# Eagle Creek Ecological Interactions:
## Distribution and migration of hatchery and wild steelhead
## Progress Report 2007

**Jeff Hogle, USFWS, and Jessica Vogt, ODFW, conducting winter steelhead redd surveys on Eagle Creek, OR**
Photo Credit: Maureen Kavanagh, USFWS

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October 2008

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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 (Eagle Creek NFH) 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 Eagle Creek NFH 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 Eagle Creek NFH. 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 for broodyears 2004-2006. This report summarizes the progress made during the 2007 field investigation to address the following objectives:

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

<u>Objective 2:</u> Estimate the number of adult hatchery steelhead returning to Eagle Creek.

<u>Objective 3</u>: Assess the distribution and outmigration timing of juvenile winter steelhead post volitional release from Eagle Creek NFH using radio-telemetry.

<u>Objective 4:</u> Determine genetic structure of hatchery and natural origin steelhead in Eagle Creek and North Fork Eagle Creek.

<u>Objective 5:</u> Determine the effect of rearing density on growth and survival of winter steelhead, both on-hatchery and post-release.

## 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. This program is part of the mitigation for habitat loss resulting from flooding, siltation, and fluctuating water levels caused by Bonneville Dam. Hatchery operations are documented in a Hatchery Genetic Management plan and guided by (Biological Opinion) a ESA Section 7 consultation issued by NOAA Fisheries 11/27/07. The current production goals for release into Eagle Creek (150,000 steelhead and 500,000 coho) are consistent with the production goals in the Columbia River Fish Management 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 Hatchery and Genetic Management Plans).

The majority of adult hatchery steelhead are present in Eagle Creek from December through March; whereas adult, wild, ESA listed, late-run winter steelhead are most present in Eagle Creek from February until June. While the peak run timing between the groups differs, 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.

## Methods

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

### ***Adult Trapping and Migration Timing***

Eagle Creek NFH owns and maintains three fish ladders on Eagle Creek at a lower (Rkm 11) and middle (Rkm 13) falls and at the hatchery (Rkm 20.1). 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. 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. 50 radiotags were available for adult steelhead. A fish was considered “wild” if there were no obvious deformed or missing fins nor coded-wire tags. 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 anesthetized with clove oil, checked for marks (adipose clips, right ventral 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. 2008). Tagged fish were placed in a tub of fresh water to regain equilibrium and then released at or near the fish 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.

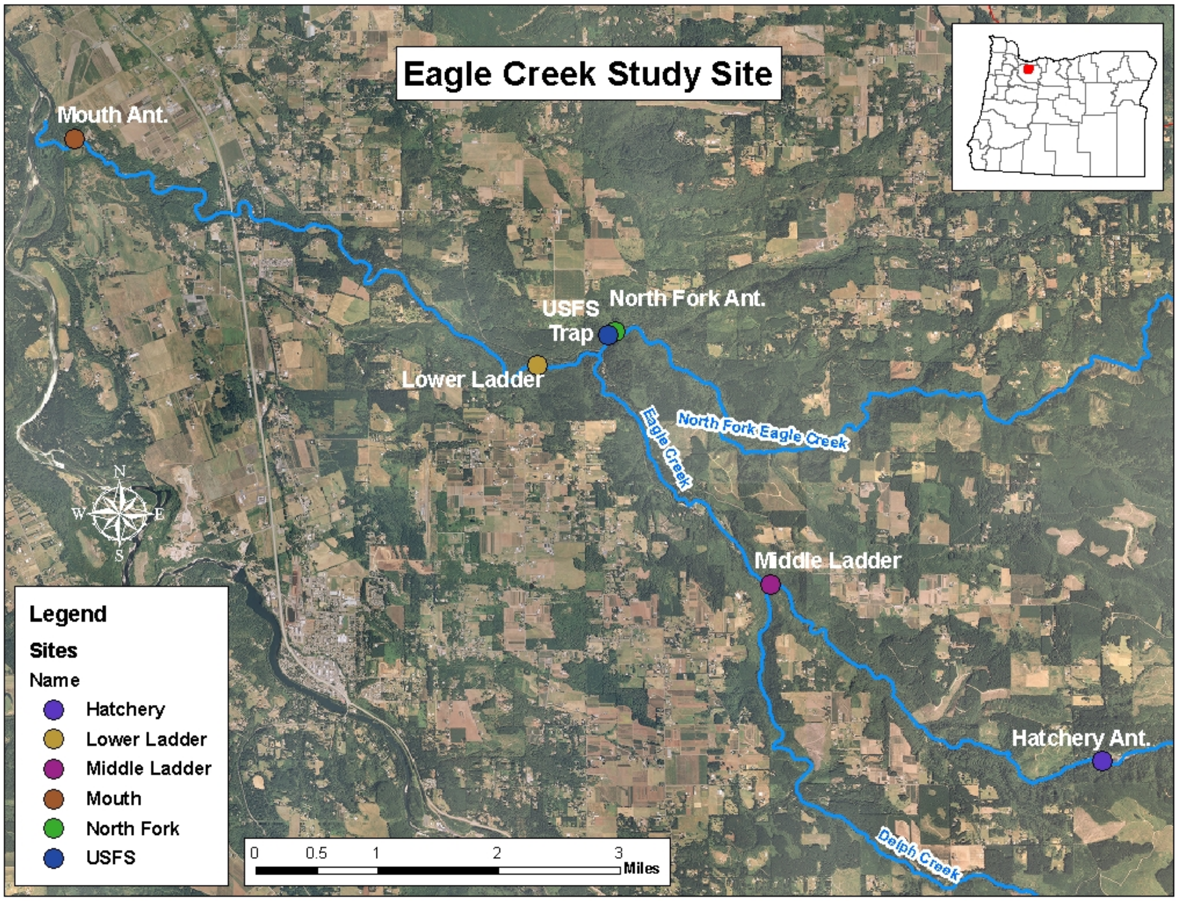


**Figure 1: Stationary antennae sites on Eagle Creek and North Fork Eagle Creek**

Objective 2: Estimate the number of adult hatchery steelhead returning to Eagle Creek

## ***Adult Population Estimates***

Coinciding with the radio-telemetry trapping at the lower ladder, adult winter steelhead were tagged with individually numbered and colored Peterson disc tags, (Floy tags), were inserted just below the dorsal fin (Figure 2). To estimate tag loss, the right opercule was marked with a small punch clip. Tag number, sex, and length of fish was recorded. Floy tagged steelhead collected during spawning operations at Eagle Creek NFH were used to estimate the population of hatchery fish at the lower fish ladder. The Chapman modification of the Lincoln-Peterson Index for calculating population density was used to account for low sample size and unbiased estimate (Van Den Avyle 1993).

$$N = \frac{(M+1)\bullet(C+1)}{(R+1)} - 1 \qquad \text{Equation 1}$$

Where *M* is the number of fish initially marked, *C* is the number of fish collected and examined for marks in the second sample period, and *R* is the number of recaptures in *C.*

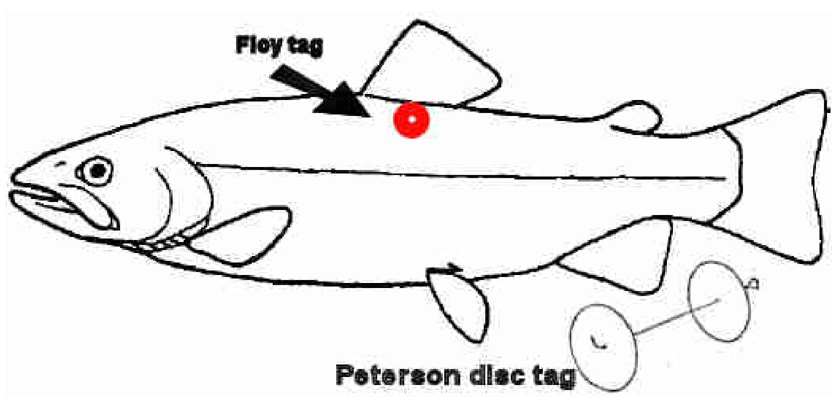


**Figure 2: Floy tag inserted below dorsal fin on adult winter steelhead (Image taken from Floy Tag catalog, FLOY TAG Inc, Seattle WA).**

Objective 3: Assess the distribution and outmigration timing of juvenile winter steelhead post volitional release from Eagle Creek NFH using radio-telemetry.

## ***Juvenile Radio-Telemetry***

In March 2007, 45 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. Five 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. The relationship between smolt size at release and migration time from the hatchery to the mouth of Eagle Creek was analyzed using a linear regression.

Objective 4: Determine genetic structure of hatchery and natural origin steelhead in Eagle Creek and North Fork Eagle Creek

## ***Genetics***

The Eagle Creek watershed was divided into three sample reaches, and genetic samples were collected from juvenile steelhead in each reach (Figure 3). 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 was comprised of North Fork Eagle Creek, and reach 3 began at the confluence of Eagle Creek and North Fork Eagle Creek and extended up to the Eagle Creek NFH (Upper EC). 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.

