# Recovery Monitoring of Endangered Coho Salmon in the Russian River

Final Report for US Army Corps of Engineers Contract W912P7-10-C-0011

*Prepared by:*

Mariska Obedzinski, Nick Bauer, Sarah Nossaman, and Paul Olin
University of California Cooperative Extension and California Sea Grant

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University of California Cooperative Extension Sonoma County
133 Aviation Blvd., Rm. 100 Santa Rosa, CA 95403-2810

**UCCE/CSG 2010-2011 Monitoring Team:**
Nick Bauer
Henning Fett
Jennifer Hoey
Francis Hourigan
Patrick Hilton
Sarah Nossaman
Mariska Obedzinski
Paul Olin
Taylor Spaulding
Andrew Wilbur

**Cover photograph**: Adult male coho salmon captured in the Mill Creek trap during the winter of 2010-2011.

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# EXECUTIVE SUMMARY

The Russian River Coho Salmon Captive Broodstock Program (RRCSCBP), initiated by the California Department of Fish and Game, National Marine Fisheries Service, and U.S. Army Corps of Engineers in the late 1990's, is working to recover endangered coho salmon populations by stocking offspring of wild, captive-reared coho raised at Don Clausen Warm Springs Hatchery into historic coho tributaries within the Russian River watershed. Each year, fish are released at different lifestages (spring and fall young-of-year, and age-one smolts), and of different genetic cross types (pure Russian River strain and Russian River/Olema Creek hybrids).

Since 2004, University of California Cooperative Extension and California Sea Grant personnel have worked with agency partners to implement a monitoring program to evaluate the effectiveness of the RRCSCBP by documenting whether released coho are surviving in the streams in which they are stocked and returning as adults to spawn. The work conducted under this contract was a continuation of this monitoring program from April 2010 through June 2011. Overwinter survival monitoring, summer survival monitoring, and escapement monitoring were the three main activities conducted during the timeframe of this contract.

To estimate smolt abundance and overwinter survival of released coho, downstream migrant traps were operated in combination with PIT (passive integrative transponder) antennas on Mill and Green Valley Creeks between March and June of 2010 and 2011, and PIT antennas were operated on Grape Creek in 2011. Average smolt size and winter growth were estimated by taking length and weight measurements on a portion of the coho captured in the traps.

In 2010 and 2011, over 18,000 smolts were estimated leaving Mill and Green Valley Creeks combined, an indication that hatchery-released juveniles are able to survive and develop in program streams. Stocking to smolt survival estimates for the spring release group (June-June) averaged 0.16 and ranged from 0.05 (Grape 2010-11) to 0.39 (Green Valley 2010-11). Overwinter survival estimates for the fall release group averaged 0.27 and ranged from 0.12 (Mill 2010-11) to 0.46 (Green Valley 2010-11). Stocking to smolt survival estimates for the smolt release group (April-June) averaged 0.66 and ranged from 0.60 (Mill 2010-11) to 0.75 (Green Valley 2010-11). Because of the variability in survival and migration timing among streams and years for each release group, we recommend that the RRCSCBP continue to release fish at each life stage as a bet-hedging strategy. Winter survival was either similar among genetic cross types or lower for pure Russian River crosses, suggesting that there was no negative effect of hybridizing Russian River strain coho with Olema Creek coho on instream overwinter survival of offspring. Fish of all release groups increased in length and weight each winter. In the Mill Creek watershed, spring-released coho were smallest in length and weight and the smolt-released coho were largest. In Green Valley Creek, the fall and smolt release groups were similar in size. Size and growth were higher in Green Valley Creek than in the Mill Creek watershed, and no differences were observed in growth among cross types.

During the summer of 2010, PIT tag wanding and electrofishing surveys were conducted to estimate oversummer survival and growth of juvenile coho stocked into selected reaches of Grape, Mill, Palmer, and Green Valley Creeks. High variation in oversummer survival was

observed among reaches, ranging from 0.19 on lower Grape Creek to 0.87 in upper Green Valley Creek. These results can be used to guide selection of suitable spring release reaches where observed survival was high, and to encourage flow and habitat enhancement work where observed survival was low. Survival was either similar among cross types or lower for pure Russian River crosses, suggesting, if anything, a positive effect of crossing Russian River and Olema Creek broodstock on instream summer survival of offspring. In all reaches, spring-released fish increased in length and weight between June and October. Growth rates were similar among reaches and cross types.

Escapement monitoring methods during the winter of 2010-2011 included spawner surveys, adult trapping and operation of PIT antennas on Mill Creek, video monitoring by the Sonoma County Water Agency on the mainstem Russian River, and juvenile presence/absence snorkeling surveys the following summer. A minimum of 95 adult coho were documented returning to the Russian River watershed with an increased minimum estimate of 192 based on PIT tag data collected on Mill Creek. This was a significant increase in the minimum number of returns compared to recent years, which averaged less than six fish per year between 2000 and 2009. Presence of wild juvenile coho was documented in 19 of 23 tributaries surveyed during the summer of 2011, and adult coho were thought to have spawned in 14 of those streams the previous winter. Four of the streams with wild coho had not previously been stocked with program fish.

The increasing number of adult coho returning to the Russian River is likely a result of the increased number of juveniles released each year as well as increased marine survival. The upward trend is evidence that the RRCSCBP is helping to prevent extirpation of coho from the Russian River, however, the program is far from reaching long term recovery targets of thousands of adult coho returns each year. In future years it will be important to document the number of wild adult returns to evaluate whether coho are completing their life cycle in the natural environment.

Specific tasks as identified in the contract and completed as part of this contract include the following:

Task 2.1: Kickoff Meeting
Task 2.2: Project Coordination
Task 2.3: Project Research Plan
Task 2.4: Permitting, Stream Access, and Notification
Task 2.5: Summer Survival Monitoring
Task 2.6: Summer Survival Monitoring Report
Task 2.7: Winter Survival Monitoring
Task 2.8: Winter Survival Monitoring Report
Task 2.9: Escapement Monitoring
Task 2.10: Escapement Monitoring Report
Task 2.11: Final Report
Task 2.12: Monthly Safety Exposure Report

We are pleased to report that throughout this program there were no instances in which personnel were injured or exposed to any hazardous materials. The ARRA support for this effort resulted in 5.5 FTE positions that are continuing beyond this initial ARRA funding period.

## INTRODUCTION

### Russian River Coho Salmon Captive Broodstock Program

To aid in the effort to recover coho salmon in the state and federally endangered Central California Coast Coho Salmon ESU, California Department of Fish and Game (CDFG), National Marine Fisheries Service (NMFS), and the US Army Corps of Engineers (USACE) initiated the Russian River Coho Salmon Captive Broodstock Program in the late 1990s. Under this program, offspring of wild, captive-reared coho are stocked as juveniles into tributaries within their historic range. These fish are released during different seasons (spring and fall fingerlings, and winter smolt) and into multiple historic tributaries within the Russian River drainage. Fish of three genetic cross types are released each year, including Russian River female by Russian River male (RRxRR), Russian River female by Olema Creek male (RRxOC), and Olema Creek female by Russian River male (OCxRR). A summary of annual coho releases from Don Clausen Fish Hatchery from 2004 through 2010 is provided in **Figure 1**.

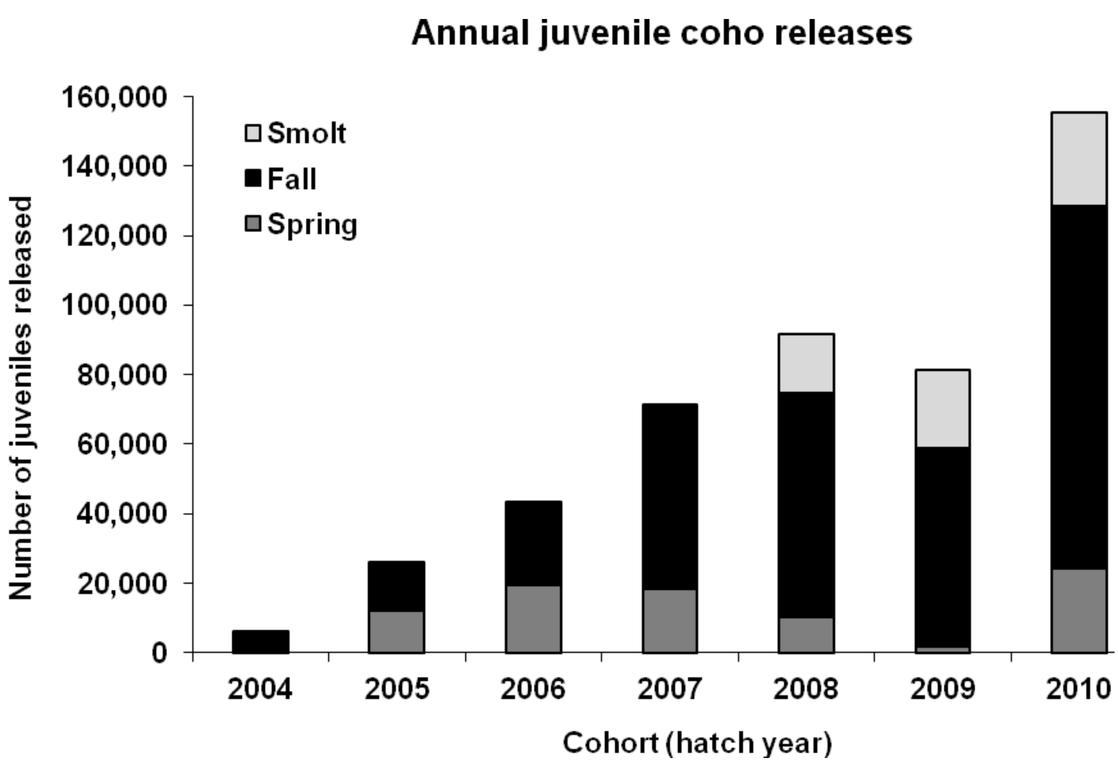



**Figure 1.** Number of juvenile coho released annually into tributaries of the Russian River from 2004 through 2010.

## Monitoring Component of RRCSCBP

Since 2004, University of California Cooperative Extension (UCCE) and California Sea Grant (CSG) personnel have worked with agency partners to develop and implement a monitoring and evaluation component for the RRCSCBP. The overall monitoring goal is to evaluate the effectiveness of the RRCSCBP by documenting whether released program coho return as adults and successfully complete their life cycles. Different hatchery release protocols and stocking environments are assessed to determine the optimal stocking strategies for successfully restoring coho to the Russian River system. Monitoring efforts are designed to evaluate three primary components: summer survival, winter survival, and adult escapement. This information provides resource managers with documentation regarding the success of the hatchery program, as well as the ability to make informed decisions about the future direction of the program and adaptively manage release strategies for optimal survival. Results from monitoring efforts are routinely reported at RRCSCBP Committee meetings. The RRCSCBP Committee (representing county, state, and federal agencies, non-governmental organizations, and public and private parties), in turn, provides feedback and suggestions about how to improve the monitoring program and the RRCSCBP in general.

## Project purpose and time frame

As stated in NMFS' Russian River Biological Opinion, the USACE is required to ensure that monitoring and evaluation of the RRCSCBP is conducted to evaluate the effectiveness and performance of the program (NMFS 2008). The monitoring conducted by UCCE and CSG under USACE contract W912P7-10-C-0011 represents the first year of fulfilling that requirement. The original timeframe for the contract was April 2010 through March 2011, however, with the assistance of the Sonoma County Water Agency (SCWA), partial monitoring continued through June 2011 and is also summarized in this report.

### *Monitoring Objectives*

The three monitoring components outlined in contract W912P7-10-C-0011 are 1) summer survival monitoring, 2) winter survival monitoring, and 3) escapement monitoring. After meeting with a technical advisory group including representatives of NMFS, CDFG, and USACE, a research plan was developed for the timeframe of the contract and approved by the three agencies. Specific objectives for each of these components between April 2010 and June of 2011 were as follows:

1) Winter survival monitoring (April 2010-June 2010, March 2011-June 2011):
    - Estimate the migration timing, abundance, size, and condition factor of spring, fall, and smolt-released coho smolts emigrating from Mill and Green Valley Creeks
    - Estimate instream survival and growth of coho released into Mill, Palmer, and Green Valley Creeks during the spring and fall of 2009 and 2010, or as smolts in 2010 and 2011

- Estimate migration timing and instream survival of spring and fall juveniles released into Grape Creek in the spring and fall of 2010

2) Summer survival monitoring (June 2010-October 2010):
    - Estimate oversummer (June-October) survival, size, and growth of program coho released into selected reaches of Mill, Palmer, Green Valley, and Grape Creeks during spring of 2010

3) Escapement monitoring (October 2009-February 2010, July-August 2010):
    - Estimate the number and distribution of adult coho returning to program streams during the winter of 2009-2010
    - Conduct snorkeling surveys in program tributaries during summer of 2010 to determine the presence/absence of wild juvenile coho young-of-year that may have resulted from spawners during the winter of 2009-2010

## MONITORING COMPONENTS

### Winter Survival Monitoring

#### *Methods*

In order to estimate smolt abundance and overwinter survival of released coho, downstream migrant traps were operated on Mill and Green Valley Creeks from mid-March through mid-June, 2010. Weirs and funnel traps (**Figure 2**) were placed near the mouths of each stream (**Figure 3, Figure 4**) and operated daily during the smolt migration period. All fish captured in the downstream migrant traps were anesthetized, measured for fork length and weight, scanned for presence and location of a CWT and/or PIT tag, and then released downstream of the trap. During storm events, the traps were opened up to prevent injury to fish, avoid loss of equipment, and ensure the safety of the staff.

Stationary PIT tag antennas were operated immediately upstream of each trap (**Figure 3, Figure 4**, **Figure 5**). A two-trap mark recapture design (Bjorkstedt 2005, Bjorkstedt 2010) was used to estimate the total number of smolts leaving each creek during the time that each trap was in operation. PIT-tagged fish passing over the antenna served as the marking event, and fish captured in the trap served as the recapture event. PIT-tagged fish detected at both the antenna and in the trap were counted as recaptures, and the sum of non-PIT-tagged fish and PIT-tagged fish only detected in the trap were counted as unmarked fish.

Funding permitted operation of the Mill Creek trap and antennas for an additional season in 2011, and data was collected with the sampling locations and methods used in 2010. In Green Valley Creek, an antenna was operated for duration of the smolt migration period, and a trap was operated by the SCWA between 4/11/11 and 5/5/11, after which it was removed because endangered California freshwater shrimp were incidentally captured in the trap. A new lower trap and antenna location was used in 2011 (**Figure 4**) because the previous year's trap efficiency was low due to the stream channel configuration at that site. Because of the limited window of trapping in 2011, an *ad hoc* method was used to estimate the total number of smolts emigrating from Green Valley Creek during the spring of 2011. Antenna efficiency and PIT to non-PIT-tagged fish ratios were estimated for the period that the trap was in operation, and then applied to the total detections on the antenna to estimate smolt abundance for the entire season.

PIT tag detections at multiple antenna and trap sites were used to estimate stock-to-smolt survival for the different release groups (tributary, season, and genetic cross-type). In the Mill Creek watershed, a multistate emigration model (Horton et. al. 2011) as implemented in Program MARK (White and Burnham 1999) was used to compare survival of spring, fall, and smolt releases into Mill and Palmer Creeks, as well as three genetic cross-types released into the Mill Creek watershed during the fall. Because antennas were operated year round in Mill Creek, emigration could be separated from survival estimates. In Green Valley Creek, antennas were operated only during the time that the traps were in operation, therefore, a Cormack Jolley Seber model (Lebreton et. al. 1992), as implemented in program MARK (White and Burnham 1999), was used to estimate apparent survival (confounded probability of surviving and staying in the stream) for all PIT-tagged release groups (smolt release in 2010, spring, fall and smolt in 2011).

A pair of stationary PIT tag antennas was operated continuously on Grape Creek after the first Grape Creek release during the spring of 2010 (**Figure 6**). A multistate emigration model (Horton et. al. 2011), as implemented in program MARK (White and Burnham 1999), was used to estimate stock-to-smolt survival of the spring and fall release groups for that cohort.

In order to gain some understanding of overwinter habitat use in different reaches of Green Valley Creek and investigate the low overwinter apparent survival of coho releases observed in 2007-2008 and 2008-2009, in 2010 we operated a second smolt trap on Green Valley Creek downstream of the stocking reach (9.32 km from the confluence with the Russian River and 7 km upstream of the first trap) (**Figure 4**). Prior to release downstream of the trap, a portion of the coho captured in this trap were fin clipped so that they could be identified as recaptures in the lower trap.

Average smolt length, weight, and condition factor were estimated using data collected at downstream migrant traps. Data collected on PIT-tagged coho was used to estimate release-specific averages (spring, fall, and smolt) for Mill and Palmer releases (2010 and 2011), and for Green Valley releases in 2011. Coded wire tag data was used to distinguish release groups for the Green Valley estimates in 2010 because only a portion of the smolt release group was PIT tagged.

Overwinter growth rates were estimated for PIT-tagged fish released in the fall and recaptured in the smolt traps the following spring. Specific growth rates for length were calculated for individual PIT-tagged fish as $(FL_2\text{-}FL_1)/(t_2\text{-}t_1)$ where $FL_1$= fork length at hatchery prior to release, $FL_2$= fork length at the smolt trap, $t_1$=date measured at hatchery, and $t_2$= date captured in the smolt trap. Similarly, specific growth rates for weight were calculated for individual PIT-tagged fish as $\ln(WT_2)\text{-}\ln(WT_1))/(t_2\text{-}t_1)$ where $WT_1$=weight at hatchery prior to release, $WT_2$= weight at the smolt trap, $t_1$=date measured at hatchery, and $t_2$= date captured at the smolt trap.

The RRCSCBP tested three methods of acclimating smolts released in the spring of 2010: 1) holding fish in a pond created by a flashboard dam high in the watershed (pond release), 2) holding smolts in an enclosed trap box anchored to the stream bottom (box release), and 3) releasing fish directly into the stream (stream release). Although there is uncertainty regarding the amount of time necessary for smolts to imprint, the goal for this trial was to retain the fish for three weeks in the release stream. Pond acclimation was attempted on Mill Creek and Green Valley Creek in 2010, and box and stream releases were attempted in the Mill Creek watershed in 2010 (**Figure 3, Figure 4**). Stream releases occurred at the same locations as the box releases. Pond releases were conducted once in 2010, and box and stream releases were conducted twice. A portion of each release group was PIT tagged in order to document the amount of time each group remained in the watershed. Additional antennas were operated upstream of the smolt trap locations and downstream of the smolt release locations to document migration timing for each release group (**Figure 3, Figure 4**). Based on monitoring results from 2010, smolts were acclimated in either tanks (Dutch Bill Creek) or ponds (Mill and Green Valley Creeks) during the spring of 2011.

