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

Phase 1 Report
2006-07 Winter

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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 to be rotated annually between the two staffs.

DEDICATION

This report is dedicated to Scott Gibson, who passed away unexpectedly on June 14, 2008. Scott was passionate about his work in fisheries, and loved being on the river. Scott was full of knowledge, ingenuity, and was a perfectionist when it came to writing field notes, drawing maps, or 'dialing out traps'. Scott worked for the Yurok Tribal Fisheries Program for almost ten years, during which time he trained many biologists and rescued hundreds of juvenile coho, chinook, steelhead, and cutthroat as tributaries went subsurface in the late spring. He was instrumental in assessing the role of off-channel habitats to juvenile coho in the lower Klamath River. Scott will be greatly missed and was an irreplaceable part of our crew—he will hold a place in our hearts forever.

– Monica Hiner

Scott Gibson sampling juvenile coho, spring 2008

Executive Summary

In 2006, the U.S. Bureau of Reclamation (USBR) funded the Karuk and Yurok tribes to initiate a multi-year study to assess key aspects of seasonal life history patterns of juvenile coho (*Oncorhynchus kisutch*) 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 through March 2007. Following Phase 1, the scope of the study was broadened to address habitat utilization patterns of pre-smolt juvenile coho in all seasons.

This report presents results for Phase 1 activities, though it also includes some information collected in April-May 2007 for the sake of completeness.

The overall purpose of the study 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 term "mainstem Klamath River corridor" in this report is meant to encompass the main river channel and its side channels, off-channel habitats (alcoves, ponds, and groundwater channels associated with the floodplain), 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 purpose of Phase 1 activities was to perform a reconnaissance of potential types of coho overwintering habitats within the mainstem corridor and to evaluate various methods of capture and marking that could be effective at assessing overwintering habitat use. During the course of Phase 1, activities were expanded to initiate a level of semi-continuous monitoring at one site to begin assessing movement patterns.

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. 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. In addition, the study will provide needed information to guide the development of potential habitat enhancement and restoration projects to improve the survival of juvenile coho that use mainstem corridor habitats.

Project Objectives

The objectives of this multi-year study are:

1. Identify/describe habitats used by juvenile coho seasonally within the mainstem Klamath River corridor;
2. Assess relative rates of seasonal utilization by juvenile coho within the range of habitats in the mainstem corridor;
3. Assess seasonal movement patterns of juvenile coho into and out of habitats being used within 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. To the extent feasible, assess the relative distribution of juvenile coho within segments of the mainstem corridor between the Shasta River and the Klamath River (addressing this

objective is uncertain; if addressed, it would likely be during a fourth study year, but see below).

Objectives for Phase 1 activities (winter 2006-07) were much narrower in scope than the overall project objectives; they were:

1. Conduct a reconnaissance of different types of fall-winter habitats potentially used by juvenile coho within the mainstem Klamath River corridor;
2. Evaluate a range of fish sampling methods (including marking/tagging) across all types of potential fall-winter habitats.

Project Approach

The project has been designed to extend over a minimum of three years—having begun in 2006—and to consist of at least three phases or years:

Phase 1: Reconnaissance and methods evaluation;
Phase 2: Habitat identification and inventory, habitat utilization, and fish movement assessment; and
Phase 3: Completion of inventory, utilization, and movement assessments—with emphasis in this phase on assessing the extent of seasonal movements by expanding tagging efforts in the basin.

The study is being conducted in the mainstem Klamath River between the river mouth and the confluence of the Shasta River. Responsibilities have been divided so that Yurok staff are responsible for work conducted downstream of Trinity River, while Karuk staff are focusing on areas upstream of that point.

The sampling design for the project is formulated around the major events or factors that affect movement and habitat use patterns: life history stages (e.g., fry emergence, summer rearing, and overwintering), flow patterns and water temperature regimes. Due to the widely different characteristics of the mainstem river compared to the other adjoining habitats within the mainstem corridor (i.e., lower ends of tributaries and off-channel habitats), different strategies for sampling in these areas need to be applied.

Marking and tagging of fish and their subsequent recovery are key components of all aspects of the project. Phases 1 and 2 are aimed at developing the techniques and the overall distribution of effort of marking/tagging and recapture activities to culminate in the major emphasis on assessing movement patterns in Phase 3.

Reconnaissance of Overwintering Habitats

A reconnaissance of habitats potentially used for overwintering by juvenile coho was performed in both study areas as part of Phase 1. The purpose was to identify the types of habitats likely to be used, obtain a qualitative assessment of their distribution within the study area, and obtain initial information on how their characteristics change as a result of variation in flow.

We characterized patterns of flow variation within each of the study areas to aid in understanding the effects of flow on habitats of interest. Very different characteristics in annual peak flow and interannual flow variation exist within and between the study areas, corresponding to climate and geological patterns within the basin. These characteristics likely influence patterns of habitat residency and movement by juvenile coho during fall and winter differently within the two study areas.

Habitats of particular interest in this project are bank edge habitats and floodplain channels of various types along the mainstem Klamath River and the lower portions of tributaries within the mainstem corridor. These features tend to have physical and thermal characteristics most suitable to juvenile coho during summer and winter.

Within the mid-Klamath study area (upstream of Trinity River), habitats were described at the following sites:
  ➢ Seiad Creek;
  ➢ Cade Creek;
  ➢ Bulk Plant backwater and floodplain channel;
  ➢ Independence Creek floodplain channel;
  ➢ Sandy Bar Creek floodplain channel; and
  ➢ Mainstem river backwater pools and bank edge habitats.

Within the lower-Klamath study area (downstream of Trinity River), habitats were described at the following sites:
  ➢ Roaches and Tectah Creek confluences;
  ➢ Tarup Creek floodplain channel and ponds;
  ➢ McGarvey Creek;
  ➢ Resighini floodplain channel and ponds;
  ➢ Waukell Creek and Junior Creek Pond;
  ➢ Richardson Creek ponds;
  ➢ Salt Creek-Spruce Creek complex;
  ➢ South Slough complex; and
  ➢ Mainstem river bank edge habitats.

Evaluation of Fish Sampling Methods

The Phase 1 reconnaissance called for evaluating a suite of fish capture methods across the range of habitat conditions. Similarly, Phase 1 called for evaluating and gaining experience at marking and tagging juvenile fish under the field conditions that occur during winter.

Fish capture methods evaluated as part of Phase 1 were fyke net, seine, minnow trap, and fence-type trap. Snorkeling was used in limited situations to augment observations made with one of the other methods. In addition, the duration of operation of a rotary screw trap at Big Bar (RM 50) on the mainstem Klamath River was extended longer into the winter than in previous years.

In the mid-Klamath study area, we employed fyke net, seine, minnow traps, a rotary screw trap, and an upstream/downstream migrant trap in one tributary. The total amount of fishing effort

expended was 698 24-hr fishing periods for all capture methods combined, where each gear type fished on one day was counted as a 24-hr sampling period. A total of 133 juvenile coho were captured between all gear types and all locations sampled, substantially fewer than the number of steelhead and chinook caught. It bears noting that the coho fry recruitment in 2006 in the Klamath basin, which are the juveniles we sampled in winter 2006-07, was low.

In the lower-Klamath study area , fyke nets were used almost exclusively for capturing juvenile salmonids. We found very quickly after initiating the project that fyke nets were extremely effective in many types of habitats where coho would likely be found. Therefore, it was decided to concentrate efforts on fyke nets, deploying them extensively and intensively at sites within the study area. We deployed them extensively by sampling periodically at a variety of sites within the lower 8 miles of the river corridor. We also deployed them more intensively at several sites within the Waukell Creek drainage to begin collecting information on movement patterns.

The total amount of fishing effort expended with fyke nets at all sites combined in the lower river study area during Phase 1 was 321 24-hr fishing periods. A total of 503 juvenile coho were captured between all sampling sites combined. Catches of both steelhead and cutthroat were substantially larger.

Field crews in both study areas successfully implemented marking and tagging operations on juvenile coho during Phase 1. Activities were primarily aimed at familiarizing and training the crews with both freeze branding and PIT tagging. Fish were marked and tagged under a range of field conditions at several sites.

Freeze branding was determined to be an effective method of marking juvenile coho for subsequent mark detection upon recapture. We will continue using this procedure in year 2 of the project for fish too small to PIT tag.

PIT tagging is to be implemented at all sampling sites in year 2 of the study.

Movement Patterns

The assessment of juvenile coho movement patterns was originally to begin in year 2 of the project. Early in Phase 1, we concluded that it would be efficient to initiate some level of monitoring to begin the assessment immediately.

A set of fyke nets were deployed in the Waukel drainage to assess upstream and downstream movements past various sites. Some level of trapping occurred on a semi-continuous basis throughout the season at selected strategic sites, as well as at several other sites higher in the Waukell system to learn where fish were migrating to. Trapping occurred between mid November, 2006 and mid May, 2007.

We determined that fish were moving upstream into the two main branches of Waukell Creek upstream from the lower trap site -- Junior Creek and upper Waukell Creek. In Junior Creek, fish were found to be moving into a pond (0.6 acres in size). Fish were also found moving into a wetland marsh area in mainstem Waukell Creek upstream of the confluence with Junior Creek.

We concluded on the basis of sampling at various sites in the system and from mark recoveries that most coho were moving into Junior Pond, though a substantial number were also moving into upper Waukell Creek.

Upstream movement by juvenile coho was strongly correlated with mainstem river flow events between mid November and the end of December. The major immigration of coho into the creek from the mainstem Klamath River ended around the end of the calendar year. Thereafter, only occasional upstream movement occurred, excluding observations of young-of-the-year (YOY), regardless of flow levels in the mainstem river.

Juvenile coho, excluding YOY fish, displayed almost no downstream movement past the trap site until late March. Emigration then increased as yearling fish moved seaward as smolts.

The overall pattern that emerges is that juvenile coho moved from the mainstem in late fall and early winter during periods of high flow to find suitable overwintering habitat. Having found it, few or none left until their smolt migration. This pattern is one of high fidelity to good overwintering habitat. It suggests that the habitat upstream of the trap site is highly suitable for overwintering. We also concluded that most of the upstream migrants moved into Junior Pond, with others moving into the wetland marsh.

Outmigrant smolts were exceptionally large, indicating high rates of growth within Waukell Creek. Large smolts are indicative of overwintering conditions that produce high overwinter survival rates. Large smolts also often experience higher marine survival rates than smaller smolts.

Project Refinements and Recommendations

We foresee implementing the following refinements to the project in the next phases:

Identification and characterization of overwintering habitats
- Complete the inventory of potential overwintering habitats within the study areas by identifying locations of the various habitat types used for overwintering; and
- Improve the characterization of connectivity of floodplain channels and ponds to the mainstem river.

Assessment of relative utilization rates of habitats by juvenile coho
- Expand the sampling coverage for fish utilization to more overwintering sites in both study areas;
- Initiate sampling of mainstem edge and backwater habitats using a boat electrofisher following the basic study design applied by Beechie et al. (2005);
- Intensify sampling in the various channels of the South Slough over the course of one fall-winter period to assess relative distribution and residency; and
- Implement full-scale marking and tagging coverage—with strong emphasis on PIT tagging—to characterize durations of residency at index sites associated with various habitats.

<u>Assessment of seasonal movement patterns</u>
  - ➢ Implement full-scale marking and tagging coverage in all seasons—with strong emphasis on PIT tagging, expanding opportunities for recovery of marks and tags; these data will be used to assess the extent and patterns of seasonal movements within the mainstem corridor; marking and tagging should occur mostly at strategic sites within the corridor where fish are likely to move with environmental stimuli or at sites believed to be contributors of juvenile fish into the corridor; and
  - ➢ Expand coverage for fish recapture by systematically operating fish capture gear at a cross section of habitat types within both study areas.

<u>Assessment of juvenile fish performance within the river corridor</u>
  - ➢ Assess survival at several key sites where numbers of fish entering and leaving can be reliably monitored—data collected will also enable other measures of performance to be described, i.e., growth and length of residency; and
  - ➢ Assess fish size, growth, and habitat residency systematically at sites representative of the range of habitats used to some extent.

We anticipate a very significant expansion of use of PIT tags to assess movement patterns, habitat residency, and performance. We also anticipate formulating refinements to the study design to more effectively use PIT tag recoveries as a way of assessing seasonal survival rates in different habitats or areas of the river basin.

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The Role Of The Klamath River Mainstem Corridor In The Life History And Performance Of Juvenile Coho Salmon (*Oncorhynchus kisutch*) - Phase 1

1.0 Introduction

In 2006, the U.S. Bureau of Reclamation (USBR) funded the Karuk and Yurok tribes to initiate a multi-year study to assess key aspects of seasonal life history patterns of juvenile coho (*Oncorhynchus kisutch*) 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 through March 2007. Following Phase 1, the scope of the study was broadened to address habitat utilization patterns of pre-smolt juvenile coho in all seasons.

This report presents results for Phase 1 activities, though it also includes some information collected in April-May 2007 for the sake of completeness. Fish that overwintered in 2006-07 were emigrating from habitats in April and May and observations made in those months help show patterns of habitat usage during winter.

The overall purpose of the study 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 term "mainstem Klamath River corridor" in this report is meant to encompass the main river channel and its side channels, off-channel habitats (alcoves, ponds, and groundwater channels associated with the floodplain), 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 purpose of Phase 1 activities was to perform a reconnaissance of potential types of coho overwintering habitats within the mainstem corridor and to evaluate various methods of capture and marking that could be effective at assessing overwintering habitat use. During the course of Phase 1, activities were expanded to initiate a level of semi-continuous monitoring at one site to begin assessing movement patterns.

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. 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. In addition, the study will provide needed information to guide the development of potential habitat enhancement and restoration projects to improve the survival of juvenile coho that use mainstem corridor habitats.

1.1 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 patterns of water temperature (Mike Deas, *personal communications*) and river flow (derived using USGS data) for the lower Klamath River. Evidence exists that juvenile coho movements within the mainstem corridor of this river are related to these patterns.
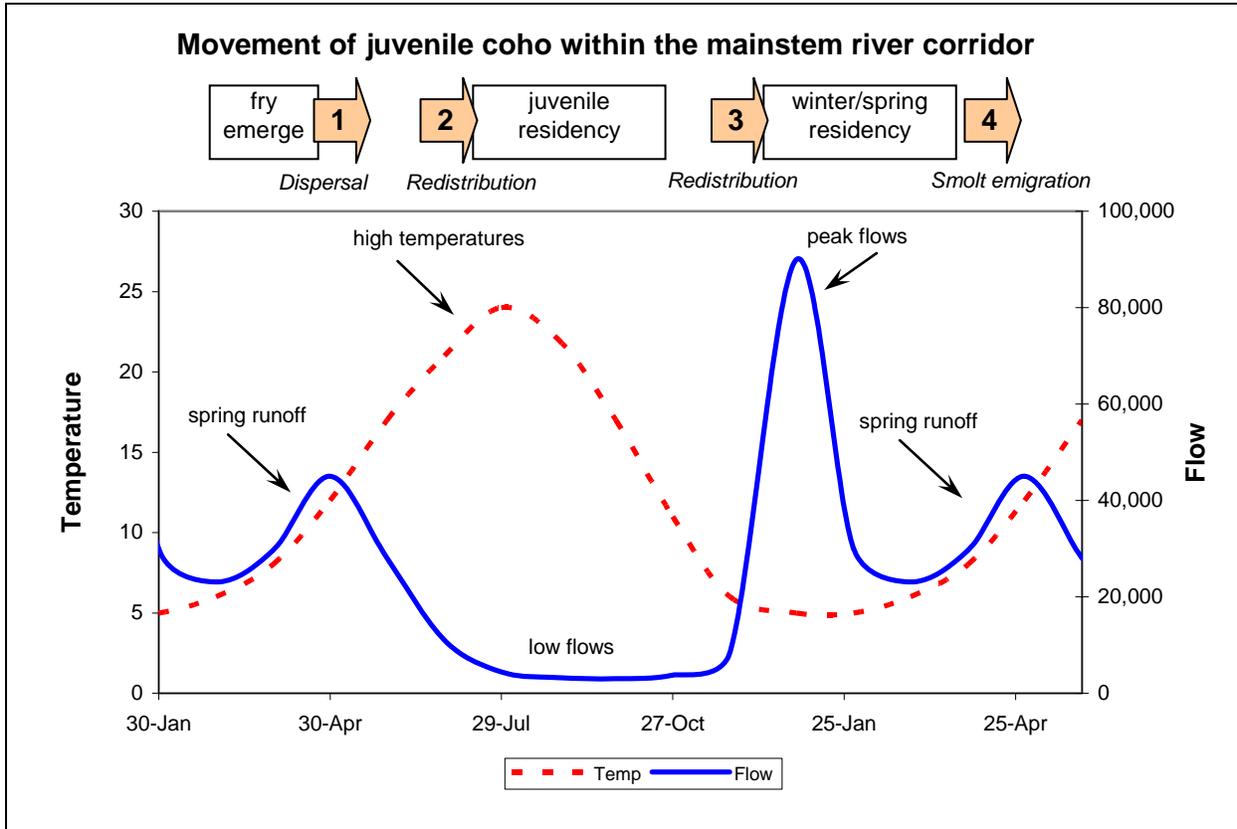
Figure 1. Movement patterns of juvenile coho expected within the mainstem Klamath River corridor corresponding to temperature and flow patterns. (1) Fry that disperse from natal tributaries enter the mainstem corridor during spring runoff. (2) Some juveniles within corridor habitats move again in early summer with rising water temperatures in search of thermal refuge. Little movement is believed to occur 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.

These movement patterns of juvenile coho can generally be described as follows. Immediately following emergence from spawning gravels during spring[1], some coho fry disperse downstream. In rivers fed by snow-pack, 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 mainstem rivers are primarily edge units along the river shoreline or within backwater units (Beechie et al. 2005; Lestelle 2007). Some of these dispersing fry can also move

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[1] / Spawning principally occurs in tributaries to mainstem rivers for wild fish, though it occurs to a limited extent in some areas of mainstem rivers under certain conditions (see Lestelle 2007).

into off-channel habitats, such as ponds and groundwater 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 can initiate another movement in search of thermal refuge. This pattern of movement has been observed in the Umpqua River (Kruzic 1998) and appears to occur in the Klamath basin. Some juveniles are known to find areas that provide thermal relief in the mainstem Klamath River corridor (Sutton et al. 2002; Deas and Tanaka 2006; Sutton 2007), either at sites in the mainstem river or in the lower reaches of cool water tributaries. 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, though some movement over short distances is known to occur (Kahler et al. 2001). We hypothesize that limited movement would occur if the fish had been concentrated into thermal refugia that do not have adequate cover or food.[3] 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). These movements are known to cover up to 40 miles in some rivers and it is suspected that distances traveled might exceed 250 miles in some cases, such as in the Fraser River (see discussion in Lestelle 2007). Large numbers of fish have been found immigrating into very small off-channel habitats adjacent to mainstem 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.

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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 suggest 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. 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 one case by documenting travel of one fish (PIT tagged) of approximately 12 miles between two tributaries (Tom Martin and Fort Goff creeks) to the mainstem river.

[3] / The documented movement by the PIT tagged fish mentioned in footnote 2 provides evidence for this hypothesis.

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 high growth in early spring, surviving juvenile coho begin the smolt transformation and start their seaward migration.

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

1.2 Project Objectives

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

6. Identify/describe habitats used by juvenile coho seasonally within the mainstem Klamath River corridor;
7. Assess relative rates of seasonal utilization by juvenile coho within the range of habitats in the mainstem corridor;
8. Assess seasonal movement patterns of juvenile coho into and out of habitats being used within the mainstem corridor;
9. Assess measures of seasonal performance of juvenile coho to the extent feasible (growth, survival, length of residency in different habitats); and
10. To the extent feasible, assess the relative distribution of juvenile coho within segments of the mainstem corridor between the Shasta River and the Klamath River (addressing this objective is uncertain; if addressed, it would likely be during a fourth study year, but see below).

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 are to be identified and described.

Objective 2 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 the different habitats within the corridor, e.g., which habitats have the most affinity for juvenile coho. (This objective does not endeavor 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 3 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 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.[4] 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.

Objective 5 is not planned to be addressed during the three-year period of the study unless work to meet the other objectives is progressing ahead of schedule and resources exist to pursue this item. The objective is listed here to keep it identified as being important to the overall purpose of the study. This objective addresses the question: What is the relative distribution of juvenile coho by season within the mainstem corridor between the Shasta River the Klamath River mouth? The other objectives are being addressed by focusing on selected study reaches. Habitat types within those study areas are to be described and sampled. However, to more fully assess the role of the mainstem corridor in the life history of juvenile coho also requires a broader perspective that considers how the fish are distributed by season over the entire river length of interest. Knowledge about the relative distribution over the entirety of the river's length would be of value in targeting areas for habitat enhancement or restoration.

Objectives for Phase 1 activities (winter 2006-07) were much narrower in scope than the overall project objectives; they were as follows:

3. Conduct a reconnaissance of different types of fall-winter habitats potentially used by juvenile coho within the mainstem Klamath River corridor;
4. Evaluate a range of fish sampling methods (including marking/tagging) across all types of potential fall-winter habitats.

These objectives served to launch the project in the fall of 2006. At that time, Phase 1 was considered a pilot phase to determine the feasibility for moving the project forward. However, during the course of Phase 1 work, we concluded that it would be efficient to initiate work to begin addressing objective 3 of the overall study, i.e., to assess movement patterns into and out of a selected overwintering site. Hence, activities were modified accordingly from the original work plan for Phase 1.

1.3 Organization of Report

The report is organized into six sections:
1. Introduction
2. Project approach
3. Reconnaissance of overwintering habitat
4. Evaluation of fish sampling methods
5. Assessment of movement patterns

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[4] / 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).

6. Project refinements and recommendations

2.0 Project Approach

The project has been designed to extend over a minimum of three years—having begun in 2006—and to consist of at least three phases or years:
  Phase 1: Reconnaissance and methods evaluation;
  Phase 2: Habitat identification and inventory, habitat utilization, and fish movement assessment; and
  Phase 3: Completion of inventory, utilization, and movement assessments—with emphasis in this phase on assessing the extent of seasonal movements by expanding tagging efforts in the basin.

Phase 1 was intended to be a pilot phase. The Klamath River is a large and dynamic river, posing significant challenges for observing and capturing juvenile salmonids at some times of the year, particularly in winter. Prior to initiation of the study, we were uncertain what methods would be most effective for the study. Therefore, the study was intended at the outset to be adaptive. Project activities in Phases 2 and 3 would need to be adapted to knowledge gained in an earlier phase. Phase 1 was to consist principally of a reconnaissance of habitats potentially used for overwintering by juvenile coho, in conjunction with an evaluation of methods that could be used to capture and mark/tag fish at those locations.

The project is intended to be collaborative with other studies in the basin. Work undertaken in this study is being coordinated with other startup or on-going projects of relevance to this one. For example, efforts are being taken to encourage and coordinate marking and tagging of juvenile coho at sites higher in the watershed. This study will provide extensive opportunities for recapturing marked/tagged fish to assess juvenile movement patterns and growth rates in the basin during winter. In particular, it is expected that brood year 2007 will be a strong year class. Therefore, we are coordinating with other entities in the basin to expand PIT tagging efforts on young-of-the-year juveniles in 2008.

The study is being conducted in the mainstem Klamath River between the river mouth and the confluence of the Shasta River. Responsibilities have been divided so that Yurok staff are responsible for work conducted downstream of Trinity River, while Karuk staff are focusing on areas upstream of that point (Figure 2). A scientific advisor with extensive experience in studying coho life history is providing assistance in study design, implementation, and analysis.

The sampling design for the project is formulated around the major events that affect movement and habitat use patterns (Figure 3). Due to the widely different characteristics of the mainstem river compared to the other adjoining habitats within the mainstem corridor (i.e., lower ends of tributaries and off-channel habitats), different strategies for sampling in these areas need to be applied.

