The Role Of The Klamath River Mainstem Corridor In The Life History And Performance Of Juvenile Coho Salmon (*Oncorhynchus kisutch*)

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EXECUTIVE SUMMARY

The purpose of the project is twofold. The first part is to assess how juvenile coho seasonally utilize the range of habitats that exist within the mainstem Klamath River corridor prior to seaward smolt migration. The second part is to assess the significance of the fish that use corridor habitats to the overall performance of Klamath River coho populations. The second part of the purpose is more difficult to address than the first part—it requires a basin-scale perspective on population performance that takes into account the characteristics of viable salmon populations (i.e., abundance, productivity, biological diversity, and spatial structure, see McElhany et al. 2000). An integration of the information being collected in this project with assessment work being done in other areas of the river basin, such as in the Scott and Shasta rivers, will be required to address the second part of the purpose. This report is focused primarily on addressing the first part of the purpose. We provide some preliminary conclusions, however, that begin to address the second part of the project purpose.

The term “mainstem Klamath River corridor” refers to habitats within the main river channel and its side channels, off-channel habitats (alcoves, ponds, and groundwater channels associated with the floodplain), the lower reaches of small tributaries—including their confluences with the mainstem, and the estuarine zone from the head of tidal influence to the river mouth. The mainstem river corridor habitats are used by both juvenile natal coho (produced by parents spawning in those areas) and non-natal coho (fish that moved from their natal streams to rear in mainstem river corridor habitats).

This report encompasses data on coho juvenile performance in the Klamath River corridor associated with brood years 2006-2009 along with some data for brood year 2010 fish. The smolts from these brood years emigrated seaward as age-1 (yearling) fish in the spring of 2008 through 2011. We also include some information on age-0 (young-of-year) fish that used river corridor habitats in spring and summer of 2011. Extensive information is presented here on patterns of movement, residency, and performance (fish size, growth, and, where available, abundance and survival) of juvenile coho for different river corridor habitats.

It should be noted that this document is an updated version of a report submitted in August 2013. This version provides a more comprehensive analysis of data collected through approximately the end of summer 2011. In presenting a more comprehensive analysis, this report provides a greater understanding of how juvenile coho used the mainstem river corridor in 2008-2011. This understanding is being applied in the analysis of data for the period 2011-2015, the basis of the fourth report in the series. That report is expected in spring of 2016.

Knowledge gained through this study is deemed crucial in understanding the role of mainstem corridor habitats to the overall performance of Klamath River wild coho populations. Such understanding is needed to evaluate the implications of flow regulation to the performance of juvenile coho that use the mainstem river for some portion of their life history. The study also provides information crucial for guiding the development of habitat enhancement and restoration projects to improve the survival of juvenile coho that use mainstem corridor habitats. Moreover, project results will provide valuable information in recovery planning for Klamath River coho, which is an ESA listed species within the Klamath River basin.

We expect that knowledge being gained through this study will be vital in evaluating how the removal of the mainstem Klamath River dams will affect coho performance within the river corridor. Dam removal is expected to begin in 2020.

Information presented herein demonstrates that the Klamath River mainstem corridor provides critical habitat for juvenile coho during all seasons of the year. Corridor habitats are used by both natal and non-natal rearing juvenile coho. Non-natal fish exhibit extensive redistributions within the corridor from natal spawning streams during virtually every month, but the movements are particular evident in spring, early summer, fall, and early winter. The patterns of these re-distributions are consistent with those observed in numerous other streams within the range of the species (Quinn 2005; Lestelle 2007), though our findings generally show greater distances being travelled than reported in other studies.

Our findings show that substantial numbers of young-of-the-year progeny (age-0 coho) move downstream from their natal spawning streams and into the mainstem Klamath River in spring and early summer, and then undertake two significant re-distributions within the river corridor. First, in spring and early summer, the small juveniles continue to move (generally downstream) in search of slow-velocity habitats, such as backwaters, edge habitats along the mainstem, floodplain channels (particularly small tributary-fed floodplain channels, including ponds), and low velocity small tributaries. All of these habitat types occur to a limited amount within the mainstem river corridor, but their distribution along the river is not uniform. As temperatures increase in the river in early summer, movement to find refuge habitats that contain both low velocities and cool water becomes essential for survival. The distance of this early summer redistribution of age-0 fish from their natal tributaries appears to be mostly less than about 30 miles, though Shasta River fish have been found to move up to 200 miles during this early summer window to find refuge habitat in the corridor.

A second, more extensive re-distribution occurs with the advent of fall rains. This movement occurs for fish that had moved into corridor habitats from natal areas during spring and early summer, as well as other fish moving from the natal streams during fall and early winter. In this case, the age-0 juveniles move to find suitable overwintering habitats containing either complex habitat structure (such as large, stable wood) or low velocity sites with some type of protection from periodic higher flows, such as occurs in floodplain channels with ponded habitat or isolated ponds with connected egress channels. It is not uncommon for fish to travel 100 miles within the Klamath River mainstem corridor—some traveling farther—before taking up residence in a suitable overwintering site, if they survive the journey. Based on this study and others (see Lestelle 2007), low velocity habitats that are well protected from the high velocities of the mainstem river during winter (e.g., in off-channel ponds) generally provide the highest overwintering survival rates along with high growth rates.

The Klamath River mainstem corridor contains a very limited number of high quality summer and/or overwintering habitats (generally small in size with sparse distribution). This is also true of most of the spawning tributaries in the river basin. These conditions are at least partly (varies by subbasin) the result of past and/or current land use practices (e.g., mining, road building, logging, agriculture) (NMFS 2014).

Despite limited availability of high quality habitats in summer and winter within the river corridor, the importance of the role of the corridor to juvenile coho may be much greater today than its historic role. Historically, when habitats in the Shasta and Scott rivers were intact, those streams would have been capable of supporting a diverse range of life histories. Both rivers would have been major producers of coho salmon (NMFS 2014). However, it is likely that as habitats in those river valleys declined dramatically in quality and quantity due to land uses that a greater proportion of the juveniles produced there have relied on habitats within the Klamath River mainstem corridor. Lestelle (2009) reported such a pattern in the Clearwater River on the Olympic Peninsula in Washington. In that case, the effects of logging appear to have diminished the quality and quantity of overwintering habitats in tributary habitats, resulting in a trend for a greater proportion of juveniles relying on overwinter habitats within the mainstem river corridor.

The Karuk Tribe, working in conjunction with the Mid-Klamath Watershed Council, and the Yurok Tribe are engaged in restoring or creating new habitats within the Klamath River mainstem corridor having suitable thermal and/or velocity characteristics that attract—and hold—juvenile coho that are seasonally redistributing within the corridor. The premise is that by increasing the frequency of suitable refuge sites within the corridor (thereby making it easier for redistributing juveniles to find them), and strategically locating them in areas within or near natal tributaries, that survival and growth will be improved for fish that find and use them. As a result, the overall performance of the many population units in the basin whose juveniles use the mainstem corridor for rearing should be improved. The next project report, expected in spring 2016 and covering years 2012 to 2015, will provide results on how juvenile coho are using restored/enhanced habitat sites.

ACKNOWLDGEMENTS

This study was funded by the U.S. Bureau of Reclamation through the Klamath Basin Area Office. Special thanks are given to the several Bureau administrators since the beginning of the project for their assistance in securing and administering the contracts for this project.

Many other staff members of the Yurok Fisheries Program and the Karuk Department of Natural Resources were instrumental in the work described in this report. Their dedication and hard work are especially appreciated.

REPORT AUTHORSHIP

The study is jointly managed and overseen by the Karuk and Yurok tribes. The order of authorship on jointly authored reports as part of this study is rotated between the two staffs.

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1.0 Introduction

This report is an updated version of the third project report for what has become known as the Klamath River coho salmon ecology project. This updated version provides a more comprehensive analysis of data collected through approximately the end of summer 2011; the earlier version of the report was submitted in August 2013. In presenting a more comprehensive analysis, this report provides a greater understanding of how juvenile coho used the mainstem river corridor in 2008-2011. This understanding is being applied in the analysis of data for the period 2011-2015, the basis of the fourth report in the series. That report is expected in spring of 2016.

The purpose of the project is twofold. The first part is to assess how juvenile coho seasonally utilize the range of habitats that exist within the mainstem Klamath River corridor prior to seaward smolt migration. The second part is to assess the significance of the fish that use corridor habitats to the overall performance of Klamath River coho populations. The second part of the purpose is more difficult to address than the first part—it requires a basin-scale perspective on population performance that takes into account the characteristics of viable salmon populations (i.e., abundance, productivity, biological diversity, and spatial structure, see McElhany et al. 2000). An integration of the information being collected in this project with assessment work being done in other areas of the river basin, such as in the Scott and Shasta rivers, will be required to address the second part of the purpose. This report is focused primarily on addressing the first part of the purpose. We provide some preliminary conclusions, however, that begin to address the second part of the project purpose.

The term "mainstem Klamath River corridor" refers to habitats within the main river channel and its side channels, off-channel habitats (alcoves, ponds, and groundwater channels associated with the floodplain), the lower reaches of small tributaries—including their confluences with the mainstem, and the estuarine zone from the head of tidal influence to the river mouth. The mainstem river corridor habitats are used by both juvenile natal coho (produced by parents spawning in those areas) and non-natal coho (fish that moved from their natal streams to rear in mainstem river corridor habitats).

In 2006, the U.S. Bureau of Reclamation (USBR) funded the Karuk and Yurok tribes to initiate this multi-year study. The study is being carried out by the Karuk Department of Natural Resources (KDNR) and the Yurok Tribal Fisheries Program (YTFP).

To date, the study has determined that substantial numbers of juvenile coho use various habitats within the mainstem river corridor for extended periods of summer and/or winter rearing. Patterns of movement and habitat use within the corridor are diverse. The extent of movement and the numbers of fish using different corridor habitats appear to vary by the type of hydrologic year that occurs (wet or dry) and the relative number and distribution of spawners in the river basin. Coho spawning escapements are known to vary widely from year to year and over the stream network in the Klamath basin—and spatial distribution of spawners can differ significantly between years.

The first project report covered results of the study through May 2007 (Soto et al. 2008). That report presented a general reconnaissance of habitats within the mainstem Klamath River corridor and results for initial sampling that occurred during the period.

The second report covered the period from June 2008 to July 2009 (Hillemeier et al. 2009). It generally addressed life history patterns and habitat use of juvenile coho produced in brood years 2006 and 2007. These fish were the progeny of parents that spawned in the fall and winter of 2006-07 and 2007-08.

This third report encompasses data on coho juvenile performance in the Klamath River corridor associated with brood years 2006-2009 along with some data for brood year 2010 fish. The smolts from these brood years emigrated seaward as age-1 (yearling) fish in the spring of 2008 through 2011. We also include some information on age-0 (young-of-year) fish that used river corridor habitats in spring and summer of 2011. Extensive information is presented here on patterns of movement, residency, and performance (fish size, growth, and, where available, abundance and survival) of juvenile coho for different river corridor habitats.

Knowledge gained through this study is deemed critical in understanding the role of mainstem corridor habitats to the overall performance of Klamath River wild coho populations. Such understanding is needed to evaluate the implications of flow regulation to the performance of juvenile coho that use the mainstem river for some portion of their life history. The study also provides information crucial for guiding the development of habitat enhancement and restoration projects to improve the survival of juvenile coho that use mainstem corridor habitats. Moreover, project results will provide valuable information in recovery planning for Klamath River coho, which is an ESA listed species within the Klamath River basin.

We expect that knowledge being gained through this study will be vital in evaluating how the removal of the mainstem Klamath River dams will affect coho performance within the river corridor. Dam removal is expected to begin in 2020.

1.1 Project History

The USBR initiated funding in 2006 for the Karuk and Yurok tribes to begin a multi-year study to assess key aspects of seasonal life history tactics of juvenile coho within the mainstem Klamath River corridor. The study began with a focus on just overwintering habitats in and along the mainstem river. Phase 1 tasks covered the period between October 2006 and March 2007. Following Phase 1, the scope of the study was enlarged to address habitat utilization patterns of pre-smolt juvenile coho in all seasons.

The first two years of the study were aimed largely at conducting a reconnaissance of the key habitats, evaluating methods, and assessing some of the movement patterns of coho associated with those habitats. Activities conducted in those years are described in Soto et al. (2008) and Hillemeier et al. (2009). During these years, representative key habitats were identified and described. Methods for marking and tagging juvenile coho were formulated. Many of the sampling sites that have been used to the current time were selected.

In the third year of study (June 2008 through May 2009), PIT tag arrays for continuous monitoring were installed by both KDNR and YTFP at several locations within the mainstem corridor. In the Mid Klamath study area, arrays were installed at Sandybar Creek, a tributary-fed floodplain channel at RM 78, and in the Bulk Plant backwater pool on the mainstem river at RM 112. In the Lower Klamath study area, arrays were installed in lower Waukell Creek, lower Panther Creek, and lower Salt Creek, all located within the estuarine zone of the river. The emphasis in year 3 was on doing a further characterization of habitats, assessing movement patterns, and assessing utilization rates of different habitats.

In the fourth year of study (June 2009 through May 2010), another PIT tag array was installed in the Mid Klamath area in lower Seiad Creek (RM 129) and two additional arrays were installed in the Lower Klamath area in lower Terwer Creek (RM 8). The Terwer arrays were partially funded by NOAA and BOR; in addition to increasing detections for this project, these arrays were intended to assess habitat restoration efforts in Terwer Creek. These additional detection sites have improved detection capability at strategic sites in the basin and they provide greater opportunities to assess coho production patterns in these streams. In this year, juvenile coho were tagged with PIT tags over a much broader distribution in the basin—in both non-natal and natal streams —to help determine how seasonal redistributions of juveniles are affected by hydrologic zone.

The fifth year of study began in June 2010 and ended in summer 2011. The emphasis in this year continued to look at habitat utilization patterns and rates, movement patterns, and juvenile performance.

1.2 Background

Seasonal distribution and habitat use patterns of pre-smolt juvenile coho within the mainstem river corridor of a large river like Klamath are related to flow and temperature patterns, as well as to the types and distribution of available habitats (Lestelle 2007). Significant movements of juvenile coho in Pacific Northwest rivers often occur on increasing or declining limbs of either the temperature or flow pattern or both. Movements are believed to be triggered or strongly influenced by these patterns. Figure 1 displays generalized patterns of water temperature and river flow for the lower Klamath River. Juvenile coho movements within the mainstem corridor are related to these patterns.

These movement patterns can generally be described as follows. Immediately following emergence from spawning gravels during spring[1], some coho fry disperse downstream. This dispersal can be facilitated in part by spring runoff. Some of these fry move into the mainstem river, where they might find low-velocity habitats to colonize. Such habitats in large mainstem

[1] / Spawning principally occurs in tributaries to mainstem rivers for wild fish, but it also occurs to a much more limited extent in some areas of mainstem rivers under certain conditions.

rivers are primarily edge units along the river shoreline or within backwater units (Beechie et al. 2005; Lestelle 2007). Some of these dispersing fry also move into off-channel habitats, such as ponds and floodplain channels, if available. Once this initial dispersal ends and fry find suitable habitats, movement to new locations slows significantly and they begin rearing within localized areas. Subsequently, as water temperatures increase, and if reaching high enough levels, the juveniles may initiate another movement in search of thermal refuge. This pattern of movement in response to high water temperatures is strongly evident in the Klamath basin (Sutton et al. 2002; Deas and Tanaka 2006; Sutton 2007; Sutton 2009). Within the mainstem corridor, some juveniles find thermal relief either at sites of cold water seeps in the mainstem river or in the lower reaches of cool water tributaries.

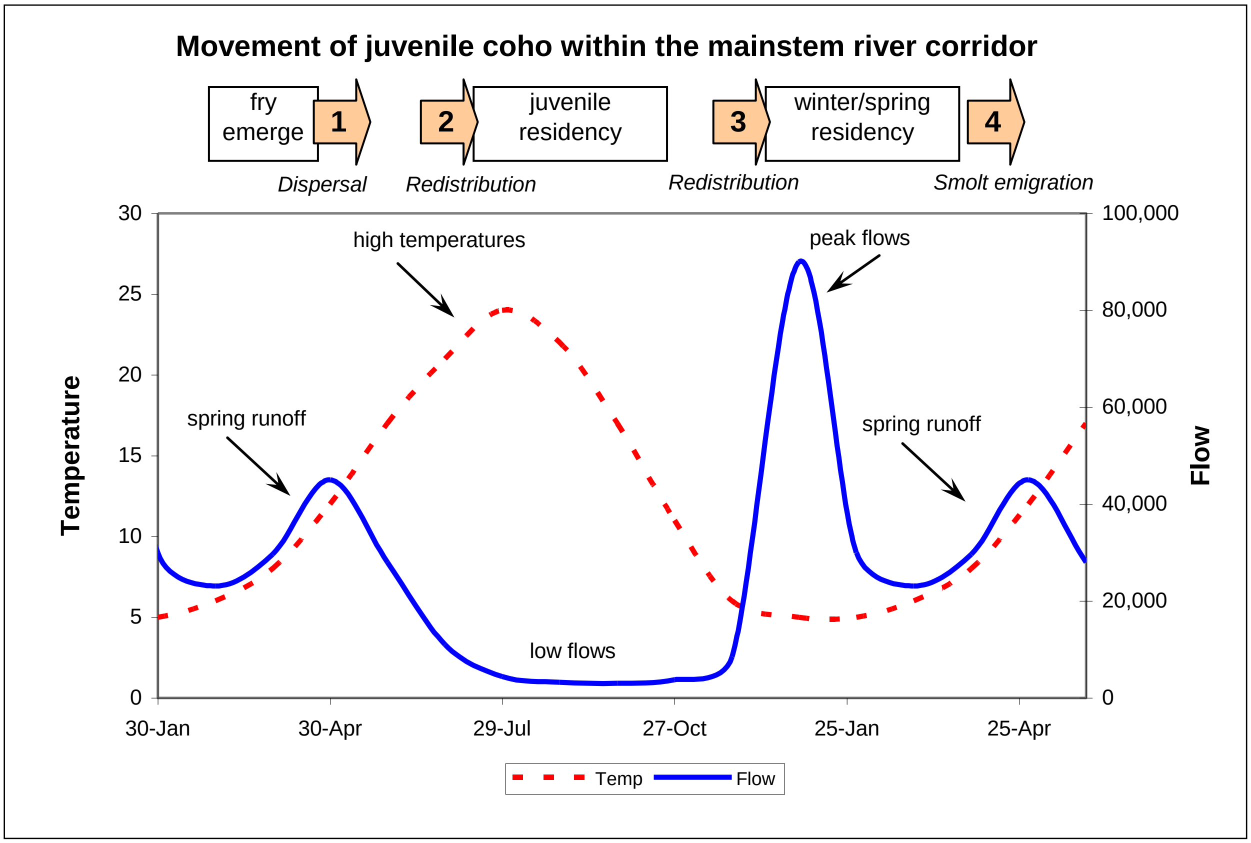

Figure 1. Generalized movement patterns of juvenile coho within the mainstem Klamath River corridor corresponding to temperature and flow patterns. (1) Fry that disperse from natal tributaries enter the mainstem corridor during spring runoff. (2) Some juveniles within corridor habitats move again in early summer with rising water temperatures in search of thermal refuge. Relatively little movement occurs for the remainder of summer. (3) Another redistribution is expected to occur in fall and early winter during periods of increased flows as juveniles search for suitable overwintering habitats. Rate of movement slows significantly following the bulk of redistribution with stable residency following. (4) Smolt migration begins in early spring.

After temperatures in the mainstem river reach critical thresholds for juvenile coho, it appears that the redistribution ceases—though it is expected that some fish would attempt to move if conditions of flow or temperature pose likely death.[2] Sites that juvenile coho inhabit at this time must necessarily also provide low-velocities, such as those occurring within edge units and backwaters within the mainstem river. The suitability of rearing sites in summer, and especially in winter, is strongly determined by water velocity—slow being better.

As water temperatures decline in September, juvenile coho generally remain associated with the localized areas in which they had been rearing. No extensive movement pattern is evident at this time in Pacific Northwest streams, including in the Klamath River, though some movement over short distances is known to occur (Kahler et al. 2001). Within the mainstem corridor, juvenile coho during the late summer period are most likely to be found in edge and backwater units of the mainstem river, in some off-channel habitats having access during earlier movements (and suitable temperatures during the hot part of summer), and in the lower portions of both non-natal and natal tributaries. Their distribution and abundance at this time are the result of prior movements and various factors affecting survival, including the severity of summer high temperatures and low flows.

With the advent of fall rains and increasing flows, some juvenile coho are known to undertake another redistribution movement to find habitats more suited to overwintering (Peterson and Reid 1984; Hillemeier et al. 2009). These movements are known to cover up to 40 miles in some rivers and it had been suspected that distances traveled might exceed 250 miles in some cases, such as in the Fraser River (see discussion in Lestelle 2007). Data reported on in this report, in addition to more recent data collected through this project, demonstrate redistribution distances in excess of 200 miles. Large numbers of fish will immigrate into very small off-channel habitats adjacent to the mainstem Klamath River, as well as in many other rivers. This redistribution is one of the most remarkable aspects of juvenile coho life history that has been observed. One of the primary objectives of this study in the Klamath River is to learn the extent and importance of such movements in this river system.

Once the fall-early winter redistribution is over, juvenile coho remain relatively stable in their habitat residency through the remainder of winter and into spring. Following a spurt of rapid growth in early spring, surviving juvenile coho begin the smolt transformation and start their seaward migration, which typically peaks in April and May in the Klamath basin.

This study is designed to improve understanding about these life history tactics within the mainstem Klamath River corridor.

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[2] / While the redistribution on a large scale (i.e., between mainstem reaches) seems to stop, some movement appears to continue at a smaller scale between habitat units. Observations show that some fish move daily between the lower end of some cool water tributaries and adjacent habitat units in the mainstem according to the diurnal temperature pattern, thereby taking advantage of the greater food supply in the mainstem river as temperatures allow (Witmore 2014). Summer temperatures in the mainstem can also decline during summer thunderstorms or other weather related cold spells, allowing for some amount of movement on a somewhat larger scale. We have observed such movement in the mainstem Klamath River corridor.

1.3 Project Objectives

The objectives of this multi-year study are as follows:

1. Identify and describe habitats used by juvenile coho seasonally within the mainstem Klamath River corridor;
2. Assess seasonal movement patterns of juvenile coho into and out of habitats being used within the mainstem corridor;
3. Assess relative rates of seasonal utilization by juvenile coho within the range of habitats in the mainstem corridor;
4. Assess measures of seasonal performance of juvenile coho to the extent feasible (growth, survival, length of residency in different habitats); and
5. Assess the significance of life history tactics that use the corridor to the overall Klamath coho populations.

Objective 1 addresses the question: What habitats are used by juvenile coho within the mainstem corridor during spring of fry emergence, summer, late summer/early fall, and winter? These habitats have been identified and described.

Objective 2 addresses the question: What are the seasonal movement patterns by juvenile coho into and out of the types of habitats that occur within the mainstem corridor? This objective aims to describe temporal and spatial patterns of movement associated with mainstem corridor habitats, and to learn how these patterns correspond with environmental factors, such as flow and temperature.

Objective 3 addresses the question: To what extent are the different habitats in the mainstem corridor utilized by juvenile coho and how does utilization vary by season? This objective aims to assess in a relative way the magnitude of use of different habitats within the corridor, e.g., which habitats have the most affinity for juvenile coho. (This objective does <u>not</u> aim to assess the relative extent that corridor habitats are used by the Klamath basin coho population as a whole, since the scope of the study does not extend outside the mainstem corridor. The results of this study will be useful, however, in considering this aspect as more is learned about coho production levels in the various subbasins.)

Objective 4 addresses the question: How well do juvenile coho perform by season in different types of habitat within the mainstem corridor? Performance can be measured by survival, growth and size, and length of residency within a habitat.[3] This objective aims to learn, using one or more of these performance measures, the relative benefit to performance that different habitats provide within the mainstem corridor.

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[3] / Survival and growth (or size) during a season or life stage are direct measures of how well animals perform in their environment. These performance measures, when combined across all life stages, determine how successful different life history strategies are in sustaining themselves and in contributing to overall population viability. These two measures, however, are difficult to assess for fish that move between habitats during a season. Survival is particularly difficult to measure in most types of riverine settings. The third measure listed, length of residency, can serve as an index of habitat quality (hence, survival). High residence time (or fidelity) is considered to be indicative of comparatively favorable rearing conditions under certain environmental conditions (based on Van Horne 1983, Winker et al. 1995, and Bell 2001; see discussion in Hillemeier et al. 2007).

Objective 5 addresses the question: What is the overall importance to the performance of Klamath coho populations of life history tactics that use the mainstem corridor to complete their life cycle prior to smolt emigration? This objective is aimed at addressing the second part of the project's purpose described on page 1. Some juvenile coho use various habitats within the corridor during summer and/or winter prior to exiting the river as smolts. But if the number of these fish is very small compared to those that rely on rearing within natal tributary streams, then the overall importance of the corridor to the populations could be relatively minor. No determination has been made of the relative numbers of fish that might be successfully using corridor habitats to complete their life cycles. However, even if the numbers of fish that use the corridor are relatively small compared to those relying entirely on natal tributary habitats, survival within corridor habitats could be high compared to that in natal tributaries, or growth enhancement by corridor habitats could boost marine survival rates compared to that experienced by fish that smolt from natal tributaries. This objective, therefore, aims to determine the overall importance of corridor habitats to the performance and recovery of Klamath coho populations. Objective 5 will help to prioritize recovery actions that focus habitat restoration on habitats within the corridor, but will also provide some guidance for restoration priorities within subbasins. While we give some preliminary conclusions about this matter in the final section of the report (Section 4.2), the questions associated with this objective remain to be more fully addressed.

1.4 Organization of Report

The report is organized into four sections:

1. Introduction;
2. Project design and approach;
3. Patterns of juvenile coho use by area and site;
4. River basin-wide patterns and synthesis.

2.0 Project Design and Approach

The Klamath River basin downstream of the dams that limit coho distribution can be delineated into eight different regions on the basis of hydrologic zone and major subbasins (Figure 2). The progeny of the coho spawning aggregations that use these eight regions can be expected to rely to various degrees on habitats within the mainstem Klamath River corridor as a result of differing flow patterns, channel characteristics, and relative abundance of spawners among the regions.

It bears noting here that the complexity of factors that affect the extent that the progeny produced in the different regions move from natal areas and into the mainstem corridor present challenges in addressing Objective 5 for the study. We anticipate tackling this matter through a basin wide synthesis of information that has been or is currently being collected by various entities within those regions. Some modeling of coho production patterns will also likely be needed.

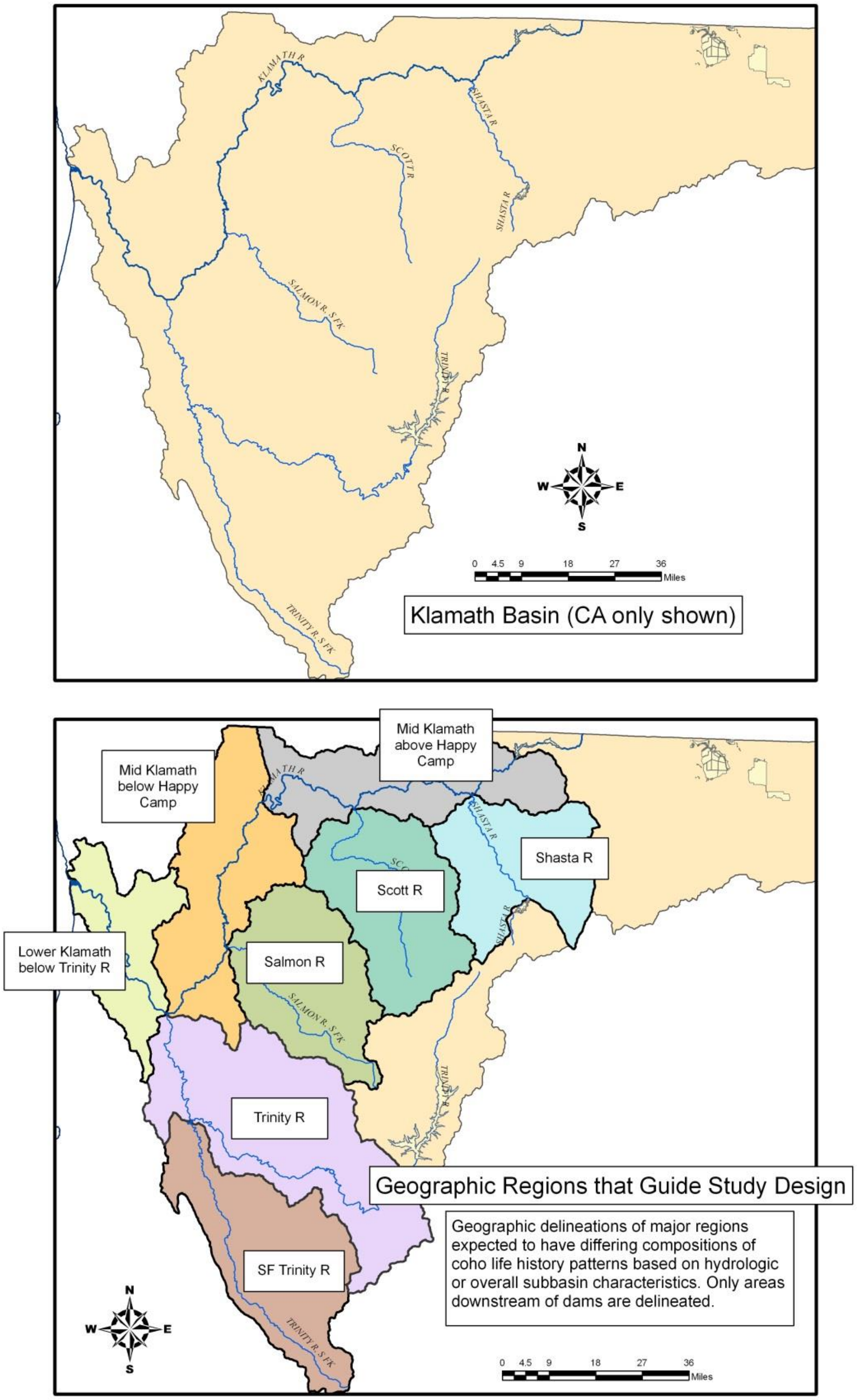


Figure 2. Study areas within the mainstem Klamath River corridor. The YTFP is responsible for activities in the Lower Klamath region and the KDNR is responsible for activities in the two Mid Klamath regions. Major subbasins within the Klamath River basin are also shown delineated.

The mainstem Klamath corridor passes through three of the eight regions (Figure 2): Mid Klamath upstream of Happy Camp (located at approximately RM 108), Mid Klamath downstream of Happy Camp and upstream of Trinity River (RM 43), and the Lower Klamath downstream of Trinity River. Each of these three regions that encompass the river corridor has a very different hydrologic pattern—and each has generally exhibited a different utilization pattern by juvenile coho within the river corridor (Hillemeier et al. 2009).

The KDNR and YTFP staffs have focused their sampling efforts in the three regions that encompass the mainstem Klamath corridor. KDNR is responsible for sampling in the two Mid Klamath regions and Yurok handles sampling in the Lower Klamath region. The staffs assist one another on occasion when joint sampling is needed.

Sampling is performed in three categories of tasks that address the various objectives. These categories are (1) juvenile utilization and production, (2) marking and tagging, and (3) spawner assessments.

Juvenile utilization and production covers those tasks aimed at assessing movement patterns, habitat utilization, performance, and abundance (standing stock or smolt yield) at specific study sites or streams representative of other streams in a region.

Marking and tagging covers those tasks aimed at either marking with an external mark (on fish too small to tag) or PIT tagging juvenile coho at various natal and non-natal sites in the basin. Broad and extensive coverage, encompassing a range of habitats, has been applied.

Spawner assessments is a task directed at determining the relative distribution and abundance of spawners (based on redd and/or fish counts) either associated with streams being assessed for utilization and production or with subbasins where PIT tagging is expected occur. Results obtained in the years in focus in this report are not reported herein; those results will be presented with data on encounters of PIT tagged returning adults.

The sampling design calls for broad sampling in spring, summer, fall, and winter at a variety of streams and sites. The sites and streams are grouped into the general levels of sampling intensity that occur at them. Relatively few sites and streams are sampled intensively, whereas a larger number of sites and streams are sampled extensively. Combined, the information collected between the two groups provides a large amount of information on how coho use the habitats in the regions. The sites and streams have been selected based on how representative they are of other streams in the region, feasibility and efficiency in sampling, and their relative use by coho.

Sites and streams that are sampled the most intensively for juvenile utilization and production are those that have had remote stream-width passive interrogation (SPI) PIT tag monitoring systems installed at them. In the Lower Klamath region, four streams have been monitored on an intensive basis: Waukell Creek, McGarvey Creek, Panther Creek (tributary to Hunter Creek), and Salt Creek. Sampling in these streams is routinely performed using fyke net traps (and pipe trap in McGarvey Creek) in conjunction with the SPI monitoring. SPI systems have also been installed in off-channel sites in lower Terwer Creek. In addition, sampling with fyke net traps has been conducted on a semi-intensive basis in some off-channel ponds in the vicinity of where the

SPI stations are located. It is noted that these areas where intensive or semi-intensive sampling occur have had some restoration projects completed—the sampling being done there is being used to help evaluate the results of those projects.

In the two Mid Klamath regions, two streams are being monitored on an intensive basis: Sandybar floodplain channel (in the region downstream of Happy Camp) and lower Seiad Creek (in the region upstream of Happy Camp). SPI PIT tag monitoring systems have been operated in both streams. Fyke net sampling combined with sampling by seining is done on a semi-regular basis at both sites. A SPI station has also been operated at the top end of a mainstem river backwater unit immediately upstream of Happy Camp; this site (called Bulk Plant) is essentially within a semi-protected area of the mainstem Klamath River. Other sites in the Mid Klamath regions are also being monitored intensively on a periodic basis as a part of graduate student studies associated with Humboldt State University (HSU). These sites are generally some type of off-channel pond, either naturally formed or recently constructed through the joint efforts of the Mid Klamath Watershed Council (MKWC) and KDNR. Two theses have been completed: Witmore (2014) and Krall (2016).

Besides streams being sampled intensively for juvenile life history characteristics, other streams are sampled less frequently using various means of capture. Information collected at these sites provides supplementary information on utilization rates, movement and performance (generally growth, size, and residency). These sites are also used for PIT tagging fish.

The YTFP and KDNR staffs work very closely together in reviewing and checking all biological data, including PIT tag data, collected through the study. The staffs employ some of the same data storage and analysis tools to facilitate data exchange, data checking, data reconciliation, and analysis. All of the biological data used in developing reports, particularly all PIT tag data, are subjected to the same rigorous review and reconciliation procedures.

The project was designed to be collaborative with other agencies and entities working in the basin, particularly with those that use PIT tag technology for assessing coho movement patterns. Studies being conducted by CDFW in the Shasta and Scott rivers provide the means to PIT tag juvenile coho in those subbasins, which has helped to assess movements of those fish downstream into the Klamath River corridor as part of our study. USGS maintains a centralized PIT tag database in its Klamath Falls office that stores all of the PIT tag data collected in the basin by our project, CDFW, NMFS, and students at HSU. That database, which stores a very large number of records relevant to our study, has been instrumental in facilitating data exchanges and QA/QC procedures.

3.0 Patterns of Juvenile Coho Use by Area and Site

This section presents results of sampling within the mainstem corridor to assess patterns of habitat utilization by juvenile coho, both spatially and temporally, for 2007 to 2011. These results provide the foundation for understanding how juvenile coho move through the corridor within their juvenile life history and how patterns differ between geographic areas and brood years. The section is organized into the following four subsections:

- Tagging Summary – provides an overview of the numbers of juvenile coho PIT tagged in the various geographic areas by year;
- Pattern Types and Related Factors – presents an overview of some different patterns exhibited by juvenile coho in the mainstem river corridor and describes factors that appear to influence these patterns;
- Mid-Klamath Area Summaries; and
- Lower Klamath Area Summaries.

3.1 Tagging Summary

Beginning in 2007 and continuing to mid-2011, over 31,200 juvenile coho were PIT tagged within the mainstem Klamath River corridor and in streams adjacent to the corridor. All but a small percentage of these fish were tagged by KDNR and YTFP staffs as part of this study. Relatively small numbers were tagged by CDFW staff in the Shasta and Scott river subbasins.

The sampling areas for tagging fish and re-encountering them were delineated and are referred to as geographic areas in this study, or shortened here to be GeoAreas. A list of GeoAreas, their locations, and a short description of each is given in Table 1. It is important to note that the GeoAreas include a wide variety of sampling sites, such as portions of the mainstem river, connecting side channel and off-channel sites, and tributary sites. The results that are presented in this report deal with broad-scale patterns in the corridor and provide no analysis of specific habitat features among the GeoAreas. Analyses of the influences of such features remain to be completed.

Tables 2 and 3 provide detailed summaries of the numbers of juvenile coho tagged in specific sampling areas within the basin for the years relevant to this report. A very extensive, and time consuming, review of the tagging data was carried out as part of the quality control aspects of the study. All of the data shown in Tables 2 and 3 with the exception of some data for summer and fall of 2011 have been carefully reviewed. Data that were readily summarized for late 2011, as well as early 2012, have been included in parts of this report to gain some insights into movement patterns that existed for these time periods—but some of those data are still being reconciled. All of the data prior to those months (i.e., prior to late 2011 and early 2012) have been reconciled for purposes of this report.

It is important to note that all fish represented in Tables 2 and 3 were aged for their initial capture events on the basis of length frequency analysis. While we recognize that some errors exist using this process, we believe the results are of relatively high quality for the purpose of our analysis. We also note that Chris Adams (CDFW, personal communications) provided us with his age designations for some fish originating in the Shasta River subbasin. Age of fish as applied herein is based on a January 1 birthday. Hence all young-of-the-year (YOY) fish are considered to be age-0 up through the end of December. Those fish graduate to age-1 at the start of January. In some cases, we were aware (based on progression of length frequency data) that some fish were age-2 and we have so designated them in our database.

A total of approximately 23,000 age-0 coho were tagged as part of the study reported on herein (Table 2). Another approximately 8,200 age-1 (with a few age-2) coho were also tagged (Table 3).

Table 1. Geographic areas (GeoAreas) encompassing sampling areas used for tagging juvenile coho and re-encountering them within the Klamath basin used in this study. Most GeoAreas are within the mainstem corridor, or very close to it. A few areas are located well upstream of the corridor. Landmarks for reference are also shown to indicate relative distances in the basin.

Landmark	Geographic area (GeoArea)	RM entry on Klamath R	Approx miles to Klamath R mouth	Description
Klamath R mouth				
	SouthSlough	0.2	0.2	South Slough complex near Klamath R mouth.
	SaltCr	0.8	1.4	Salt Creek.
	SpruceCr	0.8	1.3	Spruce Cr near Hunter Cr.
	MynotCr	0.8	1.5	Mynott Cr in lower Spruce Cr.
	HunterCrLow	0.8	1.6	Lower reaches of Hunter Creek, includes Panther Pond.
	HunterCrUp	0.8	5.3	Upper reaches of Hunter Cr.
	RichardCr	2.5	3.1	Richardson Cr and associated ponds.
	HoppawCr	3.0	4.0	Hoppaw Cr.
	WaukellCr	3.2	3.7	Waukell Cr, includes Junior Pond.
	ResigniniPnd	4.5	1.8	Resigini Ponds near Waukell Cr.
	TerwerCrLow	5.6	6.7	Lower reaches of Terwer Cr, includes constructed ponds.
	TerwerCrMid	5.6	14.1	Middle reaches of Terwer Cr.
	McGarveyCr	6.4	6.6	McGarvey Cr.
	KRmainLow	10.0	10.0	Lower mainstem of Klamath River, downstream of Blue Creek.
	BlueCrLow	16.0	17.4	Lower reaches of Blue Cr, includes site of rotary screw trap.
	CresCityFks	16.0	31.0	Crescent City Forks in the middle reaches of the Blue Cr subbasin.
	AhPahCr	17.3	18.3	Ah Pah Cr.
	TrinityUp	43.7	153.4	Upper Trinity R.
Trinity R enters				
	AikensCr	48.8	48.8	Aikens Cr.
	KRSlateCr	50.6	50.6	Slate Cr sites immediately associated with the Klamath R mainstem.
	KRBigBar	50.8	50.8	Big Bar on the mainstem Klamath R, site of rotary screw trap.
	BoiseCr	55.5	55.5	Boise Cr.
	CampCr	57.3	57.3	Camp Cr near town of Orleans.
Orleans location				
	KROrleans	59.4	59.4	Sampling sites in Orleans.
	KRWhitCr	62.7	62.7	Whitmore Cr sites immediately associated with the Klamath R mainstem.
Salmon R enters				
	SalmonRLow	66.3	67.3	Sampling sites in the lower area of Salmon R.
	KRIrvingCr	75.2	75.2	Irving Cr sites immediately associated with the Klamath R mainstem.
	KRStansCr	76.9	76.9	Stanshaw Cr floodplain channel (along Klamath R).
	KRSandyBCr	77.4	77.4	Sandybar Cr floodplain channel (along Klamath R).
	KRTiBar	81.0	81.0	Sampling sites in off-channel areas along Ti Bar.
	DillonCr	85.1	85.1	Dillon Cr.
	KRElliotCr	88.4	88.4	Elliot Cr sites immediately associated with the Klamath R mainstem.
	KRIndeCr	95.0	95.0	Independence Cr floodplain channel (along Klamath R).

Landmark	Geographic area (GeoArea)	RM entry on Klamath R	Approx miles to Klamath R mouth	Description
	KRTitusCr	96.7	96.7	Titus Cr sites immediately associated with the Klamath R mainstem.
	KRFerryPt	96.7	96.7	Sampling sites immediately associated with Klamath R mainstem at Ferry Pt.
	ClearCr	99.8	99.8	Clear Cr.
	KRLewisR	107.2	107.2	Sampling sites at Lewis Riffle immediately associated with the Klamath R mainstem.
Happy Camp location				
	ElkCr	106.8	115.6	Elk Cr.
	IndianCr	108.0	111.3	Indian Cr entering river in Happy Camp.
	KRBulkP	109.8	109.8	Bulk Plant mainstem site and off-channel near Happy Camp.
	CadeCr	110.6	110.9	Cade Cr.
	KRWdsBar	113.2	113.2	Sampling sites at Woods Bar immediately associated with the Klamath R mainstem.
	KRLHorse	115.7	115.7	Little Horse Cr sites immediately associated with the Klamath R mainstem.
	ChinaCr	119.3	119.5	China Cr.
	ThompCr	124.5	124.5	Thompson Cr.
	FGoffCr	128.0	128.1	Fort Goff Cr.
Seiad Valley location				
	SeiadCr	131.6	131.9	Seiad Cr, including constructed ponds.
	GriderCr	131.9	131.9	Grider Cr, including constructed pond.
	KRLadd	136.4	136.4	Sampling sites near Ladd immediately associated with the Klamath R mainstem.
	KRONeil	138.8	138.8	O'Neil Cr sites immediately associated with the Klamath R mainstem.
	KRTomM	144.2	144.2	Tom Martin Cr immediately associated with the Klamath R mainstem.
Scott R enters				
	ScottBouldCr	144.8	160.8	Scott R mainstem at Boulder Cr.
	ScottVLow	144.8	169.1	Lower Scott R valley (upstream of canyon).
	ScottVMid	144.8	189.5	Middle Scott R valley.
	ScottVUp	144.8	189.6	Upper Scott R valley.
	KRKinsmen	147.2	147.2	Kinsmen Cr immediately associated with the Klamath R mainstem.
	KRBBear	157.5	157.5	Sampling sites at Brown Bear immediately associated with the Klamath R mainstem.
	BeavCr	161.0	161.0	Beaver Cr.
	KRHumCr	173.8	173.8	Humbug Cr immediately associated with the Klamath R mainstem.
Shasta R enters				
	ShastMouth	177.0	177.1	Shasta R mouth site, location of rotary screw trap on the Shasta R.
	ShasUp	177.0	210.0	Upper Shasta R valley in the vicinity of the Big Springs complex.
	CotWdCr	184.8	185.0	Cottonwood Cr.
	KRKlamthon	186.9	186.9	Sampling sites at Klamthon immediately associated with the Klamath R mainstem.

Table 2. Summary of age-0 coho PIT tagged by geographic area and time period, 2007-2011.

Approx miles to Klamath R mouth	Geographic area (GeoArea)	Time period																Total
		2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			
		Nov- Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
0.2	SouthSlough				12													12
1.3	SpruceCr							28	6				47		11			92
1.4	SaltCr					4	2	199	3	3	1	14	8		24			258
1.5	MynotCr																	0
1.6	HunterCrLow				4	30	8	71	18	6	70	34	160	27	69	56		553
1.8	ResigniniPnd		2															2
3.1	RichardCr																	0
3.7	WaukellCr		15	96	350	45	80	529	10	25	86	88	172	373	58	262		2,189
4.0	HoppawCr																	0
5.3	HunterCrUp						212			111						251		574
6.6	McGarveyCr			30	31		188	470		208	1		286	47	51	123		1,435
6.7	TerwerCrLow					12		127	12	14		67	57	100	71	215		675
10.0	KRmainLow				1		3											4
14.1	TerwerCrMid						47			6			241			287		581
17.4	BlueCrLow						34			4								38
18.3	AhPahCr						71			103			65			127		366
31.0	CresCityFks									55			151			276		482
48.8	AikensCr			175	25	33	207	24	3	159	88	25	42		15	139	43	978
50.6	KRSlateCr					21	15			144	19	51	138		41	1		430
50.8	KRBigBar	3	2	3	44	28	7	24	8			30	18	40	14	17	11	249
55.5	BoiseCr													33	4	92	2	131
57.3	CampCr			96			64							2		52	56	270
59.4	KROrleans															8		8
62.7	KRWhitCr										13		9					22
67.3	SalmonRLow												18			28		46
75.2	KRIrvingCr												121					121
76.9	KRStansCr		1	26	34	24	150	12		26	2	55	99	50	24	113	47	663
77.4	KRSandyBCr		3	12	36	250	105	2	10	18	1	72	362	38	290	507	91	1,797
81.0	KRTiBar											23	46	6		100		175
85.1	DillonCr			44									33			78	36	191
88.4	KRElliotCr																	0
95.0	KRIndeCr		25	605	100	17	471	80	2				68			145	102	1,615
96.7	KRTitusCr			49			230			54	6	20	221		57	504		1,141
96.7	KRFerryPt														2			2
99.8	ClearCr						80											80
107.2	KRLewisR													5	2		43	50
109.8	KRBulkP	2			3									10				15
110.9	CadeCr	26	18	14			54	8		6			107			358	48	639
111.3	IndianCr														18	20		38
113.2	KRWdsBar																	0
115.6	ElkCr														30			30
115.7	KRLHorse			9			11		3	1	1		130	8		11	43	217
119.5	ChinaCr			302			152	72							4	109	23	662
124.5	ThompCr			51														51
128.1	FGoffCr			72			11	122					17			86	49	357
131.9	SeiadCr					59		225	19	385	170	111	883	16	237	464	18	2,587
131.9	GriderCr									55								55
136.4	KRLadd																	0
138.8	KRONeil						108			16			93					217
144.2	KRTomM			55			92	13	3	93	8		640	19	1	118		1,042
147.2	KRKinsmen								2						3			5
153.4	TrinityUp												99					99
157.5	KRBBear																	0
160.8	ScottBouldCr						89						15					104
161.0	BeavCr					1				89	107					25		222
169.1	ScottVLow															15		15
173.8	KRHumCr																	0
177.1	ShastMouth														110			110
185.0	CotWdCr					11										112		123
186.9	KRKlamthon																	0
189.5	ScottVMid															36		36
189.6	ScottVUp						197									320	207	724
210.0	ShasUp					125	77	36		1		3			220	8		470

Table 3. Summary of age-1 and age-2 coho PIT tagged by geographic area and time period, 2007-2011.

Approx miles to Klamath R mouth	Geographic area (GeoArea)	Time period																Total
		2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			
		Nov- Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
0.2	SouthSlough				6	1		1			1	1						10
1.3	SpruceCr				1			170	14			94		161	2		83	525
1.4	SaltCr				11	6		138	21	2	8	42		172	14		92	506
1.5	MynotCr				10													10
1.6	HunterCrLow				8	10		150	26	38	94	164	1	326	226		110	1,153
1.8	ResigniniPnd																	0
3.1	RichardCr								48									48
3.7	WaukellCr				53	74	1	827	125		211	64		256	115			1,726
4.0	HoppawCr													12				12
5.3	HunterCrUp										24	18		94	3			139
6.6	McGarveyCr				1	22		15	2			202		82	246			570
6.7	TerwerCrLow								29		23	11		83	30	1		177
10.0	KRmainLow				9			14										23
14.1	TerwerCrMid																	0
17.4	BlueCrLow																	0
18.3	AhPahCr																	0
31.0	CresCityFks																	0
48.8	AikensCr				1			2						1	2		4	10
50.6	KRSlateCr																	0
50.8	KRBigBar								1					28	2		20	51
55.5	BoiseCr													24				24
57.3	CampCr													11	16			27
59.4	KROrleans							2										2
62.7	KRWhitCr																	0
67.3	SalmonRLow																	0
75.2	KRIrvingCr																	0
76.9	KRStansCr	5	17		8	3		30	8		2	6		48	2		78	207
77.4	KRSandyBCr	13	9		51	12		58	39		1	15		202	20		1	421
81.0	KRTiBar							15	7		2			20	2		5	51
85.1	DillonCr																	0
88.4	KRElliotCr													13				13
95.0	KRIndeCr				24			16			4				1		3	48
96.7	KRTitusCr																	0
96.7	KRFerryPt																	0
99.8	ClearCr								1									1
107.2	KRLewisR							122	6		8	4		43	22		70	275
109.8	KRBulkP				18	4		22	38		1	2		4				89
110.9	CadeCr	1						1										2
111.3	IndianCr																	0
113.2	KRWdsBar					12		3										15
115.6	ElkCr																	0
115.7	KRLHorse				14	2		127	24		1	8		12	6		4	198
119.5	ChinaCr																	0
124.5	ThompCr																	0
128.1	FGoffCr																	0
131.9	SeiadCr	4						30	63		170	20		333	61		548	1,229
131.9	GriderCr																4	4
136.4	KRLadd							5	1			10		11	7		5	39
138.8	KRONeil							4	3			2		2				11
144.2	KRTomM							8	4			2		17	2			33
147.2	KRKinsmen								191			13			5		1	210
153.4	TrinityUp																	0
157.5	KRBBear								4					3	3			10
160.8	ScottBouldCr																	0
161.0	BeavCr				1													1
169.1	ScottVLow																	0
173.8	KRHumCr														1			1
177.1	ShastMouth														1			1
185.0	CotWdCr																	0
186.9	KRKlamthon								1			2						3
189.5	ScottVMid																	0
189.6	ScottVUp														46		186	232
210.0	ShasUp								60			8						68

3.2 Pattern Types and Related Factors

This section presents information on patterns of habitat use, fish movement, and fish performance seen in three areas of the Klamath River corridor: Shasta River, Mid Klamath River area, and Lower Klamath River area. Within the Mid and Lower Klamath River areas, patterns of juvenile coho use within six tributary streams are described, demonstrating distinctive ways that these fish use different habitats within corridor habitats. Two of the streams are located in the Mid Klamath River area and four streams are in the Lower Klamath River area. These streams are used for summer and/or winter rearing by either natal or non-natal coho or both. We also present information on patterns of use within mainstem corridor habitats by juvenile coho produced in the Shasta River—these patterns demonstrate some level of uniqueness compared to patterns demonstrated by juveniles produced in other areas of the Klamath River basin.

Sections 3.3 and 3.4 provide brief summaries of movement patterns seen within the mainstem corridor for many other groups of juvenile coho PIT tagged in various locations within or adjacent to corridor habitats.

The section immediately below (3.2.1) provides needed background information for interpreting results of detections of PIT tagged fish in areas reported on in subsequent sections.

3.2.1 Use of Mainstem Corridor Compared for Age-0 and Age-1 Fish

Our assessment of the role of the Klamath River corridor is based to a great extent on determining seasonal patterns of use, including emigration and immigration, associated with the various GeoAreas by juvenile coho. An important aspect of analyzing re-encounters of PIT tags is knowing the general time, or season, when fish move from an area, and then to another area.

In the very early stages of this project we learned that PIT tagged fish originating in areas distant from tributaries or off-channel habitats in the lower parts of the basin were being re-encountered with our sampling equipment. Often, these fish were re-encountered in off-channel habitats in the spring of the year at age-1. While we knew that some of these fish originated in areas of the basin many miles distant, we remained uncertain about when these fish actually moved into the tributaries or off-channel habitats where we were re-encountering them. We considered that two possibilities generally existed. These fish may have re-distributed to these areas during late fall or early winter, as is known to occur for juvenile coho, or they may have actually overwintered in or near their natal streams, then emigrated seaward during the normal springtime smolt outmigration, arriving near the river mouth at that time. As part of this outmigration, such fish might have then made short feeding excursions into adjacent tributaries and off-channel areas, at which time we could have re-encountered them. In this second case, the trap orientation or tag detector might have suggested that the fish was moving downstream (i.e., towards the mainstem river, thereby suggesting the fish had overwintered in habitat upstream)—but still we could not rule out that the fish had recently moved upstream during a feeding excursion and such movement had not been detected.

To address this question, we analyzed the PIT tag data by age group to determine whether differences existed in their re-encounter patterns. We compared re-encounter patterns of known age-1 fish soon to begin their smolt migration, or that were in the midst of the migration already, to fish that had been tagged as age-0 fish or as age-1 fish in January. Comparisons of re-encounter rates for these groups of fish are seen in Table 4 (tagged at age-0) and Table 5 (tagged at age-1). Age-1 fish tagged in the months of March to June can be safely assumed to be on the verge of their smolt migration or already in the midst of it.

The key results displayed in the tables to help address the question of when fish had moved from upstream of the Trinity River to habitats downstream of that point are contained in a comparison of re-encounter rates for age-1 and age-0 fish tagged prior to the end of February to age-1 fish tagged beginning March 1.

A total of 2,347 age-1 coho were PIT tagged upstream of the Trinity River in years 2007-2011 combined for the months of January to June (sum of 1,546 and 801, Table 5). Of these, 801 were PIT tagged after March 1; the remainder was tagged in January and February. Over the entire study to date, not a single age-1 fish tagged upstream of the Trinity River in March to June has been re-detected downstream of the Trinity River. Moreover, only very few age-1 fish tagged in January and February upstream of the Trinity River have been re-encountered downstream of the Trinity River (13 out of 1,546 or 0.8 percent).

In contrast to these findings for age-1 re-encounters, an average of over 5 percent of age-0 fish tagged in November and December are typically re-encountered downstream of the Trinity River (100 age-0 fish tagged in these months have been re-encountered downstream of the Trinity River out of 2,321 fish tagged, Table 4). Only a slightly smaller average percentage of age-0 fish tagged between July 1 and October 31 upstream of the Trinity River each year has been re-encountered downstream of the Trinity River (3.7%, Table 4).