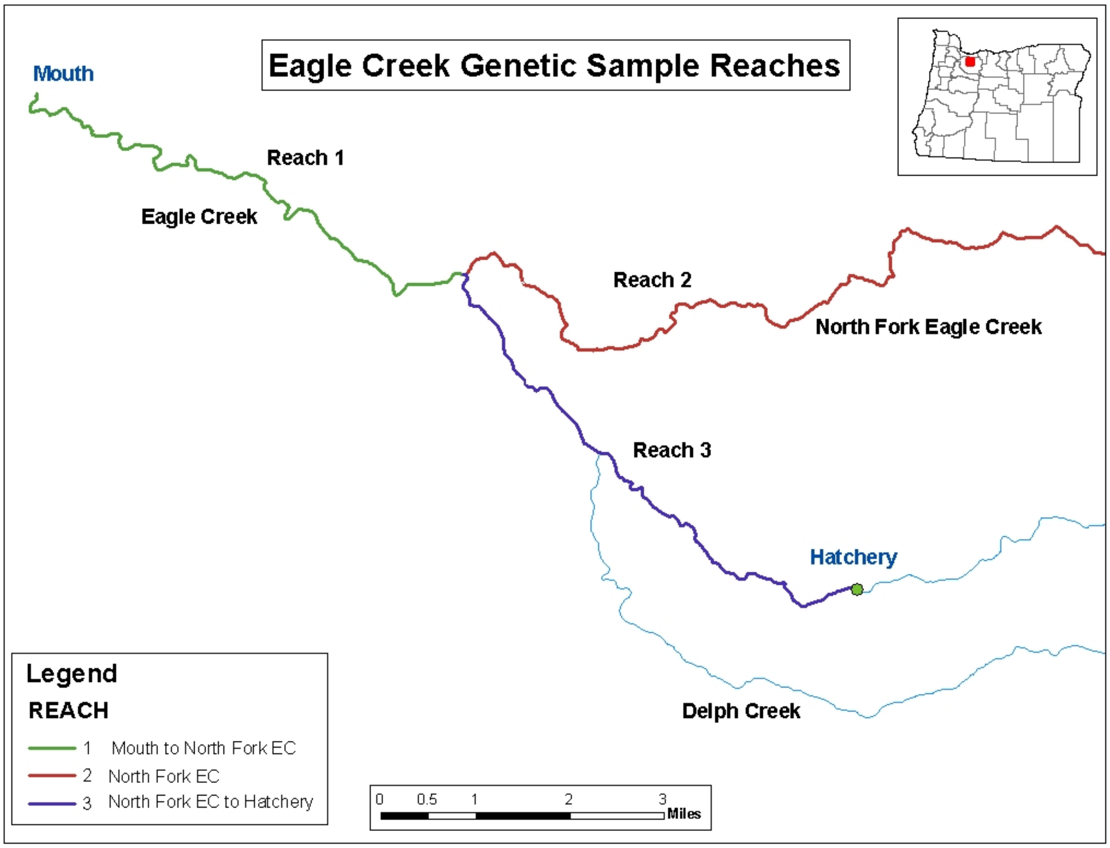


**Figure 3: Reach locations for genetic sample collections on Eagle Creek and North Fork Eagle Creek.**

Objective 5: Determine the effect of rearing density on growth and survival of winter steelhead, both on-hatchery and post-release.

## ***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:

July-

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* is the weight of fish and *L is* the length of the fish.

Density Index

$$D=W/(VL)$$

Where *W* is the weight of fish, *V* is the volume of the raceway and *L is* the length of the 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. Returning adult fish will be sampled for fork length, dorsal fin height, and to recover CWT.  A final report summarizing the results of the rearing density study will be completed in 2010 when all adult returns have been collected.

## Results

### ***Adult trapping***

182 hatchery and 31 wild adult winter steelhead were trapped at the lower ladder on Eagle Creek from January through June 2007. Two Clackamas hatchery summer steelhead and four Clackamas hatchery winter steelhead were also trapped in the ladder. Clackamas hatchery steelhead were identified by mark; summer steelhead are adipose and right maxillary clipped and winter steelhead are adipose and left ventral clipped. Eagle Creek hatchery steelhead began migrating upstream through the lower ladder in January, and the peak of the hatchery run occurred between February 1-15. Natural origin steelhead began migrating through the lower ladder in late February, and the peak of the wild run was between May 1-15 (Figure 4).

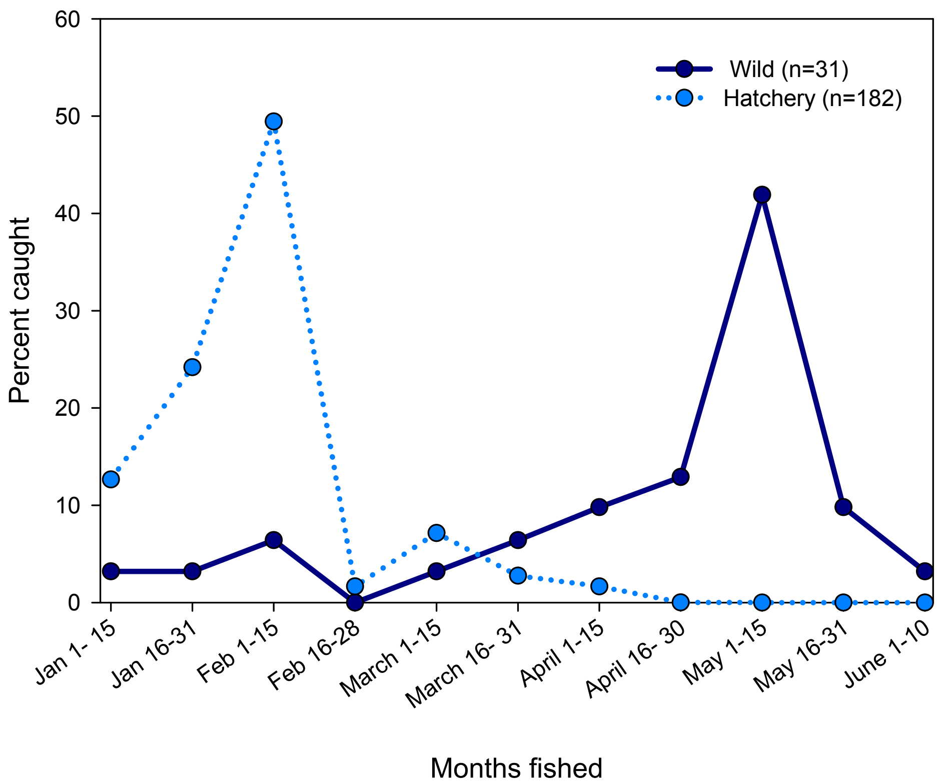


**Figure 4: Bi-weekly catch of adult winter steelhead at the lower ladder in 2007.**

Scale samples were collected from 29 natural origin steelhead trapped at the lower ladder. One scale sample collected from a wild female was unreadable and not used in data analysis. Of the 28 readable scales, 75% (21 of 28) were age 3, 25% (7 of 28) were age 4 fish (Figure 5). Mean fork length of age 3 and 4 natural origin steelhead was 62 and 75 cm (Table 2).

1436 adult winter steelhead returned to Eagle Creek NFH and 826 were bio-sampled during spawning operations at Eagle Creek NFH in 2007. For the hatchery population, 54% (777 of 1436) of returning adults were age 3 fish and 46% (659 of 1436) were age 4 fish (Figure 6). Mean fork length of age 3 and 4 hatchery steelhead was 65 and 76 cm (Table 3).

**Table 2: Mean fork lengths of natural origin steelhead trapped at the lower ladder on Eagle Creek.**

| Origin | Sex | Age 3 returns | Mean length | Std. dev | Age 4 returns | Mean length | Std. dev |
|---|---|---|---|---|---|---|---|
| Wild | | | | | | | |
| | Male | 9 | 65 | 6.97 | 2 | 79 | 11.3 |
| | Female | 12 | 65 | 3.2 | 5 | 75 | 2.96 |
| | ***Total*** | ***21*** | ***65*** | | ***7*** | ***75*** | |

**Table 3: Mean fork lengths of hatchery steelhead bio-sampled at Eagle Creek NFH.**

| Origin | Sex | Age 3 bio-sampled | Age 3 total returns | Mean length | Std. dev | Age 4 bio-sampled | Age 4 total returns | Mean length | Std. dev |
|---|---|---|---|---|---|---|---|---|---|
| Hatchery | | | | | | | | | |
| | Male | 271 | 551 | 65 | 3.61 | 94 | 191 | 77 | 4.82 |
| | Female | 150 | 226 | 64 | 3.13 | 311 | 468 | 75 | 3.69 |
| | ***Total*** | ***421*** | ***777*** | ***65*** | | ***405*** | ***659*** | ***76*** | |

