff especially Burke Strobel for their work with assisting in the collection and evaluation of genetic samples in Eagle Creek.

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Appendix A

North Fork Eagle Creek spawner survey and juvenile production data

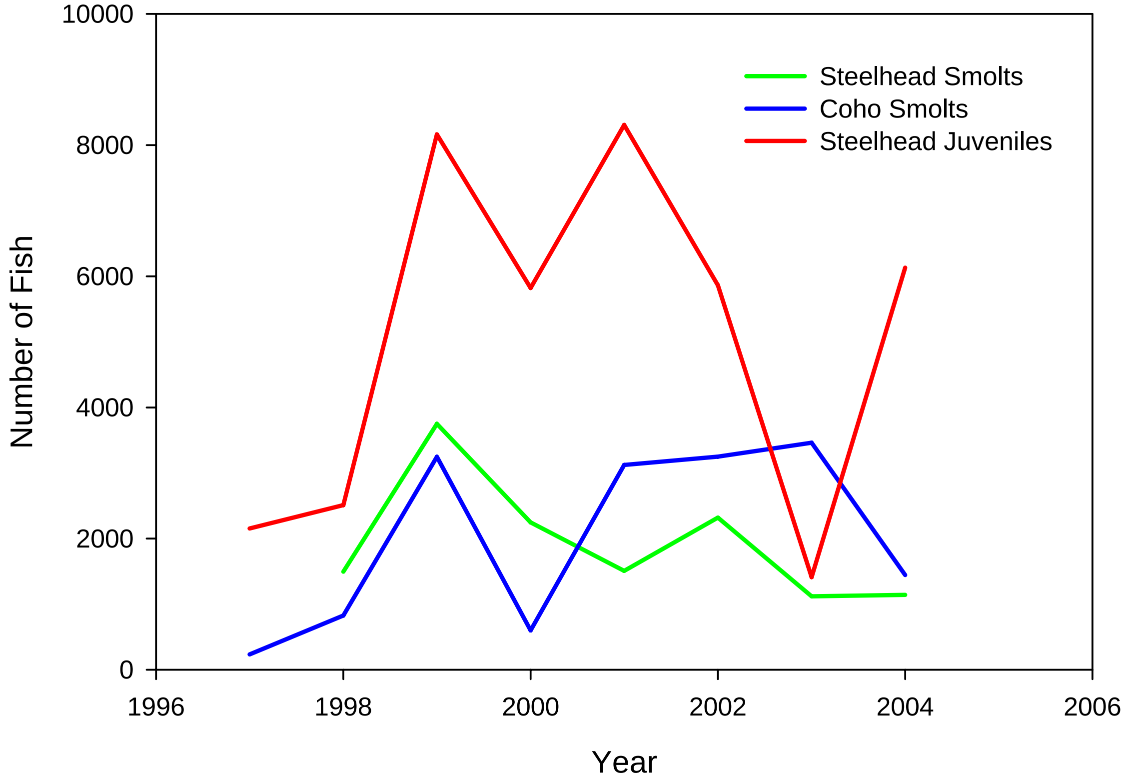

Figure 1: North Fork Eagle Creek population estimates for 1996-2005

Table 1: North Fork Eagle Creek Coho spawner survey and redd counts 1993-2005 (Clackamas River Fisheries Working Group 2004 and 2005).

Reach Descriptions:

Reach 1: RM 0.25-1.25

Reach 2: RM 1.25-2.25
Reach 3: RM 2.25-2.75 (added in 1996)
Reach 4: RM 2.75-4.5 (added in 2005)