To further examine this issue, we considered whether any evidence existed to show that coho smolts encountered in lower McGarvey Creek (RM 6.6) during March, April, and May were re-encountered in sites downstream of McGarvey Creek during the same months (either in Waukell, Panther, or Salt creek sites). If so, this might indicate that smolts leaving McGarvey Creek during the period of seaward migration might periodically enter the lower reaches of those streams and be encountered by our sampling devices, in which case suggesting that we might be drawing erroneous conclusions about where overwintering occurred for fish seen to be leaving those streams in the spring. During the years applied in this report, a total of 722 different PIT tagged coho smolts were determined to be leaving McGarvey Creek in March-May. Only one of those fish was encountered by our sampling devices at downstream sites during the same time period. That single fish that was re-encountered had emigrated from McGarvey Creek in May 2011 and was then re-encountered a day later in lower Waukell Creek. However, the same fish was then re-encountered again multiple times in January 2012 back in McGarvey Creek, suggesting that the fish was either a holdover (not having gone to sea) and had moved back to McGarvey Creek, or that it was re-encountered as a jack spawner in McGarvey Creek. In either case, the data suggest that if fish do move into these streams briefly during their smolt migration that it is rare.

Table 4. Summary of age-0 coho PIT tagged downstream and upstream of the Trinity River and the numbers found to have moved outside of the GeoArea where they were tagged or to areas downstream of the Trinity River.

Tagging period	Year 2007	2008	2009	2010	2011	Total or Mean
Age-0 fish tagged downstream of Trinity R						
No. tagged						
Mar 1-June 30	17	91	49	203	284	644
Jul 1-Oct 31	126	645	535	1,187	1,597	4,090
Nov 1-Dec 31	398	1,424	158	547		2,527
No. re-encountered in new GeoArea by tag period						
Mar 1-June 30	0	4	4	11	23	42
Jul 1-Oct 31	0	75	64	186	205	530
Nov 1-Dec 31	1	129	11	23		164
% re-encountered in new GeoArea by tag period						
Mar 1-June 30	0.0%	4.4%	8.2%	5.4%	8.1%	6.5%
Jul 1-Oct 31	0.0%	11.6%	12.0%	15.7%	12.8%	13.0%
Nov 1-Dec 31	0.3%	9.1%	7.0%	4.2%		6.7%
Age-0 fish tagged upstream of Trinity R						
No. tagged						
Mar 1-June 30	49	569	50	390	1,072	2,130
Jul 1-Oct 31	1,513	2,120	1,047	3,159	3,466	11,305
Nov 1-Dec 31	242	618	415	227	819	2,321
No. re-encountered below Trinity R by tag period						
Mar 1-June 30	0	10	0	24	17	51
Jul 1-Oct 31	37	115	46	133	75	406
Nov 1-Dec 31	13	23	19	20	25	100
% re-encountered below Trinity R by tag period						
Mar 1-June 30	0.0%	1.8%	0.0%	6.2%	1.6%	1.9%
Jul 1-Oct 31	2.4%	5.4%	4.4%	4.2%	2.2%	3.7%
Nov 1-Dec 31	5.4%	3.7%	4.6%	8.8%	3.1%	5.1%
No. re-encountered in new GeoArea by tag period						
Mar 1-June 30	1	16	0	36	46	99
Jul 1-Oct 31	47	145	61	241	91	585
Nov 1-Dec 31	15	34	22	21	27	119
% re-encountered in new GeoArea by tag period						
Mar 1-June 30	2.0%	2.8%	0.0%	9.2%	4.3%	3.7%
Jul 1-Oct 31	3.1%	6.8%	5.8%	7.6%	2.6%	5.2%
Nov 1-Dec 31	6.2%	5.5%	5.3%	9.3%	3.3%	5.9%

Table 5. Summary of <u>age-1+</u> coho PIT tagged downstream and upstream of the Trinity River and the numbers found to have moved outside of the GeoArea where they were tagged or to areas downstream of the Trinity River. (Note: age-1+ designation indicates that some age-2 fish may also be included.)

Tagging period	Year					Total or Mean
	2007	2008	2009	2010	2011	
Age-1 fish tagged downstream of Trinity R						
No. tagged						
Jan 1-Feb 28	0	99	1,315	361	1,186	2,961
Mar 1-Jun 30	0	113	265	596	636	1,610
No. re-encountered in new GeoArea by tag period						
Jan 1-Feb 28	0	0	25	16	24	65
Mar 1-Jun 30	0	1	17	6	5	29
% re-encountered in new GeoArea by tag period						
Jan 1-Feb 28		0.0%	1.9%	4.4%	2.0%	2.1%
Mar 1-Jun 30		0.9%	6.4%	1.0%	0.8%	2.3%
Age-1 fish tagged upstream of Trinity R						
No. tagged						
Jan 1-Feb 28	23	117	445	189	772	1,546
Mar 1-Jun 30	26	33	451	92	199	801
No. re-encountered below Trinity R by tag period						
Jan 1-Feb 28	0	2	0	1	10	13
Mar 1-Jun 30	0	0	0	0	0	0
% re-encountered below Trinity R by tag period						
Jan 1-Feb 28	0.0%	1.7%	0.0%	0.5%	1.3%	0.9%
Mar 1-Jun 30	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
No. re-encountered in new GeoArea by tag period						
Jan 1-Feb 28	0	2	18	6	21	47
Mar 1-Jun 30	0	0	3	1	1	5
% re-encountered in new GeoArea by tag period						
Jan 1-Feb 28	0.0%	1.7%	4.0%	3.2%	2.7%	2.9%
Mar 1-Jun 30	0.0%	0.0%	0.7%	1.1%	0.5%	0.6%

These results demonstrate that it is highly likely that fish tagged upstream of the Trinity River at age-0, and which were then re-encountered in streams downstream of that point, moved to those downstream habitats prior to their springtime smolt migration. Hence it is very likely that they spent either all or a large part of the winter downstream of the Trinity River. The results suggest that fish migrating downstream as smolts in springtime move directly seaward in the lower river without undertaking feeding excursions into tributaries in the lower river. A similar pattern appears to exist for fish that smolt from streams near the river mouth. These observations are important in interpreting the patterns presented in subsequent sections of this report.

3.2.2 Shasta River Patterns

Until 2011, it was not known how age-0 coho produced in the Shasta River might be using the Klamath River mainstem corridor for either summer or winter use. In 2011, CDFW made a concerted effort to PIT tag age-0 coho leaving the Shasta River in late spring and early summer. Details of that work are reported in Adams (2013). We present additional information here that shows that some portion of the Shasta River juvenile coho production relies on habitats within the Klamath River corridor. (Note: some of the data presented here were collected in spring of 2012.)

In addition, these results now make it clear that Shasta River coho are exhibiting an age-0 smolt at a rate that has not been documented elsewhere within the natural environment. It has been hypothesized that Shasta River coho probably produce age-0 smolts due to their unusually fast growth rate in spring (Bill Chesney, CDFW, *personal communications*). Age-0 smolts in nature are regarded as very rare (Lestelle 2007). Findings reported below, as well as those in Adams (2013), are seen as evidence for an age-0 smolt produced in the Shasta River.

During May and continuing into early July 2011, CDFW released 250 PIT tagged juvenile coho from the rotary screw trap (RST) operated in the lower most reach of the Shasta River (Table 6). Chris Adams (personal communications) determined that all but one of these were age-0 fish. A total of 23 (9.2 percent) of these fish were subsequently re-encountered by Karuk and Yurok sampling as part of this study during 2011 and 2012 within the mainstem river corridor downstream of the Shasta River.

Table 6. Summary of releases of PIT tagged coho from the Shasta River RST by CDFW in 2011 and the percent re-encountered downstream of the Shasta River in 2011 and 2012 in the Klamath River mainstem corridor.

Month	No. released	Re-encountered in KR corridor	% re-encountered
May	15	5	33.3%
June	231	18	7.8%
July	4	0	0.0%
Total	250	23	9.2%

Length frequency analysis of the fish released from the Shasta River show a distinct bi-modal pattern for size (Figure 3). Chris Adams (personal communication) attributes the pattern to differences in growth rates between fish reared in the lower and upper parts of the Shasta River, and perhaps to fish reared in the vicinity of Big Springs Creek.

Figure 4 shows the sizes of the 23 fish at the time of capture in the Shasta River RST that were subsequently re-encountered downstream of the Shasta River, indicating that the large majority of these fish were associated with the smaller size mode. Also included with these 23 fish are another six fish that subsequently were detected again in the Shasta River, four of which were re-encountered in spring of 2012 at or near the time of smoltification as age-1 fish. Hence, a total of

29 different fish from the group of 250 tagged fish released at the RST were re-encountered again in juvenile life stages within the mainstem river corridor. Figure 5 displays the sizes of the re-encountered fish compared to the sizes of all fish within the 250 fish group in relation to the date of release from the Shasta River RST.

The 29 fish were re-encountered at a wide range of locations within the mainstem corridor from shortly after release from the RST until as late as the following spring. Figures 6 and 7 provide information on the distribution of re-encounters within the mainstem river corridor. Figure 8 depicts the movement in space and time of the 23 juvenile coho that were re-encountered within the river corridor downstream of the Shasta River.

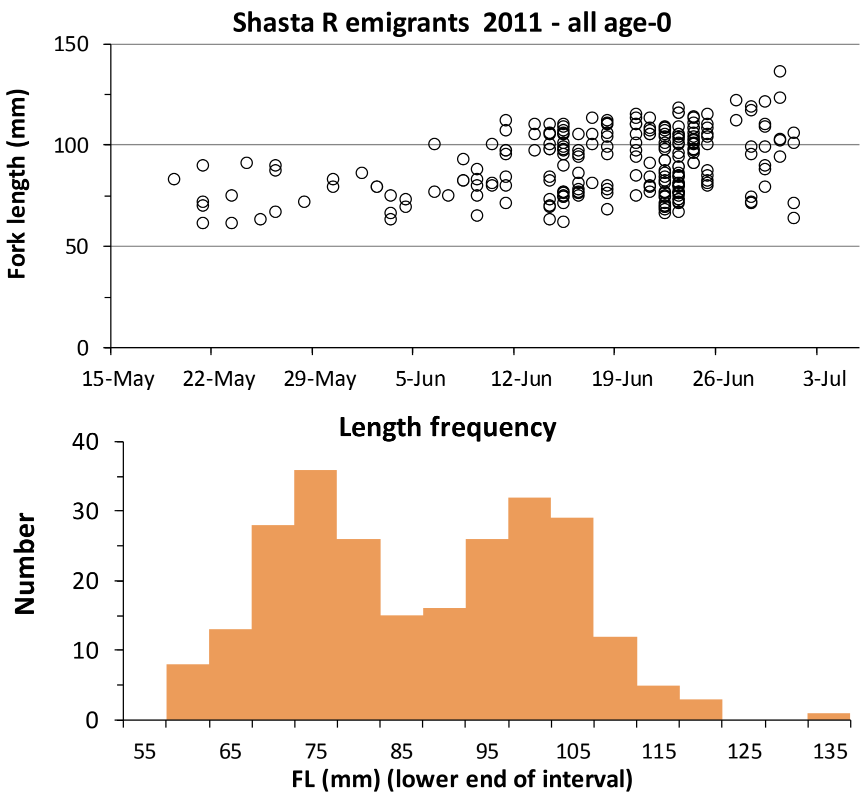


Figure 3. (Top) Fork lengths (mm) of juvenile coho released from the Shasta River RST (located at RM 0.0) in 2011 in relation to capture date. (Bottom) Length frequency histogram of the same fish. All of the fish were PIT tagged and all but the single largest fish were determined to be age-0. Data from Chris Adams (CDFW).

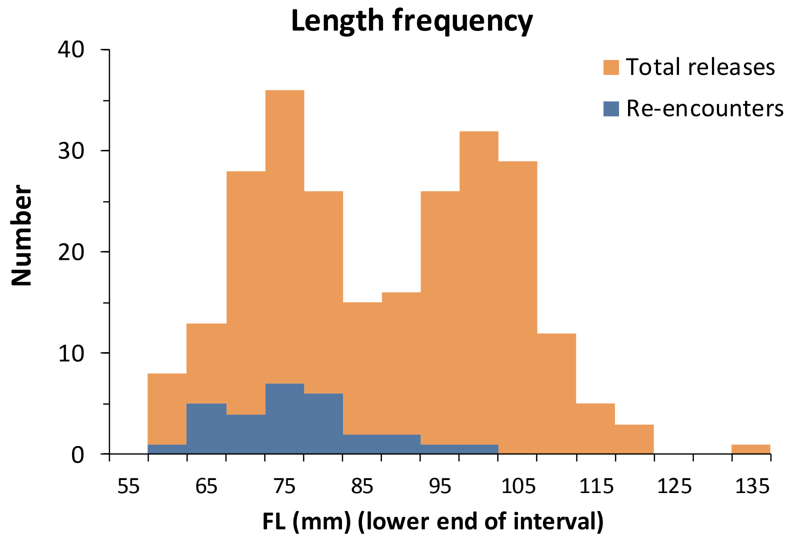


Figure 4. Comparison of fork lengths of the 250 juvenile coho released from the Shasta River RST to the 29 fish from that group subsequently detected downstream of the Shasta River within the Klamath River mainstem corridor and the lower Shasta River after release.

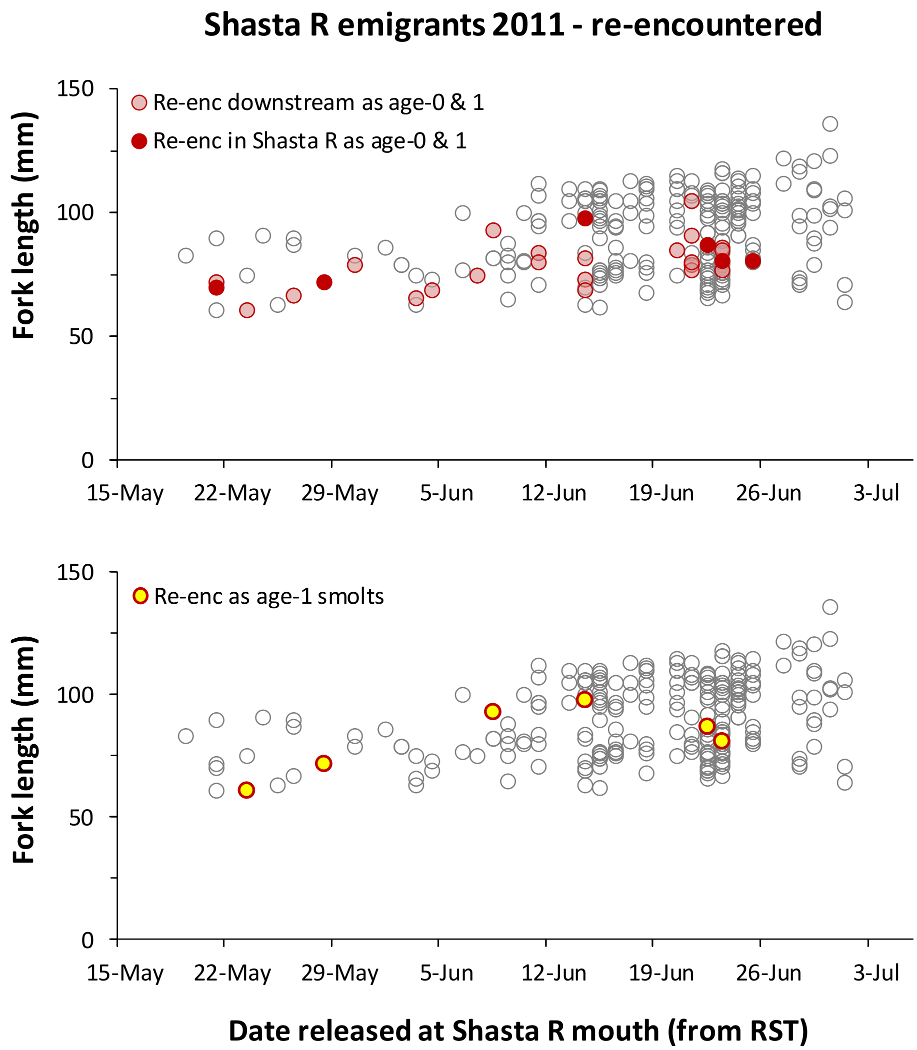


Figure 5. Fork lengths (mm) of re-encountered juvenile coho released from the Shasta River RST in 2011 in relation to capture date compared to fork lengths of fish not re-encountered.

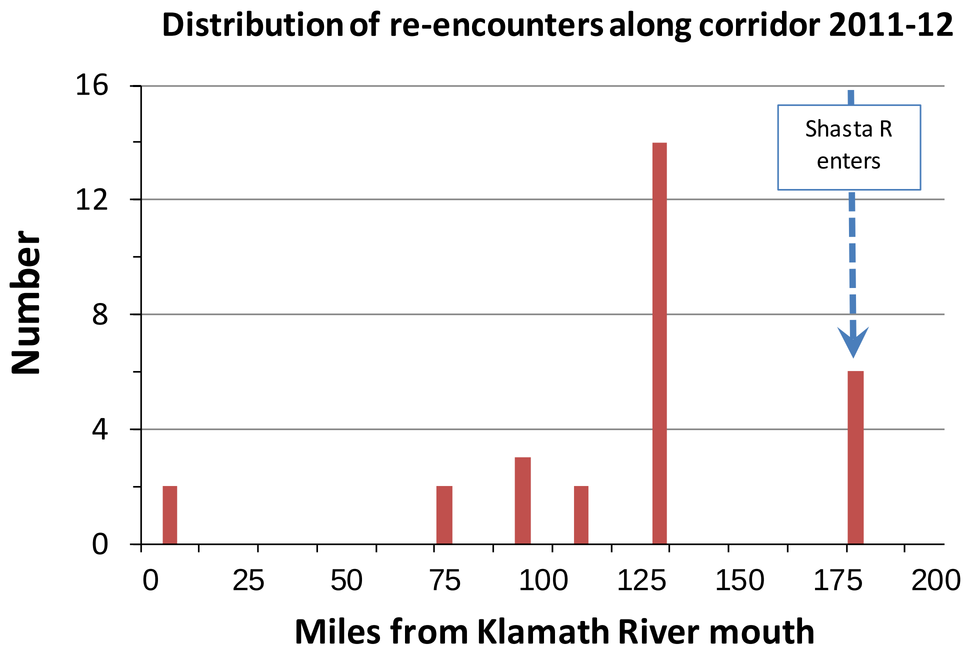
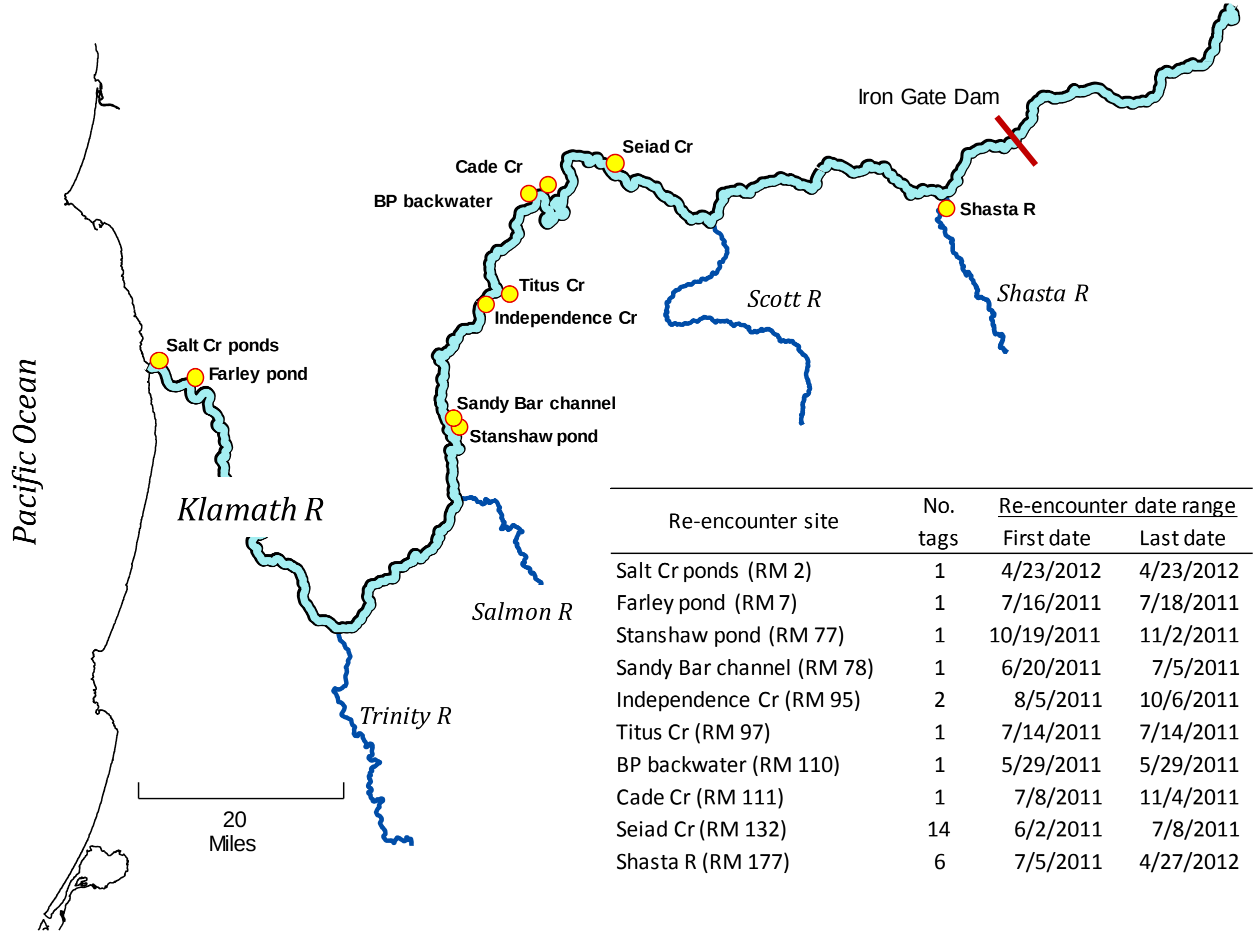


Figure 6. Distribution of re-encounters of 29 juvenile coho in 2011 and 2012 within the Klamath River corridor released from the Shasta River RST in 2011.



Re-encounter site	No. tags	Re-encounter date range: First date	Re-encounter date range: Last date
Salt Cr ponds (RM 2)	1	4/23/2012	4/23/2012
Farley pond (RM 7)	1	7/16/2011	7/18/2011
Stanshaw pond (RM 77)	1	10/19/2011	11/2/2011
Sandy Bar channel (RM 78)	1	6/20/2011	7/5/2011
Independence Cr (RM 95)	2	8/5/2011	10/6/2011
Titus Cr (RM 97)	1	7/14/2011	7/14/2011
BP backwater (RM 110)	1	5/29/2011	5/29/2011
Cade Cr (RM 111)	1	7/8/2011	11/4/2011
Seiad Cr (RM 132)	14	6/2/2011	7/8/2011
Shasta R (RM 177)	6	7/5/2011	4/27/2012

Figure 7. Locations of re-encounters of the 29 juvenile coho released from the Shasta River RST in 2011.

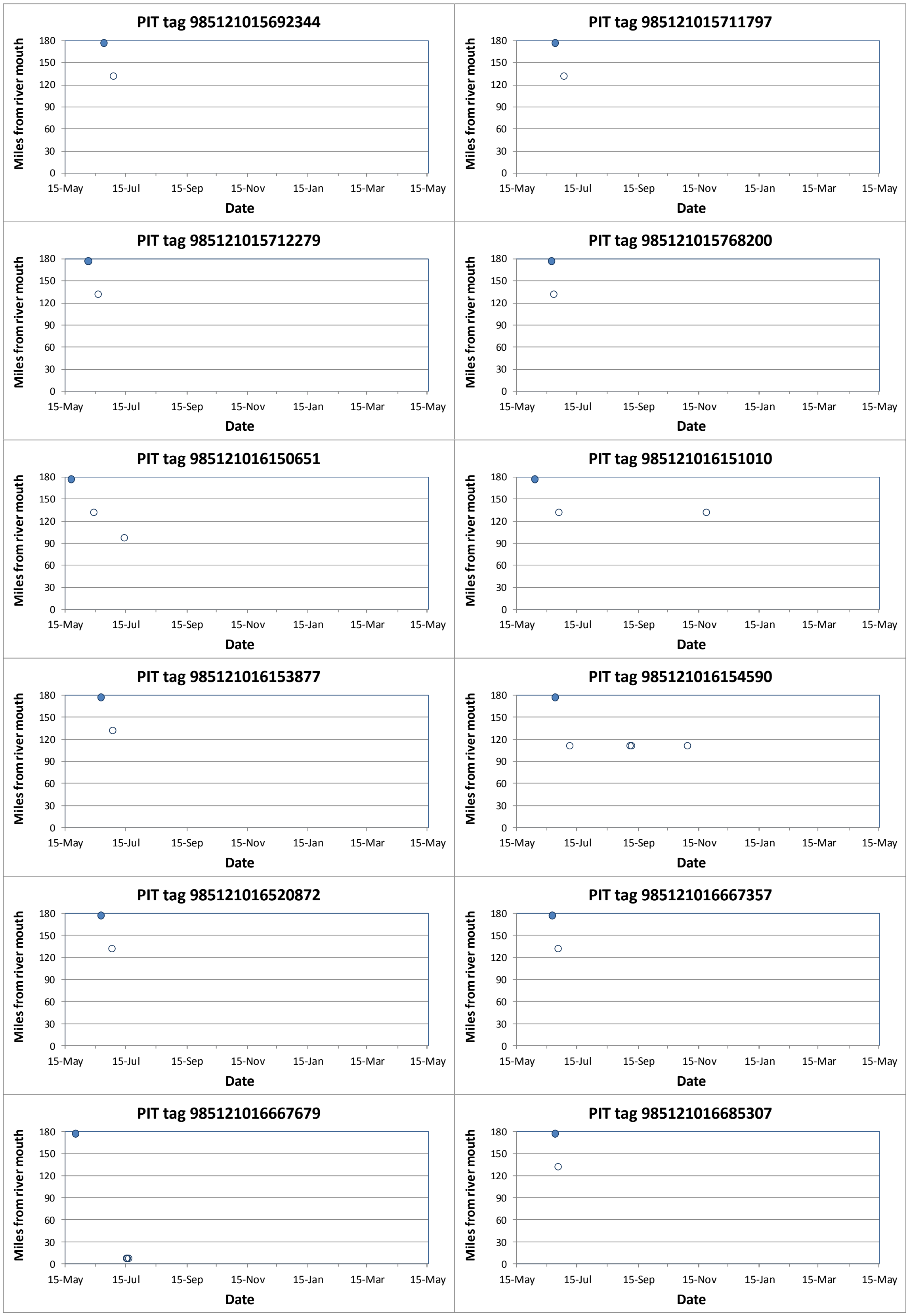


Figure 8. Spatial-temporal patterns of re-encounters of Shasta River coho in the mainstem corridor 2011-12.

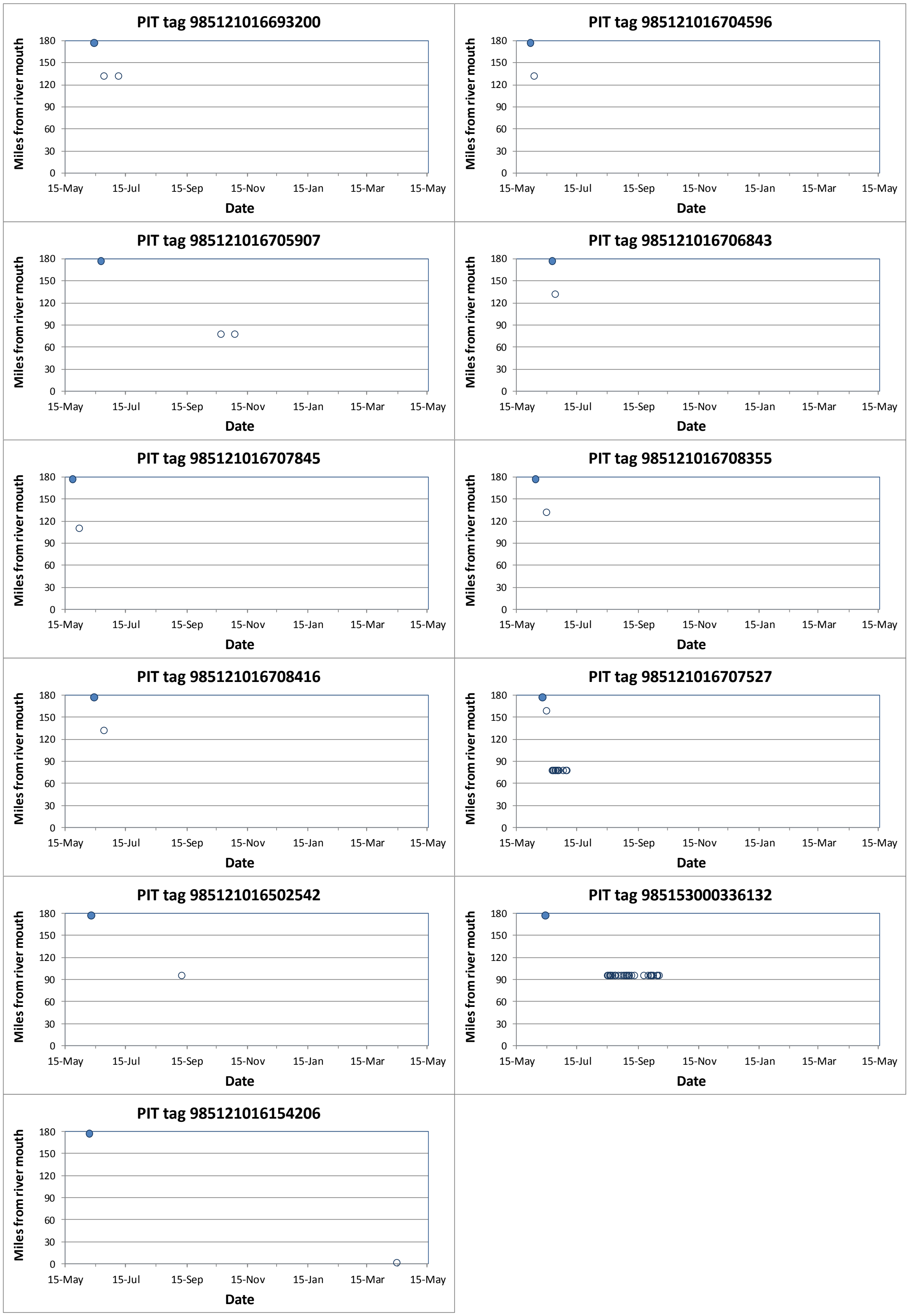


Figure 8 – continued.

The pattern of fish sizes of the re-encountered fish from the Shasta River compared to fish not re-encountered is strongly indicative of one with larger age-0 fish undergoing smoltification and seaward migration and smaller fish remaining resident in freshwater. An almost identical pattern was reported by Feldmann (1974) for hatchery coho as part of an experimental program conducted at the University of Washington (UW) to produce age-0 coho smolts. A short summary of that work here is helpful to understand the patterns exhibited by age-0 coho that emigrated from the Shasta River.

The UW hatchery coho program aimed to produce age-0 coho smolts by accelerating both incubation time (using elevated water temperatures) followed by an enhanced feeding regime (high ration with high quality foods) (Feldmann 1974; Brannon et al. 1982). The purpose of the program was to determine whether juvenile coho development could be accelerated enough to consistently produce age-0 smolts, which if successful, would return 2-year old adults to spawn (as both females and males, hence they would not be jacks or grilse), thereby cutting the life cycle by one year and potentially producing similar sized adults.

In 1971, two groups of the age-0 coho were released from the UW hatchery, having a combined length frequency histogram shown in Figure 9, which coincidentally closely resembles the histogram for the 250 Shasta River fish released at the RST (Figure 3). It is important to note that the differences in the fork lengths of the UW experimental fish were due to differences in spawning timing, the larger fish having been produced from November spawners and the smaller fish produced from December spawners. Fish from each size group were given different fin clips (left and right ventral fin clips). Both groups were released from the hatchery on the same day in late May into a freshwater canal that connects Lake Washington to Puget Sound in the middle of Seattle (Figure 10). The hope was that both groups of fish would turn west into the canal and migrate the several miles to where the canal enters Puget Sound. Within days of the release, however, a UW student doing research in small streams that entered the north end of Lake Washington (Figure 10) captured substantial numbers of juvenile coho in those streams that were marked with ventral fin clips. All but one of the fin clips matched the mark given to the smaller-sized group released from the hatchery. Those streams were located over 10 miles north of the UW hatchery following the shore of the lake. Based on continued sampling, the student concluded that some of the fish that entered those tributaries overwintered in that vicinity and smolted as age-1 fish from there.[4]

Feldmann (1974) and Brannon et al. (1982), based on scale analysis and the observations made in the small tributary streams to Lake Washington, reported that fish generally larger than 90 mm at release tended to migrate immediately seaward. Smaller sized fish delayed their seaward migration, some remaining in freshwater from a couple of months to a year longer. The larger age-0 smolts exhibited the highest marine survival rate, leading to the conclusion that successful age-0 smolts were generally larger than 100 mm in length.

The patterns described herein for age-0 coho that emigrated from the Shasta River in 2011 closely match the patterns reported by Feldmann (1974): close similarities in the length frequency histogram with some amount of extended freshwater residency occurring for fish less

[4] / The UW student was Larry Lestelle, one of the co-authors on this report; hence information reported here is based on his observations, which were documented in a manuscript report (Lestelle 1972).

than 90-100 mm in length. We think it is likely that the reason the largest age-0 Shasta River fish were not re-encountered anywhere in the mainstem corridor habitat was due to their rapid and direct migration seaward. This pattern is consistent with what we described in Section 3.2.1—i.e., fish that have undergone smoltification migrate to the ocean through the mainstem corridor without moving into connected corridor habitats outside the mainstem river, thereby avoiding being re-encountered by our sampling gear.

The habitat utilization pattern seen for Shasta River coho within the mainstem corridor in 2011 and 2012 suggests that the corridor serves as a vital rearing area for this population in at least some years. It should be noted that the number of age-0 coho that emigrated from the Shasta River in 2011 was far greater than the estimated number of age-1 smolts that emigrated in that year.

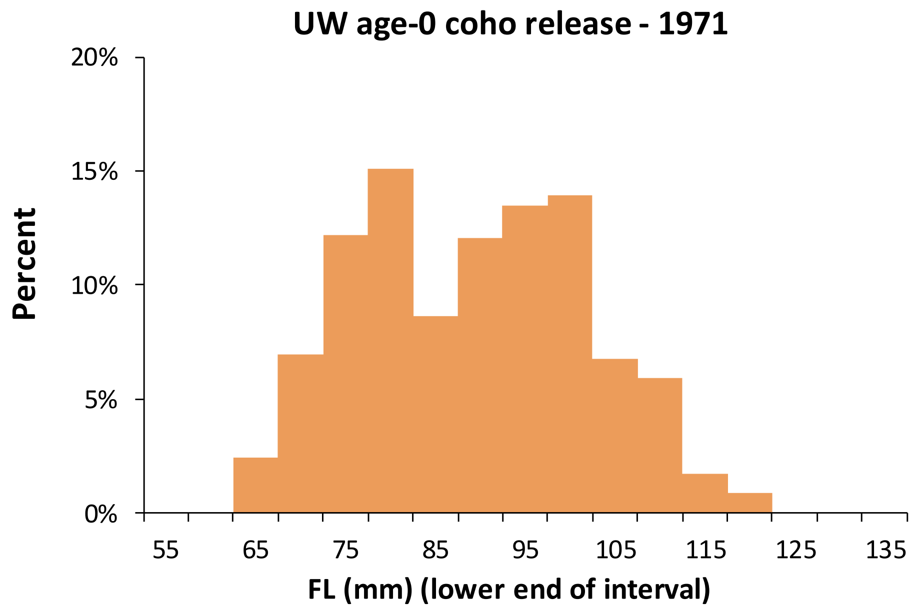


Figure 9. Length frequency histogram of age-0 juvenile coho released from the University of Washington hatchery in 1971. Data from Feldmann (1974).

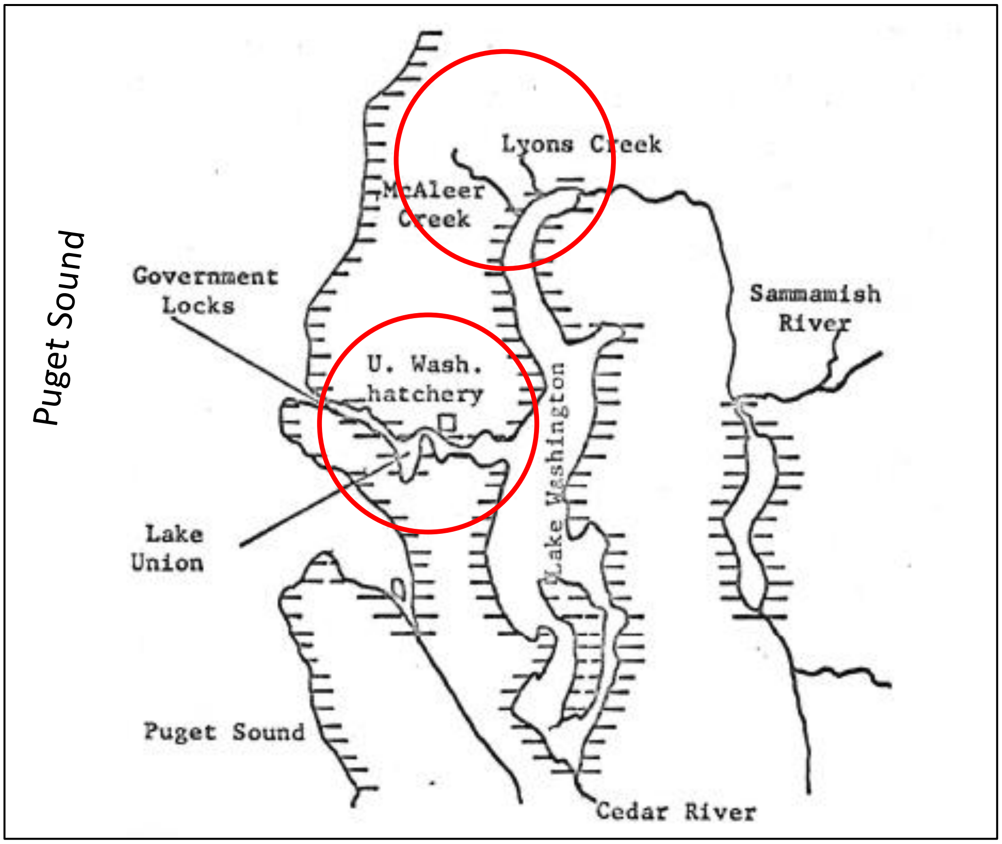


Figure 10. Map taken from Feldmann (1974) showing the location of the University of Washington hatchery in relation to the route to Puget Sound and the Lake Washington system. The streams where age-0 juvenile coho released from the UW hatchery were found are identified.

3.2.3 Mid-Klamath Patterns

This section presents patterns of habitat use and associated juvenile coho performance observed in two tributaries to the Mid Klamath study areas: Sandybar floodplain channel (RM 78) and Seiad Creek (RM 129). Sandybar floodplain channel is only used by non-natal coho. Seiad Creek is used by both natal and non-natal coho. The patterns that are described here suggest that a significant shortage of quality overwintering sites exists in the Mid Klamath regions, which has generally been known on the basis of the characteristics of the streams and the Klamath River floodplain. Significant work has occurred in recent years to increase the supply of suitable overwintering sites—that work is on-going.

3.2.3.1 Sandybar Creek Patterns

Sandybar Creek feeds a floodplain channel to the Klamath River at RM 78 (Figure 11). The creek is a small stream with a relatively high channel slope that is not used by spawning coho. All of the juvenile coho that inhabit the floodplain channel and associated creek are non-natal fish that originate elsewhere. Results of intensive monitoring at the site show that fish rearing there can originate from many different spawning streams located upstream. One of the 23

Shasta River fish that used the river corridor in 2011 moved into the Sandybar channel on June 20, ten days after being released at the Shasta River RST. It bears noting that another Shasta River fish moved into a similar site—the Stanshaw Creek floodplain channel—about the same time; this channel is a short distance downstream from the Sandybar channel.

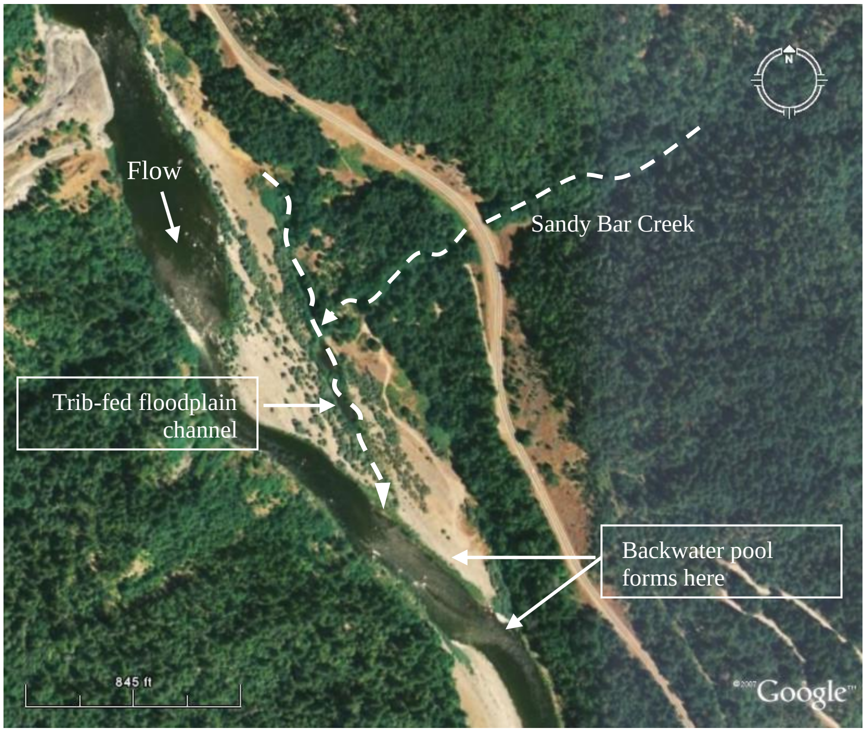


Figure 11. Aerial view of the Sandybar floodplain channel located at RM 78 on the Klamath River.

Sandybar Creek enters the floodplain channel roughly halfway through the channel's length. The floodplain has characteristics of both an intermittently connected side channel and an overflow channel. At higher flows, when the channel is still disconnected at its upper end to the river, some surface river water moves across the point bar and enters the floodplain channel slightly downstream of where Sandybar Creek joins the channel.

This floodplain channel contains several depressions that cause it to retain surface water brought in by Sandybar Creek. This results in the formation of two large ponds, one immediately upstream of where Sandybar Creek enters the channel and the other downstream of the creek. The upper pond is most sheltered from high flow effects from Sandybar Creek, as well as from relatively high mainstem river flows. The lower end of the floodplain channel can disconnect from the mainstem river once flows in the creek drop to summer low flow.

The site is intensively monitored using multiple stationary PIT tagging detectors and several traps for obtaining fish length data. Monitoring using the PIT tagging detectors began in the summer of 2008 and has continued since then. As a result of the number of detectors being used and how they are arranged in the channel, there is almost no chance a juvenile coho can visit the site without being detected. Typically, each PIT tagged coho that is either tagged at the site or immigrates into it is detected hundreds or thousands of time during its residency. Close inspection of the data shows that when a fish ceases to be detected for several days, it almost is never re-detected. We infer from this that we can reliably determine approximately when a fish arrives and when it either dies or departs. Because of this reliability, the site provides a unique opportunity to assess patterns of utilization in the channel.

We provide here the results of monitoring that occurred during three winter and springtime periods: 2008-09, 2009-10, and 2010-11.

The three years of data applied in this analysis encompass three very different utilization rates in the channel by juvenile coho. We refer to these different utilization rates as having a low, an intermediate, or a high fish density associated with them. We determined that on December 1 there were alive in the channel a total of 86, 19, and 301 PIT tagged coho in 2008, 2009, and 2010 respectively (Table 7). We are unsure about the exact total numbers of coho present in the channels on December 1 (i.e., both tagged and untagged fish), but we believe the number of tagged fish present on December 1 was a good indicator of the relative density in each year. Table 7 summarizes the key metrics for the winter and spring of each year used in our analysis.

We assessed the rates and patterns of attrition, which includes mortality as well as emigration, in the channel for each of the three years. These attrition patterns show how the number of tagged age-0 fish present on December 1 changed between that date and the end of the spring outmigration of age-1 smolts (Figure 12). A comparison of the three years shows almost no attrition to fish present on December 1 in the low density year (2009-10) until the beginning of the spring outmigration, which typically begins in mid-March for many off-channel habitats (Lestelle 2007). In contrast, attrition was considerably greater in the other two years during December and January, though it differed between those two years in later months.

Table 7. Summary of key metrics used in assessing attrition and emigration of juvenile coho in the Sandybar floodplain channel, 2008-09, 2009-10, and 2010-11.

Metric	Winter/Spring		
	2008-09	2009-10	2010-11
No. of focus tagged fish present Dec 1	86	19	301
First date tagged	29-May	28-May	23-Jun
Last date tagged	22-Nov	9-Sep	19-Nov
December			
No. of tags present begin month	86	19	301
No. of tags present end month	48	19	215
No. of tags lost during month	38	0	86
No. of tags detected downstream	7	0	24
% of tags lost in month	44.2%	0.0%	28.6%
% of lost tags re-encountered downstream	18.4%	0.0%	27.9%
% of lost tags detected below Trinity R	18.4%		24.4%
January			
No. of tags present begin month	48	19	215
No. of tags present end month	28	16	157
No. of tags lost during month	20	3	58
No. of tags detected downstream	1	1	9
% of tags lost in month	41.7%	15.8%	27.0%
% of lost tags re-encountered downstream	5.0%	33.3%	15.5%
% of lost tags detected below Trinity R	5.0%	33.3%	15.5%
February			
No. of tags present begin month	28	16	157
No. of tags present end month	20	16	58
No. of tags lost during month	8	0	99
No. of tags detected downstream	0	0	2
% of tags lost in month	28.6%	0.0%	63.1%
% of lost tags re-encountered downstream	0.0%	0.0%	2.0%
% of lost tags detected below Trinity R	0.0%		2.0%
March			
No. of tags present begin month	20	16	58
No. of tags present end month	15	10	44
No. of tags lost during month	5	6	14
No. of tags detected downstream	0	0	0
% of tags lost in month	25.0%	37.5%	24.1%
% of lost tags re-encountered downstream	0.0%	0.0%	0.0%
% of lost tags detected below Trinity R	0.0%	0.0%	0.0%
April			
No. of tags present begin month	15	10	44
No. of tags present end month	1	1	39
No. of tags lost during month	14	9	5
No. of tags detected downstream	0	0	0
% of tags lost in month	93.3%	90.0%	11.4%
% of lost tags re-encountered downstream	0.0%	0.0%	0.0%
% of lost tags detected below Trinity R	0.0%	0.0%	0.0%
May			
No. of tags present begin month	1	1	39
No. of tags present end month	0	0	0
No. of tags lost during month	1	1	39
No. of tags detected downstream	0	0	0
% of tags lost in month	100.0%	100.0%	100.0%
% of lost tags re-encountered downstream	0.0%	0.0%	0.0%
% of lost tags detected below Trinity R	0.0%	0.0%	0.0%

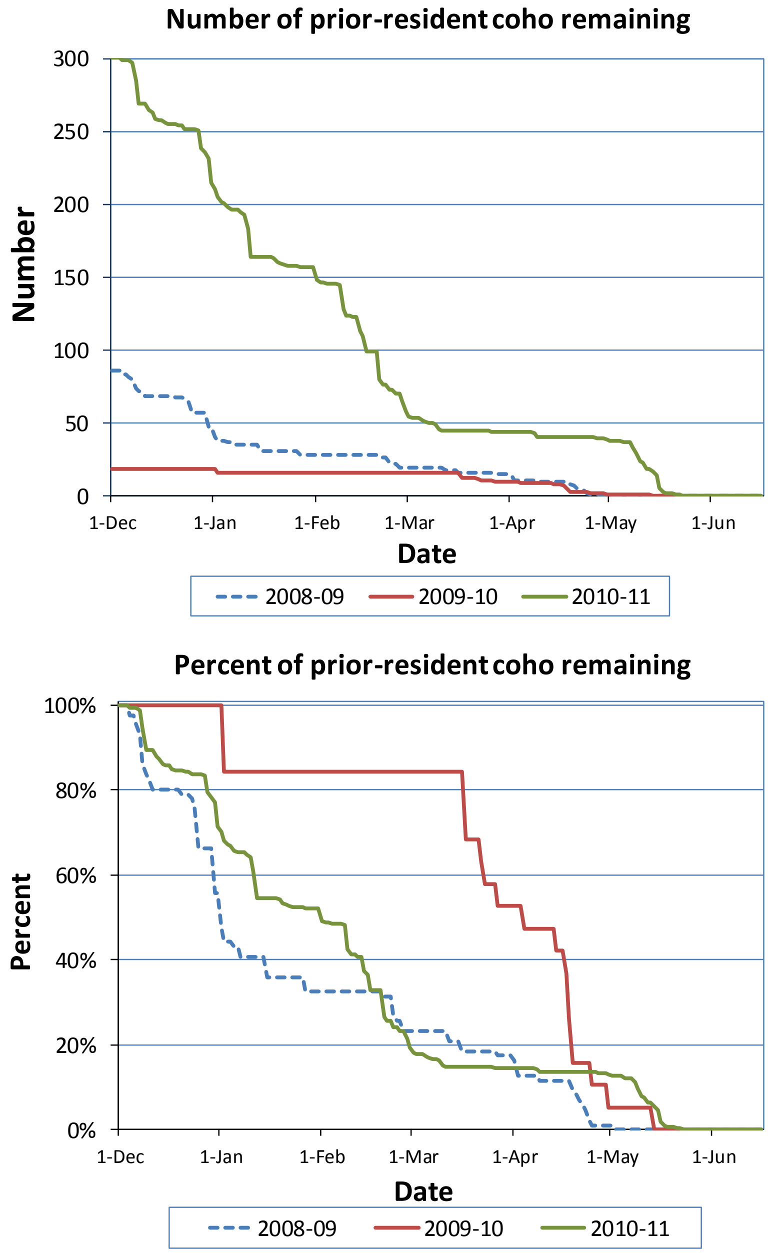


Figure 12. Attrition patterns from the Sandybar floodplain channel of PIT tagged juvenile coho that were present on December 1 of 2008, 2009, and 2010 respectively.

Examination of the monthly results in Table 7 for the three years shows a pattern in which the large majority of fish that were detected downstream of Sandybar after December 1 moved in December or January, with most of these having emigrated in December (Figure 13). For example, in the high density year, an estimated total of 86 tagged fish were lost from the channel in December, of which 24 were re-encountered downstream, and all but one of these was detected in habitats relatively close to the river mouth. In contrast, an estimated total of 99 tagged fish were lost from the channel in February and only two of these were ever re-encountered downstream. It bears noting that we have observed the same types of patterns for juvenile coho at Seiad Creek (Section 3.2.3.2; Figure 23). The clear pattern is that fish that are present in late November or early December, and that then are lost from the stream (for whatever reason), have a relatively high probability of being detected downstream of Trinity River, most of which is seen near the Klamath River estuary. This same pattern seems to hold for fish that disappear from a stream in early January. However, beginning shortly thereafter (mid-January), fish that disappear from a monitoring area are almost never detected again as juveniles. As noted earlier, fish that are tagged beginning in about mid-March, which coincides with the time of the start of the smolt outmigration, are also not detected; in that case it is believed to be due to a migration that remains associated with the main river channel and thus tagged fish are not encountered by our equipment.

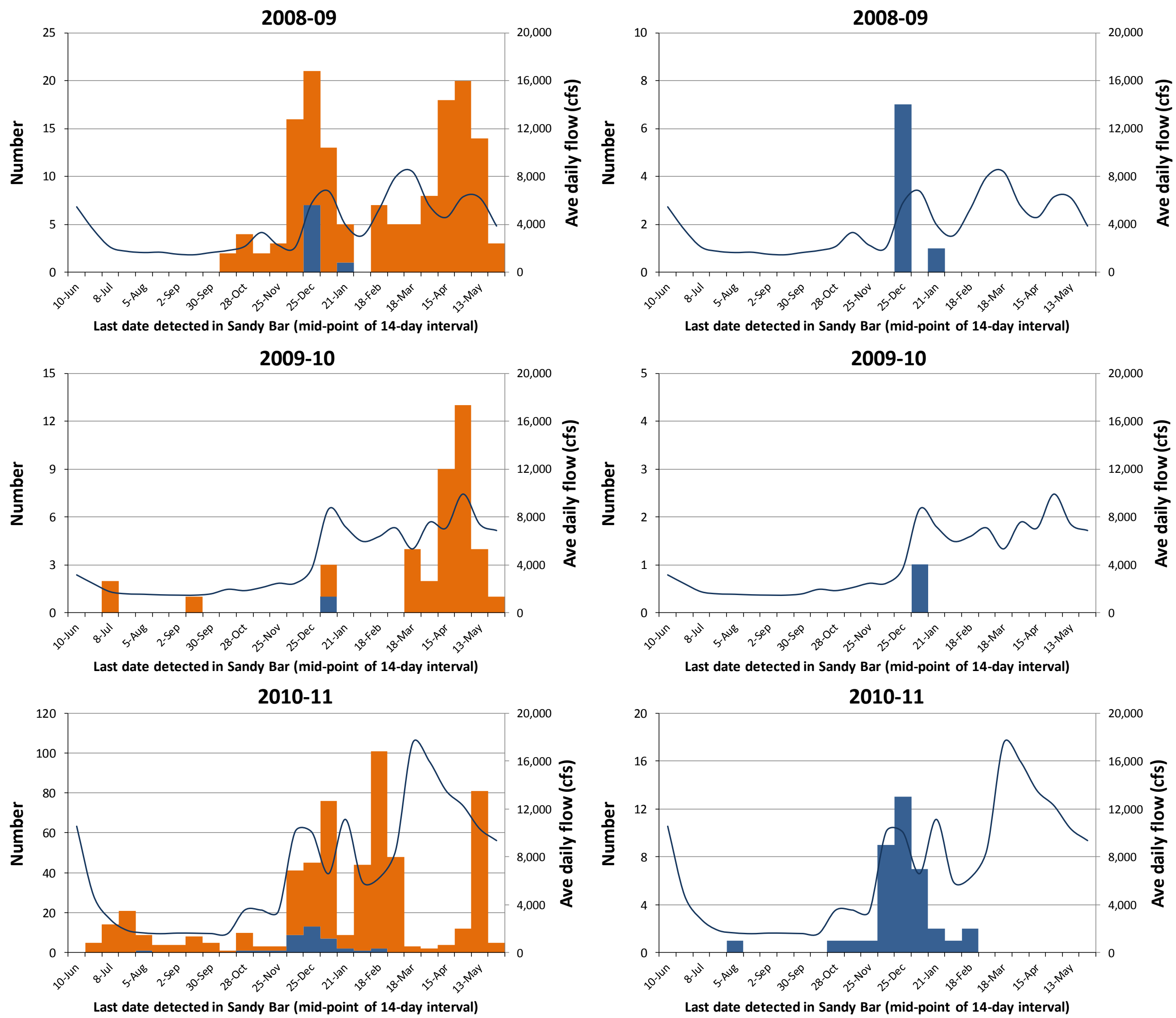


Figure 13. Numbers of fish by the last date detected in Sandybar floodplain channel for PIT tagged fish not re-encountered again downstream of the Trinity River (orange bars) and those that were re-encountered again downstream of Trinity River (blue bars). Data are grouped in two-week intervals. Average daily flows in the Klamath River during the 2-week intervals are also plotted. Plots on right show just re-encountered fish with Y-axis scale changed for closer inspection.