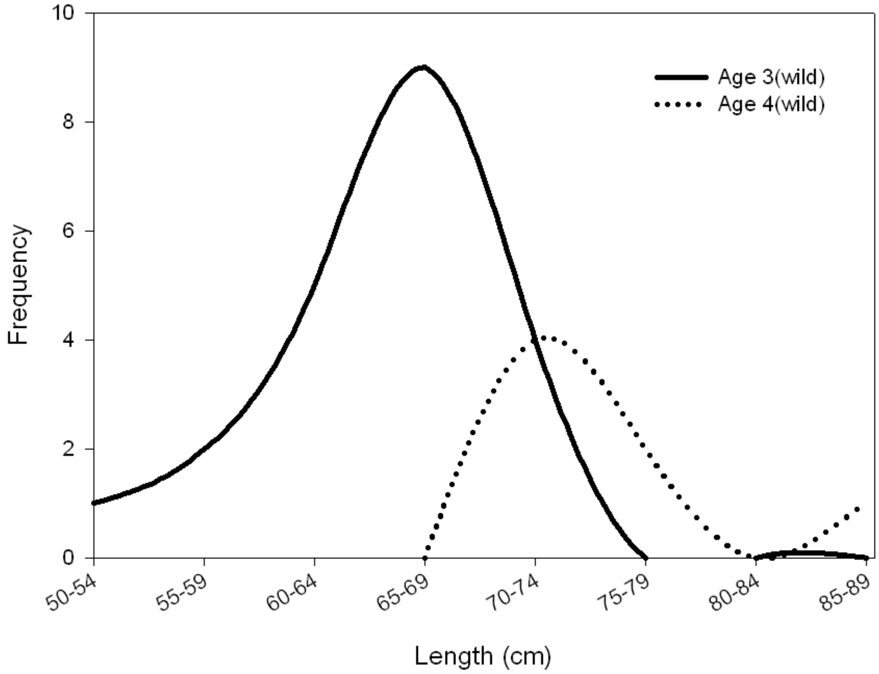


**Figure 5: Length-Frequency distribution of natural origin winter steelhead trapped at the lower ladder on Eagle Creek.**

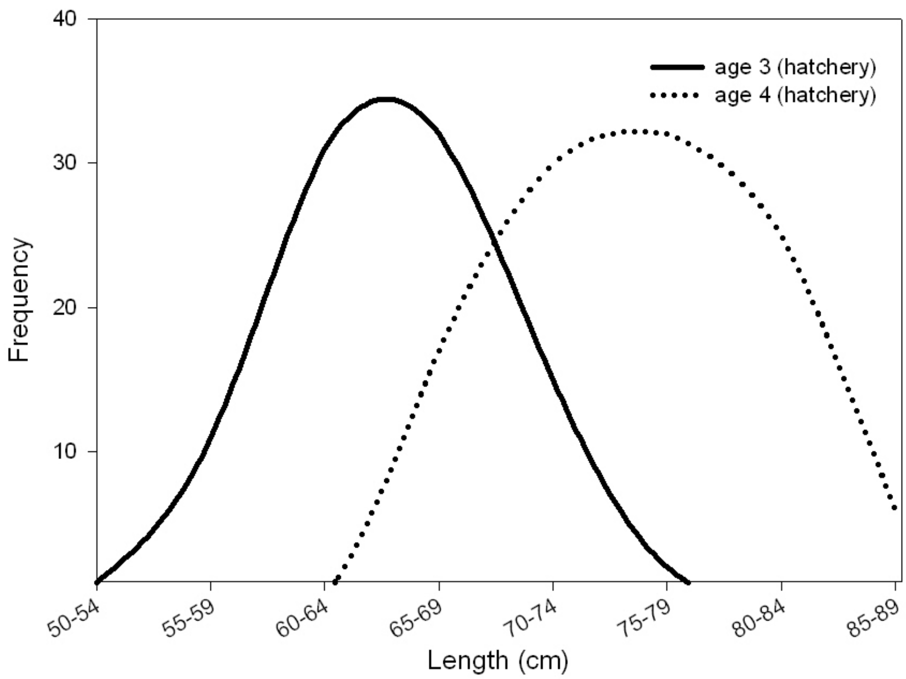


**Figure 6: Length-Frequency distribution of hatchery winter steelhead bio-sampled at Eagle Creek NFH.**

## ***Radio- telemetry***

During the trapping period, 35 adult steelhead (19 hatchery and 16 wild) were radio-tagged and released back into Eagle Creek (Table 4). For radio-tagged natural origin steelhead, 81% (13 of 16) were last detected at the mouth of Eagle Creek while the remaining three radio-tagged fish were last detected in the North Fork (1 of 16), at the lower ladder (1 of 16), and between the lower ladder and the confluence of the North Fork (1 of 16) (Table 5). In addition to the natural origin male steelhead last detected in the North Fork, three natural origin males were detected at the North Fork receiver on 4/14, 4/27, and 5/8/07, respectively. Two of these fish entered the North Fork several hours after they were radio-tagged and one entered three days post tagging. None were detected in the North Fork for longer than 24 hours, and all three were eventually last detected at the mouth receiver.

For hatchery steelhead, 32% (6 of 19) were last detected either at the mouth of Eagle Creek or in the Clackamas river several kilometers downstream from the confluence, 21% (4 of 19) entered the fish ladder at the hatchery and were recovered during spawning, 16% (3 of 19) were in upper Eagle Creek and 21% (4 of 19) were last detected at the lower ladder and we assume these fish regurgitated the tags after release, and one hatchery male was recovered in the North Fork screw trap by USFS personnel (Table 5).

**Table 4: The number of radio-tagged adult winter steelhead detected at the hatchery, North Fork, and mouth receivers from January through June 2007. Some fish were detected at multiple receivers and others only through mobile tracking.**

| | Number tagged at Lower Ladder | Passed Hatchery receiver* | Passed North Fork receiver | Passed Mouth receiver |
|---|---|---|---|---|
| Hatchery origin | 19 | 6 | 1 | 7 |
| Natural origin | 16 | 3 | 4 | 13 |

**Table 5: The number of radio-tagged adult winter steelhead last detected at the hatchery, North Fork, and mouth receivers from January through June 2007. 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 ** | Last Detection Clackamas River | Last detection below Lower Ladder |
|---|---|---|---|---|---|---|---|
| Hatchery | 4 | 1 | 3 | 3 | 3 | 4 | 1 |
| Natural | 0 | 1 | 13 | 1 | 1 | 0 | 0 |

* 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.

Figures 7-10 illustrate the distribution and movement of radio-tagged steelhead in Eagle Creek. Each line represents individual fish movement following tagging and release at the lower ladder. The last known location and fate of the radio-tagged steelhead is indicated with symbols on the graphs.