Sampling within the mainstem river is to be conducted during specific time windows following periods of expected redistributions (Figure 3). During these time windows, residency within the various habitat types is expected to be relatively stable. Within off-channel habitats and the

lower portions of non-natal and natal tributaries, sampling using capture gear or by snorkel observations is to occur during both the periods of movement and the time windows when stable residency should prevail (Figure 3). Sampling at these locations (i.e., out of the mainstem) during expected periods of movement will provide empirical data on movement timing and relative extent of movement.
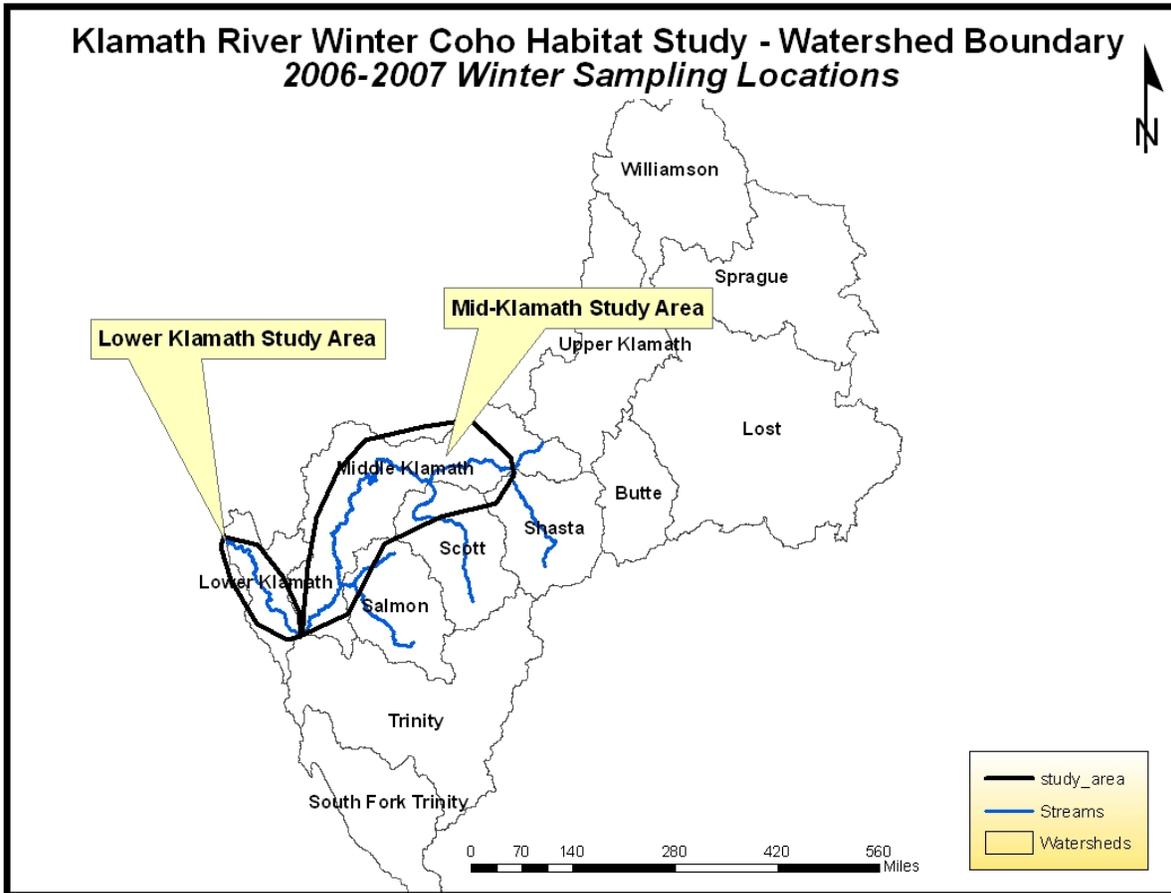
Figure 2. Study areas within the mainstem Klamath River corridor. Yurok staff are responsible for activities in the lower river study area. Karuk staff are responsible for activities in the mid-Klamath study area.

Marking and tagging of fish and their subsequent recovery are key components of all aspects of the project. Phases 1 and 2 are aimed at developing the techniques and the overall distribution of effort of marking/tagging and recapture activities to culminate in the major emphasis on assessing movement patterns in Phase 3.

3.0 Reconnaissance of Overwintering Habitats

A reconnaissance of habitats potentially used for overwintering by juvenile coho was performed in both study areas as part of Phase 1. The purpose was to identify the types of habitats likely to

be used, obtain a qualitative assessment of their distribution within the study area, and obtain initial information on how their characteristics change as a result of variation in flow.
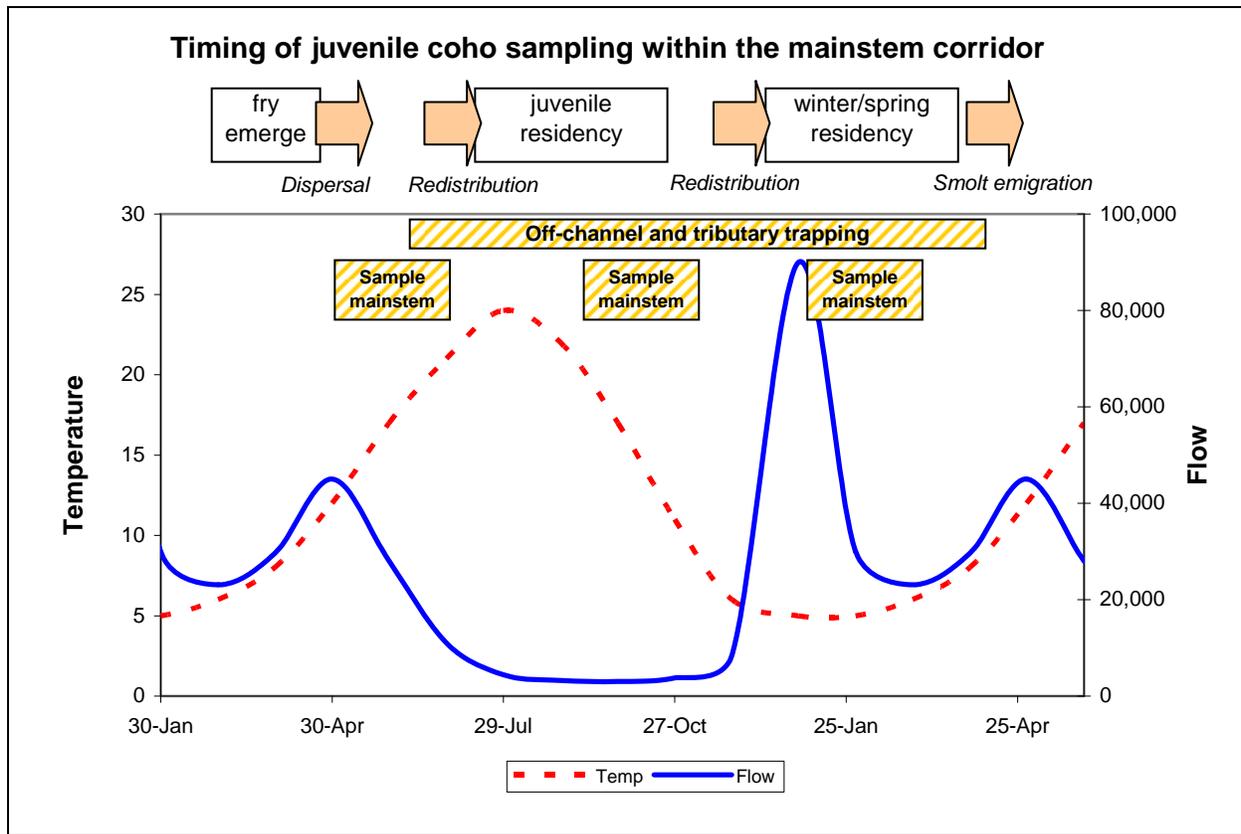
Figure 3. Timing of sampling within the mainstem Klamath River corridor during spring, summer, fall, and winter seasons. Sampling will occur as part of separate but related studies. Off-channel sites and the lower portions of selected tributaries will be sampled using a variety of capture and observation methods. Mainstem river habitats will be sampled during three periods: (1) following fry dispersal and prior to the redistribution associated with rising temperature; (2) after temperature related movements have ceased and prior to the fall/winter redistribution; and (3) following the fall/winter redistribution.

3.1 Methods

Habitats of potential interest in this project can be classified by their channel type and, at least for in-channel habitats, by mesohabitat type (Figure 4). Habitats within the Klamath River estuary can be classified by the same types, since the estuary is largely contained within the forested riverine/tidal zone, where habitat types are generally comparable to those upstream, though often on a larger scale.[5]

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[5] / The forested riverine/tidal zone is the most upstream zone within a river-mouth estuary, such as the Klamath estuary. This zone, while tidally influenced, has little or no salinity, depending on river flow. The dominant vegetation types are forested wetlands (Hayman et al. 1996; Haas and Collins 2001).

Channel and habitat types of particular interest in this study are side channels and off-channels, due to their strong attraction for juvenile coho, especially in winter (Lestelle 2007). These geomorphic features tend to be associated with the inside of meander bends. While scientists find it helpful to categorize them into types, they really are a continuum of features caused by channel migration and floodplain formation (as illustrated, for example, in Figure 5). For the sake of this report, we often refer to these channels as simply "floodplain channels" due to uncertainty about distinguishing characteristics. Our understanding of these sites is expected to improve as more observations are made across a wider range of flows than occurred in winter 2006-07.
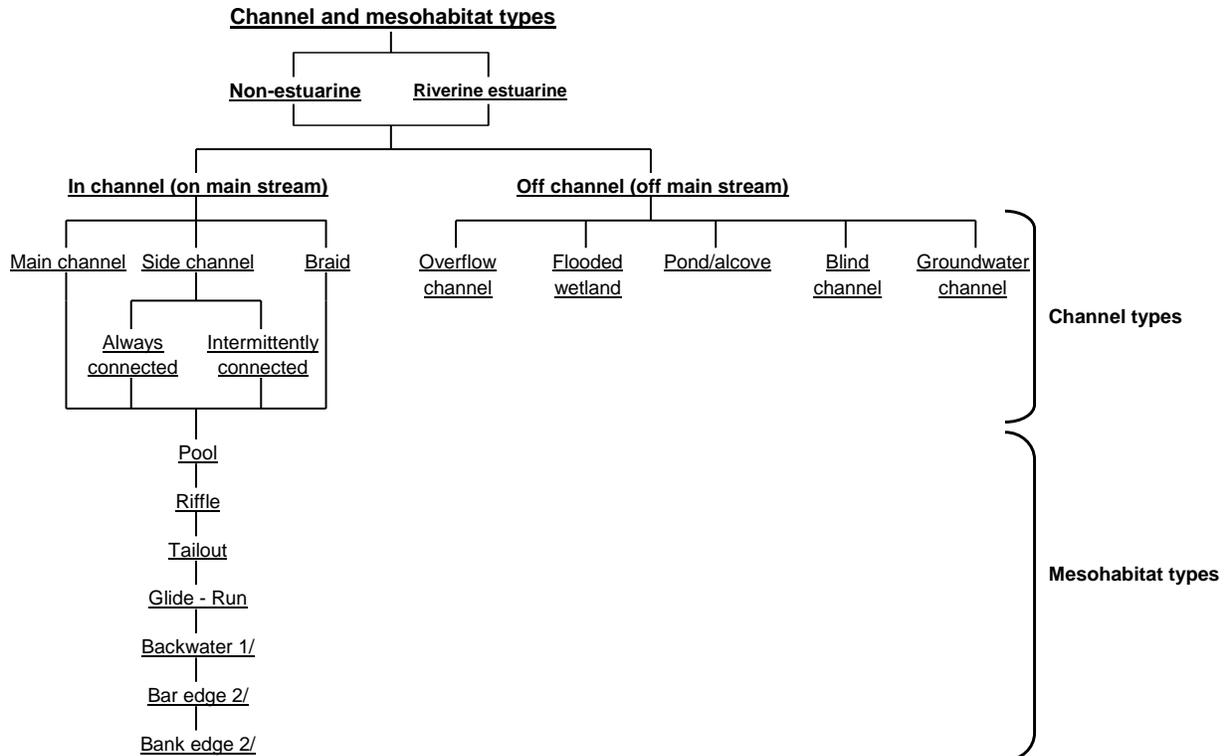
1/ Backwater units often form at mouths of remnant channels. Confluences of small tributaries (either intermittent or perennial) may also form backwater units adjoining the larger channel. Expansion eddy units, as defined by Schwartz and Herricks (2005), are considered backwater units here.
2/ Slow velocity channel margin units. These sites include deflection eddy units and hydraulic dead zone units associated with margins as defined by Schwartz and Herricks (2005).

Figure 4. Channel and mesohabitat types. The distinction between an intermittently connected side channel and an overflow channel depends on frequency of connection to the main stream. Due to uncertainty about connection frequency, we sometimes refer to these channels as simply floodplain channels in this report.

To the extent feasible, those habitat types that might be used by juvenile coho during the fall-winter seasons, excluding periods of active migration, were identified within the study reaches and generally described. Photos served to document physical characteristics of the sites. Most of the sites were visited multiple times during the season to learn how flow dynamics affected habitat characteristics.

To aid in understanding the effects of flow on habitats of interest, we characterized patterns of flow variation within each of the study areas. This allowed us to assess how typical the flows in

fall and winter of 2006-07 were compared to other years, and to compare flow patterns between study areas. Differences in flow patterns between the study areas might affect habitat presence (i.e., whether off-channel sites become sufficiently watered every year), stability, and accessibility to juvenile coho. We examined variation in annual peak flow, peak flows with recurrence intervals of both 1.5 and 2.0 years, and interannual variation in daily flow patterns. Bankfull discharge occurs with a recurrence interval of every 1.5-2.0 years on average for most rivers (Leopold et al. 1964). It is the flow level that generally governs the size and shape of the channel (Gordon et al. 2004), and serves to provide connectivity to various types of off-channel habitats. How peak flow in any given year compares to bankfull flow might also serve as an index on the severity of high flow events in regards to both survival and extent of movement by overwintering juvenile coho.
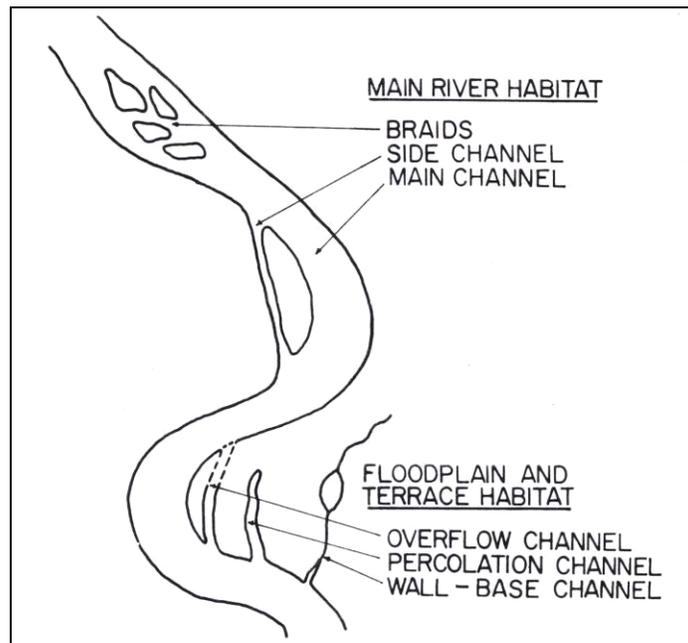
Figure 5. Main river and off-channel channel types as described by Peterson and Reid (1984) with reference to use by juvenile coho in the Pacific Northwest.

To compare interannual variation in annual peak flows between sites, we computed both coefficient of variation (C_v) and the index of variation (I_v), as described in Gordon et al. (2004). The former is a more commonly used measure of variability in flow, while the latter metric, also called the flash flood index, has been related to some general characteristics of flow patterns deemed useful here (see Earth Systems Institute 2005). High values of I_v are characteristic of semi-arid to arid regions and reflect low frequency of flood flows but which are severe in magnitude relative to more normal peak flows. Low values of I_v are more characteristic of coastal wet regions where flood flows are more common. Hence we would expect that values of I_v would increase moving from the coastal area to the interior of the Klamath basin.

We used data from four stream gauges for assessing flow patterns:
 ➢ Indian Creek at Happy Camp (USGS 11521500)(Indian Creek enters the Klamath River at RM 111);

> ➢ Seiad Valley gauge on the mainstem Klamath (USGS 11520500)(RM 129);
> ➢ Orleans gauge on the mainstem Klamath (USGS 11523000)(RM 59); and
> ➢ Terwer gauge near town of Klamath on the mainstem Klamath (USGS 11530500)(RM 6).

The Indian Creek gauge served as a way of examining tributary runoff localized to the mid portion of the middle Klamath study area. The Seiad Valley and Orleans gauges on the mainstem Klamath served to assess changes in flow patterns between the middle and lower parts of the middle Klamath study area. The Terwer gauge, located just upstream of the Klamath estuary, served to assess flow patterns in the lower Klamath study area.

At the time of preparing this report, USGS had not yet reported the peak flows for the gauge sites of interest for Water Year (WY) 2007 (October 1, 2006-September 30, 2007), even though preliminary daily average values were available on the USGS web site. For this report, we estimated the peak flows from linear regressions of peak flows versus the maximum daily average value using data for WYs 1997-2006. Each of the regressions was highly significant with r^2 values exceeding 0.98 for each mainstem site and 0.92 for Indian Creek.

3.2 Results

We present results of our analysis of flow patterns for each of the study areas, followed by descriptions of habitats potentially used for overwintering by juvenile coho within the mainstem Klamath River corridor.

3.2.1 Flow Variation

The severity of fall and winter high flow events on the mainstem Klamath River in 2006-07 was less than what occurs during an average fall and winter (Table 1). Peak flows at the three mainstem stream gauges were between 48 to 60% of the median (2-yr recurrence interval) peak flows for the periods of record. Peak flows were also less than flow levels estimated for the 1.5 recurrence intervals. Hence, bankfull flows—as measured by the three mainstem gauges—were not exceeded during fall and winter 2006-07. Peak flows in at least some tributaries, e.g., Indian Creek, were much closer to their long term average, and appear to have reached bank flow levels during 2006-07.

Peak flow patterns for the periods of record for the four stream gauges are shown in Figures 6 and 7. It is noteworthy how much peak flows along the mainstem Klamath River increase moving downstream from the interior region to the river mouth. The median peak flow increases by more than a factor of 3 between the Seiad Valley and Orleans gauges, a distance of 70 river miles, then by another factor of 2.4 between Orleans and the river mouth, a distance of roughly 50 river miles. These increases are principally due to the entry of major tributaries, notably, Indian Creek, Clear Creek, Salmon River, Trinity River, and Blue Creek.

Table 1. Peak flows in Water Year 2007 at four stream gauging stations in the Klamath basin, estimated peak flows with 1.5 and 2.0 year recurrence intervals (RI), and average peak flows. Seiad Valley, Orleans, and Klamath are located on the mainstem Klamath River. All flow units are in cfs.

Site	WY 2007 peak [1]	1.5 yr RI	2.0 yr RI	Average peak	Water years [2]	Drainage area (mi^2)
Seiad Valley	9,551	13,495	19,700	30,902	1952 - 2006 [3]	6,940
Orleans	52,351	57,229	67,600	96,273	1952 - 2006 [3]	8,475
Klamath	99,964	136,279	164,500	194,800	1963 - 2006 [4]	12,100
Indian Cr	6,720	4,680	6,780	8,220	1956 - 2006 [5]	120

1/ Peak flows for WY 2007 estimated as described in text.
2/ Statistics computed with peak flow data reported by USGS, hence WY 2007 is excluded from the computations.
3/ Years prior to 1952 were not included in the analysis because that period appeared to reflect a different climate regime.
4/ Years prior to 1963 were excluded due to the completion of Lewiston Dam on the upper Trinity River in 1962 and the corresponding change in the flow regime in that river.
5/ Period of continuous record.

Measures of variability in annual peak flow between the gauge sites are consistent with differences expected between coastal and interior regions (Table 2). The index of variability (I_v) value at the Seiad Valley gauge exceeds 0.40, while the index value decreases at Orleans and drops again near the river mouth. Earth Sciences Institute (2005) states that values in the range 0.4-0.9 are characteristic of semi-arid to arid areas, while values less than 0.4 occur within Pacific Northwest coastal areas. Values greater than 0.4 indicate that floods occur infrequently but are severe relative to median peak flow events when they occur. Values less than 0.4 indicate more frequent flood levels with severity closer to the median condition. Indian Creek, which is located within the interior though not in the highly arid region to the east, has an I_v more similar to the coastal region, indicating more frequent flooding than what occurs on the mainstem upstream of this point. Hence, tributaries in the western half of the middle study area have peak flow patterns more comparable to the coastal area, while the peak flow pattern for the mainstem displays a transition between the coast and the arid region to the east.

Table 2. Measures of flow variability at four stream gauging stations in the Klamath basin: coefficient of variation (C_v) and index of variation (I_v) on annual peak flows and the high flow to low flow ratio using the median annual peak flow (i.e., 2.0 yr recurrence interval). Seiad Valley, Orleans, and Klamath are located on the mainstem Klamath River. Flow units are cfs.

Site	C_v	I_v	Low flow [1]	2.0 yr RI	High flow/low flow ratio
Seiad	108.9%	0.42	1,068	19,700	18.4
Orleans	76.6%	0.36	1,612	67,600	41.9
Klamath	65.9%	0.32	2,761	164,500	59.6
Indian Cr	81.4%	0.34	37	6,780	184.2

Seiad Valley (Rm 129)

Orleans (RM 59)
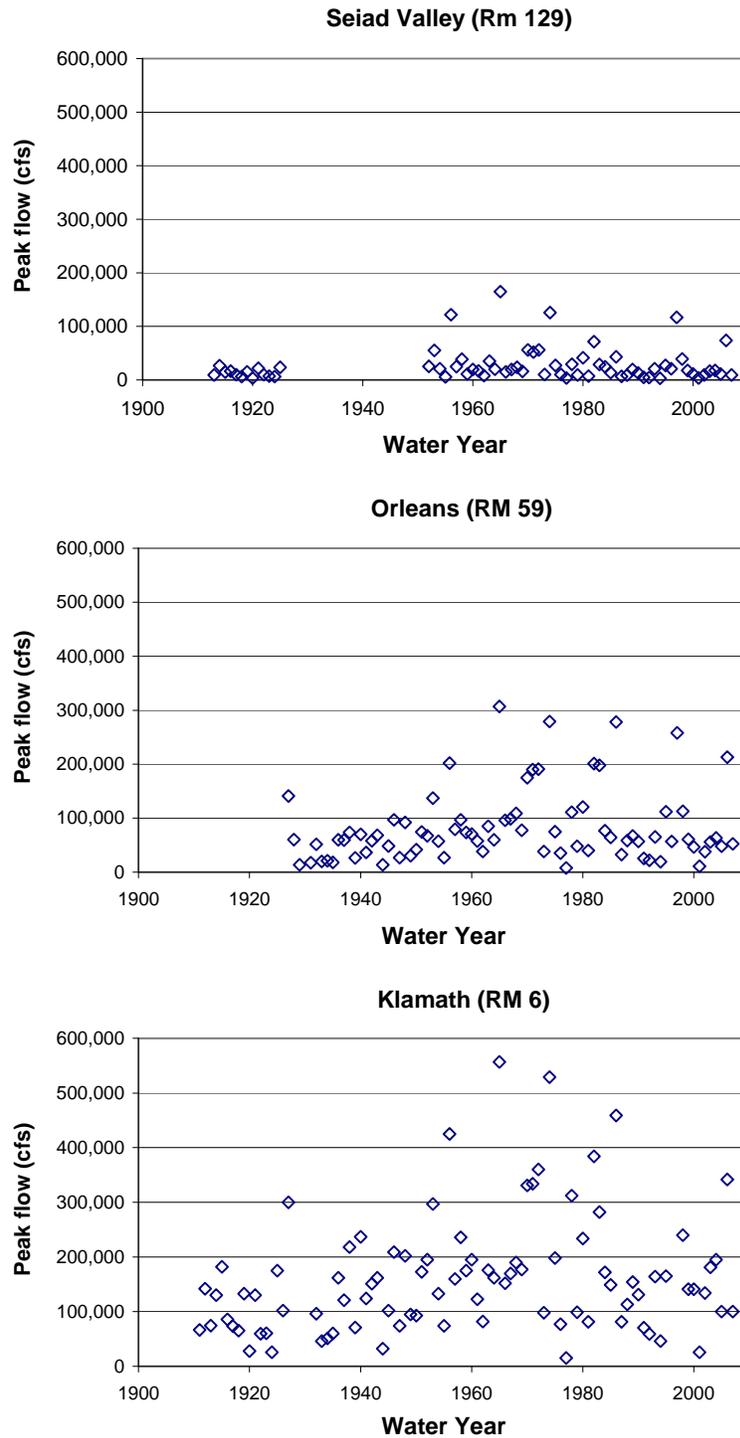
Klamath (RM 6)

Figure 6. Annual peak flows at Seiad Valley (RM 129), Orleans (RM 59), and Klamath (RM 6) on the mainstem Klamath River. The most recent data point displayed for each site is WY 2007.
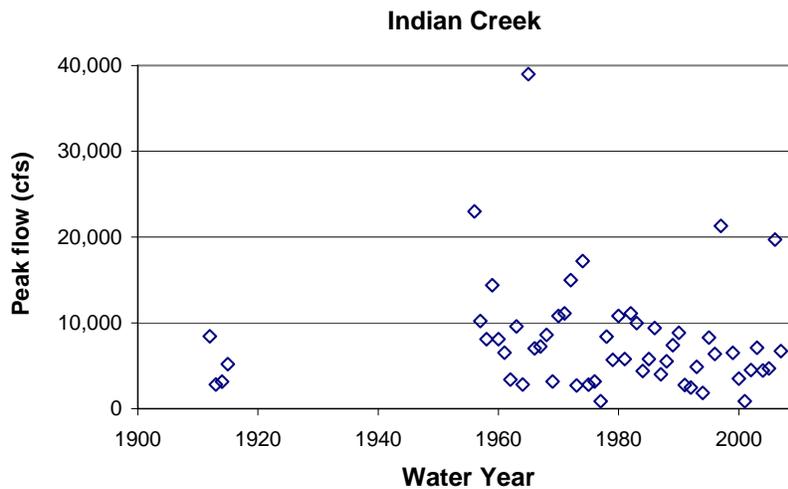
Indian Creek

Figure 7. Annual peak flows in lower Indian Creek, which enters the Klamath River at RM 111. The most recent data point displayed is for WY 2007.