Figure 14 displays patterns of daily loss rates (attrition) from the Sandybar channel for the three years together with the amount of flow estimated in the Klamath River adjacent to Sandybar exceeding 9,200 cfs. Sutton et al. (2010), using survey data and two dimensional (2-D) hydrodynamic modeling of the Sandybar area, determined that the flow in the mainstem Klamath River required to hydraulically connect with the Sandybar channel from the upstream side was 9,200 cfs. Flow is estimated for the Klamath River at Sandybar by subtracting the daily flow for Salmon River (located downstream of Sandybar) from the daily flow estimates for the Klamath River at Orleans (using USGS records for both rivers).

Figure 14 shows that when river flows exceed 9,200 cfs in December and early January that daily loss rates increase sharply. It was during such a storm event that most fish lost to the channel prior to the smolt period in the low density year (2009-10) occurred. These results suggest that the quality of overwintering habitat diminishes in the Sandybar channel during high flow events; if this happens during December and January then fish lost to the channel actively emigrate, apparently in search of better habitat.

A distinctive part of the attrition patterns seen in 2008-09 (intermediate density) and 2010-11 (high density) is the relatively high losses that occurred in late January and February when elevated flows did not occur. We have observed the same pattern in data for Seiad Creek. As noted previously, these fish generally exhibit no apparent tendency for significant downstream migration at this time. Contrasting these patterns with that seen for Sandybar channel in 2009-10 (low density) suggests that the attrition is due to density-dependent effects, such as food shortage. Figure 15, showing rates of loss and emigration rates (reflected in downstream detections), suggests that juvenile coho density is a key driver of the utilization patterns seen in the Sandybar channel.

We hypothesize that fish that leave this site, and those similar to it, in mid-winter are searching for both food and slow velocity refuge habitat, but they are not predisposed to undertake long migrations, possibly due to low water temperatures and reduced lipid reserves. If this is true, then we suggest that fish that need to search out better overwintering habitat are most inclined to do so early in winter, when water temperatures would be somewhat higher and lipid reserves greater. Fish that undertake what would seem to be a hazardous journey to the lower river, and survive to arrive there, would generally be rewarded by a higher abundance of food (call it the Costco effect) associated with warmer conditions and estuarine influences.

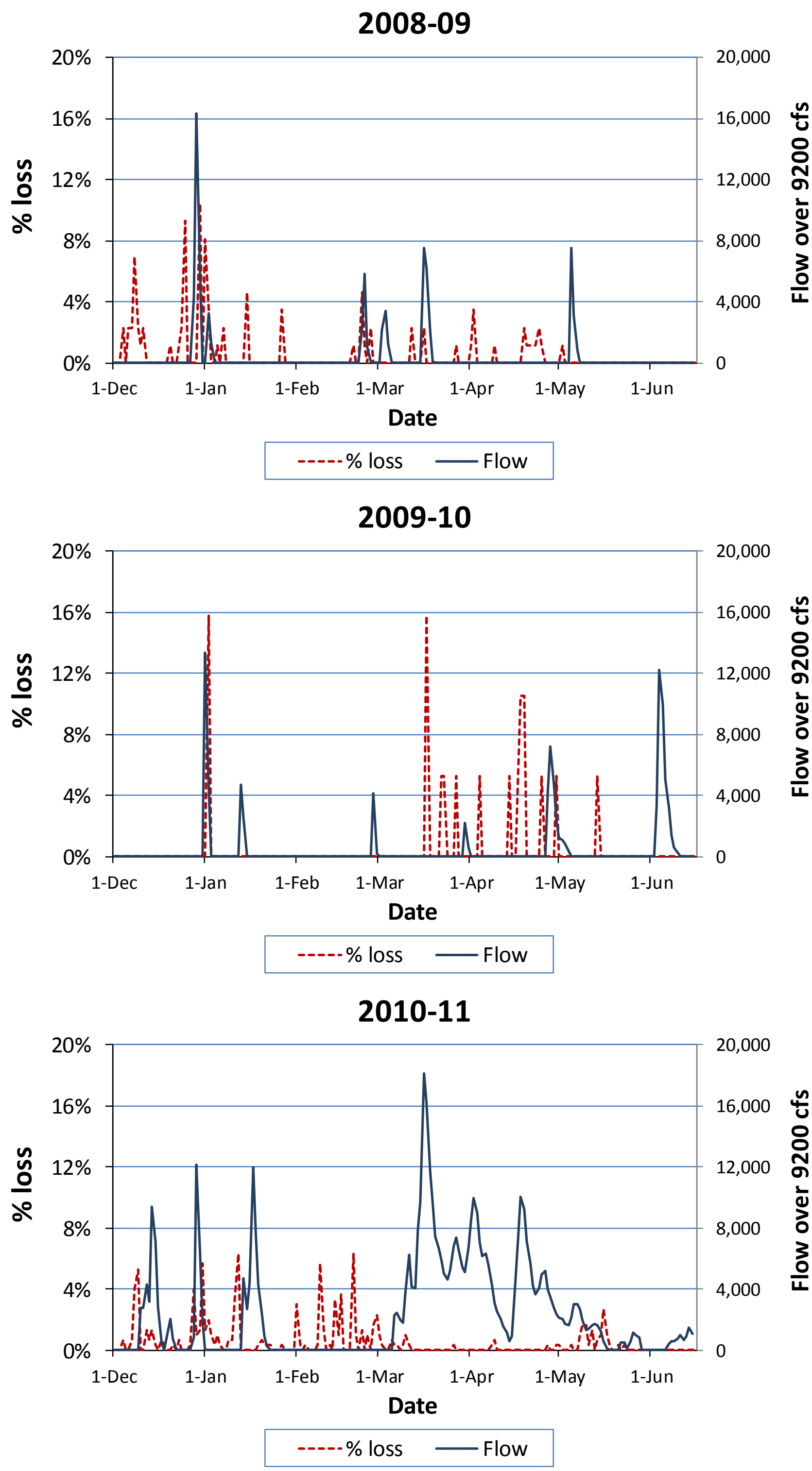


Figure 14. Estimated daily loss rates (attrition) from the Sandybar channel of PIT tagged juvenile coho that were present on December 1 of 2008, 2009, and 2010 respectively, and daily estimated flow in the main river exceeding 9,200 cfs.

We suggest that density-dependent effects in mid- to late-winter are a leading cause of overwintering mortality at many sites within the mainstem corridor. High quality overwintering habitat is generally in short supply within the corridor. The relative amount of such habitat increases in frequency and size as the river mouth is approached, but even there it is not especially abundant.

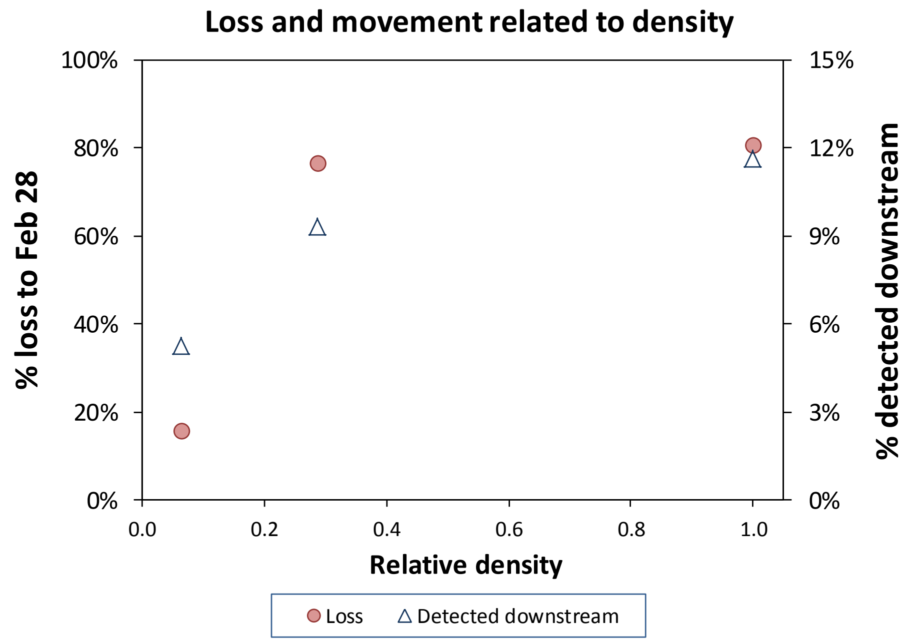


Figure 15. Patterns of percent loss from December 1 to February 28 and percent of fish lost to Sandybar channel in this period that are detected downstream (almost all near the river mouth) in relation to relative density (number of tagged fish present on December 1 divided by the number present on December 1 during the high density year).

Fork length (mm) data are graphed in two ways to show patterns of change over time. Figure 16 shows fork length in relation to date of capture and Figure 17 provides length frequency histograms for data grouped by monthly period. Particularly notable is that the average sizes of smolts that were still present in the channel near the end of the outmigration period were similar between the low density (2009-10) and high density (2011) years. It may be important to also note that sizes in both the intermediate and high density years seemed to level off through the middle part of winter, then size appeared to increase significantly after the majority of fish had disappeared in the high density year. Factors affecting these patterns remain to be understood.

Figure 18 provides patterns of dates of arrival of known PIT tagged immigrants relative to the dates when the fish were tagged moving into the Sandybar floodplain channel from other areas and last dates of detection relative to arrival dates. The patterns provide information on the lengths of time that the fish were rearing outside of the channel after being tagged, as well as the lengths of residency within the channel before the tags disappeared due to either mortality or emigration.

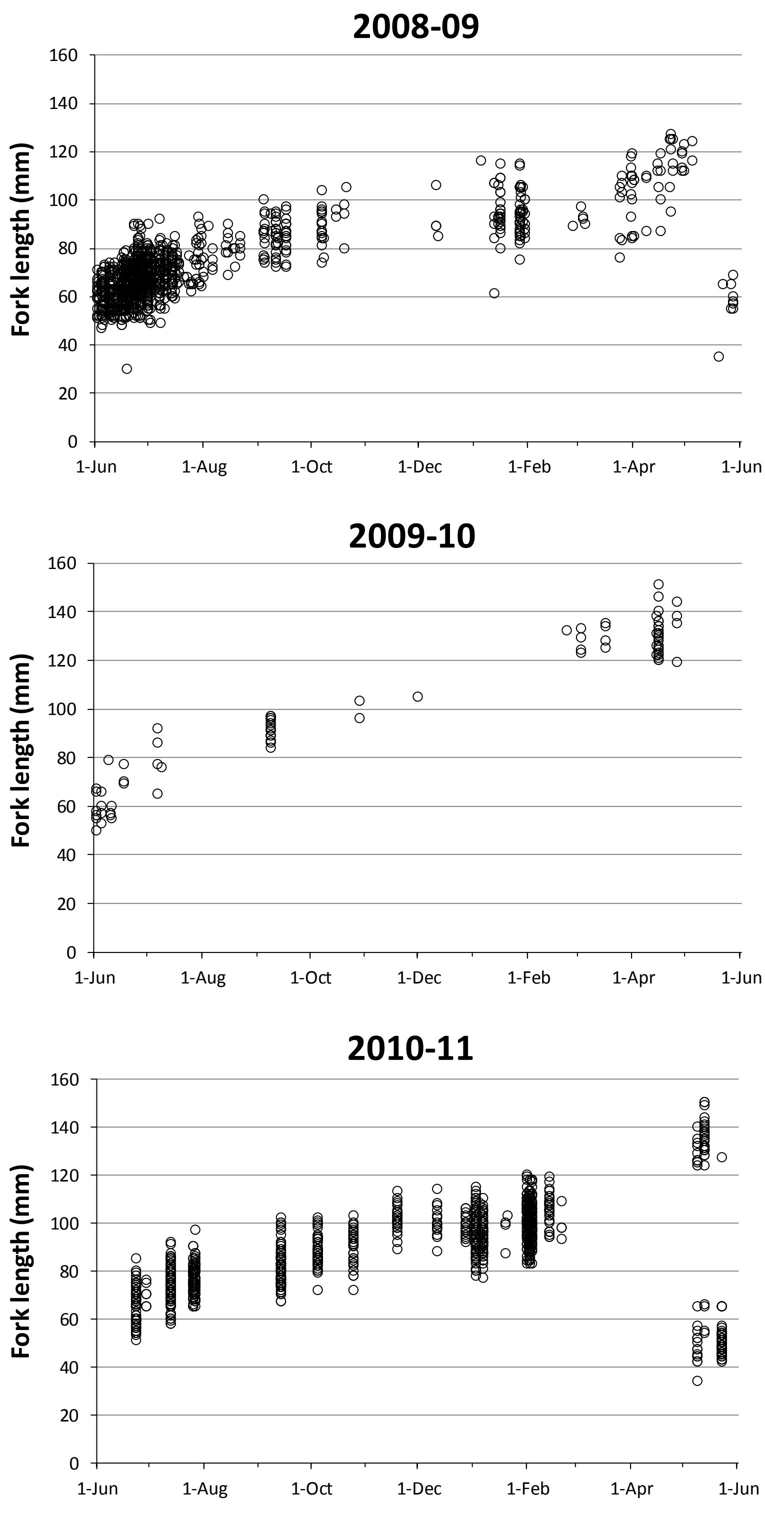


Figure 16. Fork lengths (mm) of juvenile coho sampled in Sandybar floodplain channel between June 1 and May 31 in 2008-09, 2009-10, and 2010-2011.

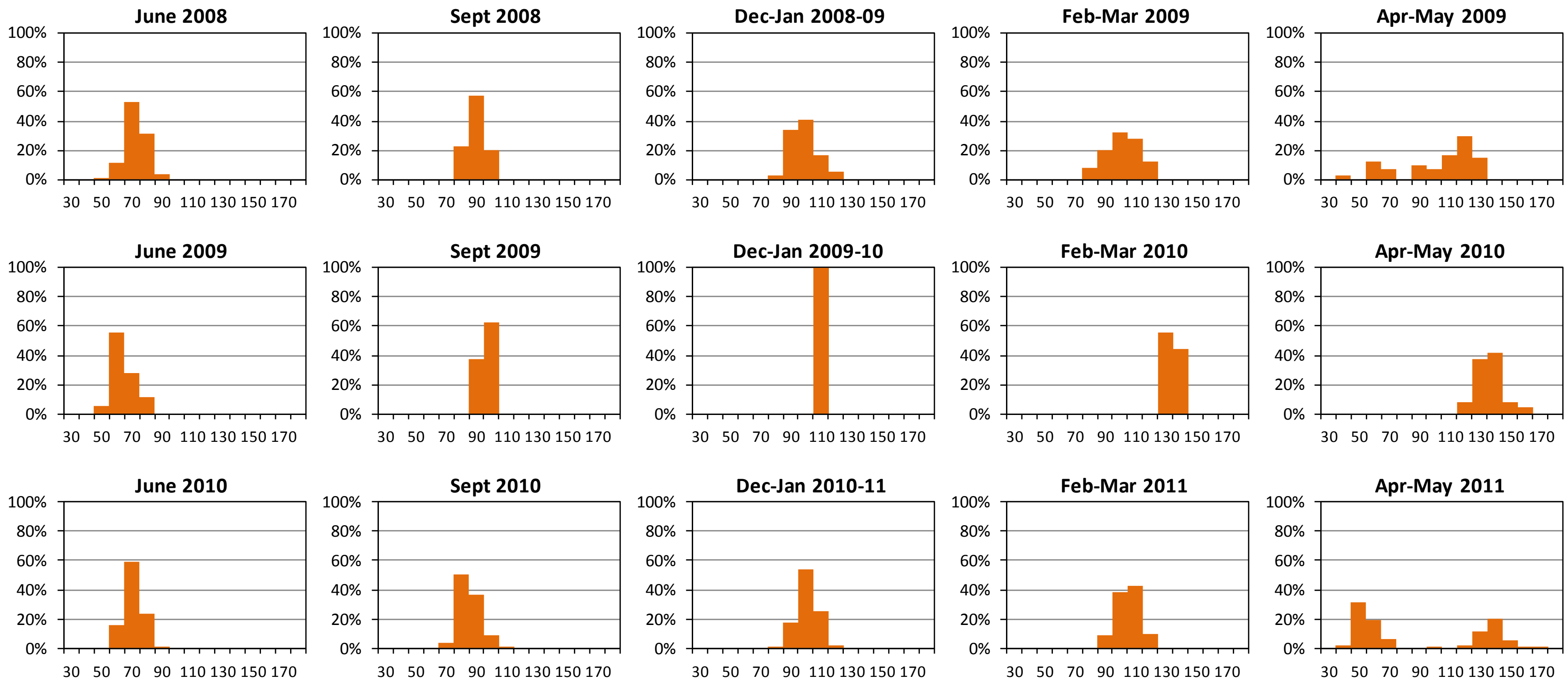


Figure 17. Length frequencies (fork length in mm) of juvenile coho sampled in Sandybar floodplain channel between June 1 and May 31 in 2008-09, 2009-10, and 2010-2011. The x-axis shows the top ends of bin ranges in mm.

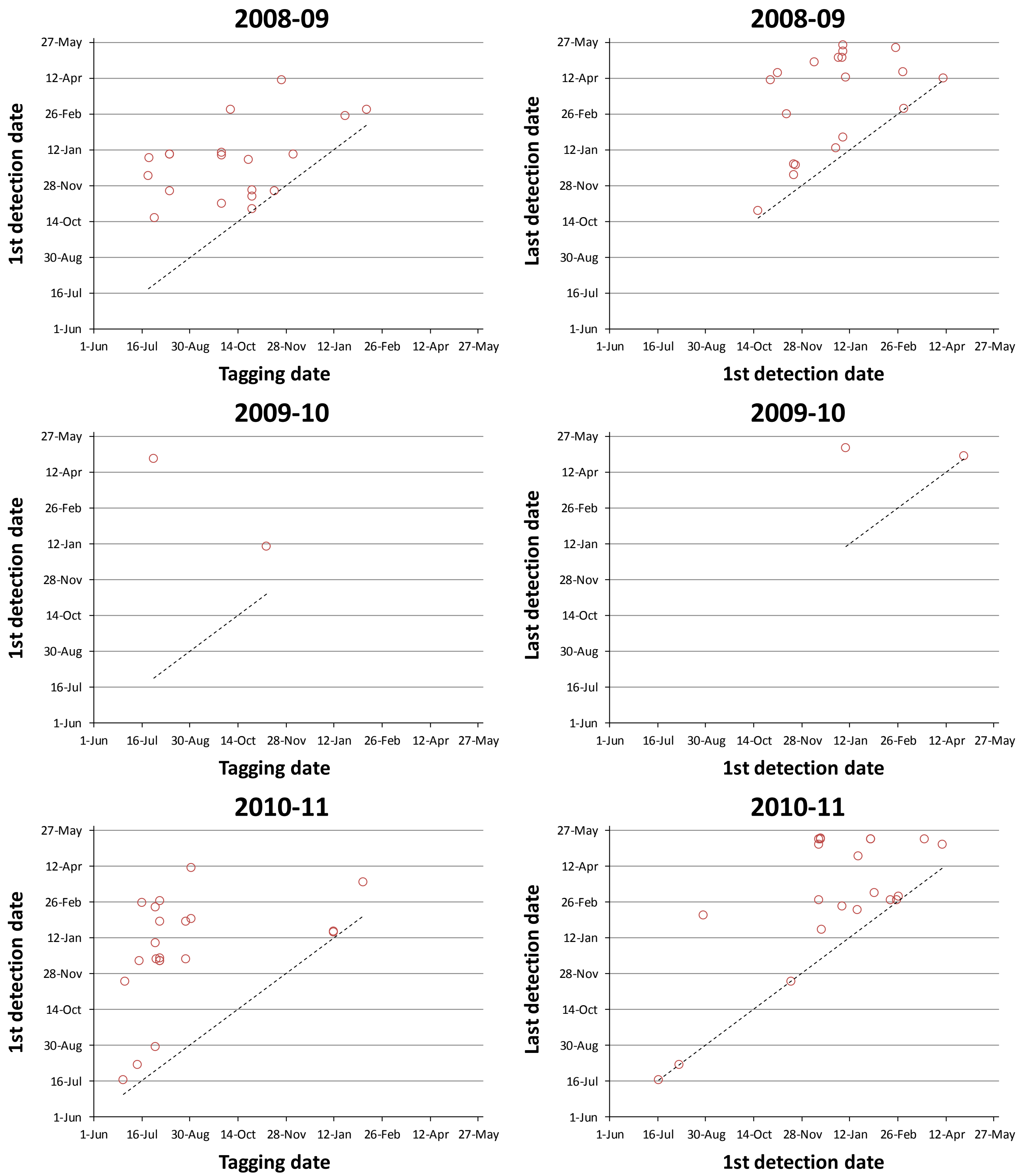


Figure 18. Left side - Relationships between tagging date and first date of detection in Sandybar floodplain channel of known PIT tagged immigrants that came into the channel from other areas where the fish were tagged. Right side – Relationships between the first date of detection and the last date of detection of known immigrants that came into the channel after being tagged. Dashed line shows where the first (on left) or last (on right) dates would equal the dates on the x-axis.

Figure 19 compares the relative contributions of fish tagged outside of the Sandybar floodplain channel that immigrated into the channel and were detected there in four years of monitoring. For the sake of spatial reference, the pie chart segments are shown colorized to show fish tagged downstream of Titus Creek or in Titus Creek (RM 97) and those tagged upstream of that location.

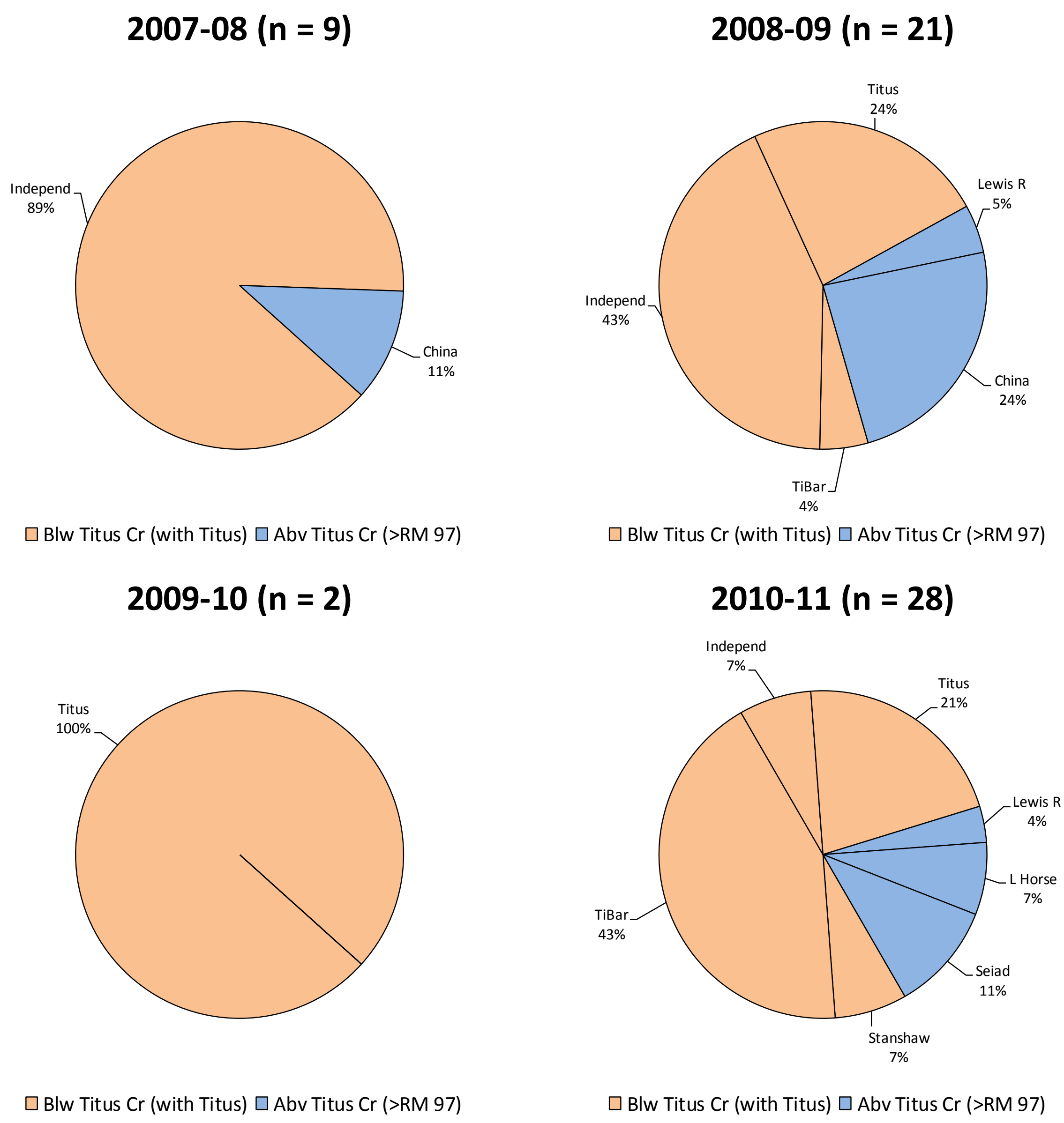


Figure 19. Source locations of known PIT tagged immigrants detected over a one year period between June 1 and May 31 in Sandybar floodplain channel in four years of monitoring. Locations where the fish were tagged are shown but the natal streams of the fish are not known. Some of the fish may have been spawned in the sites identified but some fish were very likely spawned elsewhere.

3.2.3.2 Seiad Creek Patterns

Seiad Creek (RM 129) is a small to moderately sized tributary that enters the Klamath River in the lower half of the hydrologic region referred to as Mid Klamath above Happy Camp. Characteristics of the flow pattern of the Klamath River in this region are described in Hillemeier et al. (2009). The pattern of river flows through the Seiad Valley, while affected by the Scott River, are less flashy than flows that occur between Happy Camp and Trinity River due to the increases in precipitation that occur moving downstream in the Klamath basin.

Seiad Creek has been subjected to major alterations over the past century resulting from logging, dredge mining along the lower part of the stream within the Klamath River floodplain, land conversions to agriculture in the lower subbasin, water withdrawals, and channel straightening and diking.

Despite these alterations to the stream, Seiad Creek still supports a modest run of coho spawners. Natal juvenile coho rear in all reaches downstream of the upper limits of spawning in the stream. The lower reaches of the stream are also used by non-natal juvenile coho that originate from streams upstream of Seiad Creek.

Beginning in mid-2010, the Mid Klamath Watershed Council (MKWC) in cooperation with KDNR initiated some major steps in enhancing/restoring off-channel habitat features within the Seiad Creek subbasin. Three off-channel ponds were developed and opened to fish access in November 2010. Harling (2011) gives a compelling account of pond development and the speed at which the ponds were colonized by juvenile coho. The three ponds and their locations along Seiad Creek are:

- Stender Pond at RM 2.7
- Alexander Pond at RM 3.0
- Booma Ludwig Pond at RM 3.9

MKWC working with KDNR has developed other ponds in lower Seiad Creek and at other sites in the Mid Klamath regions since those three ponds were built. Witmore's (2014) MS thesis work included assessment of fish performance in Alexander Pond along with other sites in the mainstem river corridor in 2012 in the Mid Klamath regions.

KDNR installed a SPI PIT detection system in the very lower end of Seiad Creek on January 7, 2010. The system has been operated since then except during some periods when the antenna system was damaged by extreme flows. Close examination of the data collected at the site indicates that when known PIT tagged fish located in Seiad Creek pass the SPI arrays that the fish are very likely leaving the stream. We use the data here to indicate when fish likely emigrated.

Results of sampling presented herein include emigration patterns during winter and spring based on SPI detections, patterns for which emigrants were subsequently re-encountered downstream of Trinity River, fish size and growth patterns, and source composition of non-natal juvenile immigrants encountered within Seiad Creek.

Because the SPI system was installed in January 2010, the most complete data set for analysis was collected during winter and spring of 2010-11. We present findings first for this time period then compare these to results seen in the previous year when the SPI system was operated for less time. A summary of the number of juvenile coho PIT tagged in lower and upper Seiad Creek in August-September of 2009 and 2010 and subsequent last detections of the same fish at the SPI system is given in Table 8. The area designated as lower Seiad Creek included all reaches up to the highway bridge and a short distance upstream (approximately to RM 1.4). The area designated as upper Seiad Creek encompassed reaches upstream of about RM 2.5.

In 2010-11, no detections of the fish shown tagged in Table 8 were made by the SPI system prior to November. Between November-May, a total of 250 of the 558 fish that had been tagged in lower Seiad Creek were detected leaving Seiad Creek (44.8%). During the same months, a total of 59 of the 116 fish tagged in upper Seiad Creek were detected leaving (50.9%). The results shown on a daily basis for the number (or percent) of fish remaining of the total number detected for the entire period are given in Figure 20.

Table 8. Summary of numbers of juvenile coho PIT tagged in August-September of 2009 and 2010 in lower and upper Seiad Creek and numbers of the same fish subsequently detected by the SPI PIT tag arrays in different periods of 2009-10 and 2010-11.

Yearly period	Metric	Stream section	
		Lower Seiad Cr	Upper Seiad Cr
2009-10	No. PIT tagged Aug-Sep 2009	385	
	No. detected Jan 7 - May	116	
	% detected Jan 7 - May	30.1%	
	No. detected Feb - May	115	
	% detected Feb - May	29.9%	
2010-11	No. PIT tagged Aug-Sep 2010	558	116
	No. detected Nov - May	250	59
	% detected Nov - May	44.8%	50.9%
	No. detected Feb - May	184	43
	% detected Feb - May	33.0%	37.1%

A comparison of the patterns of emigration of fish tagged in lower Seiad Creek between comparable months when detections were made in 2010 and 2011 is shown in Figure 21. In 2010, when juvenile abundance is believed to have been substantially less than in 2011, the rate of emigration from March-May appears to have been more consistent over the period, as it generally was in 2011 from the upper stream section. The results suggest that some factor prompted an early exodus from the lower section of the stream in early March 2011 compared to what occurs in at least some other years. The only factor that we have reason to suspect at this time is a higher density of fish that appears to have existed in 2011.

Figure 22 includes data for tagged fish in the upper section of stream in 2011 that were either tagged in the newly-created Alexander Pond or were known to have moved into the pond from Seiad Creek itself where they had been tagged. The patterns of emigration for fish that experienced Alexander Pond that year generally appear to be similar for fish that emigrated from the upper section of stream.

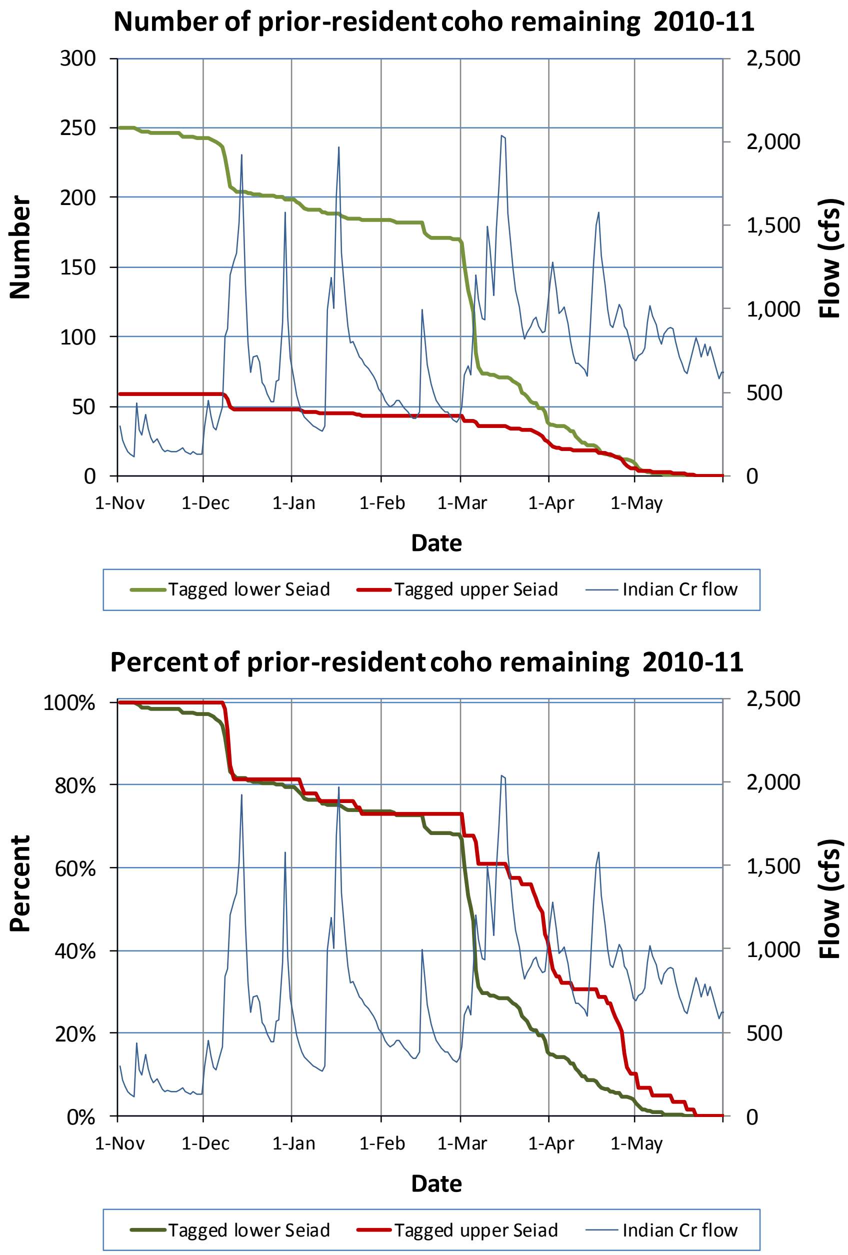


Figure 20. The numbers of prior resident PIT tagged coho remaining in Seiad Creek out of the total number detected in winter and spring at the SPI station near the mouth of Seiad Creek, 2010-11. The same data expressed as a percent of the total number detected for the period are given in the bottom graph. Stream flow (cfs) in lower Indian Creek (entering Klamath River at RM 108) is also shown.

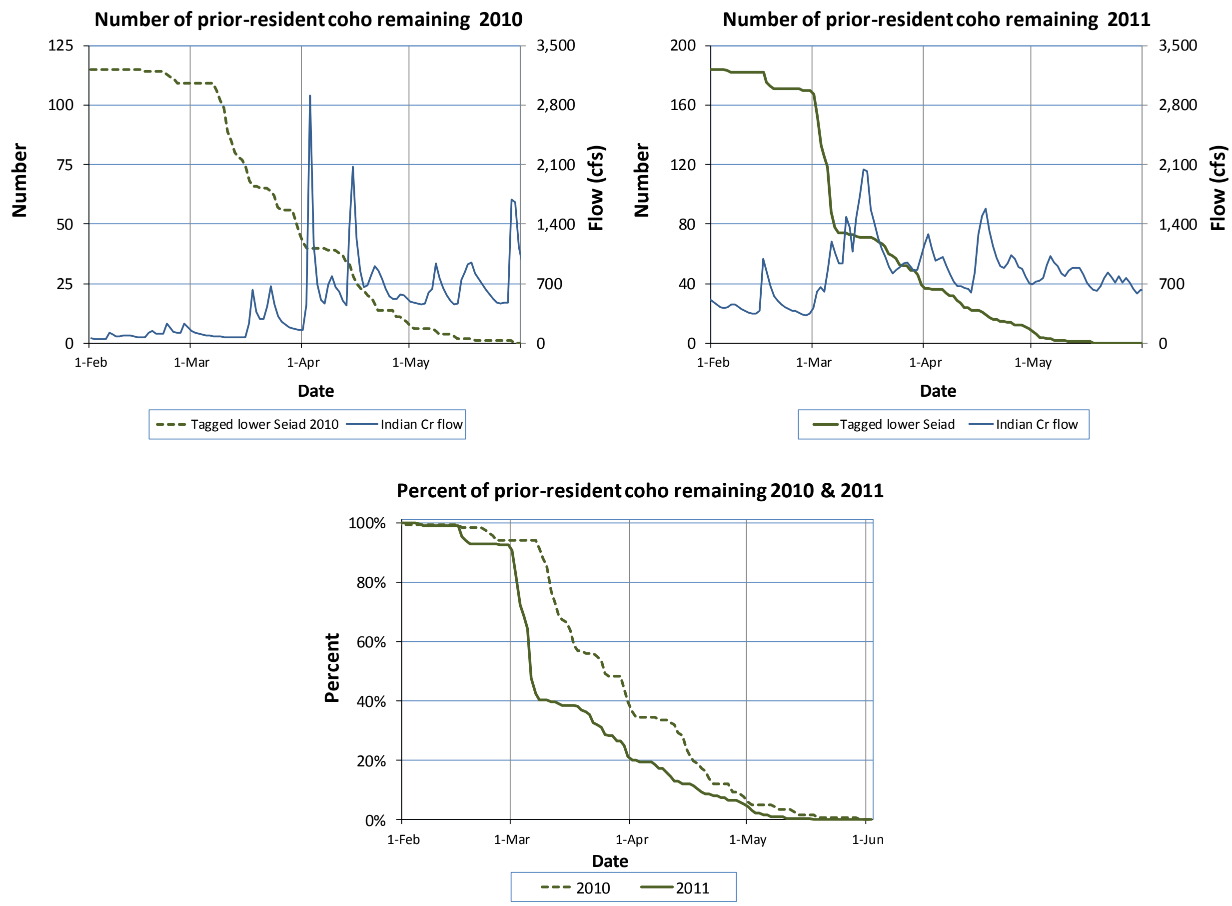


Figure 21. The numbers of prior resident PIT tagged coho remaining in Seiad Creek out of the total numbers detected in between February-May at the SPI station near the mouth of Seiad Creek in 2010 and in 2011. The same data expressed as a percent of the total number detected for the same months in both years are given in the bottom graph. Stream flow (cfs) in lower Indian Creek (entering Klamath River at RM 108) is also shown.

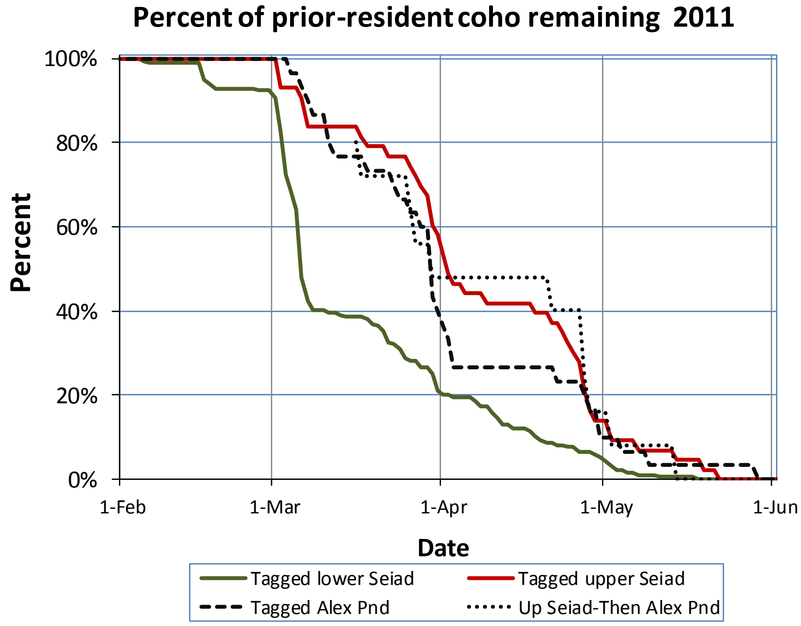


Figure 22. Data expressed as percent remaining for fish either tagged in Alexander Pond or that were detected in Alexander Pond after having been tagged in upper Seiad Creek are included with data given in Figure 20.

Figure 23 compares the emigration dates from Seiad Creek, grouped in two-week intervals, in 2009-10 and 2010-11 for fish that were subsequently re-encountered downstream of the Trinity River to those that were not. The patterns between years are nearly identical, recognizing that the SPI PIT tag detection system was not installed until January 7, 2010. Moreover, these patterns are nearly identical to those found for fish departing Sandybar Creek floodplain channel. Taken together, these observations show that when fish leave these sites in late November to early January that they have a much higher chance of being detected again downstream of Trinity River than if they emigrate from the streams at later dates. As noted earlier, fish that are tagged beginning in about mid-March, which approximately coincides with the time of the start of the active smolt outmigration, are also not detected downstream of Trinity River; in that case it is believed to be due to a migration that remains associated with the main river channel and thus tagged fish are not encountered by our equipment.

As discussed in the previous section for the Sandybar floodplain channel, our preliminary hypothesis is that fish that leave sites like Seiad Creek and Sandybar Creek in mid-winter are searching for both food and slow velocity refuge habitat, but they are not predisposed to undertake long migrations, possibly due to low water temperatures and reduced lipid reserves. We hypothesize that fish that emigrate in November and December are more predisposed to undertake a much longer migration in high water conditions to find suitable refuge habitat with abundant food. An important question is how do survival rates to adult return compare between fish that emigrate long distances in November and December to fish that emigrate in late January to early March but that are not detected again as juveniles in the river system. The question has bearing on whether greater efforts are needed to restore or enhance overwintering habitat in the Mid Klamath regions.

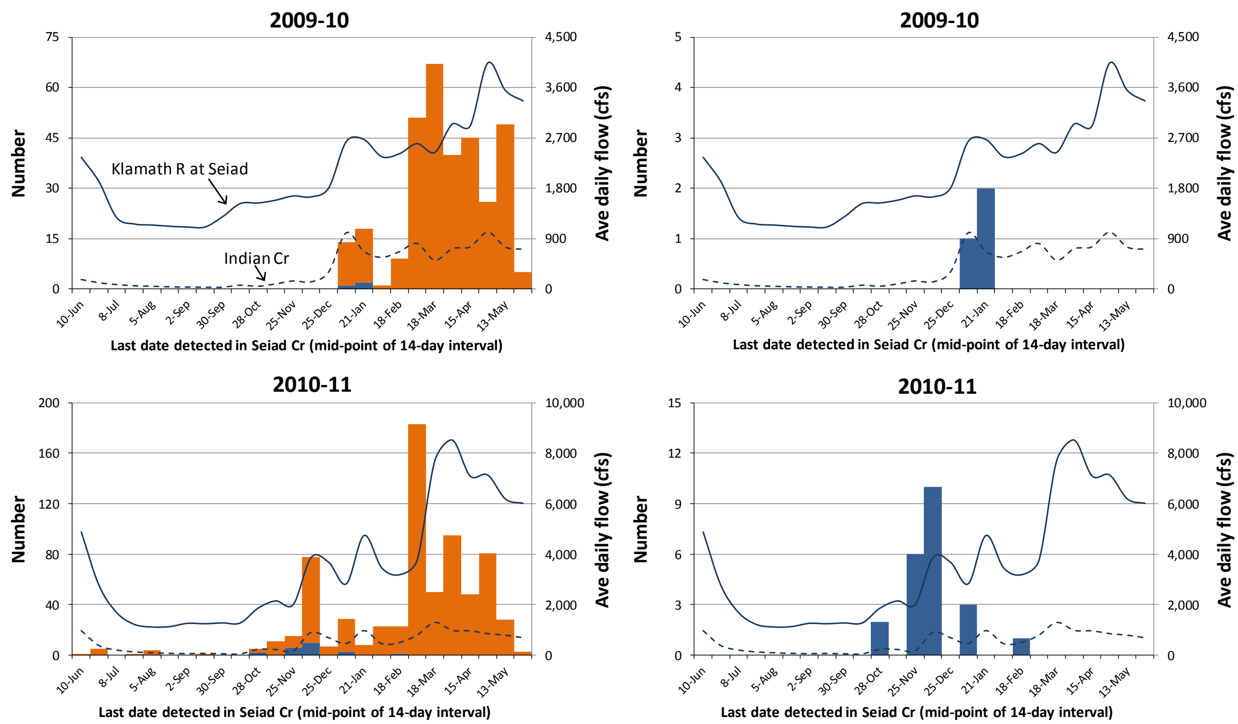


Figure 23. Numbers of fish by the last date detected in lower Seiad Creek for PIT tagged fish not re-encountered again downstream of the Trinity River (orange bars) and those that were re-encountered again downstream of Trinity River (blue bars). Data are grouped in two-week intervals. Average daily flows in the Klamath River and in Indian Creek during the 2-week intervals are also plotted. Plots on right show just the re-encountered fish with Y-axis scale changed for closer inspection. It is noted that the SPI PIT tag detection system was installed in lower Seiad Creek on January 7, 2010.

Fork length (mm) data are graphed in two ways to show patterns of change over time. Figure 24 shows fork length in relation to date of capture and Figure 25 provides length frequency histograms for data grouped by monthly period. The findings show that Seiad Creek fish, including smolts, are generally much smaller than those in the Sandybar Creek floodplain channel. It should be noted, however, that all Sandybar fish are non-natal fish, whereas the majority of fish in Seiad Creek are likely natal fish.

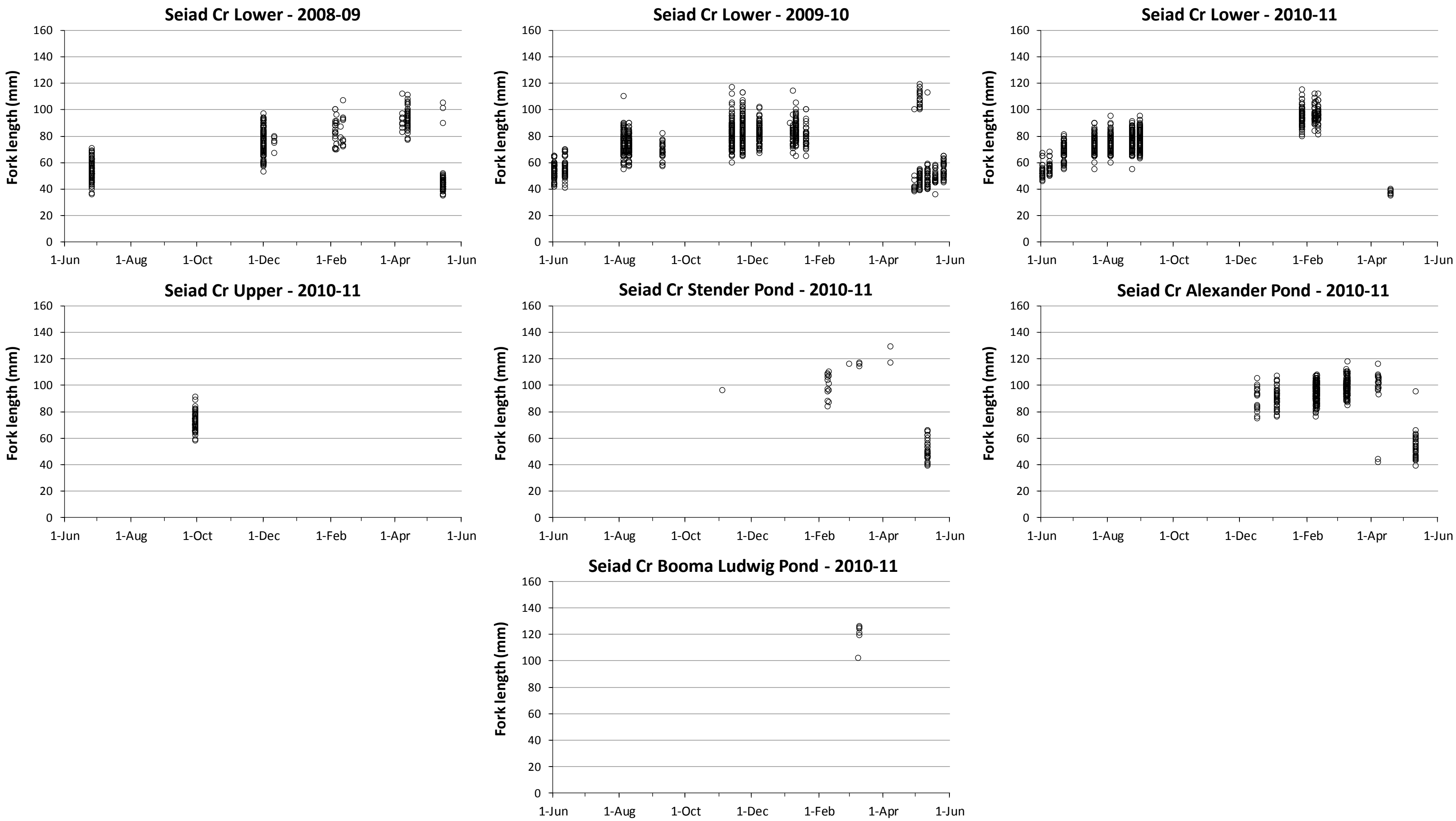


Figure 24. Fork lengths (mm) of juvenile coho sampled in Seiad Creek between June 1 and May 31 in 2008-09, 2009-10, and 2010-2011.

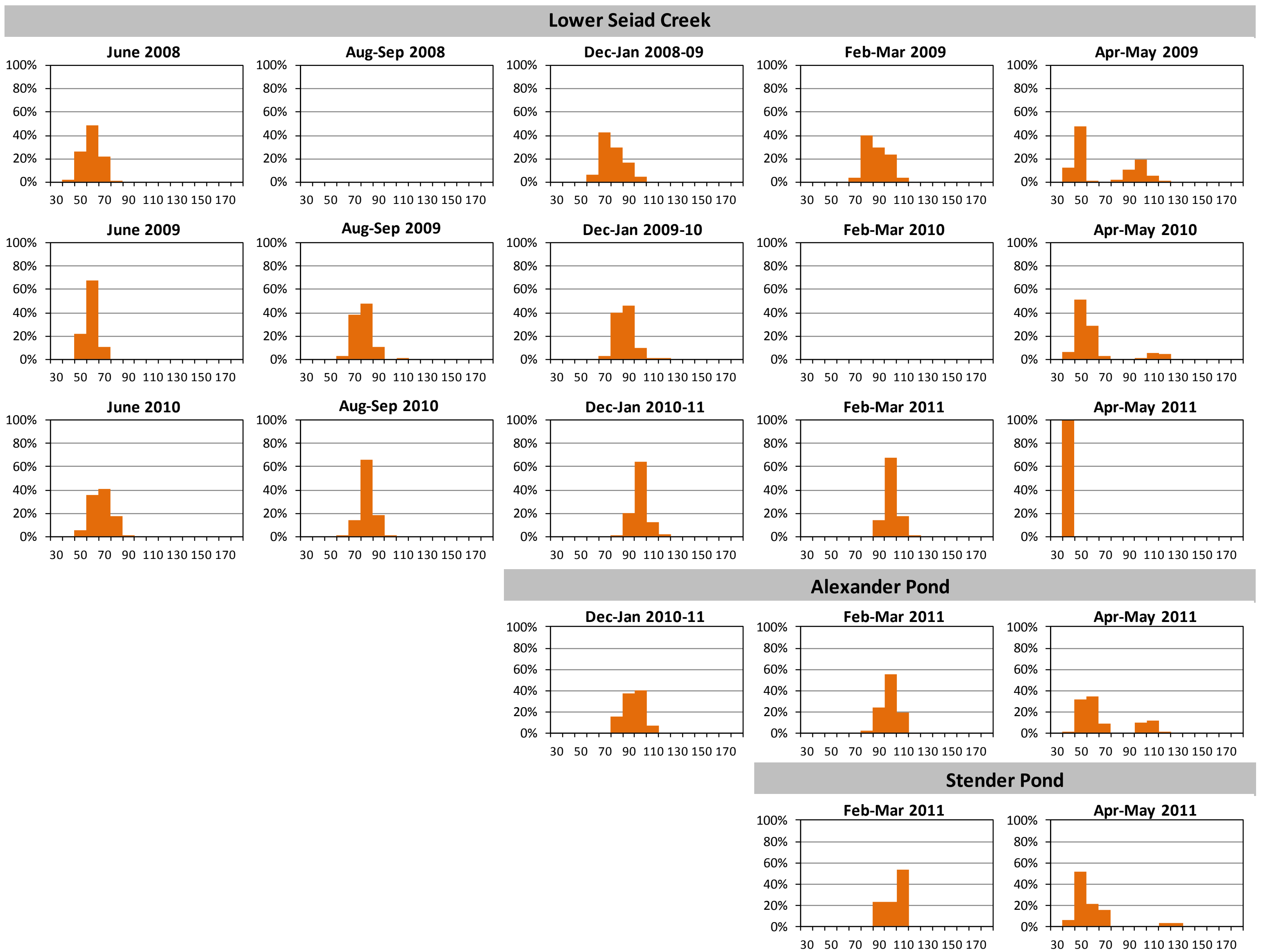
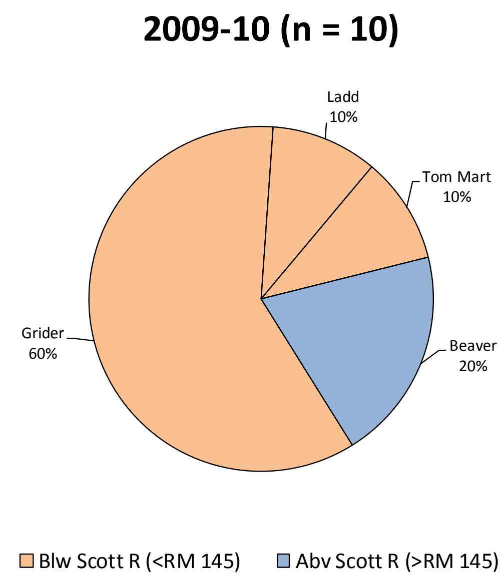


Figure 25. Length frequencies (fork length in mm) of juvenile coho sampled in Seiad Creek between June 1 and May 31 in 2008-09, 2009-10, and 2010-2011. The x-axis shows the top ends of bin ranges in mm.

Figure 26 compares the relative contributions of fish tagged outside of Seiad Creek that were then detected in Seiad Creek in two periods of monitoring, 2009-10 and 2010-11. For the sake of spatial reference, the pie chart segments are shown colorized to show fish tagged downstream of Scott River (RM 145) and those tagged upstream of that location.



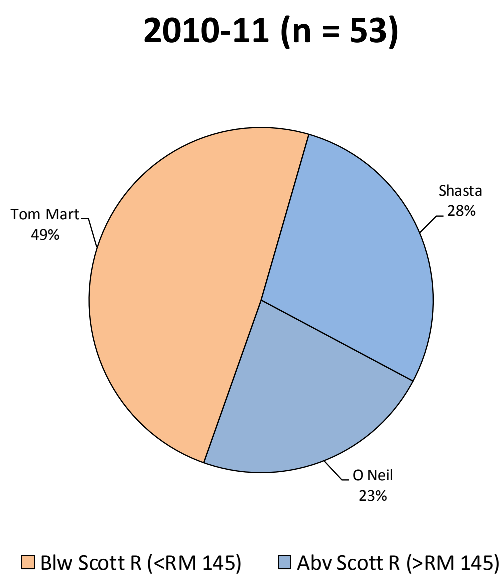


Figure 26. Source locations of known PIT tagged immigrants detected between June 1 and May 31 in Seiad Creek in periods of monitoring. Locations where the fish were tagged are shown but the natal streams of those fish are not known. Some of the fish may have been spawned in the sites identified but some fish were very likely spawned elsewhere.