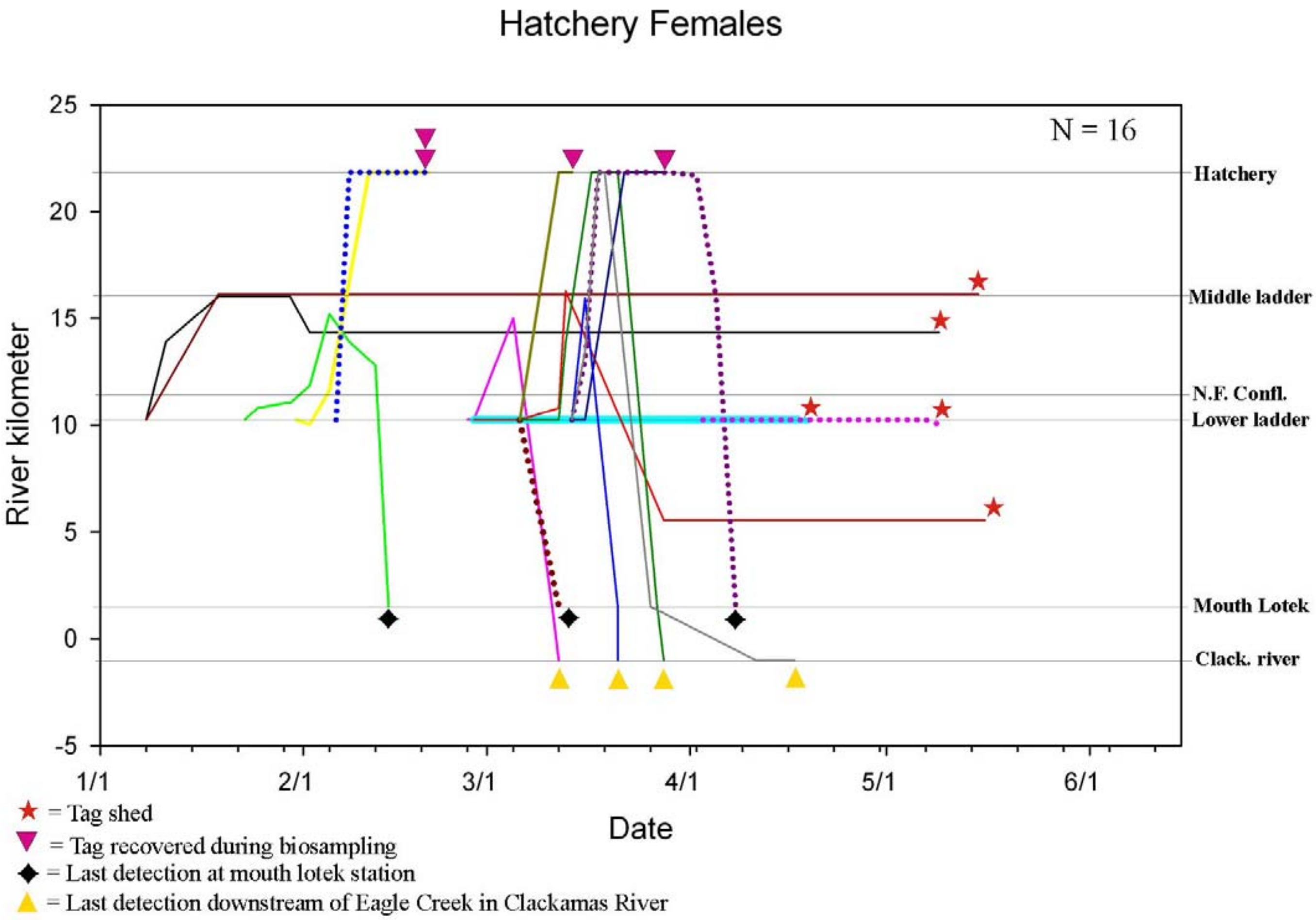


**Figure 7: Distribution and movement of radio-tagged hatchery female steelhead in Eagle Creek, Oregon.**

Hatchery Males

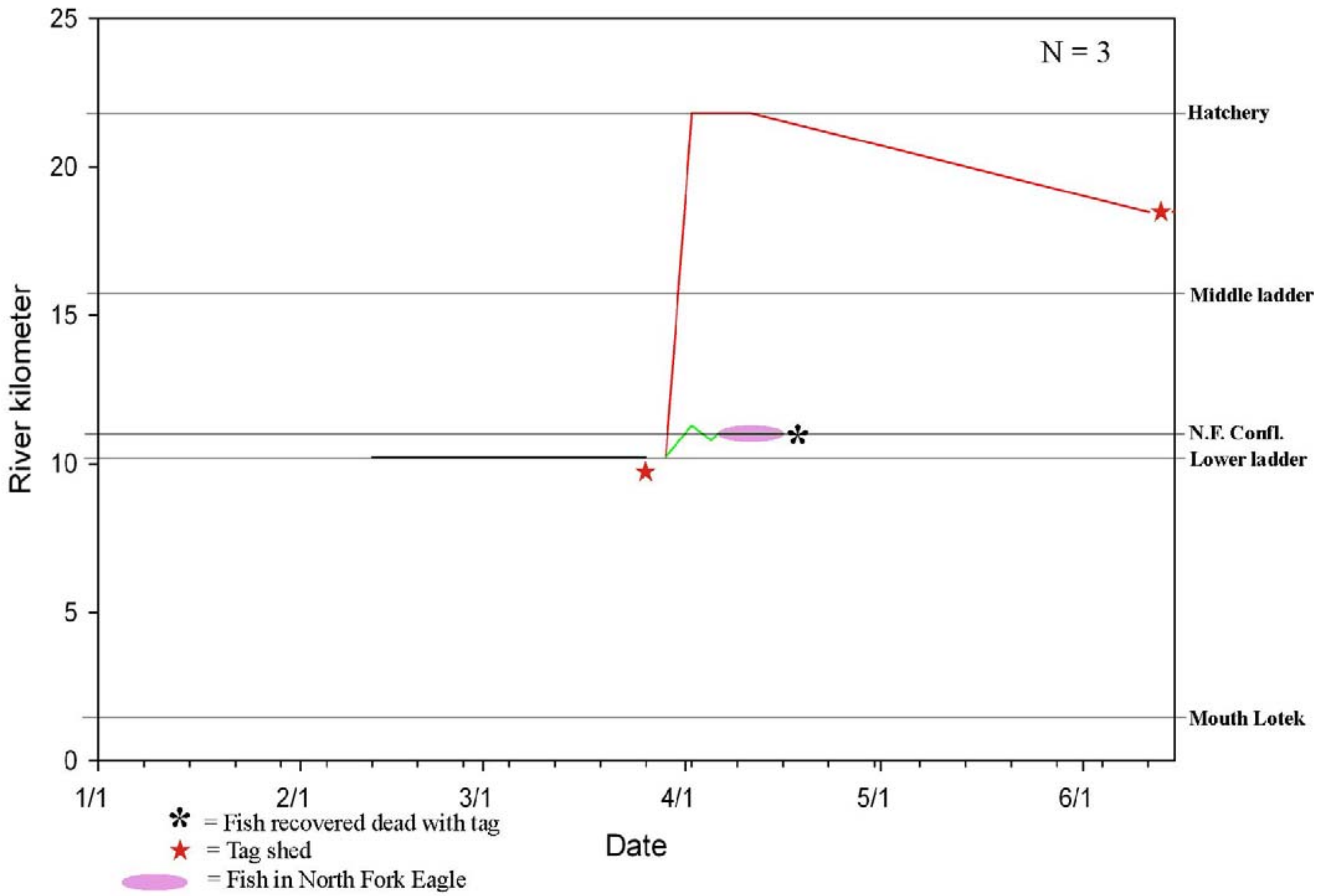


**Figure 8: Distribution and movement of radio-tagged hatchery male steelhead in Eagle Creek, Oregon.**

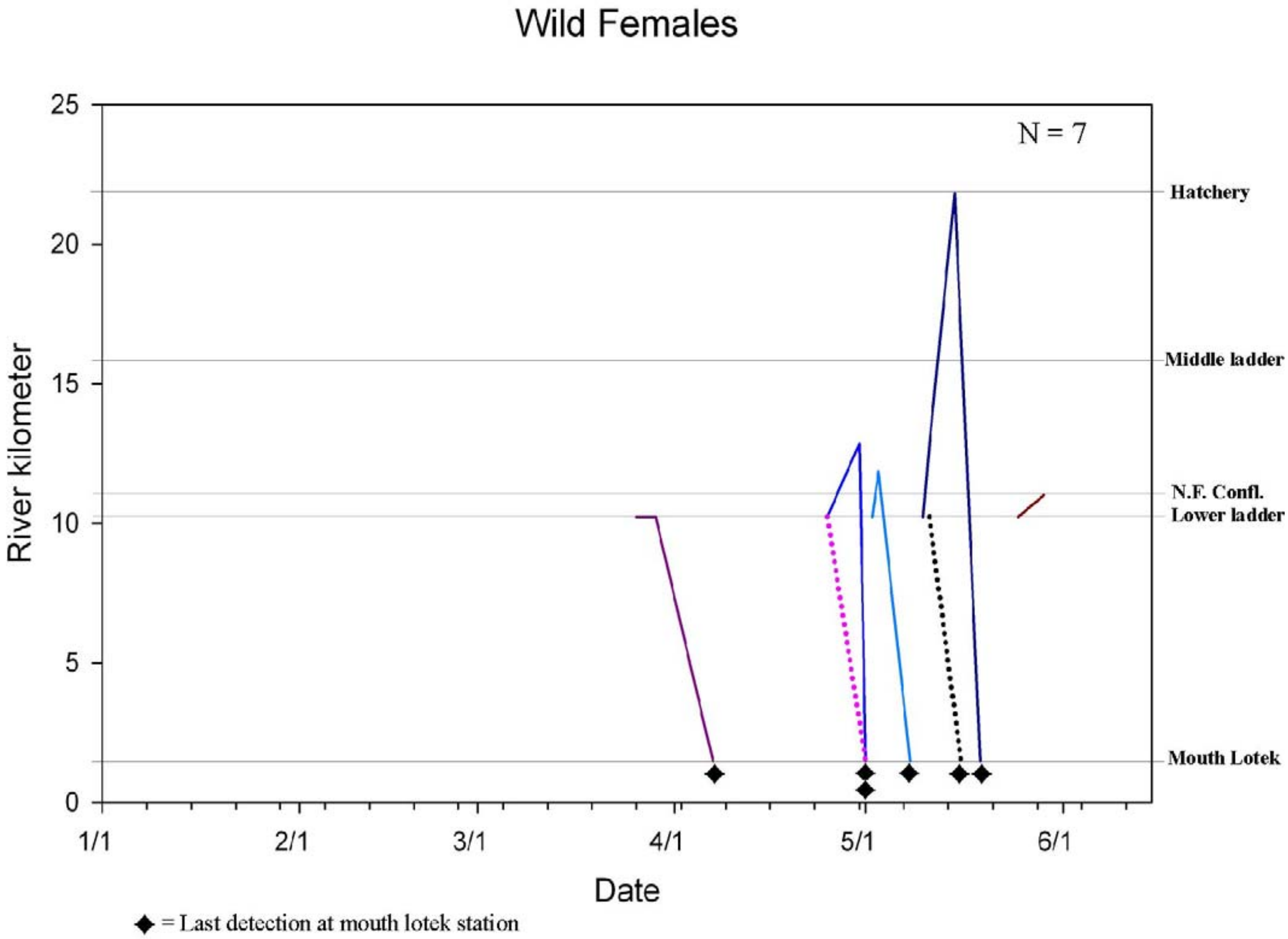


**Figure 9: Distribution and movement of radio-tagged wild female steelhead in Eagle Creek, Oregon.**

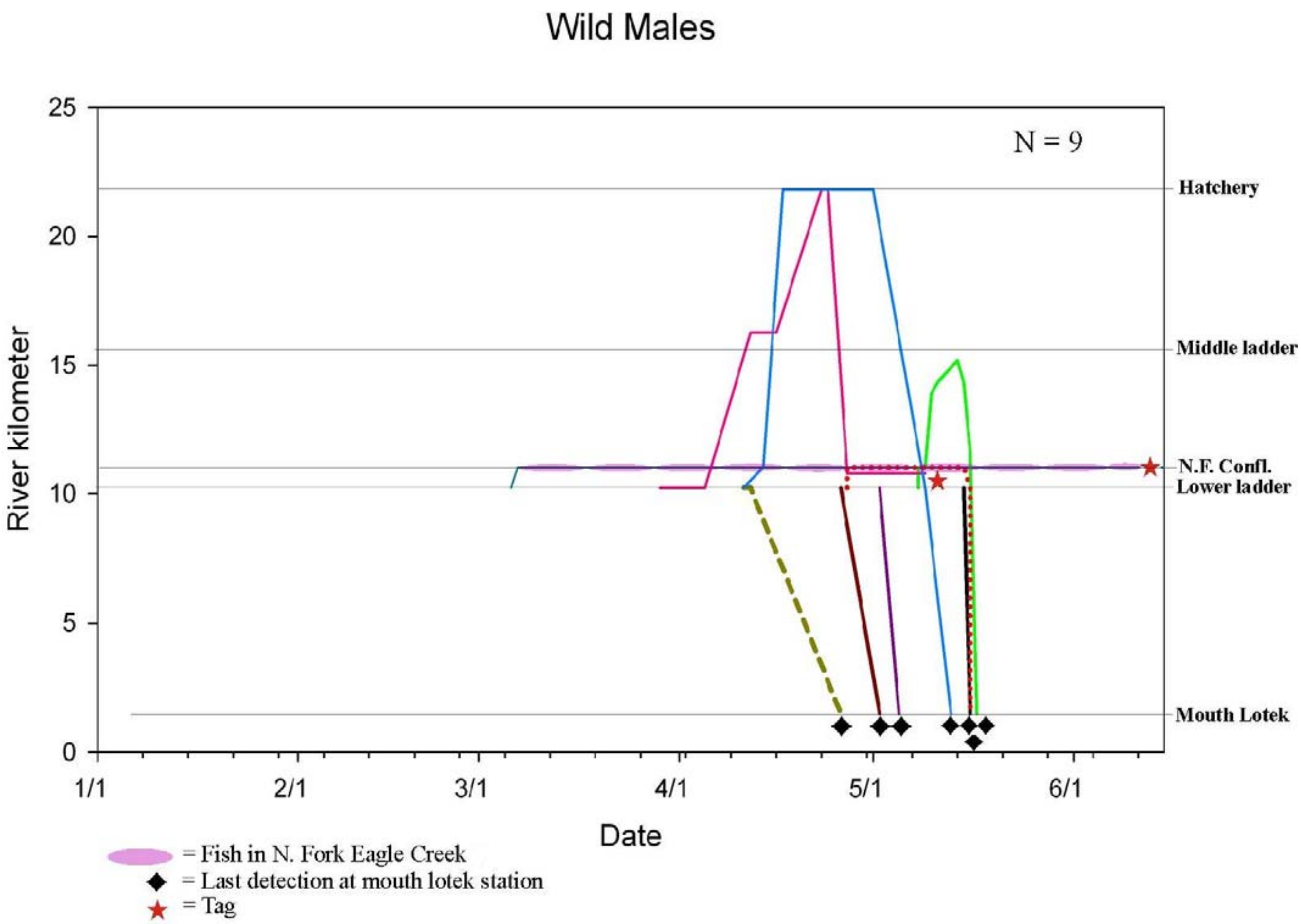


**Figure 10: Distribution and movement of radio-tagged wild male steelhead in Eagle Creek, Oregon.**

## ***Adult Population Estimates***

180 adult winter steelhead were Floy tagged during trapping operations at the lower ladder and 67 were recaptured at the hatchery during spawning operations. Tag loss was identified in four steelhead that had right opercule punches but no Floy tags. The Peterson population estimate for returning hatchery adults to the lower ladder of Eagle Creek in 2007 is 3,823 (Table 6).

Eagle Creek NFH operated the fish ladder at the hatchery from December through April and took in a total of 1,436 adult hatchery steelhead.

**Table 6: Peterson Population estimate of adult hatchery steelhead returning to Lower Eagle Creek.**

| Adult WST marked at LL | Returning adults to hatchery | Marked WST recaptured at hatchery | Reported angler catch of tagged fish | Population Estimate | 95% Upper CI | 95% Lower CI |
|---|---|---|---|---|---|---|
| 180 | 1,436 | 67 | 18 | 3,823 | 4,538 | 3,109 |

## ***Juvenile Radio-Telemetry***

In March 2007, 45 hatchery steelhead smolts were surgically implanted with coded radio transmitters prior to volitional release. Fork lengths of radio-tagged smolts were recorded prior to surgery (Table 7). Weights of individual fish were not recorded due to malfunctions with the scale therefore condition factors were not calculated for the smolts. Six tags were shed in the raceways prior to volitional release and were recovered at a later date. These fish were excluded from all data analyses.