The pattern of variation in annual peak flow along the mainstem Klamath River correlates to peak flow/low flow ratios seen at each of the mainstem stream gauges (Table 2). The ratios—computed using median annual peak flow—show increasing values moving downstream on the mainstem Klamath River. The median annual peak flow at Seiad Valley is 18X the average low flow at that point, while near the river mouth, the median peak flow is 60X the average low flow. Orleans shows an intermediate value. The peak flow/low ratio in Indian Creek—exceeding 180— is significantly higher than seen in the mainstem, illustrating a strong response to storm events that occur on average every other year. These differences in high flow to low flow ratios may lead to different patterns of residency and movement by juvenile coho between the areas during fall and winter.

Patterns of average daily flows for each of the four stream gauges over the most recent ten years (WYs 1998-2007) are presented in Figures 8-11. The patterns seen in WY 2007 generally appear to be intermediate to the extremes of drought and wet years seen during that period. It bears noting the fundamental difference in the patterns between the most upstream gauge and the lowermost one. The largest magnitude of runoff occurs during fall and winter in the lower river downstream of Trinity River, where the spring runoff pulse is comparatively much less.[6] In contrast, the magnitude of the fall and winter runoff at Seiad Valley is more comparable to the spring runoff pulse with only occasional years showing a much greater response during winter. The patterns at Orleans are intermediate between the Seiad Valley and Klamath gauges. The patterns in Indian Creek tend to be more like those at the Klamath gauge than at the Seiad Valley gauge.

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[6] / It should be noted that the spring runoff pulse in the lower Klamath River has been affected by the Trinity River Diversion (TRD) project in the upper Trinity River. The largest effect of the TRD to the Trinity River's flow regime occurs in the spring, during filling of Trinity Reservoir. Construction of the TRD was completed in 1962. See NRC (2004) for a concise description of how the Klamath River hydrograph has been affected by the TRD.

Klamath Gauge on Klamath River (RM 6)
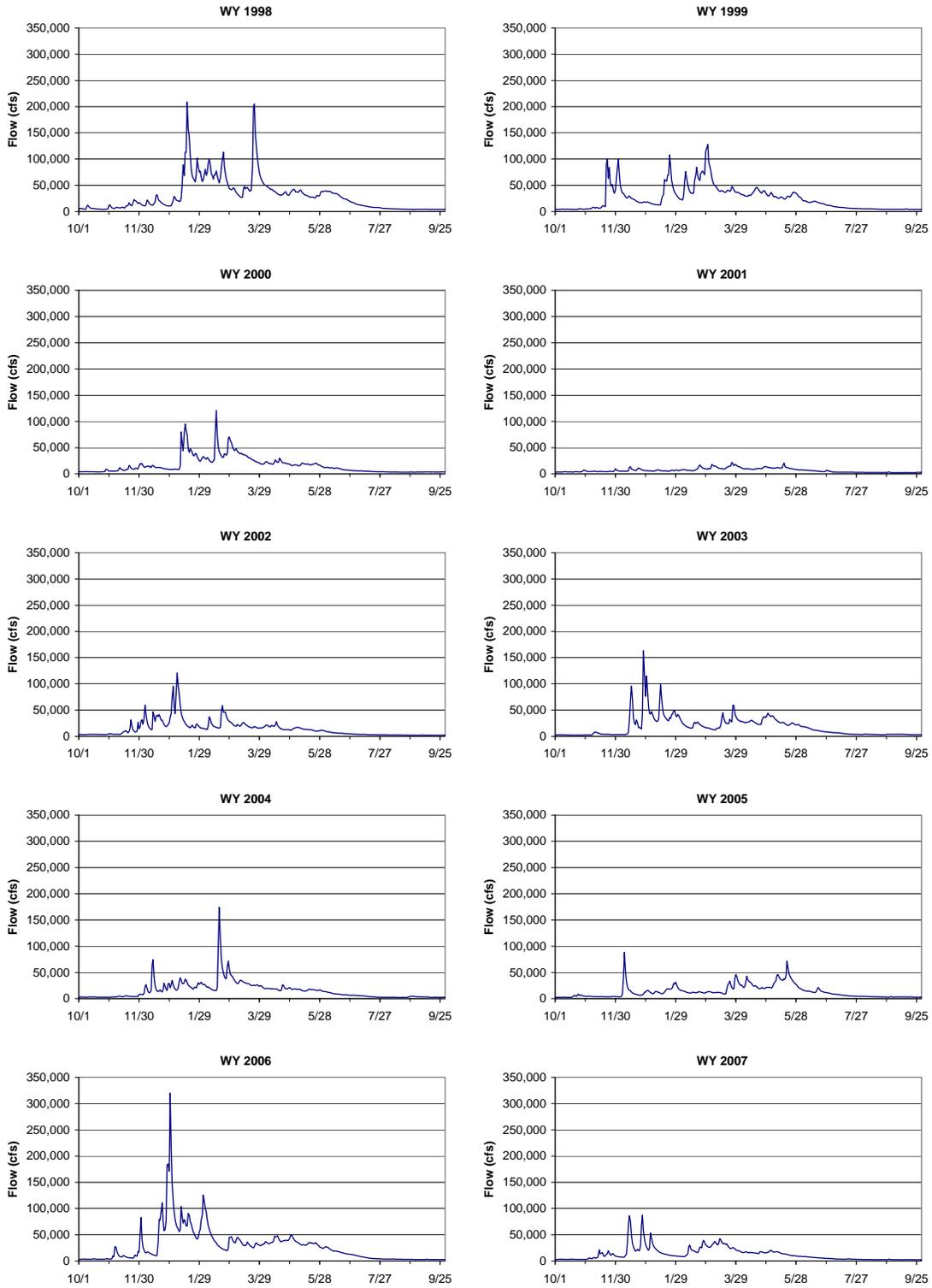
Figure 8. Daily flow at the Klamath gauge site on the mainstem Klamath River (RM 6) in WYs 1998-2007. Gauge site is USGS 11530500.

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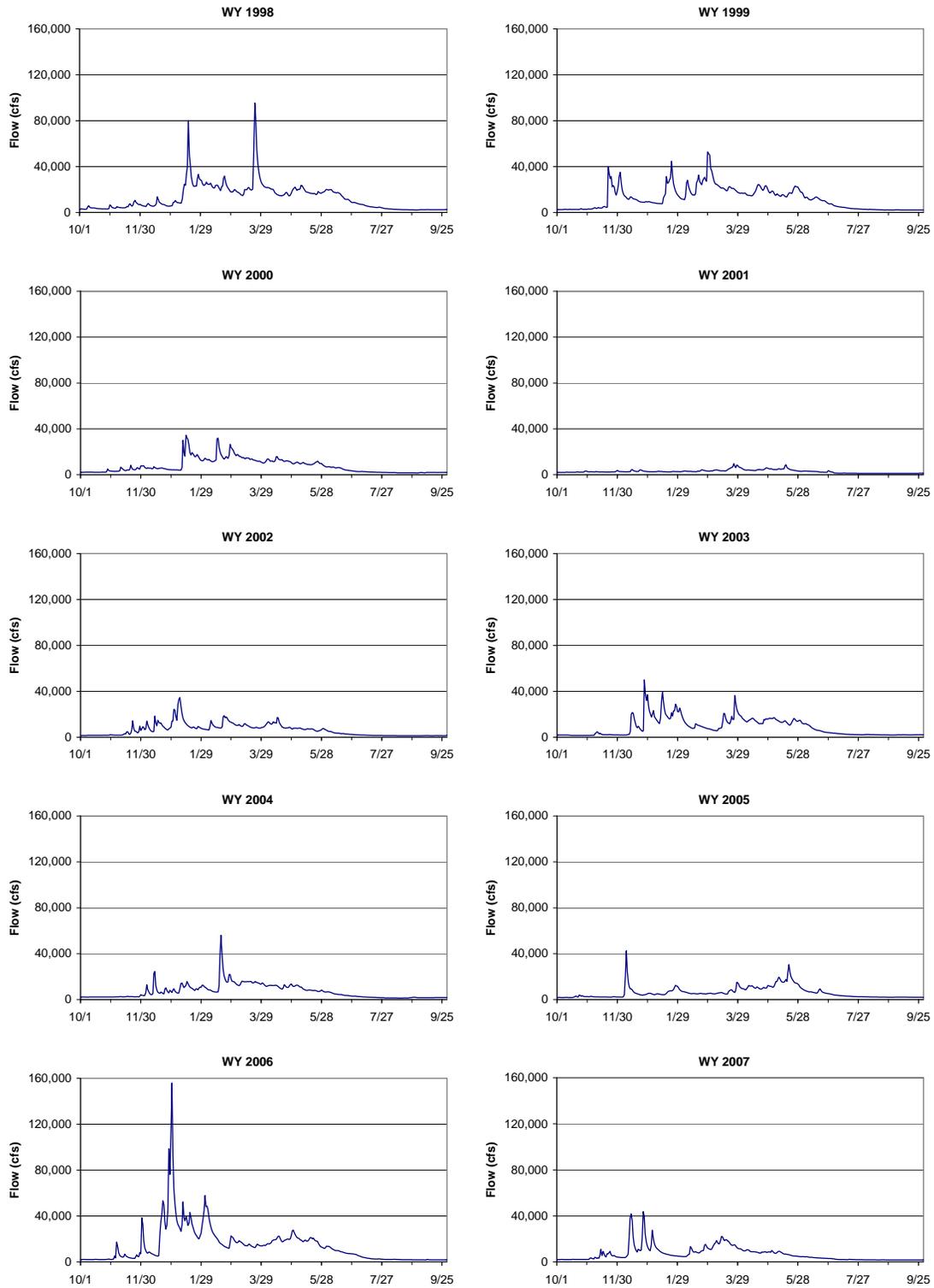
Figure 9. Daily flow at the Orleans gauge site on the mainstem Klamath River (RM 59) in WYs 1998-2007. Gauge site is USGS 11523000.

Seiad Valley Gauge on Klamath River (RM 129)
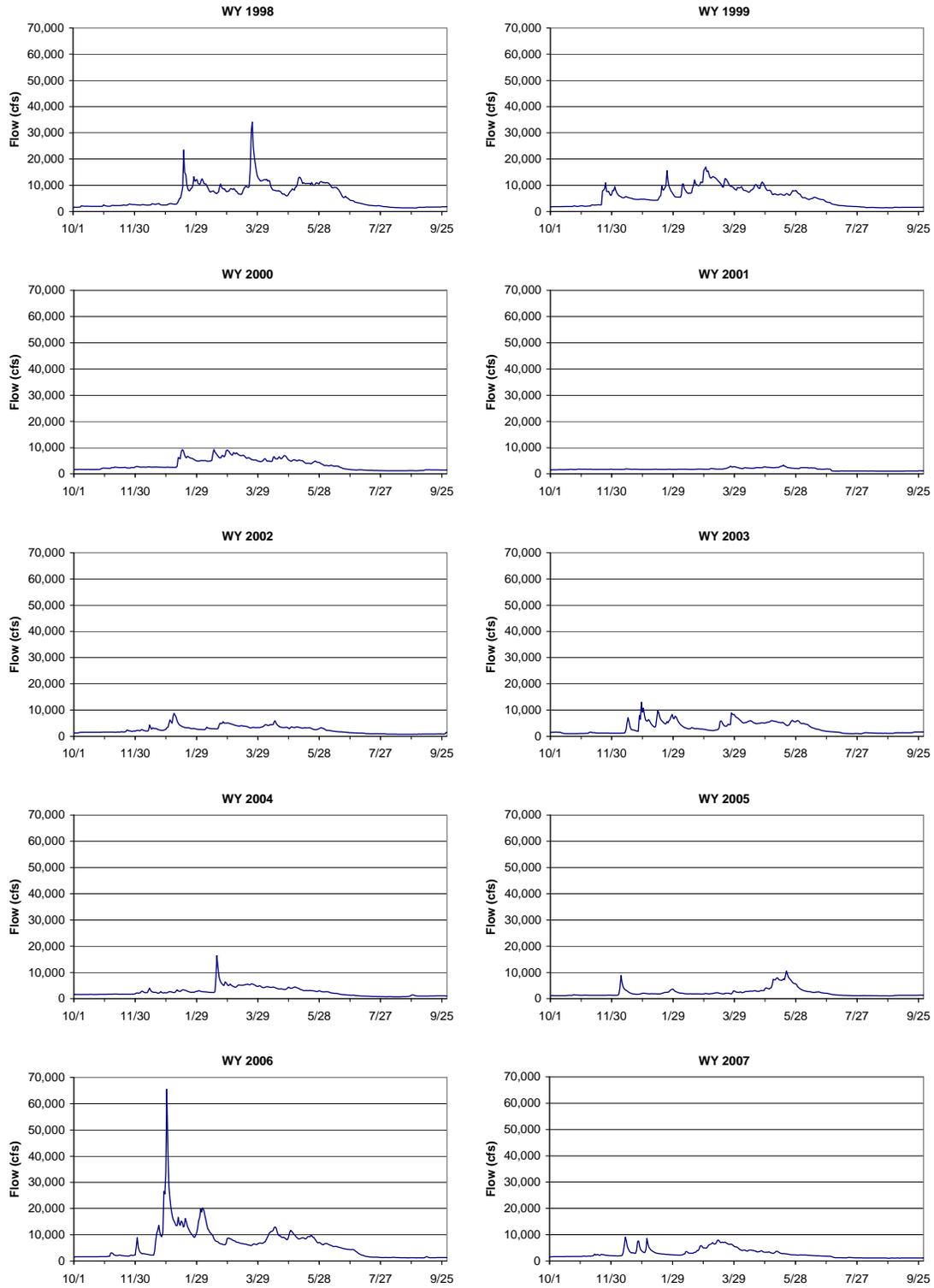
Figure 10. Daily flow at the Seiad Valley gauge site on the mainstem Klamath River (RM 129) in WYs 1998-2007. Gauge site is USGS 11520500.

Lower Indian Creek
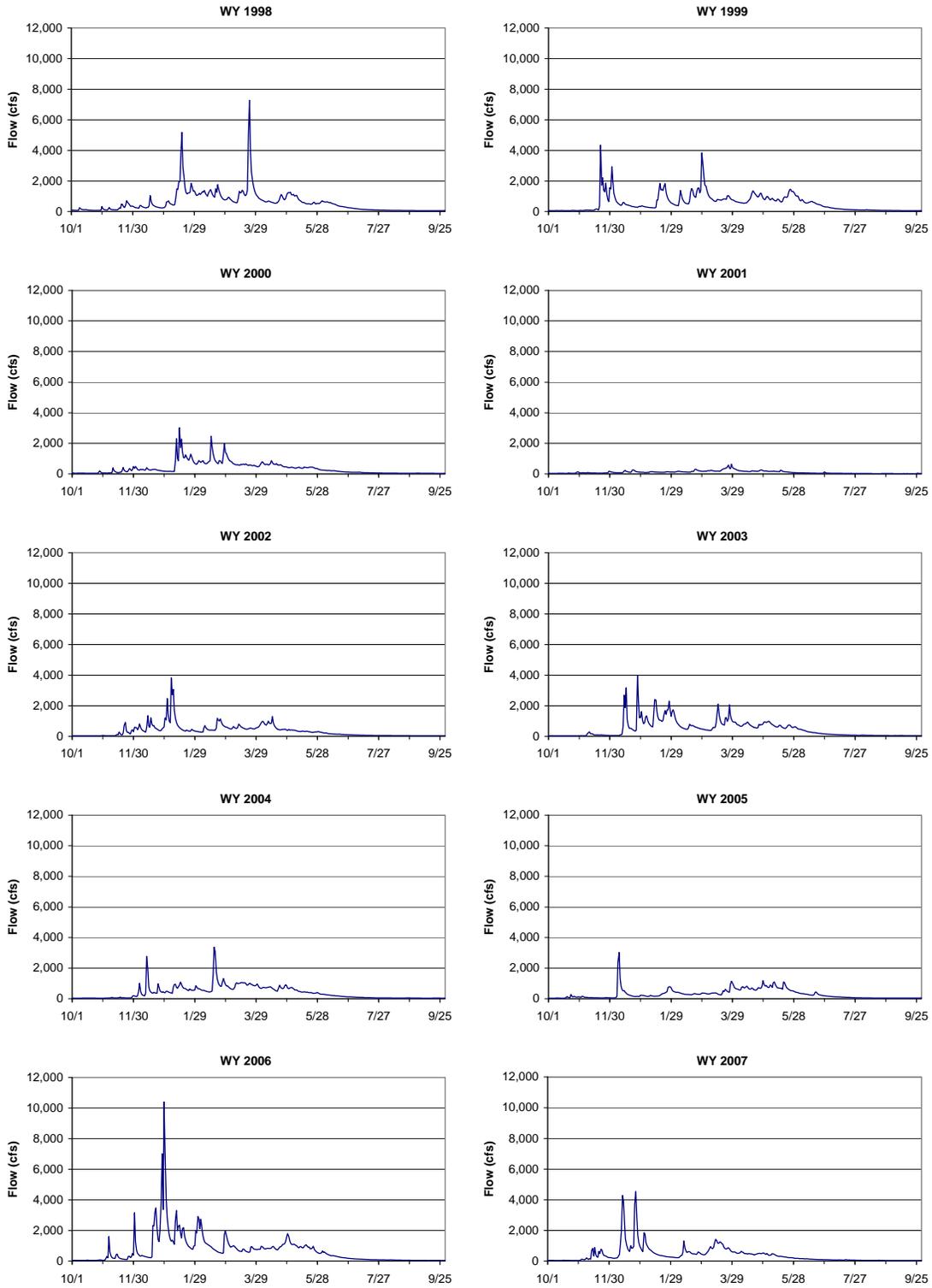
Figure 11. Daily flow on lower Indian Creek in WYs 1998-2007. Gauge site is USGS 11521500.

These flow patterns reflect fundamental differences in geology and climate between the coastal and interior regions of the Klamath basin. Unlike most large watersheds, the Klamath basin has its greatest relief and topographic complexity in the lower half rather than in the upper half of the basin (NRC 2004). The mountainous lower basin produces a rain shadow effect in the upper basin and in the Shasta Valley, resulting in a low mean annual precipitation with about half falling as snow. These characteristics, combined with extensive marshes and lakes, volcanic geology, and flow regulation, produce low runoff yields with high hydraulic retention times in the upper basin. In contrast, the lower basin has much greater precipitation, reaching 100 in/yr in the coastal region. Runoff patterns there tend to produce large peak flows during winter associated with major storm events, together with a somewhat smaller, more predictable runoff pulse in spring with snowmelt.

In summary, very different characteristics in annual peak flow and interannual flow variation exist within and between the study areas, corresponding to climate and geological patterns within the basin. These characteristics may influence patterns of habitat residency and movement by juvenile coho during fall and winter differently within the two study areas.

The flow patterns that occurred during Phase 1 of this study were generally intermediate to the extremes of conditions seen over the past decade. The peak flows that occurred in the mainstem river in 2006-07 were less than what occurs during the average fall-winter period, except in Indian Creek, where it was more typical of average conditions.

3.2.2 Middle Klamath River Study Area

The middle Klamath River study area is bounded by the Shasta River (RM 177) upstream and the Trinity River downstream (RM 43). This section of the report begins with a general description of some of the dominant characteristics of the mainstem river within the study area relevant to juvenile coho life history, followed by examples of major habitat features and types found within the study area (Figure 12). The examples are presented as they occur along the mainstem river beginning upstream, except for examples of bank edge and mainstem backwater pools , which are given at the end of the section.

Habitat examples covered here are:
  ➢ Seiad Creek;
  ➢ Cade Creek;
  ➢ Bulk Plant backwater and floodplain channel;
  ➢ Independence Creek floodplain channel;
  ➢ Sandy Bar Creek floodplain channel; and
  ➢ Mainstem river backwater pools and bank edge habitats.

3.2.2.1 General Characteristics of the Mainstem Klamath River

The Klamath River channel varies between moderately to strongly confined over most of the distance between Shasta River (RM 177) and Trinity River (RM 43)(Figure 13). No patterns are evident for either increasing or decreasing channel slope or bankfull width over this distance

(Figure 14), based on information presented in Stillwater Sciences (2004) as originally provided in Ayres (1999).

Channel slopes averaged over one mile distances vary between about 0.1-0.5% over most of the study area. There are several pockets of lower channel slope between approximately RM 75 and RM 120; Happy Camp is located at approximately RM 111. Across the entire study area distance, the gradient is consistently lowest between approximately RM 105 to RM 120. This suggests that bank edge habitats suitable for holding juvenile coho may be relatively more abundant (on a per mile basis) in this 15 mi section compared to other sections. The steepest section of river occurs upstream of RM 60 in the vicinity of Ishi Pishi Falls (RM 67). The pattern of channel slopes changes markedly at the confluence of Trinity River (RM 43), where gradient begins to steadily decline over the remaining distance to the river mouth.
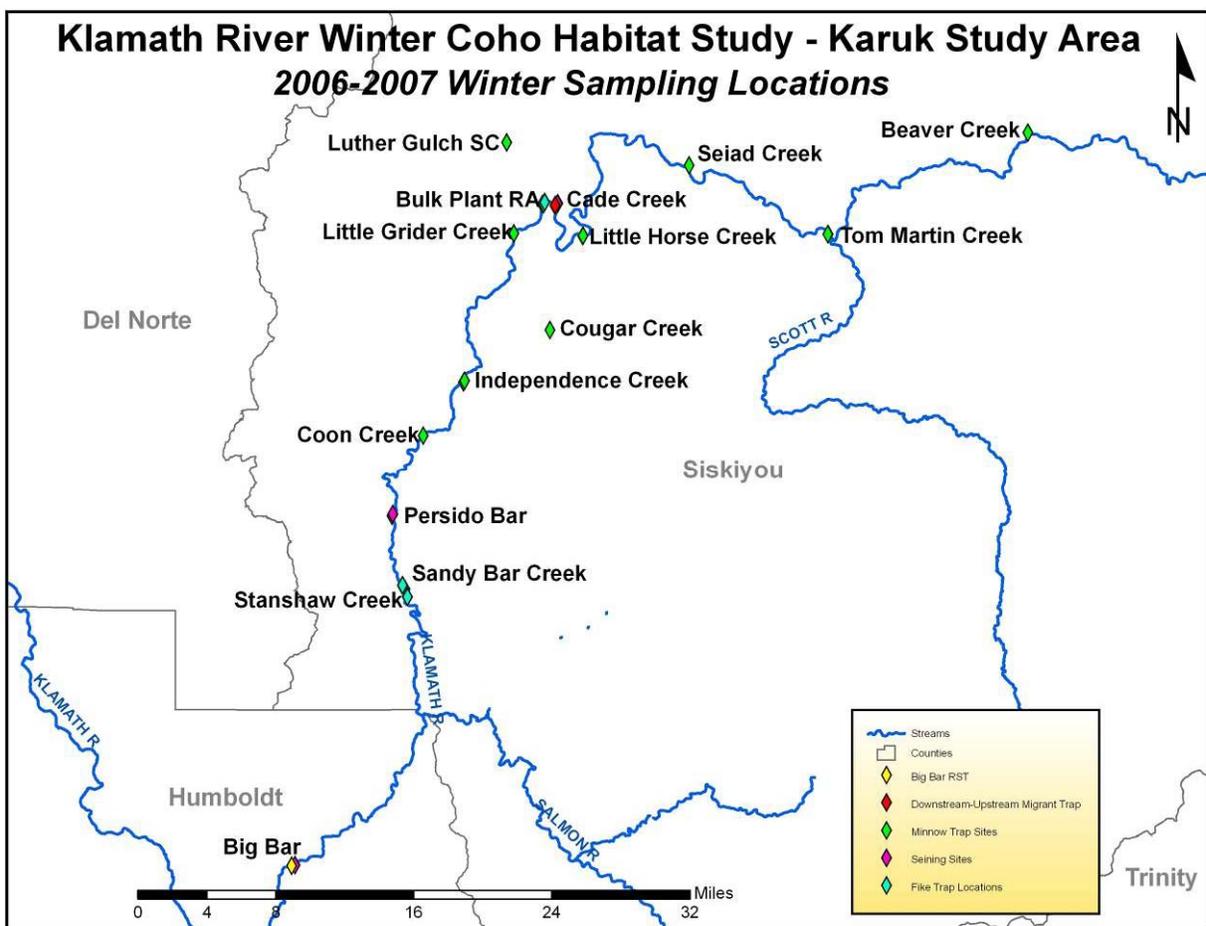
Figure 12. Habitat and fish sampling sites in the middle Klamath River study area.
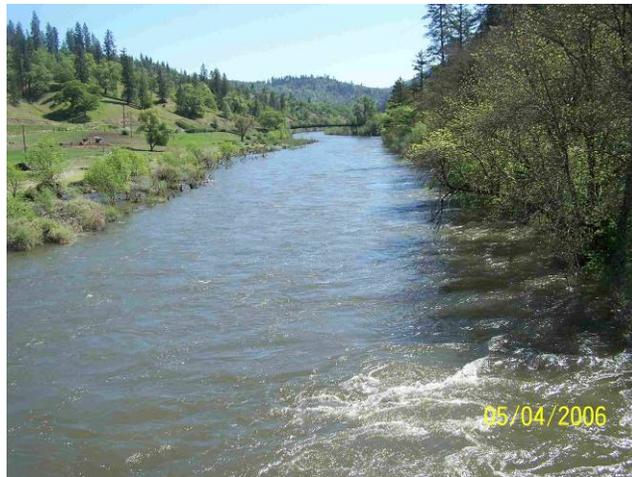
Figure 13. Examples of reach characteristics of the mainstem Klamath River within the middle study area: (top) near the mouth of the Shasta River (RM 177), upstream of Scott River (near RM 147), and within the gorge downstream of Clear Creek (downstream of RM 99). The bottom two pictures were taken during exceptionally high spring runoff.

