Fish Surveys Related to the Proposed Del Norte Highway 101 Klamath Grade Raise Project

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Abstract

Fish surveys and water quality monitoring activities were conducted in tributary and wetland habitats that may be impacted by the proposed Del Norte 101 Klamath Grade Raise, Road Rehabilitation and Bridge Replacement Project. The study was conducted during summer – fall 2009 to assess fish abundance and use of these habitats during the typical construction season. Target species for these efforts included coho salmon and longfin smelt. Mark-recapture studies were conducted in Spruce Creek, Panther Creek Pond, and Salt Creek marsh to generate population estimates for juvenile coho salmon and trout species. Additional fish surveys were conducted in lower Hunter Creek, the Hunter Road wetland, and the Arbor Glen wetland to assess fish presence and document temporal trends of target species. Juvenile coho were observed at all of the monitoring sites studied in summer – fall 2009 except the Arbor Glen wetland. The largest coho population numbers were estimated for Panther Creek Pond during June (102 fish); July (101 fish); and August (24 fish). A population of 43 coho was estimated in Spruce Creek during June; however, no salmonids were captured during July and August sampling efforts. No reliable population estimates could be generated for coho in Salt Creek marsh due to low captures. Repeat snorkel inventories conducted in lower Hunter Creek during summer 2009 revealed the presence of juvenile coho and chinook salmon, coastal cutthroat, and steelhead. No longfin smelt were observed or captured during this study; however, the methods employed were not likely effective for sampling this particular species. Dissolved oxygen levels were very low (< 6.0 mg/L) at a majority of the sites monitored during summer – early fall and affected the ability to sample fish populations. This report summarizes fish sampling efforts and describes the fish, amphibians, and the water quality conditions encountered in the project area during summer – fall 2009; as well as presents information regarding coho salmon brood year strength in the Klamath Basin and the Lower Klamath River Sub-basin; and non-natal use of the Lower River by salmonids, especially coho, emanating from throughout the Klamath Basin.

Introduction

Yurok People inhabiting the Lower Klamath have relied on the areas resources for their subsistence, cultural, and economic livelihood since time immemorial. Central to Yurok culture and livelihood is subsistence harvest of Klamath River fish populations. Anthropogenic activities occurring over the past century have drastically altered or degraded river, tributary, and estuary habitats and resulted in substantial declines to Klamath River fish runs and greatly impacted the productivity of the basin. The long-term goal and priority water resource need of the Yurok Tribe is to restore Klamath Basin habitats to levels that support robust populations of native fish. To address this long-term objective, the Yurok Tribal Fisheries Program – Lower Klamath Division (YTFP) works with restoration partners, including other Tribal Departments, state and federal resource agencies, small-scale agricultural producers, and private landowners, to assess, identify, and treat factors limiting anadromous fish in the Lower Klamath River.

Initial restoration planning efforts included developing the Lower Klamath Sub-Basin Watershed Restoration Plan that identified tributary specific upslope and fisheries restoration objectives and prioritized tributary restoration throughout the sub-basin (Gale and Randolph 2000). Restoration objectives included: 1) reducing sediment inputs from upslope sources by treating high priority watershed roads; 2) restoring native, conifer-dominated riparian forests; and 3) enhancing freshwater aquatic habitats. Since 2000, YTFP and the Yurok Tribe Watershed Restoration Department have been working cooperatively with our restoration partners to implement and update the initial sub-basin plan to meet program and water resource objectives.

The sub-basin restoration plan took a top-down approach with a strong focus on treatment of upslope sediment sources in Lower Klamath River tributaries (Gale and Randolph 2000). Recently, YTFP has focused on improving Lower Klamath tributary valley conditions and enhancing Klamath River estuary and off-estuary habitats. The Klamath River estuary serves as a vital staging area and nursery for spring and fall-run chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), steelhead trout (*O. mykiss*), coastal cutthroat trout (*O. clarki clarki*), green and white sturgeon (*Acipenser spp.*), eulachon (*Thaleichthys pacificus*), longfin smelt (*Spirinchus thaleichthys*), flounder (*Platichthys spp.*), and lamprey (*Lampetra spp.*). It is likely that tens of millions of juvenile salmonids migrate through the Klamath River estuary every year on their way to the ocean. Estuary rearing allows juvenile fish to physiologically adapt for ocean survival and to amass growth prior to ocean entry. Studies conducted in Oregon suggest ocean survival of juvenile chinook salmon was greatly increased when fish entered the ocean at larger sizes (120-160 mm) (Nicholas and Hankin 1989).