**Table 7: Mean length and weight 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.**

| Density Group | *n* | Mean fork Length (cm) | *SD±* |
|---|---|---|---|
| Low | 15 | 194 | 13.7 |
| Medium | 11 | 184 | 11.5 |
| High | 13 | 187 | 8.4 |

A data logging receiver was set up on Eagle Creek just below the volitional release pond to detect smolts as they left the hatchery. The data logger was not logging from April $20^{th}$-$23^{rd}$ due to equipment malfunctions. Smolts that volitionally left the hatchery during this time were not recorded at the hatchery receiver. Twelve smolts recorded at the mouth receiver were never recorded at the hatchery receiver therefore we assume these fish left the hatchery while the receiver was not operational. These fish are included in the total count of smolts detected at the mouth receiver, but are excluded from migration timing analyses.

27 radio-tagged hatchery steelhead smolts were detected at the fixed telemetry station located near the mouth of Eagle Creek. 5 radio-tagged steelhead smolts were detected only at the fixed station receiver located at the hatchery. Three smolts were last detected in upper Eagle Creek above the lower ladder, and one was detected in lower Eagle Creek approximately 4 *Rkm* from the mouth. Three smolts were not detected at any of the stationary receivers or through mobile tracking efforts (Figure 11).

Average migration time from the hatchery to the mouth for 15 of the radio-tagged smolts was 67 hours or approximately 3 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 12).

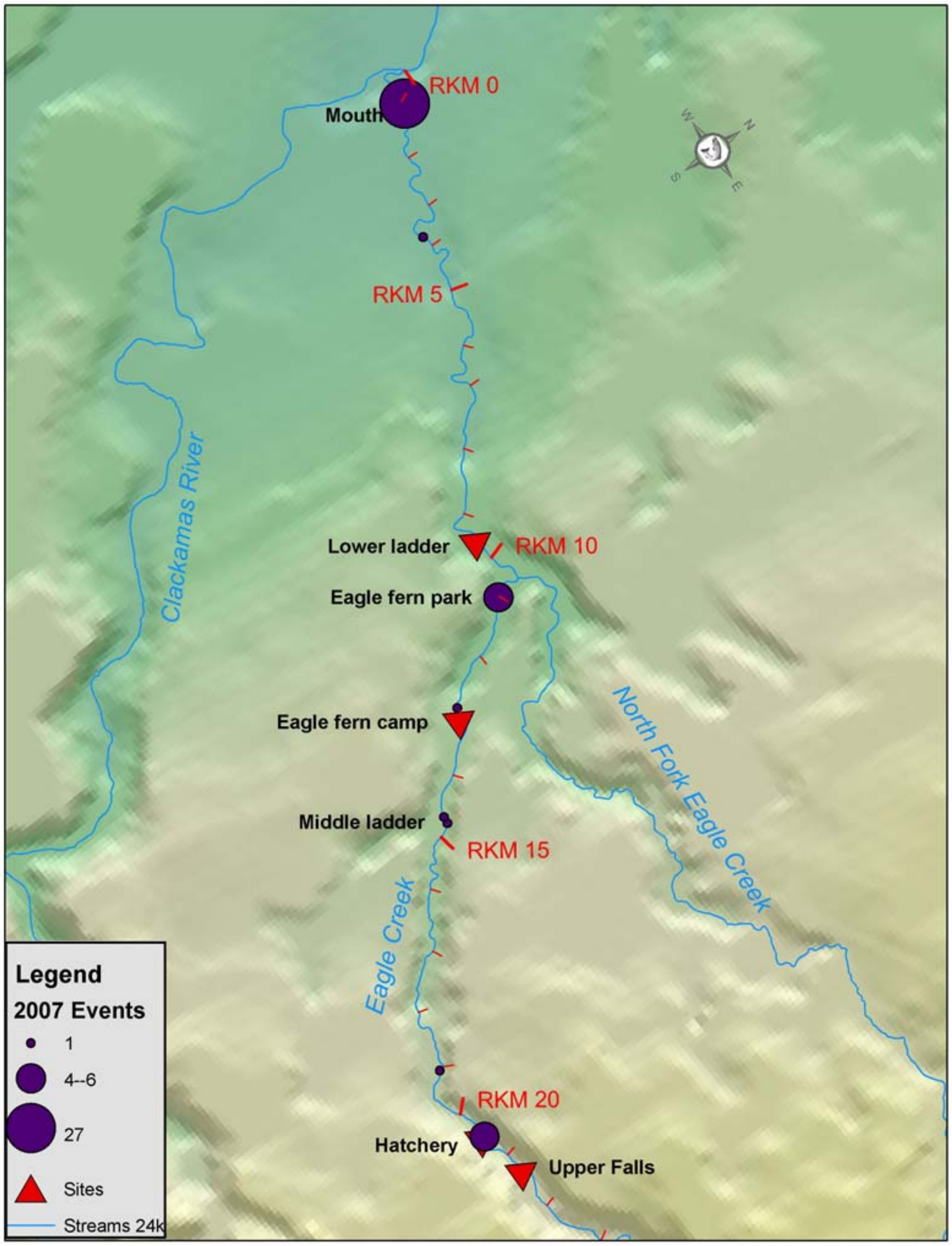


**Figure 11: Last mobile and fixed telemetry detections for hatchery steelhead smolts following volitional release from Eagle Creek NFH.**