Bankfull channel width is typically between 100-200 ft throughout most of the study area distance, interspersed with some reaches of greater width (Figure 14). This consistent range of variation—despite the very large increase in winter flow volume that occurs moving downstream—is due to periodic meander bends in lower slope areas set within a well defined range in valley confinement over the entire distance. Corresponding to the set of reaches where channel gradient is lowest (between RM 105-120), average bankfull width is greatest (approximately 200 ft) compared to other reaches. This correspondence further suggests that the relative abundance of bank edge habitats suitable for holding juvenile coho may be greater in this section of river compared to others during high flow events. It bears noting that since bankfull channel width shows no pattern of increasing width moving downstream between about RM 160 and the Trinity River (RM 43)—and winter flows increase dramatically over this distance—that both water depth and velocity are likely to generally increase during high runoff moving downstream. However, there are short sections of channel with low slopes and relatively wide valley confinement, such as in the vicinities of Orleans, Sandy Bar, and Independence Creek, as well as others, which may contain bank edge habitats suitable for holding juvenile coho. While such habitats may become more dispersed downstream of RM 120, their relative importance may increase as they become less frequent.

3.2.2.2 Seiad Creek

Seiad Creek (RM 129) is a small to moderately sized tributary that enters the Klamath River in the middle section of the study area (Figure 15). The stream supports coho spawning but it is also likely used by non-natal juvenile coho within its lower reaches. We highlight it here to represent the group of tributaries within the study area that likely support both natal and non-natal coho use. Other tributaries within this group include Beaver, Horse, Grider, West Grider, Fort Goff, Thompson, China, Indian, Elk, Independence, Dillon, Camp, Red Cap, Slate, and Aikens creeks, among others. We suspect that non-natal use in some of these streams likely occurs primarily in summer, when juvenile coho are seeking thermal refugia from high temperatures in the mainstem river. These streams that would be used primarily as thermal refugia are relatively steep within the river corridor. Some streams, like Horse, Grider, and West Grider creeks, in addition to Seiad Creek, enter the Klamath River within relatively wide valley areas of the river corridor, and appear to offer some suitable overwintering habitat (Figure 15b), despite these streams being subject to high runoff during winter. Further assessment work is required to determine relative usage of these streams within the river corridor for overwintering. We also note that those streams entering the Klamath River within wide valley locations have been particularly subject to land use practices in their lower reaches.
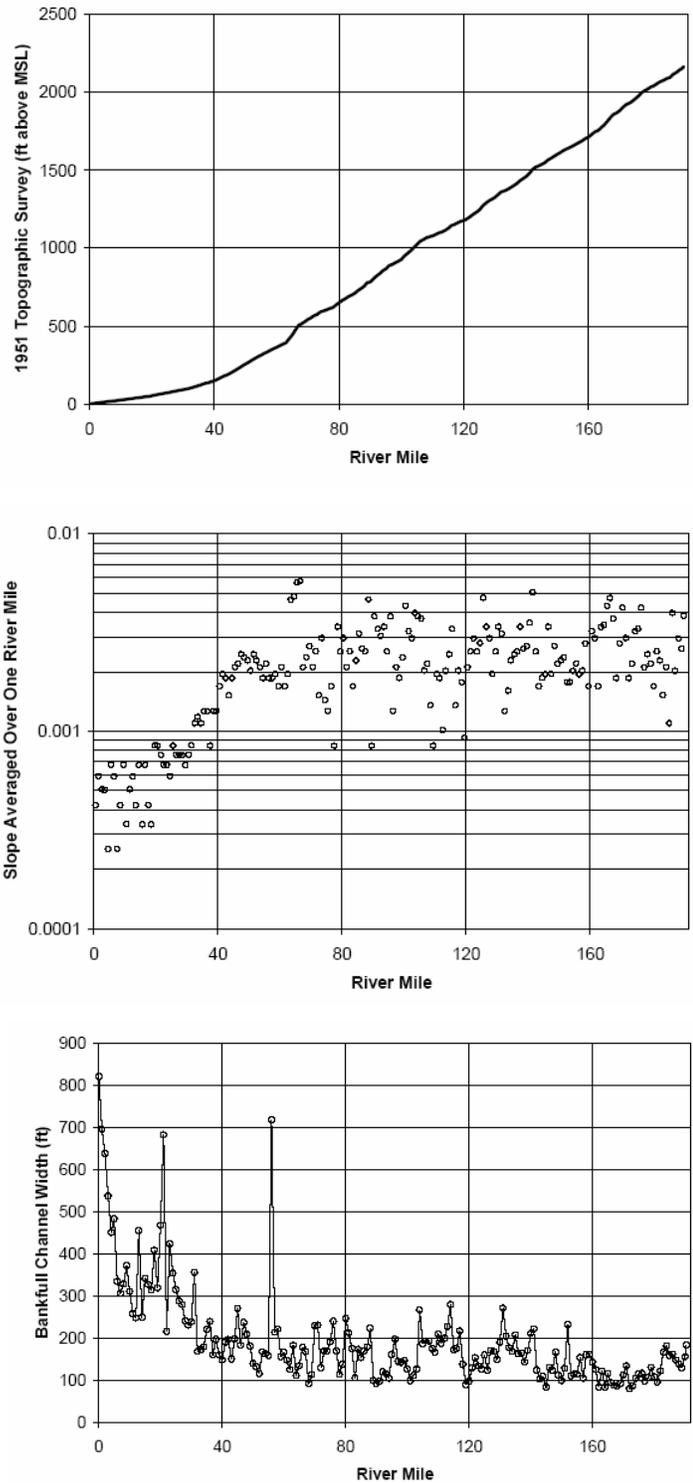
Figure 14. (top) Longitudinal profile of the Klamath River downstream of Iron Gate Dam (RM 190); (middle) channel gradient averaged over 1-mile distances; (bottom) bankfull channel widths based on 1998 1:7,500 aerial photographs. Selected reference sites are: Shasta River – RM 177, Scott River – RM 143, Seiad Valley – RM 129, Indian Creek – RM 111, Orleans – RM 59, Trinity River – RM 43. Taken from Stillwater Sciences (2004).

Figure 15. Lower reaches of Seiad Creek within the mainstem Klamath River corridor. Top picture is a channelized and diked reach.

3.2.2.3 Cade Creek

Cade Creek (RM 112) is a small tributary entering the Klamath River in the middle section of the study area that supports non-natal coho production (Figure 16). Spawning and juvenile rearing surveys indicate that the stream is only rarely, if at all, used for spawning. We have documented relatively extensive use of the stream by non-natal juvenile coho during summer, when up to 1700 ft of the lower stream is used as a thermal refuge from high temperatures in the mainstem

river (Karuk Tribe, unpublished data). The timing and pattern of utilization by juvenile coho in summer confirms that Cade Creek is not their natal stream. The stream's characteristics suggest that it may also be used by non-natal juveniles for overwintering, even though it is subject to high flow runoff during winter storms. The stream is similar in size and channel characteristics to streams used for overwintering by non-natal juvenile coho on the west side of the Olympic Mountains in Washington State (Scarlett and Cedarholm 1984 and observations by L. Lestelle). There is a general lack of large wood in the stream, however, which would tend to limit use and survival of juvenile coho that overwinter there. In addition, it has been determined that the culvert near the mouth of the stream is likely a partial barrier to upstream movement by juveniles during some flows (Karuk Tribe, unpublished data). Culverts like this one in small streams within the mainstem river corridor pose passage difficulties to juvenile coho during high flow events.
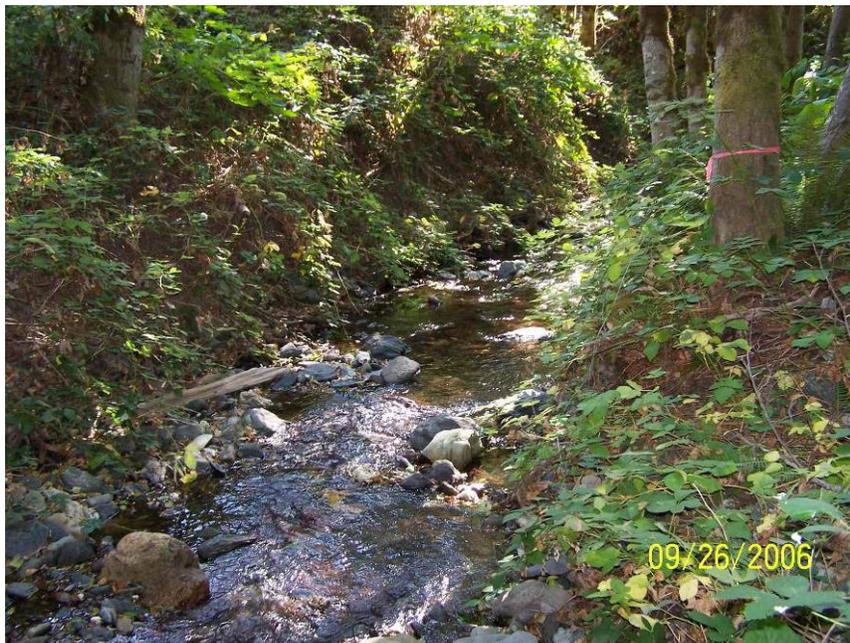
Figure 16. Lower Cade Creek.

3.2.2.4   Bulk Plant Backwater and Floodplain Channel

The Bulk Plant backwater and associated floodplain channel is located on the upstream edge of the town of Happy Camp at approximately RM 112 on the Klamath River. A backwater pool is formed at the upstream end of the floodplain channel (Figure 17a), unlike the more common location of backwater pools at the lower end of such channels. When river flow increases, the backwater pool expands downstream into the top of the floodplain channel, seen in Figures 17b and 17c. Due to uncertainty about the frequency that the floodplain channel connects from its head end to its bottom end, it is unclear whether the channel is best characterized as a side channel or an overflow channel. The channel did not connect throughout its length during winter 2006-07. Gravel extraction activities on the river bar have created a somewhat artificial situation that influences channel connectivity, and it appears that the channel may be operating principally as an overflow channel. Overflow channels only connect at flow levels higher than the 2-year

recurrence flow and fish that move into them during those periods may be subject to stranding. We conducted a rescue effort on stranded juvenile coho at this site in one previous year. It bears noting that their physical condition was found to be very good.

Figure 17. Bulk Plant backwater pool and floodplain channel on January 25, 2007 (Klamath River flow at Seiad Valley gauge at 2,450 cfs): (a) backwater pool at top end of the floodplain channel; (b) upstream section of the floodplain channel in January 2007; *continued to next page***.**

Figure 17 continued – (c) aerial view of the Bulkplant floodplain channel and backwater unit.

3.2.2.5 Independence Creek Floodplain Channel

The lower reach of Independence Creek (RM 94) flows through what appears to be an overflow channel on the inside edge of a meander bend of the Klamath River (Figures 18). This type of geomorphic feature along the Klamath River, where a tributary flows into an overflow channel or intermittent side channel, occurs in a number of locations along the river. It is the most common way that pond-like habitat is formed on the floodplain of the Klamath River between Iron Gate Dam and the upper end of the estuarine zone.

We refer to this type here as a tributary-fed floodplain channel, which occurs on the inside edge of meander bends where a small tributary enters. The development of a point bar will sometimes leave relict channel patterns on the inside edge of the bar or meander (Figure 5)(Mount 1995; Ward et al. 2002). Where hyporheic flow is pronounced, these relict channel patterns can form groundwater channels, which provide both summer and winter refuge habitat for juvenile coho. In the Klamath River mainstem corridor, where groundwater channels are not commonly found, these relict channel features on the inside edge of point bars can retain flow if they occur where a tributary enters, such as at Independence Creek.

The pattern of flow at the Independence Creek floodplain channel is unique compared to other similar features in the Klamath River corridor. The topography of the point bar at Independence Creek results in a flow direction through the floodplain channel moving toward the top end of the point bar (Figure 18c and d), which is the opposite direction that normally occurs in this type of feature.

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Figure 18. Independence Creek floodplain channel: (a and b) channel near its confluence with the mainstem river in winter; *continued to next page***.**

Figure 18 continued – (c and d) channel orientation within the mainstem river corridor.

Flow dynamics within this floodplain channel are subject to flow fluctuations in Independence Creek, as well as to periodic inundation from the river. Because Independence Creek can discharge relatively high flows, and the entire length of the floodplain channel is affected by this stream, the quality of this site for overwintering may be less than some other tributary-fed floodplain channels in the basin.

Some natal production of coho has been observed in Independence Creek, but it also appears that non-natal juveniles use the floodplain channel.

3.2.2.6 Sandy Bar Creek Floodplain Channel

This site is another example of a tributary fed-floodplain channel, located at RM 78 on the Klamath River (Figure 19). Sandy Bar 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 channel are, therefore, non-natal fish. We have determined through past sampling that non-natal coho utilize the channel during summer and fall.

Sandy Bar 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 Sandy Bar Creek joins the channel (Figure 19b).

This floodplain channel contains several depressions that cause it to retain surface water brought in by Sandy Bar Creek. This results in the formation of a large pond immediately upstream of where Sandy Bar Creek enters the channel (Figure 19c). The pond is sheltered from high flow effects from Sandy Bar 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. Future monitoring planned for this site will help us better understand connectivity between the channel and the mainstem river, as well as velocity and flow characteristics within the channel as a function of river and creek flow.

It bears noting that at higher flows, a backwater pool forms in the Klamath River immediately downstream of where the floodplain channel joins the river (Figure 19d). This backwater pool expands to a very large size, covering the lower portion of the point bar, during high flow events.

Another tributary-fed floodplain channel at Stanshaw Creek is located less than 1 mile downstream of the Sandy Bar channel. Characteristics of that floodplain channel are nearly identical to those at Sandy Bar.

Figure 19. Sandy Bar floodplain channel: (a) ponded area looking downstream from immediately below where Sandy Bar Creek enters the channel in September 2006; (b) same site and orientation in January 2007, some river flow is entering the channel from right just off the picture; *continued to next page***.**
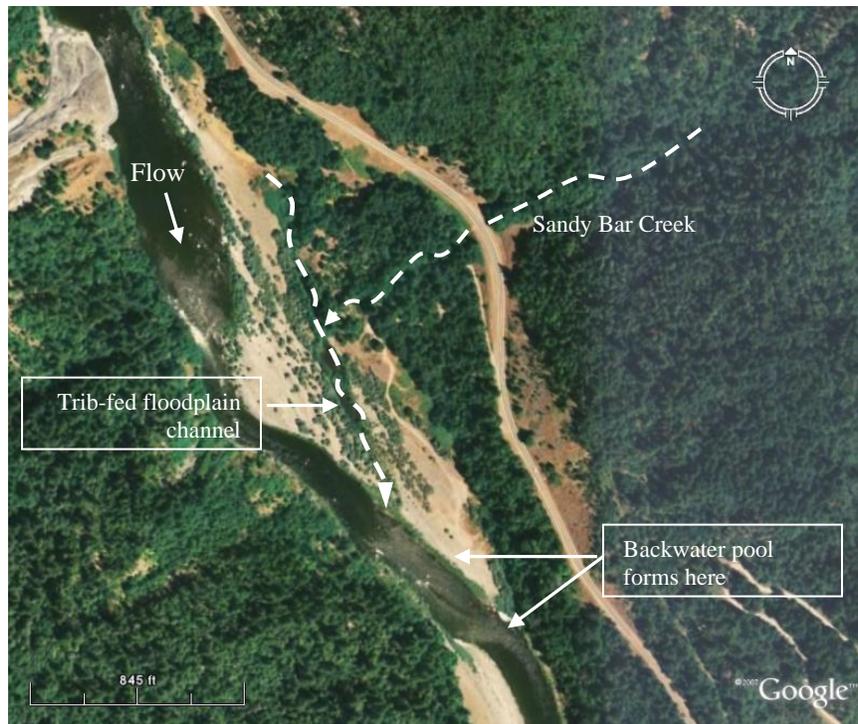
Figure 19 continued – (c) ponded area immediately upstream of where Sandy Bar Creek enters the floodplain channel in September 2006; (d) aerial view of the channel and location of backwater pool on the mainstem river downstream of the channel.

3.2.2.7 Mainstem River Backwater Pools and Edge Habitat

The mainstem Klamath River in the middle study area contains backwater pools at certain flow levels that appear to be suitable for overwintering coho, as well as bank edge habitats that could support overwintering. The backwater pool units are not abundant and different types exist. One example is the backwater unit at the top end of the Bulk Plant floodplain channel (Figure 17a). It appears that this particular backwater pool becomes most distinct at relatively low flows, whereas at flows approaching flood stage it would be subject to increased velocities due to its location on the outside edge of the meander bend (Figure 17c) A more classic backwater unit, located at the downstream end of a point bar, was present in past years at the Beaver Creek thermal refuge (Figures 12 and 20). Juvenile coho have been observed at this site during summer (e.g., Deas and Tanaka 2006), but the backwater unit was destroyed during the flood of 2005-06 and it has not reformed. Another example is the backwater unit that forms at the downstream end of the Sandy Bar channel and point bar (Figure 19d). The Sandy Bar site exemplifies a backwater unit that expands and contracts tremendously as a function of river flow (Figure 21), illustrating that its importance may only come into play at very high flows.

Examples of bank edge habitat in the upper half of the study area are shown in Figure 22. Bank edge habitat is known to be used to some extent by overwintering juvenile coho in some large rivers (e.g., Beechie et al. 2005). In the upper half of the study area, i.e., upstream of Happy Camp, severe high flows are less frequent and bank edge habitats appear to be more suitable for overwintering than those further downstream. Also, as noted earlier, the reaches near Happy Camp tend to have a lower channel slope with greater bankfull widths compared to reaches downstream to the Trinity River. Bank edges illustrated in Figure 22 appear to provide potential overwintering habitat.

Figure 20. Backwater pool on the mainstem Klamath River immediately downstream of Beaver Creek. This site was a known thermal refuge during summer for juvenile coho, as reported in Deas and Tanaka 2006. The photos here were taken in December 2005, just prior to the backwater being obliterated by flood flows at the end of December.
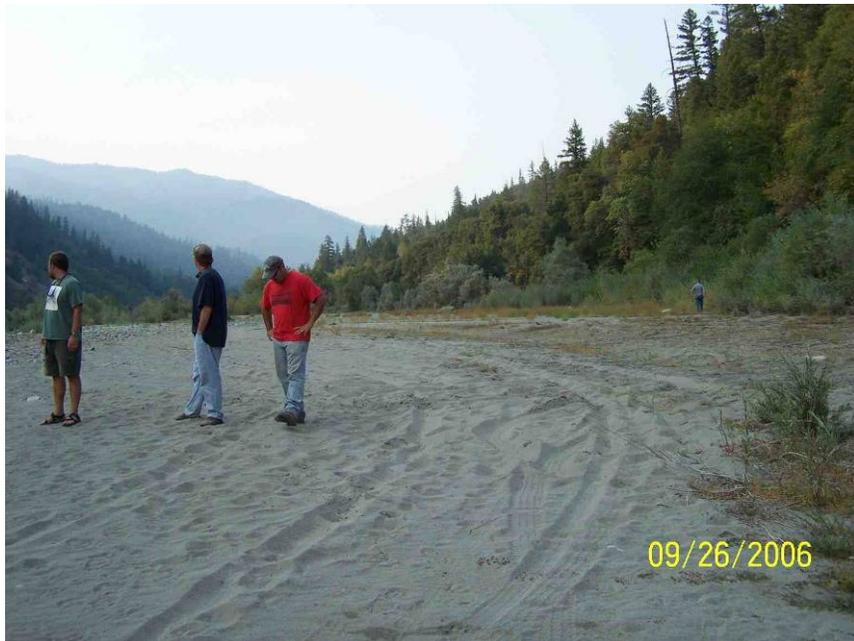
Figure 21. Backwater pool on the mainstem Klamath River immediately downstream of the Sandy Bar floodplain channel: (a) remnant of the pool unit as it existed during late summer-early fall flows in 2006; (b) view looking upstream of the dry sand bed of where the pool expands to during high flows—the (a) photo was taken shooting downstream from where the three individuals are standing in (b).
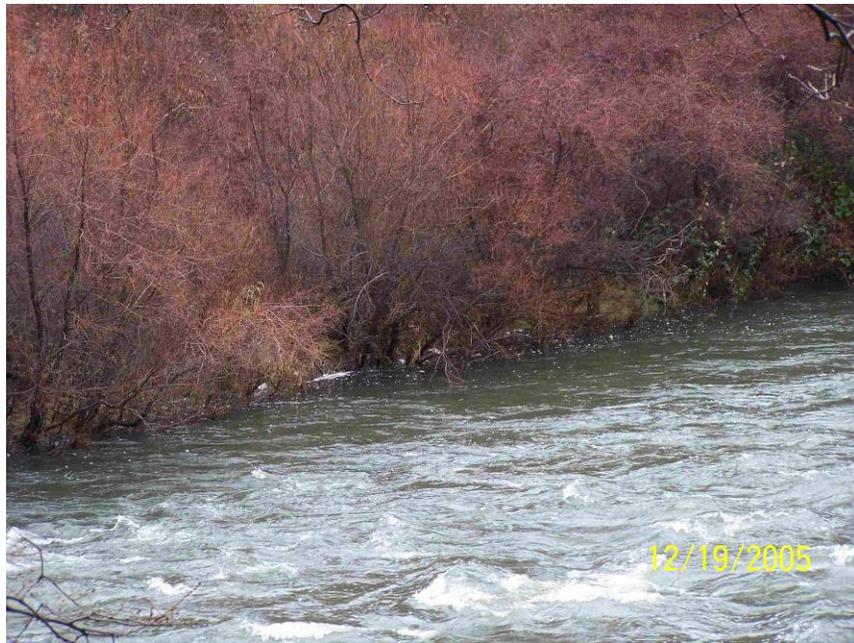
Figure 22. Representative bank edge habitats along the mainstem Klamath River during winter flows. All four photos were taken in reaches between Shasta River and Happy Camp—*continued to next page.*

Figure 22 – continued. Bank edge habitats within the middle river study area.

3.2.3 Lower Klamath River Study Area

The lower Klamath River study area is bounded by the Trinity River (RM 43) upstream and the river mouth at its lower end. This section of the report begins with a general description of some of the dominant characteristics of the mainstem river within the study area relevant to juvenile coho life history. This is followed by descriptions of examples of major habitat features and types found within the study area (Figure 23). The examples are presented as they occur along

the mainstem river beginning upstream, except for examples of bank edge habitats, which are given at the end of the section.