From 1993-2003, CDFG monitored juvenile salmonid populations in the Klamath River estuary to assess relative abundance, estimate the ratio of natural to hatchery fish leaving the basin over time, and assess the condition of juvenile salmonids relative to flow conditions (Wallace 1995a, 1995b, 2001 & 2003). In 2006, YTFP received grant funding to continue juvenile salmonid monitoring in the Klamath River estuary during the 2006 and 2007 seasons (Hiner 2008). Since 2000, YTFP has also been characterizing fish habitat, water quality, and food availability in the Klamath River estuary and its associated off-estuary tributaries (Hiner and Brown 2004; Beesley and Fiori 2004, 2007 & 2008; Hiner 2006 & 2008). Results of these studies suggest that water management activities, seasonal high water temperatures, and a lack of preferred prey items play a role in limiting residency of juvenile salmonids in the Klamath River estuary.

In 2002, YTFP began investigating lower Salt Creek to assess fisheries habitat and use of this watershed by salmonid populations; and develop restoration strategies (Beesley and Fiori 2004 & 2007). Since late 2006, YTFP has been coordinating with the Karuk Tribe and other partners to conduct the Coho Ecology Study. Project objectives include assessing and monitoring juvenile coho habitat use, movement, growth, and distribution throughout the Klamath River (Soto et al. 2008; Hillemeier et al. 2010). YTFP has mostly focused on monitoring off-estuary tributary, wetland, and slough habitats; operating several fish traps in the South Slough of the estuary and in off-estuary tributaries including: McGarvey, Waukell, Salt, Panther, Richardson, and Spruce Creeks (Figure 1). This project has relied heavily on the use of Passive Integrated Transponder (PIT) tags and mark-recapture techniques to assess migration patterns, habitat use, growth, survival, and residency. In addition to trapping, YTFP operates remote PIT tag monitoring stations in Terwer, Waukell, Salt, and Panther Creeks to continuously detect PIT tagged fish moving past the station, and record detection time, tag number, and directional movement.

Initial estuary fish investigations and the Coho Ecology Study have revealed that off-estuary and coastal tributaries, wetlands, and sloughs provide vital staging and rearing areas for migrating adult and juvenile salmonids (Beesley and Fiori 2004; Hiner and Brown 2004; Soto et al. 2008; YTFP 2009; Hillemeier et al. 2010). These habitats provide salmonids refuge from high water velocities or poor water quality conditions occurring in the river and offer diverse habitats for fish to forage or stage prior to initiating ocean entry or upriver migration. Therefore, YTFP has also been conducting comprehensive geomorphic assessments in the Klamath River estuary and its associated habitats to identify limiting factors and develop effective restoration strategies (Beesley and Fiori 2004, 2007 & 2008). Goals include developing and implementing projects that provide long-term geomorphic solutions to identified limiting factors (i.e. habitat simplification, poor hydrologic function, and limited estuary salmonid rearing capacity); enhancing existing fluvial habitats; creating complex off-estuary stream and wetland habitats to increase salmonid rearing capacity; and improving hydrologic function in the Klamath River.

Study Objectives

In 2009, the California Department of Transportation (Caltrans) funded YTFP to conduct fish surveys in tributaries that may be impacted by the proposed Del Norte 101 Klamath Grade Raise, Road Rehabilitation and Bridge Replacement (KGR) Project. These tributaries include Spruce Creek, Panther Creek, and Hunter Creek; and additional habitats: Hunter Road wetland and Arbor Glen wetland (tributaries to Salt Creek) (Figures 1-3). The primary species of interest in these surveys were coho salmon, currently listed as Threatened pursuant to both the federal and state Endangered Species acts; and the longfin smelt which was recently listed as Threatened pursuant to the California Endangered Species Act. Other species of interest were steelhead trout, coastal cutthroat trout, and chinook salmon. Salt Creek marsh was also surveyed to assess fish population dynamics outside of the KGR footprint to gain more information regarding trends in non-natal rearing and brood strength for Klamath Basin coho.