Year	Reach	Redds	Adults	Carcasses	# Surveys	Dates Surveyed
1993	1	19	9	4	4	11/15/93; 12/14/93
	2	9	0	0	2	11/23/93; 12/22/93
1994	1	33	45	31	10	10/18/94; 12/28/94
1995	1	7	0	0	10	10/17/95; 1/11/96
1996	1	12	3	2	8	10/23/96; 1/9/97
	2	6	0	0	3	10/23/96; 12/17/96
	3	5	0	0	3	10/23/96; 12/17/96
1997	1	15	4	3	5	10/20/97; 12/8/97
	2	7	0	0	3	10/23/97; 12/15/97
	3	11	4	3	3	10/23/97; 12/15/97
1998	1	24	6	19	5	11/3/98; 12/21/98
	2	10	2	4	3	11/17/98; 1/13/99
	3	12	1	0	2	11/17/98; 12/9/98
1999	1	54	54	44	5	10/27/99; 12/29/99
	2	9	3	0	2	11/1/99; 12/29/99
	3	22	8	2	2	11/1/99; 12/29/99
2000	1	139	81	86	8	9/18/00; 1/2/01
	2	35	6	8	3	11/20/00; 1/2/01
	3	46	2	6	3	11/20/00; 1/2/01
2001	1	45	2	6	5	10/2/01; 1/17/02
	2	52	16	11	2	11/7/01; 1/15/02
	3	35	16	1	2	11/7/01; 1/15/02
2002	1	80	54	37	2	11/20/02; 1/7/03

Year	Reach	Redds	Adults	Carcasses	# Surveys	Dates Surveyed
2003	1	41	17	4	2	10/22/03; 11/5/03
	2	11	3	2	2	10/22/03; 11/5/03
	3	28	10	1	2	10/22/03; 11/5/03
2004	1	25	2	1	2	11/15/04; 12/27/04
	2	11	0	0	1	12/27/2004
	3	12	0	0	1	12/27/2004
2005	1	18	6	1	3	11/9/05; 12/13/05
	2	19	0	7	1	11/22/2005
	3	13	1	0	1	11/22/2005
	4	41	0	4	1	12/12/2005

Table 2: North Fork Eagle Creek winter steelhead spawner survey and redd counts 1994-2006 (Clackamas River Fisheries Working Group 2004 and 2005).

Reach Descriptions:

Reach 1: RM 0.25-1.25

Reach 2: RM 1.25-2.25
Reach 3: RM 2.25-2.75 (added in 1997)
Reach 4: RM 2.75-4.5 (added in 2000)

Year	Reach	Redds	Adults	Carcasses	# Surveys	Dates Surveyed
1994	1	18	0	0	5	1/31/94; 6/22/94
	2	16	0	0	3	4/5/94; 6/22/94
1995	1	19	8	2	8	1/9/95; 5/22/95
	2	3	0	0	1	5/8/1995
1996	1	21	4	0	6	1/31/96; 5/30/96
	2	2	0	0	4	2/15/96; 5/30/96
1997	1	17	1	0	4	2/25/97; 6/5/97
	2	4	0	0	5	1/16/97; 6/5/97
	3	9	0	0	4	2/26/97; 6/5/97
1998	1	25	4	0	4	2/9/98; 6/4/98
	2	17	0	0	3	2/23/98; 6/4/98
	3	10	0	0	3	
1999	1	24	0	0	4	1/7/99; 6/2/99
	2	15	0	0	1	6/1/99
	3	12	0	0	1	6/1/99
2000	1	31	2	0	3	3/8/00; 5/30/00
	2	30	2	0	3	3/9/00; 5/25/00
	3	27	0	0	3	3/9/00; 5/25/00
	4	35	0	0	1	5/25/00
2001	1	25	6	2	3	3/1/01; 6/5/01
	2	21	0	0	3	2/22/01; 6/5/01
	3	14	0	0	3	2/22/01; 6/5/01
2002	1	33	0	0	1	6/5/02
	2	8	1	0	2	1/15/02; 6/5/02
	3	8	0	0	1	6/5/02