**Figure 2.** Mill Creek downstream migrant trap.

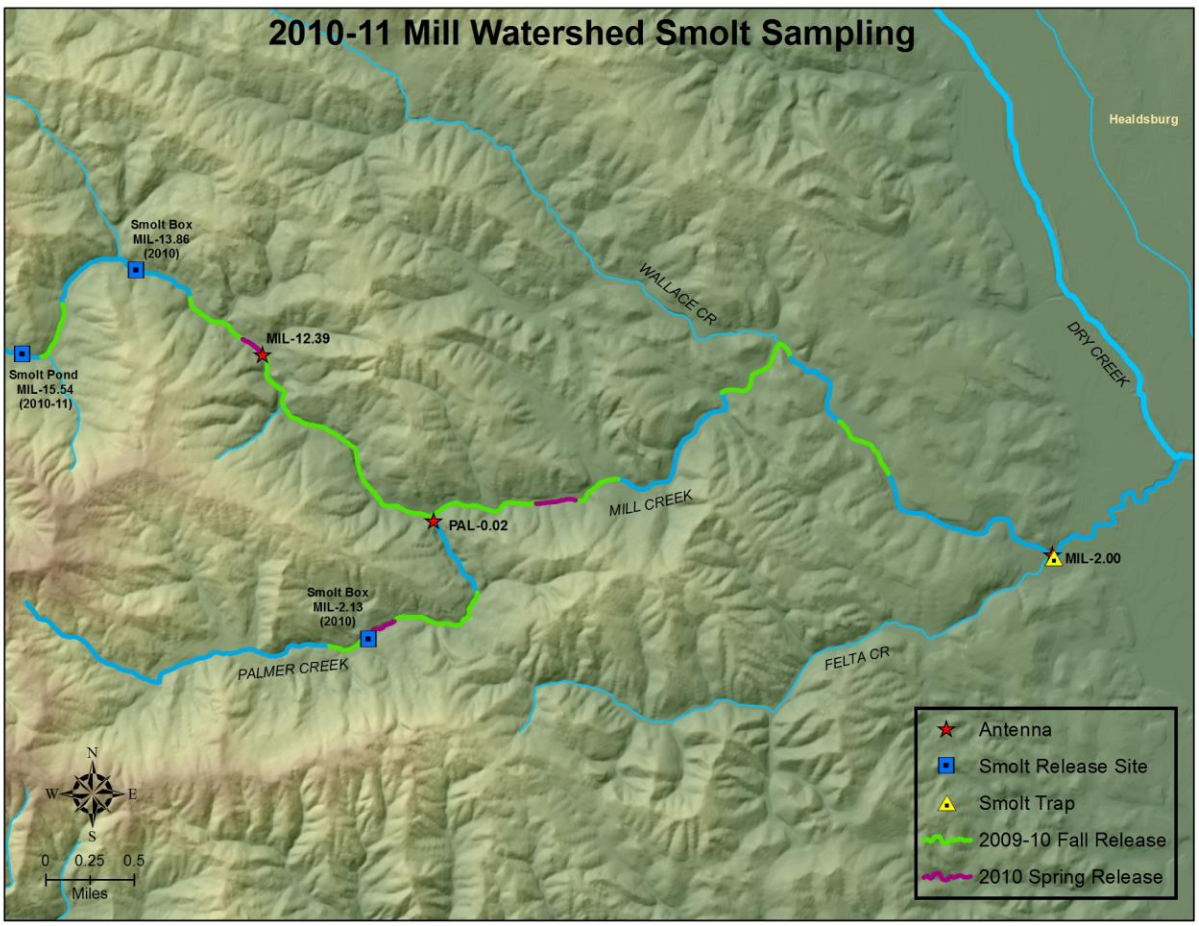



**Figure 3.** Mill Creek smolt monitoring sites, spring 2010 and 2011.

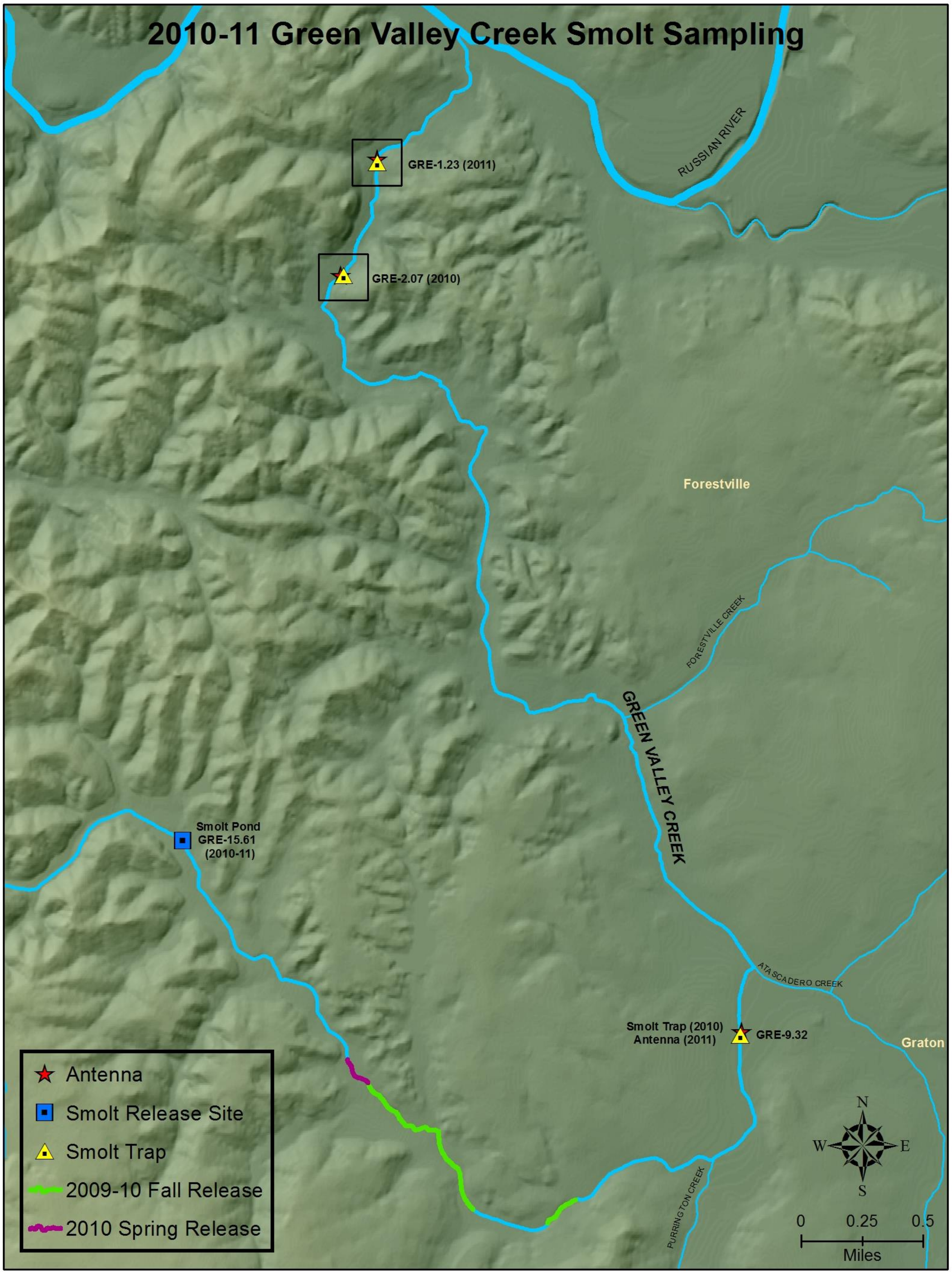



**Figure 4.** Green Valley Creek smolt monitoring sites, spring 2010 and 2011.

**Figure 5.** Stationary PIT antenna located upstream of Mill Creek smolt trap.

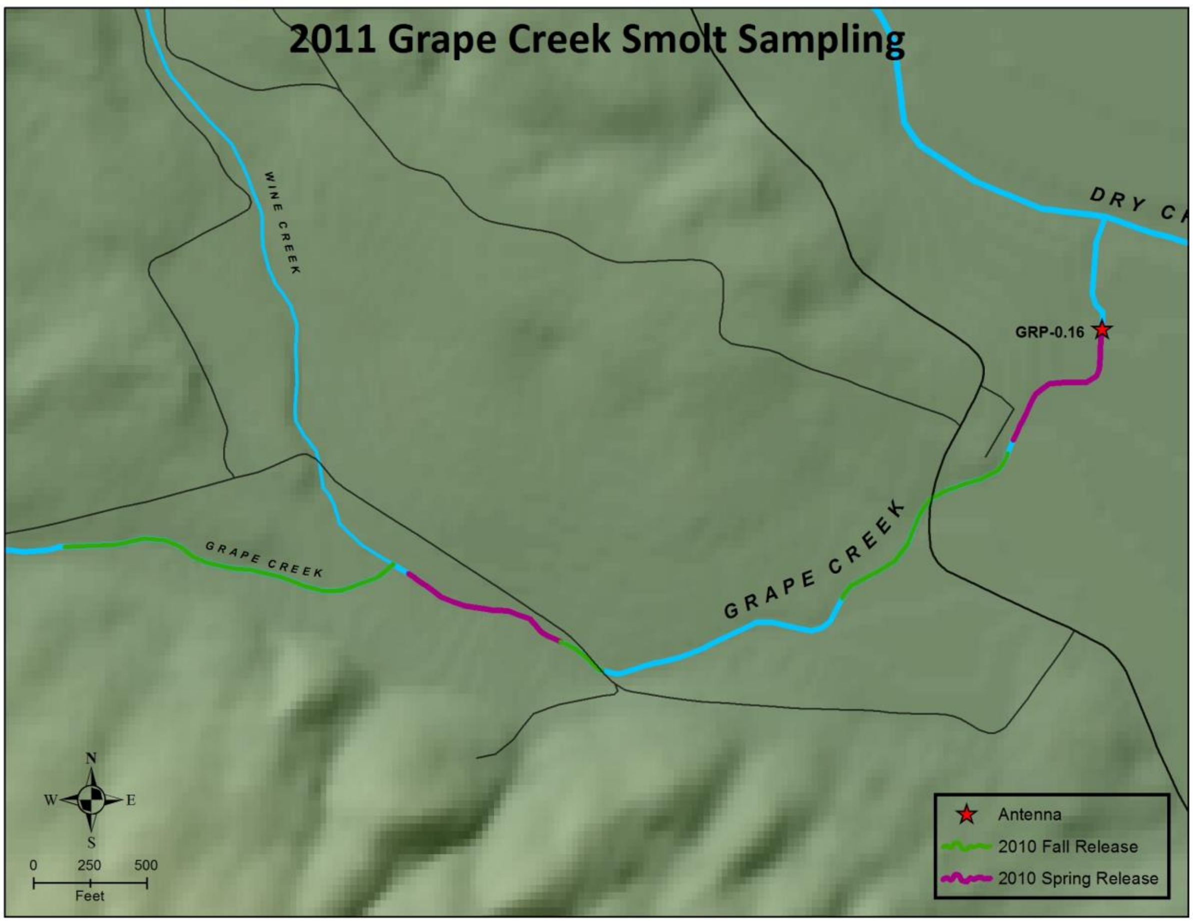



**Figure 6.** Smolt monitoring sites on Grape Creek, spring 2011.

## ***Results***

### *Trap and PIT antenna operation*

In 2010, the Mill Creek trap was installed on 3/9/10 and operated through 6/16/10. Due to storm events, it was not operated on the following dates: 3/13-3/15, 4/1-4/8, and 4/11-4/16. The upper and lower Green Valley traps were installed on 3/17/10 and operated until 6/9/10 (upper) and 6/10/10 (lower). Due to storm events, these traps were not operated on the following dates: upper: 4/1, 4/3-4/6, 4/9, 4/11-4/14, and 4/27-4/28; lower: 4/1-4/21, 4/27-4/29, and 5/29.

In 2011, the Mill Creek trap was installed on 3/10/11 and operated through 6/17/10. Due to storm events, it was not operated on the following dates: 3/14-4/5, and 6/4-6/5. The lower Green Valley trap was operated continuously by SCWA between 4/11/11 and 5/5/11, after which it was removed because endangered California freshwater shrimp were incidentally captured.

On Mill Creek, beginning on 11/1/09, a pair of PIT antennas was operated year-round immediately upstream of the smolt trap site to account for any fish emigrating from Mill outside of the typical smolt migration period between mid-March and mid-June (**Figure 3**). Due to storm events, the antennas were not in operation on the following dates: 1/13/10, 1/18-1/31/10, 2/6-2/7/10, 2/25-3/7/10, 4/6/10, 4/12-4/15/10, 12/23/10-1/3/11, 2/17-2/21/11, 3/3-3/7/11, and 3/20-3/30/11.

Antennas on Green Valley Creek were operated only during the time that smolt traps were in operation. In 2010, an antenna was installed immediately upstream of the lower trap (**Figure 4**) on 3/22 and operated until 6/28 with the exception of the following dates: 4/1-4/19, and 4/24-4/25. In 2011, an antenna was operated at river km 1.23 (2011 lower smolt trap site) (**Figure 4**). This antenna was installed on 4/4/11 and operated continuously through 6/30/11.

On Grape Creek, a pair of PIT antennas was installed near the mouth of the creek (**Figure 6**) on 11/10/10 and operated continuously with the exception of 3/25-3/28/11, when they washed to shore in a high flow event.

### *Smolt abundance and survival*

The total number of smolts estimated leaving the Mill Creek watershed (includes Mill and Palmer Creeks) was similar in 2010 and 2011 (13,280 and 12,053, respectively), despite a slight increase in the number of spring and fall-released fish in 2010 (**Table 1**). The slightly lower abundance in 2011 can be explained, in part, by lower estimated survival for spring and fall release groups during the winter of 2010-2011 (**Table 2**). In addition, emigration from Mill Creek prior to trap installation was significantly higher in 2010-2011 than in 2009-2010 (**Table 2**). For the fall release group, emigration prior to 3/1 was estimated at 0.33 and 0.19 for the Mill and Palmer release streams, respectively, whereas it was estimated at 0.02 for both release streams in 2009-2010 (**Table 2**). For the spring release group, emigration prior to 3/1 was estimated at 0.09 and 0.05 for the Mill and Palmer release streams, respectively, whereas no emigration was detected in either stream in 2009-2010 (**Table 2**).

In Green Valley Creek, a higher number of smolts was estimated leaving in 2011 than in 2010 (9,770, and 5,034, respectively) (**Table 1**). This increase in the number of Green Valley smolts from 2010 to 2011 likely resulted, at least in part, from an increase in the number of fish stocked (**Table 1**). Annual variation in survival and emigration may have also played a role, however, because the fall release group was not PIT tagged in 2010 and because PIT antennas were not operated year-round, we were not able to make this comparison.

In 2011, estimates of survival were highest on Green Valley Creek for all release groups (0.39 to 0.75) (**Table 2**), and were among the highest observed in any creek since the monitoring program began in 2004 (UCCE and CSG, unpublished data). In Grape Creek, survival was relatively high for the fall release group (0.27), but low for the spring release group (0.05) (**Table 2**). Because the spring release group experiences the summer and winter season, whereas the fall release group experiences only the winter season, these results suggest that Grape Creek had suitable overwintering conditions, but was limited in oversummer rearing conditions. Within the Mill Creek watershed, in general, survival was higher and emigration was lower for fish released into Palmer Creek compared to fish released directly into Mill Creek (**Table 2**). Survival for the smolt release group was similar among streams and years, with estimates ranging from 0.60 to 0.75 (**Table 2**).

For coho released in the fall of 2009 into Mill and Palmer Creeks, winter survival appeared slightly lower for the RRxRR cross type and higher for the OCxRR cross type, however, there was no clear pattern the following winter (**Figure 7**).

**Table 1.** Smolt abundance estimates for coho juveniles leaving Mill and Green Valley Creeks annually between March and June, 2010 and 2011.

| Trap year | Tributary | Number spring stocked | Number fall stocked | Number smolt stocked | Total trap Count | Wild smolt trap count | Overall detection efficiency (95% CI) | Smolt abundance (95% CI) |
|---|---|---|---|---|---|---|---|---|
| 2010 | Mill Creek | 1,641 | 32,114 | 7,541 | 5,051 | 9 | 0.38 (0.36-0.40) | 13,280 (12,686 - 13,875) |
| | Green Valley | 0 | 5,200 | 3,094 | 348 | 0 | 0.07 (0.05-0.14) | 5,034 (2,507 - 7,561) |
| 2011 | Mill Creek | 2,446 | 34,746 | 5,950 | 7,254 | 22 | 0.60 (0.57-0.63) | 12,053 (11,454 - 12,651) |
| | Green Valley | 1,524 | 7,933 | 4,985 | 231 | 2 | 0.92 (0.78-0.97) | 9,770 (9,235-11,506) |

**Table 2.** Estimates of survival and emigration for coho juveniles based on PIT-tagged coho released in 2009, 2010, and 2011 as young-of-year in spring or fall, or as 1+ smolts.

| Hatch year | Trap year | Tributary | Spring release | | | Fall release | | | Smolt release | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Survival interval | Survival (95%CI) | Emigration before 3/1 (95% CI) | Survival interval | Survival +/- 95%CI | Emigration before 3/1 (95% CI) | Survival interval | Survival +/- 95%CI |
| 2009 | 2010 | Mill Creek | 6/16/09-6/30/10 | 0.15 (0.15-0.15) | 0 | 11/10/09-6/30/10 | 0.23 (0.21-0.25) | 0.02 (0.01-0.02) | 3/22/10-6/30/10 | 0.62 (0.59-0.65) |
| | | Palmer Creek | 6/16/09-6/30/10 | 0.17 (0.15-0.20) | 0 | 11/10/09-6/30/10 | 0.34 (0.32-0.36) | 0.02 (0.01-0.03) | 4/2/10-6/30/10 | 0.72 (0.69-0.76) |
| | | Green Valley Creek | NA[1] | NA[1] | NA[1] | 11/4/09-6/30/10 | unknown[2] | unknown[2] | 3/25/10-6/30/10 | 0.63 (0.55-0.72) |
| 2010 | 2011 | Mill Creek | 6/15/10-6/30/11 | 0.12 (0.10-0.14) | 0.09 (0.08-0.11) | 11/2/10-6/30/11 | 0.12 (0.11-0.15) | 0.33 (0.31-0.36) | 4/1/11-6/30/11 | 0.60 (0.57-0.63) |
| | | Palmer Creek | 6/15/10-6/30/11 | 0.10 (0.08-0.13) | 0.05 (0.04-0.07) | 11/3/10-6/30/11 | 0.20 (0.18-0.23) | 0.19 (0.17-0.22) | NA[1] | NA[1] |
| | | Green Valley Creek | 6/14/10-6/30/11 | 0.39 (0.37-0.46)[3] | unknown[3] | 10/29/10-6/30/11 | 0.46 (0.43-0.54)[3] | unknown[3] | 4/4/11-6/30/11 | 0.75 (0.71-0.89) |
| | | Grape Creek | 6/16/10-6/30/11 | 0.05 (0.04-0.06) | 0.07 (0.05-0.08) | 11/11/10-6/30/11 | 0.27 (0.24-0.31) | 0.20 (0.18-0.23) | NA[1] | NA[1] |

[1] No fish were released.

[2] None of the Green Valley 2009 fall release coho were PIT tagged so survival was not estimated.

[3] PIT antennas were not operated year round on Green Valley, therefore emigration prior to March 1 could not be estimated and survival estimates are of apparent (not true) survival.

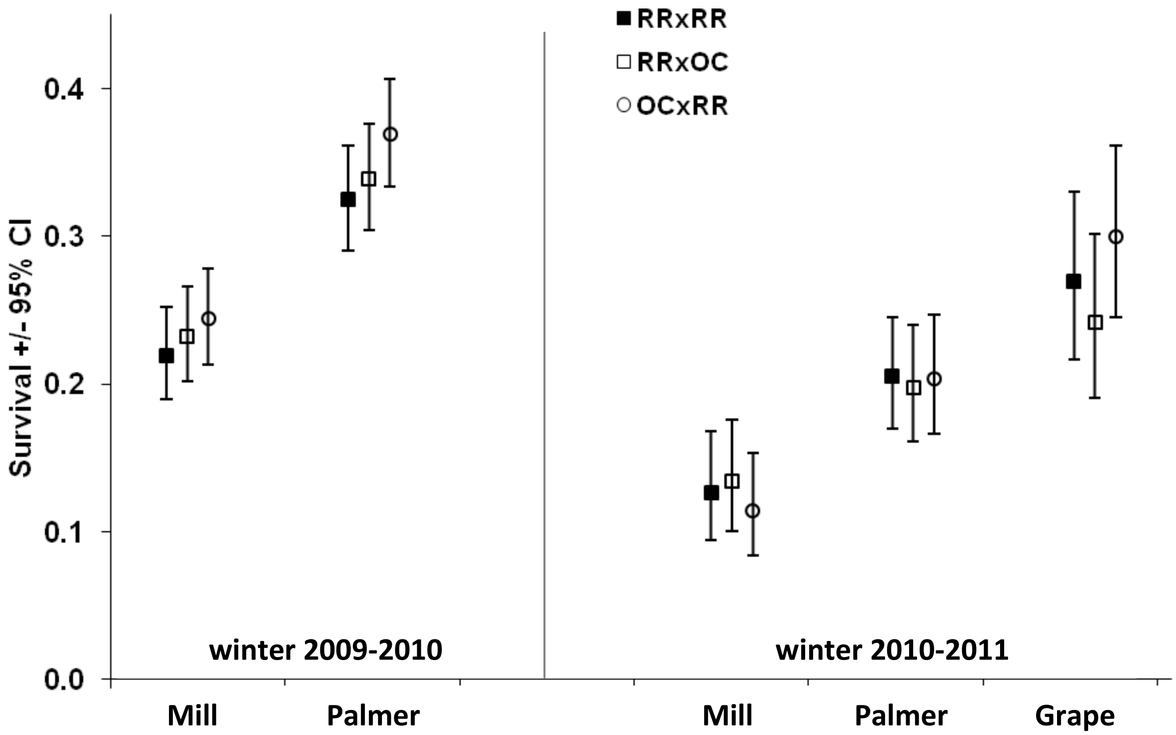



**Figure 7.** Overwinter survival (fall release to smolt) of three genetic cross-types of juvenile coho released into program stream in fall of 2009 and 2010. Cross-types include Russian River female by Russian River male (RRxRR), Russian River female by Olema Creek male (RRxOC), and Olema Creek female by Russian River male (OCxRR).

### *Green Valley Creek upper and lower trap data*

CJS models run using data from the PIT-tagged smolt-released fish indicated that survival was 0.83 (0.78-0.87) between the smolt pond and the upper trap, and 0.76 (0.65-0.85) between the upper trap and the lower trap, with a cumulative survival of 0.63 (0.55-0.72). Trap efficiencies from CJS models were applied to the number of fall-released coho passing through each trap, and based on this data, we estimate that approximately half of the fish released in the fall of 2009 moved downstream of the upper trapsite (**Figure 4**) prior to 3/17/10. This pilot data did not reveal any clear bottlenecks to survival, and based on the high survival observed during the winter of 2010-2011, either winter conditions were very different in 2007-2008 and 2008-2009 when low survival was observed, or the difficulties of trap operation on Green Valley in previous years (and lack of year-round detection systems) biased survival estimates low. Year-round antennas in multiple locations in combination with PIT tagging fish from each release group may reveal further insights to habitat use and potential bottlenecks to survival.

### *Size and growth*

On all streams and trapping locations in 2010, spring-released coho were smallest in length and weight and smolt-released fish were largest (**Figure 8**). Condition factor was variable, but with the exception of the lower Green Valley Creek trap, was lowest for the fall release group (**Figure 8**). Similar results in 2011 were observed in Mill Creek in 2011, but not in Green Valley where length and weight were similar among release groups (**Figure 9**). This is likely explained by the high growth rates observed in Green Valley Creek during the winter of 2010-2011, as compared to the other tributaries (**Figure 10**).

Growth in length during the winter of 2009-2010 was similar among the three genetic cross types, but growth in weight was slightly lower for the RRxRR cross type in Mill and Palmer Creeks (**Figure 11**). The following winter, growth in length and weight were similar but variable among cross types in Mill and Palmer Creeks, and slightly lower for the RRxOC cross type in Green Valley Creek (**Figure 11**). However, the small sample size for Green Valley Creek (11 total for all cross types) makes it difficult to draw conclusions.

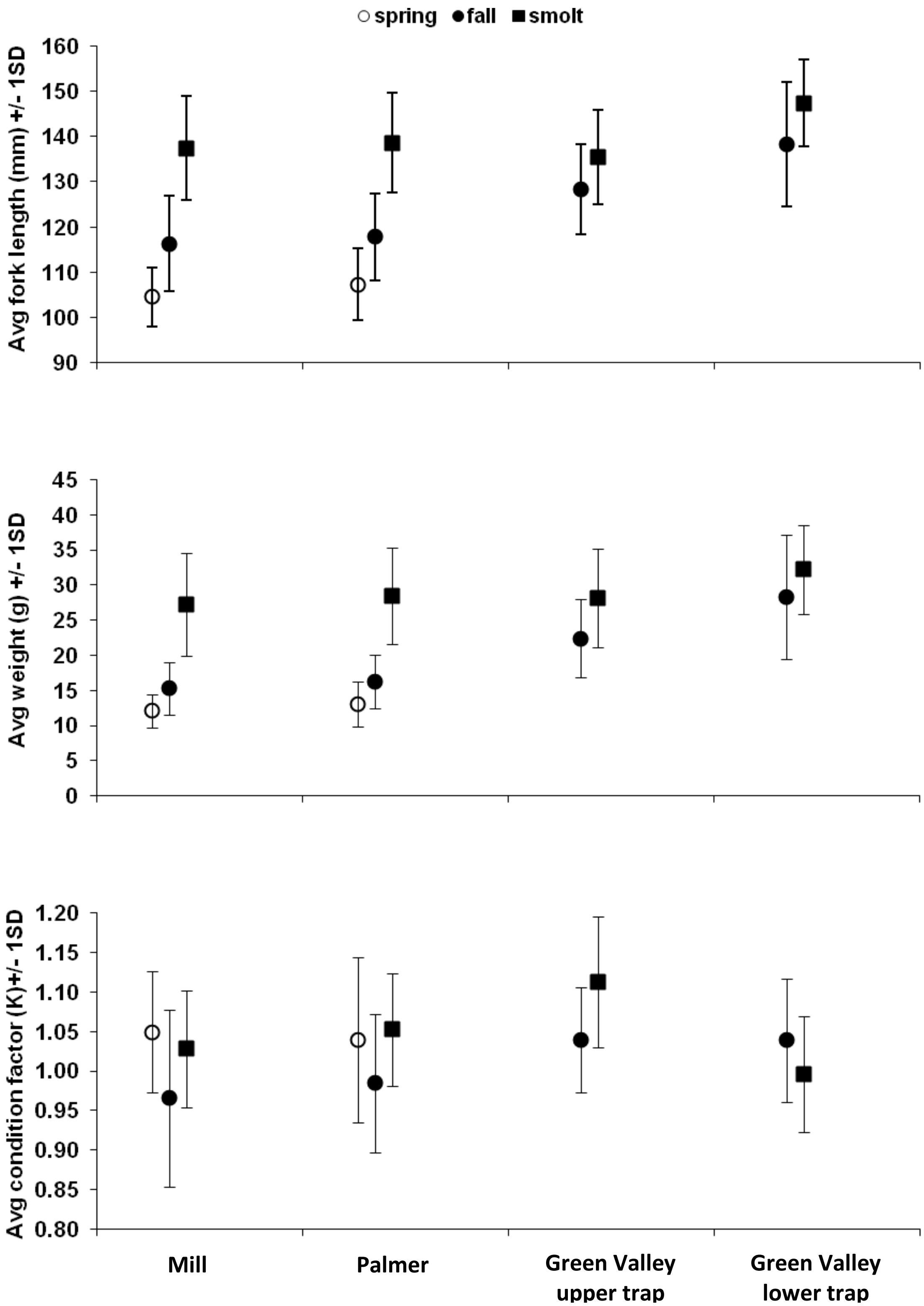



**Figure 8.** Average fork length, weight and condition factor of spring, fall, and smolt-released coho captured in Mill and Green Valley smolt traps during spring 2010.