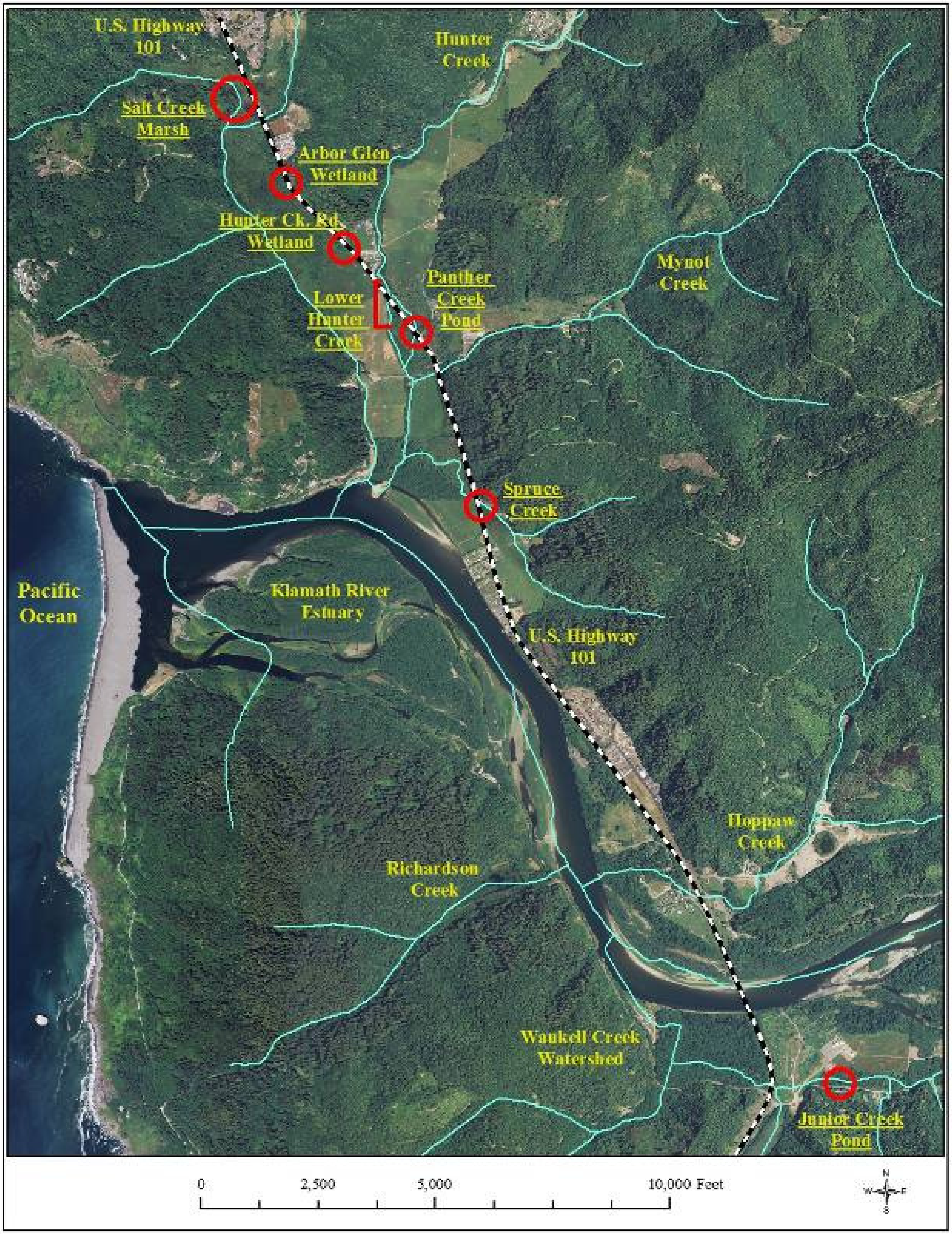


Figure 1. Map depicting several off-estuary fish monitoring sites located in the Lower Klamath River Sub-basin, California (Base Image: 2009 NAIP Imagery).