3.2.4 Lower Klamath Patterns

This section presents patterns of habitat use and associated juvenile coho performance observed in four tributaries to the lower end of the Klamath River: Waukell Creek, McGarvey Creek, Panther Creek (tributary to lower Hunter Creek), and Salt Creek (Figure 27). All of these streams enter the Klamath River downstream of RM 7.0. All but McGarvey Creek enter the section of the river that is tidally influenced under low to moderate flow conditions.

The picture that emerges of the habitat use patterns in these streams is particularly insightful to understanding the role and importance of the Klamath River mainstem corridor in the life histories of juvenile coho in the river basin. The locations of these streams—at the bottom end of the river corridor—affords them the unique position to provide the last opportunities—together with a few other streams in this area—for juveniles redistributing from upstream to find suitable freshwater habitats to complete their freshwater juvenile rearing period (summer rearing and/or overwintering). All four of these streams are used to some extent by non-natal juvenile coho produced in all other parts of the river system.

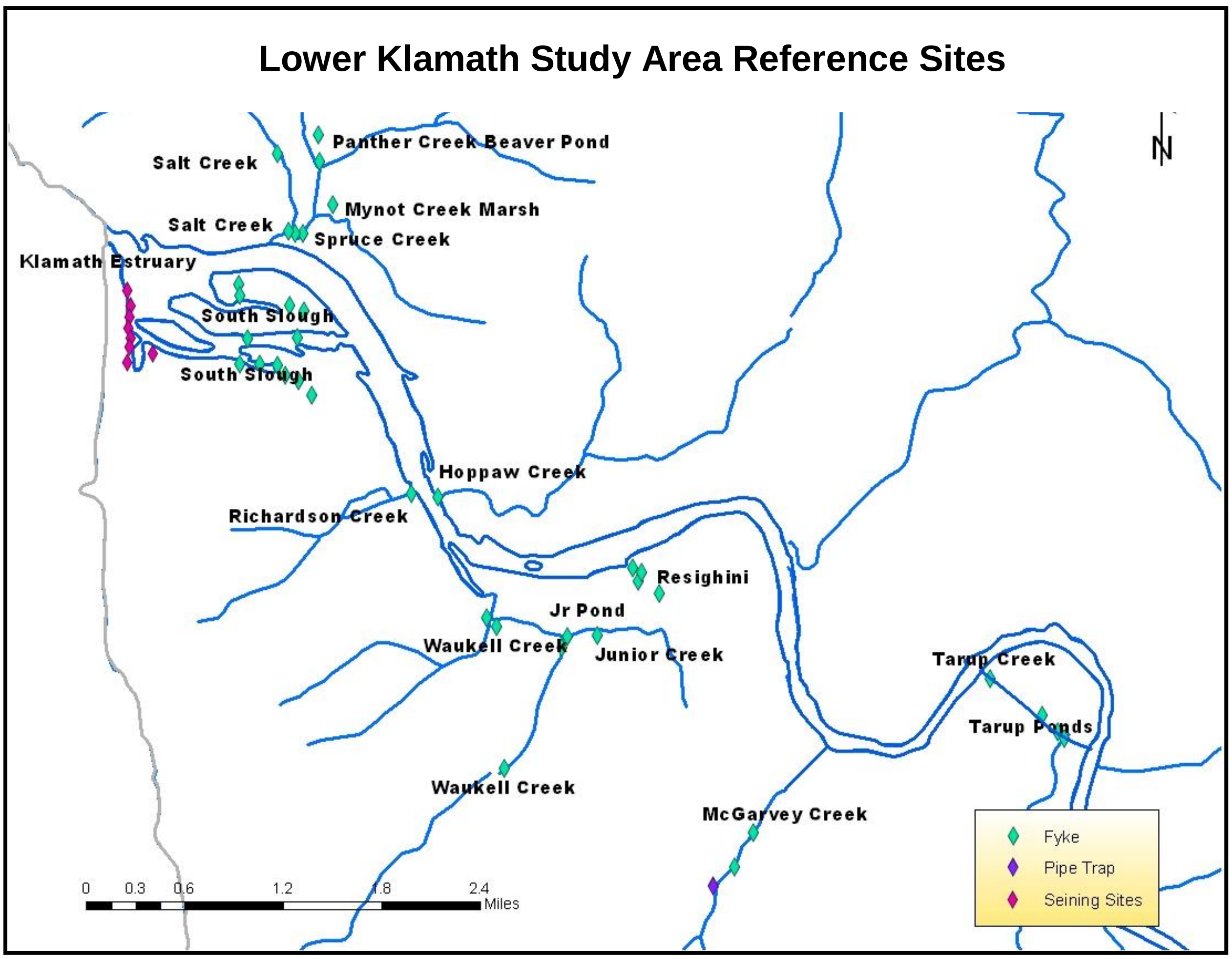


Figure 27. Map of the lower Klamath River area showing locations of the four intensively monitored streams in that area.

Each of the four streams was trapped at multiple locations using fyke net or pipe traps, as described in Hillemeier et al. (2009), Silloway (2010), Silloway and Beesley (2011), Antonetti et al. (2012), and Antonetti et al. (2014). Fish captured in these traps were sampled using standard sampling techniques for juvenile salmon (length, weight, presence of physical marks, and presence of a PIT tag using a hand-held scanner). All four streams were also equipped with at least one remote SPI PIT tag monitoring system as described in Hiner (2009) and Antonetti et al. (2012). These systems were equipped to detect full duplex PIT tags. Sampling for PIT tags enabled us to assess patterns of use by known non-natal juvenile coho, as well as patterns of use by fish tagged in these streams. Fish performance was assessed by patterns of residency, fish size and growth metrics, abundance when and where estimates were made, and survival in one stream (Waukell Creek).

Study results are described separately for each stream, though the information for some aspects is shown combined for the four streams in tables and figures to aid in making comparisons. Results are presented first for Waukell Creek—the information is more complete for this stream than for Salt and Panther creeks. McGarvey Creek data are presented here in similar format to the other streams to enable direct comparisons, though this stream has been the focus of life cycle monitoring and comprehensive reports are available (e.g., Antonetti et al. 2012; Antonetti et al. 2014). Waukell Creek appears to be used almost entirely by non-natal coho, providing a more straight-forward and less complex interpretation of the data about the role of this stream to non-natal coho produced elsewhere in the river system.

3.2.4.1 Waukell Creek Patterns

Waukell Creek is a small stream (third-order) that enters the Klamath River at RM 3.7, near the upper end of the estuarine zone (Figure 27). The lower part of the Waukell Creek subbasin is located within the Klamath River floodplain.

The Waukell Creek subbasin has been subjected to significant alteration, particularly as a result of historic logging and road construction, including the building and upgrading of Highway 101 along much of the mainstem creek. Alterations have included extensive channelization, wood removal within the channel and on the floodplain, some land clearing, harvest of old growth trees, and road and highway runoff. The YTFP in recent years has implemented restoration actions in the subbasin, including an extensive wood loading and riparian planting project in 2009 and 2010 (Beesley and Fiori 2010). Activities are on-going.

Channel gradient of the stream in the lower part of the subbasin is very flat and consequently some aspects of the available habitat are highly suited for juvenile coho, particularly for overwintering coho. A part of Junior Creek, a tributary to Waukell Creek, forms a seasonal pond that is heavily used in some years by non-natal overwintering coho. The main Waukell Creek flows through a large wetland upstream of the confluence with Junior Creek that also provides an extensive area of low velocity habitat used for overwintering. Upstream of the wetland, Waukell Creek provides some opportunity for coho spawning, as does another small tributary, Saugep Creek. However, evidence (lack of both spawners and young fry) suggest that coho use in recent years in the Waukell Creek subbasin has been almost exclusively by non-natal juveniles. See Hillemeier et al. (2009) for a more complete description of the lower parts of Waukell Creek.

Sampling using fyke net traps has occurred on a semi-regular schedule in lower Waukell Creek just upstream of the confluence with Saugep Creek since fall of 2006. The objective has been to sample using the traps at least several days each week throughout the year, except during periods of exceptionally high water when the traps are made inoperative and days when crew scheduling did not permit the traps to be checked. The trap configuration is comprised of two fyke traps, one oriented to catch upstream migrants and one to catch downstream migrants. A similar approach to trapping occurred in the outlet of Junior Pond beginning in the spring of 2007, continuing during the subsequent springs in 2008 and 2009; trapping was terminated at this site at the end of February 2010 due to a lack of access by the land owner. Several other fyke traps have also been operated in some seasons at other locations in the Waukell subbasin for reconnaissance purposes and to aid in estimating smolt yields from the subbasin.

The remote SPI PIT tag monitoring system was installed in December of 2008 and was operated continuously since then for the period reported on in this report, except during occasional times of antennae damage due to high flows and equipment malfunction. The antennas were located a short distance upstream of the lower Waukell Creek fyke net traps.

Results of sampling presented herein include trap catch patterns, fish size and growth patterns, overwinter survival, smolt yield estimates, immigrant abundance estimates, and source composition of non-natal juvenile coho as shown in re-encounters of PIT tagged fish.

Trap catch patterns from the upstream oriented fyke trap (to trap fish moving upstream) and the downstream oriented trap (to trap downstream moving fish) at the lower Waukell Creek site are displayed in Figure 28. The graphs are paired vertically, showing upstream moving fish on the top graph in a pair and downstream moving fish on the bottom graph of the pair. Five years of data are summarized. Each graph shows with a vertical bar the number of juvenile coho caught in a roughly 24-hr time period over a yearly period beginning with September 1. The days when the trap actually was operated are shown in black bars within a band at the top or bottom of each graph—enabling the reader to know when the trap was fished. It should be noted that these graphs do not reflect the age of the fish (i.e., whether fish were age-0 or age-1). That information can be roughly known by comparing these graphs to the fish size displays seen on the subsequent figures. The reader should also pay particular attention to the scale of the y-axis to know the relative magnitude of the total number of fish trapped in a season. The Klamath River flow rate (cfs in 1000s) is shown on the graphs by the blue line.

A similar set of displays is given in Figure 29 for Junior Creek at the outlet of Junior Pond. Note that trapping was terminated in this stream in late February 2010.

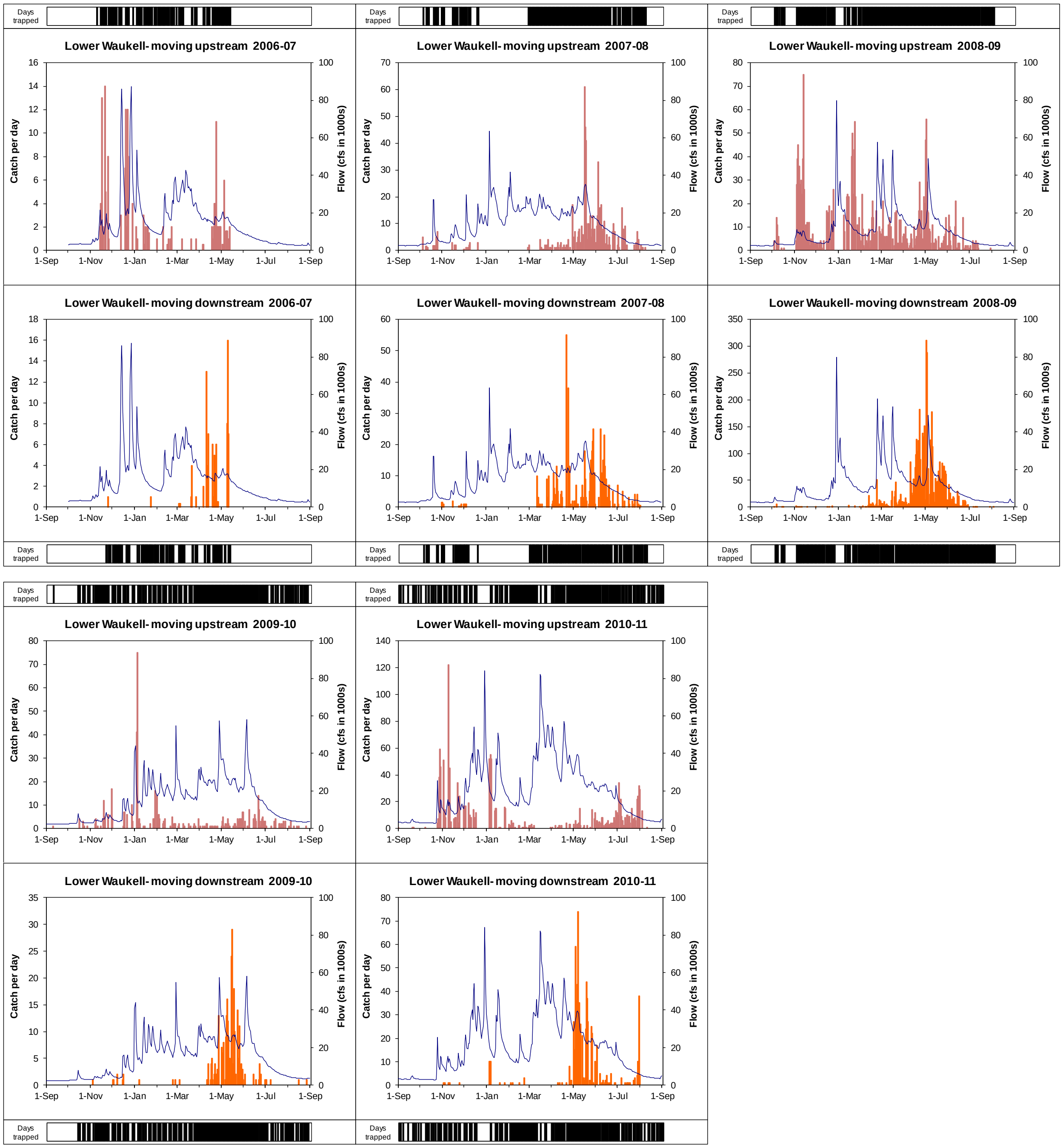


Figure 28. Catch per day of juvenile coho in upstream oriented (targets upstream moving fish) and downstream oriented (targets downstream moving fish) fyke traps in lower Waukell Creek, 2006-07 to 2010-11. Klamath River flow at the lower USGS station is also plotted. Black bands above and below each graph indicate days when a trap was operating.

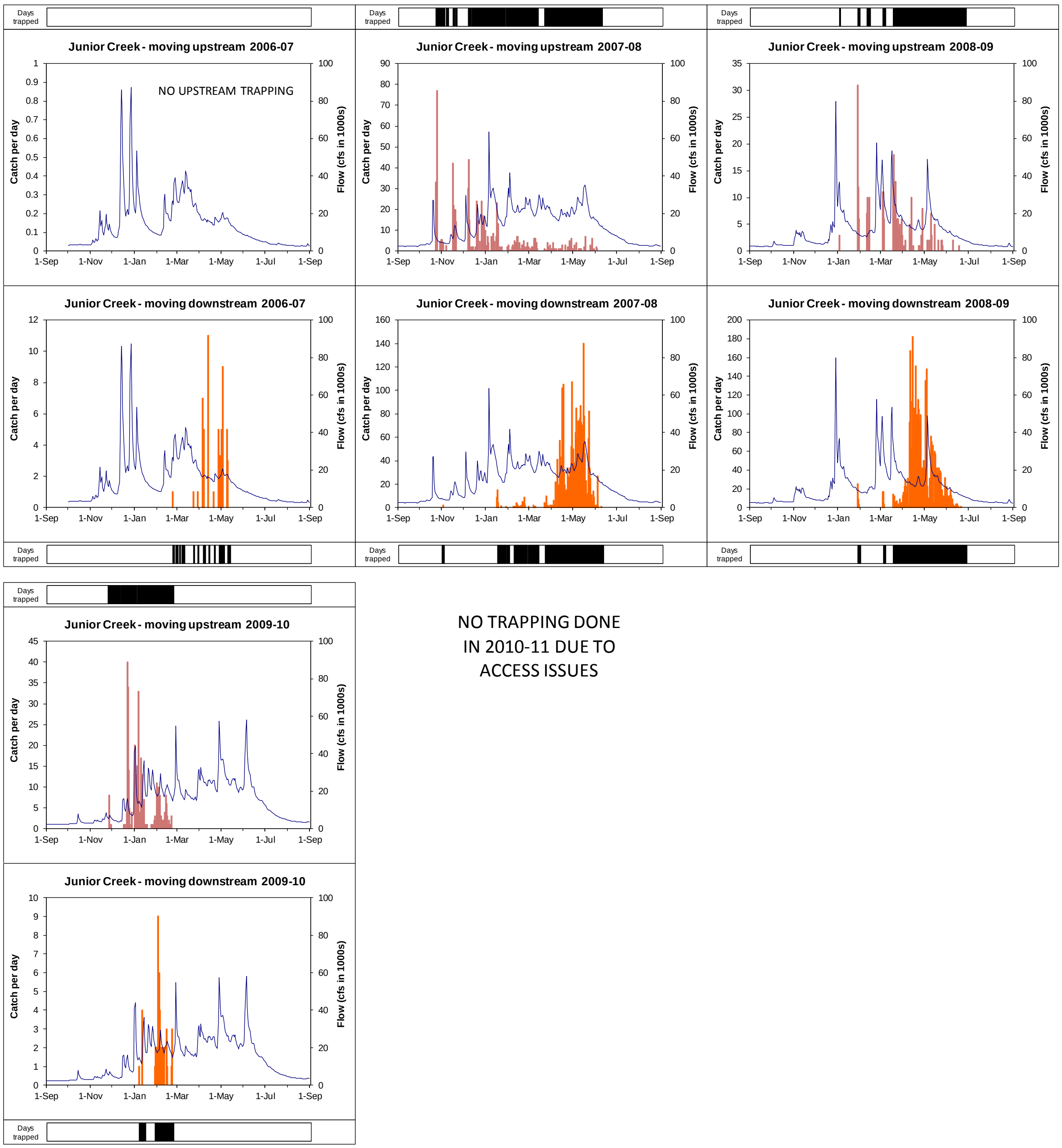


Figure 29. Catch per day of juvenile coho in upstream oriented (targets upstream moving fish) and downstream oriented (targets downstream moving fish) fyke traps in Junior Creek at the outlet of Junior Creek Pond, 2006-07 to 2010-11. Klamath River flow at the lower USGS station is also plotted. Black bands above and below each graph indicate days when a trap was operating.

We note the following from these patterns of trap catches in lower Waukell Creek and Junior Creek:

- The patterns of immigrants moving up into these streams from the Klamath River during fall and early winter closely tracked increases in flow in the Klamath River. We note, however, that trap efficiency appeared to be particularly poor at the lower Waukell site in the fall of 2007 for reasons unknown—it is clear from the pattern in the same year for Junior Creek that a normal pattern of upstream movement was in fact occurring.
- The large majority of upstream moving immigrants in fall and winter each year occurred prior to about January 15 each year, which is consistent with the patterns of attrition reported earlier in this report for the Sandybar floodplain channel. The pattern of fish leaving sites like Sandybar channel matches the pattern when immigrants arrived to sites like Waukell Creek.
- There was essentially no indication of downstream movement of fish during fall and early winter (age-0 fish), even during periods of elevated flow—in stark difference to the patterns seen for upstream movement during those same times. These observations demonstrate that at times when fish were immigrating into Waukell Creek, there were essentially no fish leaving the stream to seek refuge habitats elsewhere.
- The patterns of downstream moving migrants in late winter, spring, and early summer showed the largest numbers of fish consistently moving between early April and mid June, tending to peak in early May. In some years, however, considerable movement continued to the end of June, and size data for these years show that these fish were age-1.
- In some years (i.e., 2007-08 and 2008-09), it appears that there were substantial numbers of age-1 fish (see graphs on fish size) moving upstream into Waukell Creek during the spring. However, we conclude from close examination of PIT tag data encountered in the trap during this period that these fish were actually part of the downstream migration and were simply milling about in the lower stream before departing; consequently some of them were being re-caught in the upstream oriented trap.

Fork length (mm) data are graphed in two ways to show patterns of change over time. Figures 30 and 31 show fork length in relation to date of capture and Figures 32 and 33 provide length frequency histograms grouped for November 1-January 15 and April 1-June 15. These graphs are helpful to distinguish patterns for age-0 fish compared to age-1 fish. As will be seen in comparing these data to those collected in McGarvey Creek (where substantial spawning occurs), it is evident from the sizes of age-0 fish captured in the springtime of each year that there is no evidence of newly emerged fry being captured in Waukell Creek (fish size would typically be <35 mm). The data in Figures 30 and 31 support a conclusion that Waukell Creek is entirely, or almost so, used by non-natal coho.

Table 9 summarizes fork length data for Waukell Creek (and the other streams), giving average lengths and other metrics by age class caught in the upstream and downstream traps in the same combined months used in constructing the length frequency histograms. These data are graphed as box-and-whisker plots in Figure 34. This display is particularly useful to illustrate the amounts of growth that occurred in the stream between the period of upstream immigration in fall and early winter and the downstream emigration in spring. We note the following from the pattern seen in Figure 34:

- Waukell Creek smolts tend to be particularly large for coho smolts, which is typical of many pond-produced smolts in northern California and the Pacific Northwest (Lestelle 2007). Growth during the winter and spring is especially high in Waukell Creek, generally higher than seen in the other three streams being reported on here for the lower Klamath sites.
- As will be seen when considering the smolt yield estimates for Waukell Creek, there appears to be a substantial density effect on growth during the winter and spring months in Waukell Creek in one year. The year of especially high abundance (2008-09) showed the smallest amount of overwinter growth and the smallest smolts produced.

Survival estimates for the period between upstream immigration in fall and early winter to the time of smolt outmigration were obtained for Waukell Creek using data on the detection efficiencies of the SPI station located just upstream of the downstream outmigrant fyke trap. Table 10 summarizes data used to estimate the detection array efficiencies during the period of upstream immigration and the period of downstream emigration. To estimate the upstream immigration efficiency, the number of PIT tagged coho captured moving up in fall and early winter and released upstream of the trap was compared to the number of these same fish detected by the PIT tag arrays located just upstream. The average efficiency during this period for three years was estimated to be 0.429 (i.e., an average of 42.9% of tagged fish released were detected by the upstream SPI station), with a range of 0.284 to 0.545.

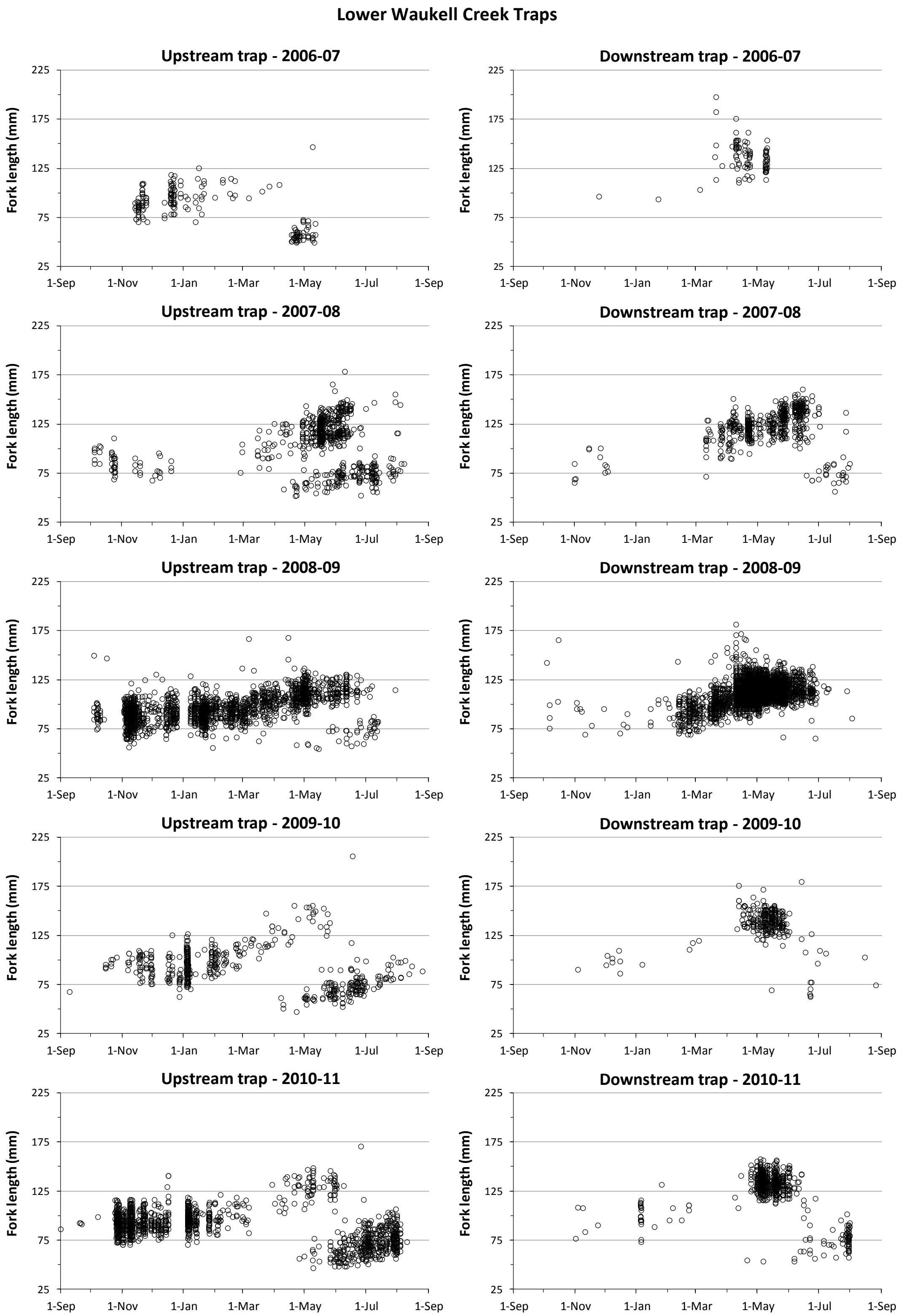


Figure 30. Fork lengths (mm) of juvenile coho sampled in lower Waukell Creek between September 1 and August 31 in 2006-07 to 2010-2011.

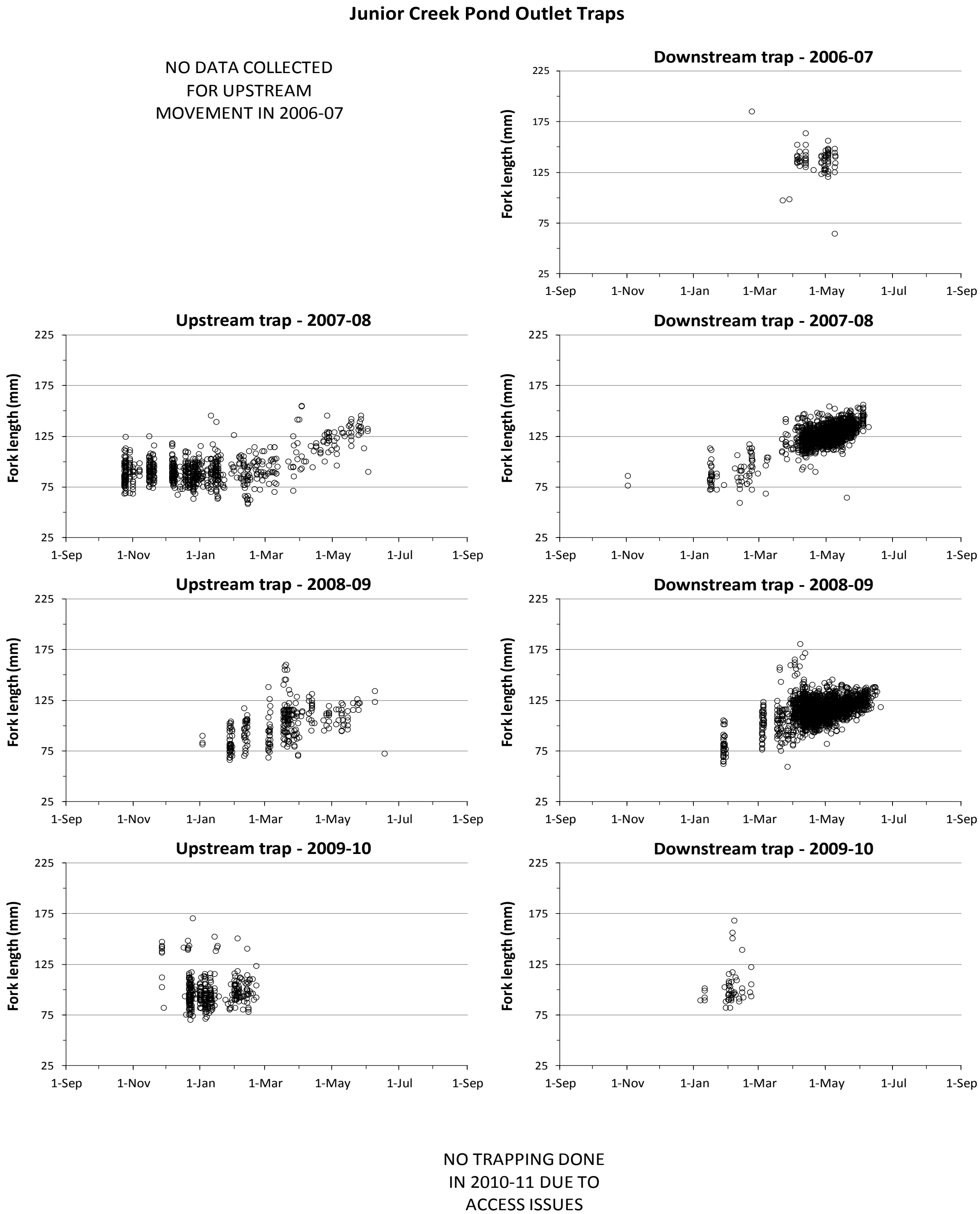


Figure 31. Fork lengths (mm) of juvenile coho sampled in Junior Creek Pond outlet between September 1 and August 31 in 2006-07 to 2010-2011.

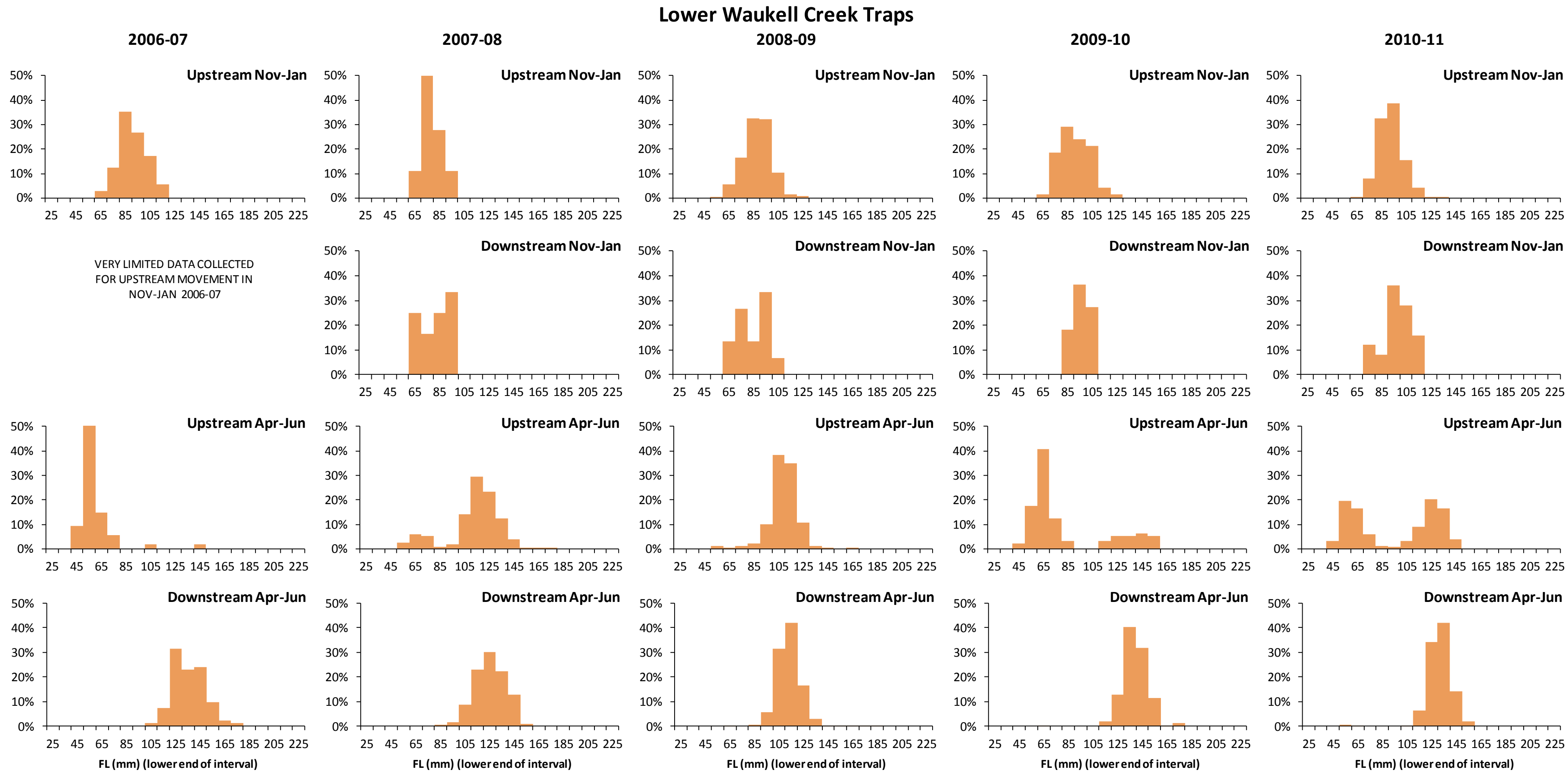


Figure 32. Length frequencies (fork length in mm) of juvenile coho sampled in lower Waukell Creek in 2006-07 to 2010-2011. The x-axis shows the lower ends of bin ranges in mm. Data are grouped for samples in November-January and April-June.

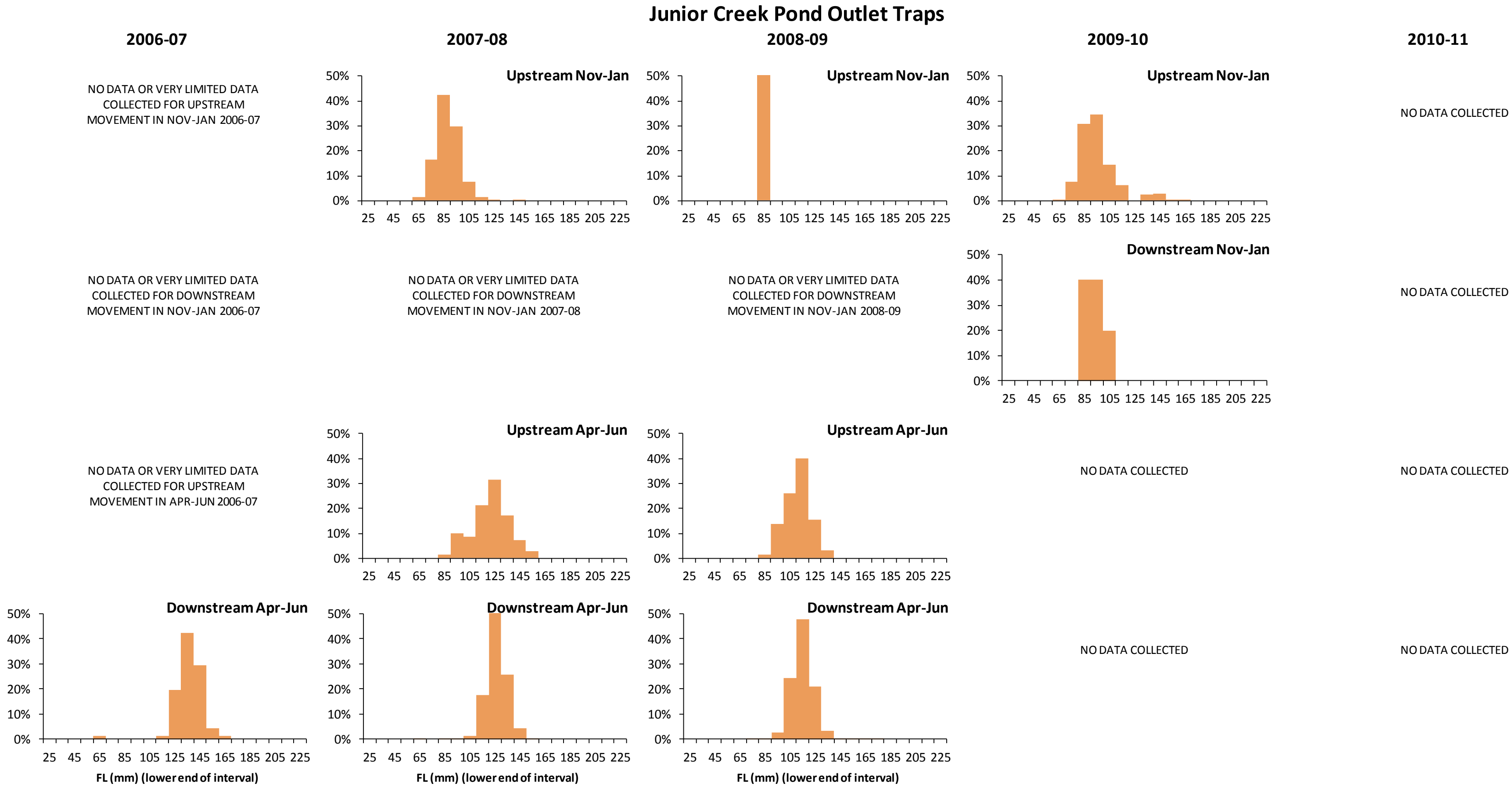


Figure 33. Length frequencies (fork length in mm) of juvenile coho sampled in Junior Creek Pond outlet in 2006-07 to 2010-2011. The x-axis shows the lower ends of bin ranges in mm. Data are grouped for samples in November-January and April-June.

Table 9. Summary of fork lengths (mm) of juvenile coho sampled in lower Waukell Creek, Junior Creek pond outlet, McGarvey Creek, Panther Creek pond outlet, and Salt Creek in 2006-07 to 2010-11. Data are grouped for samples in November-January and April-June. Upstream or downstream traps are indicated. Age 0+ indicates that fish from both December and January are included. Age 1+ indicates that some age-2 fish might be included.

			Waukell Cr lower					Junior Cr pond outlet					McGarvey Cr					Panther Cr pond outlet					Salt Cr				
Yr & mon	Age	Up or down	Avg	StD	Min	Max	n	Avg	StD	Min	Max	n	Avg	StD	Min	Max	n	Avg	StD	Min	Max	n	Avg	StD	Min	Max	n
2006-07																											
Nov-Jan	0+	Up	92.3	11.3	70	118	105																				
	0+	Down	96.0		96	96	1																				
Apr-Jun	0	Up	57.3	6.0	49	72	52																				
	1+	Up	127.0	26.9	108	146	2																				
	0	Down						64.0		64	64	1															
	1+	Down	135.5	12.6	110	175	83	137.5	8.3	120	163	70															
2007-08																											
Nov-Jan	0+	Up	79.6	7.8	67	95	18	88.8	9.6	63	145	439	88.2	10.0	75	110	31	92.0	8.5	86	104	4					
	0+	Down	82.6	12.6	65	100	12	81.0	7.1	76	86	2															
Apr-Jun	0	Up	68.0	8.0	51	89	74											64.5	7.6	50	85	69	64.0	9.2	52	82	11
	1+	Up	120.9	11.8	92	178	431	122.4	14.4	90	155	70						109.7	10.2	95	129	10	120.5	7.5	108	132	19
	0	Down						77.0	18.4	64	90	2	38.9	5.4	32	67	357	62.9	7.9	50	80	35					
	1+	Down	126.2	12.1	89	160	464	127.0	7.7	92	156	2290	110.0	10.1	74	210	664	104.8	11.1	86	158	61	125.5	9.0	105	159	242
2008-09																											
Nov-Jan	0+	Up	88.9	10.9	56	130	747	84.7	4.7	81	90	3	93.8	9.5	72	120	165	89.6	10.9	57	112	51	91.9	10.7	63	116	241
	0+	Down	85.3	10.5	69	101	14						89.0	10.4	59	121	490	92.4	9.3	83	108	7	95.0	7.9	89	104	3
Apr-Jun	0	Up	68.4	9.9	54	85	18											64.5	7.8	51	83	24					
	1+	Up	110.6	9.2	86	167	533	111.6	9.9	88	134	65						110.8	12.4	88	135	23	114.5	6.1	110	123	4
	0	Down	78.5	8.5	66	85	4						35.9	2.6	32	73	431	71.0	7.1	63	83	6					
	1+	Down	113.9	9.2	86	181	4044	115.5	8.5	80	180	3248	106.9	9.2	81	145	1400	114.9	10.1	94	140	57	125.0	7.1	120	130	2
2009-10																											
Nov-Jan	0+	Up	92.0	11.7	62	126	216	93.4	9.7	70	117	239						96.7	8.0	80	119	138	99.4	30.1	75	168	8
	0+	Down	97.1	7.0	86	109	9	94.0	5.7	89	101	5						97.7	8.3	91	107	3					
Apr-Jun	0	Up	65.6	8.2	47	90	74											65.1	9.9	47	85	44	67.7	10.5	51	87	14
	1+	Up	137.5	12.6	115	155	24											117.3	18.1	88	137	16	129.7	16.6	99	145	6
	0	Down	69.0		69	69	1						53.6	8.7	32	74	69	65.0	7.1	60	70	2	87.0		87	87	1
	1+	Down	140.2	9.6	114	179	258						120.3	8.4	88	147	532	130.8	7.9	112	142	9	143.9	20.0	123	221	24
2010-11																											
Nov-Jan	0+	Up	93.1	9.7	70	140	673						98.6	9.2	78	118	56	97.3	8.4	80	114	28					
	0+	Down	98.5	12.3	73	115	25											98.0	4.2	95	101	2					
Apr-Jun	0	Up	61.1	8.7	46	83	71											66.2	9.6	49	81	51	62.7	13.0	42	83	12
	1+	Up	127.4	11.0	95	148	82											114.5	15.2	93	147	14	106.5	10.6	99	114	2
	0	Down	55.8	4.2	53	63	5						40.9	5.4	34	68	186	56.6	13.7	45	79	5	64.0	6.3	57	74	8
	1+	Down	133.1	8.3	107	157	582						110.7	9.8	83	142	290	117.2	11.0	101	137	18	128.4	10.5	95	148	43

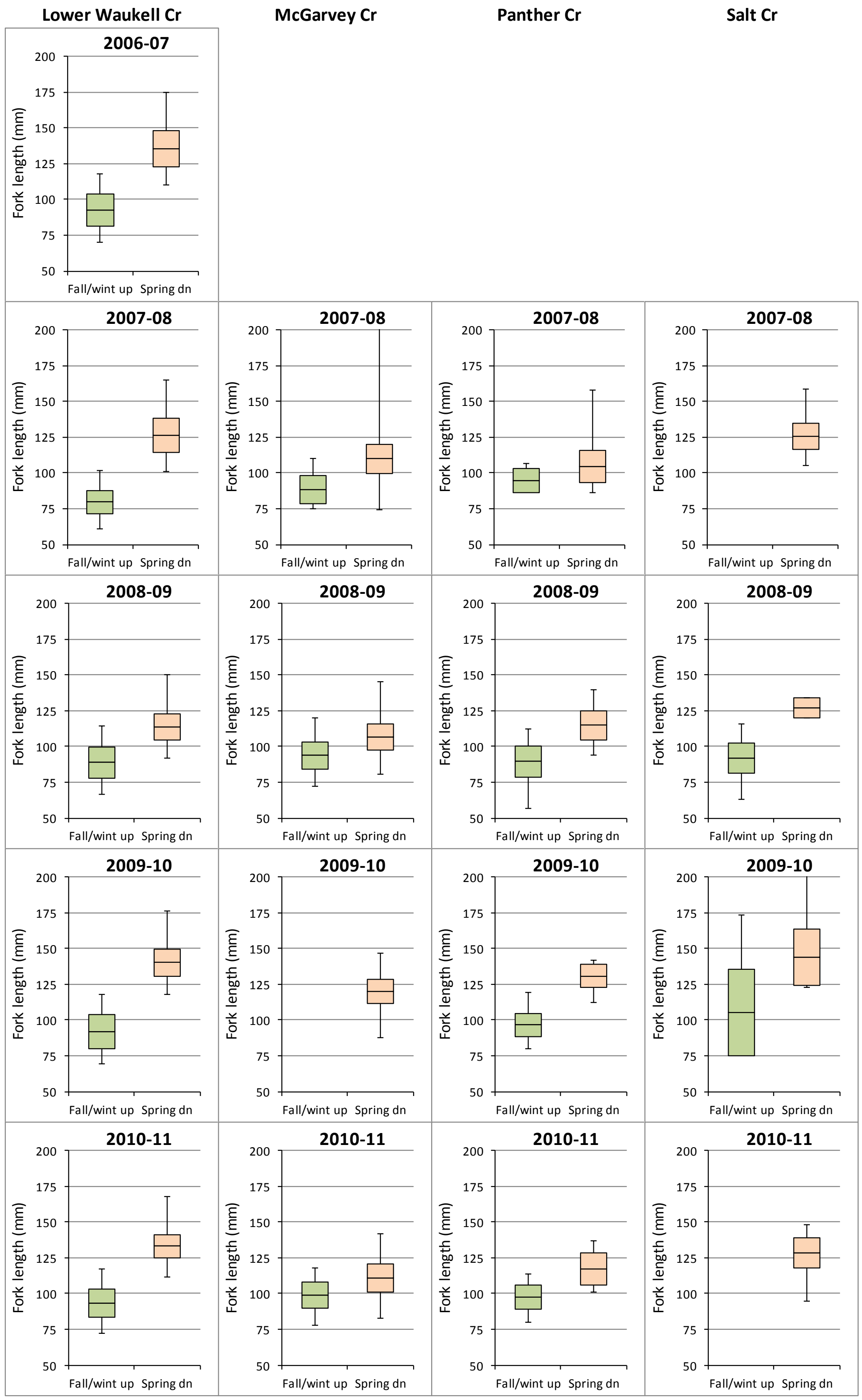


Figure 34. Box and whisker plots of fork lengths (mm) of juvenile coho in lower Waukell Creek, Junior Creek pond outlet, McGarvey Creek, Panther Creek pond outlet, and Salt Creek in 2006-07 to 2010-11. Results shown in Table 9 are plotted.

Table 10. Summary of detection efficiencies of the SPI PIT tag detection arrays located in lower Waukell Creek, 2008-09 to 2010-11.

Winter period - upstream immigration					
Year	Release site	Months	No. released	No. detected	Efficiency
2008-09	L Waukell Up	Dec-Feb	658	187	0.284
2009-10	L Waukell Up	Oct-Feb	270	124	0.459
2010-11	L Waukell Up	Oct-Feb	804	438	0.545
Average					0.429

Spring period - downstream emigration					
Year	Release site	Months	No. released	No. detected	Efficiency
2009	Junior Creek	Apr-Jun	338	320	0.947
2010	Hwy 101 Bridge	late Mar-Jun	32	30	0.938
2011	Hwy 101 Bridge	May	38	36	0.947
Average					0.944

In contrast to this relatively low detection efficiency in fall and winter, the detection efficiencies were estimated to be consistently high during the spring months in Waukell Creek, likely as a result of much lower and more stable flows in this period. To derive these estimates, we used data on the number of PIT tagged fish released upstream of the SPI station during spring of the three years. For the 2009 outmigration, we used the number of PIT tagged fish released immediately downstream of the trap at the outlet of Junior Pond (approximately 1 mile upstream of the SPI station). In 2010 and 2011, when the Junior Creek trap was not operated, we used the number of tagged fish released at an auxiliary trap located near the Highway 101 crossing of Waukell Creek (approximately 0.5 mile upstream of the SPI station). Results for the three years are given in Table 10, showing essentially the same detection efficiency in each year. Average detection efficiency for the three years was 0.944 (range of 0.938 to 0.947).

The consistently high rate of detection on tagged smolts emigrating from the system in spring provided the means to estimate overwinter survival on known PIT tagged fish encountered during the fall-early winter upstream immigration period. Overwinter survival of immigrants was calculated as the proportion of PIT tagged immigrants moving upstream in the period between September 1 and January 31 that were estimated to have emigrated in the period between March 1 and June 30 of each year. The survival, i.e., apparent survival, of immigrants ($\hat{S}_{immigrants}$) to the time of emigration was estimated as

$$\hat{S}_{immigrants} = \frac{\frac{n_2}{AE}}{n_1}$$

where n_1 is the number of PIT tagged coho immigrants released above the upstream oriented trap between September 1 and January 31, n_2 is the number of surviving PIT tagged age-1 emigrants (from the n_1 group) detected to have passed the SPI station between March 1 and June 30, and AE is the calculated array efficiency during the spring period from Table 10.

The resulting estimates of overwinter survival of immigrants to the time of emigration from lower Waukell Creek were very consistent among the three years (Table 11), averaging 0.523 with a range of 0.509 to 0.530. These estimates should be regarded as minima—hence they are referred to as apparent survivals. The estimates do not take into account fish that might have emigrated prior to March 1 (believed to be very few fish) or after June 30 (i.e., fish that might have held over until the following year, also believed to be very few fish). These survival values are consistent with those estimated elsewhere for good quality overwintering habitat (Lestelle 2007).

Table 11. Summary of estimated overwintering survivals of PIT tagged immigrants that moved into Waukell Creek between September 1 and January 31 in 2008-09 to 2010-11.

Year	Immigrants PIT tagged Sep 1 - Jan 31	Emigrants detected Mar 1 - Jun 30	Array efficiency	Est. emigrants	Survival
2008-09	898	451	0.947	476	0.530
2009-10	222	106	0.938	113	0.509
2010-11	774	387	0.947	409	0.528
Average					0.523

Estimates of smolt yield from Waukell Creek during the spring outmigration period in years 2008 to 2011 were made using mark-recapture methods (Table 12). All of the estimates of smolt yield from the Waukell Creek system (not including Junior Creek) employed a two-trap method. In 2008 and 2009, fish were captured, PIT tagged (if not tagged already), and released at the Junior Creek Pond outlet trap. This trap is approximately 1 mile upstream of the lower Waukell Creek trap, which served as the recapture site for making the yield estimates. In 2010 and 2011, the PIT tagging site for marking fish was a trap located near the Highway 101, approximately 0.5 mile upstream of the recapture trap.

Table 12. Summary of estimated smolt yields or standing stock for Waukell Creek, Junior Creek pond, McGarvey Creek, Panther Creek pond, and Salt Creek (and pond) for years 1997 to 2011.

Site	Date/Year	Objective	Pop. est.	95% CI	Estimator	Comment
Lower Waukell Cr.	2008	smolt yield	6,222	1,204 - 11,240	2-trap DARR stratified	
		smolt yield	4,849	2,336 - 7,372	2-trap Peterson type	
	2009	smolt yield	12,688	10,101 - 15,275	2-trap DARR stratified	
		smolt yield	10,899	9,186 - 12,612	2-trap Peterson type	
	2010	smolt yield	754	164 - 1,344	2-trap DARR stratified	
		smolt yield	788	380 - 1,196	2-trap Peterson type	
	2011	smolt yield	1,070	705 - 1,436	2-trap Peterson type	Truncated mark release period
Junior Cr Pond	2008	smolt yield	3,504	3,102 - 3,906	1-trap DARR stratified	
McGarvey Cr	1997	smolt yield	916	624 - 1,208	1-trap DARR stratified	
	1998	smolt yield	613	393 - 833	1-trap DARR stratified	
	1999	smolt yield	146	54 - 238	1-trap DARR stratified	
	2000	smolt yield	572	429 - 715	1-trap DARR stratified	
	2001	smolt yield	849	749 - 949	1-trap DARR stratified	
	2002	smolt yield	1,461	1,216 - 1,706	1-trap DARR stratified	
	2003	smolt yield	1,283	738 - 1,828	1-trap DARR stratified	
	2004	smolt yield	749	600 - 898	1-trap DARR stratified	
	2005	smolt yield	678	139 - 1,217	1-trap DARR stratified	
	2006	smolt yield	2,085	1,479 - 2,691	1-trap DARR stratified	
	2007	smolt yield	329	129 - 529	1-trap DARR stratified	
	2008	smolt yield	1,212	1,049 - 1,375	1-trap DARR stratified	
	2009	smolt yield	3,660	3,376 - 3,944	1-trap DARR stratified	
	2010	smolt yield	608	535 - 681	1-trap DARR stratified	
	2011	smolt yield	1,429	961 - 1,897	1-trap DARR stratified	
Panther Pond Cr	2008	smolt yield	954	71 - 2,049	1-trap DARR stratified	
Panther Pond	Mar 11-19, 2009	standing stock	890	231 - 1,549	Peterson type	Min recap criterion not met
	Mar 19-Apr 9, 2010	standing stock	524	393 - 785	Schnabel type	Some prior emigration likely
	Jan 25-Feb 2, 2011	standing stock	653	533 - 773	Peterson type	
Salt Cr	2008	smolt yield	1,737	512 - 2,962	1-trap DARR stratified	
Salt Cr Pond (marsh)	Feb 4-12, 2009	standing stock	1,193	740 - 1,645	Peterson type	
	Mar 18-Apr 1, 2010	standing stock	71	31 - 177	Schnabel type	Some prior emigration likely
	Jan 27-Feb 4, 2011	standing stock	654	372 - 936	Peterson type	

This approach of using two different trap sites separated by a substantial distance can help to avoid trap-wariness of fish, which is suspected of occurring in some smolt trapping operations that use the same trap to both capture and mark (releasing the fish a short distance upstream), then to recapture them as they move back downstream (based on observations made by Larry Lestelle on the Olympic Peninsula).

The smolt yield estimates for 2008-2010 were made using two methods: (1) using weekly stratification of the data employing the DARR 2.0 model (Bjorkstedt 2005), and (2) an unstratified simple Peterson-type estimate (Ricker 1975). DARR 2.0 applies a series of algorithms to a stratified mark-recapture data set to aggregate the strata as necessary to produce less biased estimates of abundance (using the Darroch 1961 stratified-Peterson estimator), while preserving as much structure as possible in the data (Bjorkstedt 2005). Where possible, we present both smolt estimates for a year for the sake of comparison. In 2011, the available data enabled us to only employ the simple (unstratified) Peterson-type estimate.

The annual estimates of smolt yield from the Waukell subbasin ranged from less than 800 fish to nearly 13,000 fish over the four year period (Table 12). The estimate in the high production year was about 17 times greater than it was in the low year. The estimates made using the DARR stratified method are considered to be more accurate than those made with the simple Peterson-type method.

In 2008, an estimate of the smolt yield from Junior Pond was made using a one-trap mark-recapture approach with the stratified DARR 2.0 model (Table 12). Marking was done using fin clips on a rotational basis. The resulting point estimate of about 3,500 smolts is suspected of being biased somewhat high because some fish did not leave the pond volitionally as it was drying up—and a considerable number of fin clipped fish were found holding in the pond, suggesting they were trap-wary (this would tend to bias the estimate high). Ignoring this potential bias, the results suggest that Junior Pond that year produced approximately 56% of the smolts in the Waukell Creek subbasin.