Habitat examples covered here are:
  ➢ Roaches and Tectah Creek confluences (upstream of area shown on Figure 23);
  ➢ Tarup Creek floodplain channel and ponds;
  ➢ McGarvey Creek;
  ➢ Resighini floodplain channel and ponds;
  ➢ Waukell Creek and Junior Creek Pond;
  ➢ Richardson Creek ponds;
  ➢ Salt Creek-Spruce Creek complex;
  ➢ South Slough complex; and
  ➢ Mainstem river bank edge habitats.
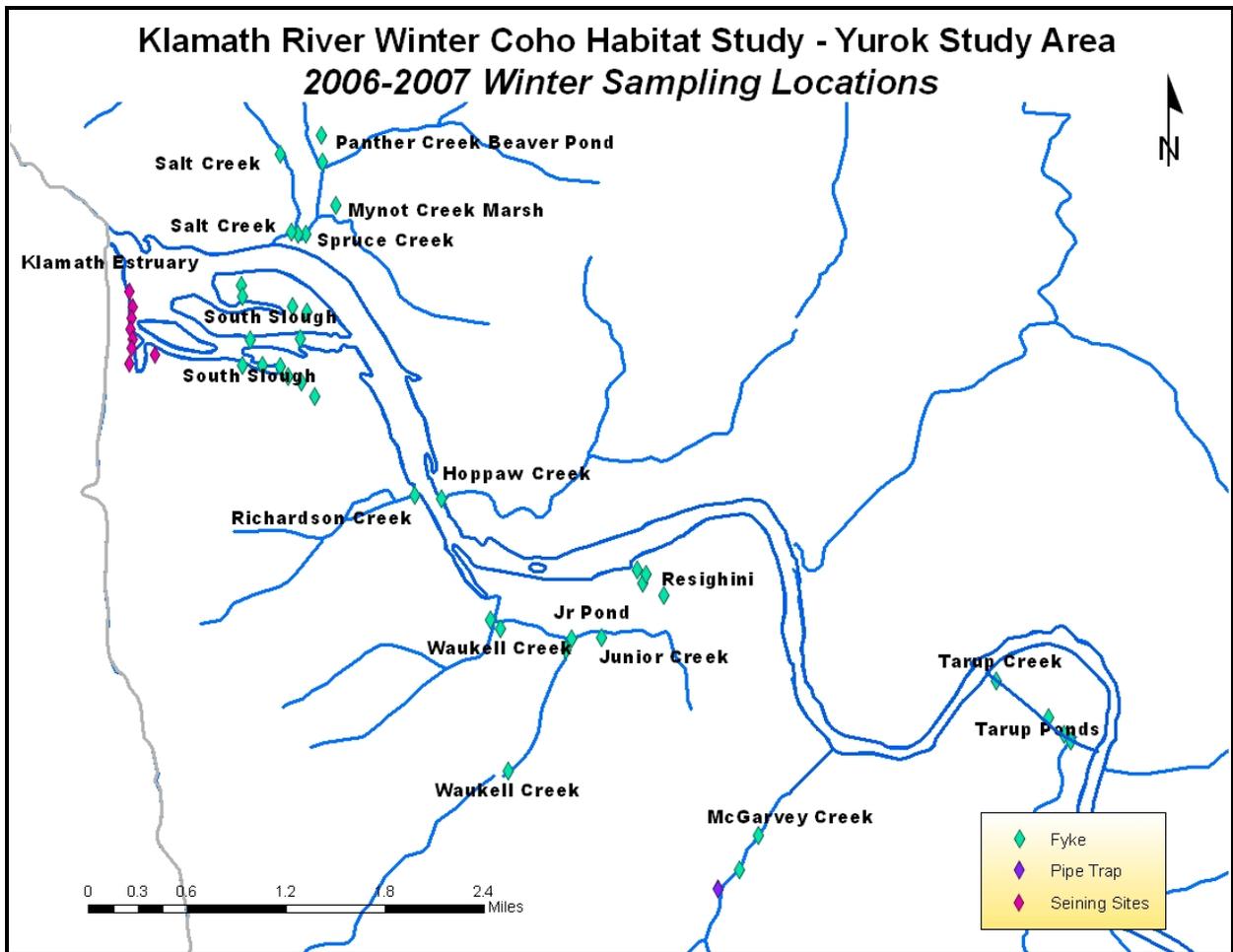
Figure 23. Habitat and fish sampling sites in the lower Klamath River study area. Roaches and Tectah creeks are located upstream of the section of river shown in the map. The map shows one stream mouth confluence for the Salt Creek complex, though there are actually two separate mouths—one for Salt Creek and one for Hunter Creek, which is the main stream fed by Spruce, Mynot, and Panther creeks.

3.2.3.1 General Characteristics of the Mainstem Klamath River

The channel characteristics of the mainstem Klamath River downstream of the Trinity River (RM 43) show distinct changes from those upstream of that point. Channel slope begins to flatten and bankfull width increases (Figure 14). These patterns—decreasing slope with increasing width—continue to the river mouth. Peak flows dramatically increase with the input of Trinity River. The scale of the river's physical features are dramatically larger than those upstream of Trinity River (Figure 24).

The river channel through most of the lower study area remains moderately to strongly confined like most of the middle study area. Upstream of the estuarine zone, much of the river's shorelines is comprised of bedrock, boulders, or large sweeping point bars (Figure 24).

As the river flows, valley width of the mainstem corridor begins to widen appreciably at about RM 8. Particularly noteworthy is the presence of three very large meander bends between that point and the river mouth (Figure 25a). The point bar features located on the south side of the river contained by these meander bends are of special interest because of the floodplain channels that cut through their inner edges. The scale of these features grows from the most upstream of the three point bar features to the most downstream one located near the mouth. It was evident at the outset of this study that potentially good overwintering habitats for juvenile coho might be concentrated at these locations.

The most downstream of these three meander bends is contained by the estuarine zone (Figure 25b). The inside of this meander bend is composed of a very large point bar type feature covered by a riparian forest, which is dissected by a number of side channels and overflow channels. This floodplain channel complex is influenced by fluctuations in both river flow and tidal energy. Saltwater intrusion apparently only affects the lower ends of these channels during some periods (Hiner and Brown 2004), but not during late fall through spring when river flows are elevated. Tidal influence still affects the channels even without saltwater intrusion, however.

This general pattern of features within the mainstem corridor between the Trinity River and the river mouth suggests that the quantity and quality of overwintering habitat for juvenile coho increases in a downstream direction.

3.2.3.2 Roaches Creek and Tectah Creek Confluences

The confluences of some small tributaries within the mainstem corridor downstream of Trinity River form habitat units that resemble backwater pools when mainstem river flows are elevated. This condition is especially pronounced when tributary flow is low and river flow is high, such as occurs during late winter and spring snow melt, as seen at Roaches Creek (RM 31.5) and Tectah Creek (RM 22.1)(Figure 26). Both of these sites appear to offer suitable velocity refuge for juvenile coho under some range of flow conditions. It is noteworthy that the transitory nature of these habitats would not be conducive to a stable residency pattern for juvenile coho throughout the winter. These sites may be most useful as stop-over sites—providing temporary refuge—for juvenile coho moving downstream in search of more stable overwintering habitat.

Figure 24. Examples of reach characteristics of the mainstem Klamath River within the lower study area: (a) large river features within a confined channel with a small floodplain near RM 22; (b) large and steep river bars located downstream of RM 22.

Figure 25. Aerial views of the lower Klamath River: (a) approximately the lower 12 miles of mainstem river showing the three prominent point bar-type features; (b) the estuarine zone and the channel complex associated with the South Slough.

Further work is needed to describe the characteristics of these types of habitats as a function of flow—both in the mainstem river and the tributaries. While these sites appear to offer suitable refuge under some conditions, their dynamics in size and flow velocity are not yet understood.
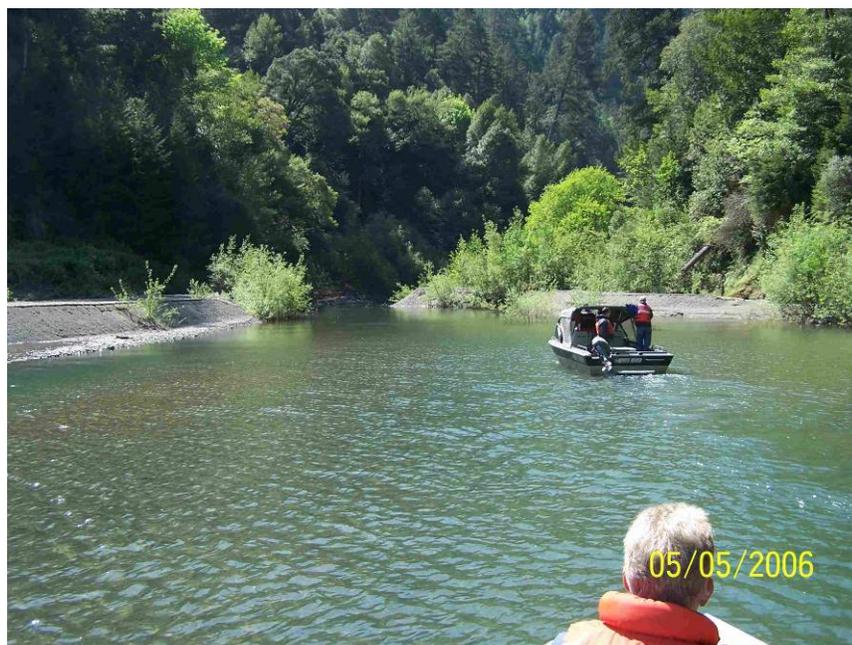
Figure 26. Tributary confluences along the lower Klamath River: (a) Tectah Creek (RM 22.1); Roaches Creek (RM 31.5). Photos taken during spring runoff on May 5, 2006 (Klamath River flow at Klamath gauge at 36,700 cfs). The clear water—compared to the highly turbid mainstem river—has very low velocity due to the impounding effect of high mainstem flow on the tributary flow.

3.2.3.3 Tarup Creek Floodplain Channel and Ponds

The Tarup Creek floodplain channel and ponds are located on the most upstream of the three meander bends described earlier (Figure 25a and Figure 27a). This channel feature is a tributary-fed floodplain channel similar to those described in the middle study area at Sandy Bar and Stanshaw creeks—only on a much large scale. Tarup Creek is a small tributary that feeds the upper end of this large floodplain channel and flow is very low in late summer.

This floodplain channel forms three ponded areas identified in Figure 27a. The ponds are quite large and are present throughout the late fall, winter, and spring (Figure 27b and c). Some parts of the ponds remain watered through the summer, which is probably the result of shallow hyporheic flow.

Connectivity of this channel at its upper end to the mainstem river only occurs at very high flows, the level of which has not been identified. It has not been determined whether connection occurred on the upper end in winter 2006-2007. The ponds associated with the channel appear to provide good overwintering habitat for juvenile coho due to the general lack of connectivity at the upper end, thereby providing a large amount of slackwater as velocity refuge.

We surmise that connection of the floodplain channel at its lower end to the mainstem river remains intact through most of a typical winter. Connection with the mainstem is lost at some point on the receding hydrograph, though we have not identified the point at which this occurs. Stranding of juvenile coho that enter the ponds for overwintering may occur to some extent as a result of disconnection between the channel and the mainstem river. Any improvements that could be made to maintain longer connectivity between ponds and at the egress to the mainstem river during spring would likely be beneficial to the coho populations that use the ponds for overwintering.
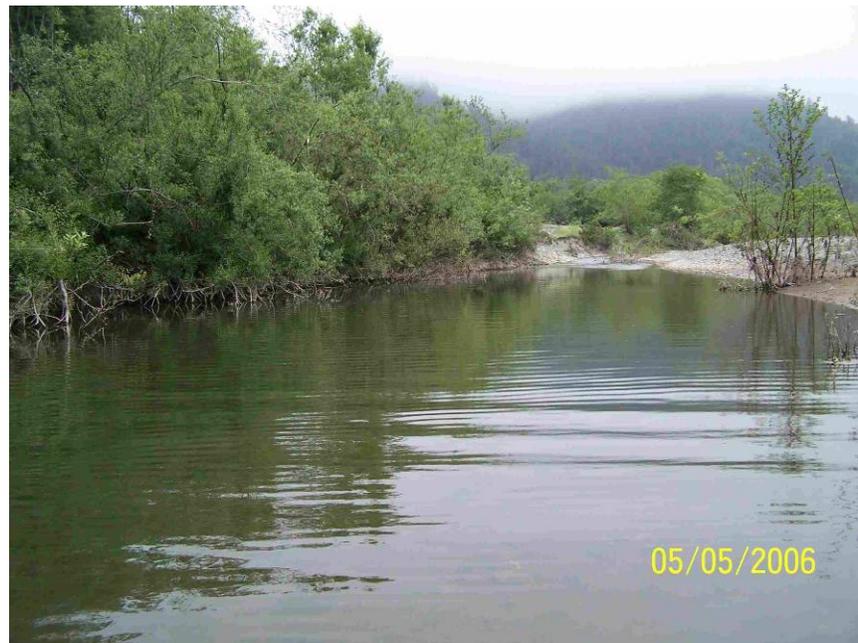
Figure 27. Tarup Creek floodplain channel and ponds: (a) aerial view of point bar and channel and pond locations; (b) lower pond at the time of spring runoff (May 5, 2006)—connection existed on the downstream end to the mainstem river but not on the upstream end (Klamath River flow at Klamath gauge at 36,700 cfs); *continued to next page.*

Figure 27 continued – (c) middle pond within the Tarup Creek floodplain channel.

3.2.3.4 McGarvey Creek

McGarvey Creek (RM 6) is a small tributary to the lower section of the lower study area. While it supports natal coho production, we also suspect it is used by non-natal juveniles originating from other spawning tributaries. Both coho smolts and spawners are annually enumerated in the stream by the Yurok Tribe. These data show a larger smolt yield that can reasonably be attributed to the number of spawners observed there, suggesting that some portion of the smolts are the result of non-natal juveniles moving into the stream for some part of their rearing prior to smolting.

McGarvey Creek is a low gradient stream (Figure 28a) that contains habitat elements consistent with good overwintering survival for juvenile coho (i.e., wood, pools, off-channel alcoves). Based on juvenile coho movements observed in other Pacific Northwest streams, it is certain that juveniles can access a substantial distance of channel in this stream during their fall redistribution to overwintering sites.

The confluence reach of this stream also supplies suitable overwintering habitat during periods of high flow in a similar fashion as that described for Roaches and Tectah creeks (Figure 28b and c). Water backed up into this reach by elevated flows in the mainstem river flood the creek's valley bottom and provide a velocity refuge area for coho in search of suitable habitat. The area that becomes flooded during high flow events is extensive. The dynamics of the McGarvey confluence with respect to ponding are not yet well described. Coho that use this area for some part of their overwintering would be subject to flow change, and therefore, the area may primarily serve for temporary overwintering refuge.

Figure 28. Lower McGarvey Creek: (a) stream upstream of the zone of inundation caused by the mainstem river; (b) lowest reach in the stream looking upstream from the mouth during summer low flow illustrating sediment deposits made due to flooding from the mainstem river in the previous spring or winter; *continued to next page.*

Figure 28 continued – (c) flooding into lower McGarvey Creek from the mainstem river during high flow event on December 15, 2006 (Klamath River flow at Klamath gauge at 76,400 cfs).

3.2.3.5 Resighini Floodplain Channels and Ponds

The Resighini floodplain channel and ponds are located on the middle meander bend of the three meander bends described earlier (Figures 25a and 29a). This feature is comprised of two parallel floodplain channels located near the inside edge of a large point bar. These channels appear to combine into one channel at very high flows.

Connectivity of these channels at their upper end to the mainstem river occurs only at very high flows, the level of which has not been identified. It is not certain that connection occurred on the upper end in winter 2006-2007. In general, the ponds associated with the channels potentially provide good overwintering habitat due to their slackwater characteristics (Figures 29b and 29c). The ponds are very extensive and remain watered to a considerable extent throughout all seasons of the year, though we are aware that summer temperatures within the ponds are high. Shallow hyporheic flow is the source of year-round water since no tributary inflow exists.

The ponds have more restricted connectivity to the mainstem river at their lower ends than does the Tarup Creek floodplain channel. The Resighini channel no. 1 (most upstream) has more prolonged connectivity than channel no. 2, though both channels currently would restrict smolt emigration through most of the period of normal outmigration timing (Figure 29c). Any improvements that could be made to maintain longer connectivity at the egress channels to the mainstem river during spring would be beneficial to the coho populations that use these ponds.

Figure 29. Resighini floodplain channels and ponds: (a) aerial view showing channel and pond locations; (b) lower end of Resighini channel no. 1 upstream of egress channel; *continued to next page.*

Figure 29 continued – (c) lower end of Resighini channel no. 2 upstream of egress channel; (d) dry egress channel from channel no. 2. Photos shown in b, c, and d taken on January 26, 2007 (Klamath River flow at Klamath gauge at 10,300 cfs).

3.2.3.6 Waukell Creek and Junior Creek Pond

Waukell Creek is a small stream that enters the Klamath River at RM 3.19, near the upper end of the estuarine zone (Figure 23). The lower part of the Waukell subbasin sits within the Klamath River floodplain. Channel gradient of the stream in this area is very low and physical habitat is

generally suitable for coho rearing. Sections of the stream, however, have undergone extensive channelization in the past and are less suited for rearing due to channel simplification and lack of cover.

This stream, including its tributary called Junior Creek and an associated pond, became the focus of much of our fish trapping in the lower study area during Phase 1 activities. Details of the trapping results are presented in Section 5.0.

Due to the low gradient, Waukell Creek in its lower reaches has very low velocities and provides good overwintering habitat in some sections (Figure 30a). As will be discussed in Section 5.0, Waukell Creek and one of its tributaries are used extensively by overwintering salmonids, including juvenile coho.

The lower reaches of the stream are subject to being impounded by the flow of the mainstem river (Figure 30b) in similar fashion as described above for Roaches, Tectah and McGarvey creeks. This expansion and contraction of habitat associated with high flow events is quite extensive here and on a greater scale than occurs in the other tributaries described above. This is due to the widening of the river floodplain as the river mouth is approached and the presence of swales and relict channels that furrow the floodplain.

An example of this expansion and contraction within Waukell Creek associated with flow events is seen in Figure 31. The site shown is a relict channel of Waukell Creek, where it diverges from the existing active channel. Figure 31a shows the water level during a storm event in mid December 2006—the floodwater shown is the result of impounding by high flow and flooding from the mainstem river. Figure 31b shows the same site several weeks later. The photos illustrate the very extensive change in water level and habitat condition that occurs as a function of flow in the mainstem river. It bears noting that we trapped the connection between Waukell Creek with its relict channel during the receding hydrograph after the photo in Figure 31a was taken. Juvenile salmonids were trapped as they returned to the main Waukell Creek from the relict channel as flows receded.

Junior Creek, a tributary to Waukell Creek (Figure 23), forms a pond approximate 0.25 miles upstream of its confluence with Waukell Creek. The pond is approximately 0.6 acres in size. The egress channel flowing out of the pond is small, less than 3 ft in width (Figure 32a), and is the site of beaver damming. The pond is seasonal, filling during the fall with the onset of rain and recharging of Junior Creek, then slowly draining in the late spring when stream flow drops. Eventually the pond becomes completely dewatered and is dry during late summer (Figure 32b). The pond, while it seems to function in a completely natural manner, is actually man-made, dating to a past era when a mill operated in the vicinity. Junior Creek pond, as we determined by Phase 1 trapping, attracts relatively large numbers of juvenile coho that move into Waukell Creek out of the mainstem river for overwintering.

Upstream of the confluence with Junior Creek, Waukell Creek flows through a swamp that appears to be well suited for overwintering coho. Further upstream, channel gradient steepens and some spawning habitat exists. From all of the information available to us, we conclude that Waukell Creek is likely used by both natal and non-natal juvenile coho.

Figure 30. Lower Waukell Creek where the stream was trapped with fyke nets in winter 2006-07: (a) reach looking upstream from trapping site during a period of low flow; (b) looking upstream to the trapping site (trap is not installed) during a high flow event on December 15, 2006, showing flow impoundment due to high mainstem flow (Klamath River flow at Klamath gauge at 76,400 cfs).

Figure 31. Connection between existing channel in lower Waukell Creek with its former channel. Photographer is standing within the actively flowing Waukell Creek shooting into the relict channel: (a) high flow event on December 13, 2006 (Klamath River flow at Klamath gauge at 67,900 cfs); (b) same site on January 26, 2007 (Klamath River flow at Klamath gauge at 10,300 cfs).

Figure 32. Junior Creek pond within the Waukell Creek system: (a) condition in mid January 2007, narrow egress channel is seen in the bottom of the photo; (b) pond in late summer with only small pockets of standing water.

3.2.3.7 Richardson Creek Ponds

Richardson Creek is a small stream that enters the Klamath River a short distance downstream of Waukell Creek at RM 2.82 (Figure 23). The creek forms at least two ponds (Figure 33a and b), which were created largely by past human activity (Hiner and Brown 2004). The upper pond, approximately 10 acres in size, is located within Redwood National Park. It served as a mill pond in the middle of the last century.

The lower reach of the creek, downstream of the lower pond, flows under a road fill adjacent to the Klamath River that is partly blocked by debris (Figure 33c), before exiting through a culvert to the river. The culvert is perched when river flow drops to a certain level, as seen in Figure 33d. We have not determined the river flow at which the culvert becomes perched.

We determined that the lower pond is used by overwintering coho and we suspect the upper pond is utilized also. We are uncertain whether the fish are natal or non-natal to the stream, but we suspect that at least some are non-natal fish. While access to the ponds is restricted under some conditions, we presume that some range of flows provide access. Any restoration work that could be performed to improve access would be beneficial to the coho populations that use these ponds.

3.2.3.8 Salt – Hunter Creek Complex

Salt Creek and Hunter Creek enter the Klamath River a short distance from one another within the estuarine zone (Figure 23 and Figure 34a). These streams support natal coho production. We suspect significant non-natal use in both streams.

Although substantial channelization and other habitat loss has occurred to these streams (e.g., Figure 34b), large amounts of habitat well suited for coho overwintering remain. Major portions of both stream systems flow through low gradient valleys, having meandering channels interspersed with large beaver ponds and wetland habitats (Figure 34c)(Beesley and Fiori 2004). The stream mouths have good connectivity to the middle part of the estuarine zone (Figure 34d). This entire stream complex appears to potentially provide substantial overwintering benefits to coho populations that use the system. Habitat restoration work could potentially increase benefits for both non-natal and natal populations utilizing these streams.

3.2.3.9 South Slough Complex

The South Slough and its many connecting channels dissect the expansive final meander bend on the river immediately upstream of the river mouth (Figure 25b). A major side channel of the river cuts through the middle of the area before joining with a large blind channel network on the southern edge of the meander bend. Numerous smaller channels and wetland ponds are connected within the area. Most of these channels are subject to tidal fluctuations, though saltwater intrusion is apparently slight or non-existent during winter flow conditions (Hiner and Brown 2004). Based on the sheer amount of low velocity habitat, and the extensive length of shorelines, this channel complex potentially represents the largest contiguous area of good overwintering habitat for juvenile coho in the Klamath River basin (Figure 35).

Figure 33. Richardson Creek and associated ponds: (a) upper pond; (b) lower pond; *continued to next page.*
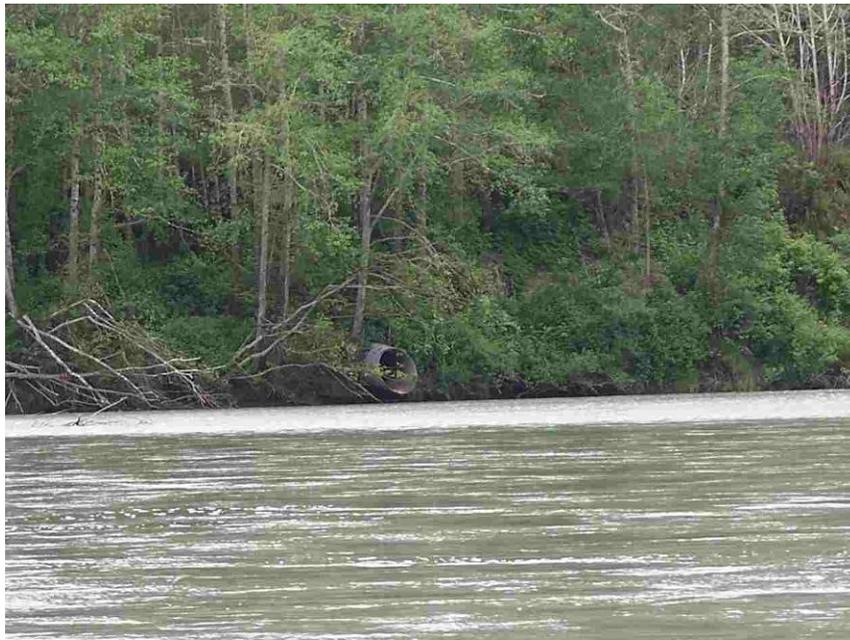
Figure 33 continued – (c) lower stream reach flowing under roadway fill, partially blocked by debris; (d) perched culvert where Richardson Creek joins the Klamath River. Photos shown in a, b, and c taken on January 9, 2007. Photo shown in d taken on May 5, 2006 when the Klamath River flow at the Klamath gauge was 36,700 cfs.

Figure 34. Salt and Hunter creek complex: (a) aerial view of valleys containing Salt and Hunter creeks and their tributaries; (b) lower Spruce Creek, tributary to Hunter Creek, showing evidence of channel simplification due to land use activities; *continued to next page.*

Figure 34 continued – (c) lower Hunter Creek immediately upstream of its confluence with the Klamath River; (d) mouth of Salt Creek as seen from the Klamath River.

Figure 35. South Slough complex: (a) looking upstream from the lower end of the large blind channel on the southern edge of the complex; (b) looking downstream from near the mid section of one of the large blind channels.

3.2.3.10 Mainstem River Edge Habitat

A large proportion of river edge habitat downstream of Trinity River is comprised of rocky bank edge (Figures 24a and 36a) and bar edge (Figure 36b). Interspersed are sections of bank edge habitat with lodged wood (Figure 36b and c) or cover provided by vegetation such as willows

and shrubs (Figure 36d). Edge width with slow velocities preferred by coho tend to be quite narrow in most places. These characteristics suggest that these edge habitats would not be used to a large extent by overwintering juvenile coho, except as stop-over sites while seeking more suitable habitats. Sampling of these sites during future winters is planned.