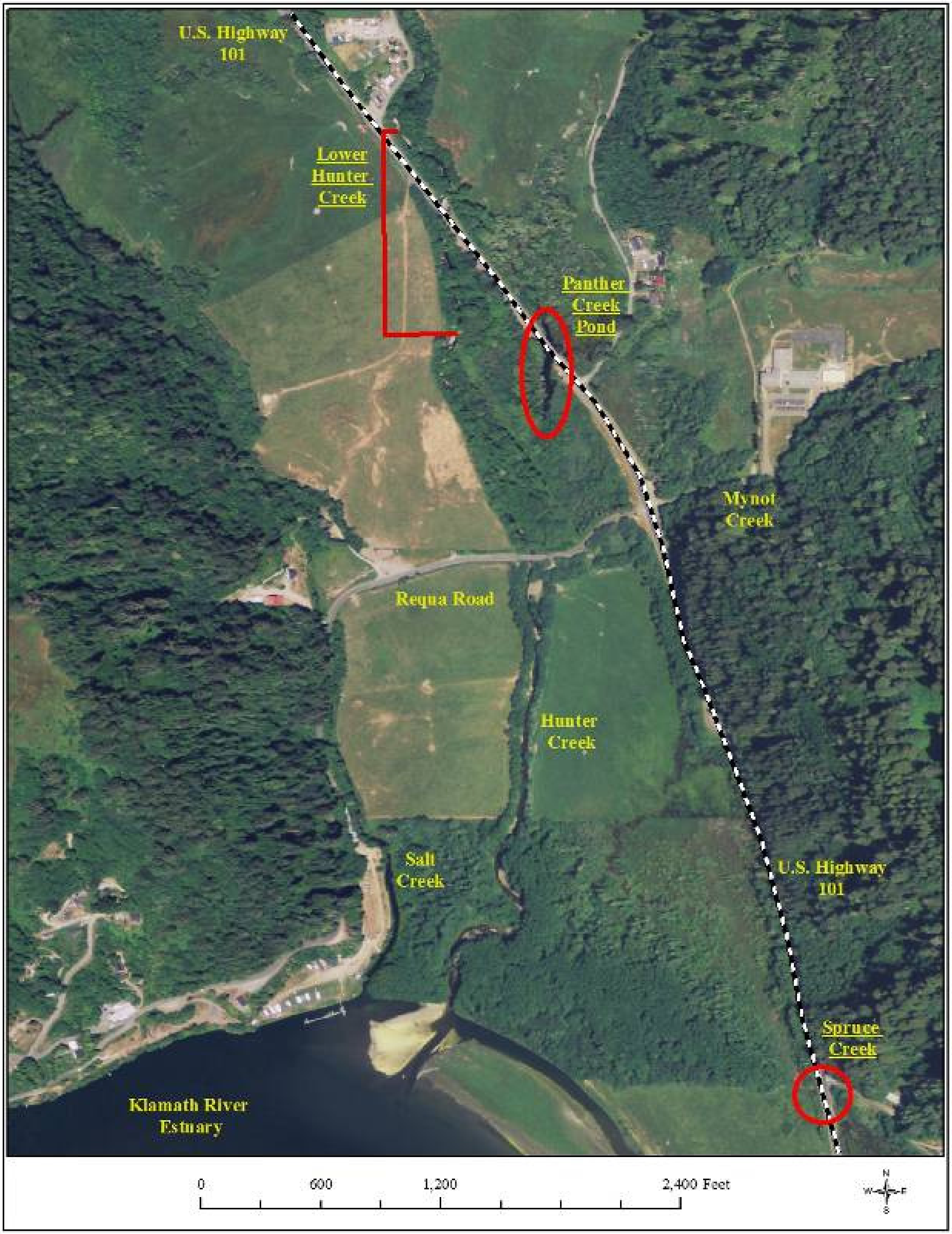


Figure 2. Map depicting fish monitoring sites located in Spruce Creek, Panther Creek, and lower Hunter Creek, Lower Klamath River Sub-basin, California (Base Image: 2009 NAIP Imagery).