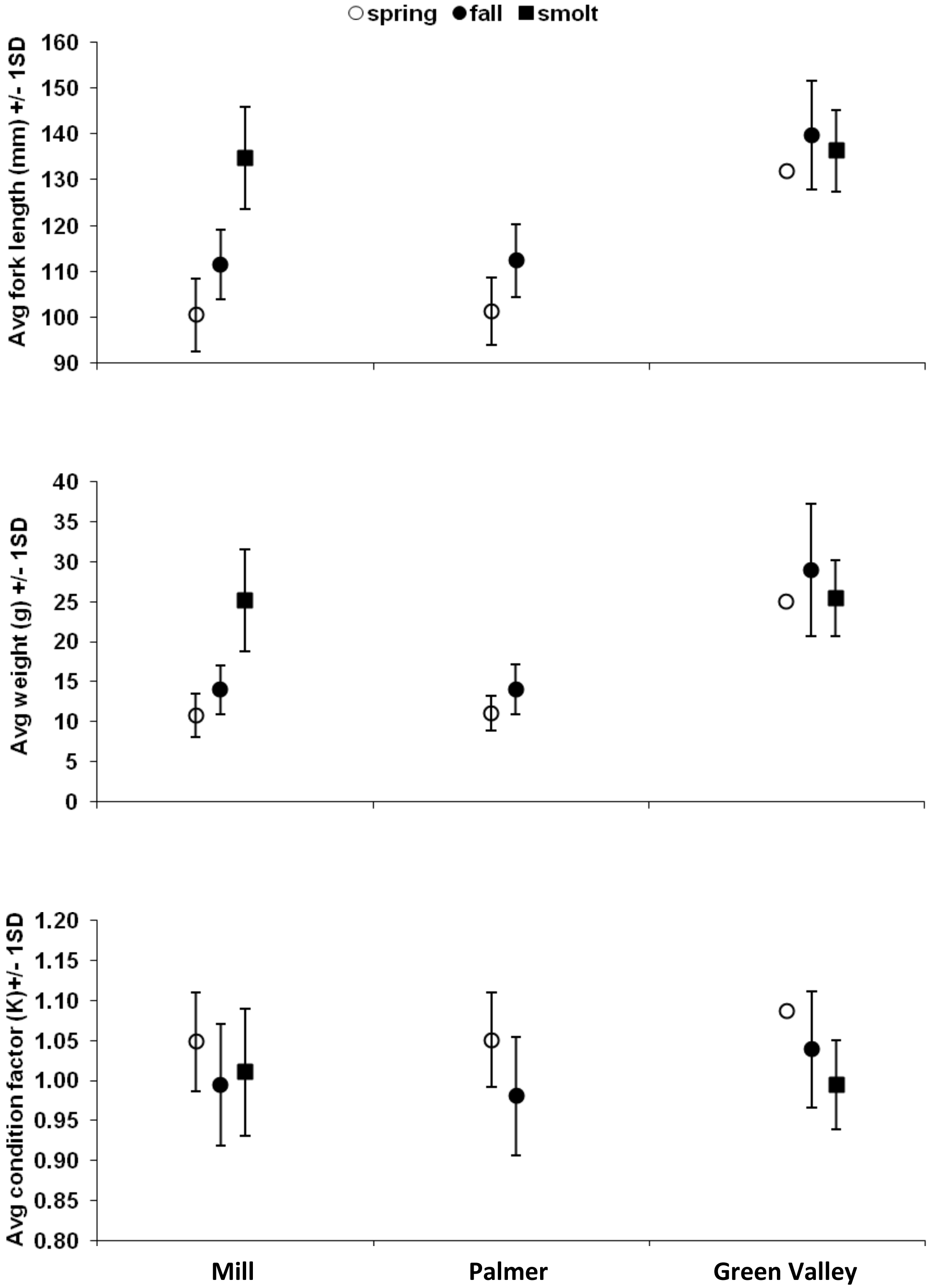



**Figure 9.** Average fork length, weight and condition factor of spring, fall, and smolt-released coho captured in Mill and Green Valley smolt traps during spring 2011. Note that the spring release in Green Valley is represented by only one fish.

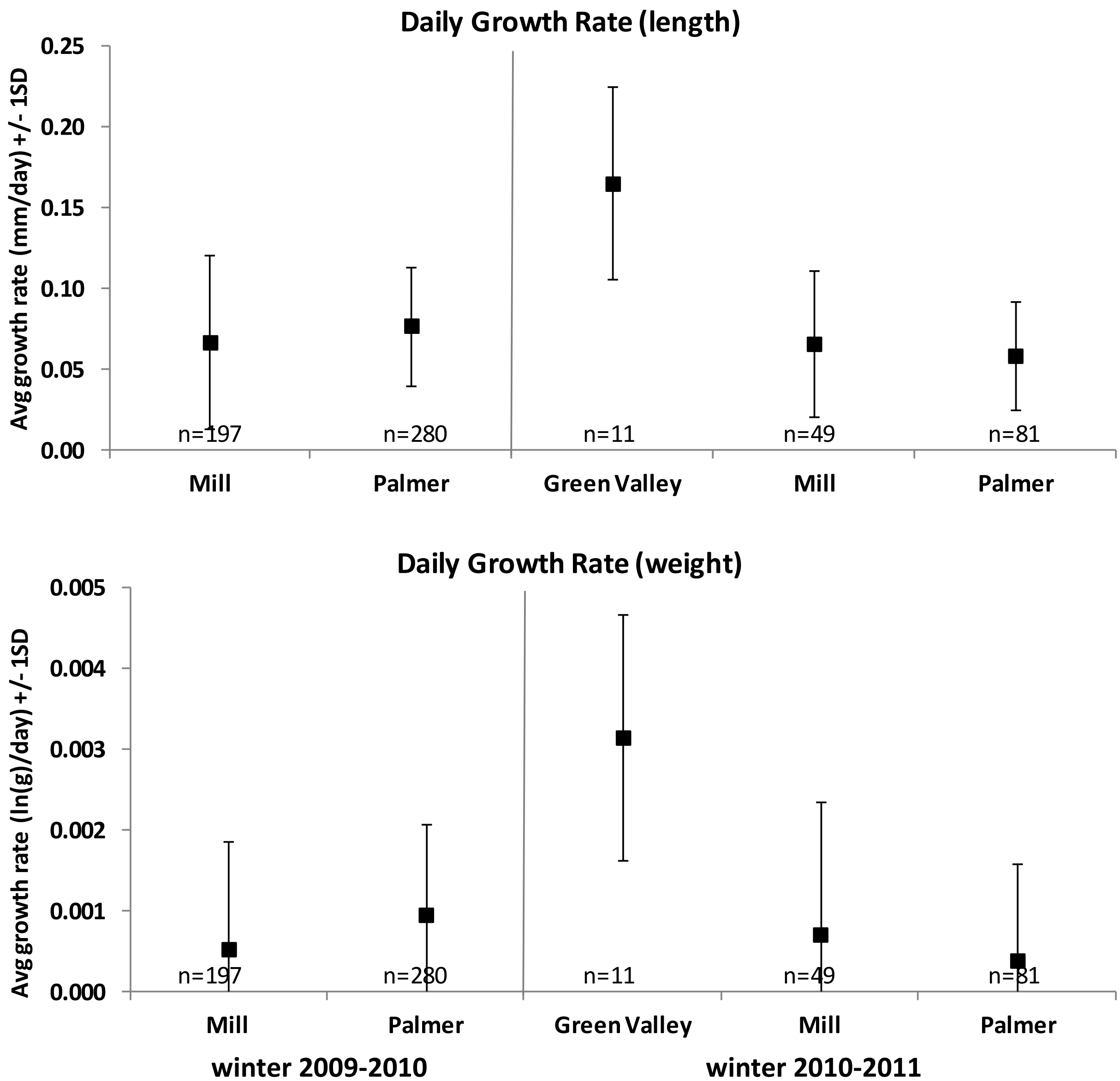



**Figure 10.** Average specific growth rates of PIT-tagged juvenile coho stocked into Mill, Palmer, and Green Valley Creeks in fall of 2009 and 2010 and recaptured as smolts in 2010 and 2011, respectively. No PIT-tagged fish were stocked into Green Valley during the fall of 2009.

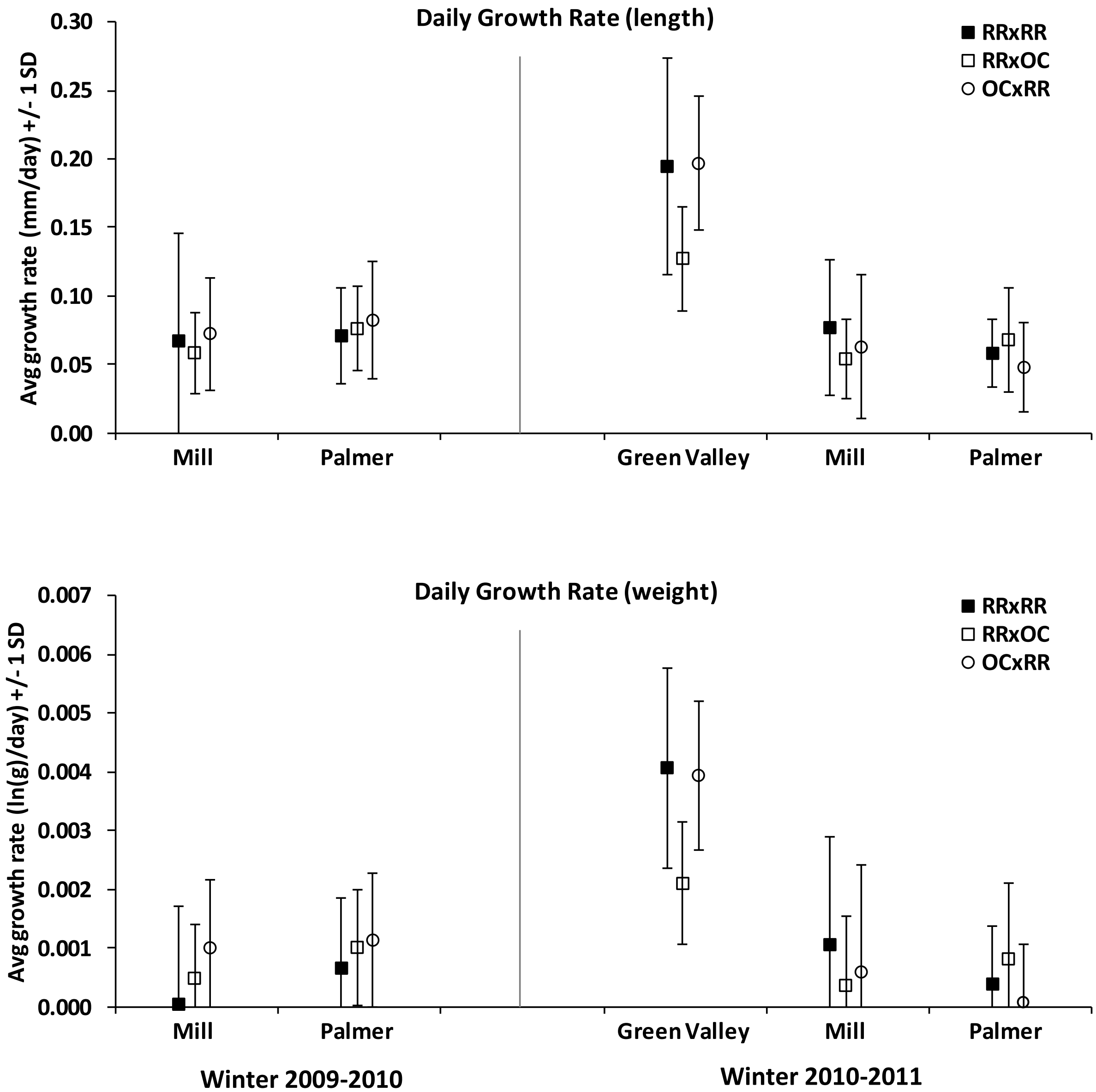



**Figure 11**. Average specific growth rates of three genetic cross-types of PIT-tagged juvenile coho stocked into Mill, Palmer, and Green Valley Creeks during the fall of 2009 (Mill and Palmer only) and 2010, and recaptured in smolt traps during spring of 2010 and 2011, respectively.

### *Migration timing*

Mill Creek

Because a pair of PIT antennas was operated continuously (with the exception of extreme high flow events), it was possible to document spring and fall-released coho emigrating from the Mill Creek watershed between the time of the fall release and installation of the smolt trap during the second week of March. During the winter of 2009-2010, very few spring or fall-released coho emigrated prior to early March (**Figure 12**), whereas in the winter of 2010-2011, significant emigration was observed in November and December (**Figure 13**). In both years, migration timing for the spring release group was approximately three weeks later than for the fall release group (**Figure 12, Figure 13**). For the smolt release group, the majority of the fish emigrated immediately after they were stocked (see *Smolt release comparisons* section for detail).

Grape Creek

As on Mill Creek, year-round antenna operation allowed us to document emigration from the stream between the time of the first fall release in 2010 through the end of the smolt migration period in June of 2011 (**Figure 14**). All of the spring-released coho emigrated fom Grape Creek before the expected smolt migration window of early March through June, and a significant portion of the fall-released coho also migrated before this window (**Figure 14**).

Green Valley Creek

For 2010, migration timing is shown for both the upper and lower trap sites for the fall and smolt release groups between mid-March and the end of June (no coho were stocked in Green Valley Creek during the spring of 2009) (**Figure 15, Figure 16**). For the fall release group, it appears that two pulses of fish passed the upper trapsite, the first during the last two weeks of March and the second between mid-April and mid-May (**Figure 15**). Only one pulse was detected at the lower trapsite between early May and early June (**Figure 15**). However, it is likely that fish were also moving the two weeks in early April when we were not able to fish the traps due to high flows (**Figure 15**). Smolt-released coho were detected at the upper trap immediately after they were released into the smolt pond on 3/25/10, and a day later at the lower smolt trap (**Figure 16**). Approximately 95% of the total number of PIT-tagged fish detected at the upper trap moved passed the upper trap site within five days. At the lower trap site, half of the detections occurred within five days and the other half were detected three or more weeks after they were stocked (**Figure 16**).

By PIT tagging a portion of the Green Valley Creek 2010 and 2011 releases and operating a PIT antenna between early April and late June of 2011, we were able to compare migration timing among release groups in 2011 (**Figure 17**). Migration timing was similar for the fall and smolt release groups with a steep pulse in early April and a broader pulse between late April and mid-June (**Figure 17**). Migration timing for the spring relase group was later, ranging from early May through mid-June (**Figure 17**).

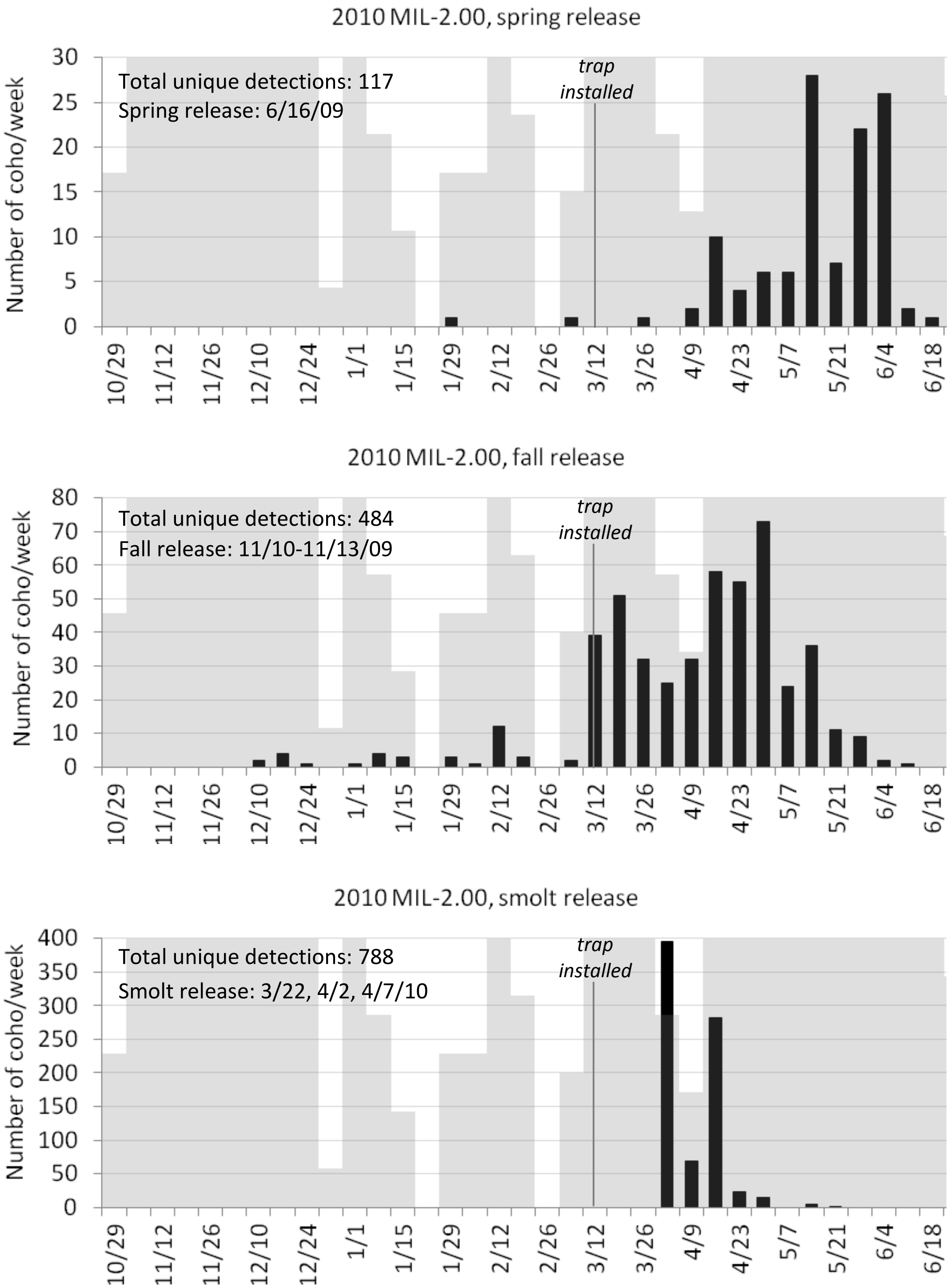



**Figure 12.** Migration timing of spring, fall, and smolt release groups past the smolt trap site on Mill Creek (river km 2.0) between late October 2009 and late June 2010. Shaded area represents the portion of the week in which at least one PIT antenna or smolt trap was in operation.

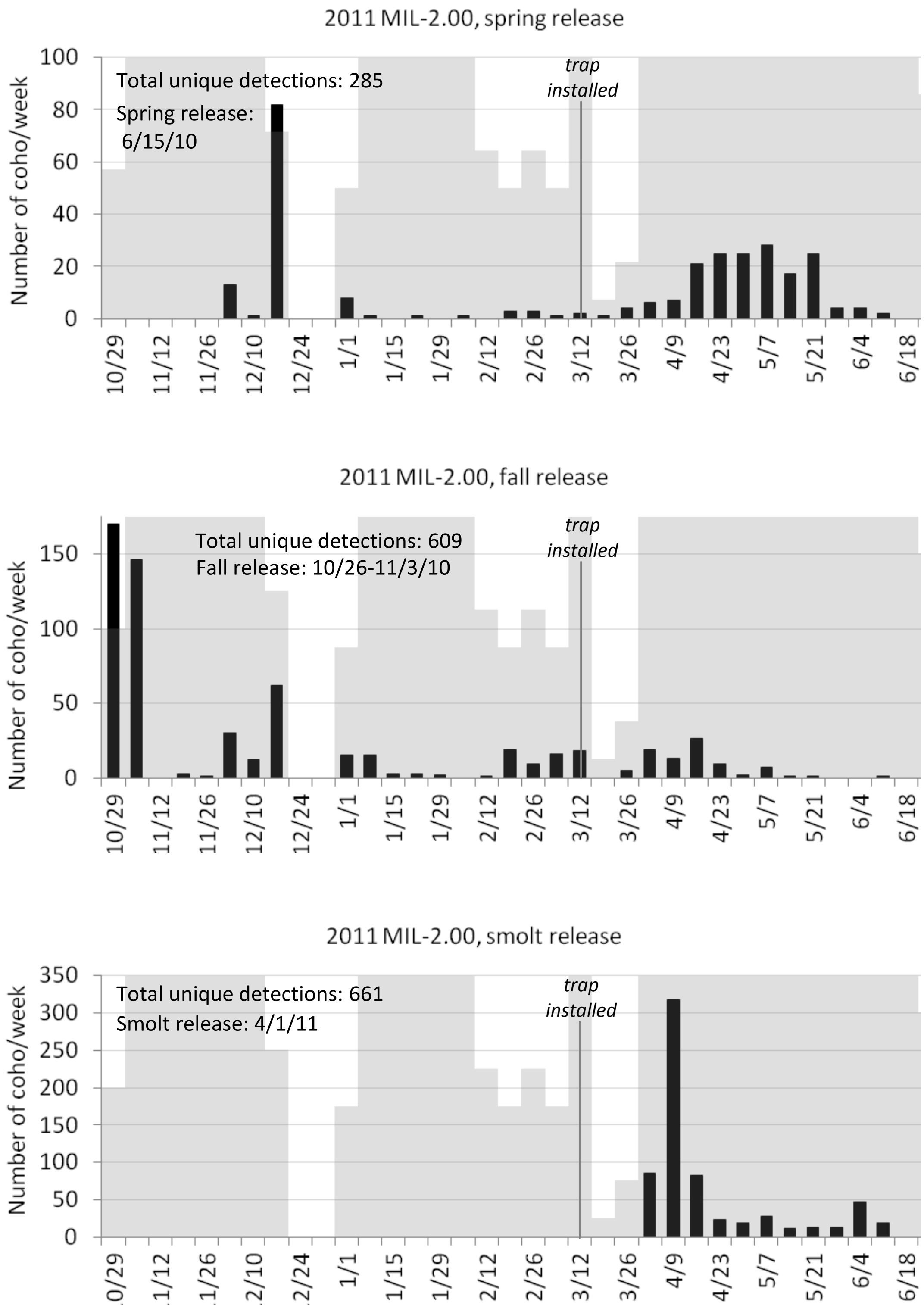



**Figure 13.** Migration timing of spring, fall, and smolt release groups past the smolt trap site on Mill Creek (river km 2.0) between late October 2010 and late June 2011. Shaded area represents the portion of the week in which at least one PIT antenna or smolt trap was in operation.