The estimates of smolt yield for Waukell Creek provide a basis for estimating the total numbers of immigrants that moved into and overwintered in this stream system in the three years with survival values available (Table 13). Because some of the immigrants that moved into Waukell Creek entered as early as spring as age-0 fish, our estimates of immigrant numbers represent the immigrant population sizes as they would have more or less been present in the stream during the fall (and early winter) period. The survival estimates are for the period from the time of the fall entry of immigrants to the spring emigrant outmigration. The estimates of immigrant abundance at the time of the fall entry were calculated by dividing the estimated smolt yields by the overwintering survival values. The immigrant abundances ranged from about 1,500 fish to 24,000 fish in the three years.

Table 13. Summary of estimated numbers of immigrants (corresponding to the number during the fall immigration period) that produced smolt yields in 2009-2011.

Year	Smolt emigrants	Smolt 95% CI	Immigrant survival	Est. immigrants	Immigrant 95% CI
2009	12,688	10,101 - 15,275	0.530	23,918	19,041 - 28,795
2010	754	164 - 1,344	0.509	1,480	322 - 2,639
2011	1,070	705 - 1,436	0.528	2,028	1,336 - 2,721

These results demonstrate that the number of non-natal fish moving into river corridor habitats in the lower Klamath River from other areas in the river basin vary significantly from year to year. In some years, these habitats provide refuge areas for large numbers of juvenile coho moving from other areas.

Figure 35 shows the relative contribution of different known groups of non-natal coho to the smolt emigrants leaving Waukell Creek during the months of March-June in 2009-2011. The charts show the relative amounts of tagged non-natal fish that had been tagged outside of the Waukell Creek subbasin, colored to indicate whether they were tagged in streams downstream of the Trinity River or in areas upstream of Trinity River. Sites where the different groups of fish were tagged are identified. It is important to note that the charts should not to be interpreted as showing the actual composition of the non-natal smolt yields leaving Waukell Creek—the relative proportions depict only the contributions of different tagged groups to the total number of PIT tagged fish that were identified in the smolt outmigration, both by the SPI arrays and by physical capture. The relative compositions of tagged non-natal fish are thus partly a function of how many fish were tagged in the various locations in the river basin where efforts were expended to capture and tag fish. On the average over the three years shown, roughly half the fish tagged outside Waukell Creek but encountered in Waukell Creek were tagged in areas downstream of Trinity River, the other half having been tagged upstream of Trinity River.

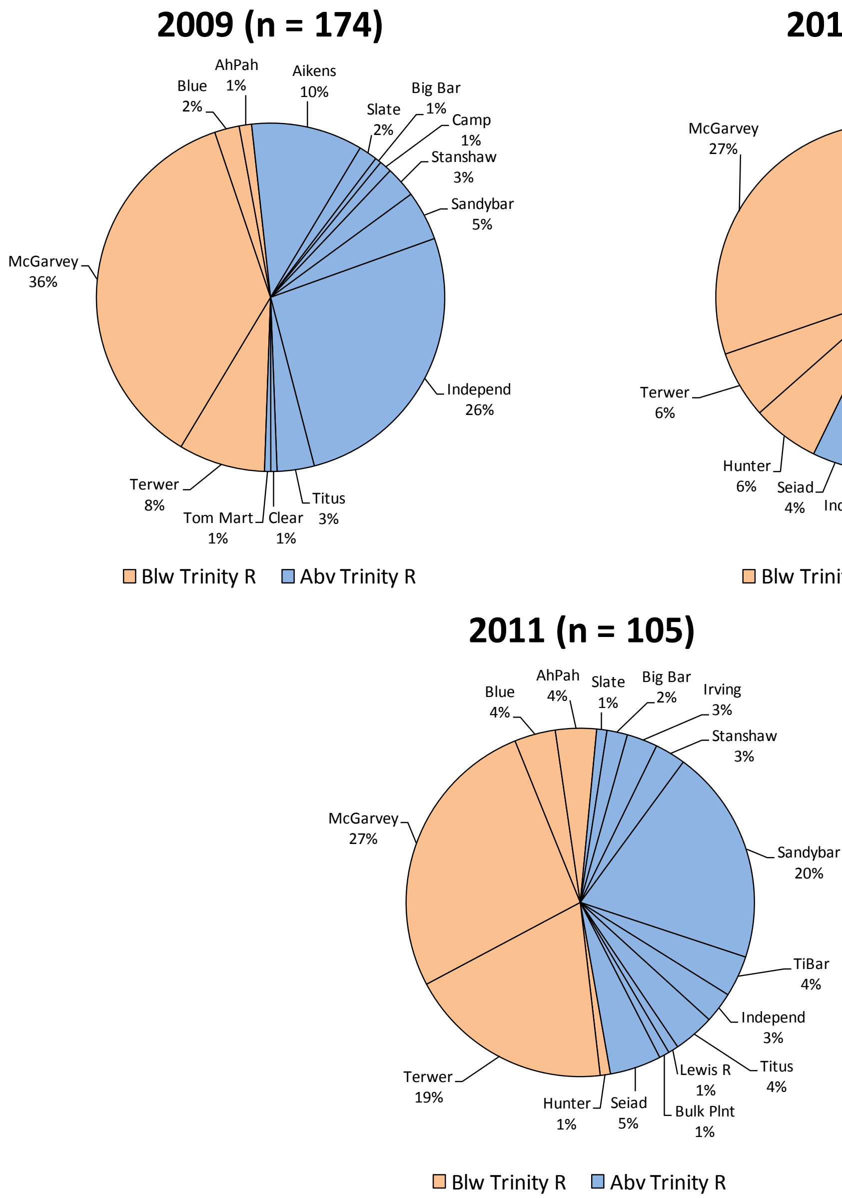


Figure 35. Source locations of PIT tagged smolts emigrating in 2009-2011 from Waukell Creek that had been tagged in locations outside of Waukell Creek. These fish are known immigrants that had moved into Waukell Creek to overwinter. Sources associated with fish that were tagged downstream and upstream of Trinity River are colored differently for reference.

Figures 36-38 compare just the relative contributions of fish tagged *upstream* of Trinity River to the smolt emigrant populations in 2009-2011 among the four streams in focus here. The tagged fish in each stream were identified both by the SPI arrays and by physical capture in each stream. It should be noted that a functional SPI station was not operative in McGarvey Creek until November 2010, so results shown for this stream in 2009 and 2010 were based solely on physical captures. Also, the reader should note that the colorized segments in these graphs show the portion of fish tagged either upstream or downstream of the Sandybar floodplain channel site (RM 77) as a reference location of reference.

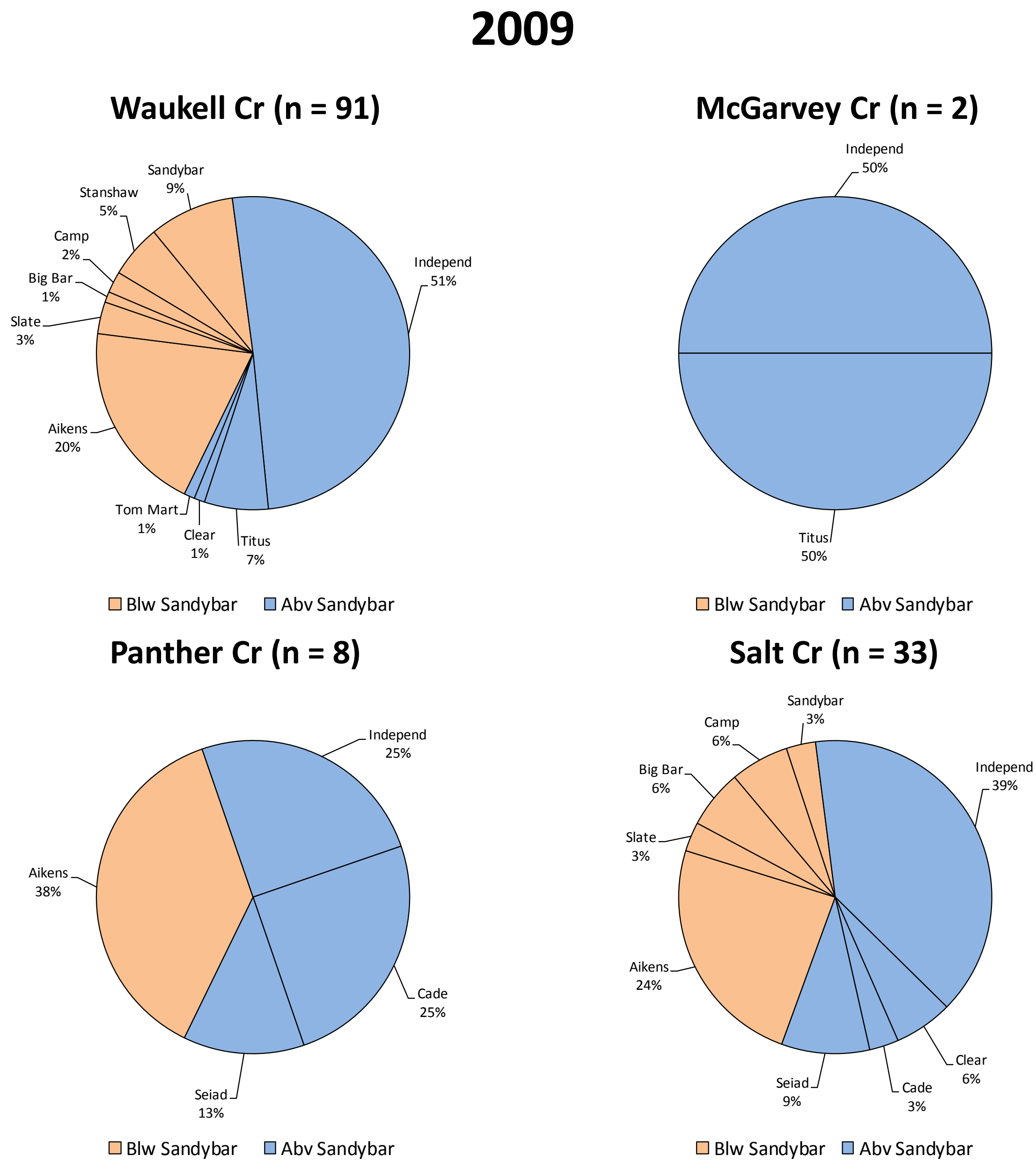


Figure 36. Comparison of source locations of PIT tagged smolts emigrating in 2009 from Waukell Creek , McGarvey Creek, Panther Creek, and Salt Creek that had been tagged in locations upstream of Trinity River. These fish are known immigrants that had moved into these streams from upstream of Trinity River to overwinter. Sources associated with fish that were tagged downstream and upstream of Sandybar floodplain channel are colored differently for reference.

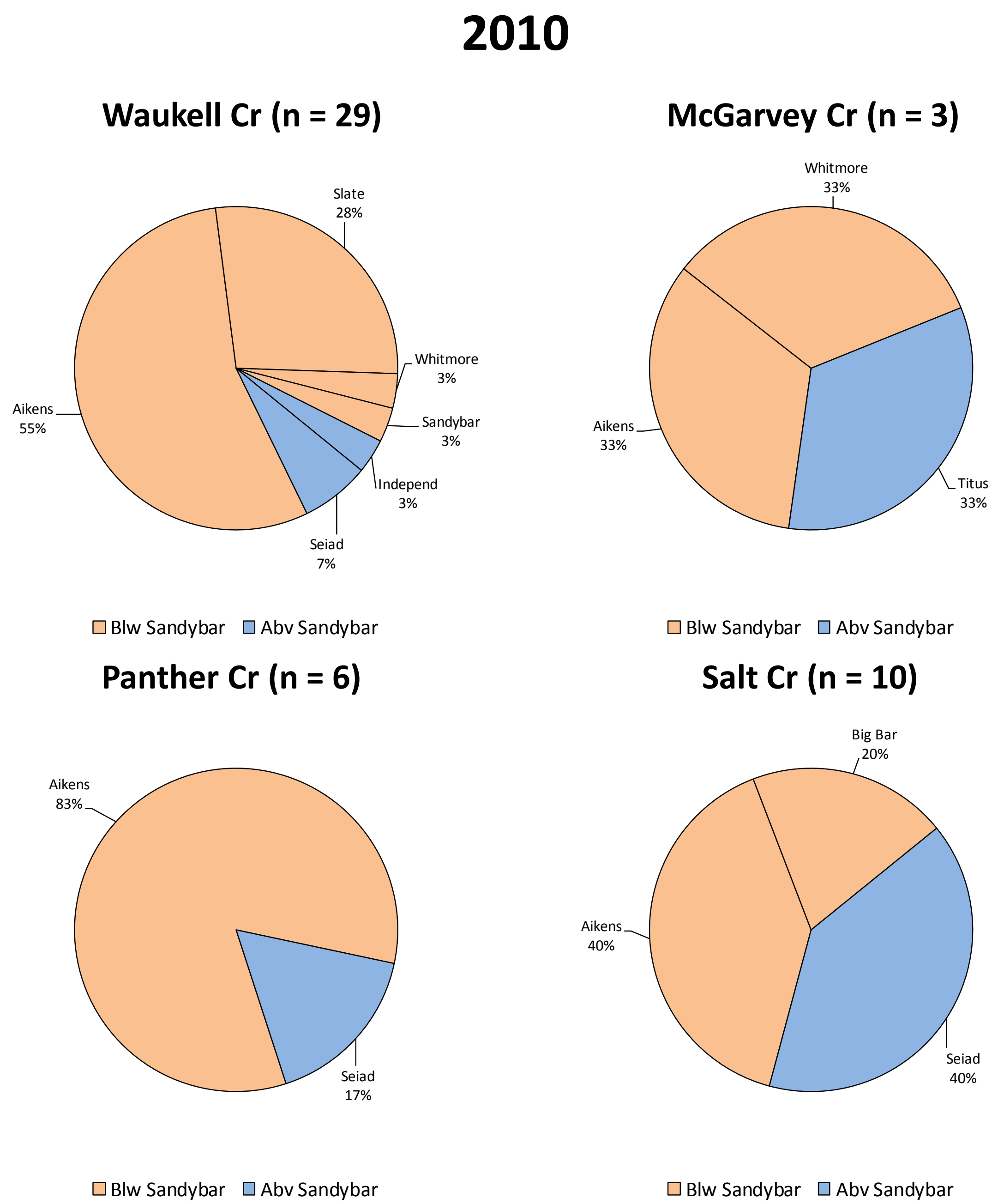


Figure 37. Comparison of source locations of PIT tagged smolts emigrating in 2010 from Waukell Creek , McGarvey Creek, Panther Creek, and Salt Creek that had been tagged in locations upstream of Trinity River. These fish are known immigrants that had moved into these streams from upstream of Trinity River to overwinter. Sources associated with fish that were tagged downstream and upstream of Sandybar floodplain channel are colored differently for reference.

2011

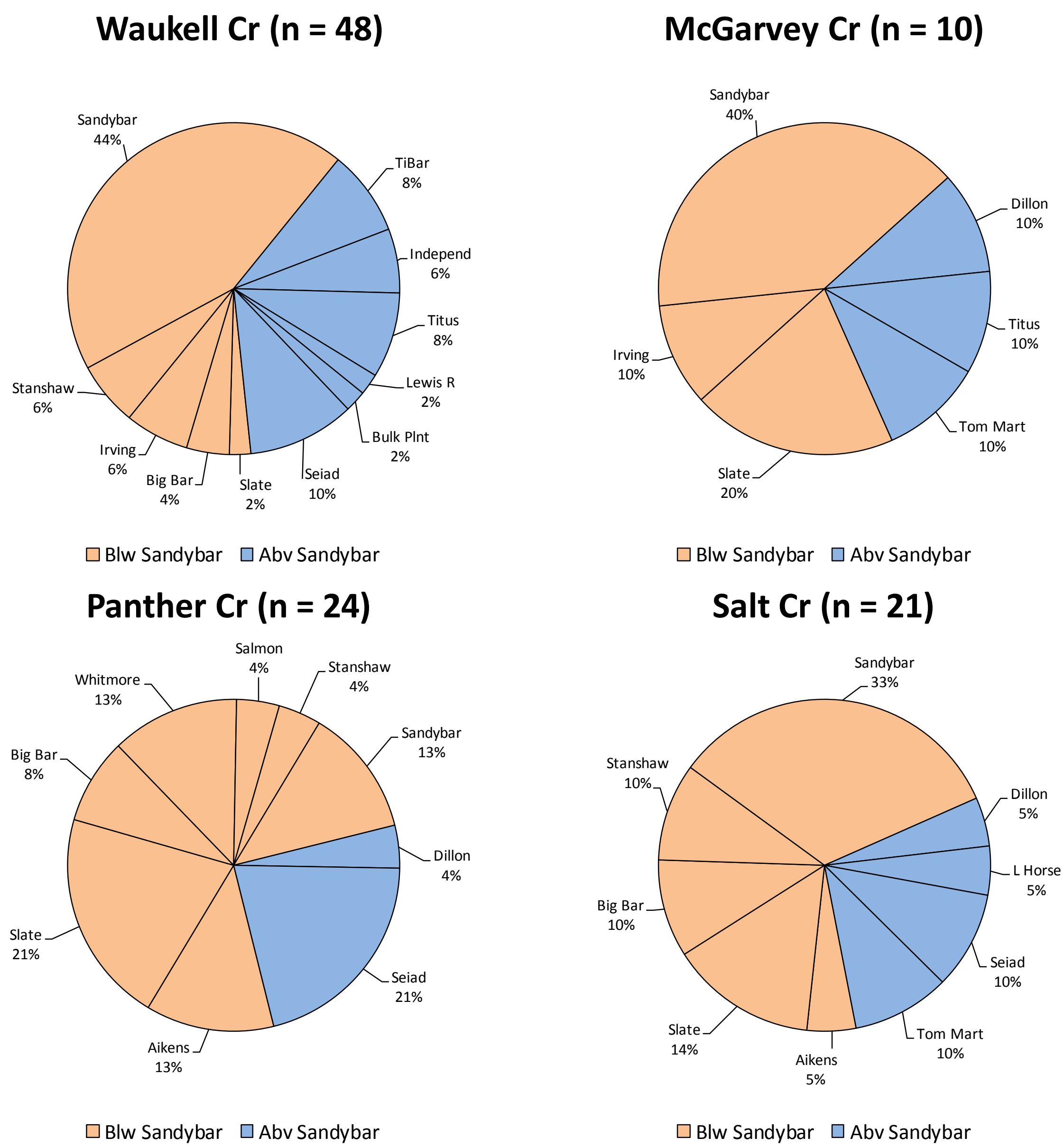


Figure 38. Comparison of source locations of PIT tagged smolts emigrating in 2011 from Waukell Creek , McGarvey Creek, Panther Creek, and Salt Creek that had been tagged in locations upstream of Trinity River. These fish are known immigrants that had moved into these streams from upstream of Trinity River to overwinter. Sources associated with fish that were tagged downstream and upstream of Sandybar floodplain channel are colored differently for reference.

The results also suggest that river corridor habitats in the lower river potentially provide extremely important refuge habitat for non-natal coho that likely originate in virtually every area of the river basin.

3.2.4.2 McGarvey Creek Patterns

McGarvey Creek is a small, low gradient stream (third order), draining approximately 8.9 mi^2 of moderately steep, forested lands. It enters the Klamath River at RM 6.4. The lower mainstem of the stream is sinuous, flowing through a broad floodplain as it nears the Klamath River. The upper mainstem is moderately steep and confined by the valley side walls and contains natural and anthropogenic barriers to anadromous fish. The West Fork of McGarvey Creek is generally a low gradient channel. The majority of the McGarvey Creek subbasin is managed for commercial timber production.

The McGarvey Creek subbasin has been subjected to intense timber harvest and road building activities for decades, including construction of the U.S. Highway 101 bypass through the headwaters in the mid-1980s (Gale and Randolph 2000). Historic and ongoing land management activities have resulted in removal of old growth conifers from riparian habitats, substantial simplification of stream and riparian habitats, increased rates of channel sedimentation, and loss of large wood and naturally formed jams within the stream channels and floodplains (Beesley and Fiori 2007).

The Yurok Tribe is significantly involved in the restoration of natural watershed processes and fish habitat in the McGarvey Creek subbasin. Beginning in the late 1990s, the tribe in conjunction with partners implemented high-risk road decommissioning, riparian plantings, and extensive instream and off-channel habitat restoration projects within the anadromous fish zone (YTFP 2013; Beesley and Fiori 2014). Large wood loading projects have been carried out in several locations beginning in 2007 and have continued to the present time. Several off-channel ponds have been constructed within the lower floodplain. These projects are especially important to coho salmon.

McGarvey Creek supports coho spawners and provides important rearing habitat for natal juveniles from fry emergence through smolt outmigration. The stream is also used by non-natal coho produced by spawners in other streams. Juvenile fish are able to access McGarvey Creek from the Klamath River for much of the year, though periods of restricted access occur during summer low flows.

The YTFP has trapped downstream migrants in the late winter and spring of each year in McGarvey Creek since 1997, continuing through the period reported on in this report (YTFP 2009; Antonetti et al. 2012). The outmigrant trap during the years relevant to this report was located at RM 1.25. Trap design has been typical of pipe traps used in northern California for smolt outmigrant studies. Other auxiliary fyke net traps located closer to the Klamath River were also periodically employed to catch upstream moving juvenile immigrants. Parts of the results from trapping beginning in fall of 2007 are presented here to illustrate patterns of use for comparison to the other streams. The reader should refer to the McGarvey Creek project reports for more extensive reporting of results (YTFP 2009; Antonetti et al. 2012; Antonetti et al. 2014).

Three SPI stations were installed in November 2010 in the McGarvey Creek subbasin. One station was located at RM 1.1 and the other two stations were placed upstream of the confluence of the West Fork and the mainstem. The lower site was located downstream of the downstream migrant pipe trap and the other sites were located upstream of that trap. The sites were operational through the end of the period reported on in this report.

Results of sampling presented herein include trap catch patterns, fish size and growth patterns, smolt yield estimates, and source composition of non-natal juvenile coho as shown in re-encounters of PIT tagged fish.

Trap catch patterns from the upstream oriented fyke trap (to trap fish moving upstream) and the downstream oriented trap (to trap downstream moving fish) at the two trap sites of relevance here are displayed in Figure 39. The charts are arranged in the same manner as seen in Figure 28 for Waukell Creek to facilitate comparison between streams, though the information is not as complete as it is for Waukell Creek. Also, the charts are paired vertically, showing upstream moving fish on the top graph within a pair and downstream moving fish on the bottom graph of the pair. Four years of data are summarized. Each graph shows with a vertical bar the number of juvenile coho caught in a roughly 24-hr time period over a yearly period beginning with September 1. The days when the trap actually was operated are shown in black bars within a band at the top or bottom of each graph—enabling the reader to know when the trap was fished. It is important to note that these graphs do not reflect fish age (i.e., whether fish were age-0 or age-1). That information can be roughly known by comparing these graphs to the fish size displays seen on the subsequent figures. The reader should also pay particular attention to the scale of the y-axis to know the relative magnitude of the total number of fish trapped in a season. The Klamath River flow rate (cfs in 1000s) is shown on the graphs by the blue line.

Fork length (mm) data are graphed in two ways to show patterns of change over time. Figure 40 shows fork length in relation to date of capture and Figure 40 provides length frequency histograms grouped for November 1-January 15 and April 1-June 15. In contrast to the fish length patterns seen in Waukell Creek, the McGarvey patterns show strong signatures of newly emerged age-0 coho moving downstream in early spring, particularly in 2008, 2009, and 2011. These observations are helpful for interpreting the trap catch patterns in the downstream migrant trap (Figure 39).

We note the following from these patterns of trap catches and fish sizes in McGarvey Creek:

- The patterns for immigrants moving upstream (presumably out of the Klamath River) in fall and early winter generally match those seen in Waukell Creek even though there were many fewer days when the upstream oriented trap was operated.
- In the single year when the downstream oriented trap was operated during the fall and early winter (2008-09), there was substantial downstream emigration, occurring during periods of elevated flows. The sizes of the fish during those periods seen in Figure 40 closely match sizes of fish captured in the upstream oriented trap in lower Waukell Creek in the same time periods (Figure 30). (Note that the lower Waukell Creek trap showed no evidence of a downstream emigration during the same time periods—Figure 28). These observations indicate that while McGarvey Creek is receiving some immigrants produced

from other streams in the fall and early winter, the stream is also exporting emigrants to other areas at the same time. As seen in Figure 35, substantial numbers of fish tagged in McGarvey Creek overwinter in Waukell Creek and smolt from there. This pattern suggests that McGarvey Creek is limited in high quality overwintering habitat in at least some years, especially in years when the abundance of age-0 fish in fall is large. Year 2008-09 was a high abundance year in both McGarvey Creek and Waukell Creek, though rearing conditions in Waukell Creek that year still enabled the habitat to absorb more immigrants and maintain high survival.

- The patterns of downstream migrants in late winter, spring, and early summer generally showed earlier pulses of fish compared to Waukell Creek, though the last part of the migration was consistent with the timing seen in Waukell Creek. Close examination of the trap catch and fish size graphs show that a substantial amount of the earlier migrants in McGarvey Creek were newly emerged age-0 fry (strongly evident in 2008 and 2009, particularly so in 2008). While both McGarvey and Waukell creeks showed pulses of age-1emigrants in late February/early March in 2009, the relative size of the early pulse was much greater in McGarvey Creek relative to the larger pulse of age-1 fish than it was in Waukell Creek. We think it is likely that the early pulses in both streams were associated with staging behavior of the fish as they were beginning to smolt (see description of staging in Lestelle 2007) and initial emigration. We suggest that the effects of capacity limitations in McGarvey Creek were greater than in Waukell Creek, prompting a larger portion of the population there to initiate early emigration. Such a pattern suggest much stronger capacity limitations are operative in McGarvey Creek than in Waukell Creek for age-1 fish.

Table 9 summarizes fork length data for McGarvey Creek (and the other streams), giving average lengths and other metrics by age class caught in the upstream and downstream traps in the same combined months used in constructing the length frequency histograms. These data are graphed as box-and-whisker plots in Figure 34. We note the following from the pattern seen in Figure 34:

- McGarvey Creek smolts in the four years with data presented were smaller in every year than in Waukell Creek—substantially smaller in three of the four years. Only in the high abundance year (2009 in both streams) did Waukell Creek smolts approach the size of those in McGarvey Creek. Smolt size was depressed in both streams in 2009, likely the result of population density effects.
- Growth during the winter and spring in the three years with data shown in Figure 34 was modest in McGarvey Creek, much less than what was generally observed in Waukell Creek, Panther Creek, and Salt Creek.

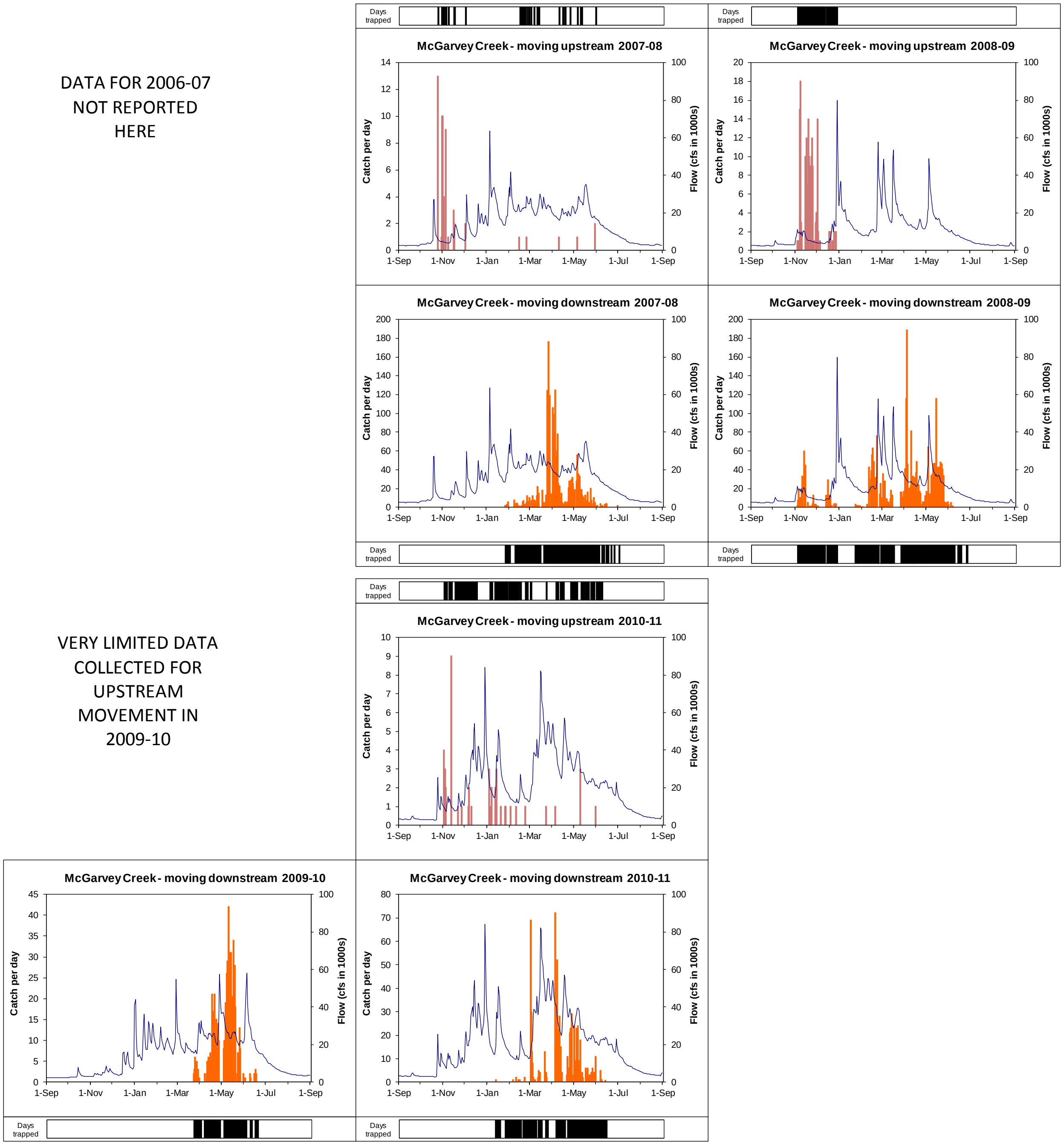


Figure 39. Catch per day of juvenile coho in upstream oriented (targets upstream moving fish) and downstream oriented (targets downstream moving fish) traps in McGarvey Creek, 2007-08 to 2010-11. Klamath River flow at the lower USGS station is also plotted. Black bands above and below each graph indicate days when a trap was operating.

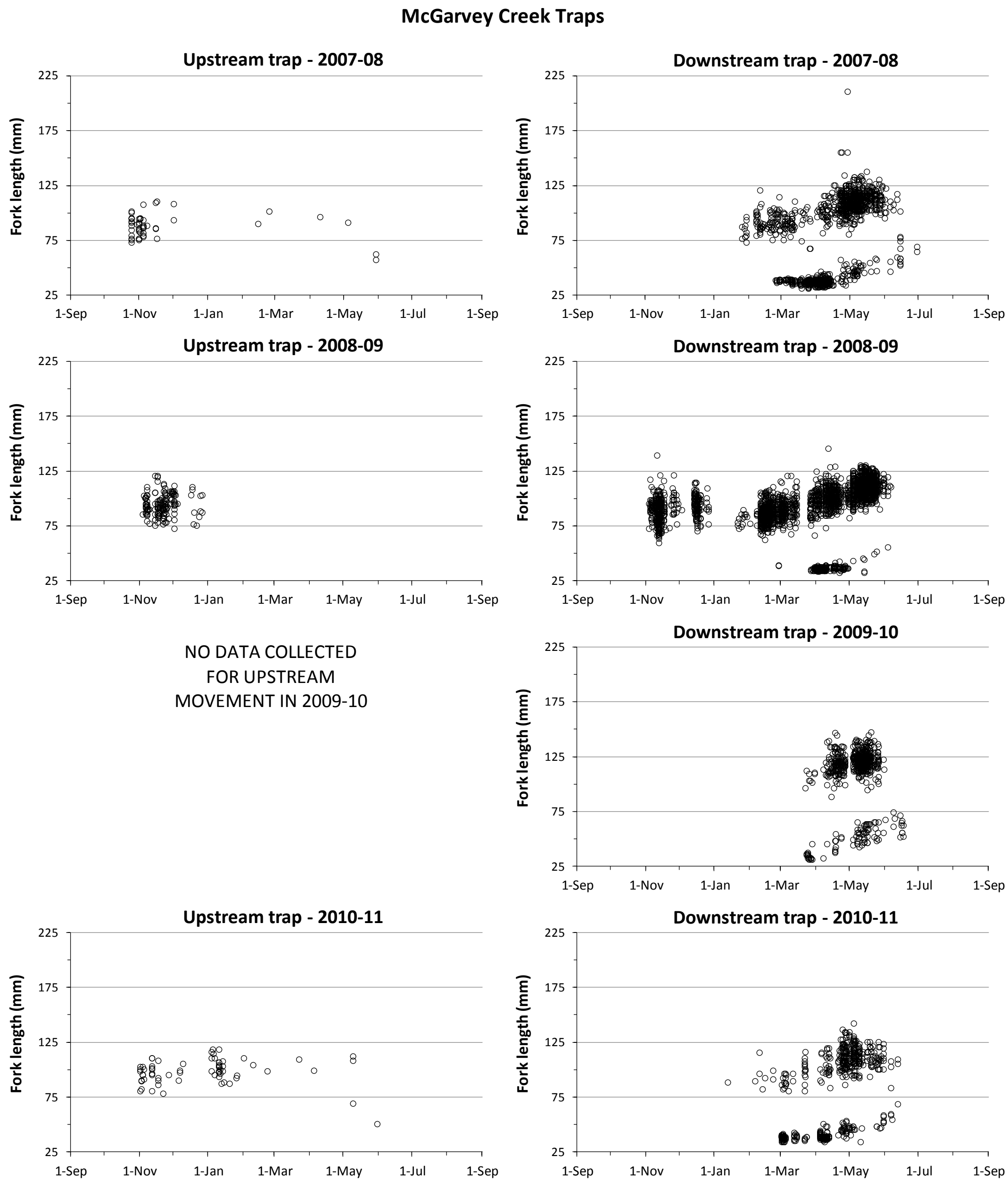


Figure 40. Fork lengths (mm) of juvenile coho sampled in McGarvey Creek between September 1 and August 31 in 2007-08 to 2010-2011.

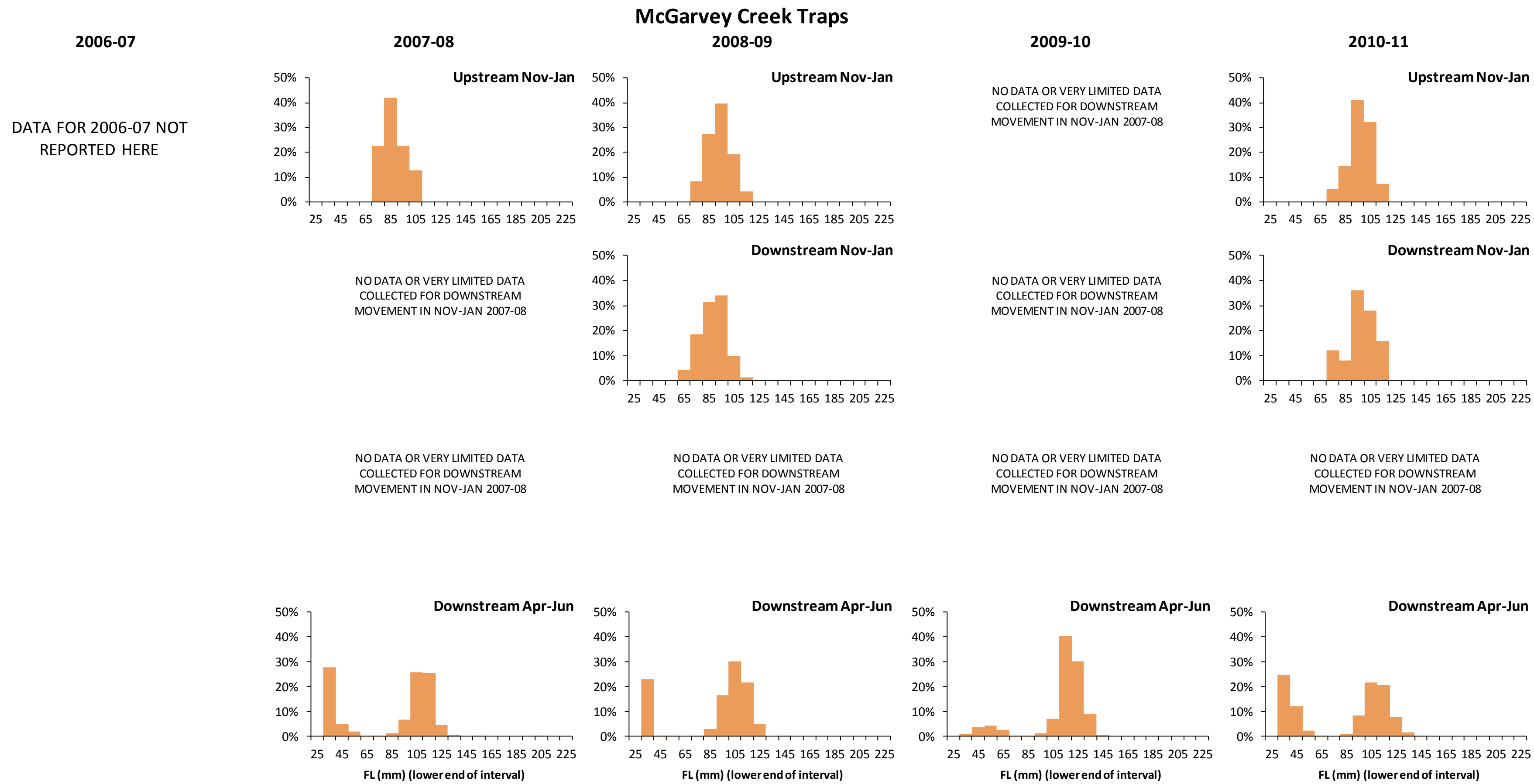


Figure 41. Length frequencies (fork length in mm) of juvenile coho sampled in McGarvey Creek in 2007-08 to 2010-2011. The x-axis shows the lower ends of bin ranges in mm. Data are grouped for samples in November-January and April-June.

Smolt yields have been estimated annually in McGarvey Creek beginning in 1997 (Table 12). The estimates have been made using a one-trap stratified DARR estimator, as described in Antonetti et al. (2012). The method has consisted of the capture of emigrants moving downstream at RM 1.25, marking the fish using a rotation of fin clips over the season, releasing the fish approximately ¼ mile upstream, and then recapturing marked fish along with the newly captured fish at the same trap. The method has been consistently applied in all years of the operation. In the four years focused upon in this report, the point estimates of smolt yield have ranged from a low of 608 (2010) to a high of 3,660 (2009), the highest abundance being six times that of the lowest abundance in these years. It is notable that the high abundance year was the same year when the highest abundance was estimated in Waukell Creek. Similarly, the low abundance year within this four year period was the same year for the lowest abundance in Waukell Creek. We also note that the high smolt yield in McGarvey Creek in 2009 was almost 1.8 times the next highest abundance estimated since 1997 (that yield was estimated to be 2,085 in 2006).

Figures 36-38 compare the relative contributions of fish tagged *upstream* of Trinity River to the smolt emigrant populations in 2009-2011 among the four streams in focus here. The tagged fish in each stream were identified both by the SPI arrays and by physical capture in each stream. It should be noted, however, that a functional SPI station was not operative in McGarvey Creek until November 2010, so results shown for this stream in 2009 and 2010 were based solely on physical captures. Also, the reader should note that the colorized segments in these graphs show the portion of fish tagged either upstream or downstream of the Sandybar floodplain channel site (RM 77).

3.2.4.3 Panther Creek Patterns

Panther Creek is a tributary to lower Hunter Creek, which enters the Klamath River less than one mile from the river mouth. Hunter Creek is a fourth-order stream with a watershed area of approximately 29 mi^2. Land use consists of timber harvest in the upper watershed and livestock grazing and residential development in the lower watershed. Historically, Salt Creek was also a tributary to lower Hunter Creek but erosion of the north bank of the Klamath River has now created two separate entry points to the river by Salt and Hunter creeks. The Salt-Hunter Creek valley was once a complex backwater feature of the Klamath River estuary comprised of a large network of low gradient, anastomosed channels and conifer-dominated wetlands. Agricultural development and other land uses in the early 1900s resulted in substantial wetland conversion and loss of channel complexity in the lower Hunter-Salt Creek valley (Beesley and Fiori 2004, 2007, 2008).

Panther Creek is primarily a spring fed system that enters lower Hunter Creek a short distance downstream from the Highway 101 crossing on Panther Creek. Panther Creek Pond is an extensive pond complex formed within the main channel of Panther Creek, having its downstream end several hundred feet upstream of the confluence of Panther Creek and Hunter Creek. The pond is comprised mostly of deep (5-11 ft), open water habitat with complex edge habitats and interconnected emergent wetlands (Silloway 2010; Silloway and Beesley 2011). The pond appears to afford high quality rearing habitat during both summer and winter for juvenile coho. Panther Creek does not appear to support spawning salmon due to an absence of spawning gravels (Silloway 2010). Hunter Creek does support spawning salmon, including coho. It should be noted that issues of access into and out of the Panther Creek Pond by juvenile coho appear to exist, as discussed in Silloway and Beesley (2011)—factors affecting access are not yet completely understood.

The YTFP initiated trapping using upstream and downstream fyke net traps within Panther Creek downstream of the pond in a significant manner in late winter of 2008. Trapping continued through the period reported on in this report. A SPI station was installed in the channel downstream of the traps in December 2008 and operated through the period of this report except during some periods of high water and equipment malfunction. Additionally, fyke nets were occasionally deployed within the pond to collect samples on fish size and to make population estimates using mark-recapture methods (Silloway 2010; Silloway and Beesley 2011). Some of these data are presented in this current report.

Results of sampling presented herein include trap catch patterns, fish size and growth patterns, smolt yield and standing stock pond abundance estimates, and source composition of non-natal juvenile coho as shown in re-encounters of PIT tagged fish.

Trap catch patterns from the upstream oriented fyke trap (to trap fish moving upstream) and the downstream oriented trap (to trap downstream moving fish) at the two trap sites of relevance here are displayed in Figure 42. The charts are arranged in the same manner as seen in Figure 28 for Waukell Creek to facilitate comparison between streams, though the information is not as complete as it is for Waukell Creek. Also, the charts are paired vertically, showing upstream moving fish on the top graph within a pair and downstream moving fish on the bottom graph of the pair. Four years of data are summarized, with a very small amount of data shown for one other year also (2006-07). Each graph shows with a vertical bar the number of juvenile coho caught in a roughly 24-hr time period over a yearly period beginning with September 1. The days when the trap actually was operated are shown in black bars within a band at the top or bottom of each graph—enabling the reader to know when the trap was fished. It is important to note that these graphs do not reflect fish age (i.e., whether fish were age-0 or age-1). That information can be roughly known by comparing these graphs to the fish size displays seen on the subsequent figures. The reader should also pay particular attention to the scale of the y-axis to know the relative magnitude of the total number of fish trapped in a season. The Klamath River flow rate (cfs in 1000s) is shown on the graphs by the blue line.

Fork length (mm) data are graphed in two ways to show patterns of change over time. Figure 43 shows fork length in relation to date of capture and Figure 44 provides length frequency histograms grouped for November 1-January 15 and April 1-June 15. We note that although there are age-0 fish evident in the springtime in the graphs, it appears that no newly emerged fry were ever captured (these fish would have been <35 mm), similar to findings in Waukell Creek but unlike McGarvey Creek.

We note the following from these patterns of trap catches (Figure 42) and fish sizes (Figures 43-44) in Panther Creek:

- Too little effective upstream trapping was done in the fall and early winter to determine the consistency of the patterns of immigration moving into the pond. The one year with substantial upstream trapping in these months (2009-10) exhibited a pattern that matched closely with the immigration pattern seen in Waukell Creek in that year (Figure 28).

- The patterns of immigration and emigration in late winter and spring consistently showed that age-0 fish were the dominate age class moving upstream during this time period and age-1 fish to strongly predominate in the downstream emigration (seen clearly in Figure 44). Some age-0 fish were also trapped in the downstream oriented trap suggesting these fish were emigrating from the pond. However, it is not clear, whether these fish were actually coming from the pond or were being captured in the downstream trap due to milling in the channel below the pond (i.e., they might have actually been trying to move upstream)—perhaps due to difficulty in successfully entering the pond (see discussion in Silloway and Beesley 2011).
- The sizes of the immigrants moving up in the spring were similar to immigrants moving upstream in Waukell, McGarvey, and Salt creeks during the same periods and were substantially larger than newly emerged fry (as seen in the downstream movement of fry in McGarvey Creek). Their sizes reflect that the fish had dispersed downstream from natal areas and had already experienced considerable growth, probably in or very near the mainstem Klamath River. It is reasonable to assume that some of these fish had previously encountered the mainstem river, where growth rates often exceed rates within small natal tributaries (see discussion in Lestelle 2007).
- The very small numbers of fish captured in the downstream trap during spring suggest that trap effectiveness at this site is so poor that it does not enable reliable data to be collected consistently; data presented in Silloway and Beesley (2011) on patterns of movement out of the pond by PIT tagged smolts as they correspond to trap catches (or in this case, not correspond) strongly suggest that downstream trapping effectiveness below the pond is poor for reasons not well understood. Silloway and Beesley (2011) also provide details on interannual differences that appear to exist with access into and out of the pond by juvenile coho, potentially related both to flow levels and encroachment of invasive reed canary grass in the area of the pond outlet.

Table 9 summarizes fork length data for Panther Creek (and the other streams), giving average lengths and other metrics by age class caught in the upstream and downstream traps in the same combined months used in constructing the length frequency histograms. These data are graphed as box-and-whisker plots in Figure 34. We note the following from the patterns seen in Figure 34:

- Panther Creek smolts in the four years with data presented were smaller in every year but one than in Waukell Creek, and generally show sizes intermediate to what is seen in Waukell and McGarvey creeks.
- Growth of fish reflected in the change in sizes of fall immigrants (age-0) to spring emigrants (age-1) also was generally intermediate between the patterns seen in Waukell and McGarvey creeks.

For the years 2008 to 2011, the smolt yield was estimated only in 2008 (Table 12). The method employed used a one-trap DARR stratified model and produced a point estimate of 954 smolts, but confidence intervals were very wide. Questions were noted by the supervising biologist about the quality of the recapture data—despite the fact that the minimum recapture criterion was just met (seven recaptures; see Seber 1982). In 2009 to 2011, estimates of standing stock abundance within the pond complex were made using mark-recapture methods with fyke net trap sets. The minimum recapture criterion was not met in 2009. The standing stock estimates should reflect the smolt yields that would have occurred in those years if the fish were able to successfully emigrate on a consistent basis from the pond. Questions exist about the ability of smolts to consistently emigrate from the pond as noted above.

We note that the size of the Panther Pond complex, combined with its water quality and diverse cover structure, should be able to support a much larger number of juvenile coho than reflected in the abundance estimates in Table 12. The reasons for what we consider to be low abundance in the pond, particularly in light of what the Waukell Creek subbasin is capable of supporting, are not yet understood. The reasons may simply be due to issues related to accessibility—both into and out of the pond—or other factors may exist, such as the location of Panther Creek in relation to the estuarine zone of the Klamath River. We do not yet understand the spatial and seasonal movement patterns of juvenile coho within the estuarine zone of the river—these patterns might affect the extent that juvenile coho produced in areas upstream of Hunter Creek utilize summer and winter habitats located in lower Hunter and Salt creeks.

Figures 36-38 compare the relative contributions of fish tagged *upstream* of Trinity River to the smolt emigrant populations in 2009-2011 among the four streams in focus here. The tagged fish in each stream were identified both by the SPI arrays and by physical capture in each stream. The reader should note that the colorized segments in these graphs show the portion of fish tagged either upstream or downstream of the Sandybar floodplain channel site (RM 77). Despite the much smaller number of known non-natal fish to have been encountered each year in Panther Creek than in Waukell Creek, it is notable that proportions of fish originating either upstream or downstream of the Sandybar floodplain channel were similar between Panther and Waukell creeks.

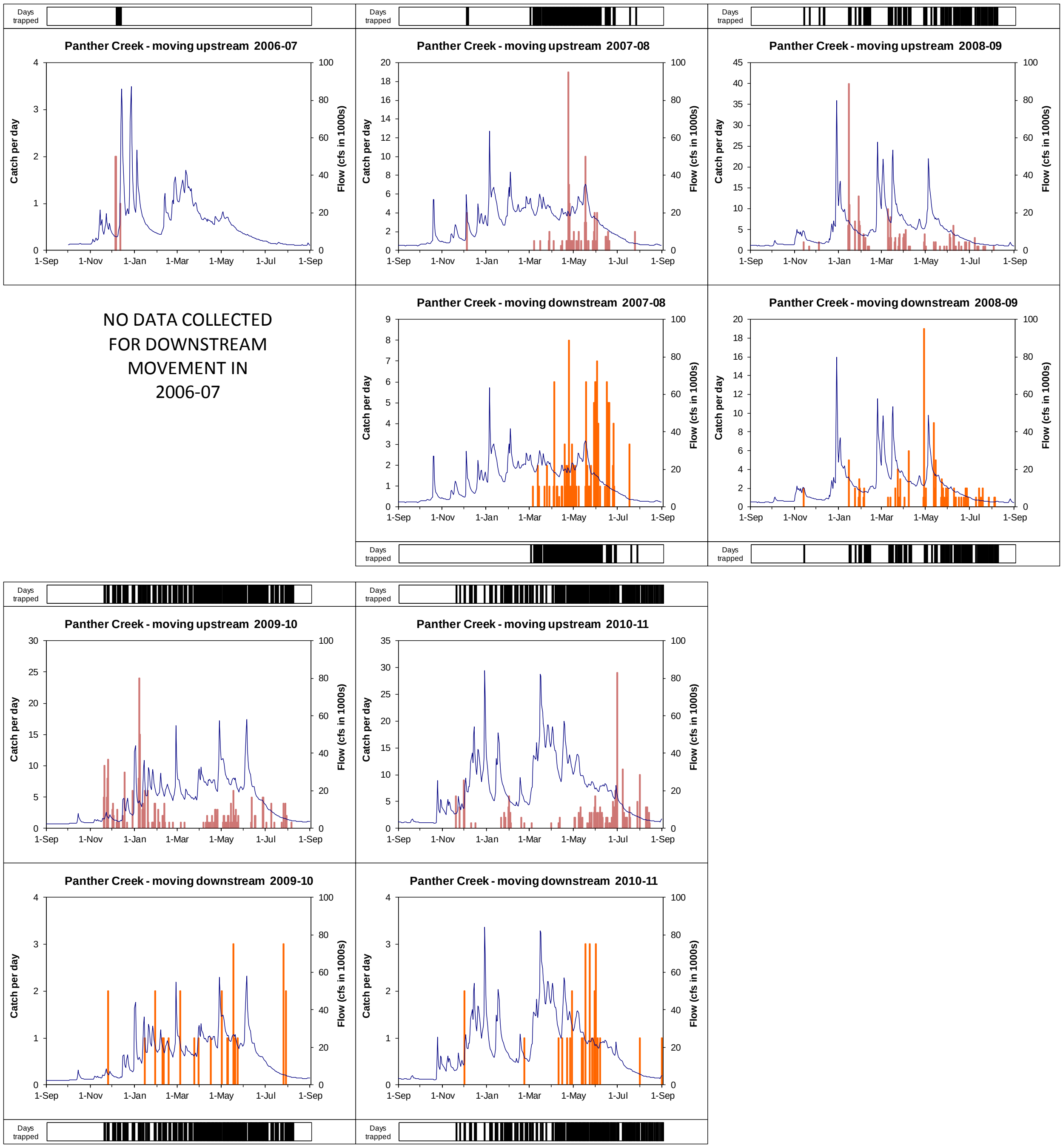


Figure 42. Catch per day of juvenile coho in upstream oriented (targets upstream moving fish) and downstream oriented (targets downstream moving fish) traps in Panther Creek, 2006-07 to 2010-11. Klamath River flow at the lower USGS station is also plotted. Black bands above and below each graph indicate days when a trap was operating.

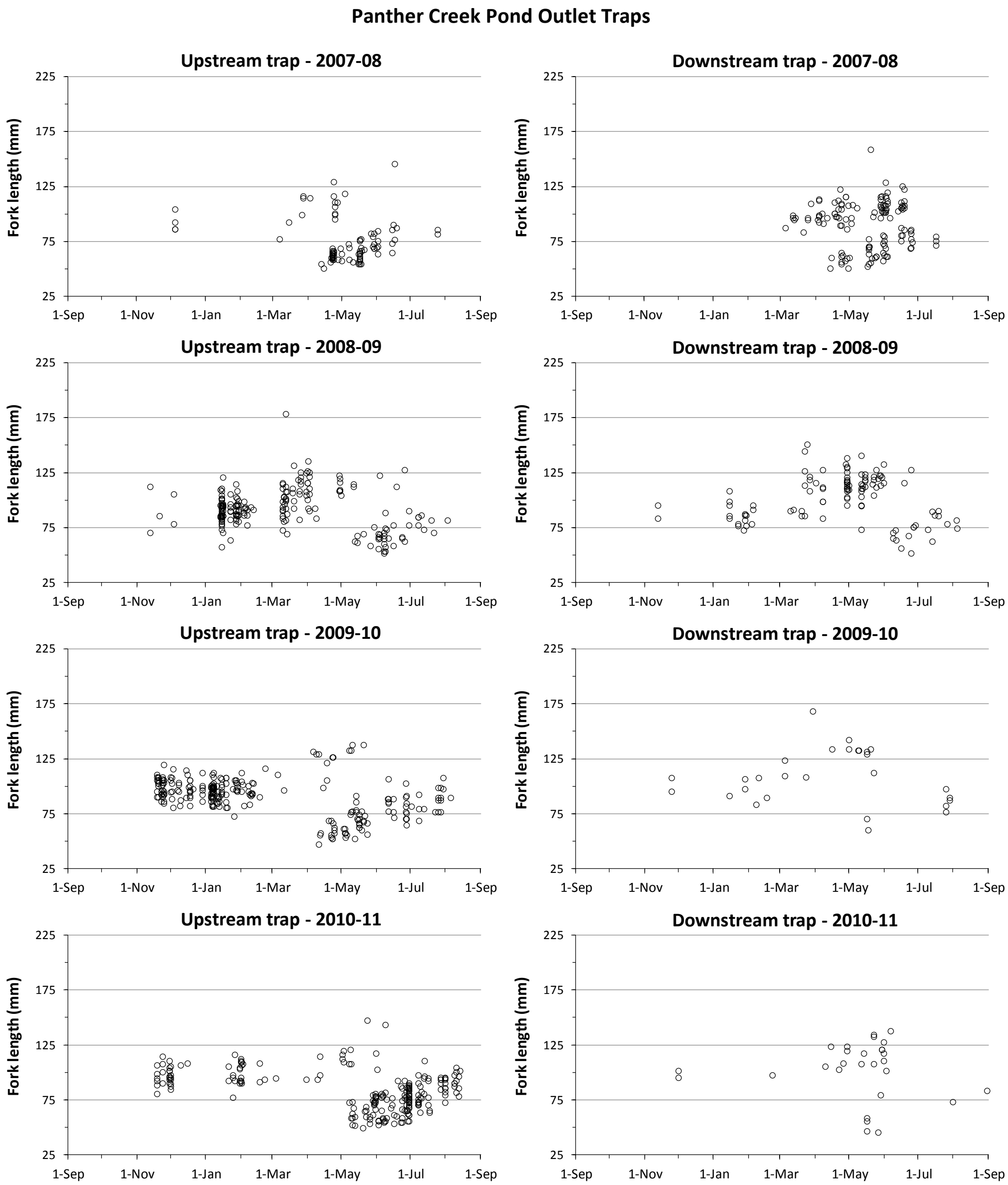


Figure 43. Fork lengths (mm) of juvenile coho sampled in Panther Creek between September 1 and August 31 in 2007-08 to 2010-2011.