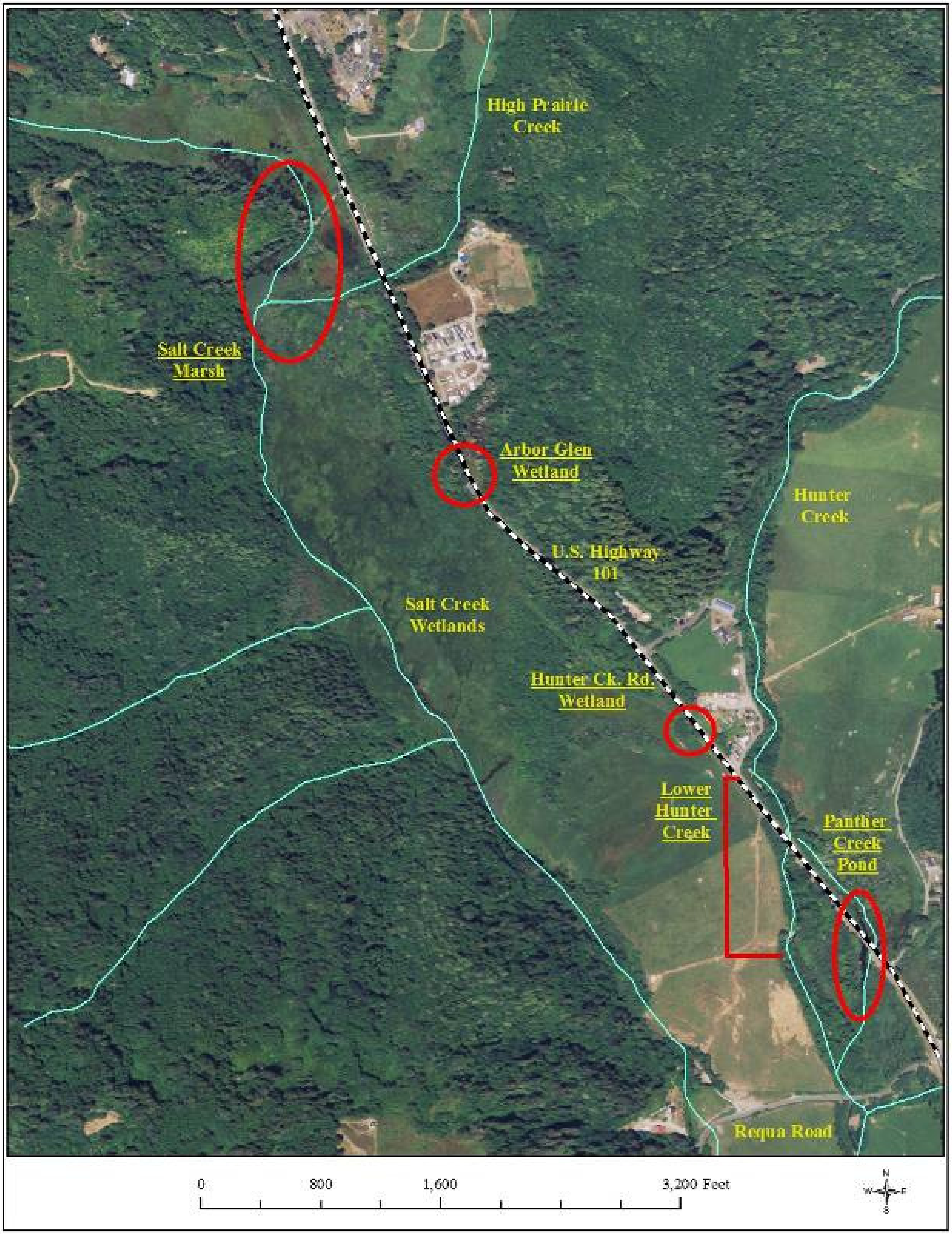


Figure 3. Map depicting fish monitoring sites located in Panther Creek, Hunter Creek, and Salt Creek (Hunter Rd. and Arbor Glen wetlands and Salt Creek marsh), Lower Klamath River Sub-basin, California (Base Image: 2009 NAIP Imagery).