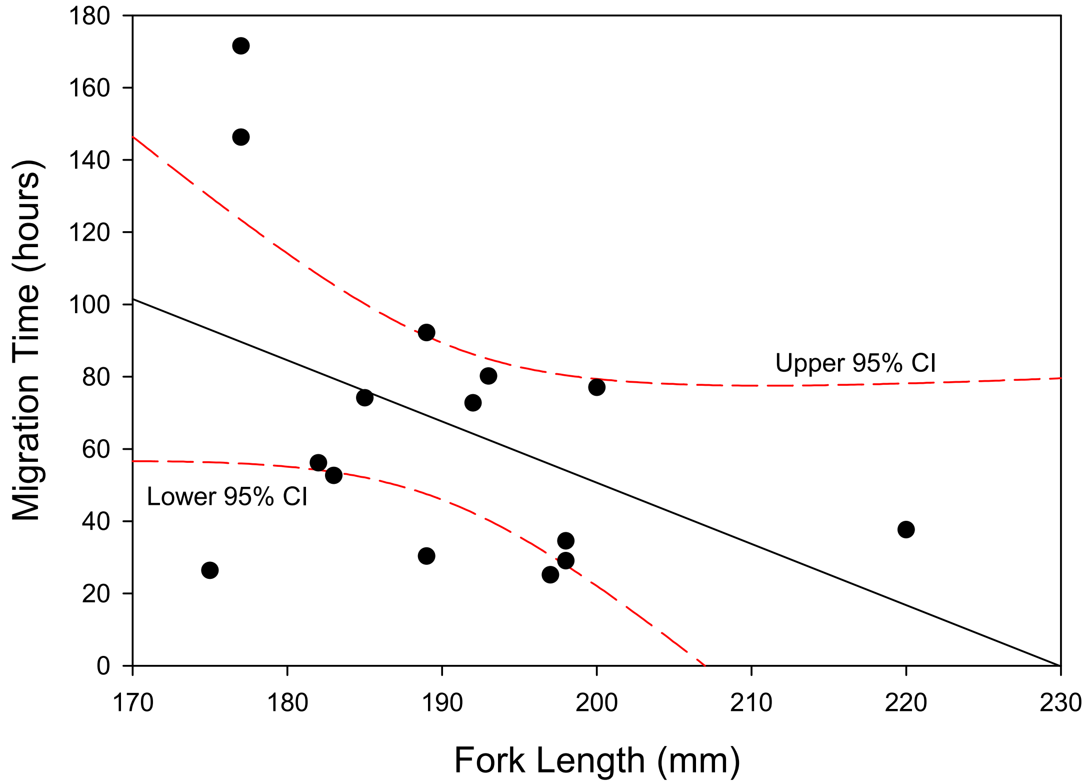


**Figure 12: Migration times for radiotagged hatchery steelhead smolts released from Eagle Creek NFH (Rkm 20.1) and detected at the fixed telemetry station at the mouth of Eagle Creek (Rkm 1.1). No significant correlation between smolt length at release and emigration time was detected** ***(F=0.05(1) 1,13=0.09,$r^2$=0.20).***

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## ***Genetics***

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 FY2007 report (Matala et al. 2008) are described in the following section. The FY2007 report was a collaborative effort between 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.

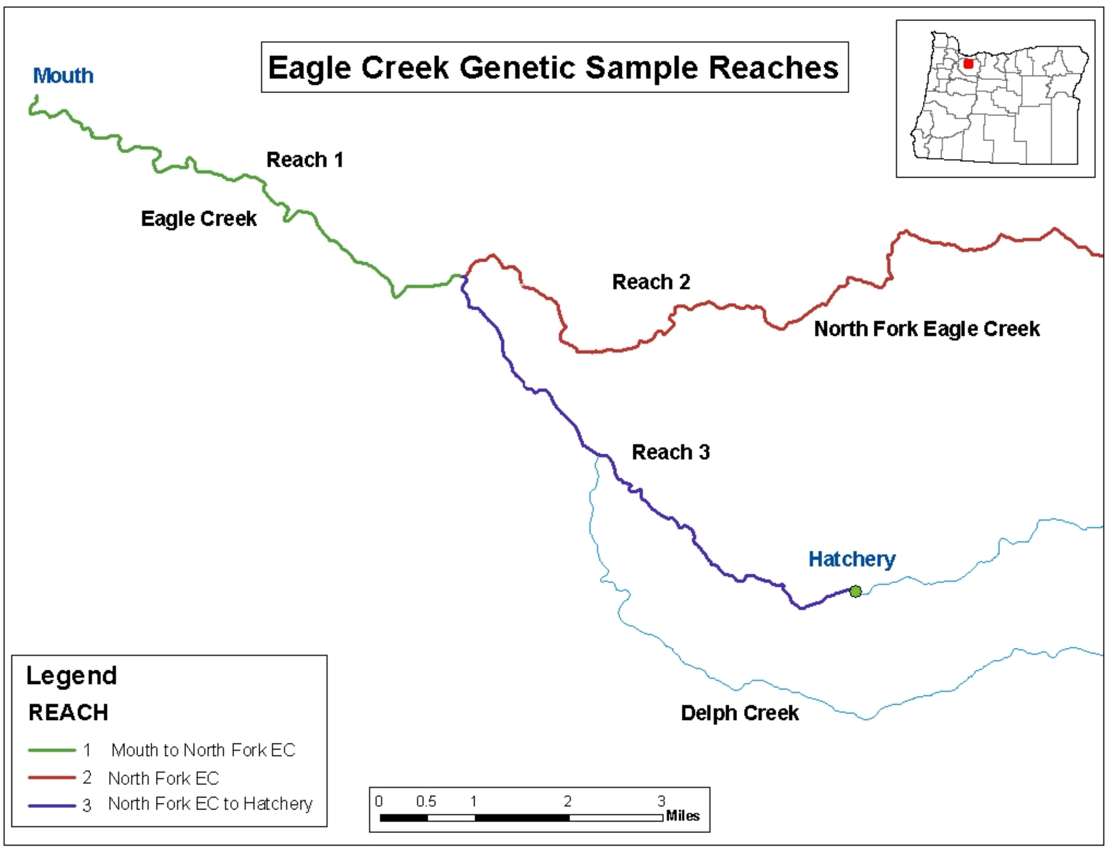


**Figure 13: Map of Genetic sample sites on Eagle Creek.**

For detailed information on genetic techniques and results see Matala et al 2008. We provide the following snapshot of information from that report.

Eagle Creek NFH 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 8). For all years evaluated, (2005-2007), significant heterogeneity among hatchery (HOR) and natural (NOR) groups is confirmed by the correlation of pairwise genetic distances shown in the topology of a neighbor-joining phylogram (Figure 14).

The results from population genetic assignment analyses (2005-2007) suggest high geneflow, (random mating), among most NOR collections in Lower Eagle Creek and North Fork Eagle Creek and restricted geneflow between HOR and NOR groups. This restricted genefow indicates samples from NOR smolts and juveniles are comprised of either NOR fish or naturally produced hatchery fish with very few introgressed individuals. For all collection years, the greatest genetic similarity between HOR and Upper Eagle Creek NOR collections occurred in 2007. These findings imply that naturally produced hatchery origin smolts collected in Upper Eagle Creek were the progeny of hatchery adults returning in 2005 and 2006.

**Table 8: The number of genetic samples collected for each sample reach in 2007. 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 Eagle Creek NFH were used as baseline groups.**

| Reach | Location | Life History Stage | Target # | Actual # sampled |
|---|---|---|---|---|
| 1 | Mouth to North Fork (Lower EC) | Juvenile (NOR) | 50 | 18 (smolts)<br>6 (juvenile) |
| 2 | North Fork | Smolt (NOR) | 50 | 49 |
| 3 | North Fork to Hatchery (Upper EC, Reach 3) | Smolt (NOR) | 50 | 62 (smolts)<br>24 (juvenile) |
| | Lower Ladder | Adult (NOR) | 50 | 38 |
| | Eagle Creek NFH | Juvenile (HOR) | 50 | 51 |