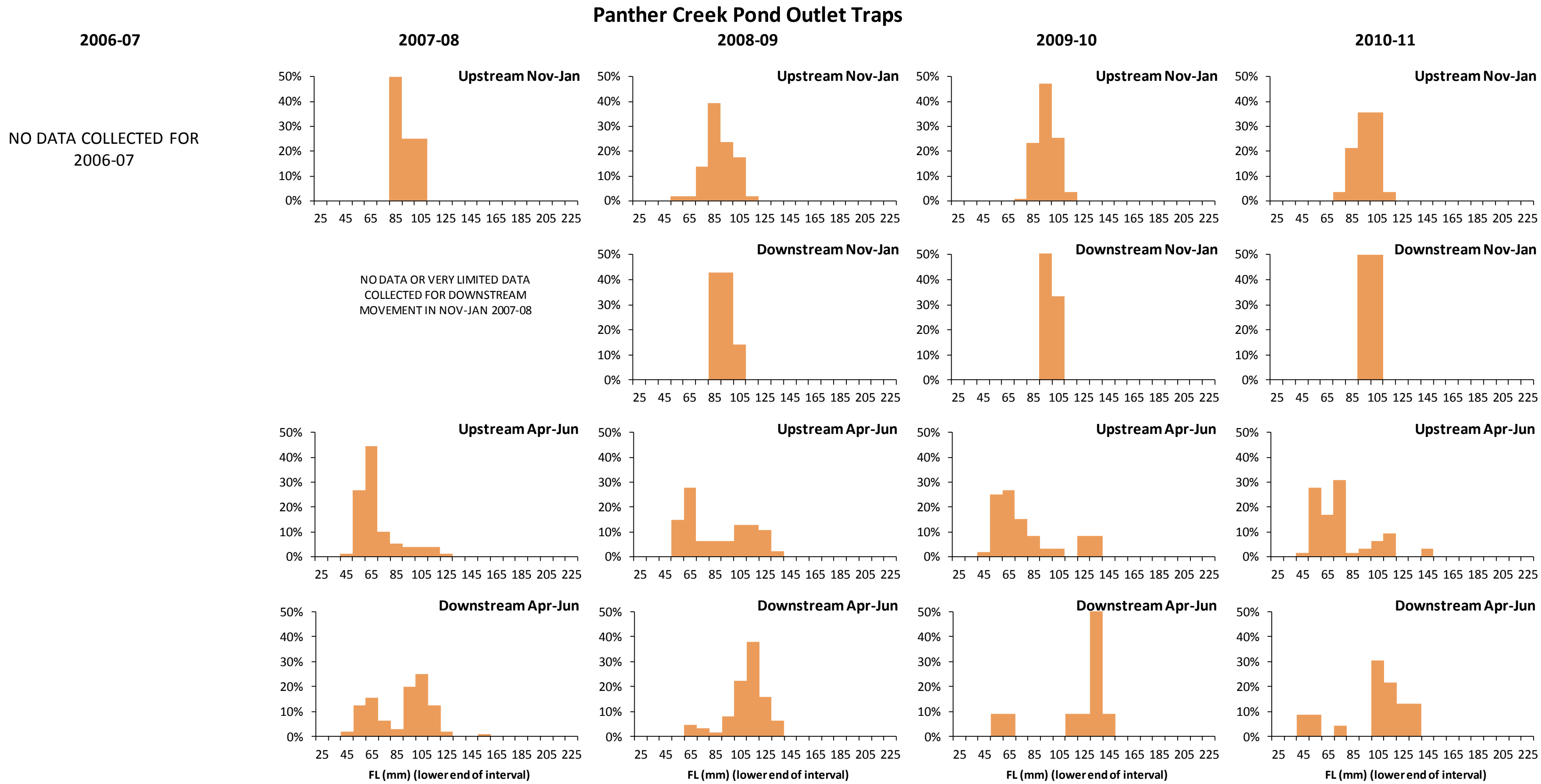


Figure 44. Length frequencies (fork length in mm) of juvenile coho sampled in Panther Creek in 2007-08 to 2010-2011. The x-axis shows the lower ends of bin ranges in mm. Data are grouped for samples in November-January and April-June.

3.2.4.4 Salt Creek Patterns

Salt Creek joins the Klamath River less than one mile upstream of the river mouth. This tributary was historically part of the Hunter Creek system but erosion of the north bank of the Klamath River has created two separate entry points to the river by Salt and Hunter creeks. As noted earlier, the Salt-Hunter Creek valley was once a complex backwater feature of the Klamath River estuary forming a large network of low gradient, anastomosed channels and conifer-dominated wetlands. Land uses in this area have dramatically simplified and altered the historic aquatic habitat features (Beesley and Fiori 2004, 2007, 2008). Despite these changes, Salt Creek still provides a substantial amount of low gradient, slow velocity habitat, supporting several beaver dams and ponds and extensive wetland habitats. Some spawning habitat is located in the Salt Creek system that could potentially support spawning by coho. Beesley and Fiori (2004) suggest that a small number of coho spawners still use the Salt Creek system.

The YTFP conducted downstream migrant trapping in lower Salt Creek in the early 2000s (Silloway 2010). Both upstream and downstream fyke trapping was initiated again as part of this study in 2007-08, though some limited sampling also occurred in late winter of 2007. Sampling continued during some months through the period of reporting in this report. A SPI station was installed in the channel downstream of the traps in December 2008 and was operated through the period of this report except during some periods of high water and equipment malfunction. Additionally, fyke nets have been occasionally deployed within the beaver ponds and wetlands to collect samples on fish size and to make population estimates using mark-recapture methods. Some of these data are presented here.

Results of sampling presented herein include trap catch patterns, fish size and growth patterns, smolt yield and standing stock pond abundance estimates, and source composition of non-natal juvenile coho as shown in re-encounters of PIT tagged fish.

Trap catch patterns from the upstream oriented fyke trap (to trap fish moving upstream) and the downstream oriented trap (to trap downstream moving fish) at the two trap sites of relevance here are displayed in Figure 45. The charts are arranged in the same manner as seen in Figure 28 for Waukell Creek to facilitate comparison between streams, though the information is not as complete as it is for Waukell Creek. Also, the charts are paired vertically, showing upstream moving fish on the top graph within a pair and downstream moving fish on the bottom graph of the pair. Four years of data are summarized, with a very small amount of data shown for one other year also (2006-07). Each graph shows with a vertical bar the number of juvenile coho caught in a roughly 24-hr time period over a yearly period beginning with September 1. The days when the trap actually was operated are shown in black bars within a band at the top or bottom of each graph—enabling the reader to know when the trap was fished. It is important to note that these graphs do not reflect fish age (i.e., whether fish were age-0 or age-1). That information can be roughly known by comparing these graphs to the fish size displays seen on the subsequent figures. The reader should also pay particular attention to the scale of the y-axis to know the relative magnitude of the total number of fish trapped in a season. The Klamath River flow rate (cfs in 1000s) is shown on the graphs by the blue line.

Fork length (mm) data are graphed in two ways to show patterns of change over time. Figure 46 shows fork length in relation to date of capture and Figure 47 provides length frequency histograms grouped for November 1-January 15 and April 1-June 15. We note that although there are age-0 fish evident in the springtime in the graphs, no evidence exists that newly emerged fry were ever captured (these fish would have been <35 mm), similar to findings in Waukell and Panther creeks but unlike McGarvey Creek.

We note the following from these patterns of trap catches (Figure 45) and fish sizes (Figures 46-47) in Salt Creek:

- Upstream trapping during fall and early winter to an extent useful here only occurred in two years, 2008-09 and 2009-10. The pattern seen in 2008-09 was consistent with the pattern for immigrants observed in Waukell Creek in the same year. Fish size of immigrants in Salt Creek also matched closely those observed in lower Waukell Creek in that year (Figures 30 and 46 and Table 9).
- The catch patterns of upstream immigration in spring in Salt Creek generally showed very few fish being caught in years when trapping was routinely conducted (2008, 2010, and 2011)—only near the end of sampling in 2011 (approaching July 1) did immigration appear to noticeably increase. Upstream immigrants were strongly dominated by age-0 fish, but none were small enough to have been considered recently emerged fry. As noted for Panther Creek, it is likely these immigrants had experienced some growth within the mainstem Klamath River.
- Patterns of downstream emigration in the spring generally matched those seen in Waukell Creek and were strongly dominated by age-1 fish. Only in 2008 were relatively substantial numbers of fish caught emigrating from the system. Catch numbers were typically small in the other two years when trapping was consistently done in the spring (2010 and 2011).

Table 9 summarizes fork length data for Salt Creek (and the other streams), giving average lengths and other metrics by age class caught in the upstream and downstream traps in the same combined months used in constructing the length frequency histograms. These data are graphed as box-and-whisker plots in Figure 34. We note the following from the patterns seen in Figure 34:

- Salt Creek smolts in the four years with data presented were typically large every year, comparable to fish sizes found in Waukell Creek.
- The quantity of data on growth of fish based on a comparison of fall immigrants (age-0) to spring emigrants (age-1) was generally insufficient for drawing conclusions.

For the years 2008 to 2011, the smolt yield was estimated only in 2008 (Table 12). The method employed used a one-trap DARR stratified model and produced a point estimate of 1,737 smolts, about 28% of the estimated yield from the Waukell Creek subbasin in the same year. In 2009 to 2011, estimates of standing stock abundance within the large pond were made using mark-recapture methods with fyke net trap sets. The standing stock estimates should reflect the smolt yields that would have occurred in those years if the fish were able to successfully emigrate from the pond. The point estimates in the three years ranged from 71 to 1,193 fish. The low abundance year coincided with low abundance years observed in the other three streams in the same years.

We suggest that the amount of low gradient habitat in the Salt Creek system should be able to support a much larger number of juvenile coho than reflected in the abundance estimates for this system in Table 12. The reasons may be due to issues related to accessibility into the various areas of the pond-wetland complex or other factors may exist. As noted for Panther Pond, one possible reason could be the location of Salt Creek in relation to the estuarine zone of the Klamath River. We do not yet understand the spatial and seasonal movement patterns of juvenile coho within the estuarine zone of the river—these patterns might affect the extent that juvenile coho produced in areas upstream of the Hunter and Salt creek systems utilize summer and winter habitats located in lower Hunter and Salt creeks. Work is continuing in an effort to understand possible factors. A better understanding of the factors affecting the use of these habitats is important for designing restoration strategies for these streams.

Figures 36-38 compare the relative contributions of fish tagged *upstream* of Trinity River to the smolt emigrant populations in 2009-2011 among the four streams in focus here. The tagged fish in each stream were identified both by the SPI arrays and by physical capture in each stream. The reader should note that the colorized segments in these graphs show the portion of fish tagged either upstream or downstream of the Sandybar floodplain channel site (RM 77). Despite the much smaller number of known non-natal fish to have been encountered each year in Salt Creek than in Waukell Creek, it is notable that proportions of fish originating either upstream or downstream of the Sandybar floodplain channel were comparable between the streams.

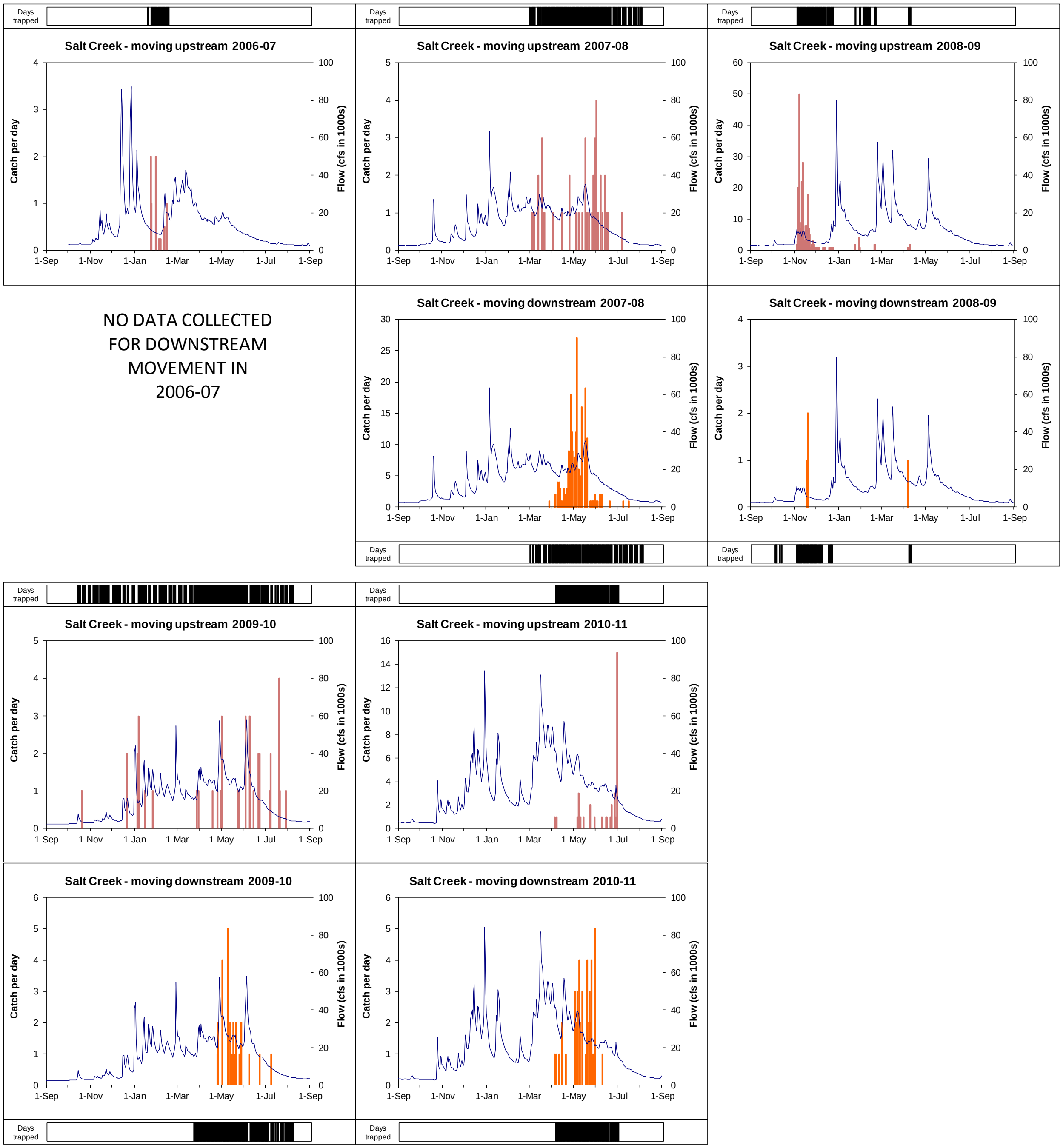


Figure 45. Catch per day of juvenile coho in upstream oriented (targets upstream moving fish) and downstream oriented (targets downstream moving fish) traps in Salt Creek, 20067-07 to 2010-11. Klamath River flow at the lower USGS station is also plotted. Black bands above and below each graph indicate days when a trap was operating.

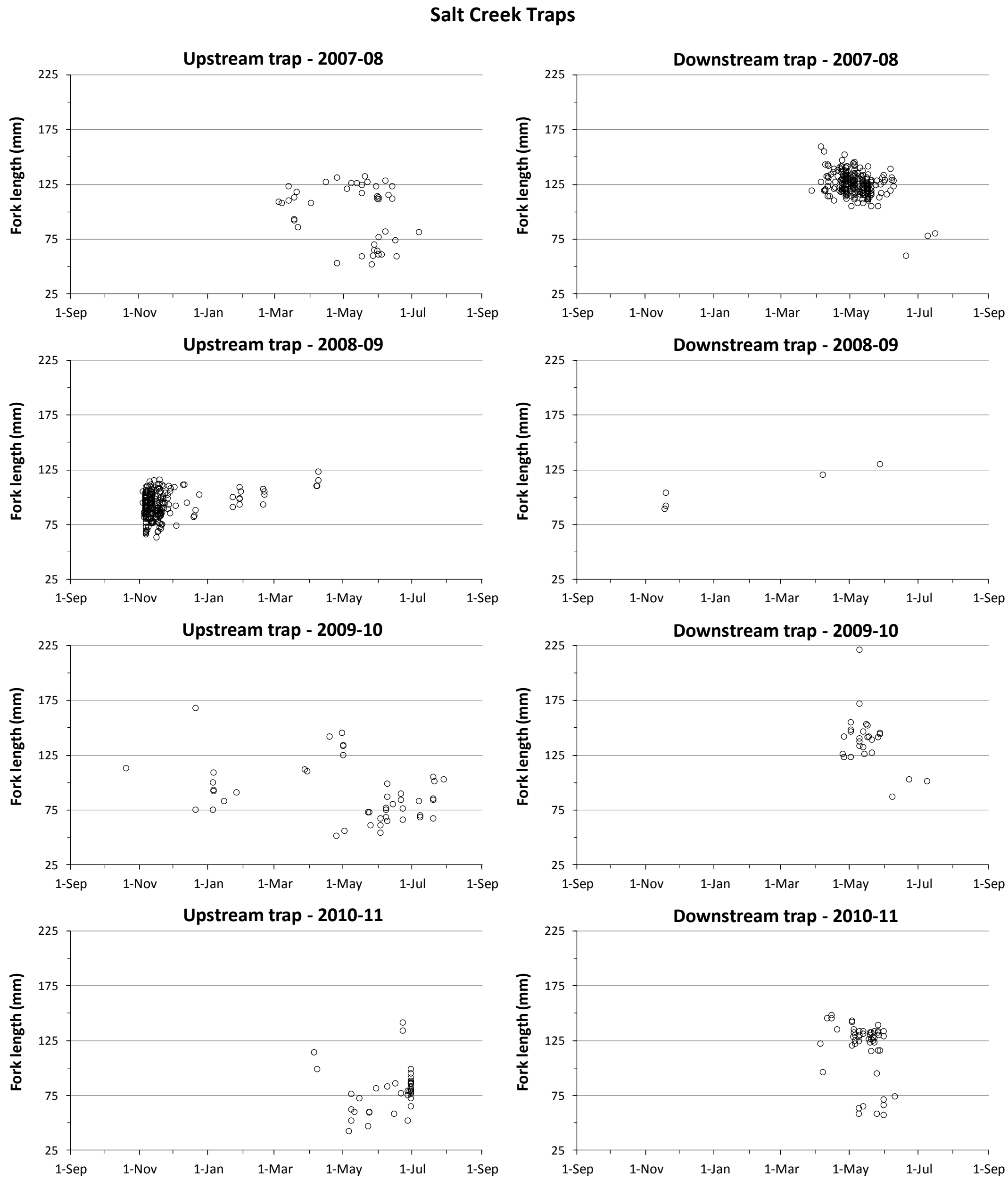


Figure 46. Fork lengths (mm) of juvenile coho sampled in Salt Creek between September 1 and August 31 in 2007-08 to 2010-2011.

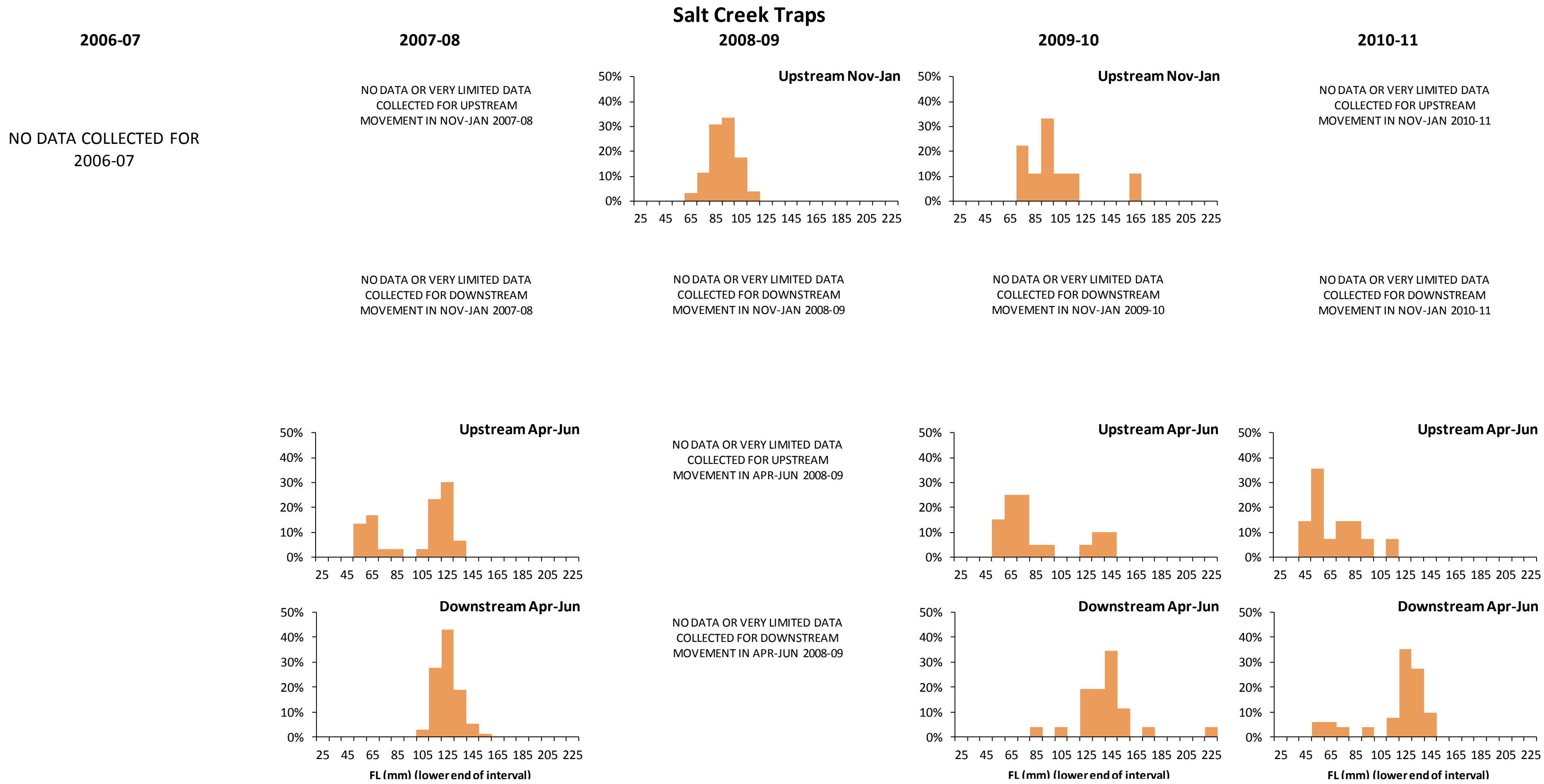


Figure 47. Length frequencies (fork length in mm) of juvenile coho sampled in Salt Creek in 2007-08 to 2010-2011. The x-axis shows the lower ends of bin ranges in mm. Data are grouped for samples in November-January and April-June.

3.3 Mid-Klamath Area Summaries

This section and Section 3.4 provide brief tabular and graphic summaries of movement patterns seen within the mainstem corridor for many groups of juvenile coho PIT tagged in various locations within or adjacent to corridor habitats. In this section, we present summaries for groups of fish PIT tagged within the Mid Klamath River region, i.e., for fish tagged in areas downstream of Shasta River and upstream of Trinity River. Section 3.4 provides the same type of summaries for fish tagged in areas downstream of Trinity River. In combination, the information presented demonstrates the scale and scope of the types of juvenile coho redistributions that occur annually within the mainstem corridor.

The tabular and graphic summaries presented here show patterns of movement away from the geographic areas (GeoAreas) where fish were tagged for all project time periods through about mid-2011. The information is given in two parts. The first part is a table that summarizes the number of fish tagged by time period t in that area, as well as the number of those tagged fish that were subsequently re-encountered in the same GeoArea but in a later time period (shown as t + 1, t + 2, and so on). At the bottom of the table, the number of tagged fish that were re-encountered either outside the GeoArea or downstream of the Trinity River is provided, together with re-encounter rates (shown as percentages). The summary focuses entirely on age-0 fish that were PIT tagged, as these fish are most informative to illustrate re-distribution among the mainstem corridor areas.

To explain by example, Table 14 presents summary data for fish tagged in Beaver Creek. One fish was PIT tagged in time period 5, which is defined here as the months of March-June in the yearly period 2008-09—i.e., the fish was tagged sometime between March and June in 2009. The fish was not re-encountered anywhere. In time period 9 (July-October for 2008-09, i.e., in this case in 2009), there were 89 fish tagged in Beaver Creek. Sixteen of those fish (18 percent) were subsequently re-encountered (recaptured in this case) within Beaver Creek and all of those re-encounters occurred in the time period t + 1, i.e., sometime during the months of November-February within the yearly period 2009-10. Two of the tagged fish were re-encountered in a different GeoArea, but none of those fish were re-encountered downstream of Trinity River.

The second part of the summary is a figure that graphically shows the pattern of re-encounters for fish re-encountered outside the tagging GeoArea—shown for each yearly period of tagging—in relation to distance from the tagging site and to the river mouth. The location of the GeoArea in relation to the Klamath River mouth is shown as a dashed red line. Each symbol shows the location and date of a PIT tag re-encounter. The reader should note that some charts are shown with two spatial scales—one covering the greatest distance relevant to this analysis and the other zooming in on the area within 10 miles of the river mouth.

3.3.1 Beaver Creek

Table 14 and Figure 48 summarize the numbers of fish tagged and re-encountered for fish tagged in Beaver Creek, a tributary to the Klamath River at RM 161.0. Beaver Creek is generally a moderately confined stream that supports natal coho production. The lower part of the stream is likely used by some non-natal fish.

Table 14. Summary of age-0 juvenile coho released in Beaver Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Beaver Creek (BeavCr)
Miles to KR mouth: 161.0

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t					1				89	107					25		
Re-encountered in t plus																	
1									16								
2																	
3																	
4																	
% in t plus																	
1									18%								
2																	
3																	
4																	
# to different GeoArea									2								
# to below Trinity R																	
% to different GeoArea									2%								
% to below Trinity R																	

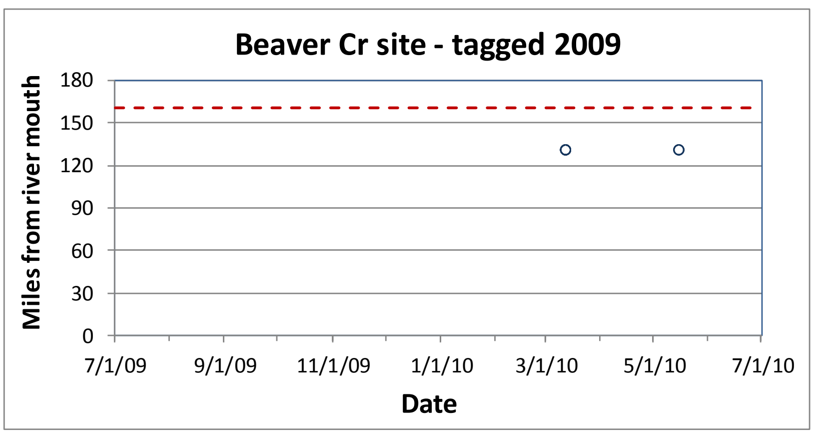


Figure 48. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Beaver Creek.

3.3.2 Tom Martin Creek

Table 15 and Figure 49 summarize the numbers of fish tagged and re-encountered for fish tagged in Tom Martin Creek, a tributary to the Klamath River at RM 144.2. Tom Martin Creek is a small, relatively steep stream that only supports non-natal coho use in its very lower end near the confluence with the river. The stream is an important thermal refuge site for juvenile coho re-distributing from upstream natal areas in the Klamath River basin.

Table 15. Summary of age-0 juvenile coho released in Tom Martin Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Tom Martin Creek at Klamath River (KRTomM)

Miles to KR mouth: 144.2

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t			55			92	13	3	93	8		640	19	1	118		
Re-encountered in t plus																	
1						39	2		12	1		212					
2						4						9					
3												4					
4																	
% in t plus																	
1						42%	15%		13%	13%		33%					
2						4%						1%					
3												1%					
4																	
# to different GeoArea			1			3			1			35			2		
# to below Trinity R						1						7			2		
% to different GeoArea			2%			3%			1%			5%			2%		
% to below Trinity R						1%						1%			2%		

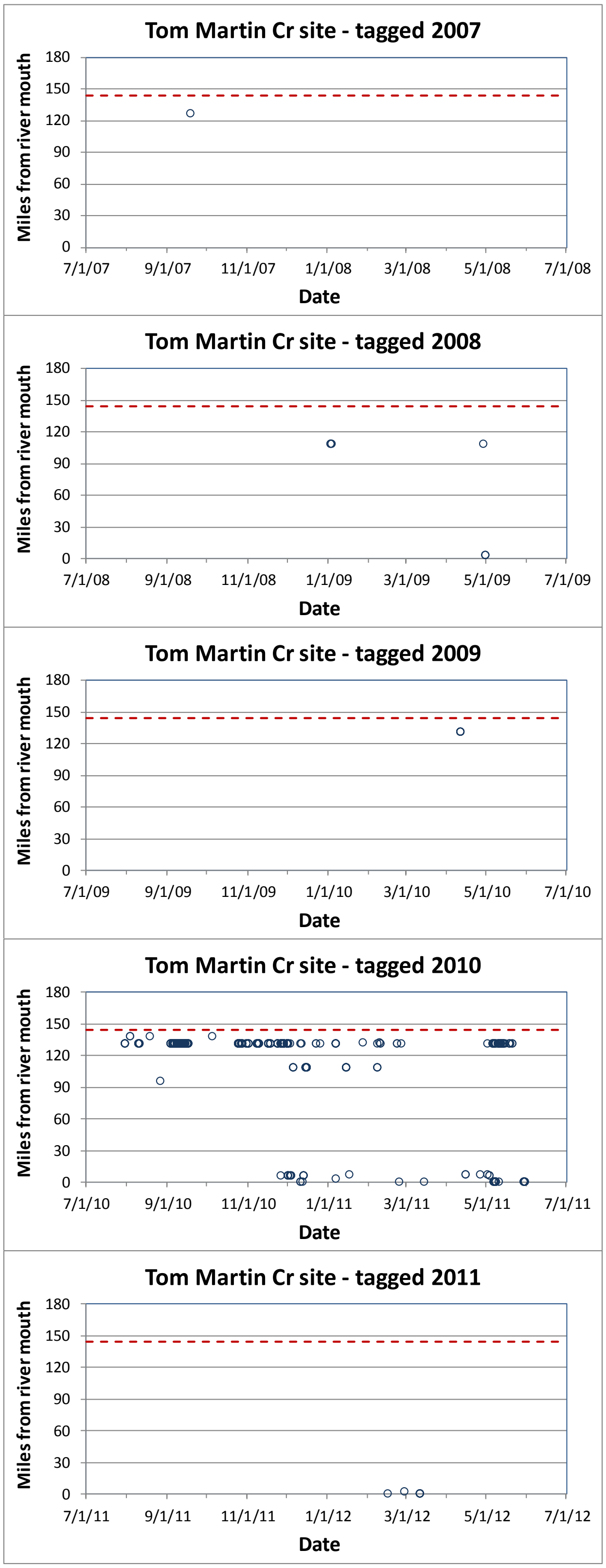


Figure 49. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Tom Martin Creek.

3.3.3 O’Neil Creek

Table 16 and Figure 50 summarize the numbers of fish tagged and re-encountered for fish tagged in O’Neil Creek, a tributary to the Klamath River at RM 138.8. O’Neil Creek is generally a moderately confined to confined stream that had been considered to only support non-natal coho production but uncertainty exists.

Table 16. Summary of age-0 juvenile coho released in O’Neil Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): O'Neil Creek at Klamath River (KRONeil)
Miles to KR mouth: 138.8

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t						108			16			93					
Re-encountered in t plus																	
1						2						1					
2						4											
3																	
4																	
% in t plus																	
1						2%						1%					
2						4%											
3																	
4																	
# to different GeoArea												12					
# to below Trinity R																	
% to different GeoArea												13%					
% to below Trinity R																	

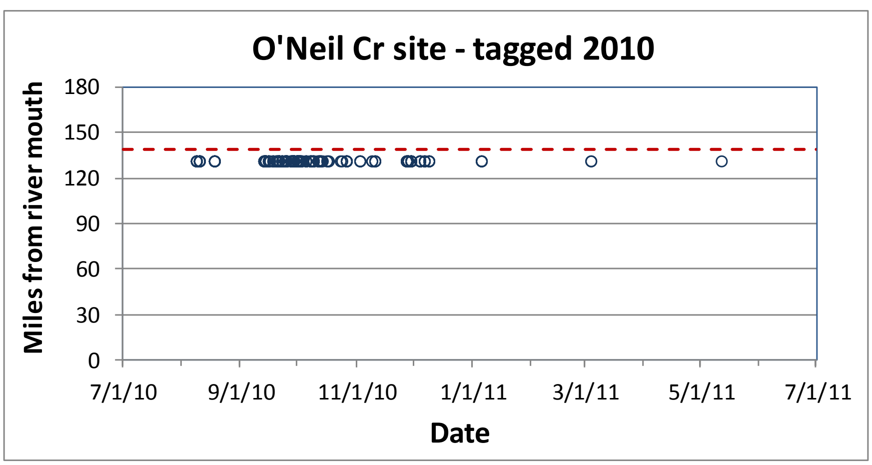


Figure 50. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea O’Neil Creek.

3.3.4 Grider Creek

Table 17 and Figure 51 summarize the numbers of fish tagged and re-encountered for fish tagged in Grider Creek, a tributary to the Klamath River at RM 131.9. Grider Creek is generally an unconfined to moderately confined stream that supports natal coho production though non-natal fish may also use the lower end of the stream.

Table 17. Summary of age-0 juvenile coho released in Grider Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Grider Creek (GriderCr)
Miles to KR mouth: 131.9

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t									55								
Re-encountered in t plus																	
1																	
2																	
3																	
4																	
% in t plus																	
1																	
2																	
3																	
4																	
# to different GeoArea									7								
# to below Trinity R																	
% to different GeoArea									13%								
% to below Trinity R																	

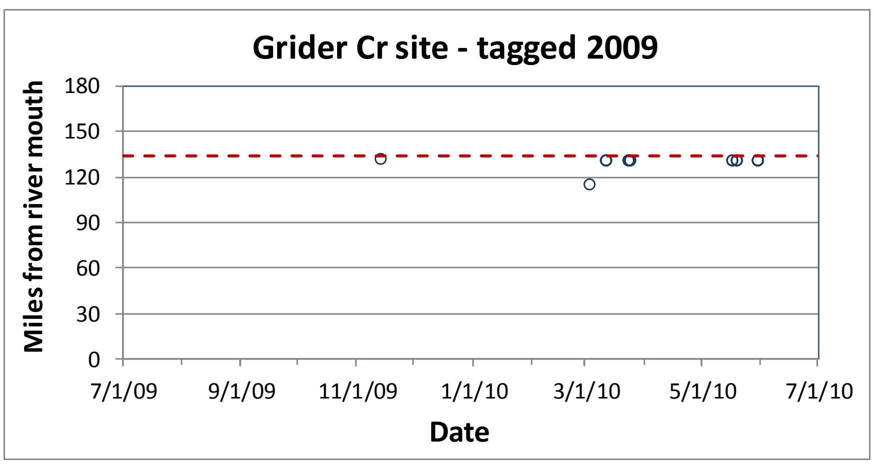


Figure 51. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Grider Creek.

3.3.5 Seiad Creek

Table 18 and Figure 51 summarize the numbers of fish tagged and re-encountered for fish tagged in Seiad Creek, a tributary to the Klamath River at RM 131.6. Seiad Creek is generally an unconfined to moderately confined stream that supports both natal coho production and non-natal rearing (summer and winter). Several off-channel ponds have been constructed adjacent to the stream.

Table 18. Summary of age-0 juvenile coho released in Seiad Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Seiad Creek (SeiadCr)
Miles to KR mouth: 131.9

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t					59		225	19	385	170	111	883	16	237	464	18	
Re-encountered in t plus																	
1									105	58	8	153	11	41	62		
2									109		22	260		23	1		
3								1	1		16						
4									2								
% in t plus																	
1									27%	34%	7%	17%	69%	17%	13%		
2									28%		20%	29%		10%	0%		
3								5%	0%		14%						
4									1%								
# to different GeoArea					2		8		10	6	7	46			1		
# to below Trinity R					2		2		7	5	4	20			1		
% to different GeoArea					3%		4%		3%	4%	6%	5%			0%		
% to below Trinity R					3%		1%		2%	3%	4%	2%			0%		

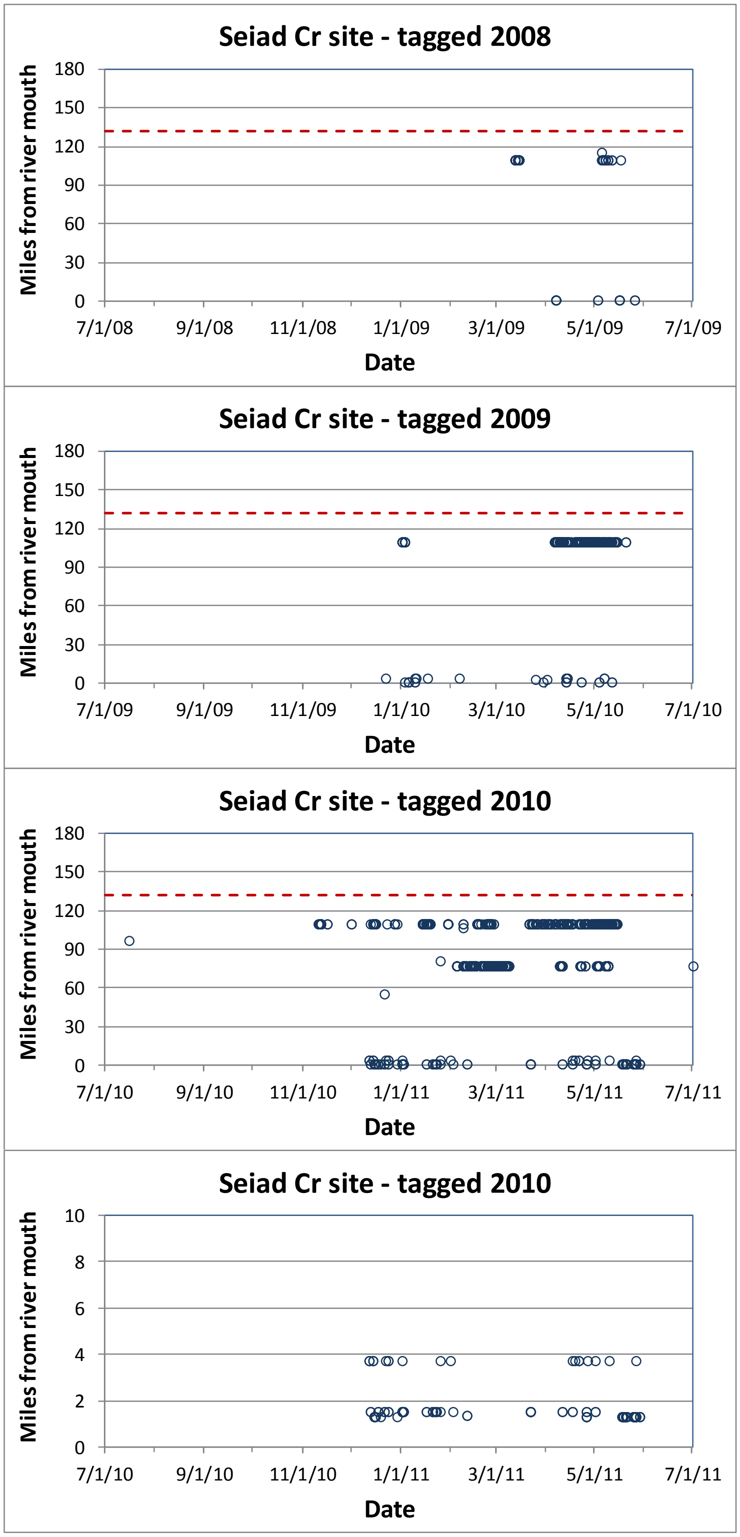


Figure 52. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Seiad Creek.

3.3.6 China Creek

Table 19 and Figure 53 summarize the numbers of fish tagged and re-encountered for fish tagged in China Creek, a tributary to the Klamath River at RM 119.5. China Creek is generally a moderately confined stream that is thought to support both natal coho production and non-natal rearing.

Table 19. Summary of age-0 juvenile coho released in China Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): China Creek (ChinaCr)
Miles to KR mouth: 119.5

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t			302			152	72							4	109	23	
Re-encountered in t plus																	
1						4								1	1		
2														1			
3																	
4																	
% in t plus																	
1						3%								25%	1%		
2														25%			
3																	
4																	
# to different GeoArea			4			10	4										
# to below Trinity R			3														
% to different GeoArea			1%			7%	6%										
% to below Trinity R			1%														

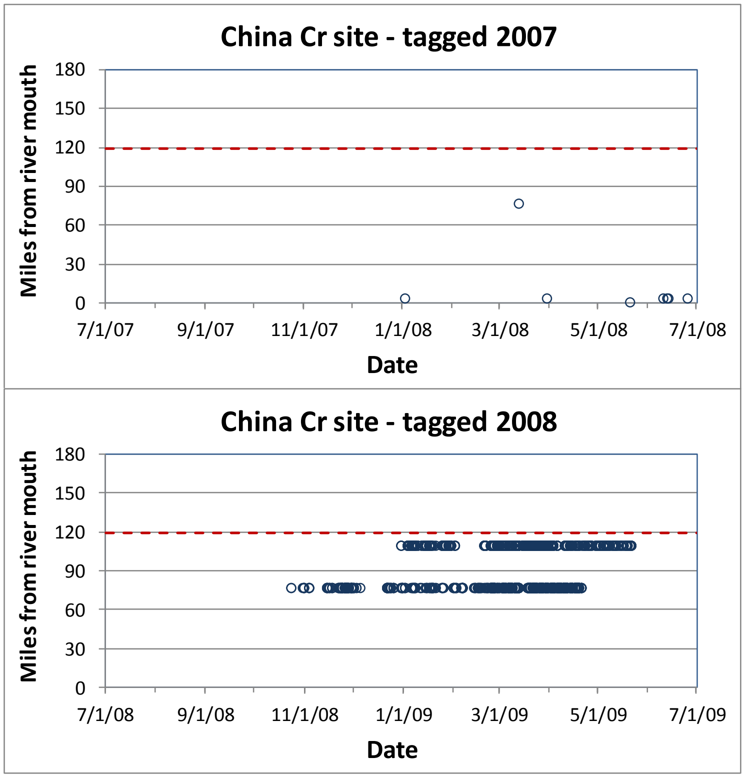


Figure 53. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea China Creek.

3.3.7 Little Horse Creek

Table 20 and Figure 54 summarize the numbers of fish tagged and re-encountered for fish tagged in Little Horse Creek, a tributary to the Klamath River at RM 115.7. Little Horse Creek is generally a moderately confined stream that may support both natal coho production and non-natal rearing though uncertainties exist.

Table 20. Summary of age-0 juvenile coho released in Little Horse Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Little Horse Creek at Klamath River (KRLHorse)
Miles to KR mouth: 115.7

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t			9			11		3	1	1		130	8		11	43	
Re-encountered in t plus																	
1												8					
2																	
3																	
4																	
% in t plus																	
1												6%					
2																	
3																	
4																	
# to different GeoArea												9				2	
# to below Trinity R												2				1	
% to different GeoArea												7%				5%	
% to below Trinity R												2%				2%	

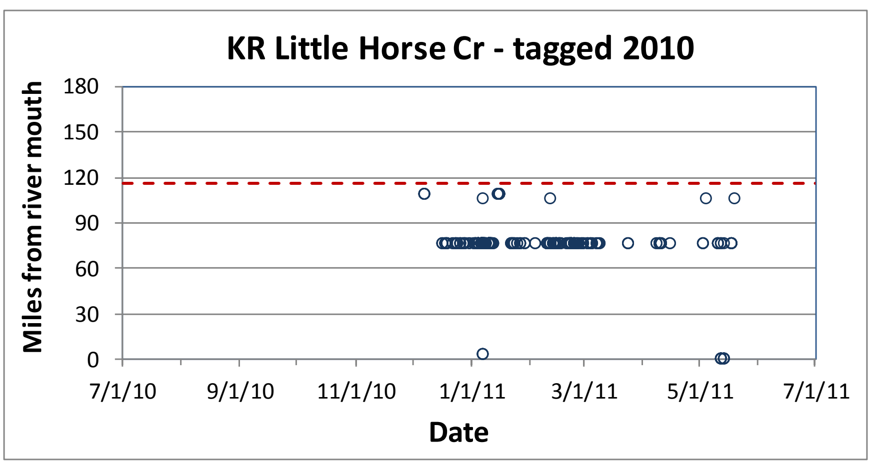


Figure 54. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea for Little Horse Creek at the Klamath River.

3.3.8 Cade Creek

Table 21 and Figure 55 summarize the numbers of fish tagged and re-encountered for fish tagged in Cade Creek, a tributary to the Klamath River at RM 110.9. Cade Creek is generally a moderately confined to confined stream that has been though to support non-natal rearing though uncertainties exist.

Table 21. Summary of age-0 juvenile coho released in Cade Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Cade Creek (CadeCr)
Miles to KR mouth: 110.9

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t	26	18	14			54	8		6			107			358	48	
Re-encountered in t plus																	
1		6				8									63		
2																	
3																	
4																	
% in t plus																	
1		33%				15%									18%		
2																	
3																	
4																	
# to different GeoArea						5	1		1			7			8		
# to below Trinity R						1	1								4		
% to different GeoArea						9%	13%		17%			7%			2%		
% to below Trinity R						2%	13%								1%		

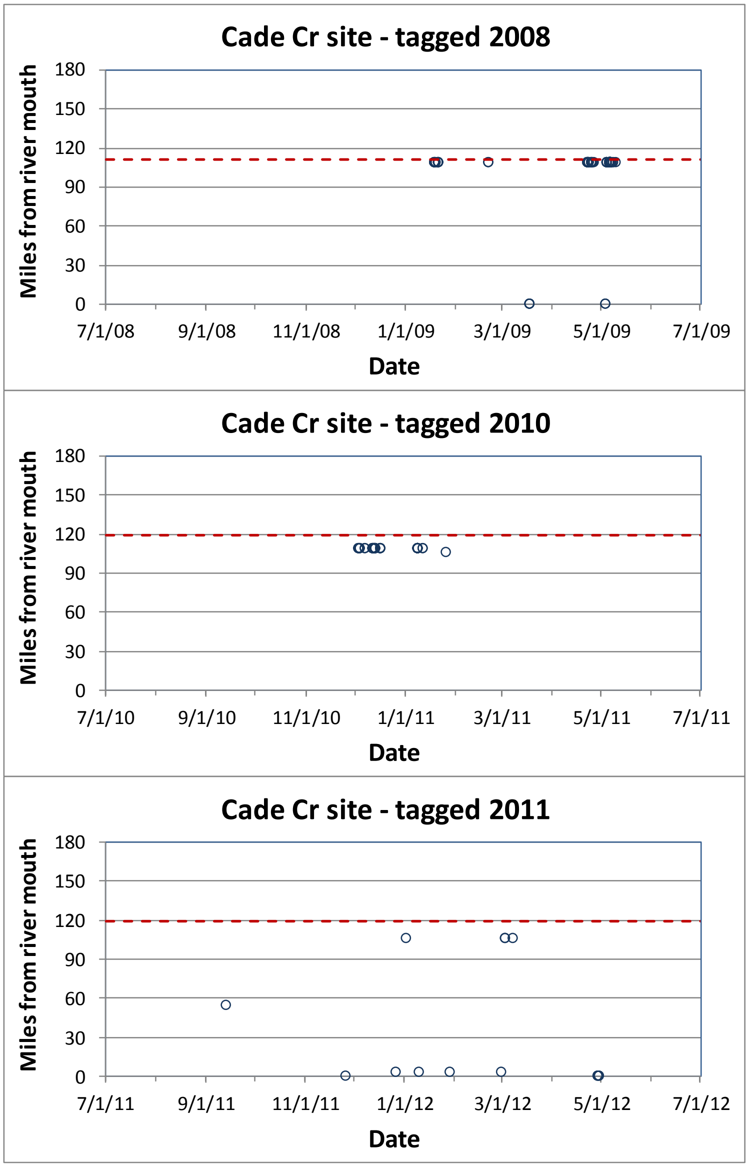


Figure 55. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Cade Creek.

3.3.9 Clear Creek

Table 22 and Figure 56 summarize the numbers of fish tagged and re-encountered for fish tagged in Clear Creek, a tributary to the Klamath River at RM 99.8. Clear Creek is generally a confined stream that supports natal coho production.

Table 22. Summary of age-0 juvenile coho released in Clear Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Clear Creek (ClearCr)

Miles to KR mouth: 99.8

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t						80											
Re-encountered in t plus																	
1																	
2																	
3																	
4																	
% in t plus																	
1																	
2																	
3																	
4																	
# to different GeoArea						5											
# to below Trinity R						5											
% to different GeoArea						6%											
% to below Trinity R						6%											

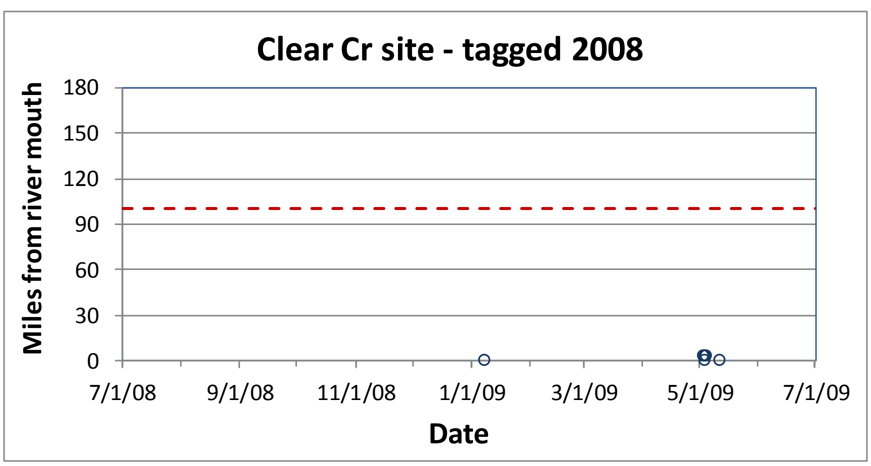


Figure 56. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Clear Creek.

3.3.10 Titus Creek

Table 23 and Figure 57 summarize the numbers of fish tagged and re-encountered for fish tagged in Titus Creek, a tributary to the Klamath River at RM 96.7. Titus Creek is generally a moderately confined stream that is thought to support both natal coho production and non-natal rearing.

Table 23. Summary of age-0 juvenile coho released in Titus Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Titus Creek at Klamath River (KRTitusCr)

Miles to KR mouth: 96.7

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t			49			230			54	6	20	221		57	504		
Re-encountered in t plus																	
1									12		4	4		14			
2																	
3																	
4																	
% in t plus																	
1									22%		20%	2%		25%			
2																	
3																	
4																	
# to different GeoArea						12			2	1	2	16		4	20		
# to below Trinity R						8			1		1	9		1	18		
% to different GeoArea						5%			4%	17%	10%	7%		7%	4%		
% to below Trinity R						3%			2%		5%	4%		2%	4%		

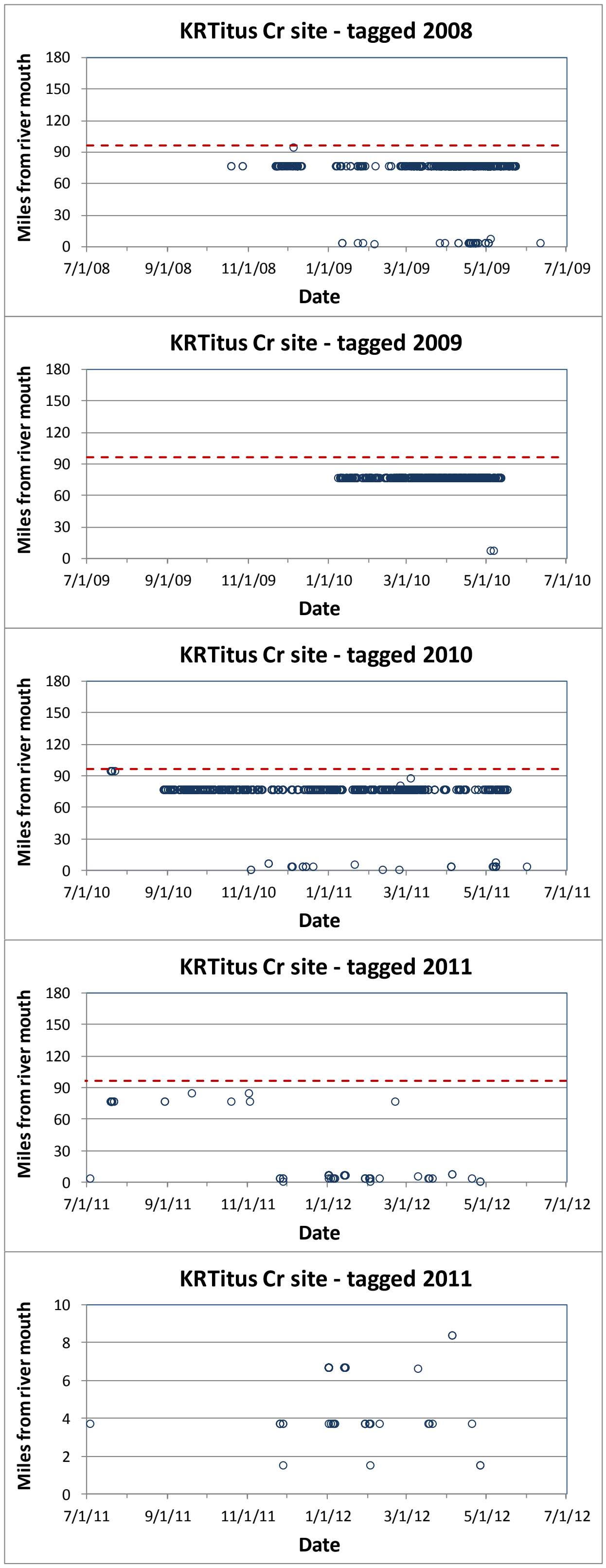


Figure 57. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Titus Creek.

3.3.11 Independence Creek

Table 24 and Figure 58 summarize the numbers of fish tagged and re-encountered for fish tagged in Independence Creek, a tributary to the Klamath River at RM 95.0. Independence Creek is a confined stream that that appears to primarily support non-natal rearing, though some natal production might occur in some years. The stream forms a tributary-fed floodplain channel adjacent to the Klamath River. In some years, this channel is heavily used by non-natal coho rearing during summer. It appears to support no or very little overwintering by coho.