The purpose of this study was to provide data relating to selected fish species and aquatic organisms (target species) within the proposed KGR project area. Specific objectives included: 1) quantify population numbers of target species in Spruce Creek, Panther Creek Pond (Panther Pond), and Salt Creek marsh; 2) assess the Hunter Road (Hunter Rd.) and Arbor Glen wetlands; 3) document fish habitat conditions and fish use within a selected reach of lower Hunter Creek; and 4) document water quality conditions at each study site. The study period was May – October 2009 to coincide with the typical construction season; and all of the study sites were within the proposed KGR project area or in close proximity (Salt Creek marsh).

Study Area

The proposed KGR project area is located on the north side of the Klamath River estuary; an area of significant spiritual, cultural, and economic importance to the Yurok People. The major watersheds draining the north side of the estuary include Hoppaw Creek, Salt Creek, and Hunter Creek (Figure 1). This study focused on lower Hunter Creek and two of its primary tributaries Spruce Creek and Panther Creek; and the Hunter Rd. and Arbor Glen wetlands that drain to lower Salt Creek (Figures 1-3). The Salt-Hunter valley was once a complex backwater feature of the Klamath River estuary comprised of a vast network of low gradient, anastamosed channels and conifer-dominated wetlands (Figure 4). Agricultural development and other land management activities conducted in the early 1900s resulted in substantial wetland conversion and loss of channel and riparian complexity (Figure 5) (Beesley and Fiori 2004, 2007 & 2008). By the mid- 1960s, most of the off-channel habitats and slough features in the valley had been altered, impaired, or filled; and Salt Creek was diverted into a very simplified channel along the western valley side wall (Figure 1). Land use activities occurring on the north side of the estuary since the 1850s have resulted in a significant loss of aquatic and terrestrial habitat quality and quantity, and continue to threaten anadromous fish populations of the Klamath River.

Salt Creek now enters the estuary less than one mile upstream of the Pacific Ocean (Figure 1). This low gradient stream embodies several current and remnant beaver dams and vast open and emergent wetland habitats. The Salt Creek watershed influences both the Arbor Glen and Hunter Rd. wetlands by inundating these areas during moderate to high water events (Beesley and Fiori 2007). Fish surveys conducted by YTFP from 1997 – 2004, revealed that the watershed supports natal populations of coastal cutthroat, steelhead, and a small run of coho salmon; and provides valuable off-estuary rearing habitat to non-natal salmonid populations (Beesley and Fiori 2004).

In lower Salt Creek, juvenile coho ranging in size from 47 – 117 mm (fork length) were captured during electrofishing surveys conducted during early May 2002 (n = 9) (Beesley and Fiori 2004). Fyke nets were also set in lower Salt Creek during eight outgoing tides in late April - early May 2002. Two juvenile coho (125 & 132 mm) were captured during trap sets in early May 2002. The dominant species encountered were coastal cutthroat ranging in size from 83 – 172 mm. In 2003, YTFP operated a downstream migrant trap in lower Salt Creek for a total of 26 capture dates in April – May 2003. During this period, 284 juvenile coho, 121 cutthroat, 136 steelhead, and a juvenile chinook were captured (Figures 6-7). Peak capture of juvenile coho occurred in early May with a total of 119 fish caught on two consecutive capture dates (Figure 7). Average fork lengths for coho salmon captured at this site during spring 2003 ranged from 110 – 128 mm.