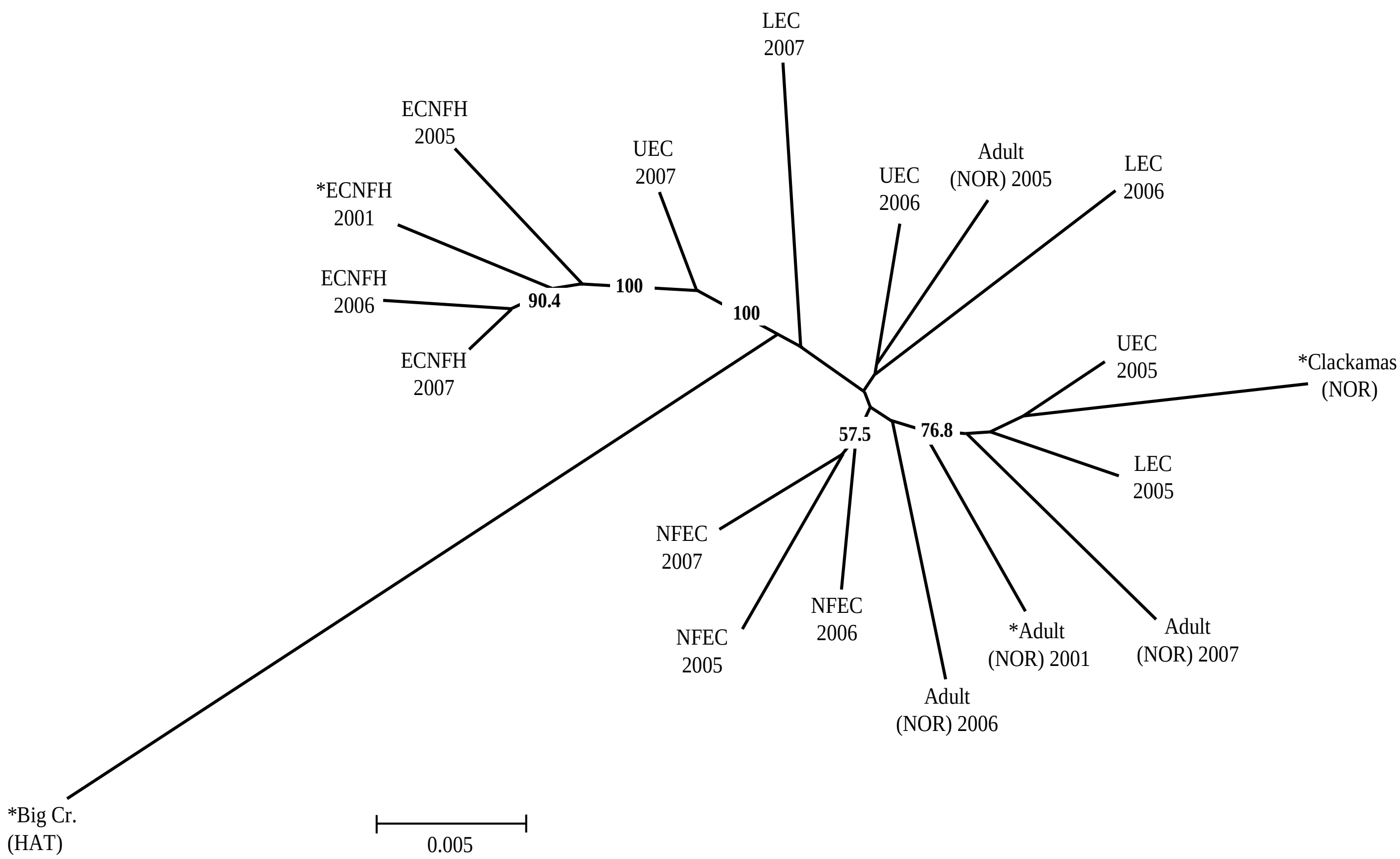


**Figure 14: Un-rooted neighbor-joining tree: The phylogram topology was constructed from pairwise genetic (chord) distances (Cavalli-Sforza & Edwards 1967), and includes the 2005-2007 Eagle Creek steelhead collections evaluated in this study, and 2001 SPAN standardized data (*) contributed by Maureen Waite and Paul Moran from NOAA fisheries. Bootstrap support among 1000 replicate data sets is shown between branch nodes, indicating concordance level among loci for each branch in the topology (Matala 2008).**

## ***Rearing Density***

In July 2006, juvenile steelhead were transferred from rearing units in the hatchery to outside raceways. Fish were sampled in October 2006 and in March 2007 prior to volitional release. Mean Fork length, condition factor, biomass and density were calculated for each raceway (Tables 9 and 10).

**Table 9: Mean fork length, condition factor, biomass, and density for broodyear 2006 hatchery juvenile steelhead in the rearing density study. Fish were sampled in October 2006.**

| Sample Date | Pond Concentration | Coded Wire Tag | # Sampled | Mean fork length (mm) | *S.D.* | Condition factor | Fish bio-mass (kg) | Density (kg/m$^3$) |
|---|---|---|---|---|---|---|---|---|
| Oct. 2006 | Low *(7,556)* | 054550 | 100 | 157 | 14.8 | 1.17 | 345.4 | 9.34 |
| | Low *(7,537)* | 054549 | 100 | 156 | 14.9 | 1.18 | 337.2 | 9.11 |
| | Low *(7,639)* | 054548 | 100 | 148 | 15.9 | 1.19 | 302.7 | 8.18 |
| | Medium *(15,071)* | 053066 | 100 | 146 | 16.5 | 1.16 | 552 | 14.92 |
| | Medium *(15,223)* | 053065 | 100 | 148 | 14.8 | 1.15 | 565.1 | 15.77 |
| | Medium *(15,020)* | 053064 | 100 | 152 | 9.5 | 1.14 | 565 | 15.77 |
| | High *(22,591)* | 053069 | 100 | 151 | 13.6 | 1.15 | 920.5 | 24.88 |
| | High *(22,588)* | 053068 | 100 | 148 | 13.3 | 1.18 | 880.5 | 23.8 |
| | High *(22,530)* | 053067 | 100 | 139 | 11.3 | 1.17 | 721.2 | 19.49 |

**Table 10: Mean fork length, condition factor, biomass, and density for broodyear 2006 hatchery juvenile steelhead in the rearing density study. Fish were sampled in March 2007 prior to volitional release. The number of fish released from each raceway is in parentheses.**

| Sample Date | Pond Concentration | Coded Wire Tag | # Sampled | Mean fork length (mm) | *S.D.* | Condition factor | Fish bio-mass (kg) | Density (kg/m$^3$) |
|---|---|---|---|---|---|---|---|---|
| March 2007 | Low *(7,379)* | 054550 | 300 | 192 | 13.0 | 1.06 | 571.3 | 15.4 |
| | Low *(7,303)* | 054549 | 300 | 193 | 17.7 | 1.04 | 563.1 | 15.2 |
| | Low *(7,414)* | 054548 | 300 | 177 | 21.3 | 1.15 | 489.5 | 13.2 |
| | Medium *(14,645)* | 053066 | 300 | 180 | 13.2 | 1.08 | 921.4 | 24.9 |
| | Medium *(14,937)* | 053065 | 300 | 176 | 18.5 | 1.04 | 850.2 | 23.0 |
| | Medium *(14,846)* | 053064 | 300 | 172 | 14.0 | 1.06 | 797.1 | 21.5 |
| | High *(22,255)* | 053069 | 300 | 175 | 16.1 | 1.07 | 1289.7 | 34.9 |
| | High *(22,209)* | 053068 | 300 | 176 | 18.5 | 1.22 | 1456.1 | 39.4 |
| | High *(22,114)* | 053067 | 300 | 174 | 15.2 | 1.00 | 1191.7 | 32.2 |

Steelhead from the low, medium, and high density raceway groups were pooled together and a one way ANOVA was used to compare fork lengths between density groups. No significant difference in fork length between density groups was detected in October 2006 or at release in 2007 (Figures 15 and 16).

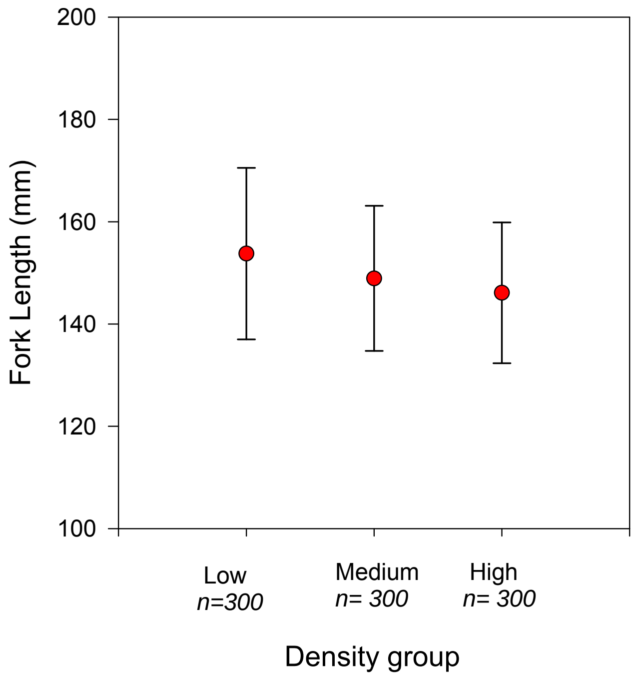


**Figure 15: Mean fork lengths of juvenile hatchery steelhead reared in low, medium, and high density raceways. Smolts were sampled in October 2006. No significant difference in fork lengths between density groups was detected.**

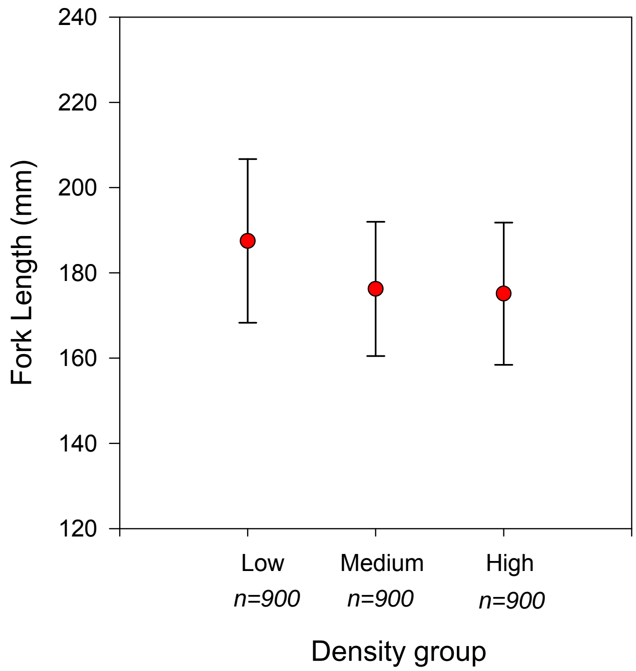


**Figure 16: Mean fork lengths of juvenile hatchery steelhead reared in low, medium, and high density raceways and released in March 2007 from Eagle Creek NFH. No significant difference in fork lengths between density groups was detected.**

**Acknowledgements**

We would like to thank the field and office staff at Eagle Creek National Fish Hatchery, especially Doug Dysart, Steve Turner, Larry Telles, Mark Galloway, and Scott Profitt, for their help with hatchery and 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 Lower Columbia River Fish Health Center, Brad Wymore and field staff with the U.S. Forest Service, for their work with assisting in the collection and evaluation of genetic samples in Eagle Creek. We would also like to thank Steve Pastor at the USFWS Columbia River Fisheries Program Office who provided database management support for hatchery records, and the CRFPO marking crew for supervision of marking and tagging of hatchery steelhead and assistance with adult bio-sampling and aging scales. We also wish to acknowledge NOAA fisheries and their support through Mitchell Act funding.