Table 24. Summary of age-0 juvenile coho released in Independence Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Independence Creek at Klamath River (KRIndeCr)

Miles to KR mouth: 95.0

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t		25	605	100	17	471	80	2				68			145	102	
Re-encountered in t plus																	
1		4	45		3	115	3								13	4	
2					1	4									2		
3																	
4																	
% in t plus																	
1		16%	7%		18%	24%	4%								9%	4%	
2					6%	1%									1%		
3																	
4																	
# to different GeoArea		1	30	6	3	58	13					5			2	2	
# to below Trinity R			22	4	3	52	12					3			2	1	
% to different GeoArea		4%	5%	6%	18%	12%	16%					7%			1%	2%	
% to below Trinity R			4%	4%	18%	11%	15%					4%			1%	1%	

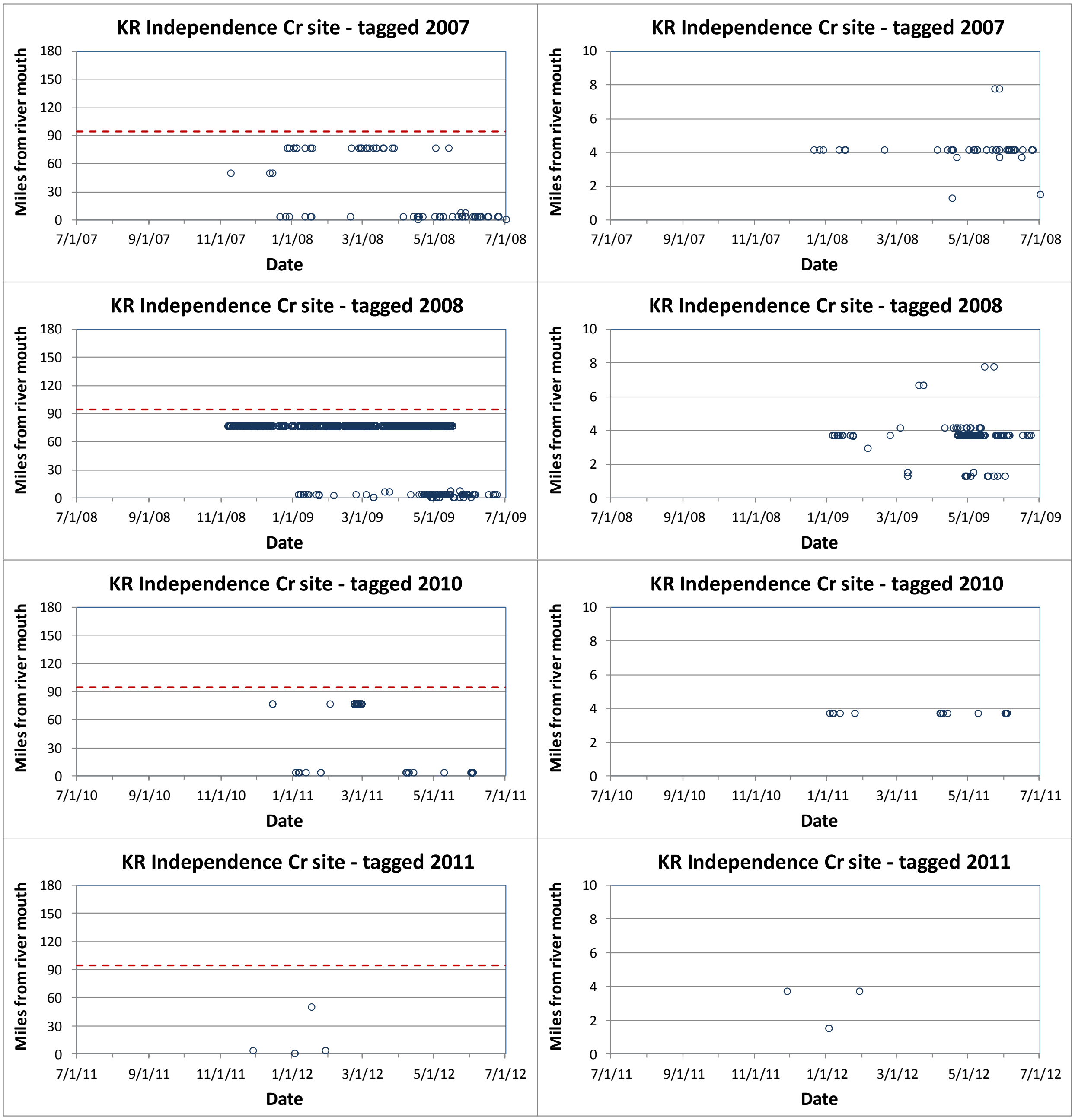


Figure 58. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Independence Creek. Graphs with two different Y-axis scales are shown.

3.3.12 Dillon Creek

Table 25 and Figure 59 summarize the numbers of fish tagged and re-encountered for fish tagged in Dillon Creek, a tributary to the Klamath River at RM 85.1. Dillon Creek is a confined stream that supports natal coho production and may support some non-natal summer rearing in its lower end.

Table 25. Summary of age-0 juvenile coho released in Dillon Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Dillon Creek (DillonCr)

Miles to KR mouth: 85.1

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t			44									33			78	36	
Re-encountered in t plus																	
1															22		
2																	
3																	
4																	
% in t plus																	
1															28%		
2																	
3																	
4																	
# to different GeoArea			3									4				4	
# to below Trinity R			3									4				4	
% to different GeoArea			7%									12%				11%	
% to below Trinity R			7%									12%				11%	

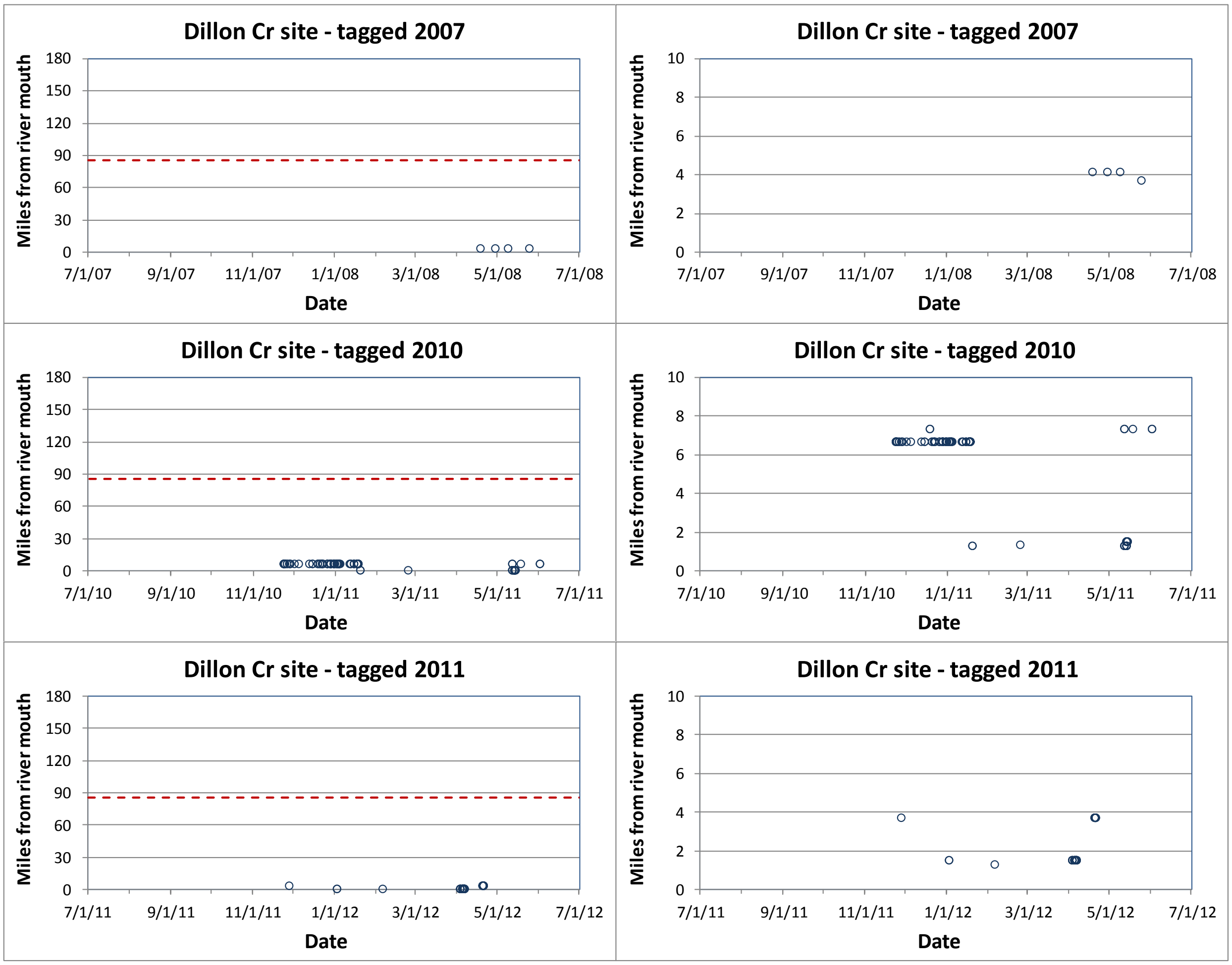


Figure 59. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Dillon Creek. Graphs with two different Y-axis scales are shown.

3.3.13 Ti Bar (small creek)

Table 26 and Figure 60 summarize the numbers of fish tagged and re-encountered for fish tagged in Ti Bar (Teep Teep) Creek, a tributary to the Klamath River at RM 81.0. Ti Bar (Teep Teep) Creek is a small stream that is unconfined near its confluence with Klamath River, believed to support only non-natal coho production.

Table 26. Summary of age-0 juvenile coho released at Ti Bar, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): TiBar small creek at Klamath River (KRTiBar)
Miles to KR mouth: 81.0

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t											23	46	6		100		
Re-encountered in t plus																	
1											9	20					
2											5				1		
3																	
4																	
% in t plus																	
1											39%	43%					
2											22%				1%		
3																	
4																	
# to different GeoArea											6	9					
# to below Trinity R											4	2					
% to different GeoArea											26%	20%					
% to below Trinity R											17%	4%					

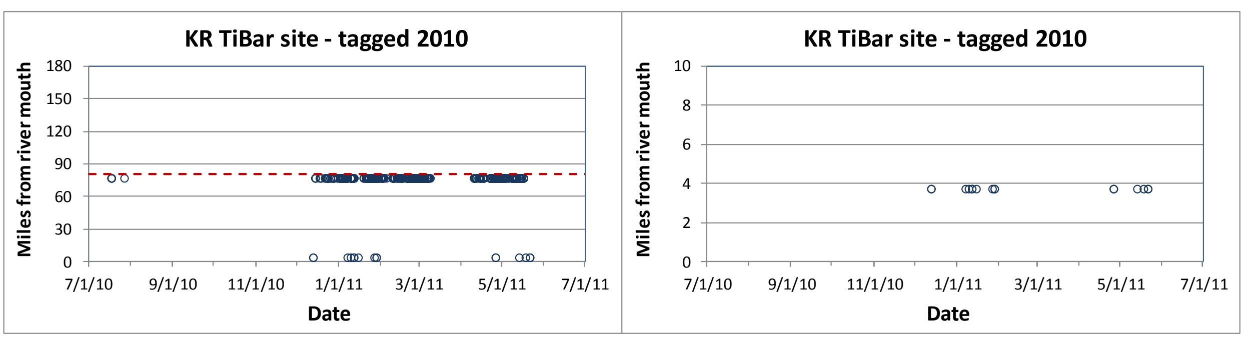


Figure 60. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Ti Bar. Graphs with two different Y-axis scales are shown.

3.3.14 Sandybar Creek floodplain channel

Table 27 and Figure 61 summarize the numbers of fish tagged and re-encountered for fish tagged in the Sandybar Creek-fed floodplain channel that enters the Klamath River at RM 77.4. This floodplain channel functions as an off-channel habitat until the river bar that separate it from the mainstem river is breached at a flow of about 9,200 cfs (see Section 3.2.3.1 of this report). The channel is used for non-natal coho rearing during both summer and winter.

Table 27. Summary of age-0 juvenile coho released in Sandybar Creek floodplain channel, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Sandybar Creek at Klamath River (KRSandyBCr)

Miles to KR mouth: 77.4

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t		3	12	36	250	105	2	10	18	1	72	362	38	290	507	91	
Re-encountered in t plus																	
1			9	5	116	33	1	4	16	1	58	255	6	179	94		
2		1	3		51	5		3	13		45	50		25			
3		1			13			3			5						
4																	
% in t plus																	
1			75%	14%	46%	31%	50%	40%	89%	100%	81%	70%	16%	62%	19%		
2		33%	25%		20%	5%		30%	72%		63%	14%		9%			
3		33%			5%			30%			7%						
4																	
# to different GeoArea				2	9	6			1		8	49	10	14	25	2	
# to below Trinity R				2	4	5			1		4	40	10	8	16	2	
% to different GeoArea				6%	4%	6%			6%		11%	14%	26%	5%	5%	2%	
% to below Trinity R				6%	2%	5%			6%		6%	11%	26%	3%	3%	2%	

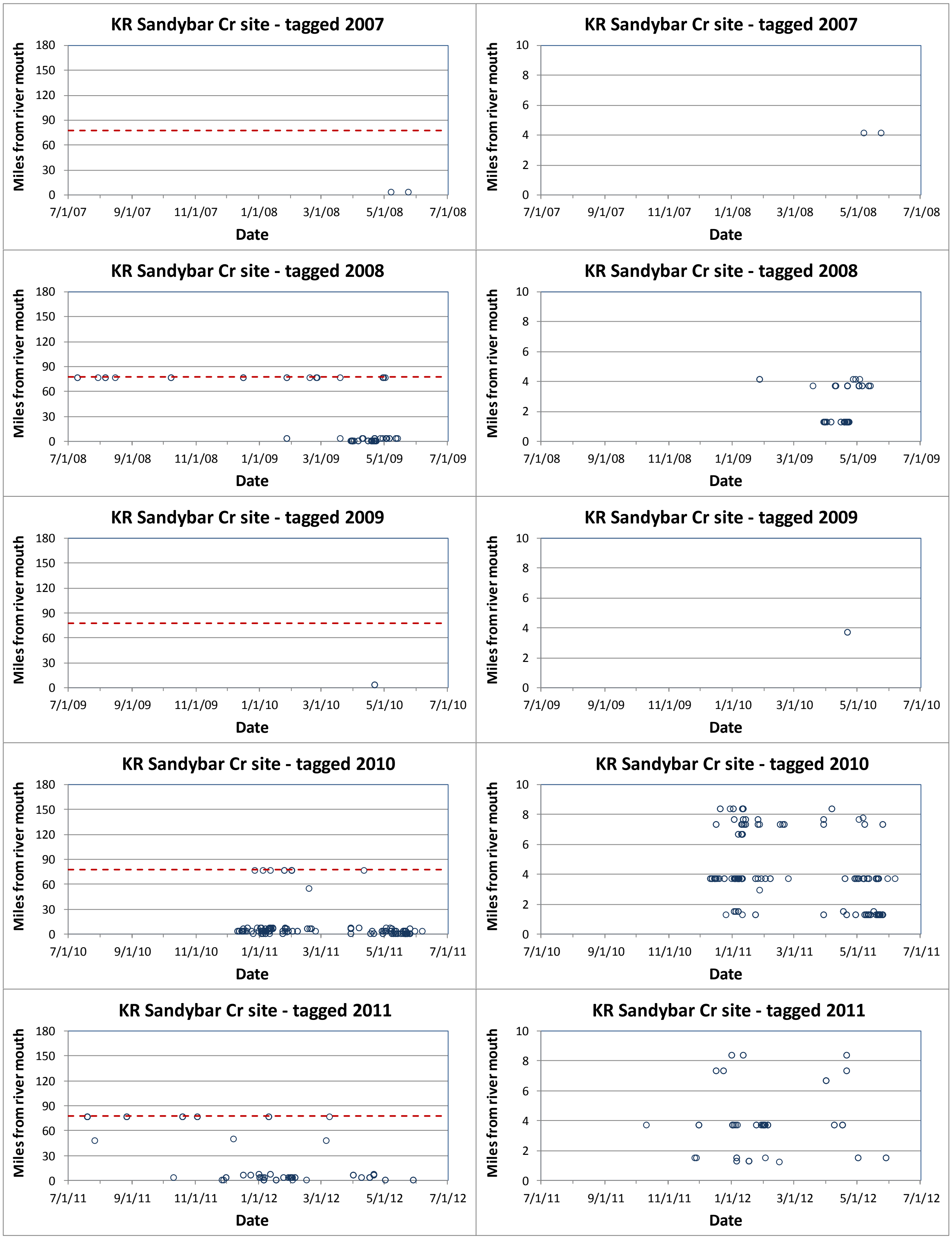


Figure 61. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Sandybar Creek floodplain channel. Graphs with two different Y-axis scales are shown.

3.3.15 Stanshaw Creek floodplain channel (pond)

Table 28 and Figure 62 summarize the numbers of fish tagged and re-encountered for fish tagged in the Stanshaw Creek-fed floodplain channel (pond) that enters the Klamath River at RM 76.9. This habitat feature functions as an off-channel pond until the river bar that separate it from the mainstem river is breached at high flows. The channel is used for non-natal coho rearing during both summer and winter.

Table 28. Summary of age-0 juvenile coho released in Stanshaw Creek channel, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Stanshaw Creek at Klamath River (KRStansCr)

Miles to KR mouth: 76.9

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t		1	26	34	24	150	12		26	2	55	99	50	24	113	47	
Re-encountered in t plus																	
1			5	9	13	55	3		7	2	26	58	7	3	31	6	
2			4		3	16			9		27	6		1	2		
3					1						2			1			
4																	
% in t plus																	
1			19%	26%	54%	37%	25%		27%	100%	47%	59%	14%	13%	27%	13%	
2			15%		13%	11%			35%		49%	6%		4%	2%		
3					4%						4%			4%			
4																	
# to different GeoArea				2		7	1				3	5	2				
# to below Trinity R				2		5	1				1	4	2				
% to different GeoArea				6%		5%	8%				5%	5%	4%				
% to below Trinity R				6%		3%	8%				2%	4%	4%				

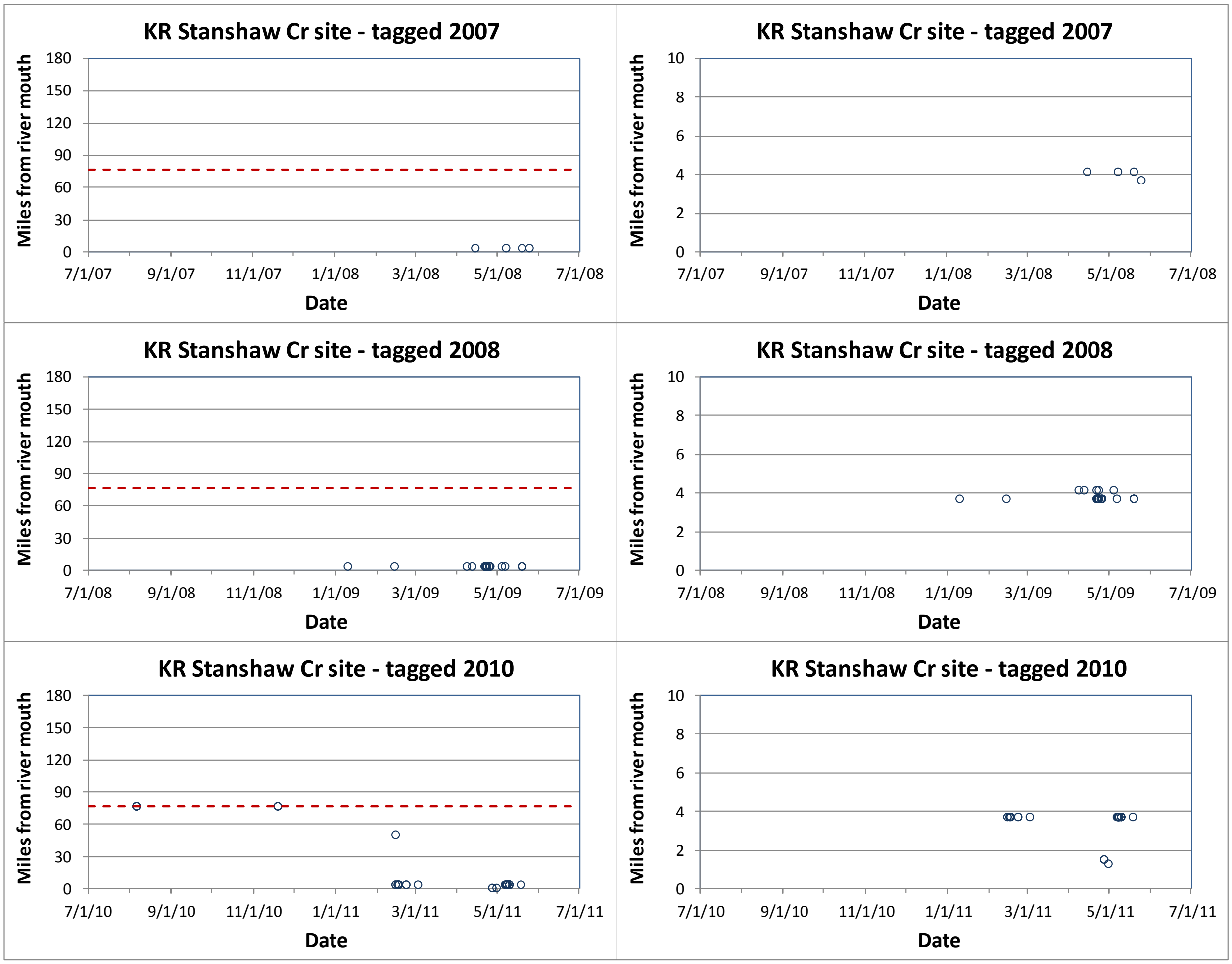


Figure 62. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Stanshaw Creek channel. Graphs with two different Y-axis scales are shown.

3.3.16 Irving Creek

Table 29 and Figure 63 summarize the numbers of fish tagged and re-encountered for fish tagged in Irving Creek, a tributary to the Klamath River at RM 75.2. Irving Creek is a small stream that is unconfined near its confluence with Klamath River, believed to support only non-natal coho production.

Table 29. Summary of age-0 juvenile coho released in Irving Creek channel, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Irving Creek at Klamath River (KRIrvingCr)
Miles to KR mouth: 75.2

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t												121					
Re-encountered in t plus																	
1																	
2																	
3																	
4																	
% in t plus																	
1																	
2																	
3																	
4																	
# to different GeoArea												13					
# to below Trinity R												12					
% to different GeoArea												11%					
% to below Trinity R												10%					

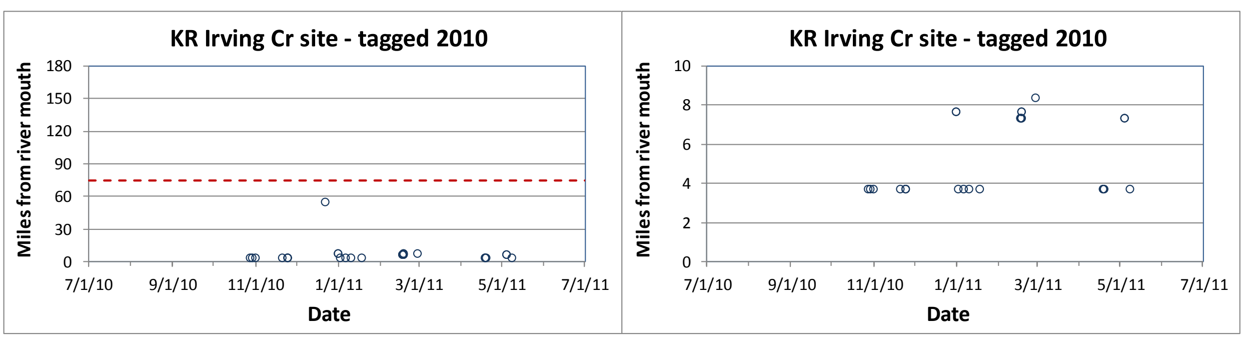


Figure 63. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Irving Creek. Graphs with two different Y-axis scales are shown.

3.3.17 Salmon River

Table 30 and Figure 64 summarize the numbers of fish tagged and re-encountered for fish tagged in the Salmon River subbasin, a major tributary to the Klamath River at RM 66.3. Salmon River is a large river that moderately confined or confined over large amounts of its length. It supports natal coho production but the run is believed to be small due largely to the natural conditions of the watershed.

Table 30. Summary of age-0 juvenile coho released in Salmon River, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Salmon River lower (SalmonRLow)
Miles to KR mouth: 67.3

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t												18			28		
Re-encountered in t plus																	
1																	
2																	
3																	
4																	
% in t plus																	
1																	
2																	
3																	
4																	
# to different GeoArea												3			5		
# to below Trinity R												3			5		
% to different GeoArea												17%			18%		
% to below Trinity R												17%			18%		

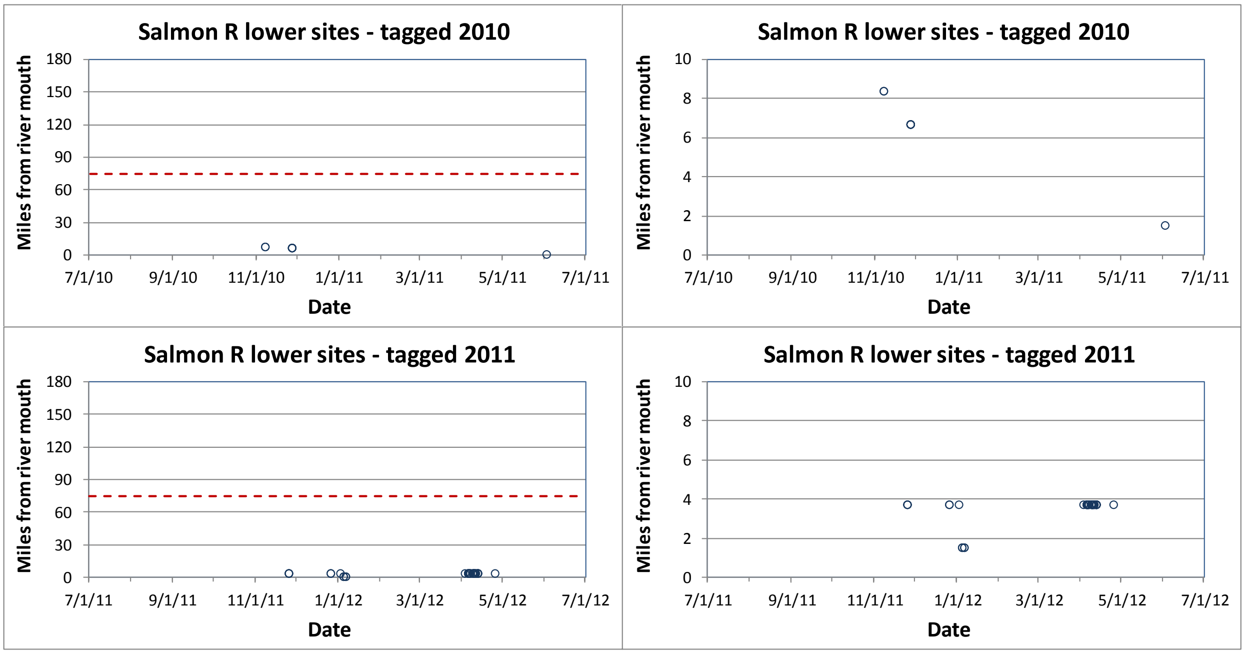


Figure 64. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Salmon River at the Klamath River. Graphs with two different Y-axis scales are shown.

3.3.18 Whitmore Creek

Table 31 and Figure 65 summarize the numbers of fish tagged and re-encountered for fish tagged in the Whitmore Creek floodplain channel, which enters the Klamath River at RM 62.7. Whitmore Creek is a small stream that is unconfined near its confluence with Klamath River; the floodplain channel is believed to support only non-natal coho production.

Table 31. Summary of age-0 juvenile coho released in Whitmore Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Whitmore Creek at Klamath River (KRWhitCr)

Miles to KR mouth: 62.7

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t										13		9					
Re-encountered in t plus																	
1																	
2																	
3																	
4																	
% in t plus																	
1																	
2																	
3																	
4																	
# to different GeoArea										4		3					
# to below Trinity R										4		3					
% to different GeoArea										31%		33%					
% to below Trinity R										31%		33%					

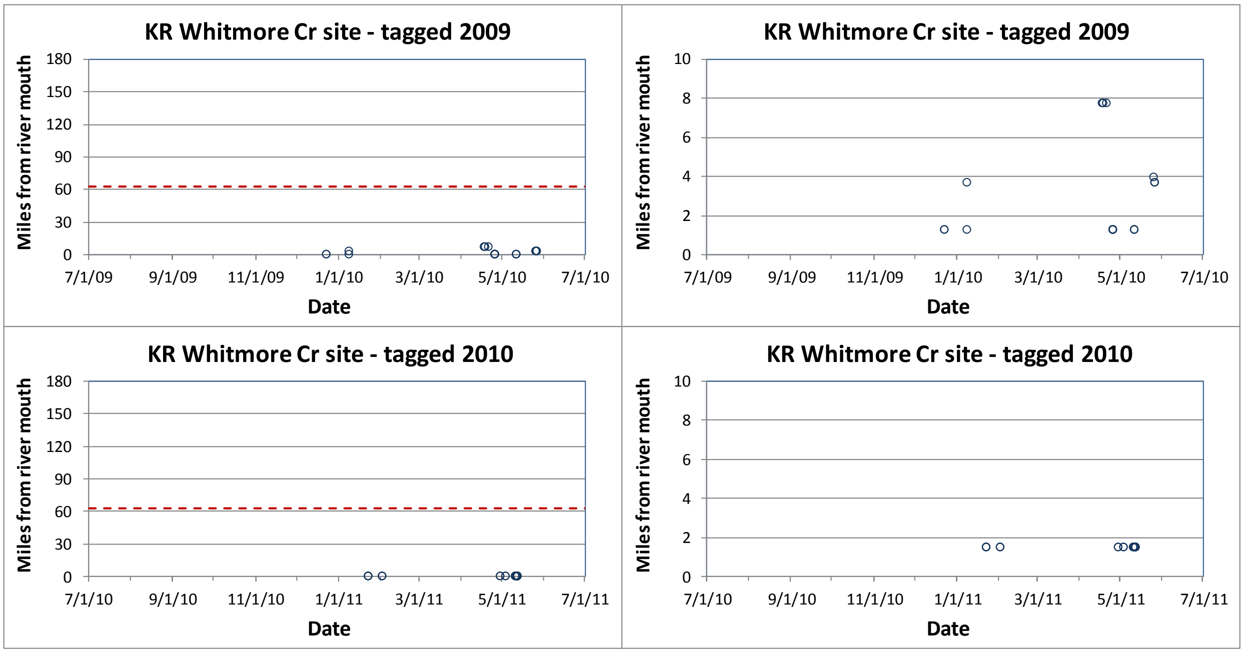


Figure 65. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Whitmore Creek at the Klamath River. Graphs with two different Y-axis scales are shown.

3.3.19 Camp Creek

Table 32 and Figure 66 summarize the numbers of fish tagged and re-encountered for fish tagged in Camp Creek, a tributary to the Klamath River at RM 57.3. Camp Creek supports natal coho production and may support some non-natal summer rearing in its lower end.

Table 32. Summary of age-0 juvenile coho released in Camp Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Camp Creek (CampCr)
Miles to KR mouth: 57.3

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t			96			64							2		52	56	
Re-encountered in t plus																	
1															4		
2																	
3																	
4																	
% in t plus																	
1															8%		
2																	
3																	
4																	
# to different GeoArea			4			5									2	4	
# to below Trinity R			4			5									2	4	
% to different GeoArea			4%			8%									4%	7%	
% to below Trinity R			4%			8%									4%	7%	

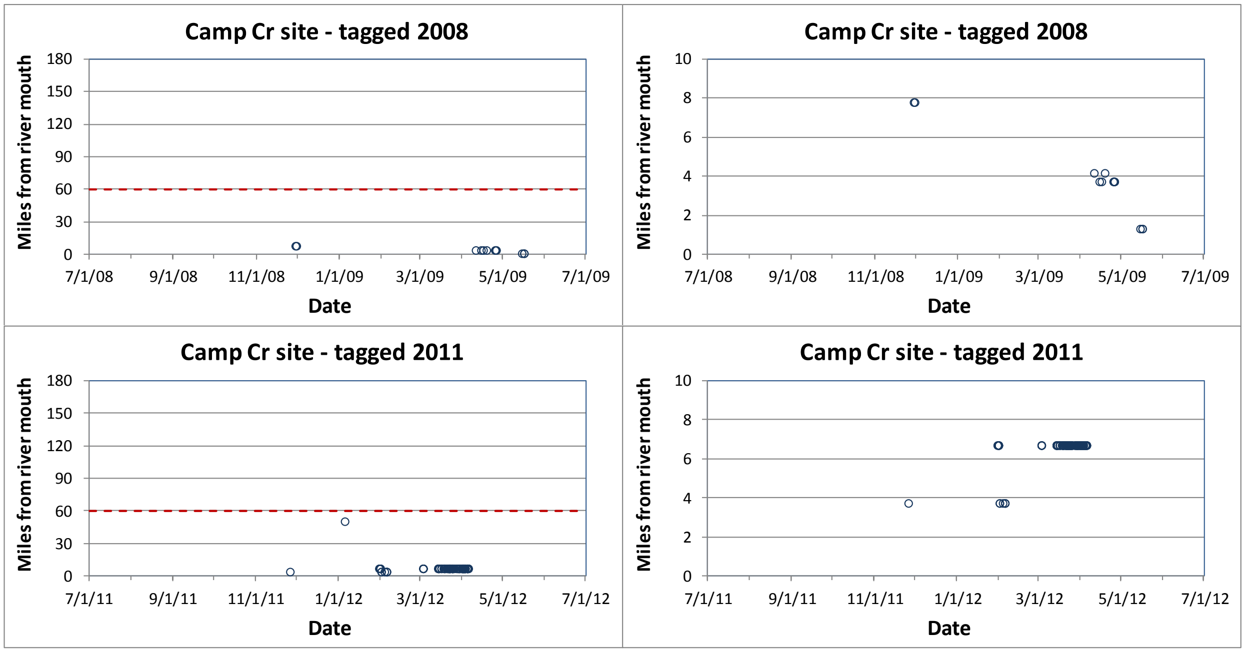


Figure 66. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Camp Creek. Graphs with two different Y-axis scales are shown.

3.3.20 Boise Creek

Table 33 and Figure 67 summarize the numbers of fish tagged and re-encountered for fish tagged in the Boise Creek and the associated floodplain channel and ponds that enter the Klamath River at RM 55.5. The lower end of this habitat feature contain off-channel ponds formed in part by beaver activity. The feature is used for non-natal coho rearing during both summer and winter; the creek also likely supports some natal production.

Table 33. Summary of age-0 juvenile coho released in Boise Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Boise Creek (BoiseCr)
Miles to KR mouth: 55.5

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t													33	4	92	2	
Re-encountered in t plus																	
1														1	3		
2																	
3																	
4																	
% in t plus																	
1														25%	3%		
2																	
3																	
4																	
# to different GeoArea															4		
# to below Trinity R															3		
% to different GeoArea															4%		
% to below Trinity R															3%		

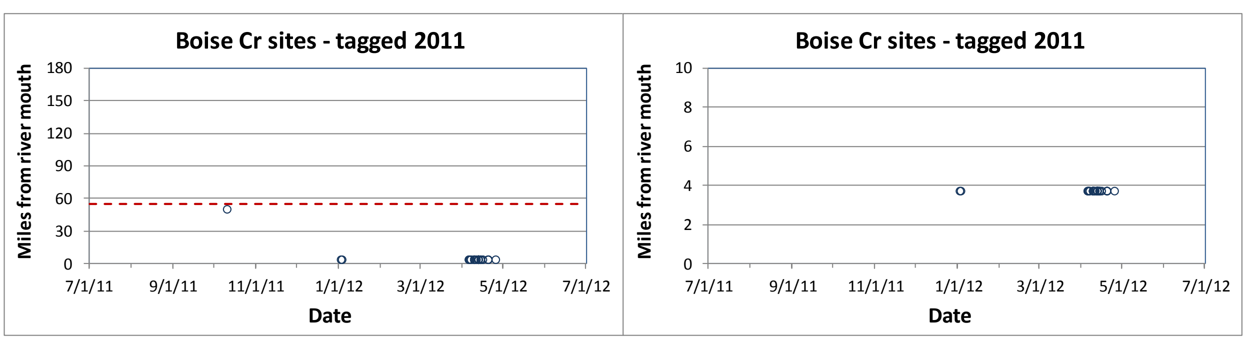


Figure 67. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Boise Creek. Graphs with two different Y-axis scales are shown.

3.3.21 Big Bar rotary screw trap on Klamath River

Table 34 and Figure 68 summarize the numbers of fish tagged and re-encountered for fish tagged at the Big Bar rotary screw trap operated on the mainstem Klamath River by the Karuk Tribe. The trap is operated at RM 50.8.

Table 34. Summary of age-0 juvenile coho released at the Big Bar RST, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Big Bar rotary screw trap site on Klamath River (KRBigBar)

Miles to KR mouth: 50.8

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t	3	2	3	44	28	7	24	8			30	18	40	14	17	11	
Re-encountered in t plus																	
1																	
2											1						
3																	
4																	
% in t plus																	
1																	
2											3%						
3																	
4																	
# to different GeoArea				4		1	2				3	2	5	1		2	
# to below Trinity R				4		1	2				3	2	5			2	
% to different GeoArea				9%		14%	8%				10%	11%	13%	7%		18%	
% to below Trinity R				9%		14%	8%				10%	11%	13%			18%	

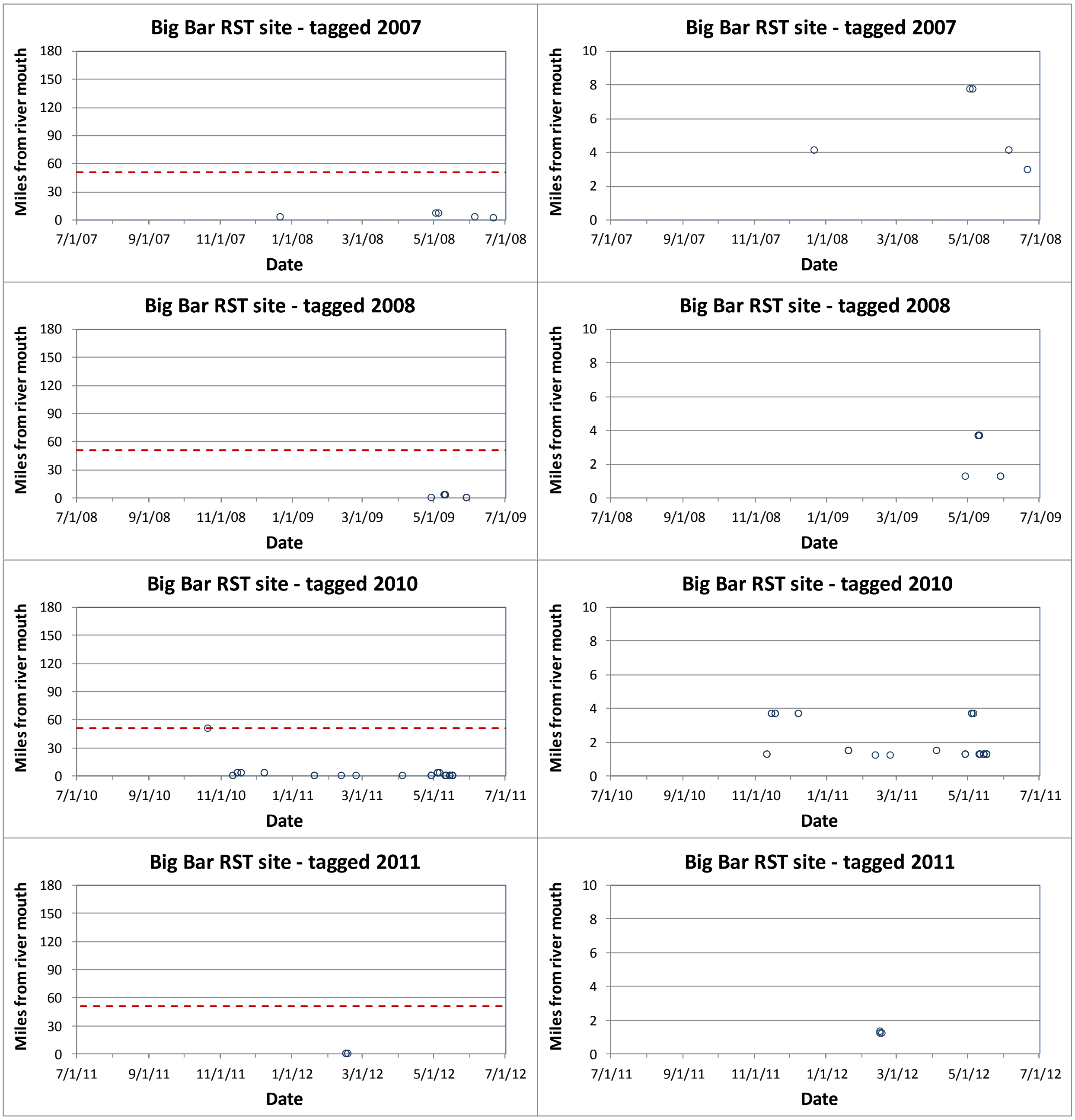


Figure 68. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Big Bar RST site. Graphs with two different Y-axis scales are shown.

3.3.22 Slate Creek

Table 35 and Figure 69 summarize the numbers of fish tagged and re-encountered for fish tagged in Slate Creek, a tributary to the Klamath River at RM 50.6. The stream is moderately confined to confined and supports natal production, though non-natal use also likely occurs near the stream mouth.

Table 35. Summary of age-0 juvenile coho released Slate Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Slate Creek at Klamath River (KRSlateCr)

Miles to KR mouth: 50.6

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t					21	15			144	19	51	138		41	1		
Re-encountered in t plus																	
1					5				61		25	4					
2											2						
3																	
4																	
% in t plus																	
1					24%				42%		49%	3%					
2											4%						
3																	
4																	
# to different GeoArea					1	5			14		6	15		2			
# to below Trinity R						5			14		6	15		2			
% to different GeoArea					5%	33%			10%		12%	11%		5%			
% to below Trinity R						33%			10%		12%	11%		5%			

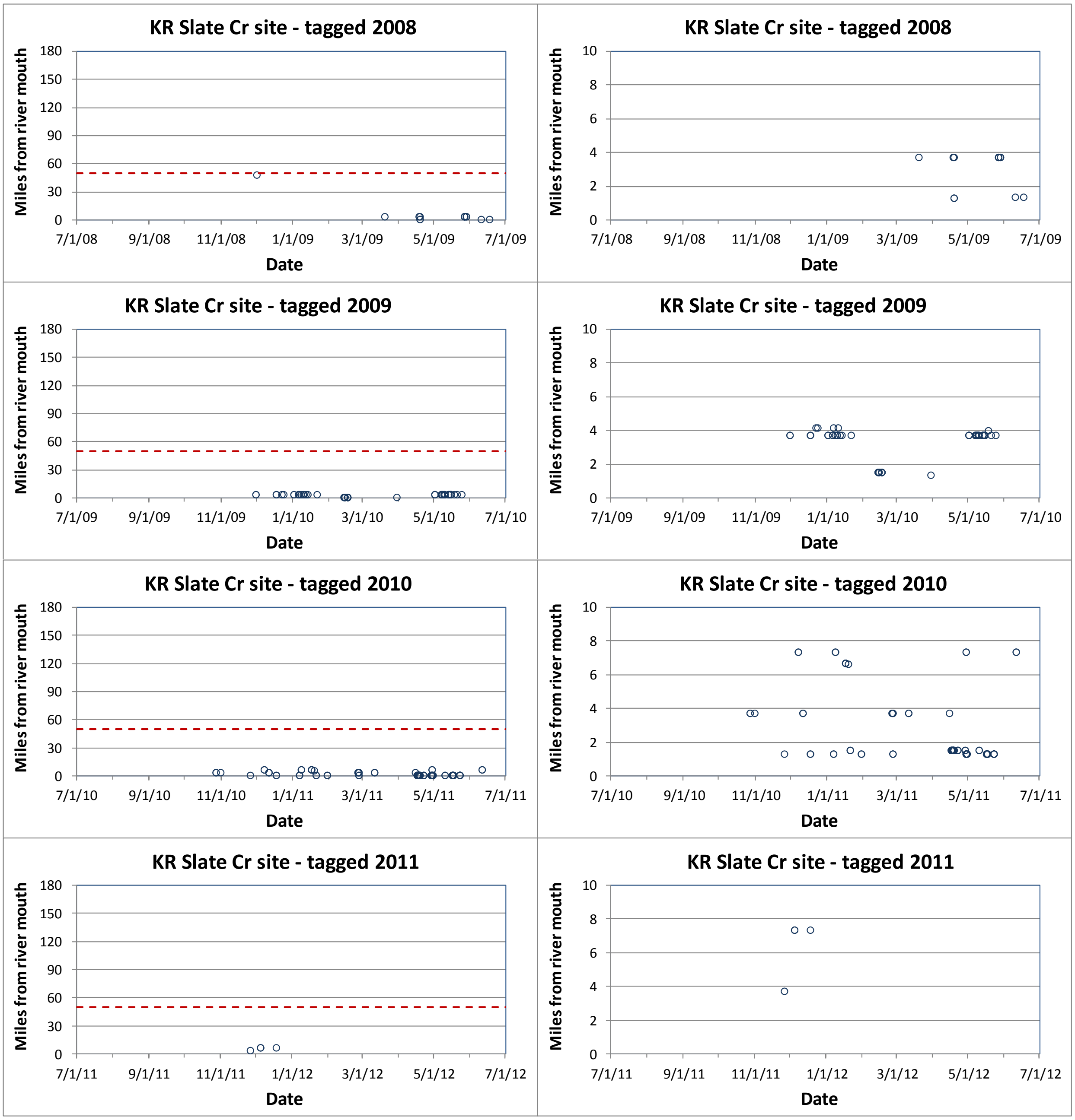


Figure 69. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Slate Creek at the Klamath River. Graphs with two different Y-axis scales are shown.

3.3.23 Aikens Creek

Table 36 and Figure 70 summarize the numbers of fish tagged and re-encountered for fish tagged in Aikens Creek, a tributary to the Klamath River at RM 48.8. The stream is moderately confined to confined and supports natal coho production, though non-natal use also likely occurs near the stream mouth.

Table 36. Summary of age-0 juvenile coho released in Aikens Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Aikens Creek (AikensCr)

Miles to KR mouth: 48.8

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t			175	25	33	207	24	3	159	88	25	42		15	139	43	
Re-encountered in t plus																	
1			5		6	10		2	74		2	1		1	25		
2					1			1				1		2	3		
3																	
4																	
% in t plus																	
1			3%		18%	5%		67%	47%		8%	2%		7%	18%		
2					3%			33%				2%		13%	2%		
3																	
4																	
# to different GeoArea			3	1	1	27	5		23	11	1	7		4	18	9	
# to below Trinity R			3	1	1	27	5		23	10	1	7		4	18	9	
% to different GeoArea			2%	4%	3%	13%	21%		14%	13%	4%	17%		27%	13%	21%	
% to below Trinity R			2%	4%	3%	13%	21%		14%	11%	4%	17%		27%	13%	21%	

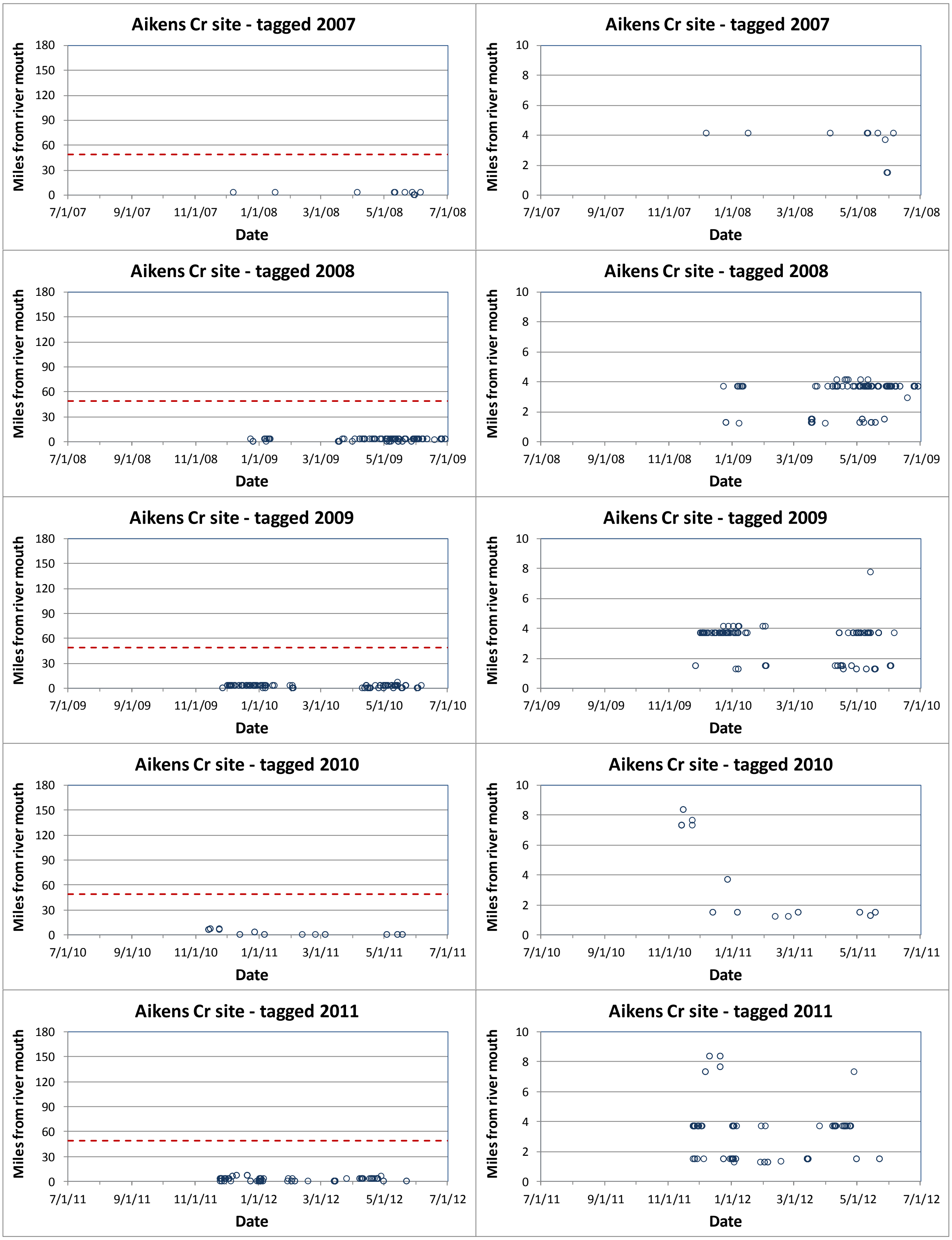


Figure 70. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Aikens Creek. Graphs with two different Y-axis scales are shown.

3.4 Lower Klamath Area Summaries

This section provides the same type of information as given in the previous section. Here we provide brief tabular and graphic summaries of movement patterns seen within the mainstem corridor for groups of juvenile coho PIT tagged at sites downstream of the Trinity River. In combination with the patterns seen in the previous section, the information presented demonstrates the scale and scope of the types of juvenile coho redistributions that occur annually within the mainstem corridor.

The tabular and graphic summaries presented show patterns of movement away from the geographic areas (GeoAreas) where fish were tagged for all project time periods through about mid-2011. The information is given in two parts. The first part is a table that summarizes the number of fish tagged by time period t in that area, as well as the number of those tagged fish that were subsequently re-encountered in the same GeoArea but in a later time period (shown as t + 1, t + 2, and so on). At the bottom of the table, the number of tagged fish that were re-encountered outside the GeoArea where the fish were tagged is provided, together with re-encounter rates (shown as percentages). The summary focuses entirely on age-0 fish that were PIT tagged, as these fish are most informative to illustrate re-distribution among the mainstem corridor areas.

To explain by example, Table 37 presents summary data for fish tagged in Crescent City Forks, a tributary to Blue Creek, which then joins the Klamath River at about RM 16.0. Fifty-five fish was PIT tagged in time period 9, which is defined here as the months of July-October in the yearly period 2009-10, i.e., the fish was tagged sometime between July and October in 2009. None of those fish were subsequently re-encountered in Crescent City Forks (no subsequent sampling occurred when they could have been re-encountered). One fish, however, was re-encountered outside the GeoArea where tagging occurred, in this case in a stream that enters the estuarine zone of the river. In time period 12 (July-October for 2010-11 (but in 2010), 151 fish were tagged in Crescent City Forks. Thirty-five of those fish (23 percent) were subsequently re-encountered outside of the tagging area.

The second part of the summary is a figure that graphically shows the pattern of re-encounters for fish re-encountered outside the tagging GeoArea—shown for each yearly period of tagging—in relation to distance from the tagging site and to the river mouth. The location of the GeoArea in relation to the Klamath River mouth is shown as a dashed red line. Each symbol shows the location and date of a PIT tag re-encounter. Note that the figure for each year is shown with two charts, displaying two spatial scales—one covering the greatest distance relevant to this analysis and the other zooming in on the area within 10 miles of the river mouth.

3.4.1 Crescent City Forks (Blue Creek)

Table 37 and Figure 71 summarize the numbers of fish tagged and re-encountered for fish tagged in Crescent City Fork, a tributary to Blue Creek. The confluence with Blue Creek is located approximately 31 miles upstream of the Klamath River mouth. Blue Creek enters the Klamath River at approximately RM 16.0. Crescent City Forks supports natal coho production.