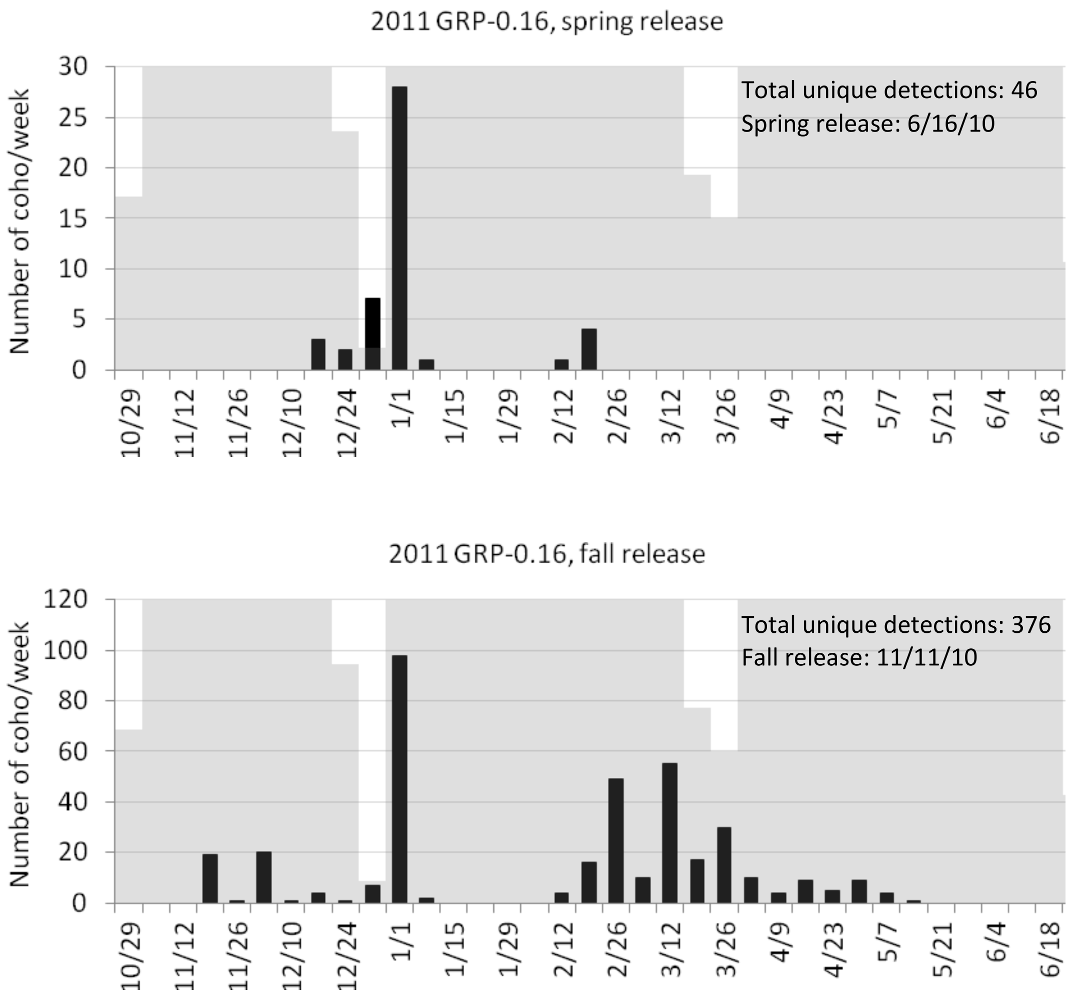



**Figure 14.** Migration timing of spring and fall release groups past a pair of antennas near the mouth of Grape Creek (river km 0.16) between late October 2010 and late June 2011. Shaded area represents the portion of the week in which at least one PIT antenna was in operation.

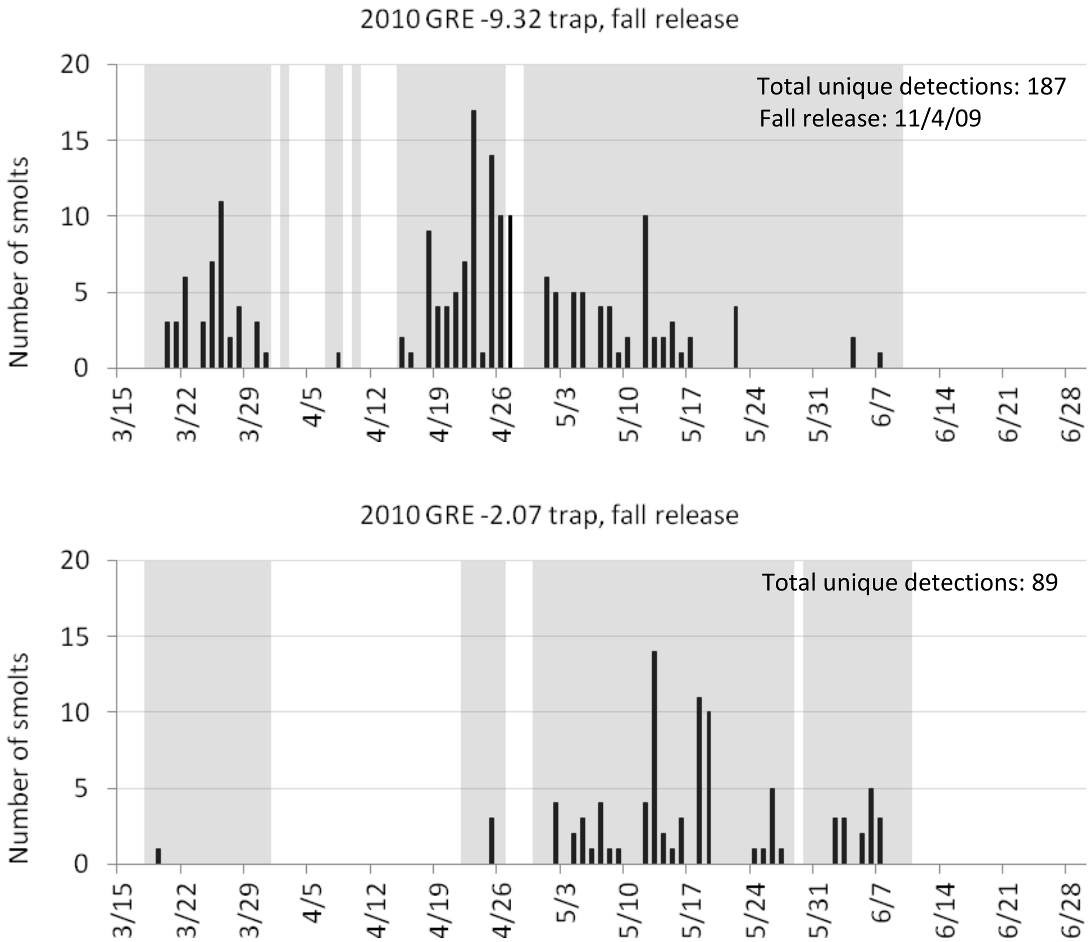



**Figure 15.** Migration timing of fall-released coho past the upper (river km 9.32) and lower (river km 2.07) smolt trap sites on Green Valley Creek between mid-March and late June 2010. Shaded area represents days that the smolt trap was in operation.

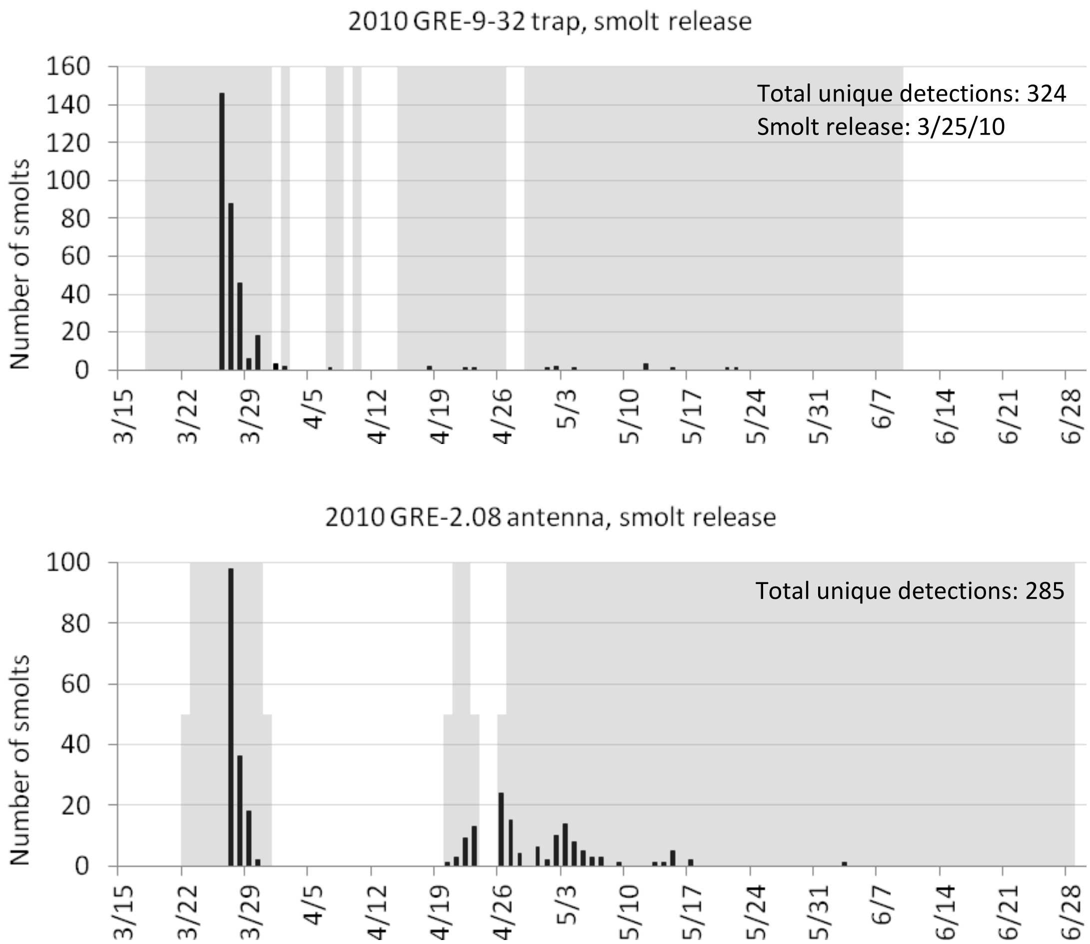



**Figure 16.** Migration timing of smolt-released coho past the upper smolt trap (river km 9.32) and lower PIT antenna (river km 2.08) on Green Valley Creek between mid-March and late June 2010. Shaded area represents days that the smolt trap or antenna was in operation.

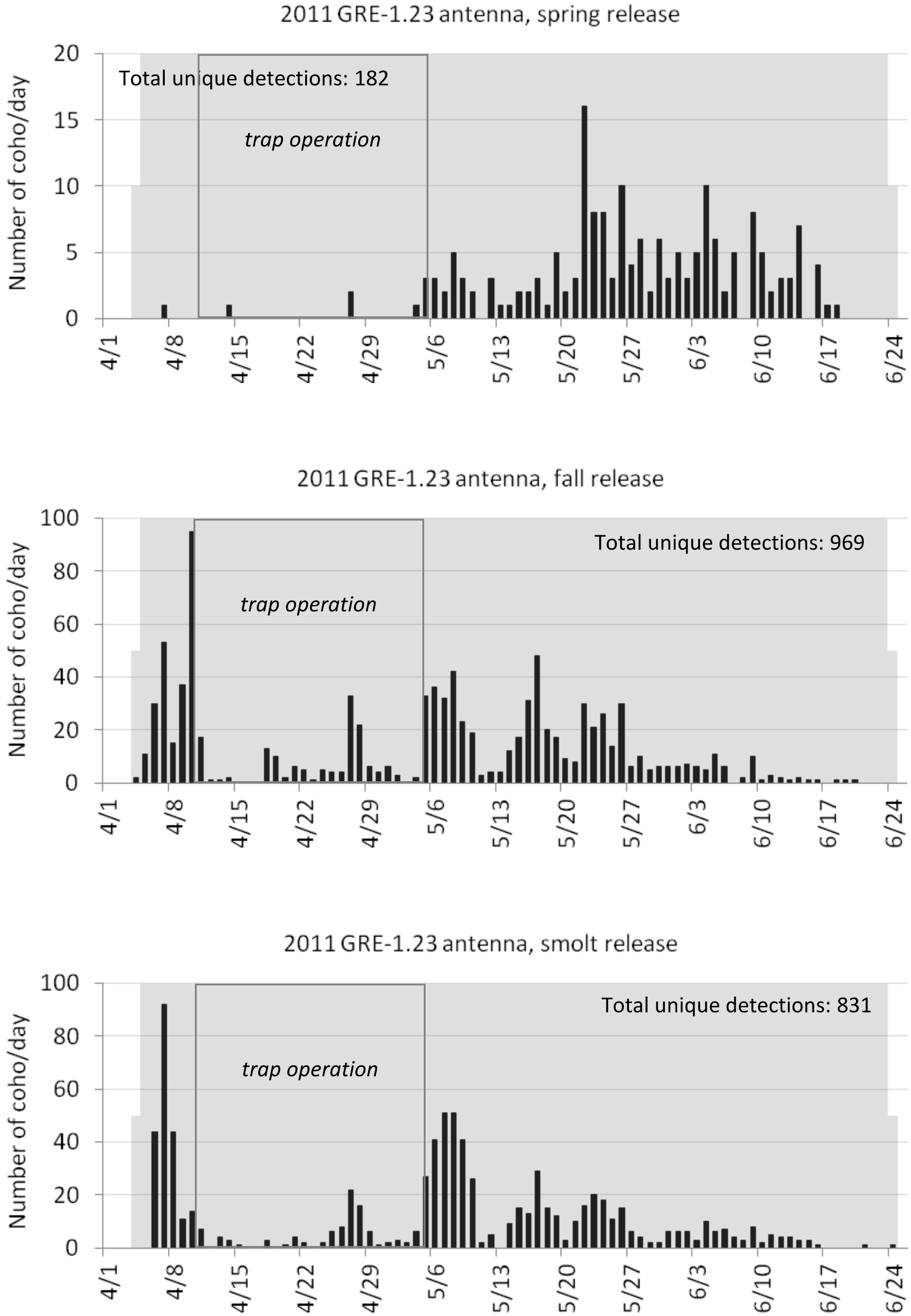



**Figure 17.** Smolt migration timing of spring, fall, and smolt release groups past a PIT antenna operated 1.23 km upstream of the mouth of Green Valley Creek between April and late June, 2011. Shaded area represents the portion of the day that the antenna was in operation.

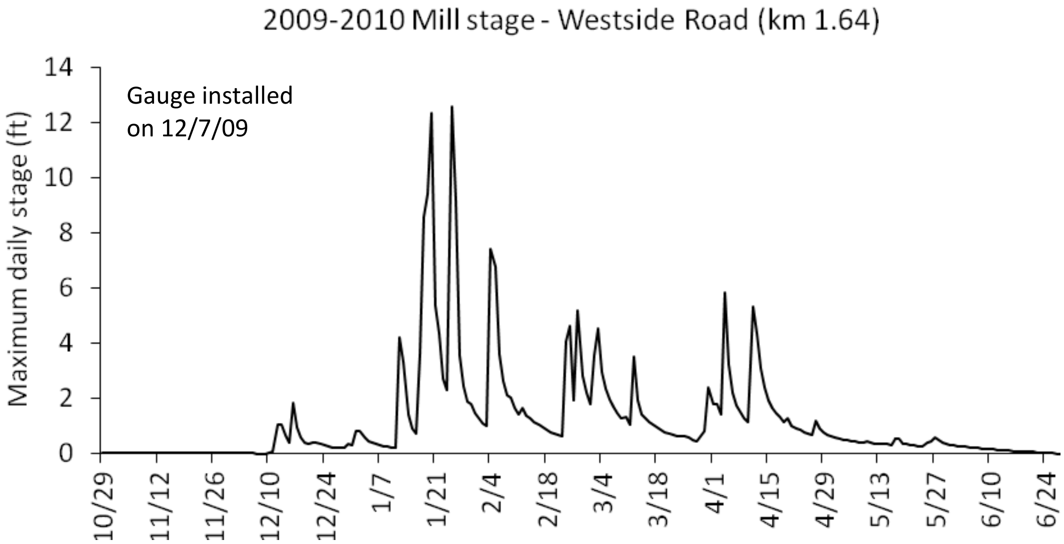
Run timing and stream flow

Stage height data collected by UCCE and CSG on Mill Creek and by the State Water Resources Control Board on Green Valley Creek are shown in **Figure 18** and **Figure 19**. Although the continuous stage height logger was not installed in Mill Creek until after the fall release in 2009 and 2010, a California Irrigation Management and Information Service (CIMIS) weather gauge in Healdsburg, CA indicated a total precipitation of < 0.5 inches between the fall release and gauge installation in both years.

Despite high flows on Mill Creek during January and February of 2010, very few coho were detected emigrating from the watershed during this time (**Figure 12**, **Figure 18**). In contrast, during the winter of 2010-2011, a pulse of spring and fall-released fish were detected leaving Mill Creek following a storm event during the first week of December 2010 (**Figure 13**, **Figure 18**). The large pulse of fall-released fish detected leaving Mill Creek immediately following the fall release did not appear to be triggered by a flow event (**Figure 13**, **Figure 18**). A rain event did occur Nov 5-6, 2010 (CIMIS weather gauge), however, the majority of the pulse of fish had already migrated past the antenna.

Although stage data was not collected on Grape Creek, it can be presumed that storm events would be similar to those that occurred on Mill Creek. The pulses of spring and fall-released fish detected leaving Grape Creek during the first week of January, 2011 appear to follow a storm event that occurred during the last week of December, 2010 (**Figure 14**, **Figure 18**).

On Green Valley Creek, no clear relationship between stage height and migration timing was observed in 2010 or 2011 (**Figure 15, Figure 16, Figure 17, Figure 19**). Investigations comparing additional factors such as release size, day length, and temperature may provide further insight into variability in migration timing among streams, release groups, and years.



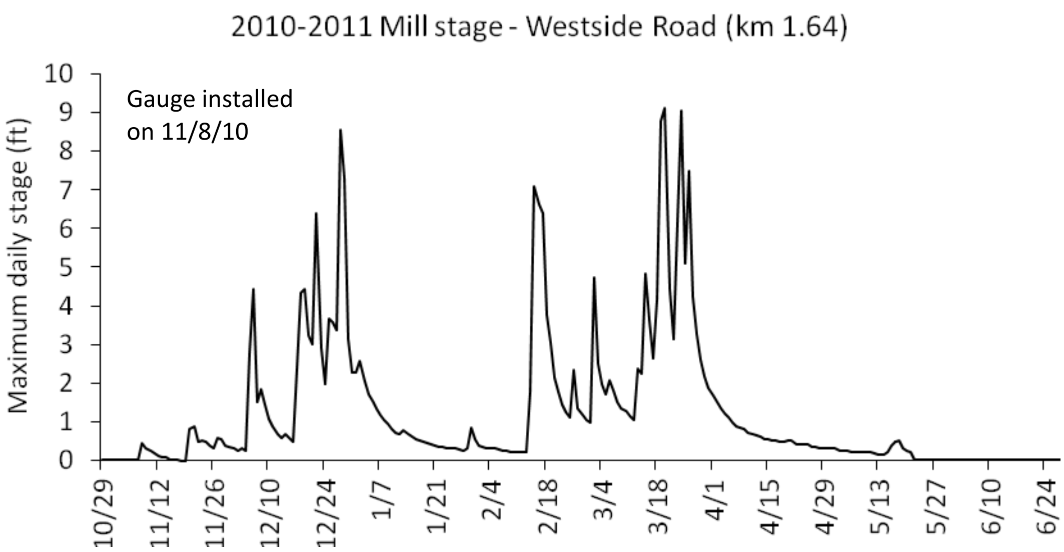
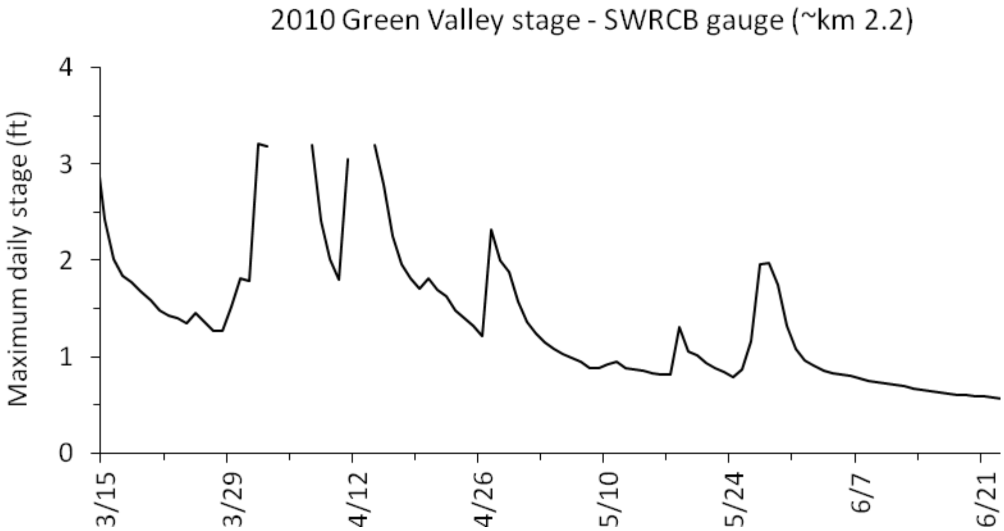




**Figure 18.** Stage height data collected where Westside Road crosses over Mill Creek at river km 1.64 during the winters of 2009-2010 and 2010-2011.



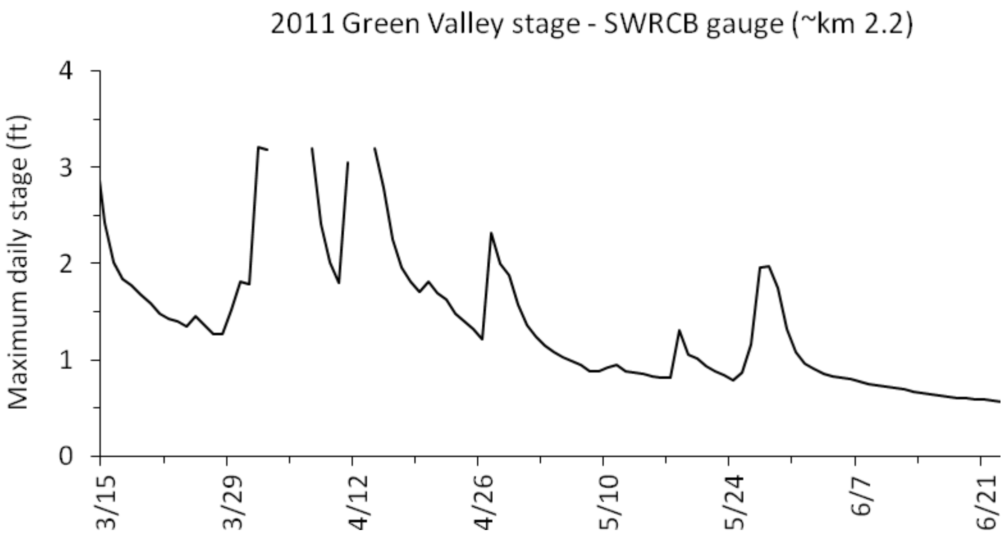




**Figure 19.** Stage data collected by the State Water Resources Control Board located approximately 2.2 km upstream of the mouth of Green Valley Creek. Missing data represents stage height > 3.33 ft.