Figure 36. Examples of bank edge habitats along the mainstem Klamath River downstream of Trinity River during a moderate winter flow. All four photos were taken between Tectah Creek and the Tarup Creek floodplain channel: (a) rocky bank edge; (b) lodged large wood pieces along a deep bank edge; *continued to next page.*

Figure 36 continued—(c) stable redwood root mass along a deep bank edge; (d) vegetated bank edge with submerged branches and roots.

4.0 Evaluation of Fish Sampling Methods

The diverse conditions that exist across the range of habitats within the study areas, including seasonal variations in flow, require that consideration be given to deploying various means of capturing fish. The Phase 1 reconnaissance called for evaluating a suite of fish capture methods across the range of habitat conditions. Similarly, Phase 1 called for evaluating and gaining

experience at marking and tagging juvenile fish under the field conditions that occur during winter.

Two tasks were performed:

1. Sample representative potential overwinter habitat types using one or more fish capture methods at various times and flows; and
2. Apply and evaluate potential marking and tagging procedures under field conditions encountered.

4.1 Methods

Fish capture methods evaluated as part of Phase 1 were fyke net, seine, minnow trap, and fence-type trap. Snorkeling was used in limited situations to augment observations made with one of the other methods. Hook and line was also used at one site. In addition, the duration of operation of a rotary screw trap at Big Bar (RM 50) on the mainstem Klamath River was extended longer into the winter than in previous years.

The fyke net design employed consisted of a rectangular opening, measuring 96 cm x 66 cm, two internal fykes, a 15 m center lead and 8 m side wings. Mesh size was approximately 6 mm bar measure. The nets were used with and without the side wings and lead net, depending on conditions. Traps were deployed with different orientations depending on flow patterns and whether upstream or downstream moving fish were being targeted. These trap nets were used in both the middle and lower study areas. In one stream in the lower study area, the fyke net trap installation was enlarged to provide better coverage across the channel using fence panels constructed of 2 x 4 frames and hardware cloth.

Two types of seine nets were employed. A beach seine was used on a limited basis in the lower estuary using a 46 m x 3 m x 6.4 mm mesh net deployed from a bow of a boat (after Wallace 2003 and Hiner and Brown 2004). A small beach seine was also deployed at several suitable sites along the mainstem river in the middle study area. In addition, a stick seine was used in tributary and floodplain channel habitat in the middle study area.

Gee-type minnow traps were tested in the middle study area. Traps were deployed both baited and unbaited for testing.

In one stream in the middle study area, an emigration/immigration trap was built from a design used successfully in Southeast Alaska (Bramblett et al. 2002; Mason Bryant U.S.F.S., *personal communications*).

During Phase 1, we determined that it would be highly desirable to evaluate the use of a boat electrofisher in the mainstem river as done by Beechie et al. (2005) on the Skagit River in Washington. It was not possible to test this method during Phase 1; however, we plan on using such gear during year 2 of the study.

All salmonids captured as part of this task were measured for fork length and examined for marks.

Assessment of habitat residency and movement patterns by juvenile coho requires some form of marking or tagging fish. Phase 1 activities called for applying marks and tags on a limited basis to evaluate their effectiveness in this study.

Use of passive integrated transponder (PIT) tags is the most effective way of assessing both residency and movement patterns of juvenile salmonids. It has been used successfully in evaluating juvenile coho life history and survival during different seasons in previous studies (e.g., Quinn and Peterson 1996; Ebersole et al. 2006). Based on information contained in PIT Tag Steering Committee (1999) and through discussions with other researchers, we selected a minimum size for tagging to be 65 mm. Full duplex tags (12 mm size) were used and standard protocols for tagging were followed after PIT Tag Steering Committee (1999).

One disadvantage of PIT tags is that small juveniles cannot be tagged. The need to assess movement of juveniles between fry emergence and size at approximately 65 mm, therefore, cannot be met with PIT tags. To address this need, we considered three forms of visually marking small juveniles: freeze brands, elastomer injections, and tattooing with the Panjet instrument. Based on the experience of several participants in the study, it was decided that freeze branding would be the easiest and quickest to apply under expected field conditions. Other field studies on juvenile coho life history have found that freeze brands are an effective way of marking small juveniles and subsequently detecting them all the way to the smolt stage (Peterson and Reid 1984; Scarlett and Cederholm 1984; Bramblett et al. 2002). We used the dry ice and acetone procedure for freeze branding as described by Everest and Edmondson (1967). Trained technicians can very effectively freeze brand very small fry, such as those in the 35-45 mm size range (based on extensive experience of L. Lestelle). Therefore, the technique can work well on the full size range of fish expected to be encountered up to the 65 mm threshold for PIT tagging.

We used Phase 1 to familiarize the crews with freeze branding and detecting different types of brand marks in the field. Brands applied to the left side of fish are reserved for the lower study area, while right side brands are reserved for the middle study area. We have brand emblems that can be used to create at least 18 distinct marks in both study areas. Plans to evaluate mark retention under controlled conditions at a hatchery facility were delayed until year 2 of the study. Guidelines for application of brand marks to juvenile salmonids are provided in Bryant (1990).

4.2 Results and Discussion

Results are first presented for evaluation of fish capture methods, followed by the evaluation of fish marking and tagging.

4.2.1 Fish Capture

Results are first presented for the middle Klamath River study area, followed by those for the lower study area.

4.2.1.1 Middle Klamath River Study Area

Fyke net, seine, minnow traps, a rotary screw trap, and an upstream/downstream migrant trap were used in the middle Klamath River study area for capturing juvenile salmonids during Phase 1 activities. The total amount of fishing effort expended was 698 24-hr fishing periods for all capture methods combined, where each gear type fished on one day is counted as a 24-hr sampling period (Table 3). A total of 133 juvenile coho were captured between all gear types and all locations sampled, substantially fewer than the number of steelhead and chinook caught (Table 3). Catches and average sizes of juvenile coho, steelhead, and chinook made with each capture method by habitat category and month are summarized in Tables 4-6. It bears noting that the coho fry recruitment in 2006 in the Klamath basin, which are the juveniles we sampled in winter 2006-07, is believed to have been low.[7]

Table 3. Summary of juvenile salmonid catches for all methods and sampling sites combined within the mainstem Klamath River corridor between Shasta River and Trinity River in November 2006 – May 2007. Catch per effort (CPUE) is computed as catch divided by the number of 24-hr fishing periods.

Species	24-hr periods	Catch	CPUE
Coho	698	133	0.2
Steelhead	698	763	1.1
Chinook	698	846	1.2

Results for each sampling method are discussed below.

Cade Creek

Method of capture: Upstream/Downstream migrant traps

An upstream/downstream migrant trap was installed lower Cade Creek to monitor movements of juvenile salmonids into and out of Cade Creek during fall and winter. The trap was located approximately 150 ft upstream of the stream mouth.

Trap design was based on traps used for this same type of monitoring in Southeast Alaska by the U.S. Forest Service (Mason Bryant, USFS, *personal communications*). The trap consisted of a weir type design with ¼ in mesh mounted on wood A-frame panels (Figure 37). Live boxes were located mid-stream and had square openings with screen shaped to make a small slot entrance. Weir frames were held to the substrate with rebar stakes. Screen with 1/8 in mesh was attached to the base of the trap and buried in the substrate on both upstream and downstream sides to ensure fish did not go under or around the trap.

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[7] / Spawning escapements for two of the three brood lines of wild Klamath coho—based on a dominant three year life cycle for this species in the Pacific Northwest and California—in recent years, including brood year 2005, are considered to be exceptionally small. One of the three brood lines (i.e., 2000, 2003, 2006) is considered to be relatively strong compared to the other two.

Table 4. Summary of juvenile <u>coho</u> catches by sampling method in off-channel, main channel, and tributaries within the mainstem Klamath River corridor between Shasta River and Trinity River in November 2006 – May 2007.

Trinity River to Happy Camp

Klamath R. Off-Channel Habitats

Months	Method	24-hr periods	Catch	Avg. length
Nov - Feb	Fyke[1]	12	14	98
Nov - Feb	Minnow[1]	66	0	-
Nov - Feb	Seine[2]	2	5	111
March - May	Fyke[1]	65	60	113

Klamath R. Main Channel Habitats

Months	Method	24-hr periods	Catch	Avg. length
Nov - Feb	Fyke[1]	4	1	92
Nov - Feb	Minnow[1]	56	0	-
Nov - Feb	Seine[2]	6	0	-
Nov - Feb	Screw trap[3]	52	4	95
March - May	Fyke[1]	30	2	127
March - May	Seine[2]	7	0	-

Klamath River Tributaries (Stanshaw, L. Grider, and Elk creeks)

Months	Method	24-hr periods	Catch	Avg. length
Nov - Feb	Minnow[1]	3	0	-
Nov - Feb	Seine[2]	1	0	-

Happy Camp to Shasta River

Klamath R. Off-Channel Habitats

Months	Method	24-hr periods	Catch	Avg. length
Nov - Feb	Minnow[1]	23	0	-
March - May	Fyke[1]	3	0	-

Klamath R. Main Channel Habitats

Months	Method	24-hr periods	Catch	Avg. length
Nov - Feb	Fyke[1]	21	3	96
Nov - Feb	Minnow[1]	37	0	-
Nov - Feb	Seine[2]	3	0	-
March - May	Fyke[1]	3	0	-
March - May	Minnow[1]	6	0	-

Klamath River Tributaries (Cade, Tom Martin, L. Horse, and Seiad Creeks)

Months	Method	24-hr periods	Catch	Avg. length
Nov - Feb	Up stream[1]	84	1	87
Nov - Feb	Down stream	51	0	-
Nov - Feb	Minnow[1]	129	25	88
Nov - Feb	Seine[2]	3	17	82
March - May	Minnow[1]	31	1	91

[1] Every trap fished for one day is counted as one 24 hour period. For example, three minnow traps fished on January 1 would equal three 24 hour periods sampled.

[2] Each site sampled on a single day is counted as one 24 hour period, regardless of how many passes were made at the site. For example, two sites seined on January 1, making three seine hauls at each site, would equal two 24 hour periods sampled.

[3] Rotary screw trap located at Big Bar RM 50.

Table 5. Summary of juvenile <u>steelhead</u> catches by sampling method in off-channel, main channel, and tributaries within the mainstem Klamath River corridor between Shasta River and Trinity River in November 2006 – May 2007.

Trinity River to Happy Camp
Klamath R. Off-Channel Habitats

Months	Method	24-hr periods	Catch	Avg. length
Nov - Feb	Fyke[1]	12	21	91
Nov - Feb	Minnow[1]	66	5	57
Nov - Feb	Seine[2]	2	2	181
March - May	Fyke[1]	65	156	120

Klamath R. Main Channel Habitats

Months	Method	24-hr periods	Catch	Avg. length
Nov - Feb	Fyke[1]	4	1	112
Nov - Feb	Minnow[1]	56	28	84
Nov - Feb	Seine[2]	6	5	112
Nov - Feb	Screw trap[3]	52	261	143
March - May	Fyke[1]	30	105	123
March - May	Seine[2]	7	2	150

Klamath River Tributaries (Stanshaw, L. Grider, and Elk creeks)

Months	Method	24-hr periods	Catch	Avg. length
Nov - Feb	Minnow[1]	3	1	110
Nov - Feb	Seine[2]	1	0	-

Happy Camp to Shasta River
Klamath R. Off-Channel Habitats

Months	Method	24-hr periods	Catch	Avg. length
Nov - Feb	Minnow[1]	23	0	-
March - May	Fyke[1]	3	0	-

Klamath R. Main Channel Habitats

Months	Method	24-hr periods	Catch	Avg. length
Nov - Feb	Fyke[1]	21	30	68
Nov - Feb	Minnow[1]	37	31	103
Nov - Feb	Seine[2]	3	0	-
March - May	Fyke[1]	3	2	126
March - May	Minnow[1]	6	5	95

Klamath River Tributaries (Cade, Tom Martin, L. Horse, and Seiad Creeks)

Months	Method	24-hr periods	Catch	Avg. length
Nov - Feb	Up stream[1]	84	11	126
Nov - Feb	Down stream	51	3	62
Nov - Feb	Minnow[1]	129	71	80
Nov - Feb	Seine[2]	3	11	68
March - May	Minnow[1]	31	12	92

[1] Every trap fished for one day is counted as one 24 hour period. For example, three minnow traps fished on January 1 would equal three 24 hour periods sampled.

[2] Each site sampled on a single day is counted as one 24 hour period, regardless of how many passes were made at the site. For example, two sites seined on January 1, making three seine hauls at each site, would equal two 24 hour periods sampled.

[3] Rotary screw trap located at Big Bar RM 50.

Table 6. Summary of juvenile <u>chinook</u> catches by sampling method in off-channel, main channel, and tributaries within the mainstem Klamath River corridor between Shasta River and Trinity River in November 2006 – May 2007.

Trinity River to Happy Camp
Klamath R. Off-Channel Habitats

Months	Method	24-hr periods	Catch	Avg. length
Nov - Feb	Fyke[1]	12	0	-
Nov - Feb	Minnow[1]	66	0	-
Nov - Feb	Seine[2]	2	5	125
March - May	Fyke[1]	65	48	57

Klamath R. Main Channel Habitats

Months	Method	24-hr periods	Catch	Avg. length
Nov - Feb	Fyke[1]	4	0	-
Nov - Feb	Minnow[1]	56	0	-
Nov - Feb	Seine[2]	6	6	184
Nov - Feb	Screw trap[3]	52	182	115
March - May	Fyke[1]	30	257	52
March - May	Seine[2]	7	149	47

Klamath River Tributaries (Stanshaw, L. Grider, and Elk creeks)

Months	Method	24-hr periods	Catch	Avg. length
Nov - Feb	Minnow[1]	3	0	-
Nov - Feb	Seine[2]	1	0	-

Happy Camp to Shasta River
Klamath R. Off-Channel Habitats

Months	Method	24-hr periods	Catch	Avg. length
Nov - Feb	Minnow[1]	23	0	-
March - May	Fyke[1]	3	2	69

Klamath R. Main Channel Habitats

Months	Method	24-hr periods	Catch	Avg. length
Nov - Feb	Fyke[1]	21	0	-
Nov - Feb	Minnow[1]	37	0	-
Nov - Feb	Seine[2]	3	0	-
March - May	Fyke[1]	3	197	55
March - May	Minnow[1]	6	0	-

Klamath River Tributaries (Cade, Tom Martin, L. Horse, and Seiad Creeks)

Months	Method	24-hr periods	Catch	Avg. length
Nov - Feb	Up stream[1]	84	0	-
Nov - Feb	Down stream	51	0	-
Nov - Feb	Minnow[1]	129	0	-
Nov - Feb	Seine[2]	3	0	-
March - May	Minnow[1]	31	0	-

[1] Every trap fished for one day is counted as one 24 hour period. For example, three minnow traps fished on January 1 would equal three 24 hour periods sampled.

[2] Each site sampled on a single day is counted as one 24 hour period, regardless of how many passes were made at the site. For example, two sites seined on January 1, making three seine hauls at each site, would equal two 24 hour periods sampled.

[3] Rotary screw trap located at Big Bar RM 50.

The trap functioned well at lower water levels, as long as leaf litter build-up was removed during daily checks. The trap was repeatedly overwhelmed by higher water later in the season. It was removed on December 24, 2006. It was subsequently replaced with the upstream box/downstream pipe trap. We concluded that the weir trap based Bryant's design is well suited to trapping during periods of lower, stable flow as in summer and fall, but not during high water events.

Figure 37. Cade Creek weir trap based on design received from Mason Bryant (USFS, personal communications). View is from upstream of the trap.

The redesigned trap was installed on January 11, 2007. This trap consisted of two 1.3 m by 2 m wood framed panels with 6 mm in mesh arranged in a V-shape to guide downstream migrating fish into an 5 cm diameter pipe. The pipe extended approximately 2.5 m downstream and emptied into a 1.3 m x 1.3 m x 0.7 m live box. Upstream trap boxes were located on each end of the V at the edge of both banks. The boxes had funnel entrances created by modifying half of a Gee minnow trap. Trap parts were held to the substrate with rebar stakes. Rock and gravel were used to block flow around the upstream boxes. This trap was checked daily.

This second trap design was more efficient at higher flows than the weir type design, and would be the preferred method for migrant trapping at this site during winter. We note, however, that any full spanning trap structure in Cade Creek will be very difficult to maintain during high flow events in both fall and winter. A high debris load consisting of mostly leaves would require opening the structure to pass some portion of the high flow. We further note that this trap design would not function at the lowest summer water levels as the pipe entrance could not be kept submerged. Modifications to the trap could be made by installing a small dam structure just below the trap to create a pool for maintaining flow through the pipe.

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Method of capture: Minnow traps

Gee minnow traps were deployed in various locations in Cade Creek with some success. The minnow traps appeared to work best in areas where fish had been sighted in the immediate vicinity by snorkel observations. The traps performed with similar success whether baited with roe or left without bait.

We conclude that minnow traps are generally effective only when fish have been spotted and targeted (i.e., when traps are placed where coho have already been found by divers). Their appeal for use is that they are highly portable and easily deployed. We fished them at many sites without success. The traps do not seem to be a good method for searching for juvenile coho. This may explain why minnow traps are quite effective in Alaska for capturing juvenile coho. The distribution and density of juvenile coho in Southeast Alaska is expected to be much greater than occurs in the Klamath River corridor. We conclude that the traps have very limited application to our project. Also, other methods (e.g. seining) were found to be more effective at capturing larger numbers of fish when fish had been located by divers.

Bulk Plant Backwater and Floodplain Channel

Method of capture: Fyke net

A fyke net with lead and wings designed for fishing lakes was deployed in the mainstem Klamath River in the large backwater pool unit described in Section 3.2.2.4 (Figure 38). This method was successful, and will be continued. Changing flow conditions on the mainstem require some adjustments to the set during daily checks.

The same gear was deployed within the Bulk Plant floodplain channel pond with little success. However, neither seines nor divers could confirm the presence of fish in the pond. We expect this method would be successful at this site if a seine or divers were to confirm the presence of fish.

Overall, we found fyke nets to be a very versatile and effective method to capture fish in a variety of habitats and conditions in the mainstem corridor. The nets are very portable, requiring only stakes to anchor the trap. They can be fished in some backwater and pond-like locations as they are typically set in lakes, with the lead stretching to shore and the wings set perpendicular to the lead, guiding fish into the fyke. In flowing stream locations, the lead can be removed and the wings can be used to guide fish into the trap. In very small streams, the wings can be removed and the frame can be used alone.

We found that fyke nets are a very good method for locating juvenile coho. They were generally effective at capturing juvenile coho in habitats that appeared to have favorable conditions, but their presence had not been first confirmed by divers.

Figure 38. Setting the fyke net at Bulk Plant backwater site.

Method of capture: Seine

Seines have been used successfully in the Bulk Plant floodplain channel in previous years, however, only a few fish were caught in repeated attempts this year. We will continue to use seining as a method of monitoring coho utilization at this site in the future.

Overall, we have found that seining is a versatile and effective method of capturing juvenile coho in various habitats within the middle Klamath River study area. Seines are extremely effective in small tributaries and off-channel ponds, especially when fish have first been located by divers. They also are a good searching method in the main river channel, allowing for quick spot checks of potential habitats when visibility is poor. Their use is limited, however, anywhere cover is heavy and are thus only useful at certain sites.

Sandy Bar Mainstem Backwater

Method of capture: Fyke net

A fyke net with lead and wings was successfully used in the backwater pool just below the confluence of the Sandy Bar floodplain channel with the mainstem river (Figures 19d and 39).

We expect to continue its use at this site in the future. Changing flow conditions on the mainstem will require some adjustments to the set during daily checks. As noted earlier, we have concluded that fyke nets are a versatile and effective method for capturing juvenile coho in a variety of habitats in the mainstem corridor.

Figure 39. Fyke net set in backwater pool downstream of the Sandy Bar floodplain channel.

Method of capture: Seine

Seining was performed successfully in the backwater pool downstream of Sandy Bar Creek. We expect to continue its use at this site into the future. As noted earlier, we have found that seining is a versatile and effective method of capturing juvenile coho in various habitats within the middle Klamath River study area.

Method of capture: Minnow trap

Gee minnow traps were deployed in various locations in the Sandy Bar backwater with very limited success. As described above, we found minnow traps to only work effectively at sites where we first spotted juvenile coho by snorkel observations. Such observations can rarely be made at this site during winter due to flow and turbidity conditions, rendering use of minnow traps less effective at this site.

Sandy Bar Creek Floodplain Channel Pond

Method of capture: Fyke net

A fyke net with lead and wings was successfully used in the Sandy Bar floodplain channel pond (Figures 19d and 40). This site is more stable than the mainstem backwater site and requires less trap maintenance. However, very high Klamath River flows are likely to inundate the area and disrupt the trap when fishing during such times. We expect to continue to use fyke nets as a primary method of monitoring juvenile coho at this site.

Figure 40. Fyke net set at Sandy Bar floodplain channel pond. Flow from the mainstem Klamath River is influencing the pond at the time of photo. The trap is configured to catch fish moving upstream.

Method of capture: Seine

Seines were used successfully in the pond within the Sandy Bar floodplain channel. Use of this method will be continued.

Stanshaw Creek Floodplain Channel Pond

Method of capture: Fyke net

A fyke net with lead and wings was successfully used in the Stanshaw floodplain channel pond (Figures 12 and 41). This site is more stable than the mainstem backwater site downstream of Sandy Bar Creek and requires less trap maintenance. However, very high Klamath River flows are likely to inundate the area and disrupt the trap when fishing during such times. We expect to continue to use fyke nets as a primary method of monitoring juvenile coho at this site.

Method of capture: Seine

Seines were used successfully at Stanshaw Creek pond and will be used in future seasons.

Figure 41. Fyke net set at Stanshaw Creek floodplain channel pond.

4.2.1.2 Lower Klamath River Study Area

Fyke nets were used almost exclusively for capturing juvenile salmonids during Phase 1 activities in the lower Klamath River study area. We found very quickly after initiating the project that fyke nets were extremely effective in many types of habitats where coho would likely be found in the study area. Therefore, it was decided to concentrate efforts on fyke nets, deploying them extensively and intensively at sites within the study area. We deployed them extensively by sampling periodically at a variety of sites within the lower 8 miles of the river corridor. We also deployed them more intensively at several sites within the Waukell Creek drainage to begin collecting information on movement patterns.

We decided to forego sampling at sites within the mainstem river upstream of the estuarine zone, including at confluence habitats like those at Roaches and Tectah creeks, until we had access to a boat electrofisher. The big river characteristics, with flows fluctuating more rapidly than occurs in the upper half of the middle study area, make it difficult to sample sites where coho would tend to be found with other gear available to us. Plans exist to begin sampling with a boat electrofisher at mainstem river sites upstream of the estuarine zone in year 2 of the study.

Some very limited beach seining was conducted at sites in the lower estuary during Phase 1 (Figure 23) but no juvenile salmonids were captured. Additional sampling is to be conducted at these sites in future years to improve understanding of how this area is used during winter.

Crews gained experience at marking/tagging juvenile salmonids during Phase 1. Freeze brands were successfully used for marking both coho and steelhead in both study areas. The method appears to be well-suited for assessing movement patterns for fish too small to PIT tag. PIT tags

were used to tag juvenile coho captured within the study area upstream of Trinity River. Both of these methods will be deployed during Phase 2 to monitor movements.

The total amount of fishing effort expended with fyke nets at all sites combined in the lower river study area during Phase 1 was 321 24-hr fishing periods (Table 7). A total of 503 juvenile coho were captured between all sampling sites combined. Catches of both steelhead and cutthroat were substantially larger. Summaries of catch and average size of juvenile coho, steelhead, cutthroat, and chinook for each sampling area are given in Tables 8-11.

Table 7. Summary of juvenile salmonid catches for all methods and sampling sites combined within the mainstem Klamath River corridor downstream of Trinity River in November 2006 – May 2007. Catch per unit effort (CPUE) is computed as catch divided by the number of 24-hr fishing periods.

Species	24-hr periods	Catch	CPUE
Coho	321	503	1.6
Steelhead	321	2,026	6.3
Cutthroat	321	1,308	4.1
Chinook	321	25	0.1

Comparisons of catch per unit effort (CPUE) values between sites, trap orientation (i.e., fishing for emigrants or immigrants), month, and species are shown in Figure 42. The comparisons shown are meant only to illustrate very general differences in CPUE because the level of effort, trap coverage, and dates fished differed substantially between site. We believe it is especially noteworthy that the highest CPUE values for juvenile coho occurred within South Slough and an estuarine side channel (near Salt and Hunter creeks) in mid winter. The South Slough sets were all in the upstream half of the complex, where habitat characteristics appear to be especially good for overwintering coho. The CPUE of juvenile coho at the South Slough sites dropped markedly in May, when smolts would be departing the river system. May is a period when water quality conditions within the South Slough begin to deteriorate due to rising temperature and declining dissolved oxygen (Hiner and Brown 2004). It is further noted that the few juvenile coho caught in the South Slough in May were young-of-the-year fish exclusively (Table 8).