Table 37. Summary of age-0 juvenile coho released in Crescent City Forks, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Crescent City Forks (CresCityFks)

Miles to KR mouth: 31.0

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t									55			151			276		
Re-encountered in t plus																	
1																	
2																	
3																	
4																	
% in t plus																	
1																	
2																	
3																	
4																	
# to different GeoArea									1			35			38		
% to different GeoArea									2%			23%			14%		

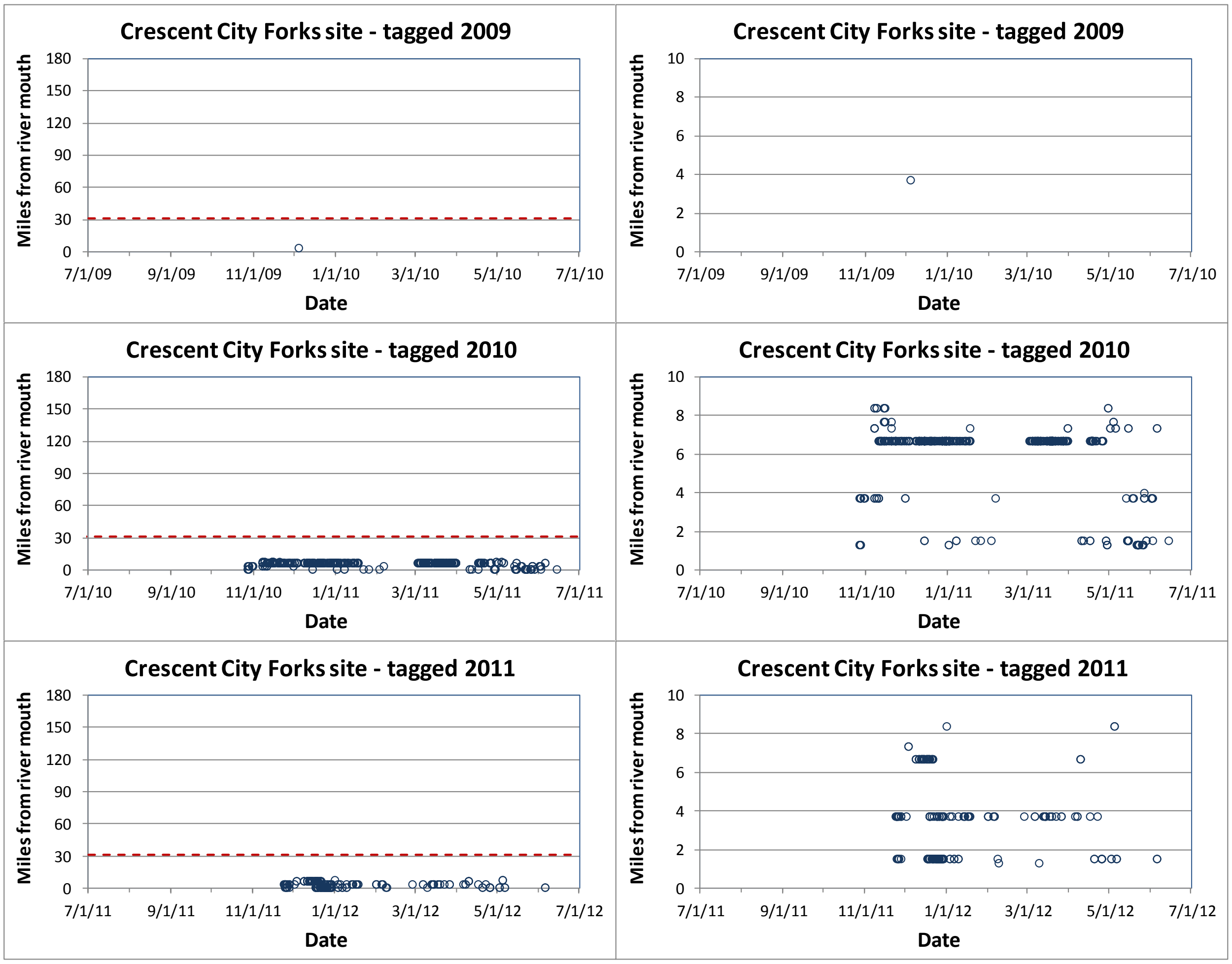


Figure 71. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Crescent City Forks.

3.4.2 Ah Pah Creek

Table 38 and Figure 72 summarize the numbers of fish tagged and re-encountered for fish tagged in Ah Pah Creek, a tributary to the Klamath River at RM 17.3. The stream is moderately confined and supports natal coho production, though non-natal use may also occur in the lower reaches.

Table 38. Summary of age-0 juvenile coho released in Ah Pah Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Ah Pah Creek (AhPahCr)

Miles to KR mouth: 18.3

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t						71			103			65			127		
Re-encountered in t plus																	
1																	
2																	
3																	
4																	
% in t plus																	
1																	
2																	
3																	
4																	
# to different GeoArea						6			2			7			12		
% to different GeoArea						8%			2%			11%			9%		

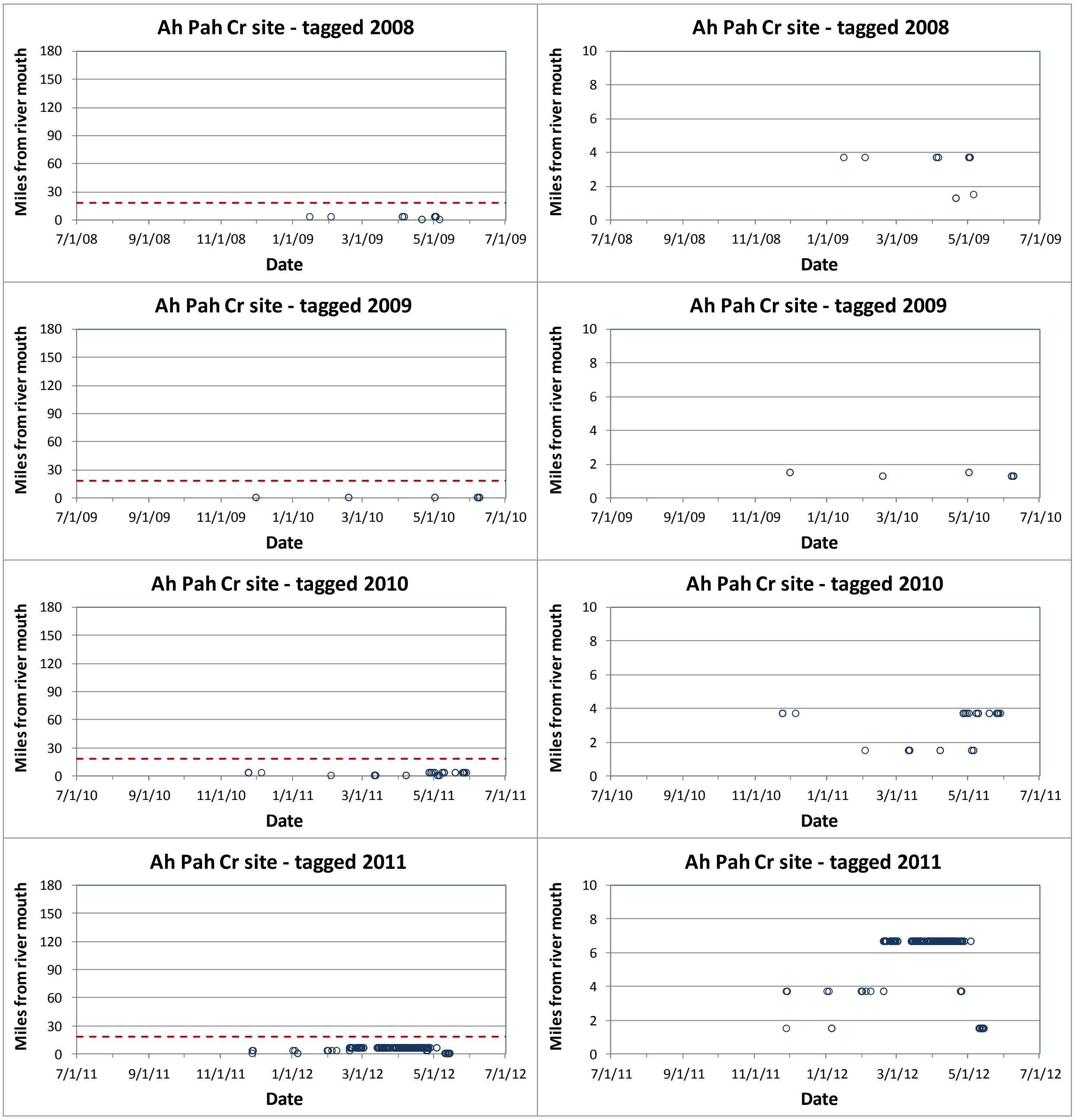


Figure 72. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Ah Pah Creek.

3.4.3 Blue Creek rotary screw trap site

Table 39 and Figure 73 summarize the numbers of fish tagged and re-encountered for fish tagged at the Blue Creek rotary screw trap, which is operated by the YTFP on mainstem Blue Creek. Blue Creek joins the Klamath River at RM 16.0.

Table 39. Summary of age-0 juvenile coho released at the Blue Creek rotary screw trap site, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Blue Creek RST site (BlueCrLow)
Miles to KR mouth: 17.4

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t						34			4								
Re-encountered in t plus																	
1																	
2																	
3																	
4																	
% in t plus																	
1																	
2																	
3																	
4																	
# to different GeoArea						8			1								
% to different GeoArea						24%			25%								

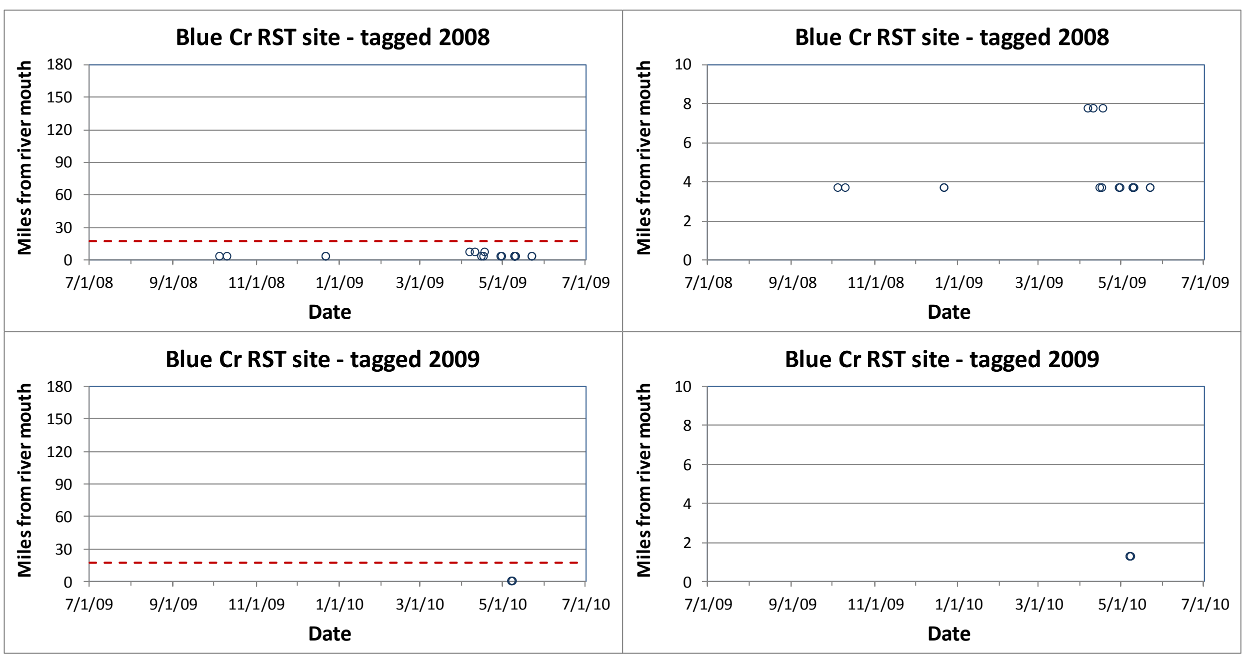


Figure 73. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Blue Creek RST site.

3.4.4 Terwer Creek middle reach

Table 40 and Figure 74 summarize the numbers of fish tagged and re-encountered for fish tagged in mid section of Terwer Creek, which is located at least 14.1 miles from the Klamath River mouth. Terwer Creek enters the Klamath River at approximately RM 6.7. This area of Terwer Creek supports natal coho production. It is unlikely that non-natal rearing occurs in this area.

Table 40. Summary of age-0 juvenile coho released in Terwer Creek middle reach, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Terwer Creel middle reach (TerwerCrMid)

Miles to KR mouth: 14.1

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t						47			6			241			287		
Re-encountered in t plus																	
1																	
2																	
3																	
4																	
% in t plus																	
1																	
2																	
3																	
4																	
# to different GeoArea						13			1			55			48		
% to different GeoArea						28%			17%			23%			17%		

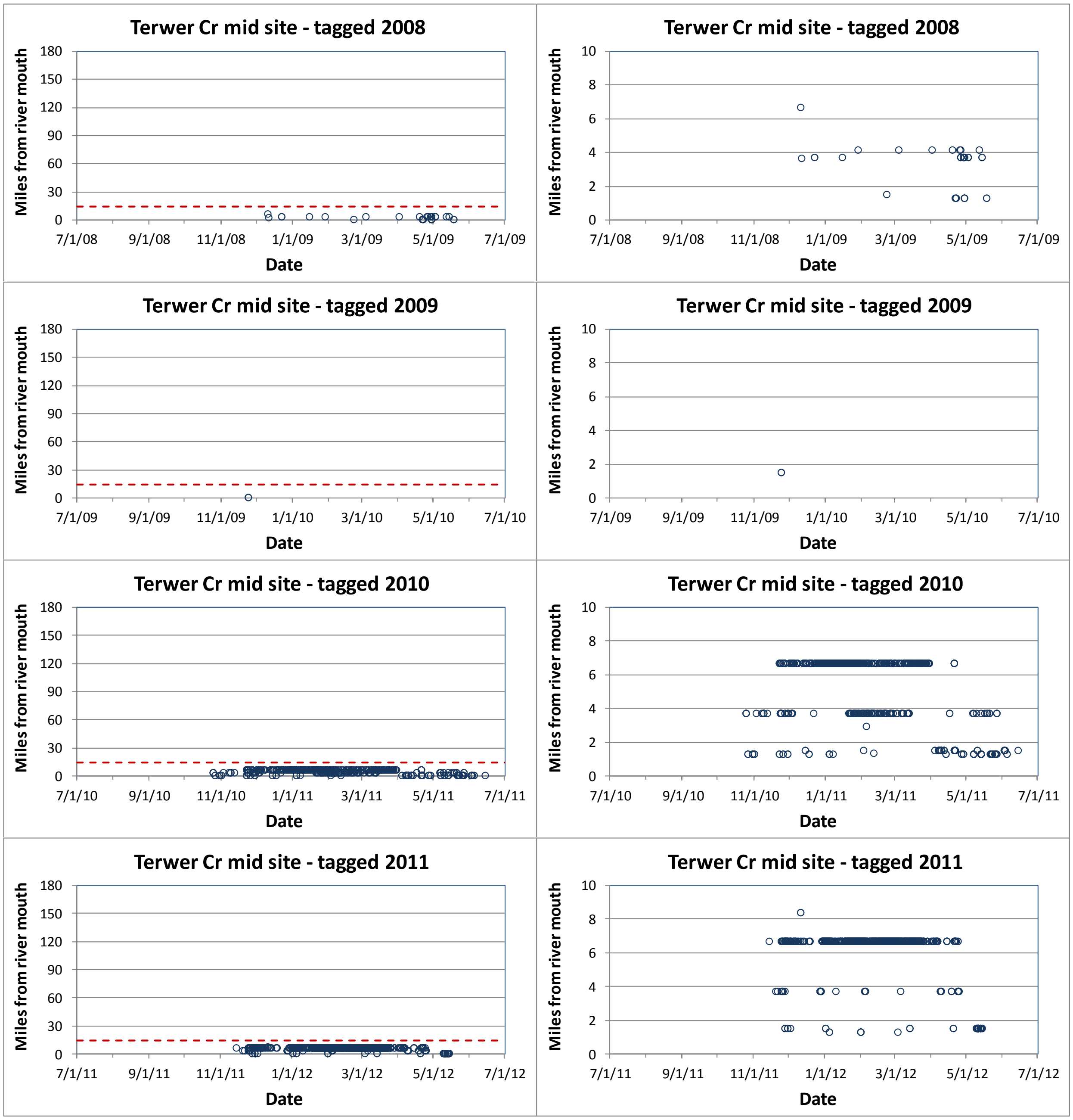


Figure 74. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Terwer Creek middle reach.

3.4.5 Terwer Creek lower reach

Table 41 and Figure 75 summarize the numbers of fish tagged and re-encountered for fish tagged in lower reach of Terwer Creek. Terwer Creek enters the Klamath River at approximately RM 6.7. The YTFP completed multiple restoration projects in lower Terwer Creek, including wood loading and construction/enhancement of off-channel ponds (YTFP 2013). This area of Terwer Creek supports both natal and non-natal coho production. Also, fish rescue operations have been occasionally carried out in this area due to severe channel dewatering—rescued fish have been PIT tagged and released downstream into the mainstem Klamath River.

Table 41. Summary of age-0 juvenile coho released in Terwer Creek lower reach, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Terwer Creek lower reach (includes constructed ponds) (TerwerCrLow)
Miles to KR mouth: 6.7

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t					12		127	12	14		67	57	100	71	215		
Re-encountered in t plus																	
1											4		17	11	1		
2																	
3																	
4																	
% in t plus																	
1											6%		17%	15%	0%		
2																	
3																	
4																	
# to different GeoArea					2		18	4	4		5	12	13	10	51		
% to different GeoArea					17%		14%	33%	29%		7%	21%	13%	14%	24%		

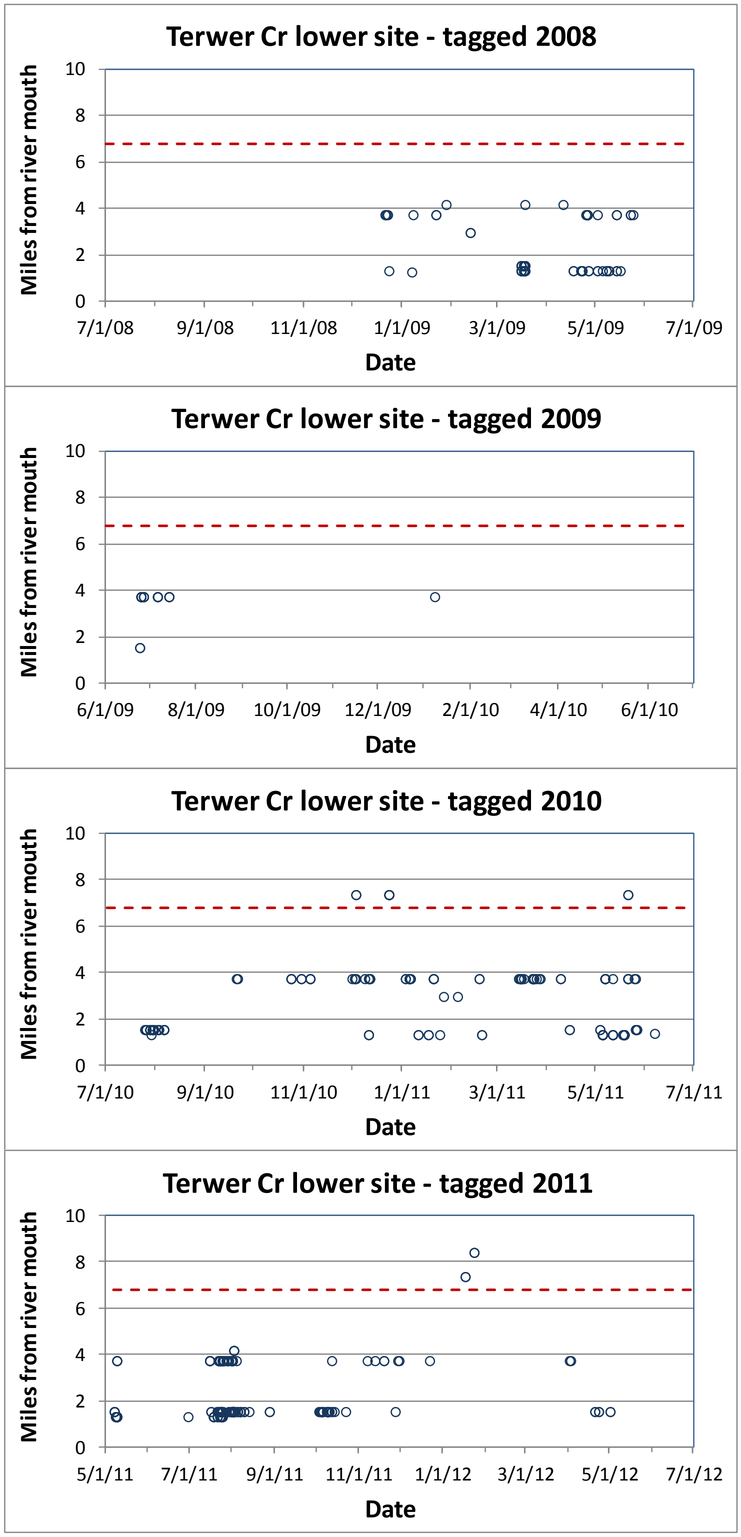


Figure 75. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Terwer Creek lower reach.

3.4.6 McGarvey Creek

Table 42 and Figure 76 summarize the numbers of fish tagged and re-encountered for fish tagged in McGarvey Creek, a tributary to the Klamath River at RM 6.4. McGarvey Creek is a small, largely unconfined stream that supports both natal and non-natal coho production. The YTFP has completed multiple restoration projects in McGarvey Creek starting in 2009, including wood loading and construction of off-channel ponds (YTFP 2013; Beesley and Fiori 2014).

Table 42. Summary of age-0 juvenile coho released in McGarvey Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): McGarvey Creek (McGarveyCr)

Miles to KR mouth: 6.6

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t			30	31		188	470		208	1		286	47	51	123		
Re-encountered in t plus																	
1				2		18	24					110	10	1	39		
2			1			9			7			59		14	33		
3														2			
4																	
% in t plus																	
1				6%		10%	5%					38%	21%	2%	32%		
2			3%			5%			3%			21%		27%	27%		
3														4%			
4																	
# to different GeoArea				1		14	102		38			53	6	11	17		
% to different GeoArea				3%		7%	22%		18%			19%	13%	22%	14%		

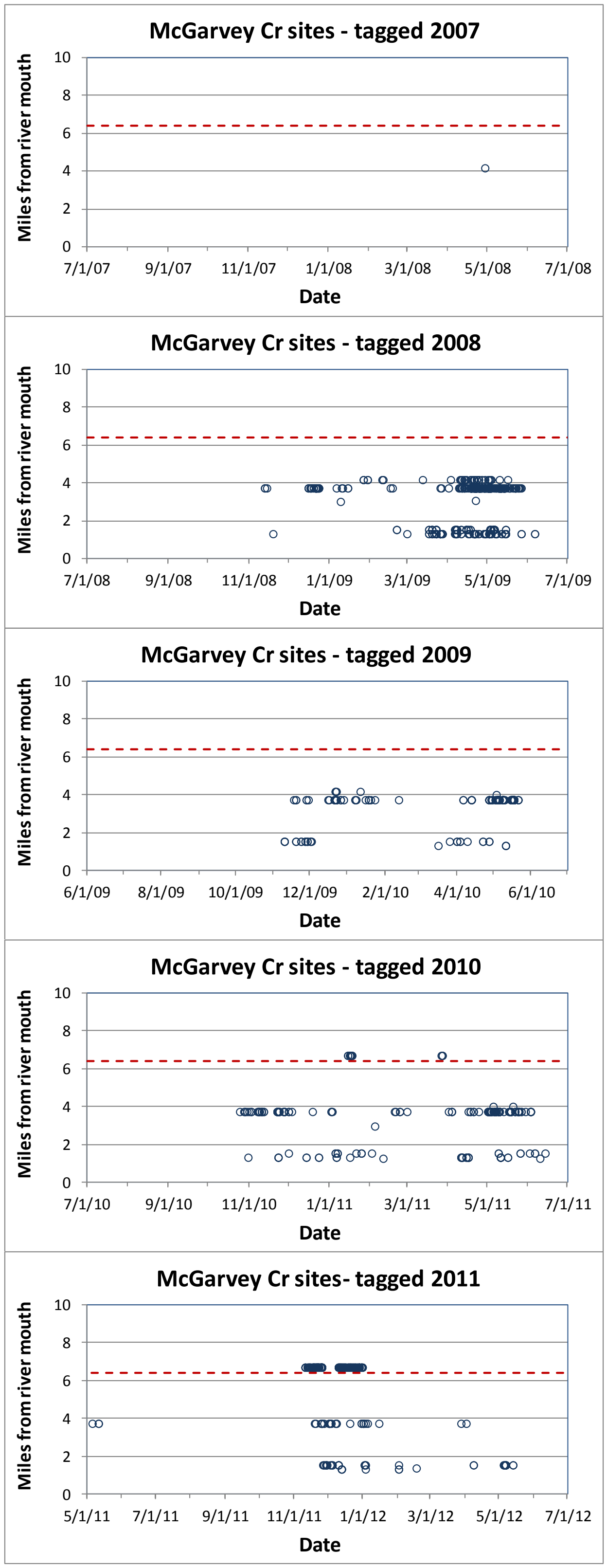


Figure 76. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea McGarvey Creek.

3.4.7 Waukell Creek

Table 43 and Figure 77 summarize the numbers of fish tagged and re-encountered for fish tagged in Waukell Creek, a tributary to the Klamath River at RM 3.2. Waukell Creek is a small, largely unconfined stream that historically supported natal coho production, but currently only appears to support non-natal rearing. Junior Creek and Junior Creek Pond are located in the Waukell Creek subbasin. Waukell Creek flows through a large wetland complex upstream of Junior Creek. The YTFP in recent years has implemented restoration actions in the Waukell Creek subbasin, including an extensive wood loading and riparian planting project in 2009 and 2010 (Beesley and Fiori 2010). Activities are on-going.

Table 43. Summary of age-0 juvenile coho released in Waukell Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Waukell Creek (WaukellCr)

Miles to KR mouth: 3.7

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t		15	96	350	45	80	529	10	25	86	88	172	373	58	262		
Re-encountered in t plus																	
1			2	108		7	250	1	4	38	3	18	201	6	17		
2			39	10		17	1	2	4		9	81			7		
3			3		8			2			28			3			
4																	
% in t plus																	
1			2%	31%		9%	47%	10%	16%	44%	3%	10%	54%	10%	6%		
2			41%	3%		21%	0%	20%	16%		10%	47%			3%		
3			3%		18%			20%			32%			5%			
4																	
# to different GeoArea							2		1	3		1	2		2		
% to different GeoArea							0%		4%	3%		1%	1%		1%		

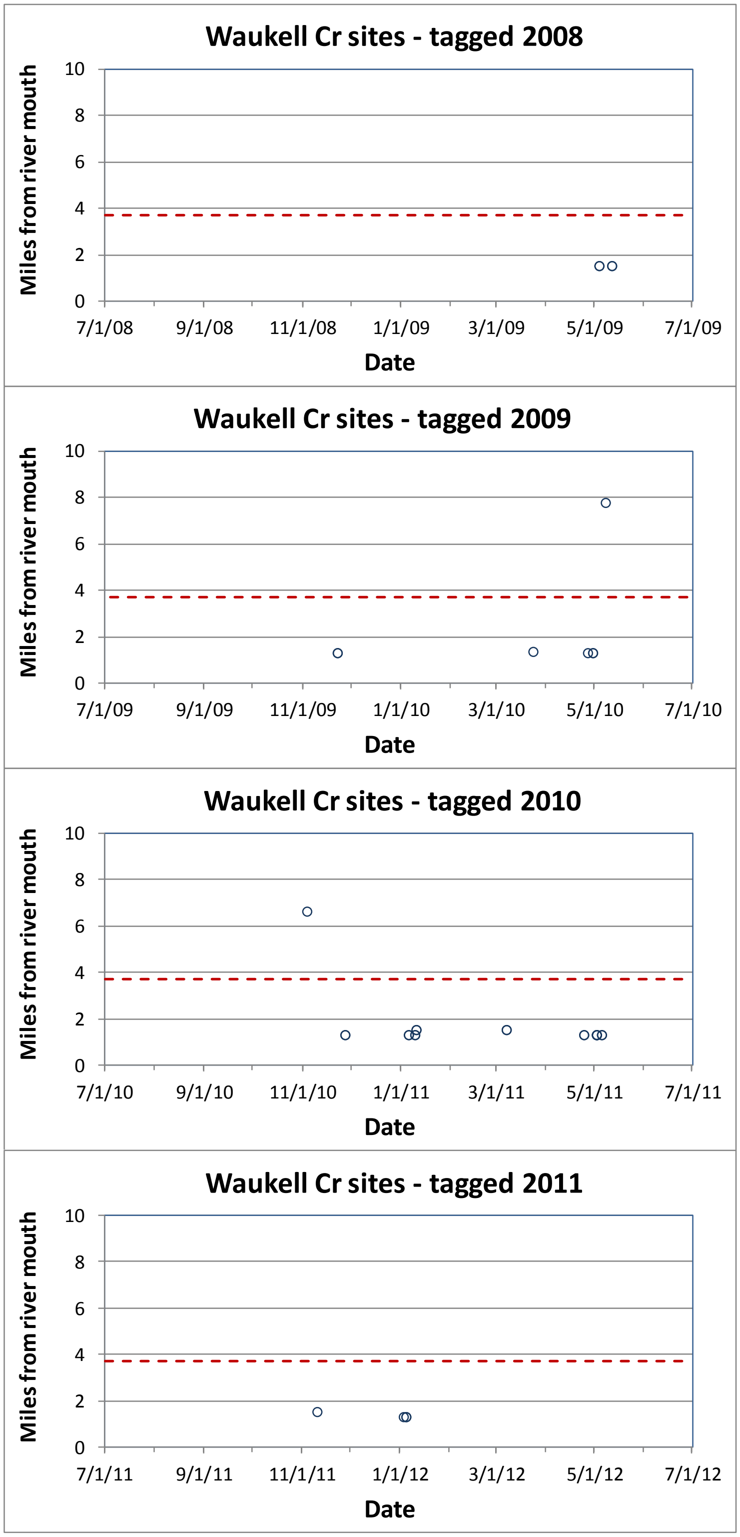


Figure 77. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Waukell Creek.

3.4.8 Hunter Creek upper reach

Table 44 and Figure 78 summarize the numbers of fish tagged and re-encountered for fish tagged in upper reaches of Hunter Creek, tributary to the Klamath River at RM 0.8. The distance from the tagging area to the Klamath River mouth is approximately 5.3 miles. Panther Creek and Panther Creek Pond are located in the lower part of the Hunter Creek subbasin—that area is treated as a separate GeoArea here. Re-encounters of fish tagged in the upper Hunter Creek to a large extent occur either in Panther Creek or in Salt Creek.

Table 44. Summary of age-0 juvenile coho released in Hunter Creek upper reach, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Hunter Creek upper reach (HunterCrUp)

Miles to KR mouth: 5.3

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t						212			111						251		
Re-encountered in t plus																	
1																	
2															1		
3																	
4																	
% in t plus																	
1																	
2															0%		
3																	
4																	
# to different GeoArea						33			15						37		
% to different GeoArea						16%			14%						15%		

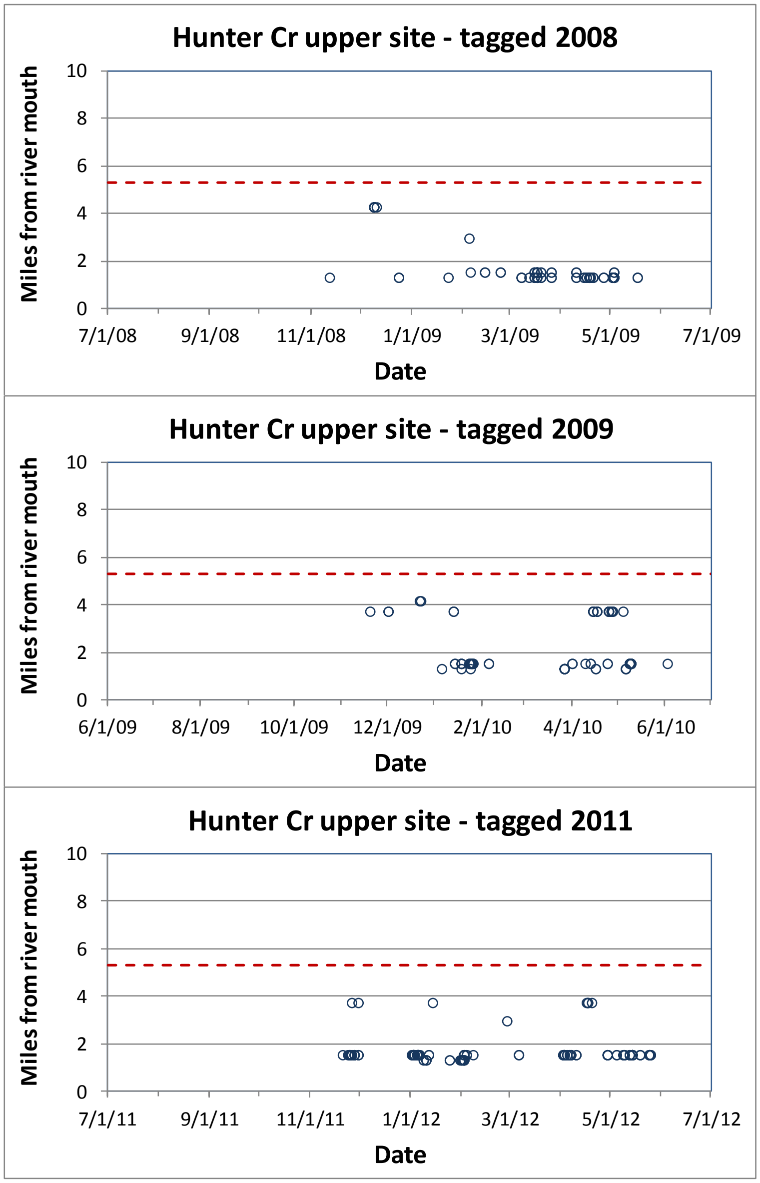


Figure 78. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Hunter Creek upper reach.

3.4.9 Hunter Creek lower reach

Table 45 and Figure 79 summarize the numbers of fish tagged and re-encountered for fish tagged in lower area of Hunter Creek, tributary to the Klamath River at RM 0.8. The tagging area includes Panther Creek and Panther Creek Pond. The lower Hunter Creek area may support some natal coho production, though Panther Creek and Panther Creek Pond probably do not (i.e., fish produced in Panther Creek). The distance from the tagging area to the Klamath River mouth is approximately 1.6 miles. This GeoArea is treated as a separate area from upper Hunter Creek.

Table 45. Summary of age-0 juvenile coho released in Hunter Creek lower reach, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Hunter Creek lower reach (includes Panther Cr pond and Panther Cr) (HunterCrLow)

Miles to KR mouth: 1.6

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t		15	96	350	45	80	529	10	25	86	88	172	373	58	262		
Re-encountered in t plus																	
1						1	5	5	2	33	1	29	9	14	3		
2						4		1	2		2	40		6	3		
3					2			1			7			7			
4							1					1					
% in t plus																	
1						1%	1%	50%	8%	38%	1%	17%	2%	24%	1%		
2						5%		10%	8%		2%	23%		10%	1%		
3					4%			10%			8%			12%			
4							0%					1%					
# to different GeoArea					2		6		1	8	1	17	2	1			
% to different GeoArea					4%		1%		4%	9%	1%	10%	1%	2%			

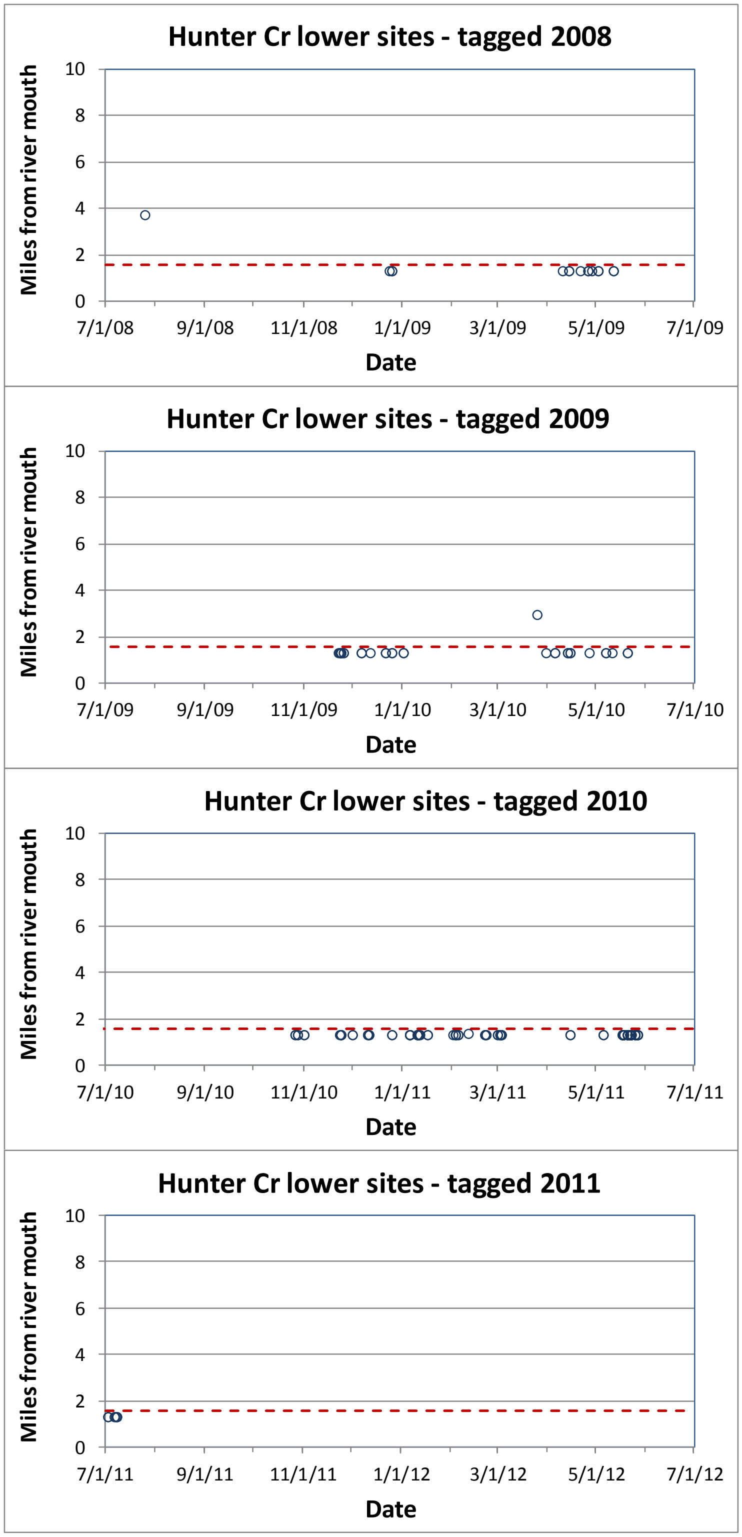


Figure 79. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Hunter Creek lower reach.

3.4.10 Spruce Creek

Table 46 and Figure 79 summarize the numbers of fish tagged and re-encountered for fish tagged in the Spruce Creek area. Spruce Creek enters lower Hunter Creek just upstream of the confluence with the Klamath River. Hunter Creek joins the Klamath River at RM 0.8. The Spruce Creek channel between Highway 101 and Hunter Creek is comprised mostly of beaver influenced ponds and sinuous channel reaches formed primarily by backwater processes. This GeoArea is treated here as a separate area from the other Hunter Creek areas. The distance from the tagging area to the Klamath River mouth is approximately 1.3 miles.

Table 46. Summary of age-0 juvenile coho released in Spruce Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Spruce Creek (SpruceCr)

Miles to KR mouth: 1.3

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t							28	6				47		11			
Re-encountered in t plus																	
1							1					7					
2																	
3																	
4																	
% in t plus																	
1							4%					15%					
2																	
3																	
4																	
# to different GeoArea							1							1			
% to different GeoArea							4%							9%			

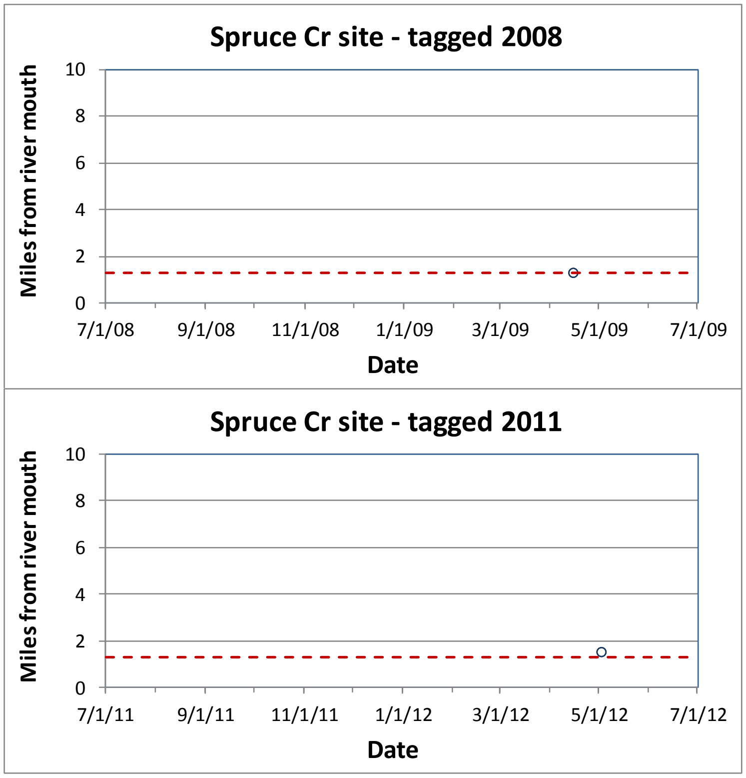


Figure 80. Spatial-temporal pattern of PIT tag re-encounters of juvenile coho away from the tagging GeoArea Spruce Creek.

3.4.11 Salt Creek

Table 47 summarizes the numbers of fish tagged and re-encountered for fish tagged in Salt Creek, a tributary to the Klamath River at approximately RM 0.8. The distance from the tagging area to the Klamath River mouth is generally at least 1.4 miles.

Table 47. Summary of age-0 juvenile coho released in Salt Creek, those found to still be present in a subsequent time period, and re-encounters outside the GeoArea.

Geographic area (GeoArea): Salt Creek (SaltCr)
Miles to KR mouth: 1.4

Metric	Time period (t)																
	2006-07	2007-08			2008-09			2009-10			2010-11			2011-12			2012-13
	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun	Jul-Oct	Nov-Feb	Mar-Jun
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tagged in Period t					4	2	199	3	3	1	14	8		24			
Re-encountered in t plus																	
1							74				1			1			
2									1		1	1		1			
3					2			1			4						
4																	
% in t plus																	
1							37%				7%			4%			
2									33%		7%	13%		4%			
3					50%			33%			29%						
4																	
# to different GeoArea																	
% to different GeoArea																	

4.0 River Basin-Wide Patterns and Synthesis

This section provides a broad-scale perspective on seasonal use and movement patterns by juvenile coho within the Klamath River corridor. The final part provides some preliminary conclusions on the role of the mainstem corridor to coho populations in the Klamath River basin.

4.1 Broad-Scale Seasonal Use and Movement Patterns

Two sets of graphs are provided that show general patterns of seasonal movements as a function of where juvenile coho were PIT tagged. Results are shown for age-0 coho that were PIT tagged in 2007 to 2011 in displays showing movement from upstream of Trinity River to areas below, and in 2008 to 2011 in displays showing movement from one geographic area (GeoArea) to another. Data were insufficient to assess movements from one GeoArea to another in 2007.

Figure 81 shows patterns of PIT tag re-encounter rates made downstream of Trinity River for five years of grouped releases made from April through October and for November through December. It should be recognized that re-encounter rates for tagged fish released in 2011 are not yet complete as they do not include all data for late in 2011 and in 2012. Re-encounter rates tend to be greater for groups of fish tagged in November and December compared to earlier months, presumably due to lesser amount of mortality that would have been operative over a shorter time period. The highest re-encounter rates tend to occur on groups of fish tagged downstream from about Happy Camp (RM 108). It is noted, however, that while the 2009 releases tended to show very low re-encounter rates, probably due to low densities of fish, two groups of tagged coho in November-December showed high re-encounter rates. The highest re-encounter rate for those two groups was likely due to random chance associated with the very small group of fish tagged.

Figure 82 shows patterns of PIT tag re-encounter rates for fish that moved from one GeoArea to another. The results are displayed in a manner to compare movements that occurred in summer and early fall (April to October re-encounters) to movements associated with winter. Generally, the patterns show a much greater degree of movement occurs associated with winter than with summer, as expected.

4.2 Preliminary Conclusions on the Role of the Mainstem Corridor

This project has demonstrated that the Klamath River mainstem corridor provides critical habitat for juvenile coho during all seasons of the year. Corridor habitats are used by both natal and non-natal rearing juvenile coho. Non-natal fish exhibit extensive redistributions within the corridor from natal spawning streams during virtually every month, but the movements are particular evident in spring, early summer, fall, and early winter. The patterns of these re-distributions are consistent with those observed in numerous other streams within the range of the species (Quinn 2005; Lestelle 2007), though our findings generally show greater distances being travelled than reported in other studies.

Our findings show that substantial numbers of young-of-the-year progeny (age-0 coho) move downstream from their natal spawning streams and into the mainstem Klamath River in spring and early summer, and then undertake two significant re-distributions within the river corridor. First, in spring and early summer, the small juveniles continue to move (generally downstream) in search of slow-velocity habitats, such as backwaters, edge habitats along the mainstem, floodplain channels (particularly small tributary-fed floodplain channels, including ponds), and low velocity small tributaries. All of these habitat types occur to a limited amount within the mainstem river corridor, but their distribution along the river is not uniform. As temperatures increase in the river in early summer, movement to find refuge habitats that contain both low velocities and cool water becomes essential for survival. The distance of this early summer redistribution of age-0 fish from their natal tributaries appears to be mostly less than about 30 miles, though Shasta River fish have been found to move up to 200 miles during this early summer window to find refuge habitat in the corridor.

A second, more extensive re-distribution occurs with the advent of fall rains. This movement occurs for fish that had moved into corridor habitats from natal areas during spring and early summer, as well as other fish moving from the natal streams during fall and early winter. In this case, the age-0 juveniles move to find suitable overwintering habitats containing either complex habitat structure (such as large, stable wood) or low velocity sites with some type of protection from periodic higher flows, such as occurs in floodplain channels with ponded habitat or isolated

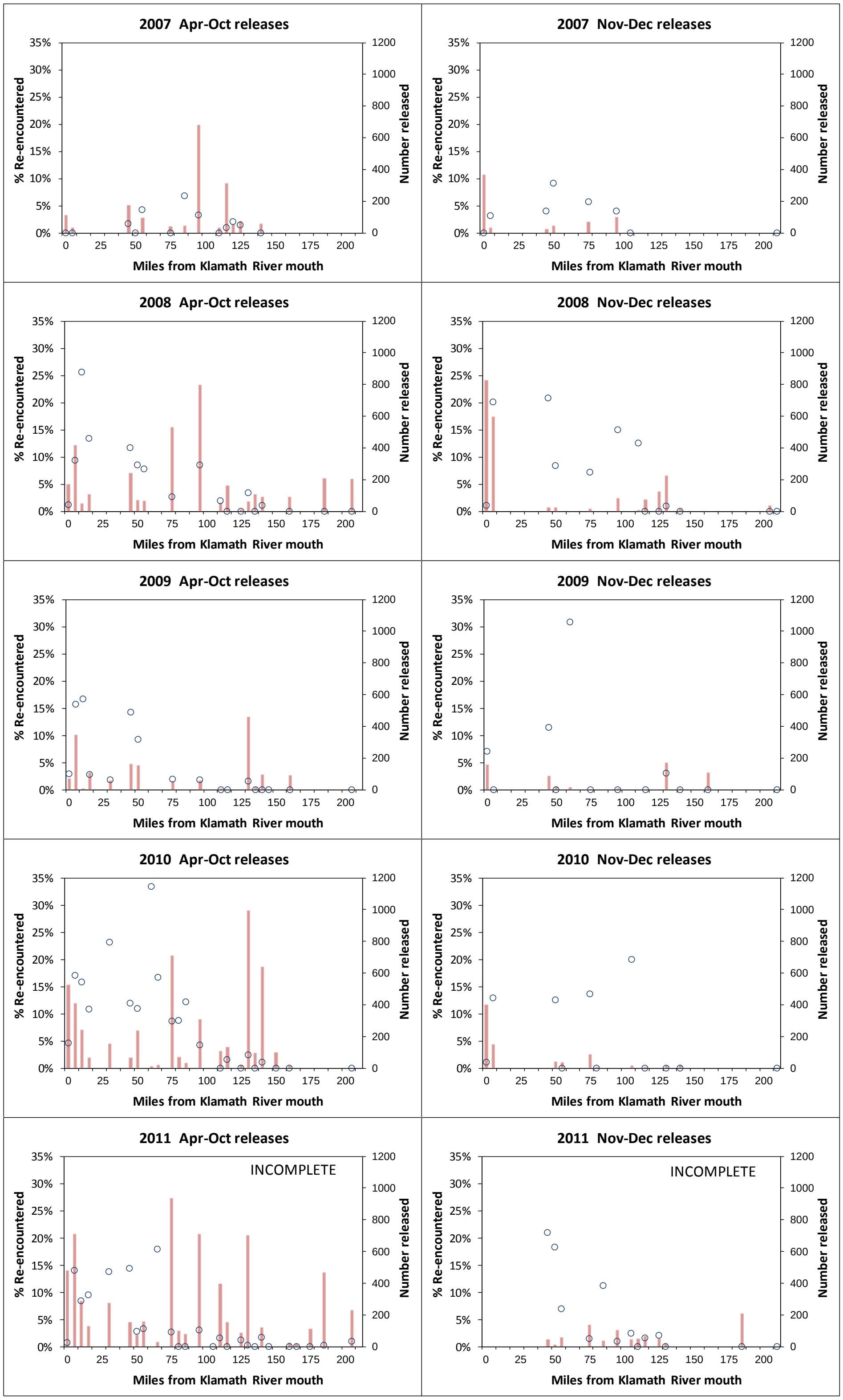


Figure 81. Re-encounter rates for coho PIT tagged at age-0 that moved from upstream of Trinity River to sites downstream (between GeoAreas if fish were tagged below Trinity River). Open circles show % re-encountered; bars show numbers of fish released. Results for 2011 releases are incomplete.

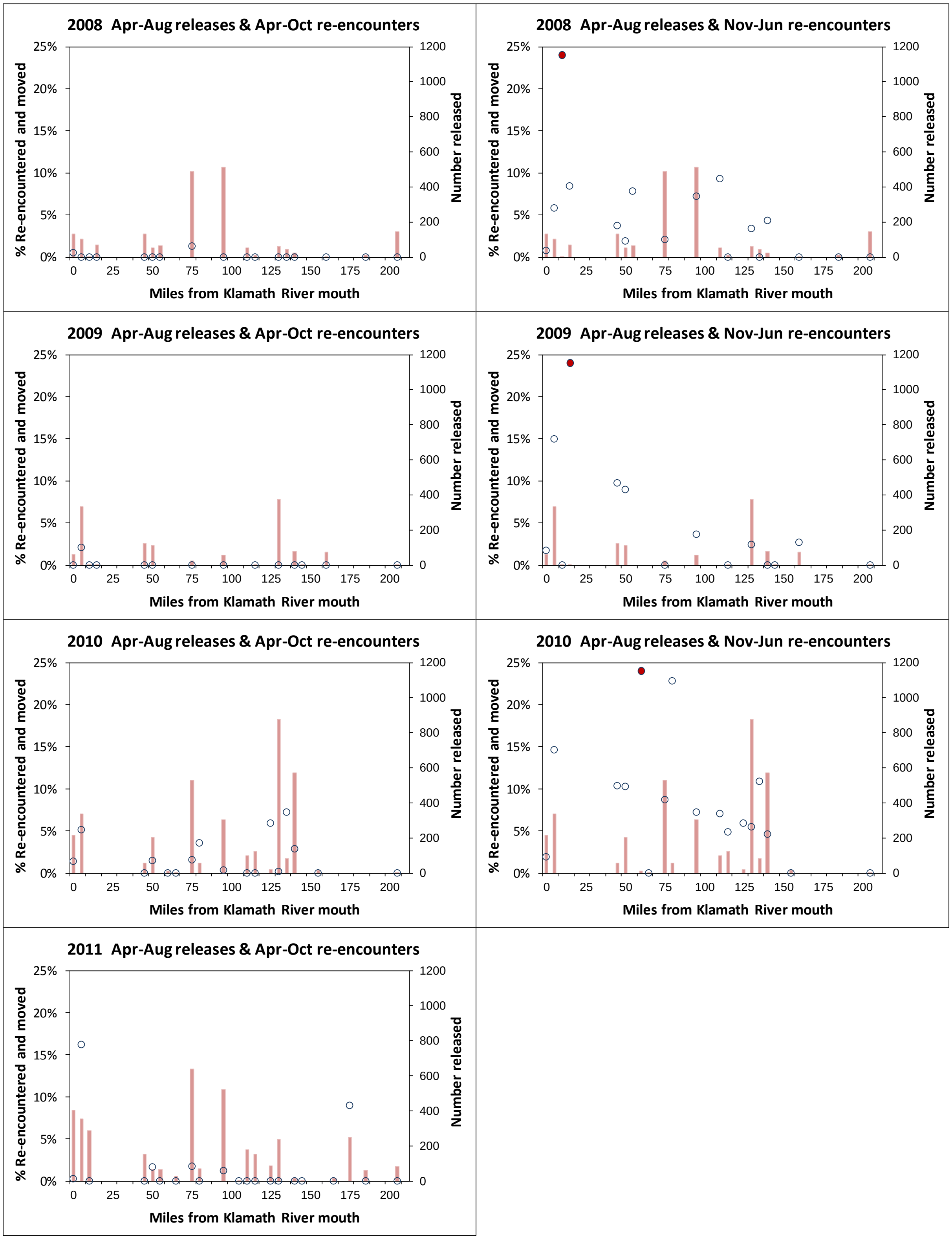


Figure 82. Re-encounter rates for coho PIT tagged at age-0 that moved from one GeoArea to another. Open circles show % re-encountered; bars show numbers of fish released. Solid red circles indicate that the value exceeded the upper end of the y-axis. Results for 2011 releases are incomplete.

ponds with connected egress channels. It is not uncommon for fish to travel 100 miles within the Klamath River mainstem corridor—some traveling farther—before taking up residence in a suitable overwintering site, if they survive the journey. Based on this study and others (see Lestelle 2007), low velocity habitats that are well protected from the high velocities of the mainstem river during winter (e.g., in off-channel ponds) generally provide the highest overwintering survival rates along with high growth rates.

The Klamath River mainstem corridor contains a very limited number of high quality summer and/or overwintering habitats (generally small in size with sparse distribution). This is also true of most of the spawning tributaries in the river basin. These conditions are at least partly (varies by subbasin) due to past and/or current land use practices (e.g., mining, road building, logging, agriculture) (NMFS 2014).

Despite limited availability of high quality habitats in summer and winter within the river corridor, the importance of the role of the corridor to juvenile coho may be much greater today than its historic role. Historically, when habitats in the Shasta and Scott rivers were intact, those streams would have been capable of supporting a diverse range of life histories. Both rivers would have been major producers of coho salmon (NMFS 2014). However, it is likely that as habitats in those river valleys have declined dramatically in quality and quantity due to land uses that a greater proportion of the juveniles produced there now rely on habitats within the Klamath River mainstem corridor. Lestelle (2009) reported such a pattern in the Clearwater River on the Olympic Peninsula in Washington. In that case, the effects of logging appear to have diminished the quality and quantity of overwintering habitats in tributary habitats, resulting in a trend for a greater proportion of juveniles relying on overwinter habitats within the mainstem river corridor.

The Karuk Tribe, working in conjunction with the Mid-Klamath Watershed Council, and the Yurok Tribe are engaged in restoring or creating new habitats within the Klamath River mainstem corridor having suitable thermal and/or velocity characteristics that attract—and hold—juvenile coho that are seasonally redistributing within the corridor. The premise is that by increasing the frequency of suitable refuge sites within the corridor (thereby making it easier for redistributing juveniles to find them), and strategically locating them in areas within or near natal tributaries, that survival and growth will be improved for fish that find and use them. As a result, the overall performance of the many population units in the basin whose juveniles use the mainstem corridor for rearing should be improved. The next project report, expected in spring 2016, covering years 2012 to 2015, will provide results on how juvenile coho are using restored/enhanced habitat sites.

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