*Smolt release comparisons*

In 2010, smolts were released into the Mill Creek pond on 3/22 and the Green Valley Creek pond on 3/25 (**Table 3, Figure 3, Figure 4**). Additionally, on 4/2 and 4/7, fish were either released into the stream or placed in an acclimation box at a site on Mill Creek and second site on Palmer Creek (**Table 3, Figure 3, Figure 4**). Boxes were opened for the first acclimation group on 4/7, and for the second group on 4/16 (**Table 3**).

In Green Valley Creek, despite strong efforts to retain smolts in the holding ponds, smolts were detected at the upper trap site the day after they were released into the pond, indicating that they were able leave the pond immediately (**Figure 20**). Approximately half of the fish detected passed by the lower trap site within a week of being released into the pond, whereas the other half remained for a minimum of three weeks (**Figure 20**). Fish were retained longer in Mill Creek, with a portion of the fish leaving the pond sooner than intended due to two high flow events in early April, but the majority leaving only after the pond was opened on 4/19, as indicated by detections at an antenna at river km 12.39 (**Figure 21**).

For all stream releases into Mill and Palmer Creeks, fish were detected at antennas downstream of their release sites the day following the release, and within two days at the Mill Creek trapsite at river km 2.0 (**Figure 22**, **Figure 23**). Similarly, upon release from the boxes, box-acclimated fish were detected at antennas downstream within one to two days of the box opening (**Figure 22**, **Figure 23**). The proportion of the PIT-tagged smolt-released fish that were later detected in the traps is an indicator of the number of fish that survived and left each tributary. The longer the fish were acclimated, the lower the proportion of fish detected leaving the streams, with the highest proportion of detections for the stream-released fish and the lowest for the pond-released fish in Mill Creek (**Table 3**).

**Table 3.** Summary of 2010 smolt releases into Mill, Palmer, and Green Valley Creeks.

| Tributary | Release date | Release type | Date box/pond opened | Days in pond/box | Total released | # PIT released | Number of unique PIT detections | Proportion unique PIT detections |
|---|---|---|---|---|---|---|---|---|
| Green Valley | 3/25 | pond | *NA* | *NA* | 3,095 | 499 | 384 | 0.77 |
| Mill | 3/22 | pond | 4/19 | 28 | 3,995 | 500 | 312 | 0.62 |
| | 4/2 | box | 4/7 | 5 | 463 | 250 | 218 | 0.87 |
| | | stream | *NA* | *NA* | 250 | 250 | 236 | 0.94 |
| | 4/7 | box | 4/16 | 9 | 453 | 250 | 206 | 0.82 |
| | | stream | *NA* | *NA* | 250 | 250 | 245 | 0.98 |
| Palmer | 4/2 | box | 4/7 | 5 | 823 | 250 | 242 | 0.97 |
| | | stream | *NA* | *NA* | 250 | 250 | 243 | 0.97 |
| | 4/7 | box | 4/16 | 9 | 808 | 250 | 225 | 0.90 |
| | | stream | *NA* | *NA* | 249 | 249 | 240 | 0.96 |

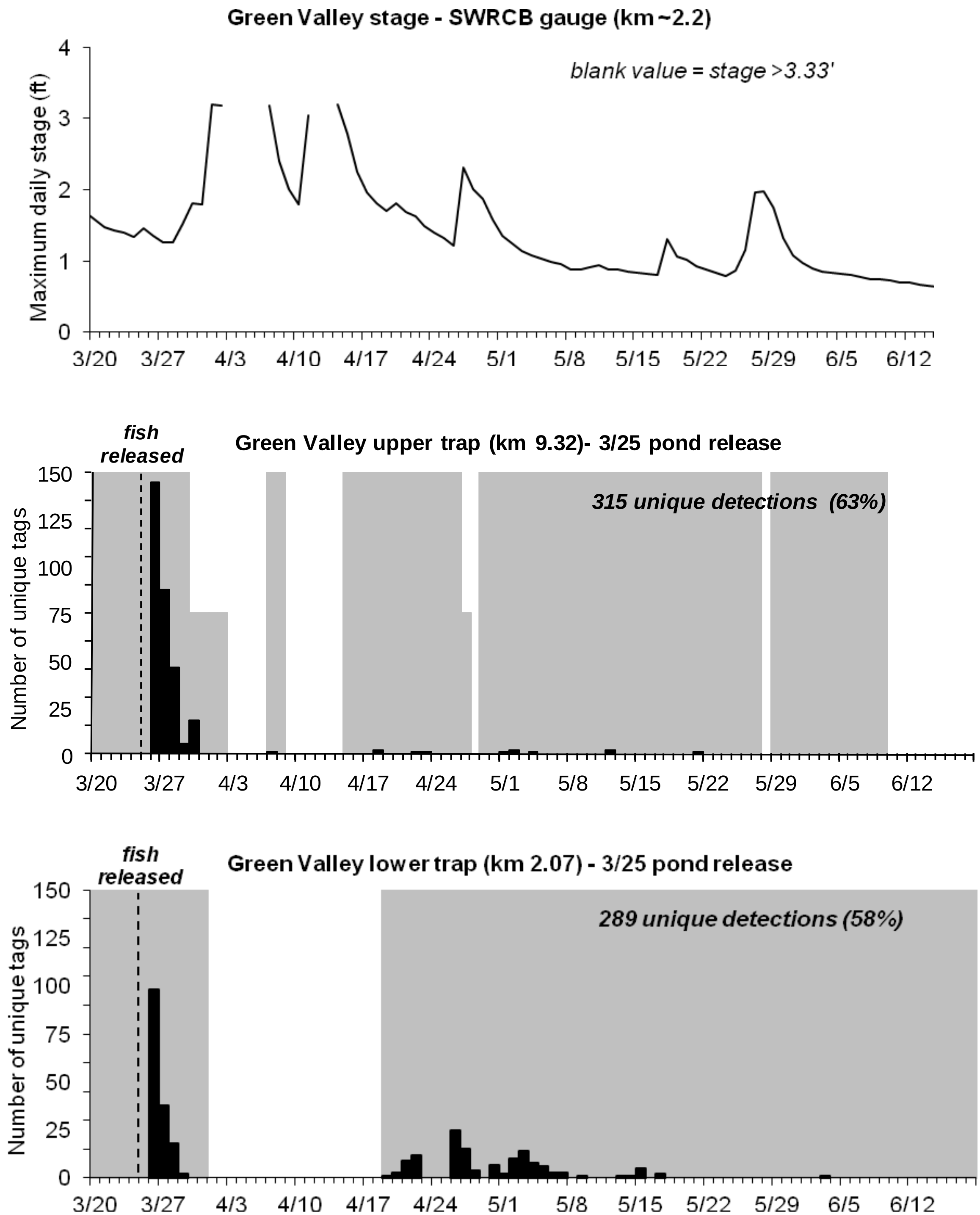



**Figure 20.** Migration timing of smolts released into a holding pond on Green Valley Creek on 3/25/10. Stage data was taken from the State Water Resource Control Board gauge.

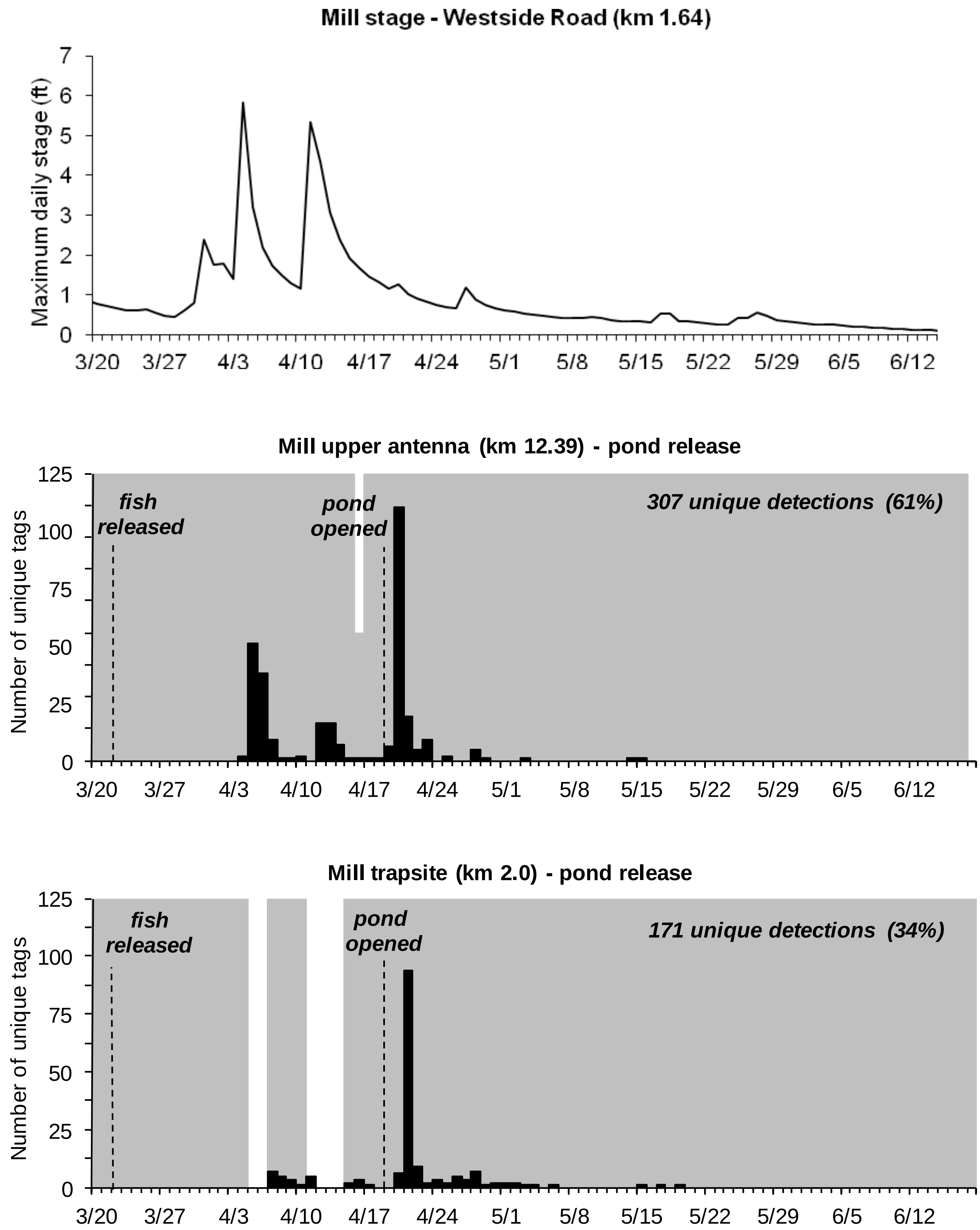



**Figure 21.** Migration timing of smolts released into a holding pond on Mill Creek on 3/22/10.

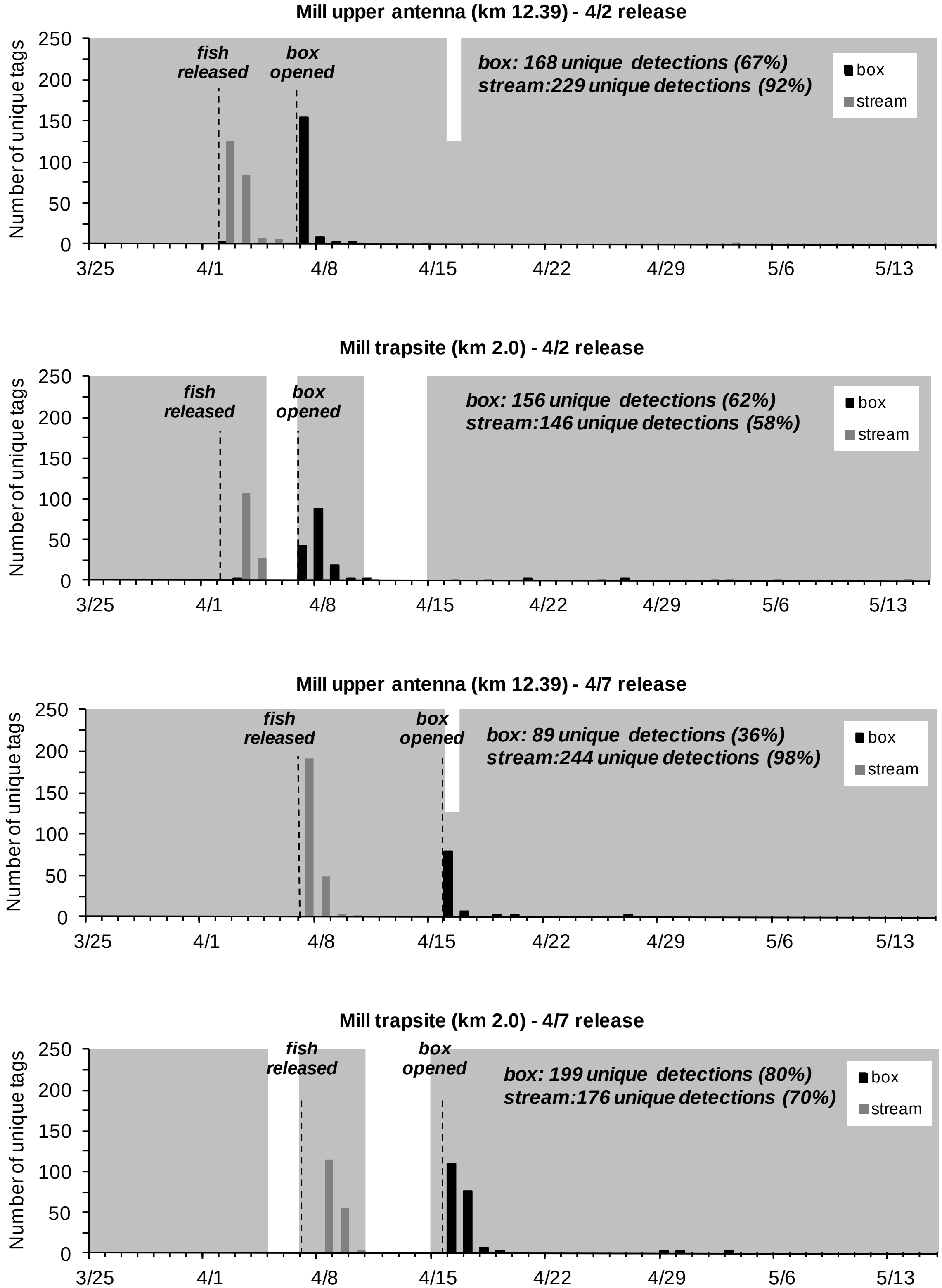



**Figure 22.** Migration timing of pond, box, and stream-acclimated smolts released into Mill Creek on 4/2 and 4/7/10.

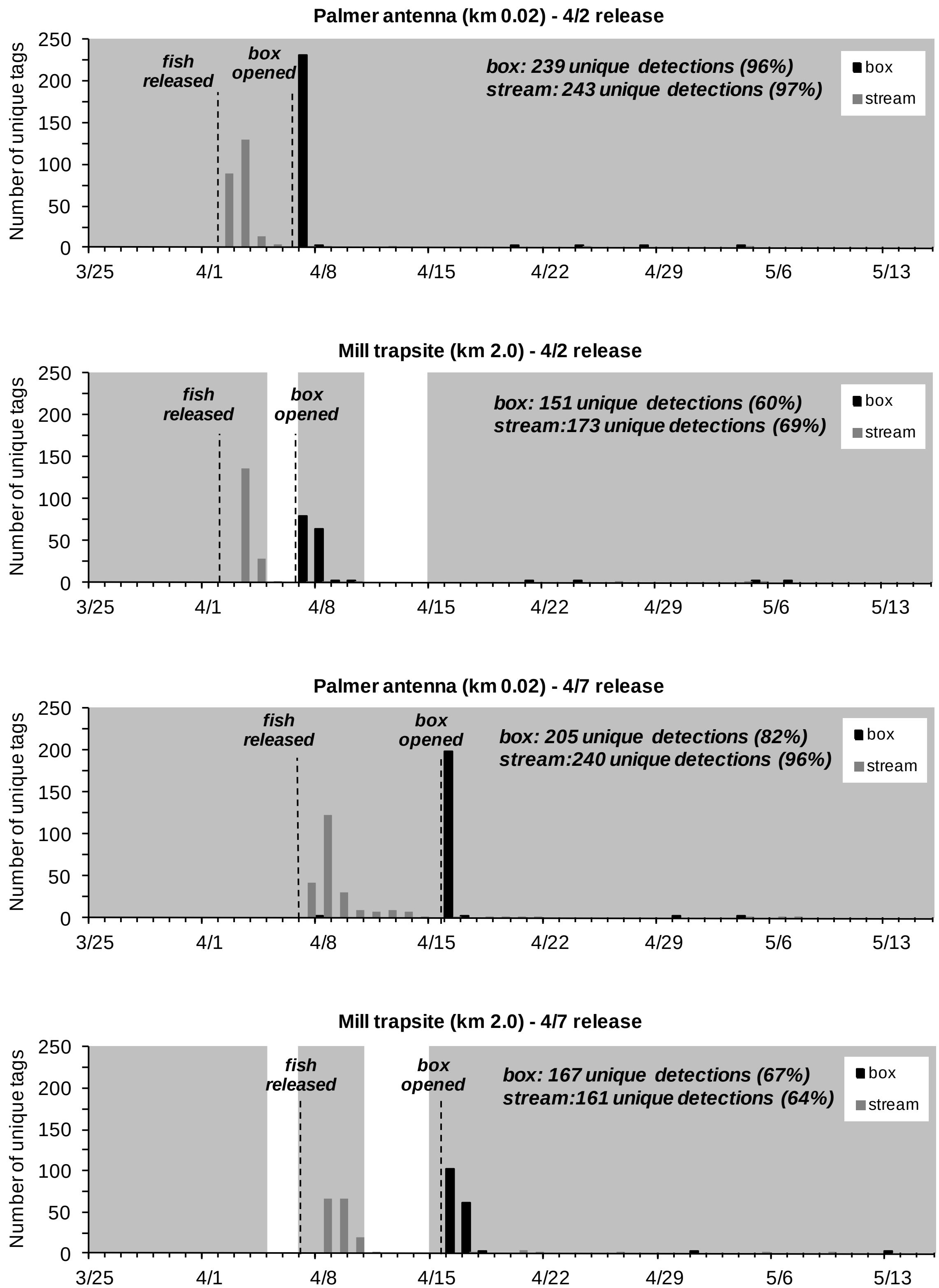



**Figure 23.** Migration timing of pond, box, and stream acclimated smolts released into Palmer Creek on 4/2 and 4/7/10.

### ***Discussion/recommendations***

Monitoring results for 2010 and 2011 documented thousands of coho smolts emigrating from Mill, Green Valley, and Grape Creeks **(Table 1)**, a positive indication that hatchery-released coho are able to survive and develop in program streams. Survival and growth were highest in Green Valley Creek during the winter of 2010-2011, a contrast to low smolt abundance and survival observed in previous years. Further monitoring through use of year-round PIT antennas placed at significant changes in habitat, in combination with additional monitoring of environmental variables, would help to unravel the high annual variation in survival observed in this stream. Efforts should be coordinated with the Gold Ridge RCD, which is conducting water quality monitoring on Green Valley Creek. If high survival is observed consistently in future years, the program could consider increasing the number of fish released into this stream.

Differences in survival, size, and run timing were observed between the spring and fall release groups (**Table 2, Figure 8, Figure 9, Figure 12, Figure 17**). As expected, more fish are lost to mortality for the spring release group, which must experience a full year in the stream as compared to the fall release group, which only experiences the winter season before leaving as smolts. Although stocking fish in the spring results in a smaller proportion of smolts than the fall release, we encourage the program to continue with stocking fish during both seasons as a way of hedging bets. Although not enough adults have returned to evaluate differences in marine survival among release groups, it is possible that the spring release group could have a higher adult return rate. Spring releases have also been valuable in estimating oversummer survival, an important metric in evaluating the long term potential of reestablishing self-sustaining runs in specific streams.

Only slight differences were observed in survival among genetic cross types in 2010, with RRxRR fish slightly lower than the RRxOC and OCxRR (**Figure 7**), suggesting that there was not a negative effect of hybridization with Olema Creek broodstock on instream overwinter survival of offspring.

PIT tagging a portion of all release groups and operating year-round antennas on Mill Creek proved to be an effective way of teasing apart survival from emigration (**Table 2**). As we observed during the two winters in this study, winter emigration can vary significantly from year to year which, in turn, can influence our conclusions. For example, it is possible that differences in winter emigration could explain the annual variation in survival in Green Valley Creek. Minimum apparent survival estimates in Green Valley Creek during the winters of 2007-2008 and 2008-2009 were less than 0.05 (UCCE and CSG unpublished data). It is possible that a high proportion of stocked fish left prior to installation of our traps each spring and true survival was much higher. We suggest applying the monitoring approach used on Mill Creek to additional representative program streams including Green Valley, Dutch Bill, and Willow Creeks. The combination of PIT tagging a portion of each release and operating year-round antennas in combination with downstream migrant traps would allow us to estimate both freshwater and marine survival among release groups in multiple streams.

Important insights were gained from the smolt acclimation trials conducted in 2010, and we found that there are tradeoffs to each method. While instream survival was highest for the direct stream releases, almost all of the fish left within a few days after being released. The box and pond acclimation were both successful at holding smolts in the stream for as long as the fish were prevented from leaving the boxes or ponds. The latter two methods had higher mortality than the direct stream releases and have the disadvantage of being vulnerable to storm events. For these reasons, we think that attempting to operate streamside acclimation tanks would be a worthwhile approach.

## Oversummer Survival Monitoring

### *Methods*

During the spring of 2010, six study reaches were selected in Green Valley, Mill, Palmer, and Grape Creeks to monitor oversummer survival and growth of hatchery-released juvenile coho salmon (**Figure 24 to Figure 26**). Reaches were between 220 and 370m long and contained between nine and 15 pools per reach. Fish were stocked at a density of approximately two fish/stream meter and densities changed throughout the summer as flows dropped. Prior to stocking, all fish were PIT tagged at Don Clausen Warm Springs Hatchery and measured for fork length (mm) and weight (g). In order to compare survival among three genetic cross-types (RRxRR, RRxOC, and OCxRR), fish were tagged according to cross type. In mid-June, the fish were released into each reach by carefully transporting them from a hatchery truck to individual pools using aerated backpacks. To account for fish that moved out of the study site, a stationary PIT tag antenna was installed and operated at the downstream end of each reach between June and October.