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# Appendix A

## ***Coded Wire Tag Recoveries from Winter Steelhead:***

| **CWT: 0501040408** | Broodyear: 2004 | | Tagged: 7,443 | Shed tags: 0 | | |
|---|---|---|---|---|---|---|
| | *Age* | *Sex* | *Length* | *SD* | *# Returns* | *% Returns* |
| | 3 | Male | 66 | 3.019 | 34 | 0.4568 |
| | 3 | Female | 66 | 2.743 | 20 | 0.2657 |
| | ***Total*** | | | | ***54*** | ***0.7255*** |

| **CWT:0501040409** | Broodyear: 2004 | | Tagged: 7,462 | Shed tags: 0 | | |
|---|---|---|---|---|---|---|
| | *Age* | *Sex* | *Length* | *SD* | *# Returns* | *% Returns* |
| | 3 | Male | 66 | 3.329 | 33 | 0.4422 |
| | 3 | Female | 64 | 3.426 | 25 | 0.3350 |
| | ***Total*** | | | | ***58*** | ***0.7773*** |

| **CWT:0501040501** | Broodyear: 2004 | | Tagged: 7,404 | Shed tags: 45 | | |
|---|---|---|---|---|---|---|
| | *Age* | *Sex* | *Length* | *SD* | *# Returns* | *% Returns* |
| | 3 | Male | 68 | 3.110 | 24 | 0.3241 |
| | 3 | Female | 64 | 1.577 | 18 | 0.2431 |
| | ***Total*** | | | | **42** | **0.5673** |

| **CWT: 0501040502** | Broodyear: 2004 | | Tagged: 14,926 | Shed Tags:30 | | |
|---|---|---|---|---|---|---|
| | *Age* | *Sex* | *Length* | *SD* | *# Returns* | *% Returns* |
| | 3 | Male | 65 | 3.226 | 53 | 0.3551 |
| | 3 | Female | 64 | 3.998 | 23 | 0.1541 |
| | ***Total*** | | | | ***76*** | ***0.5092*** |

| **CWT: 0501040503** | Broodyear: 2004 | | Tagged: 14,889 | Shed Tags: 30 | | |
|---|---|---|---|---|---|---|
| | *Age* | *Sex* | *Length* | *SD* | *# Returns* | *% Returns* |
| | 3 | Male | 65 | 3.015 | 59 | 0.3963 |
| | 3 | Female | 65 | 4.055 | 34 | 0.2284 |
| | ***Total*** | | | | ***93*** | ***0.6246*** |

| **CWT: 0501040504** | Broodyear: 2004 | | Tagged: 14,253 | Shed Tags: 750 | | |
|---|---|---|---|---|---|---|
| | *Age* | *Sex* | *Length* | *SD* | *# Returns* | *% Returns* |
| | 3 | Male | 65 | 3.256 | 50 | 0.3508 |
| | 3 | Female | 64 | 2.575 | 24 | 0.1684 |
| | ***Total*** | | | | ***74*** | ***0.5192*** |

| CWT: 0501040505 | Broodyear: 2004 | | Tagged: 22,323 | Shed tags: 87 | | |
|---|---|---|---|---|---|---|
| | *Age* | *Sex* | *Length* | *SD* | *# Returns* | *% Returns* |
| | 3 | Male | 64 | 3.085 | 52 | 0.2329 |
| | 3 | Female | 63 | 2.538 | 22 | 0.0986 |
| | ***Total*** | | | | ***74*** | ***0.3315*** |

| CWT:0501040506 | Broodyear: 2004 | | Tagged: 22,232 | Shed tags: 0 | | |
|---|---|---|---|---|---|---|
| | *Age* | *Sex* | *Length* | *SD* | *# Returns* | *% Returns* |
| | 3 | Male | 65 | 3.037 | 38 | 0.1709 |
| | 3 | Female | 63 | 2.895 | 18 | 0.0810 |
| | ***Total*** | | | | ***56*** | ***0.2519*** |

| CWT:0501040507 | Broodyear: 2004 | | Tagged: 22,362 | Shed tags:135 | | |
|---|---|---|---|---|---|---|
| | *Age* | *Sex* | *Length* | *SD* | *# Returns* | *% Returns* |
| | 3 | Male | 64 | 3.074 | 52 | 0.2325 |
| | 3 | Female | 64 | 2.961 | 27 | 0.1207 |
| | ***Total*** | | | | **79** | **0.3533** |

| CWT: 052496 | Broodyear: 2005 | | Tagged: 3,643 | Shed Tags: 96 | | |
|---|---|---|---|---|---|---|
| | *Age* | *Sex* | *Length* | *SD* | *# Returns* | *% Returns* |
| | 2 | Male | 46 | 0 | 1 | 0.0274 |
| | ***Total*** | | | | **1** | **0.0274** |

| CWT: 052497 | Broodyear: 2005 | | Tagged: 3,721 | Shed Tags: 115 | | |
|---|---|---|---|---|---|---|
| | *Age* | *Sex* | *Length* | *SD* | *# Returns* | *% Returns* |
| | 2 | Male | 46 | 0 | 1 | 0.0269 |
| | ***Total*** | | | | **1** | **0.0269** |

| CWT: 052674 | Broodyear: 2005 | | Tagged: 7,328 | Shed Tags: 149 | | |
|---|---|---|---|---|---|---|
| | *Age* | *Sex* | *Length* | *SD* | *# Returns* | *% Returns* |
| | 2 | Male | 46 | 4.243 | 2 | 0.0273 |
| | ***Total*** | | | | **2** | **0.0273** |

## *2007 National Wild Fish Health Survey Summary (Eagle Creek)*

| Case Number | Date | Species | Location | # of fish sampled | Findings |
|---|---|---|---|---|---|
| W07-043 | 5/02/07 | Steelhead | Middle Ladder | 3 | The fish appeared to be in good health. |
| W07-044 | 5/02/07 | Coho salmon | Middle Ladder | 10 | The fish appeared to be in good health. |
| W07-045 | 5/02/07 | Sculpin | Middle Ladder | 6 | The fish appeared to be in good health. |
| W07-048 | 5/10/07 | Coho salmon | Eagle Fern Park | 10 | The fish appeared to be in good health . |
| W07-049 | 5/10/07 | Steelhead | Eagle Camp | 2 | *Renibacterium salmoninarum*, Bacterial Kidney Disease (BKD), detected by ELISA and confirmed by PCR. |
| W07-050 | 5/17/07 | Steelhead | Above Middle ladder | 11 | The fish appeared to be in good health. |
| W07-053 | 5/31/07 | Steelhead | Below hatchery | 4 | The fish appeared to be in good health. |
| W07-054 | 5/31/07 | Coho salmon | Below hatchery | 1 | The fish appeared to be in good health. |

**Data collected and analyzed by USFWS Lower Columbia River Fish Health Center, 201 Oklahoma Rd. Willard, WA 98605.**

## *2007 Report of Hatchery Fish Health (Eagle Creek)*

| Date | Species | Location | Findings |
|---|---|---|---|
| 1/10/07 | Adult Steelhead | Eagle Creek NFH | Adult winter steelhead were spawned from 1/10 to 2/21/07. Test for viruses on ovarian fluid and male viscera (kidney,spleen, and gills) were negative by cell culture. Tests for bacteria were negative. R.salmoninarum was detected by ELISA at a low level in 4/150 females and 2/60 males; the remaining fish were in the "not detected" or very low level ELISA categories. Ceratomyxa Shasta was observed in 6/20 hindguts at low to moderate levels. |
| 1/24/07 | Juvenile hatchery smolts | Eagle Creek NFH | Kidney, spleen, and gill tissue samples were collected from smolts in low and high density raceways. Tissue samples were negative for virus by cell culture and no obvious differences detected from smolts in low and high density raceways. |
| 2/21/07 | Juvenile hatchery smolts | Eagle Creek NFH | Kidney, spleen, and gill tissue samples processed in 3-fish pools were negative for virus by cell culture. There was no bacterial growth on TSA, no R.salmoninar detected on kidney smears by DFAT, and heads were negative for Myxobolus cerebralis. One henneguya spore was observed in one 20-fish head pool. |
| 3/7/07 | Juvenile hatchery smolts | Eagle Creek NFH | Steelhead look good with a few poor and eroded dorsal fins. Usual parasite load. |

**Data collected and analyzed by USFWS Lower Columbia River Fish Health Center, 201 Oklahoma Rd. Willard, WA 98605.**