Table 8. Summary of juvenile <u>coho</u> catches and average lengths captured with fyke nets by site, trap orientation, and monthly period within the mainstem Klamath River corridor downstream of Trinity River in November 2006 – May 2007. The term "age 0+/1+" here represents fish that emerged in the previous spring, or in rare cases, one year prior to the previous spring (depending on month of capture, fish may have been age 0+ or 1+). The term "YOY" here refers just to fish that emerged in late winter or spring of the year of capture.

Site	Method	Months	24-hr periods[1]	Catch 0+/1+	Catch YOY	Ave length (mm) 0+/1+	Ave length (mm) YOY
Salt Cr.	Upstream fyke	Jan - Feb	27	10	0	101.7	
South Slough[2]	Pond set fyke	Jan-Feb	13	46	0	115.3	
South Slough[2]	Pond set fyke	May	2	0	2		71.5
Estuarine side channel[3]	Pond set fyke	Jan	3	17	0	100.2	
Panther Cr.	Upstream fyke	Dec	7	3	0	100.0	
Spruce Cr.	Upstream fyke	Dec	1	0	0		
Hoppaw Cr.	Upstream fyke	Nov	3	2	0	92.0	
Tarup ponds	Pond set fyke	Feb	8	4	0	155.8	
Resighini ponds	Pond set fyke	Feb - May	15	6	3	146.3	77.0
Lower Waukell	Upstream fyke	Nov - Feb	77	122	0	93.7	
Lower Waukell	Upstream fyke	Mar - May	23	5	52	111.0	57.3
Lower Waukell	Downstream fyke	Nov - Feb	54	2	0	94.5	
Lower Waukell	Downstream fyke	Mar - May	36	90	0	136.2	
Waukell backwater	Upstream fyke	Dec	7	0	0		
Jr. pond	Downstream fyke	Feb - May	24	74	0	136.0	
Waukell below swamp	Downstream fyke	Mar - May	13	64	0	124.5	
Waukell above swamp	Downstream fyke	Mar - May	8	0	1		62.0

[1] Each trap fished for one day is counted as one 24 hour period.

[2] Seven different sites were sampled in the South Slough complex between January and May.

[3] This side channel on the main river was located immediately adjacent to Salt Creek and Spruce (Hunter) Creek.

Table 9. Summary of juvenile <u>steelhead</u> catches and average lengths captured with fyke nets by site, trap orientation, and monthly period within the mainstem Klamath River corridor downstream of Trinity River in November 2006 – May 2007.

Site	Method	Months	24-hr periods[1]	Catch[2]		Ave length (mm)[2]	
				<120 mm	>120 mm	<120 mm	>120 mm
Salt Cr.	Upstream fyke	Jan - Feb	27	115	70	83.1	187.3
South Slough[3]	Pond set fyke	Jan-Feb	13	24	11	86.1	198.1
South Slough[3]	Pond set fyke	May	2	0	0		
Estuarine side channel[4]	Pond set fyke	Jan	3	3	2	92.7	183.0
Panther Cr.	Upstream fyke	Dec	7	12	2	86.9	153.0
Spruce Cr.	Upstream fyke	Dec	1	0	3		135.0
Hoppaw Cr.	Upstream fyke	Nov	3	21	3	73.0	166.7
Tarup ponds	Pond set fyke	Feb	8	63	12	75.7	160.3
Resighini ponds	Pond set fyke	Feb - May	15	2	8	82.0	253.4
Lower Waukell	Upstream fyke	Nov - Feb	77	354	242	83.8	175.5
Lower Waukell	Upstream fyke	Mar - May	23	39	12	96.2	135.4
Lower Waukell	Downstream fyke	Nov - Feb	54	93	83	87.7	185.0
Lower Waukell	Downstream fyke	Mar - May	36	369	225	103.4	156.7
Waukell backwater	Upstream fyke	Dec	7	2	22	97.5	203.8
Jr. pond	Downstream fyke	Feb - May	24	74	12	92.6	150.2
Waukell below swamp	Downstream fyke	Mar - May	13	85	18	102.4	131.1
Waukell above swamp	Downstream fyke	Mar - May	8	21	24	107.2	131

[1] Each trap fished for one day is counted as one 24 hour period.

[2] Two size classes are shown (<120 and >120). Previous analyses suggest that during this period most age 1+ trout are <120 mm and most age 2+ trout are >120 mm.

[3] Seven different sites were sampled in the South Slough complex between January and May.

[4] This side channel on the main river was located immediately adjacent to Salt Creek and Spruce (Hunter) Creek.

Table 10. Summary of juvenile <u>cutthroat</u> catches and average lengths captured with fyke nets by site, trap orientation, and monthly period within the mainstem Klamath River corridor downstream of Trinity River in November 2006 – May 2007.

Site	Method	Months	24-hr periods[1]	Catch[2] <120 mm	Catch[2] >120 mm	Ave length (mm)[2] <120 mm	Ave length (mm)[2] >120 mm
Salt Cr.	Upstream fyke	Jan - Feb	27	14	28	91.7	255.3
South Slough[3]	Pond set fyke	Jan-Feb	13	29	17	91.2	238.1
South Slough[3]	Pond set fyke	May	2	0	3		208.3
Estuarine side channel[4]	Pond set fyke	Jan	3	0	2		248.0
Panther Cr.	Upstream fyke	Dec	7	9	1	94.5	141.0
Spruce Cr.	Upstream fyke	Dec	1	0	0		
Hoppaw Cr.	Upstream fyke	Nov	3	9	0	61.9	
Tarup ponds	Pond set fyke	Feb	8	1	2	108.0	375.0
Resighini ponds	Pond set fyke	Feb - May	15	1	25	85.0	165.0
Lower Waukell	Upstream fyke	Nov - Feb	77	183	55	88.1	197.6
Lower Waukell	Upstream fyke	Mar - May	23	39	58	105.0	151.4
Lower Waukell	Downstream fyke	Nov - Feb	54	13	16	93.3	241.6
Lower Waukell	Downstream fyke	Mar - May	36	127	387	110.3	148.3
Waukell backwater	Upstream fyke	Dec	7	0	1		260.0
Jr. pond	Downstream fyke	Feb - May	24	69	100	105.2	144.8
Waukell below swamp	Downstream fyke	Mar - May	13	31	64	111.7	154.1
Waukell above swamp	Downstream fyke	Mar - May	8	13	11	104.9	151

[1] Each trap fished for one day is counted as one 24 hour period.

[2] Two size classes are shown (<120 and >120). Previous analyses suggest that during this period most age 1+ trout are <120 mm and most age 2+ trout are >120 mm.

[3] Seven different sites were sampled in the South Slough complex between January and May.

[4] This side channel on the main river was located immediately adjacent to Salt Creek and Spruce (Hunter) Creek.

Table 11. Summary of juvenile <u>chinook</u> catches and average lengths captured with fyke nets by site, trap orientation, and monthly period within the mainstem Klamath River corridor downstream of Trinity River in November 2006 – May 2007. The term "age 0+/1+" here represents fish that emerged in the previous spring (depending on month of capture, fish may have been age 0+ or 1+). The term "YOY" here refers just to fish that emerged in late winter or spring of the year of capture.

Site	Method	Months	24-hr periods[1]	Catch		Ave length (mm)	
				0+/1+	YOY	0+/1+	YOY
Salt Cr.	Upstream fyke	Jan - Feb	27	0	0		
South Slough[2]	Pond set fyke	Jan-Feb	13	0	0		
South Slough[2]	Pond set fyke	May	2	0	0		
Estuarine side channel[3]	Pond set fyke	Jan	3	0	0		
Panther Cr.	Upstream fyke	Dec	7	0	0		
Spruce Cr.	Upstream fyke	Dec	1	0	0		
Hoppaw Cr.	Upstream fyke	Nov	3	0	0		
Tarup ponds	Pond set fyke	Feb - May	8	0	0		
Resighini ponds	Pond set fyke	Feb - May	15	23	0	124.4	
Lower Waukell	Upstream fyke	Nov - Feb	77	0	0		
Lower Waukell	Upstream fyke	Mar - May	23	0	2		59.5
Lower Waukell	Downstream fyke	Nov - Feb	54	0	0		
Lower Waukell	Downstream fyke	Mar - May	36	0	0		
Waukell backwater	Upstream fyke	Dec	7	0	0		
Jr. pond	Downstream fyke	Feb - May	24	0	0		
Waukell below swamp	Downstream fyke	Mar - May	13	0	0		
Waukell above swamp	Downstream fyke	Mar - May	8	0	0		

[1] Each trap fished for one day is counted as one 24 hour period.

[2] Seven different sites were sampled in the South Slough complex between January and May.

[3] This side channel on the main river was located immediately adjacent to Salt Creek and Spruce (Hunter) Creek.
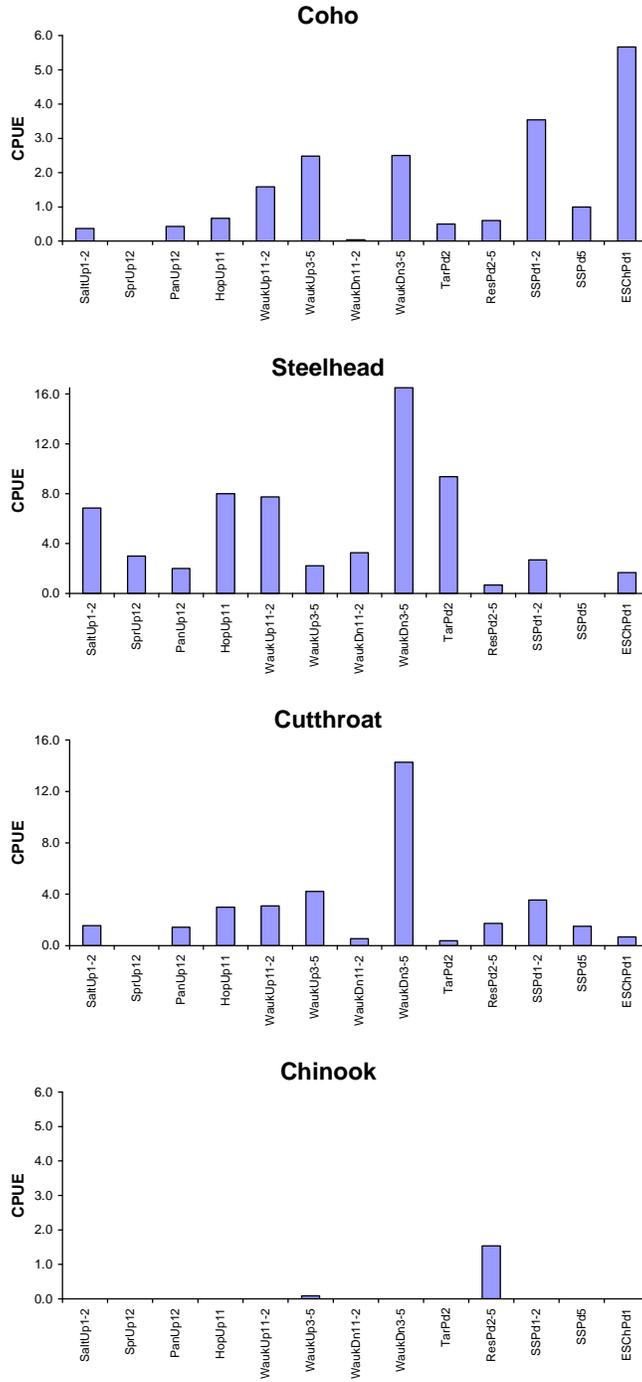
Figure 42. Comparison of CPUE by species, site, trap orientation, and month for fyke net catches at selected sampling sites within the mainstem Klamath River corridor downstream of Trinity River in November 2006 – May 2007. Abbreviations are SaltUp1-2 – Salt Cr with upstream fyke in Jan and Feb, SprUp12 –Spruce Cr with upstream fyke in Dec, PanUp12 – Panther Cr with upstream fyke in Dec, HopUp11 – Hoppaw Cr with upstream fyke in Nov, WaukUp11-2 – Lower Waukell Cr with upstream fyke in Nov-Feb, WaukUp3-5 – Lower Waukell Cr with upstream fyke in Mar-May, WaukDn11-2 – Lower Waukell Cr with downstream fyke in Nov-Feb, WaukDn3-5 – Lower Waukell Cr with downstream fyke in Mar-May, TarPd2 – Tarup Ponds with pond fyke in Feb, ResPd2-5 – Resighini Ponds with pond fyke in Feb-May, SSPd1-2 – South Slough with pond fyke in Jan-Feb, SSPd5 – South Slough with pond fyke in May, and ESChPd1 – Estuarine side channel with pond fyke in Jan.

Comparisons of species composition in fyke net catches between site, trap orientation, and month are shown in Figure 43. As noted for CPUE, the comparisons shown are meant only to illustrate very general differences in species composition because of differences in fishing effort, trap coverage, and dates fished between sites. The highest percentages of juvenile coho in fyke net catches between all sites occurred in the South Slough and the estuarine side channel.
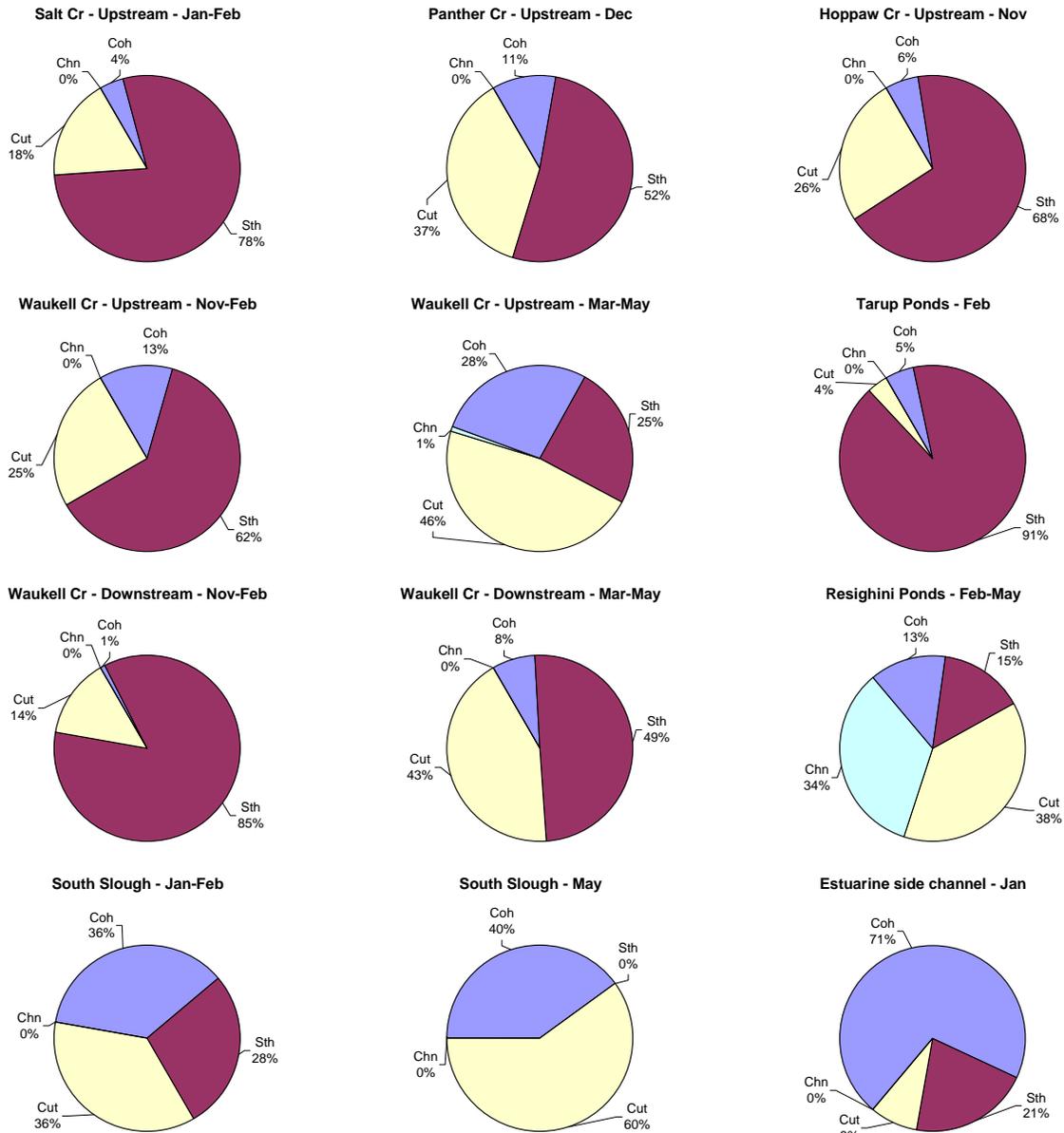

Figure 43. Comparison of species composition in fyke net catches between site, trap orientation, and month at selected sampling sites within the mainstem Klamath River corridor downstream of Trinity River in November 2006 – May 2007. Abbreviations are Chn – Chinook, Coh – coho, Cut – cutthroat, and Sth – steelhead.

4.2.2 Fish Marking and Tagging

Field crews in both study areas successfully implemented marking and tagging operations on juvenile coho during Phase 1. Activities were primarily aimed at familiarizing and training the crews with both freeze branding and PIT tagging (Figures 44-45). Fish were marked and tagged under a range of field conditions at several sites. No recovery data are being reported here as the scale of the activities was small in this first year of work.

Freeze branding was determined to be an effective method of marking juvenile coho for subsequent mark detection upon recapture. We will continue using this procedure in year 2 of the project. We plan to evaluate mark retention under controlled conditions at a hatchery facility in year 2.

PIT tagging is to be implemented at all sampling sites in year 2 of the study.

5.0 Movement Patterns

The assessment of juvenile coho movement patterns was originally to begin in year 2 of the project. Early in Phase 1, we concluded that it would be efficient to initiate some level of monitoring to begin the assessment immediately. In doing so, information could be collected to help understand the level of interannual variability in movement patterns that occurs at one location and to help guide planning for year 2 activities.

It was determined within several days of initiating sampling in lower Waukell Creek in November 2006 that juvenile salmonids—including coho—were actively immigrating into the stream from the mainstem river. Therefore, sampling was intensified at the site to ensure that some level of trapping would occur on a semi-continuous basis throughout the season. Additional traps were also placed higher in the Waukell system to learn where fish were migrating to.

We determined that fish were moving upstream into the two main branches of Waukell Creek upstream from the lower trap site -- Junior Creek and upper Waukell Creek. In Junior Creek, fish were found to be moving into the pond described in Section 3.2.3.6. Fish were also found moving into a wetland marsh area in mainstem Waukell Creek upstream of the confluence with Junior Creek. We concluded on the basis of sampling at various sites in the system and from mark recoveries that most coho were moving into Junior Pond, though a substantial number were also moving into upper Waukell Creek.

Results presented herein will focus on data collected at the lower Waukell trap site (Figure 23).

5.1 Methods

A fyke net was initially installed in Waukell Creek on November 9, 2006 to trap fish moving upstream. Subsequently, as interest in the site increased, a downstream trap was installed on November 21. Screen panels built of 2 x 4 lumber and hardware cloth were added to the installation to increase trap efficiency at the site (Figure 46).

Figure 44. Freeze branding a juvenile coho with a V-brand. The fish is between 55-60 mm in length. The mark, shown as a white upside down V, will turn dark gray to black within a few days. At time of smolting, the mark will still be clearly visible but without color.

Figure 45. PIT tagging a juvenile coho approximately 75 mm in length.

The traps were removed periodically to give attention to trapping other sites in the lower river study area. The traps were also inundated by high flows on several occasions. Scour also occurred at the site requiring that some adjustments be made to trap configuration.

No estimates of trap efficiency were made during the course of the season. There is no doubt that trap efficiency was variable during the season for a variety of reasons.

When fishing, the traps were checked daily or every other day. On rare occasions—when few fish were migrating—the traps were fished for three consecutive days without being checked.

Periodically the traps were plagued by mink and otter. These animals at various times entered the traps, preyed on captured fish, and either successfully left through the trap opening or chewed holes in the net to escape. We routinely operated live mink traps to catch them—when successful, we transported them off site. This issue requires additional attention to reduce risk of fish mortality in future years.

Trapping occurred at the site on a semi-continuous basis until the middle of May 2007. The traps were removed on May 12, 2007.

Figure 46. Fyke net trap installation in lower Waukell Creek. View is looking downstream. In this photo (March 2007), two traps are installed side by side on right bank, oriented to catch downstream moving fish. The upstream trap is on the left bank. Screen panels are installed between the traps to increase efficiency.

5.2 Results and Discussion

Patterns of upstream movement by coho, steelhead, and cutthroat at the lower Waukell Creek trap site between mid November and the end of March are displayed in Figures 47-49. The figures show catch per day (i.e., CPUE), days when fishing occurred, and flow in the Klamath River at the Terwer gauge (RM 6).

Upstream movement by juvenile coho was strongly correlated with mainstem river flow events between mid November and the end of December (Figure 47). The first day of trapping (November 19-20) occurred prior to a marked increase in flow—no juvenile coho were captured. Shortly thereafter flow spiked up and coho were caught in the upstream trap. During late

November, flows and coho catches corresponded with one another as juvenile coho moved into Waukell Creek during high flow events. During a period of steadily receding flows between late November and early December, no coho were captured. A major freshet then occurred in mid December with flows exceeding 80,000 cfs in the Klamath River. The trap was pulled during the high flow, but was reinstalled as flows dropped, producing coho catches that showed active upstream migration. Major freshets occurred again in late December and early January, producing catches that showed a slowing rate of immigration. The major immigration of coho into Waukell Creek ended around the end of the calendar year. Occasional upstream movement was observed through the end of March, excluding observations of young-of-the-year (YOY), regardless of flow levels in the mainstem river.

Coho catches in Waukell Cr. upstream trap
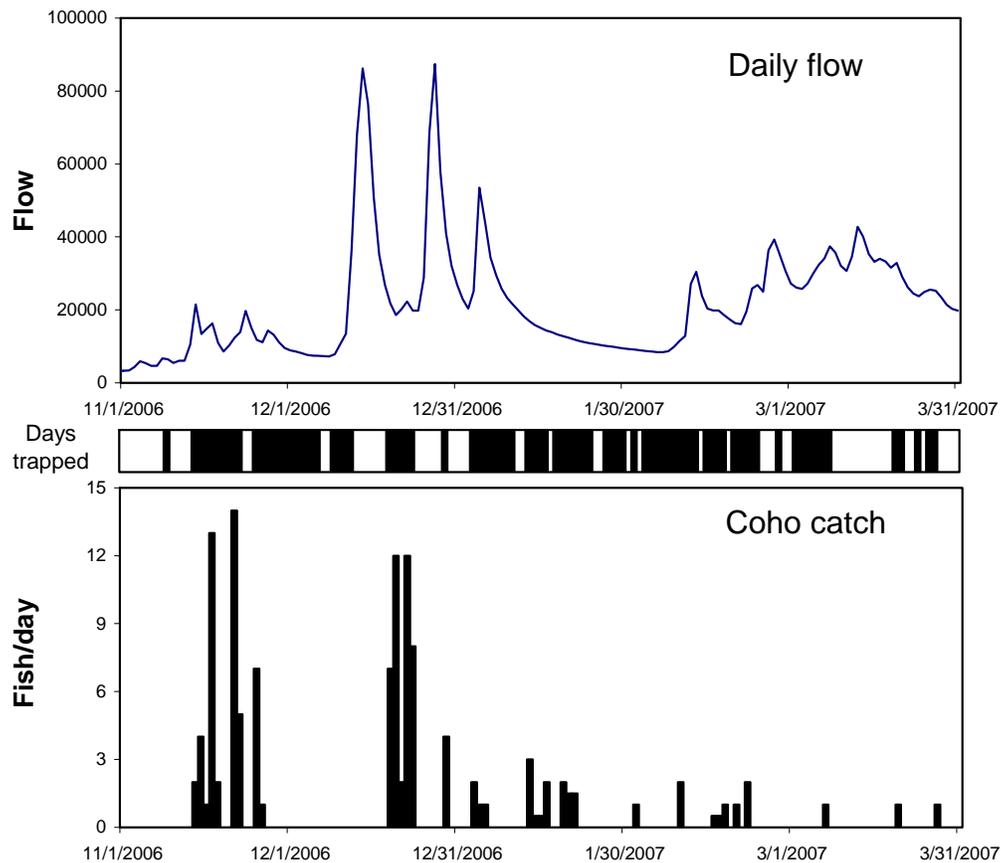
Figure 47. Catch per day of juvenile coho in the upstream trap in lower Waukell Creek, days fished, and flow in the Klamath River (Terwer gauge near Highway 101) between November 1, 2006 and March 31, 2007.

Upstream movement patterns for steelhead and cutthroat differed from the coho pattern. Steelhead movement showed a greater correspondence with flow over a greater period of time than seen for coho, though spikes in catch also occurred when no significant flow signal occurred (Figure 48). Notably, steelhead catches trailed off during the long period of receding flows in January and early February. When flows spiked up in mid February, steelhead catches also jumped, in contrast to the lack of response from coho.