In coordination with a National Fish and Wildlife Foundation funded fine scale study comparing monthly summer survival in relation to environmental variables, each reach was "wanded" monthly between June and October using a portable PIT tag detection system. Additional PIT tag wanding was also conducted upstream of each reach to account for any fish that migrated upstream of the reach. These data were used to estimate monthly survival for the fine scale study and cumulative estimates of survival for this study. A robust design mark recapture model (Pollock 1982, Kendall 1997) as implemented in program MARK (White and Burnham 1999) was used to estimate survival for each reach.

To collect size data at the end of the summer, a one-pass electrofishing sample was conducted in each reach where water quality conditions were suitable in late September/early October. All coho were scanned for the presence of a PIT tag, inspected for an adipose clip, and measured for length and weight. Fin tissue was also collected on wild coho (no adipose clips) for subsequent genetic analysis. Growth rate in length and weight were calculated for individual PIT-tagged fish using the same formulas used for overwinter growth (*see Overwinter survival monitoring section*) except that $FL_1$ and $WT_1$ were length or ln(weight) at the hatchery prior to spring release and $FL_2$ and $WT_2$ were length or ln(weight) in the electrofishing sample.


**Figure 24.** Summer survival reaches and antenna sites on Grape Creek, 2010.

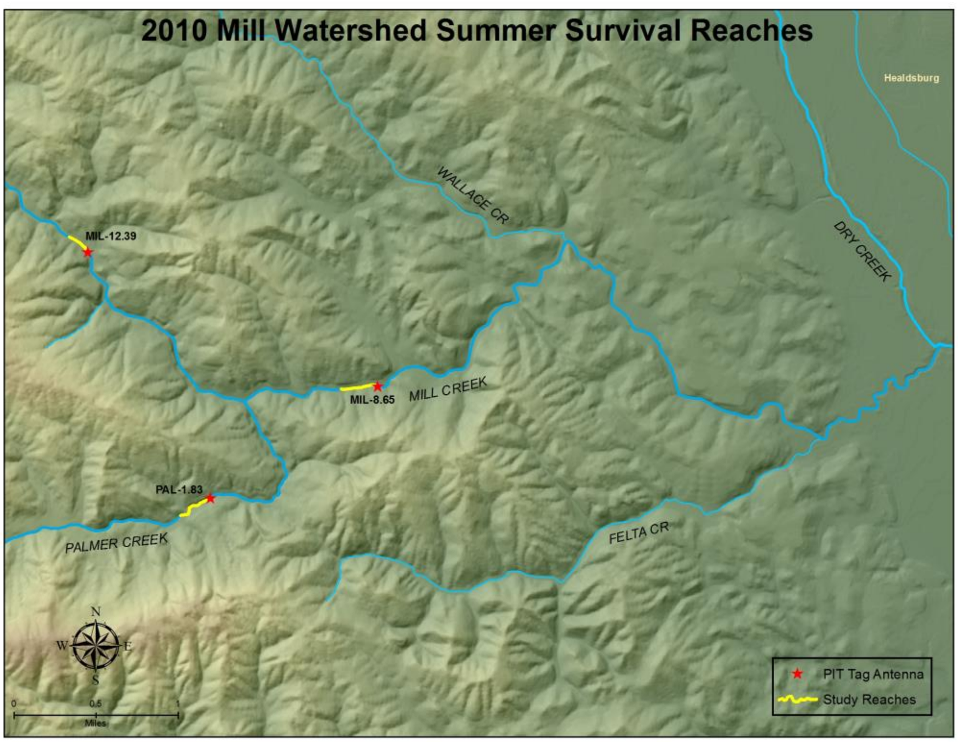



**Figure 25.** Summer survival reaches and antenna sites in the Mill Creek watershed, 2010.

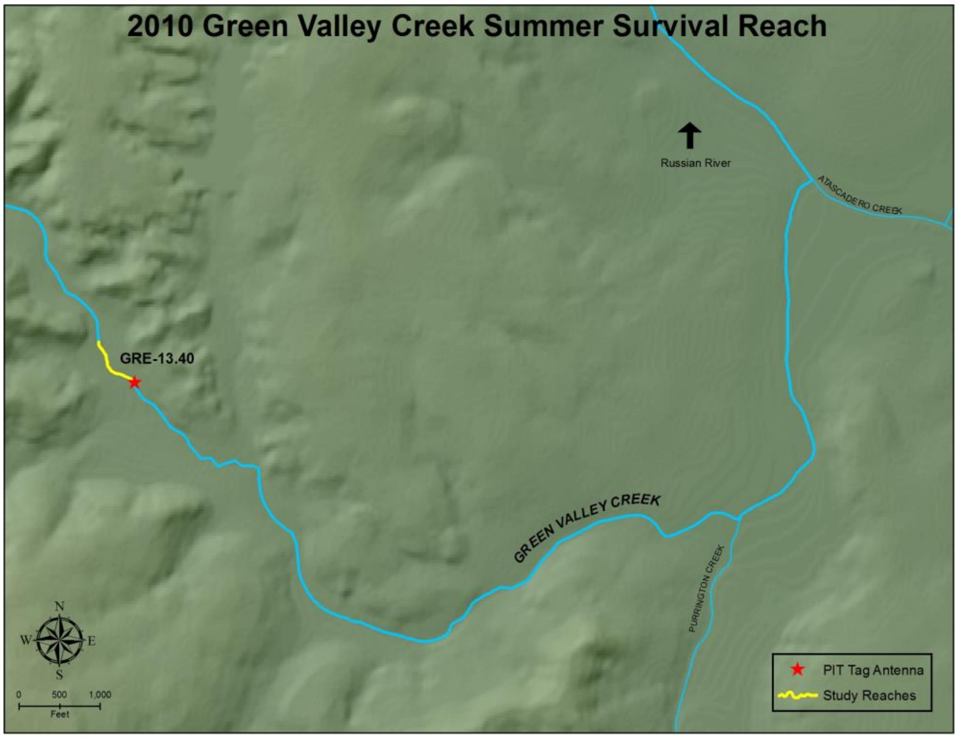



**Figure 26.** Summer survival reaches and antenna sites in Green Valley Creek, 2010.

## *Results*

### *Summer survival*

Oversummer survival of coho young-of-year (yoy), between the mid-June release and the final wand sample in mid-October, varied among streams and between reaches within streams (**Figure 27**). Oversummer survival was lowest in Grape Creek (0.19 in GRP-0.16, 0.42 in GRP-1.14) (**Figure 27**). While these rates are relatively low for this study, they are within the range of streamwide survival estimates on other Coho Broodstock Program streams between 2005 and 2009 (Obedzinski et. al. 2009, UCCE and CSG unpublished data). Survival within the Mill Creek watershed ranged between 0.6 in MIL-12.39 and 0.75 in the PAL-1.83 (**Figure 27**). Survival in the Green Valley Creek reach (0.87) was higher than any summer survival rate previously observed in Russian River tributaries as part of the Coho Broodstock Program's monitoring effort (Obedzinski et. al. 2009, UCCE and CSG unpublished data) (**Figure 27**). While there was no strong evidence for a difference in survival among cross types, survival was lowest for the RRxRR cross type in four out of six reaches (**Figure 28**).

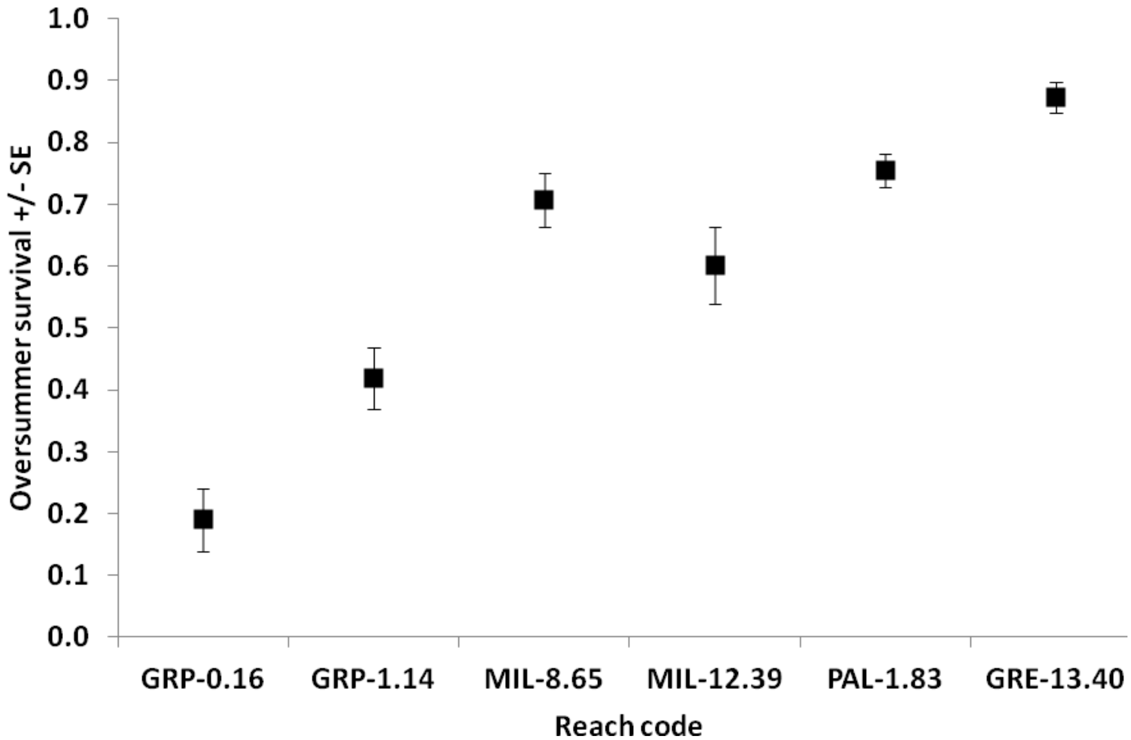



**Figure 27.** Oversummer survival (June to October) of juvenile coho released into program stream reaches in spring 2010. Reach codes are created using a three letter code for a stream (GRP= Grape, MIL=Mill, PAL=Palmer, GRE=Green Valley) followed by the river kilometer at the downstream end of the reach (e.g. GRP-0.16 is a reach on Grape Creek that begins 0.16 km from the mouth of Grape Creek).

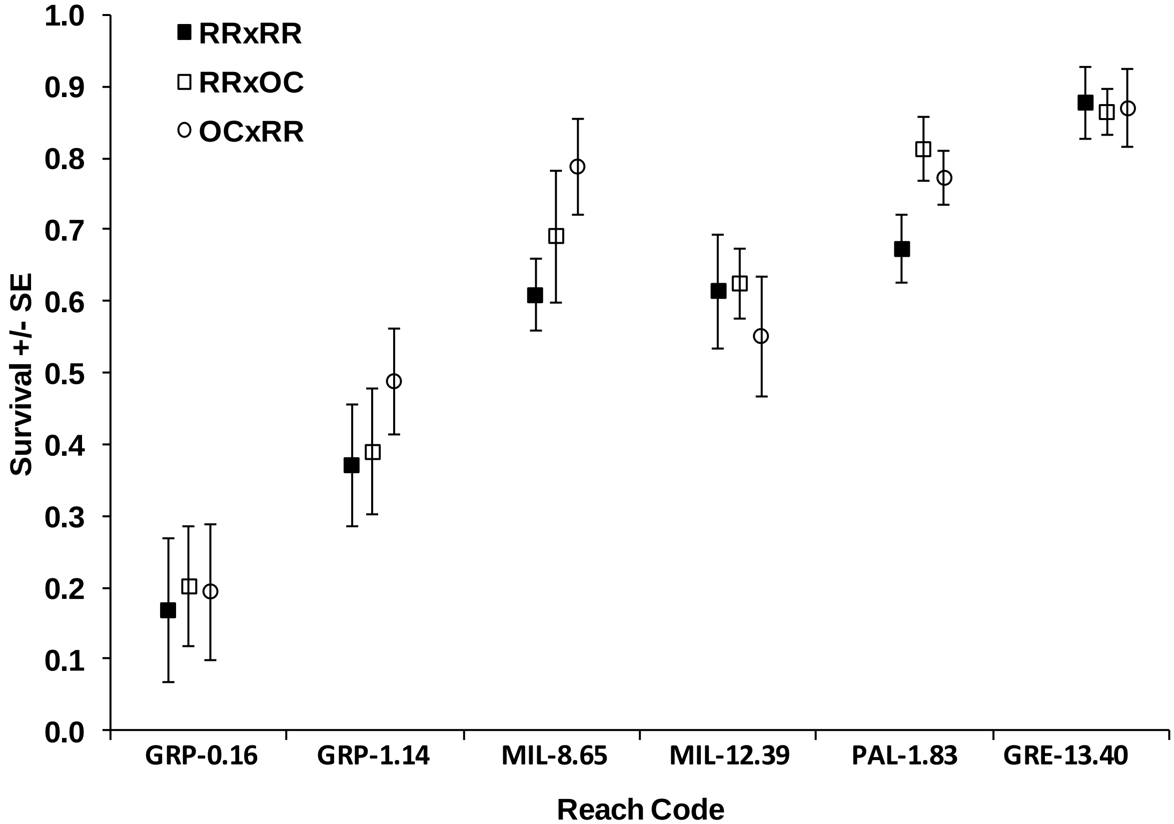



**Figure 28.** Oversummer survival (June to October) of three genetic cross-types of juvenile coho released into program stream reaches in spring 2010. Cross-types include Russian River female by Russian River male (RRxRR), Russian River female by Olema Creek male (RRxOC), and Olema Creek female by Russian River male (OCxRR).

### *Size and growth*

Between the first week of June when the coho were tagged and the fall electrofishing sample, coho yoy increased in length and weight, and decreased in condition factor (**Table 4**). On average, coho increased in size by 9mm and 1.1g over the course of the summer, and average condition factor decreased by 0.12. Growth rates were similar among reaches with the highest growth observed in MIL-8.65 and the lowest in GRP-1.14 (**Figure 29**). No clear differences in growth among cross types were observed (**Figure 30**).

**Table 4.** Average fork length (FL), weight (WT), and condition factor (K) of all juvenile coho prior to release in spring and coho captured during fall electrofishing in 2010.

| Reach Code | Prestocking Size | | | | | Fall Size | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Date Range | N | FL (mm) +/- 1 SD | WT (g) +/- 1 SD | K +/- 1 SD | Sample Date Range | N | FL (mm) +/- 1 SD | WT (g) +/- 1 SD | K +/- 1 SD |
| GRP-0.16 | 6/1 - 6/4 | 494 | 66.0 +/- 5.5 | 3.48 +/- 1.06 | 1.18 +/- 0.09 | 10/27 | 6 | 74.5 +/- 7.3 | 4.38 +/- 1.15 | 1.04 +/- 0.06 |
| GRP-1.14 | 6/1 - 6/4 | 507 | 66.8 +/- 4.8 | 3.50 +/- 0.87 | 1.15 +/- 0.08 | 10/27 | 48 | 77.0 +/- 7.1 | 4.90 +/- 1.76 | 1.04 +/- 0.08 |
| MIL-8.65 | 6/1 - 6/4 | 808 | 66.8 +/- 5.9 | 3.58 +/- 1.14 | 1.17 +/- 0.08 | 10/5 - 10/7 | 264 | 77.6 +/- 6.4 | 5.16 +/- 1.33 | 1.09 +/- 0.10 |
| MIL-12.39 | 6/1 - 6/4 | 812 | 65.6 +/- 4.9 | 3.43 +/- 0.91 | 1.19 +/- 0.09 | 9/27 - 9/29 | 218 | 74.4 +/- 5.8 | 4.32 +/- 1.19 | 1.02 +/- 0.10 |
| PAL-1.83 | 6/1 - 6/3 | 823 | 65.9 +/- 5.5 | 3.53 +/- 1.07 | 1.20 +/- 0.09 | 9/30 - 10/4 | 415 | 74.4 +/- 7.0 | 4.42 +/- 1.47 | 1.04 +/- 0.13 |
| GRE-13.40 | 6/1 - 6/4 | 506 | 65.8 +/- 5.2 | 3.39 +/- 1.04 | 1.16 +/- 0.09 | 10/8 - 10/11 | 252 | 75.0 +/- 6.2 | 4.54 +/- 1.27 | 1.06 +/- 0.08 |

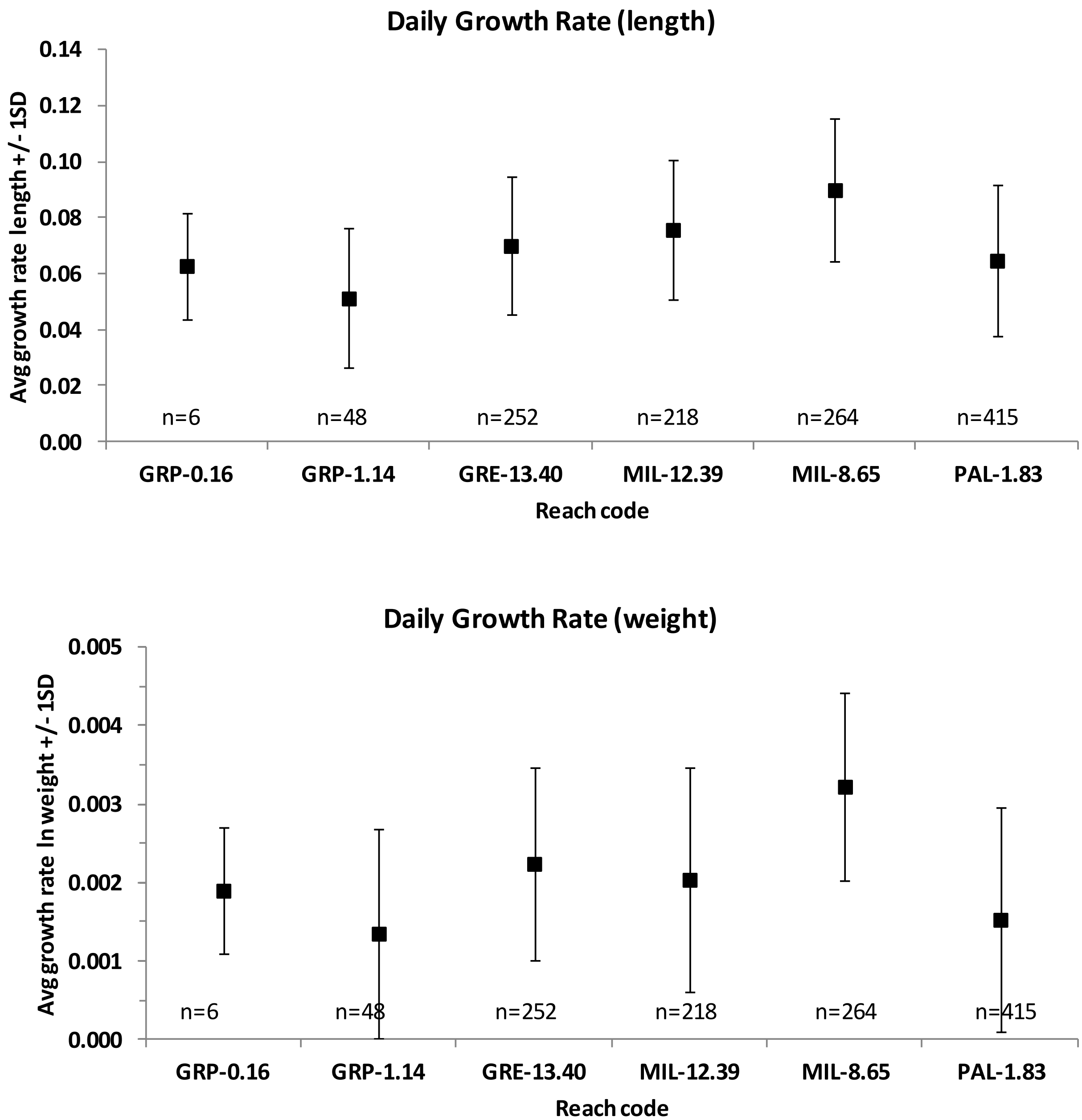



**Figure 29.** Average specific growth rates of juvenile coho stocked into reaches of Russian River tributaries in spring and recaptured in fall 2010.

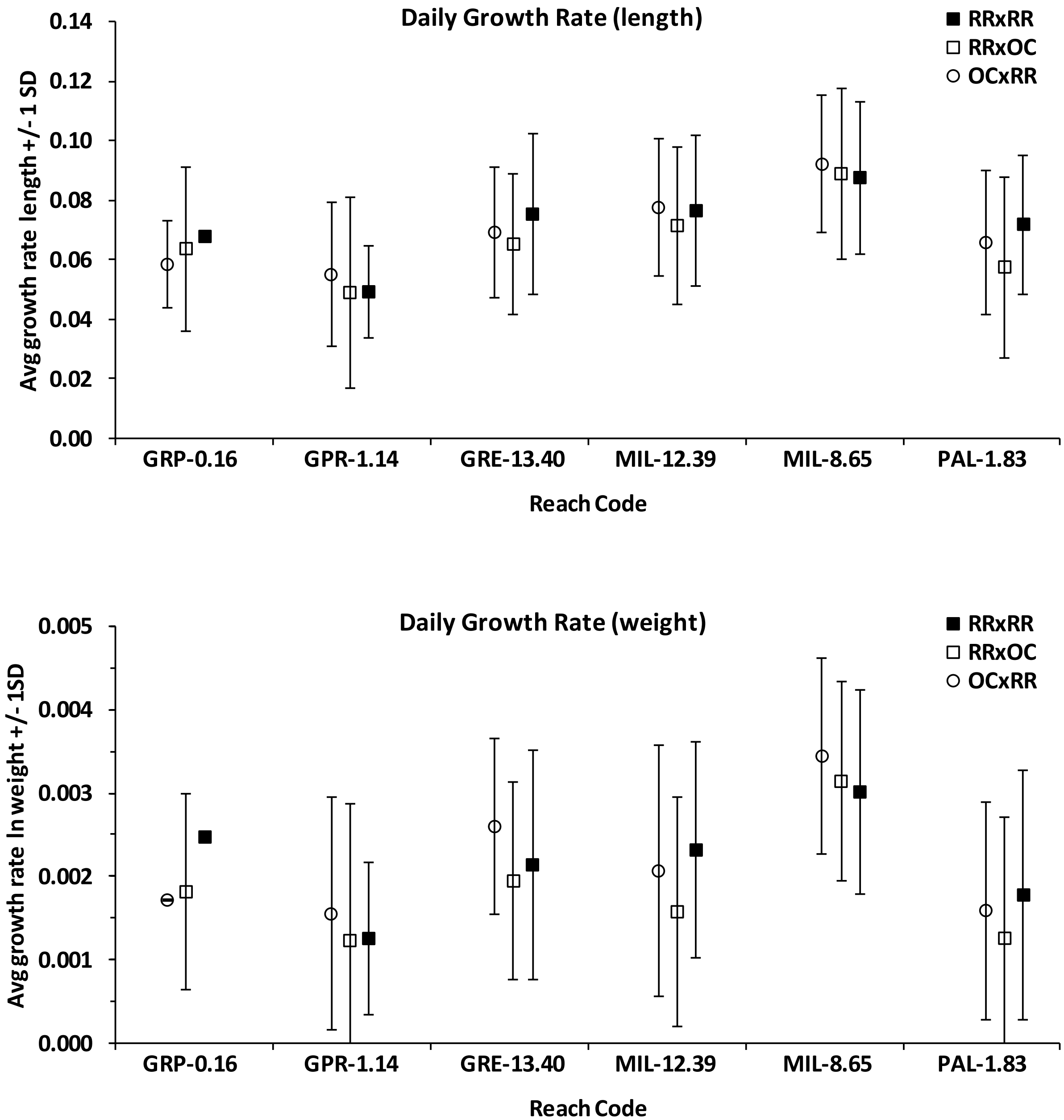



**Figure 30.** Average specific growth rates of three genetic cross-types of juvenile coho stocked into reaches of Russian River tributaries in spring and recaptured in fall 2010. Note that sample size was extremely small in GRP-0.16 (1-3 fish).