Year	Reach	Redds	Adults	Carcasses	# Surveys	Dates Surveyed
2003	1	30	2	0	2	3/18/03; 5/29/03
	2	13	4	0	2	3/18/03; 5/29/03
	3	21	0	0	2	3/18/03; 5/29/03
	4	41	0	0	2	3/20/03; 5/27/03
2004	1	39	0	0	2	3/16/04; 5/20/04
	2	15	3	0	2	3/16/04; 5/20/04
	3	24	0	0	2	3/16/04; 5/20/04
		72	1	0	2	3/22/04; 5/24/04
2005	1	19	3	0	2	4/29/05; 7/5/05
	2	3	0	0	1	4/29/2005
	3	15	0	0	1	4/29/2005
	4	29	0	0	1	5/2/2005
2006	1	19	0	0	2	4/4/06; 6/1/06
	2	9	0	0	2	4/4/06; 6/1/06
	3	13	0	0	2	4/4/06; 6/1/06
	4	30	0	0	1	6/5/06

Appendix B

Adult winter steelhead radio-telemetry detections

Table 1: Origin, sex, tag date, and detection locations and dates for radio-tagged adult winter steelhead (M= mouth, H= Hatchery, NF= North Fork, ML=Middle Ladder, LL= Lower Ladder, EFC= Eagle Fern Camp, EFP= Eagle Fern Park, SB= Snuffin Rd. Bridge, ND= not detected). Last known dates and locations for radio-tagged steelhead are indicated in bold.

Ch-code	Origin	Sex	Tag Date	1st Detection Location	1st Detection Date	2nd Detection Location	2nd Detection Date	3rd Detection Location	3rd Detection Date	4th detection Location	4th detection Date
2-1	W	F	4/5	NF	4/5 - 4/9	**M**	**4/9**				
2-2	H	F	4/5	H	4/7 - 4/8	**M**	**4/14**				
2-3	H	U	4/6	H	4/12 - 4/16	H	4/19	**M**	**4/22**		
2-4	H	M	4/7	**LL**	**4/11 - 4/15**						
2-5	W	F	4/7	**M**	**4/11**						
2-6	H	M	4/12	H	4/16 - 4/19	H	4/23 - 4/24	H	5/4	**H**	**5/9**
2-7	W	M	4/12	H	4/19 - 4/21	**H**	**4/26 - 4/29**				
2-8	W	M	4/12	**LL**	**4/18 - 4/22**						
2-9	W	F	4/13	**LL**							
2-9	W	M	4/21	**EFP**	**4/25 - 4/29**						
2-10	W	F	4/13	ML	4/18	H	4/21 - 4/25	**H**	**4/28 - 4/30**		
2-11	W	M	4/19	EFP	4/25	NF	4/25 - 4/27	H	4/28	**NF**	**5/5**
2-12	W	M	4/21	**LL**	**4/25 - 4/29**						
2-13	W	F	4/26	EFC	5/2	**M**	**5/7**				
2-14	W	F	4/26	**NF**	**4/27- 5/4**						
2-15	W	F	5/5	**M**	**5/9**						
3-1	H	U	1/20	**H**	**1/26 - 2/9**						
3-1	W	F	3/18	ML	3/21 - 3/25	**NF**	**3/26**				
3-2	H	U	1/20	**ND**							
3-3	H	U	1/21	H	1/23 -1/26	**H**	**1/28 - 2/9**				