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Cutthroat movement was at a low level in November and early December in contrast to the coho and steelhead patterns (Figure 49). The large flow events between mid December and early January appear to have produced somewhat larger upstream movements. Like steelhead, cutthroat movement trailed off in mid to late January as flows dropped. The large increase in flow between mid to late February appears to have triggered the most significant upstream movement seen for cutthroat.

Upstream and downstream movement patterns for coho (excluding YOY fish), steelhead, and cutthroat at the lower Waukell Creek trap site are compared in Figures 50-52. The figures show catch per day and days when fishing occurred for the upstream and downstream traps.

Steelhead catches in Waukell Cr. upstream trap
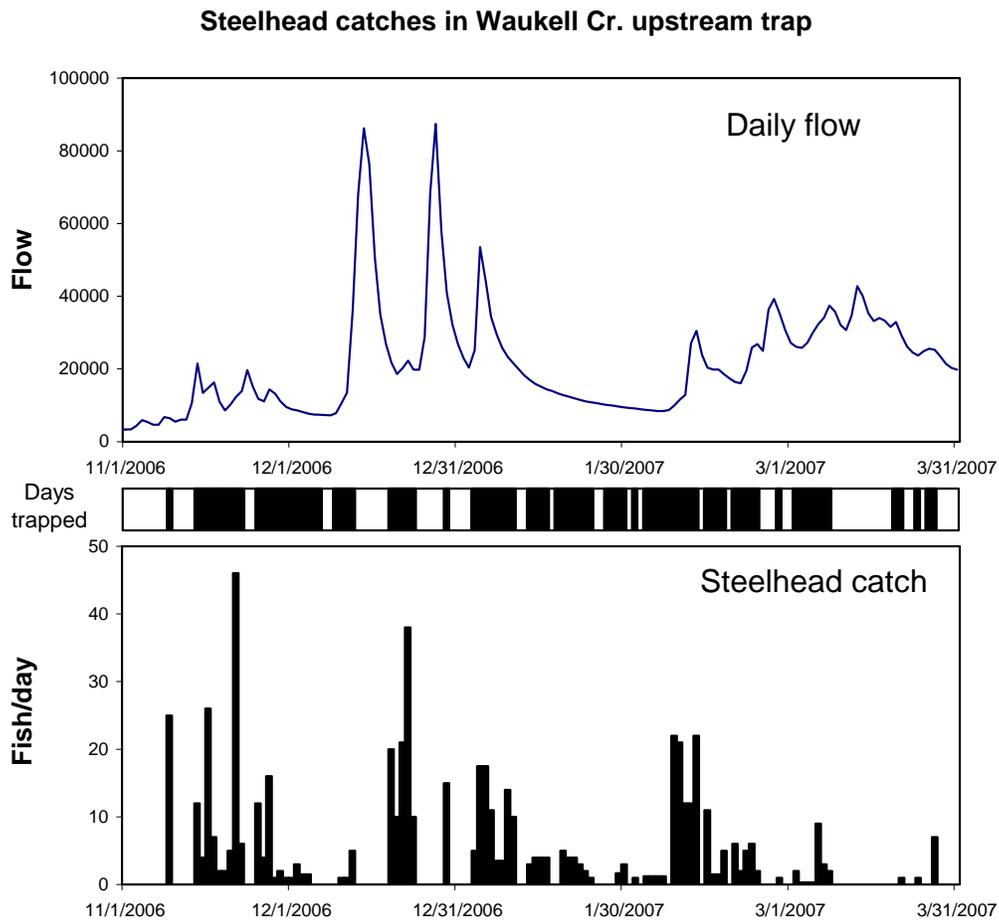
Figure 48. Catch per day of juvenile steelhead in the upstream trap in lower Waukell Creek, days fished, and flow in the Klamath River (Terwer gauge near Highway 101) between November 1, 2006 and March 31, 2007.

Juvenile coho, excluding YOY fish, displayed almost no downstream movement past the trap site until late March. Thereafter, emigration increased as yearling fish moved seaward as smolts. In comparing the patterns for upstream and downstream movement, it is apparent that immigrants moved upstream from the trap site and found the type of overwintering habitat they were seeking. Only a few were caught in the downstream trap prior to the smolt migration, and

these may have been caught simply due to localized movements of fish seeking temporary
shelter or escaping predators. The overall pattern that emerges for coho is that they moved from
the mainstem in late fall and early winter during periods of high flow to find suitable
overwintering habitat. Having found it, few or none left until their smolt migration. This pattern
is one of high fidelity to good overwintering habitat. It suggests that the habitat upstream of the
trap site is highly suitable for overwintering. As noted earlier, we also concluded that most of the
upstream migrants moved into Junior Pond, with others moving into the wetland marsh.

Cutthroat catches in Waukell Cr. upstream trap
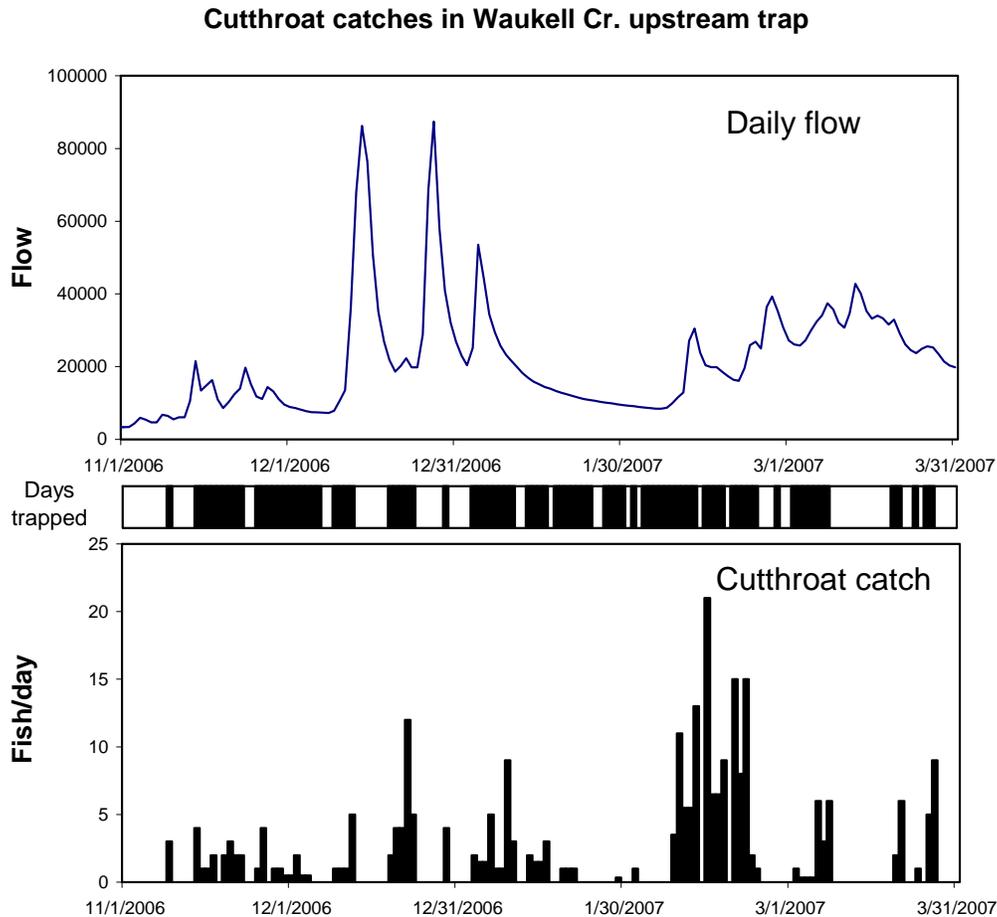
**Figure 49. Catch per day of cutthroat in the upstream trap in lower Waukell Creek, days fished, and flow in
the Klamath River (Terwer gauge near Highway 101) between November 1, 2006 and March 31, 2007.**

The comparison between upstream and downstream moving steelhead is generally similar to that
of coho but it shows a much higher degree of fish moving downstream prior to the onset of the
smolt migration. The smolt migration also appears to have begun earlier than for coho. The
relatively larger number of steelhead moving downstream over the course of trapping compared
to coho may reflect fish moving upstream then moving back down soon thereafter. This suggests
that some steelhead are wandering, with shorter periods of residency than seen for coho,
representing a greater range of habitat preferences than exhibited by coho (as discussed in
Lestelle 2007).

The downstream movement of cutthroat was very slight through the fall and winter, then increased substantially in mid March. The total number of cutthroat moving downstream in spring was much larger than the number moving upstream in earlier months, indicating that most of the production represented in downstream movement was likely the result of natal fish leaving the stream for the first time.

The upstream-downstream migration patterns of juvenile coho through lower Waukell Creek is characteristic of coho movements found in streams connecting off-channel ponds to rivers on the Olympic Peninsula in Washington (Peterson 1982a; Peterson and Reid 1984). In those river systems, the advent of fall rains and increased river flow trigger some juvenile coho to initiate a redistribution movement from late summer rearing sites in rivers and creeks to low velocity habitats in off-channel areas. Peterson (1982a) observed large numbers of juvenile coho moving from a mainstem river into off-channel ponds via small egress channels. Once the coho entered the ponds in fall and early winter, few subsequently moved back out to the river until spring when the smolt migration commenced. Survival and growth rates in the ponds were high compared to what typically occurs in runoff streams (Peterson 1982b; Lestelle 2007). The movement patterns of coho observed in lower Waukell Creek are very similar to those found by Peterson.
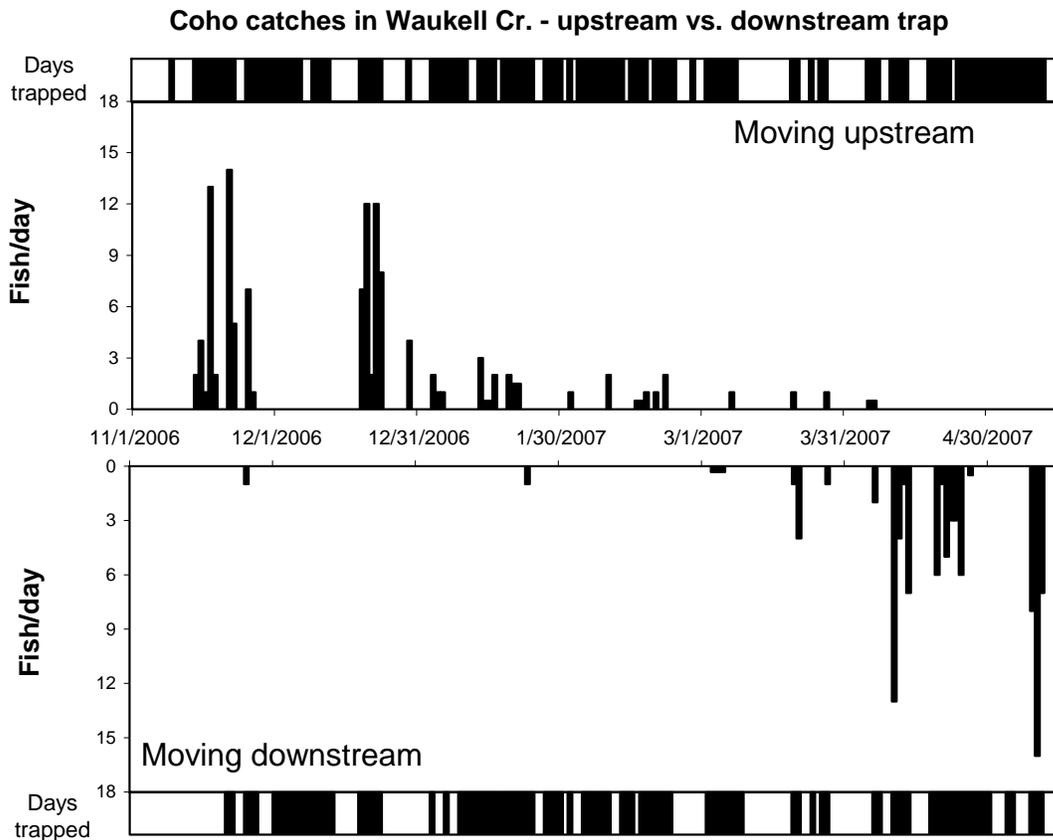

Figure 50. Upstream and downstream catches of juvenile coho and days fished in lower Waukell Creek between mid November 2006 and mid May 2007.

It is noteworthy that juvenile coho also move into small runoff tributaries, like Cade Creek described earlier in this report, during fall and early winter. Similar finding were also noted by Peterson. In these cases, juvenile coho are much more transient than occurs when they move into ponds, with some residing through the winter while others stay only a short period before moving back to the mainstem (Scarlett and Cederholm 1984). It is hypothesized that these transients are using the small tributaries as short-term refuge from high flows in the mainstem river before continuing to move in search of more productive habitat for overwintering (Lestelle 2007).

A comparison of the sizes of juvenile coho moving upstream into Waukell Creek to those subsequently moving out as smolts shows that this drainage is very productive for coho overwintering (Figure 53). It is evident that coho moving upstream into Waukell Creek experienced high growth rates, given the large sizes of smolts that emigrated in spring. The average size outmigrating smolts was 136 mm. Coho smolts emigrating from typical small natal tributaries often average approximately 100 mm at time of their seaward migration (Lestelle 2007). The smolts leaving Waukell Creek were exceptionally large, characteristic of coho that overwinter in ponds and lakes (Peterson 1982b; Quinn and Peterson 1996). Large smolts are indicative of overwintering conditions that produce high overwinter survival rates. Moreover, large smolts often experience higher marine survival rates than smaller smolts.
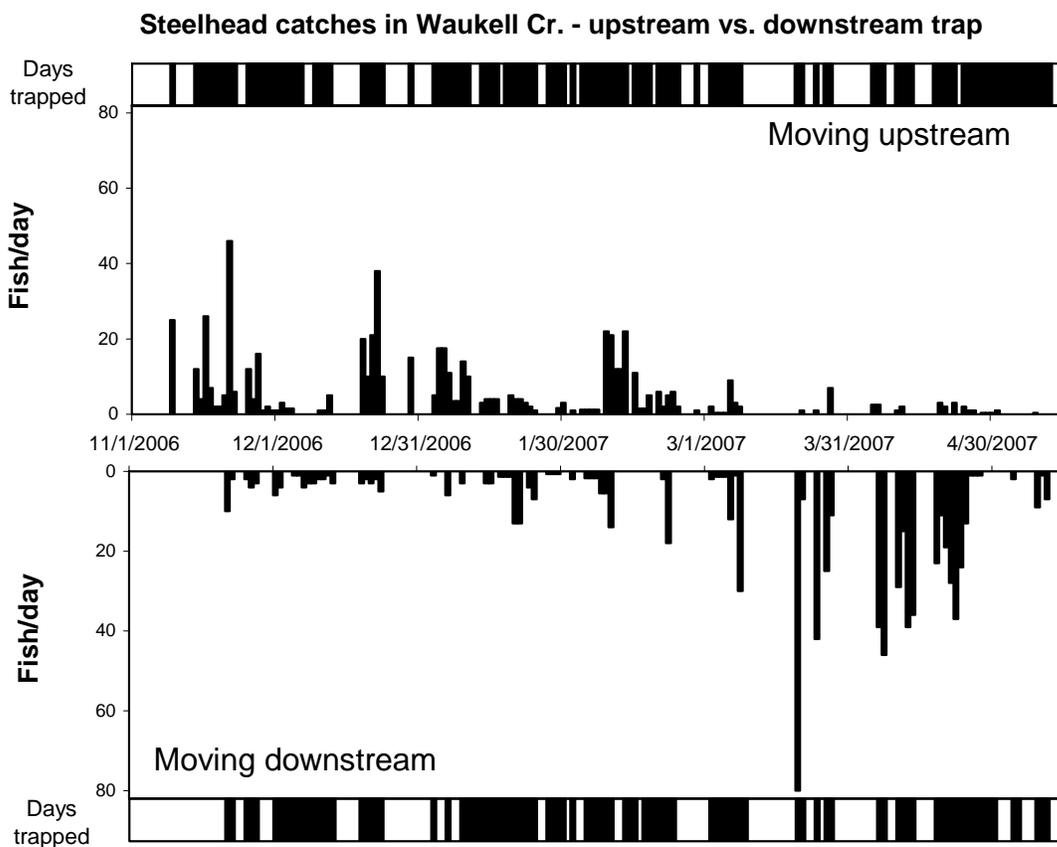
Figure 51. Upstream and downstream catches of juvenile steelhead and days fished in lower Waukell Creek between mid November 2006 and mid May 2007.

It is also noteworthy that the Waukell immigrants tended to be quite large when they moved into the stream from the mainstem river (Figure 53). Fish of this size are often associated with river corridor habitats during the late summer rearing period. Food resources in those habitats are usually greater than found in small natal streams. Consequently, fish that undergo redistribution movements out of mainstem corridor habitats and into high quality overwintering habitats are often of relatively large size (Marshall and Britton 1980; Scarlett and Cederholm 1984; Peterson and Reid 1984), however, this may not be the case where corridor habitats have high summer temperatures. Assessing these patterns of fish size during late summer, fall, and winter is expected to be extremely important in understanding coho performance in the Klamath River basin.

Waukell Creek also exhibits an upstream movement by YOY coho during spring when smolts are departing, as seen in the trap catches (Table 8). These fish are relatively large for this period, indicating that they had already experienced good growth conditions prior to being captured.
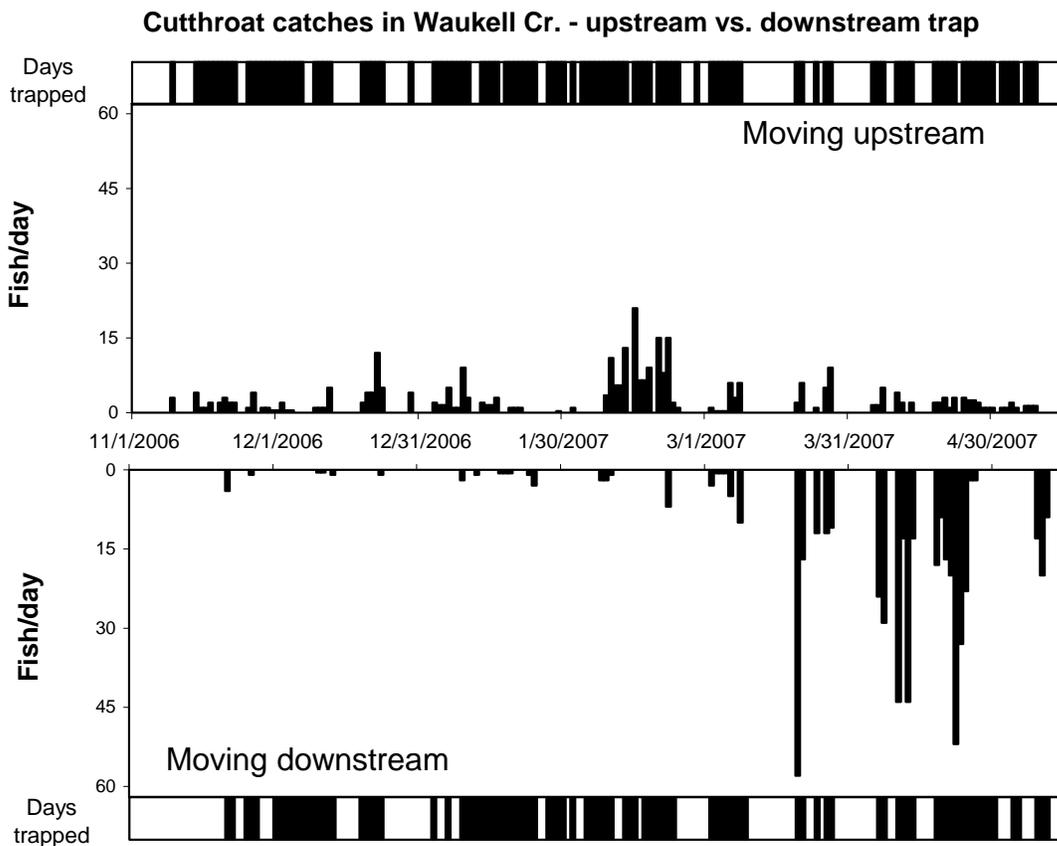

Figure 52. Upstream and downstream catches of cutthroat and days fished in lower Waukell Creek between mid November 2006 and mid May 2007.

Moving upstream Nov - Feb

Ave = 94 mm

n = 122

Moving downstream Mar - May

Ave = 136 mm

n = 90
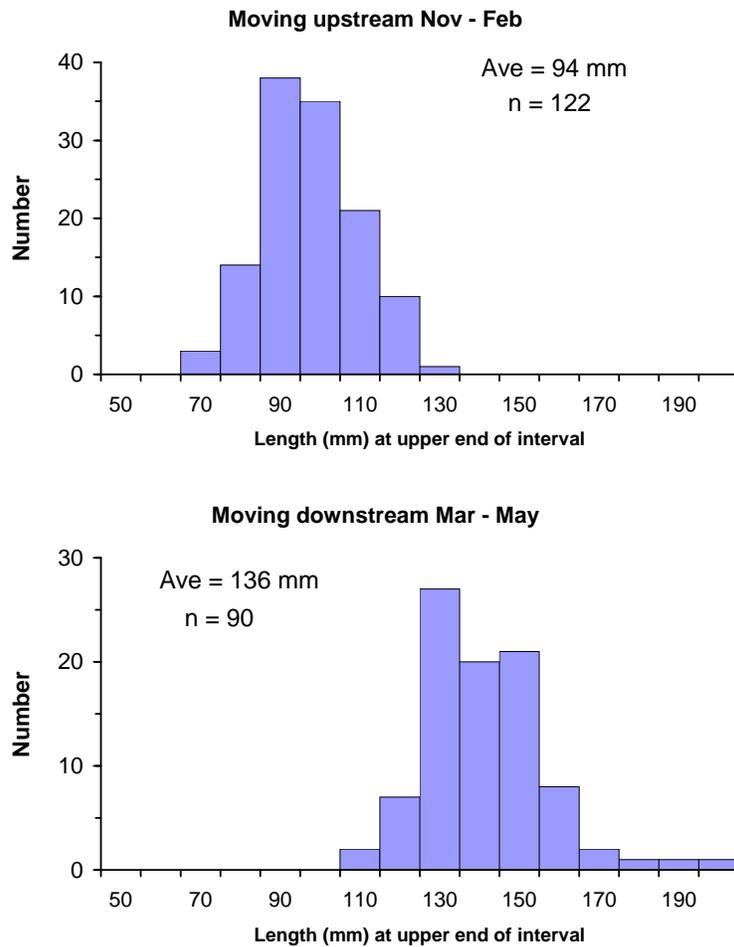
Figure 53. Length frequencies of juvenile coho captured in lower Waukell Creek moving upstream between November, 2006 through February, 2007 and moving downstream between March through May, 2007.

6.0 Project Refinements and Recommendations

The objectives for Phase 1 were met. We successfully carried out a reconnaissance of the range of different fall-winter habitats potentially used by juvenile coho in the mainstem Klamath River corridor. We evaluated a suite of fish sampling methods available to our staffs to be used in these habitats. The evaluation of fish capture methods will be expanded in year 2 to include the use of a boat electrofisher for sampling mainstem river habitats. Additionally, we initiated activities to begin collecting information on coho movement patterns within the river corridor—these activities were not scheduled to start until year 2.

We foresee implementing the following refinements to the project in the next phases:

Identification and characterization of overwintering habitats
  ➢ Complete the inventory of potential overwintering habitats within the study areas by identifying locations of the various habitat types used for overwintering; and

> Improve the characterization of connectivity of floodplain channels and ponds to the mainstem river.

Assessment of relative utilization rates of habitats by juvenile coho
> Expand the sampling coverage for fish utilization to more overwintering sites in both study areas;
> Initiate sampling of mainstem edge and backwater habitats using a boat electrofisher following the basic study design applied by Beechie et al. (2005);
> Intensify sampling in the various channels of the South Slough over the course of one fall-winter period to assess relative distribution and residency; and
> Implement full-scale marking and tagging coverage—with strong emphasis on PIT tagging—to characterize durations of residency at index sites associated with various habitats.

Assessment of seasonal movement patterns
> Implement full-scale marking and tagging coverage in all seasons—with strong emphasis on PIT tagging, expanding opportunities for recovery of marks and tags; these data will be used to assess the extent and patterns of seasonal movements within the mainstem corridor; marking and tagging should occur mostly at strategic sites within the corridor where fish are likely to move with environmental stimuli or at sites believed to be contributors of juvenile fish into the corridor; and
> Expand coverage for fish recapture by systematically operating fish capture gear at a cross section of habitat types within both study areas.

Assessment of juvenile fish performance within the river corridor
> Assess survival at several key sites where numbers of fish entering and leaving can be reliably monitored—data collected will also enable other measures of performance to be described, i.e., growth and length of residency; and
> Assess fish size, growth, and habitat residency systematically at sites representative of the range of habitats used to some extent.

We anticipate a very significant expansion of use of PIT tags to assess movement patterns, habitat residency, and performance. We also anticipate formulating refinements to the study design to more effectively use PIT tag recoveries as a way of assessing seasonal survival rates in different habitats or areas of the river basin.

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