### *Discussion/recommendations*

The summer of 2010 was a relatively “wet” year, with higher winter and spring precipitation than in recent years. With the exception of the lower Grape Creek reach, all of the spring release reaches were selected because they were of relatively high habitat quality and were known to remain wet even in years with low precipitation. For this reason, we think that the survival rates observed represent what is possible under the most favorable conditions in Russian River tributaries. Conditions in many reaches of Russian River tributaries are similar to the lower Grape Creek reach, which is characterized by minimal instream cover and extreme low flow conditions during summer months. While the RRCSCBP can accommodate these potential summer bottlenecks by choosing not to stock fish in reaches with poor quality summer habitat, offspring of returning adults will ultimately be affected. We have observed this in Mill and Felta Creeks where returning adults spawn low in the watershed each year, and in most summers these reaches dry out. For long term recovery, it will be critical to improve summer rearing conditions through flow and habitat enhancement projects so that offspring of returning hatchery adults can complete their life cycles. In the interim, we recommend that the RRCSCBP continue to release fish in the spring into reaches that are known to remain wet all summer. To address the fact that potentially thousands of wild juveniles may become stranded in the lower Mill Creek watershed each year, we think that it is important that the program develops and implements a fish rescue plan.

## Escapement monitoring

The flashy nature of Russian River tributaries during the winter months presents numerous challenges for adult coho monitoring. In order to get the most accurate and comprehensive data, multiple methods were used to develop a minimum count for escapement in the Russian River watershed, including spawner surveys, adult trapping, PIT tag detection systems, video monitoring, and snorkel surveys.

### *Methods*

#### *Spawner surveys*

Spawner, redd, and carcass surveys were conducted between November, 2010 and March, 2011 on seven streams in which the RRCSCBP anticipated the return of adult program coho (Sheephouse Creek, Gray Creek, Gilliam Creek, Dutch Bill Creek, Green Valley Creek, Mill Creek, and Palmer Creek). Selected spawning reaches within these streams were surveyed on a weekly basis, as flow conditions allowed. Devil Creek and Freezeout Creek were also surveyed, though not on a weekly basis.

Spawner surveys were conducted according to CDFG protocols (Gallagher and Gallagher 2005). During surveys, the number of live spawners, carcasses, and redds were recorded. Live adult fish were identified to species and sex. Approximate fork length, fish condition, and location were also recorded. Photographs and video footage of spawning behavior were taken to help confirm sightings and identification. All carcasses were scanned for presence of a CWT, PIT tag, adipose clip, and other marks or tags. If a CWT was detected, the head of the carcass was removed and the CWT was retrieved to determine release year, season, and stocking stream. A unique identifier tag was attached to all carcasses to estimate escapement and observer efficiency. Additional sampling from carcasses included scale sampling, fin clipping for genetic analysis, and otolith extraction.

When a completed redd was observed, pot and tail spill measurements were taken (**Figure 31, Figure 32**). If a redd was built by an unknown species of salmonid, these metrics aided in species identification (Gallagher and Gallagher 2005). Redd locations were flagged and mapped using a handheld GPS unit. On subsequent visits, redd age and condition was noted until the redd was no longer visible.

**Figure 31.** A spawner surveyor measures a redd in Mill Creek, January, 2011.

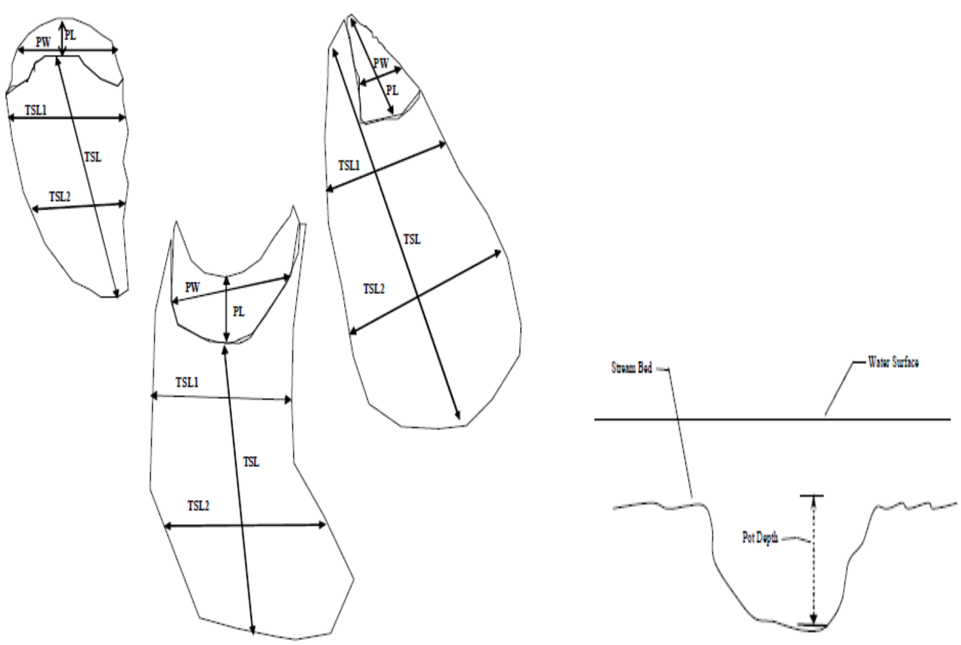



**Figure 32.** Examples of metrics taken from salmonid redds during spawner surveys (taken from Gallagher et al. 2007).

### *Adult trapping*

A resistance board weir and trap was operated on Mill Creek during the winter of 2010-2011 at river km 2.35 (**Figure 33**). A resistance board weir was chosen because of the flashy nature of Russian River tributaries and the difficulties associated with operating fixed weirs, which often washed downstream during high flow storm events in previous years. The floating weir panels of a resistance board weir are designed to rise and fall with changes in the hydrograph and allow debris to wash over the top. The design used for construction of the trap followed the general design from the Alaska Department of Fish and Game's Resistance Board Weir Panel Construction Manual (Stewart 2002), and incorporated modifications suggested by Sean Gallagher (CDFG) and Sean Hayes (NMFS).

The trap was checked at least once per day, and up to three times per day during the peak run. Fish captured in the trap were measured to fork length and scanned for presence of marks/tags. Floy tags and an opercule punch were applied (**Figure 34**), and the fish were released upstream. Re-sightings of floy-tagged fish during spawner surveys would have been used to estimate adult abundance, had enough fish been captured.

**Figure 33.** Mill Creek resistance board weir and trap, December, 2010.

**Figure 34.** An adult coho salmon with opercule punch and floy tag in the Mill Creek adult trap. December, 2010.

### *Video monitoring*

During fall and early winter of 2010-2011, SCWA created video clips of all potential coho sightings at the Wohler Dam fish ladders. Biologists from UCCE and CSG, SCWA, and NMFS reviewed these video clips to confirm any coho sightings. Each observer identified each fish to species, with a varying level of confidence (1-4). These observations and ratings were added to the minimum count of coho observations in the Russian River. This data is helpful in that it allows us to know approximately how many fish are moving through the system, and at what times and flows.

### *Snorkel surveys*

Snorkel surveys were conducted throughout the summer of 2011 in order to document adult returns and successful spawning events from the previous winter. The goal of these surveys was to determine presence or absence of wild coho salmon yoy in Freezeout, Sheephouse, Gilliam, Thompson, Gray, Devil, Dutch Bill, Green Valley, Purrington, Mark West, Porter, Mill, Felta, Palmer, Angel, Crane, Grape, and Pena Creeks. Dive reaches in each of these creeks were selected based on habitat suitability for spawning and rearing, and landowner access. In each reach, two-person teams snorkeled every pool and recorded the number of juvenile coho and the composition of other aquatic species (**Figure 35**). The number of ad-clipped (hatchery) fish, as well as non-clipped (wild) individuals was recorded.

**Figure 35.** A snorkeler searches for juvenile coho in Mill Creek.

## *Results*

### *Spawner surveys*

In 2010-2011, twenty-four live coho, seven coho carcasses, nine steelhead, and three unknown adult salmonids were observed in project streams during spawner surveys (**Table 5**). Twelve coho redds, one steelhead redd, and eleven redds from unknown salmonids were also observed. The majority of unknown redds were observed when large numbers of coho were known to be in the system, so they were likely coho redds. Observations from Grape Creek and Devil Creek were not made during planned spawner surveys, but were a result of sightings made during PIT tag antenna maintenance and by third party observers.

We were unable to generate an estimate of the total number of adult spawners based on spawner survey observations due to the low numbers of fish and redds observed, however the data was used to establish a minimum count and to provide a relative comparison to minimum counts from previous and subsequent years.

Distribution of observed redds is shown in **Figure 36** through **Figure 39**. The number of redds observed on Sheephouse and Dutch Bill Creeks was so low that no patterns in distribution could be determined (**Figure 36, Figure 37**). On Green Valley Creek, redds were concentrated high in the spring and fall stocking reaches, however, it is difficult to draw conclusions because a significant portion of the spawning habitat could not be surveyed due to lack of landowner access (**Figure 38**). In Mill Creek, all coho redds and most steelhead/unknown redds were found in the lowest survey reach, downstream of a partial fish passage barrier located upstream of the adult trap site (**Figure 39**).

Detailed information on spawner survey methods and results in comparison to previous years are documented in our annual reports which can be downloaded at:
http://ca-sgep.ucsd.edu/russianrivercoho

**Table 5.** 2010-2011 Spawner survey summary table by stream.

| 2010-2011 Spawner Survey Summary Table | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Stream** | **Number of Surveys** | **Live Coho** | **Coho Carcasses** | **Coho Redds** | **Live Steelhead** | **Steelhead Redds** | **Unknown Salmonids** | **Unknown Carcasses** | **Unknown Salmonid Redds** |
| Sheephouse Creek | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Freezeout Creek | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gilliam Creek | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gray Creek | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Devil Creek | 1* | 5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Dutch Bill Creek | 16 | 5 | 0 | 2 | 3 | 0 | 0 | 1 | 0 |
| Green Valley Creek | 8 | 7 | 1 | 4 | 6 | 1 | 0 | 0 | 2 |
| Mill Creek | 23 | 7 | 5 | 5 | 0 | 0 | 2 | 3 | 7 |
| Palmer Creek | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Grape Creek | 0* | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| **TOTAL** | **62** | **24** | **7** | **12** | **9** | **1** | **3** | **4** | **11** |

*Observations from Grape Creek and Devil Creek were not made during planned spawner surveys, but were a result of sightings made during PIT tag antenna maintenance and by third party observers.

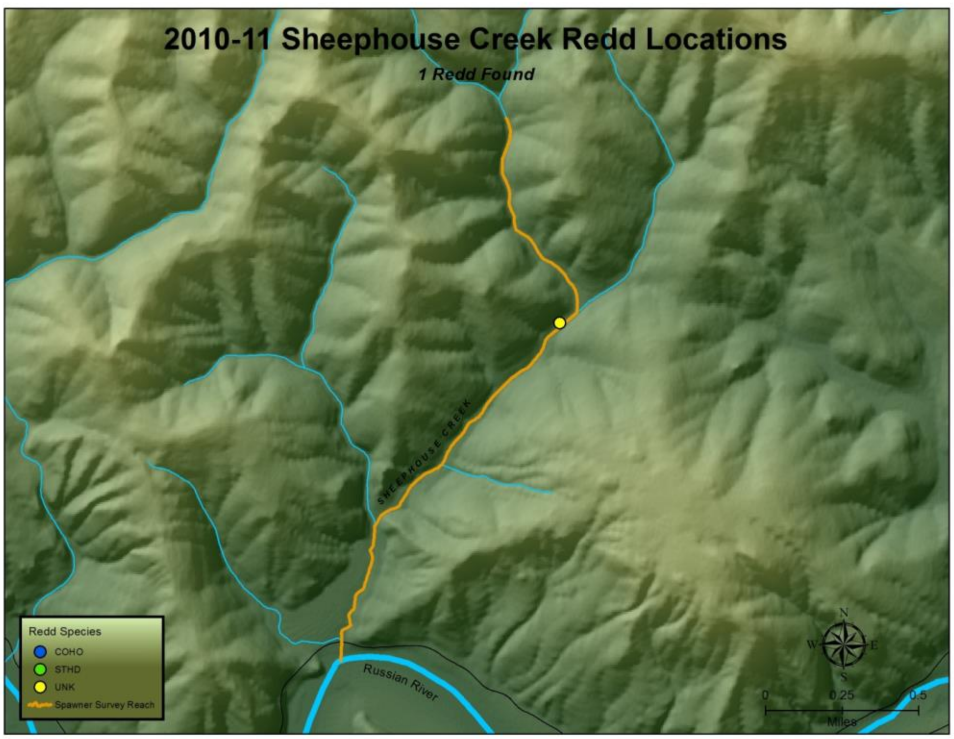



**Figure 36.** Sheephouse Creek spawner survey reaches and redd locations.

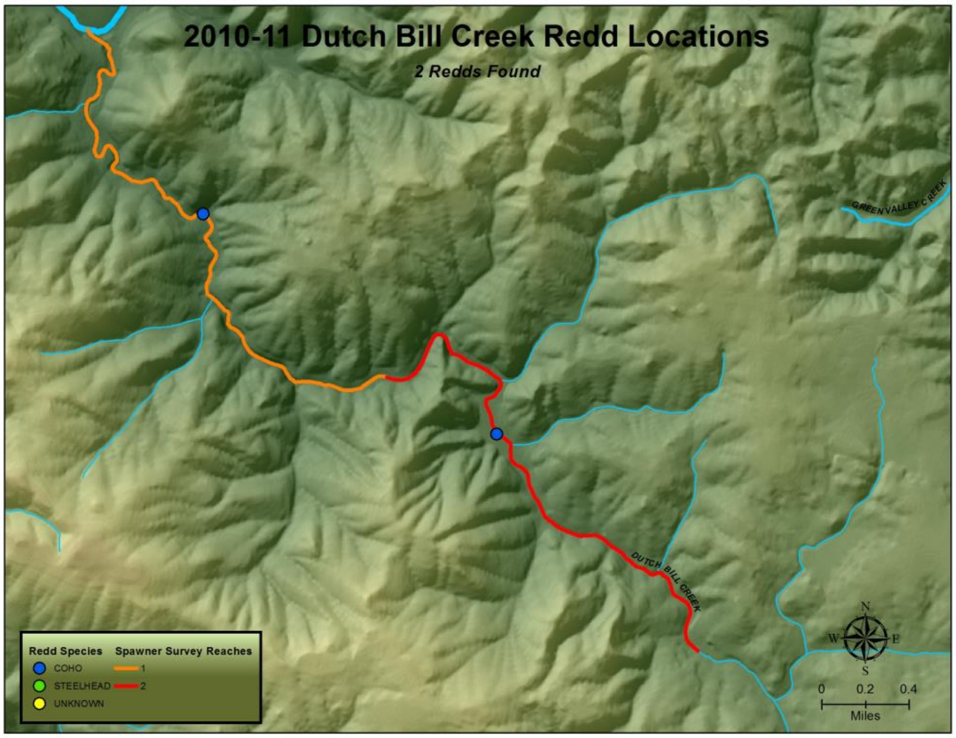



**Figure 37.** Dutch Bill Creek spawner survey reaches and redd locations.

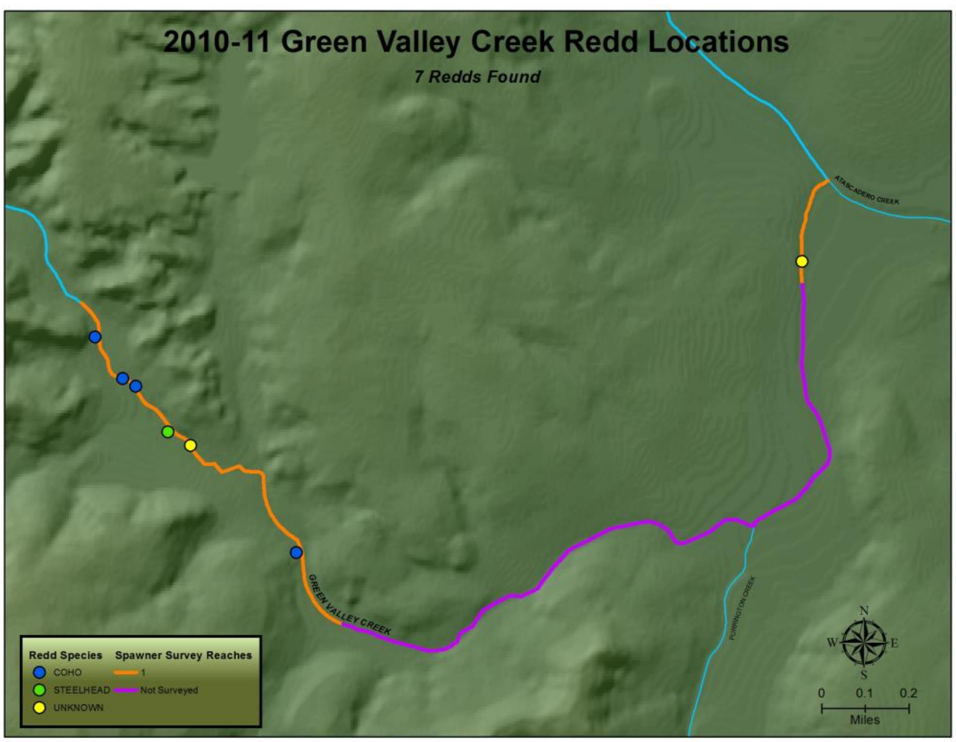



**Figure 38.** Green Valley Creek spawner survey reaches and redd locations.

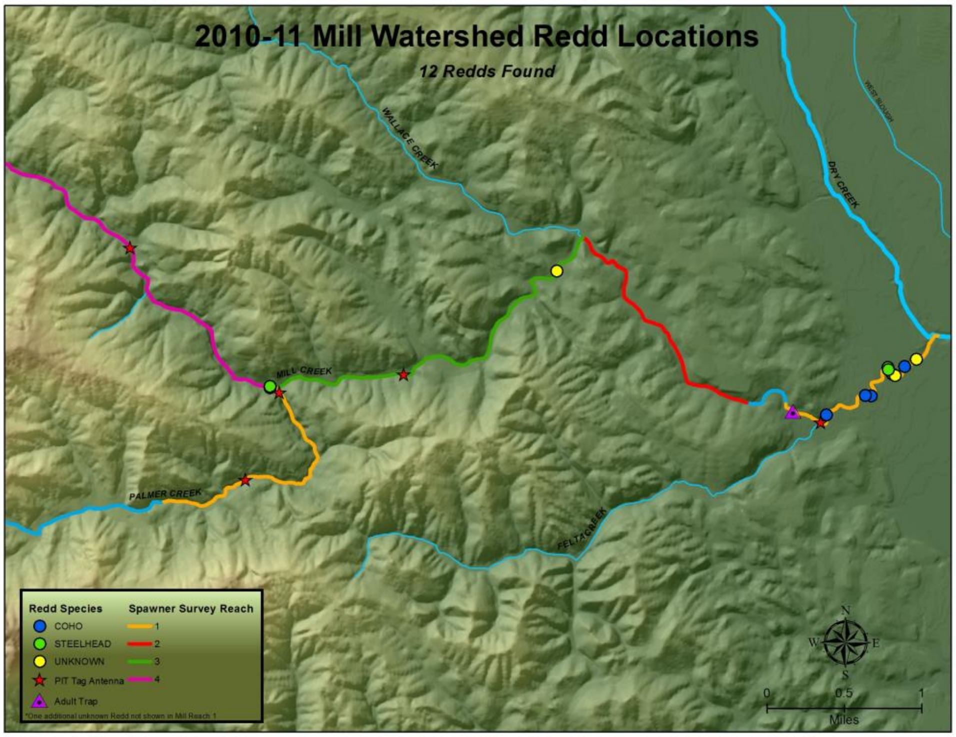



**Figure 39.** Mill Creek watershed spawner survey reaches and redd locations.

### *Adult trapping*

During the winter of 2010-2011, a total of nine individual coho were captured in the Mill Creek trap **(Table 6, cover photo**). Seven of the coho were larger three-year-old adults and two of the coho were two-year-old jacks **(Table 6)**. All fish were captured between 12/6-12/8/10 and were adipose fin clipped (hatchery origin) (**Table 6**). One coho was captured on 12/7 and recaptured the next day on 12/8 (**Table 6**). No other captures of adult salmonids were made.

**Table 6.** Summary of all fish captured at the Mill Creek adult trap during the 2010-2011 season.

| Mill Creek Adult Trap Summary 2010-2011 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Species | Ad Clip | Sex | FL (cm) | Girth (cm) | Estimated Weight (g) | Recap | Floy Tag Applied | Punch type | Pit tag applied | Comments |
| 12/6/2010 | Coho | Y | F | 62 | 33.5 | 2665.10 | N | Y | circle | Y | Healthy. Took pics. |
| 12/6/2010 | Coho | Y | M | 58 | 30.5 | 2066.62 | N | Y | circle | Y | Caudal peduncle deformity |
| 12/6/2010 | Coho | Y | M | 45.5 | 22.5 | 882.28 | N | Y | circle | N | |
| 12/7/2010 | Coho | Y | M | 73 | 35.6 | 3543.69 | N | N | circle | N | Smolt release fish, Mill Creek, 2009 |
| 12/7/2010 | Coho | Y | M | 65 | 34 | 2878.09 | N | Y | circle | Y | |
| 12/7/2010 | Coho | Y | F | 59.1 | 29.2 | 1930.13 | N | Y | circle | Y | |
| 12/7/2010 | Coho | Y | F | 57.1 | 29.5 | 1903.32 | N | Y | circle | Y | predator wound |
| 12/7/2010 | Coho | Y | M | 44.5 | 21.5 | 787.90 | N | Y | circle | Y | |
| 12/8/2010 | Coho | Y | F | 68.5 | 34.5 | 3122.92 | N | Y | circle | Y | Kype not well defined |
| 12/8/2010 | Coho | Y | F | n/a | n/a | n/a | Y | N | circle | N | Recap fish. Lost Floy tag. |

Trap related disturbance and mortality

In the late afternoon of December 8th, 2010, three adult coho were observed washing up on the upstream side of the adult trap weir. They appeared to be fish that had been worked up earlier that day (size, color, floy tag). The fish were continually washing up on the weir out of the water before vigorously swimming upstream (**Figure 40**). This behavior was documented and the trapping crew stood ready to transfer fish downstream if they were unable to free themselves after washing up. Our crew stayed and watched the fish until it was too dark to observe them any longer. Upon checking the trap the next day, one dead coho was discovered on the weir. It was a fish that had been captured and tagged two days prior. Following this incident, a small section of weir was opened to allow adult passage. No other mortalities were observed and no captures were made after that point.