Ch-code	Origin	Sex	Tag Date	1st Detection Location	Date	2nd Detection Location	Date	3rd Detection Location	Date	4th detection Location	Date
3-3	H	F	3/18	H	3/20 - 3/22	**M**	**3/26**				
3-4	H	U	1/20	**H**	**2/6**						
3-5	H	U	1/27	**M**	**2/28**						
3-6	H	U	1/27	**LL**	**2/28**						
3-7	H	U	1/27	H	2/20						
3-8	H	U	2/4	**H**	**3/1- 3/16**						
3-8	H	F	3/18	H	3/23	**M**	**3/27**				
3-9	H	U	2/8	**LL**	**2/14**						
3-10	H	U	2/8	**ML**	**3/23**						
3-11	H	U	2/8	**LL**							
3-12	H	U	2/8	H	2/19 - 3/2	**H**	**3/6**				
3-13	H	U	2/8	**> LL**	2/28						
3-14	W	U	2/25	ML	2/28	**M**	**3/17**				
3-15	H	F	2/25	**SB**	**2/28**						
3-16	H	U	2/25	**LL**							
3-17	H	M	3/1	**< LL**							
3-17	H	M	3/22	**M**	**4/19**						
3-18	H	F	3/1	H	3/6 - 3/7	H	3/13	M	3/14	**H**	**3/16**
3-19	W	U	3/1	**ND**							
3-20	H	M	3/1	**< ML**	**3/28 - 4/1**						
3-21	H	U	3/1	H	3/10	**H**	**3/11- 3/17**				
3-21	H	M	3/18	H	3/23 - 4/20	**M**	**4/22**				
3-22	W	F	3/18	H	3/20	H	3/23	H	3/26- 3/27	**M**	**3/28**

Ch-code	Origin	Sex	Tag Date	1st Detection Location	1st Detection Date	2nd Detection Location	2nd Detection Date	3rd Detection Location	3rd Detection Date	4th detection Location	4th detection Date
3-23	H	M	3/1	**M**	**4/5**						
3-24	H	U	3/1	**H**	**3/4-3/5**						
3-25	H	F	3/2	ML	3/4	**H**	**3/7 - 3/11**				
4-1	W	U	3/2	ML	2/28	H	3/12- 3/13	**H**	**3/15**		
4-2	W	U	3/2	EFP	2/28	H	3/11	**H**	**3/13**		
4-3	W	U	3/2	ML	2/28	H	3/14- 3/18	**H**	**3/28**		
4-4	W	M	3/3	ML	3/7	H	3/19	H	3/27- 3/30	**EFC**	**4/29 - 4/29**
4-5	H	U	3/3	**H**	**3/13 - 3/16**						
4-5	H	F	3/18	**LL**	**4/5**						
4-6	H	U	3/3	**H**	**3/27 - 3/29**						
4-7	W	F	3/3	**ND**							
4-8	W	F	3/3	NF	3/7	NF	3/17	**M**	**3/20**		
4-9	H	U	3/3	**H**	**3/9 - 3/16**						
4-9	H	M	3/18	NF	3/19	NF	4/11	**M**	**4/12**		
4-10	H	U	3/4	**LL**							
4-11	H	U	3/4	**LL**							
4-12	H	F	3/4	**H**	**3/8**						
4-13	H	U	3/8	H	3/10	**M**	**3/19**				
4-14	H	M	3/8	EFP	3/11	**H**	**3/16- 4/18**				
4-14	H	M	3/18	H	4/4	**H**	**4/22**				
4-15	H	M	3/8	**H**	**4/15**						
4-16	H	F	3/8	**ML**	**3/7**						
4-17	H	U	3/8	**LL**	**3/7**						
4-18	H	M	3/15	**H**	**3/20**						
4-18	H	F	3/18	H	3/26-4/4	**M**	**4/9**				
4-19	H	F	3/17	ML	3/28-5/2						

Ch-code	Origin	Sex	Tag Date	1st Detection Location	1st Detection Date	2nd Detection Location	2nd Detection Date	3rd Detection Location	3rd Detection Date	4th detection Location	4th detection Date
4-20	H	F	3/18	**LL**	**4/20**						
4-21	H	F	3/18	H	3/20	H	3/26 - 4/1	**M**	**4/3**		
4-22	W	M	3/18	H	3/14	H	3/16	EFC	3/21- 3/25	**H**	**3/28**
4-23	W	F	3/18	NF	3/18	NF	3/19	**NF**	**3/21**		
4-24	H	M	3/18	H	3/20	H	3/26 - 4/1	H	4/6 - 4/12	**M**	**4/28**
4-25	H	M	3/18	H	3/19 - 3/21	H	3/23 - 24	**H**	**3/27 - 4/3**		