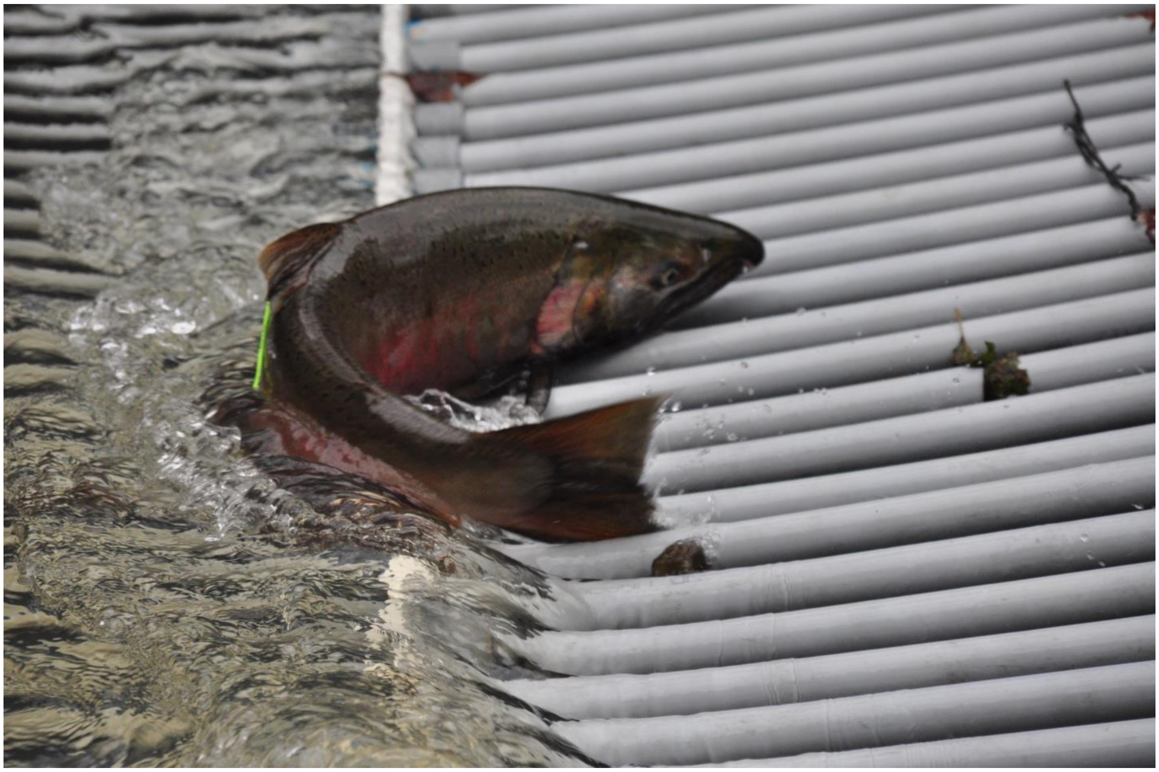


**Figure 40.** An adult coho briefly washes up on the Mill Creek adult trap. December, 2010.

Comparison of trap data with snorkeling and PIT antenna data

In early January, a snorkel survey in the large pool (waterfall pool) upstream of the adult trap revealed that a minimum of 30 adult coho had passed the trap. It appeared that these fish were unable to travel any further upstream due to a human-modified waterfall in the creek. These results lead us to question our adult trap capture efficiency (8 captures out of 30+ fish).

Pass through PIT tag antennas installed in project streams were operated throughout the winter season, as flows allowed. The PIT tag antennas in Mill Creek produced more detections of adult coho than the adult trap (31 on antennas, 9 in trap), and enabled estimation of the total number of adult spawners on Mill Creek (141). The antennas withstood higher flows when the trap became unfishable, or fish were able to easily swim around the trap (**Figure 41**, **Figure 42**).

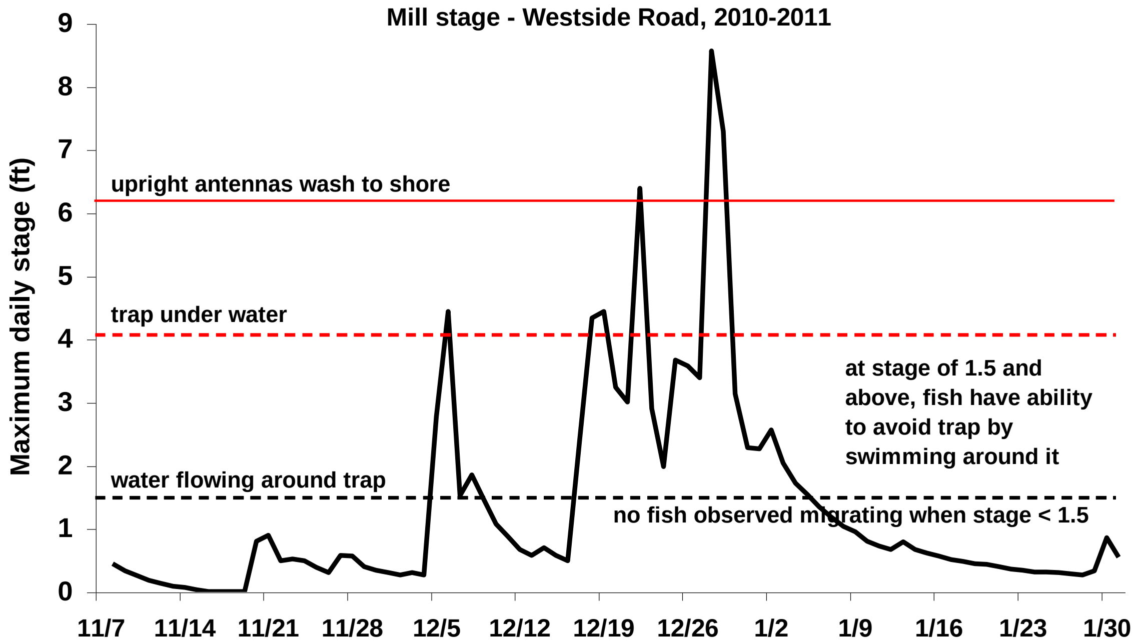



**Figure 41.** Operation status of Mill Creek adult trap and PIT tag antennas in relation to stage height.

**Figure 42.** Mill Creek adult trap in high flow conditions when fish are able to swim around and over the trap.

### *Wohler video monitoring*

During the fall and winter of 2010-2011, a minimum of 25 individual coho were observed passing through Wohler Dam (**Figure 43**, **Table 8**). It is known that many more fish passed the dam that season based on PIT tag detections upstream of Wohler, but video detections were limited to when the dam was in operation and the when water visibility was high.

**Figure 43.** A coho salmon observed on the Sonoma County Water Agency's Wohler video camera.

### *Snorkel surveys*

A total of 5,390 wild juvenile coho were observed in Russian River tributaries during the summer 2011 snorkeling surveys, or incidentally during other monitoring activities conducted by CDFG or SCWA (**Table 7**). Wild juveniles were observed in 19 of the 23 streams surveyed (**Table 7, Figure 44**). Based on where fish were observed in each stream relative to juvenile barriers and distance from the mouth, we think that coho spawned in 14 of the streams.

**Table 7.** Minimum number of wild young-of-year coho observed in Russian River tributaries during summer 2011.

| Tributary | Minimum number of wild juvenile coho |
|---|---|
| Willow Creek | 20 [3] |
| Freezeout Creek | 0 |
| Sheephouse Creek | 128 |
| Gilliam Creek | 12 |
| Thompson Creek | 0 |
| Gray Creek | 97 |
| Devil Creek | 89 |
| Dutch Bill Creek | 559 |
| Green Valley Creek | 1,488 [2] |
| Purington Creek | 2 [2] |
| Mark West Creek | 27 |
| Porter Creek (Mark West) | 0 [2] |
| Porter Creek | 68 [2] |
| Dry Creek | 19 [3] |
| Crane Creek | 15 [3] |
| Mill Creek | 1,585 [1] |
| Felta Creek | 310 [2] |
| Palmer Creek | 3 |
| Angel Creek | 0 |
| Grape Creek | 717 |
| Wine Creek | 87 |
| Pena Creek | 133 [2] |
| Redwood Creek (Maacama) | 31 [3] |
| **TOTAL** | **5,390** |

[1] 1,253 below waterfall. 332 above waterfall.

[2] Limited access.

[3] Survey associated with CDFG restoration work or SCWA steelhead monitoring activities.

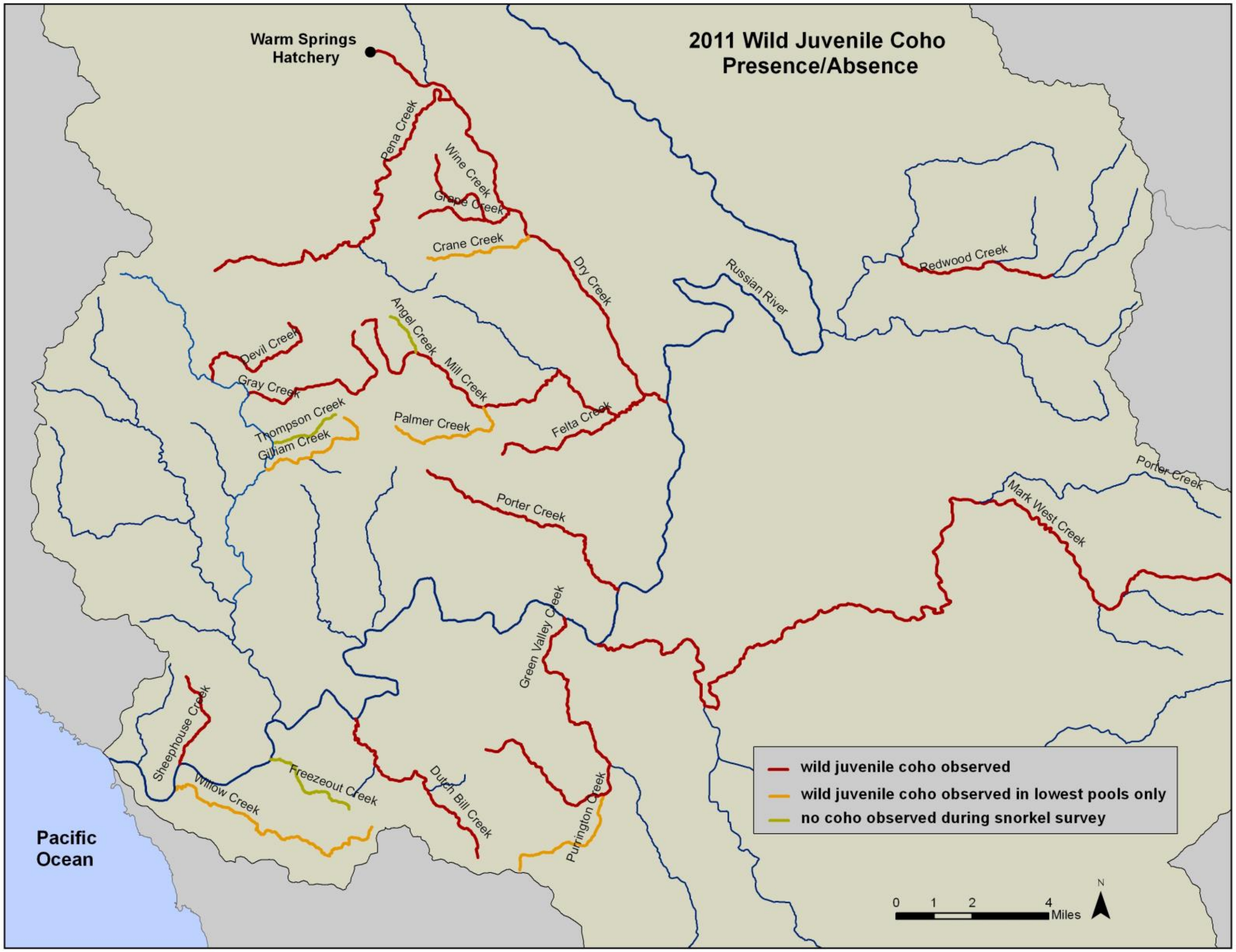



**Figure 44.** Wild juvenile coho presence/absence in Russian River tributaries in summer 2011.

### *Total adult coho observations*

The total number of adult coho observed returning to the Russian River watershed in the winter of 2010 to 2011 was 95, based on all monitoring methods utilized. On Mill Creek, we were able to estimate the total number of returning adults by applying the ratio of PIT-tagged to non-PIT-tagged smolts captured in the downstream migrant trap in 2008 to the number of PIT-tagged adults detected on the Mill Creek antennas during the winter of 2010-2011. If we include this estimate, we can increase our minimum *count* for the Russian to a minimum *estimate* of 192 (**Table 8**).

**Table 8.** Minimum adult coho returns to the Russian River, winter 2010-2011.

| Stream | Wohler Video | Mill trap | Spawner surveys | PIT tag detection | Hatchery return | 3rd party observation | Juvenile surveys summer 2011 | Total (minus potential redundancy) |
|---|---|---|---|---|---|---|---|---|
| Devil Creek | *na* | *na* | *na* | *na* | *na* | *5* | | 5 |
| Dry Creek | *na* | *na* | *na* | *na* | 8 | 6 | | 14 |
| Dutch Bill Creek | *na* | *na* | 4 | *na* | *na* | *1* | | 5 |
| East Austin Creek | *na* | *na* | 4 | *na* | *na* | *na* | | 4 |
| Gilliam Creek | *na* | *na* | 0 | *na* | *na* | *na* | | 0 |
| Grape Creek | *na* | *na* | 1 | 5 | *na* | *na* | | 6* |
| Gray Creek | *na* | *na* | 0 | *na* | *na* | *na* | 2 | 2 |
| Green Valley Creek | *na* | *na* | 7 | *na* | *na* | *na* | | 7 |
| Mark West Creek | *na* | *na* | *na* | *na* | *na* | *na* | 2 | 2 |
| Mill Creek | *na* | 9 | 12 | 31 | *na* | *na* | | 44** |
| Palmer Creek | *na* | *na* | 0 | 0 | *na* | *na* | | 0 |
| Pena Creek | *na* | *na* | *na* | na | *na* | *na* | 2 | 2 |
| Porter Creek | *na* | *na* | *na* | na | *na* | *na* | 2 | 2 |
| Redwood Creek (Maacama) | *na* | *na* | *na* | na | *na* | *na* | 2 | 2 |
| Russian River mainstem | 25 | *na* | *na* | *na* | *na* | *na* | | 25 |
| Sheephouse Creek | *na* | *na* | 0 | *na* | *na* | *na* | 2 | 2 |
| Mark West Creek | na | *na* | *na* | *na* | *na* | *na* | 2 | 2 |
| | | | | | | | **Russian River Total:** | **95*** ** |
| | | | | | | | **Estimated minimum count based on Mill PIT tag data:** | **192** |

*Four Grape fish also detected on Mill antenna

**141 estimated returning to Mill Creek based on PIT tag data

***If individual fish were counted at more than one monitoring station (e.g. Mill trap and PIT tag antenna), they are only counted once in the totals. Wohler video counts are excluded from the overall total because they are potentially the same fish observed in Mill and Dry Creeks.

NOTE: All 6 "3rd party observation" fish on Dry Ck observed by hatchery staff in channel immediately downstream of hatchery, above fish ladder. 3rd party observations on Dutchbill and Devil Creeks were video recordings by landowners.

## ***Discussion/recommendations***

The 2010-2011 winter spawning season documented the highest number of returning adults in recent years, which correlates with the highest number of wild juveniles observed the following summer in the greatest number of streams (**Table 7, Table 8**). In general, the increased number of adult returns correlates with an increased number of fish produced by the hatchery each year (**Figure 45**). It is also likely that the increasing number of returning adults has been influenced by ocean conditions, as increases in adult returns have been documented in other California streams (CDFG and National Park Service staff, personal communication). While the upward trend is encouraging and suggests that the broodstock program is helping to prevent extirpation of coho in the Russian River, returns are still far from the NMFS' recovery target of 10,100 adult coho per year (NMFS 2010). In the winter of 2010-2011 only one of the adults was a wild return, and the remaining 94 were adipose-clipped hatchery fish. Increasing numbers of wild adults in future years will be a strong indicator that coho are able to complete their full life cycle in their natural environment.

Although we have not found any fixed counting station method that is robust to the extremely flashy nature of Russian River tributaries during the winter, in 2010-2011 we found that operation of stationary PIT antennas was the most successful. In Mill Creek, we detected the highest number of returning adults using this method, it did not interfere with migration or cause injury or mortality to fish, and it was the least expensive to operate. Because a pair of antennas was operated in tandem, we were able to estimate detection efficiency, and use the portion of PIT-tagged to non-PIT-tagged fish captured as smolts to estimate the total number of adult returns to Mill Creek. Additional information was also gained regarding a partial barrier located on Mill Creek upstream of the adult trapsite. Adults were detected migrating upstream passed the antennas (km 2.0) in early December and then migrating back downstream three weeks later, suggesting that they were not able to negotiate the barrier located approximately 0.5 km upstream of the antennas. After this occurred, four of the fish detected in Mill Creek were detected on PIT antennas in Grape Creek.

Using PIT tag detection systems as a method for estimating adult escapement requires PIT tagging a portion of all releases so that inferences for the entire population can be made. The program is currently taking this approach to improve winter and summer survival monitoring. The main disadvantage to this method is that wild adult coho are currently not detected on antennas. We recommend that the program begins PIT tagging wild juveniles during summer electrofishing surveys, and at the downstream migrant traps, so that similar return data can be collected on wild fish.

As increasing numbers of wild juveniles are observed in program streams each year, it will be important to develop a release strategy that minimizes stocking hatchery fish in stream reaches with high densities of wild fish. We suggest using a combination of CDFG habitat survey data, UCCE and CSG monitoring data, and professional knowledge of streams to develop juvenile targets for each program stream. Each year after the spawning season, we would use results from adult monitoring to estimate the number of wild juveniles expected in each stream. If no wild fish are known to inhabit a given stream in a given year, then the target number would be stocked into that stream. If wild fish are occupying a stream in a given year, the estimated number of wild fish would be subtracted from the target number, and the remainder would be the number of hatchery fish released into the stream. Redd distribution data could also be utilized to help avoid stocking fish into areas with high densities of wild fish.

With the increasing number of streams stocked each year and the fact that program adults are beginning to return to unstocked streams, the current monitoring strategy will need to be adapted. In previous years, when between three and five streams were stocked annually, we attempted to monitor as many life stages as possible on all of the release streams. As this is no longer practical, we will need to take a different approach that includes intensive sampling on selected streams and reduced sampling on a greater number of streams. We suggest following the approach outlined in California's Coastal Salmonid Population Monitoring Plan (Adams et al. 2011). Intensive monitoring would be conducted on life cycle monitoring streams (e.g., Mill, Green Valley, Dutch Bill, and Willow Creeks) to estimate annual variation in freshwater and marine survival and compare release groups. A randomly stratified sampling approach (Adams et. al. 2011) would be taken on other program and non-program streams in the basin to identify broader status and trends of hatchery and wild coho. As CDFG initiates implementation of this plan in the Russian River watershed, it will be important to coordinate efforts so that shared objectives can be met.

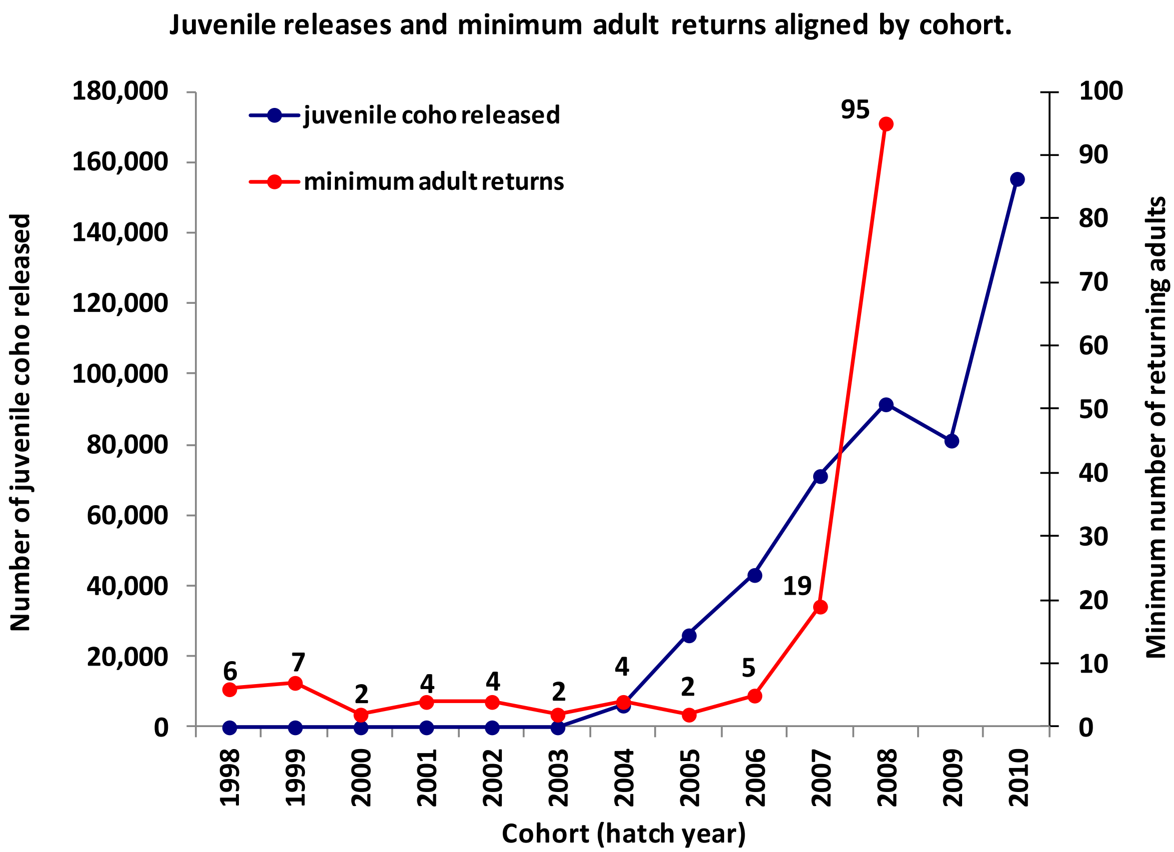



**Figure 45.** Juvenile releases and minimum number of adult coho returns to the Russian River (2000 through 2011).

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