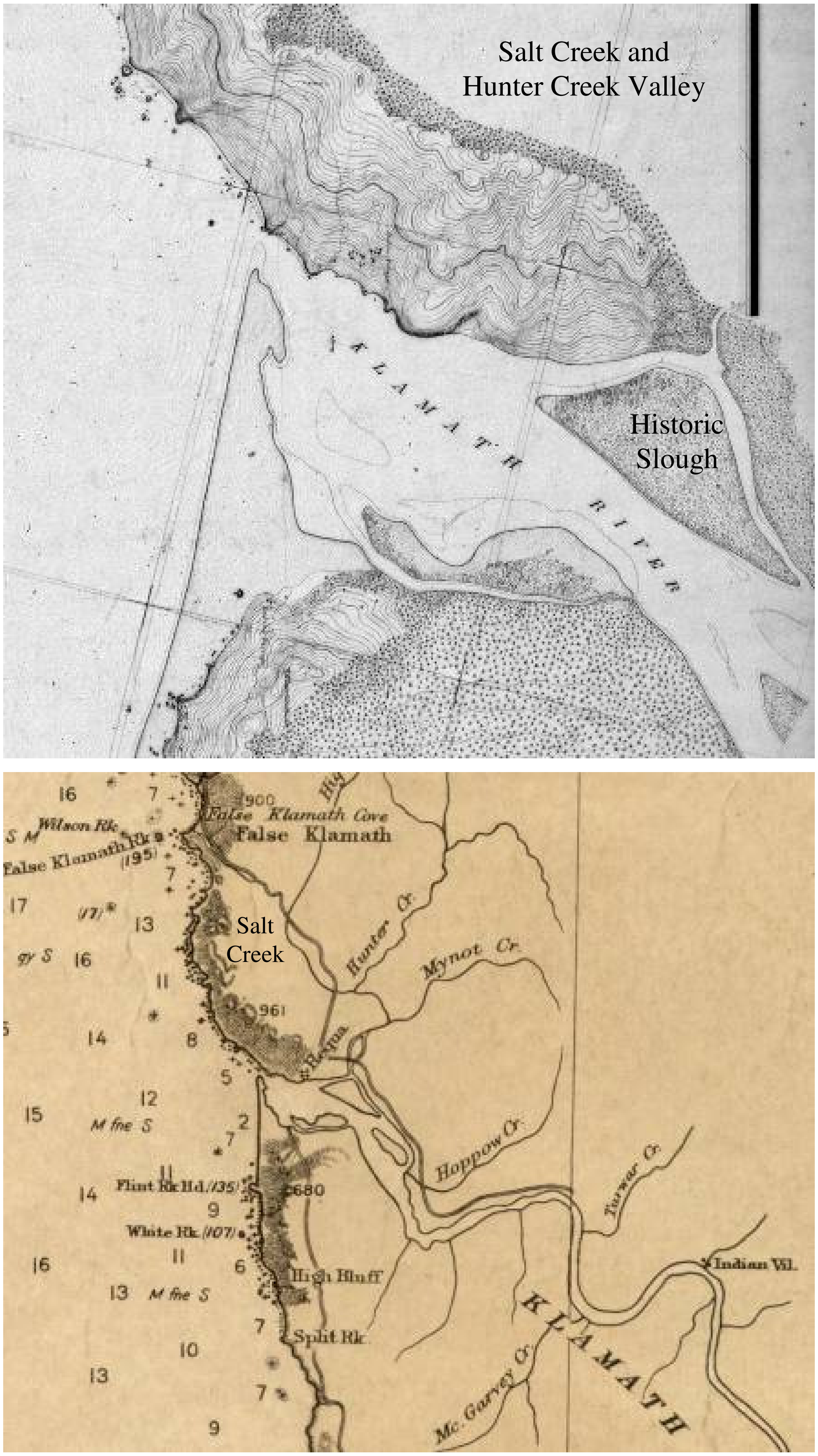


Figure 4. U.S. Coast and Geodetic Survey (USCGS) 1874 topographic map of the Lower Klamath River (T-1370) (scale 1:10,000) (Top); and USCGS, Nautical Chart 5702 1st edition, 1915 U.S. Coast California-Oregon Trinidad Head to Cape Blanco (Scale 1:200,000) (Bottom).

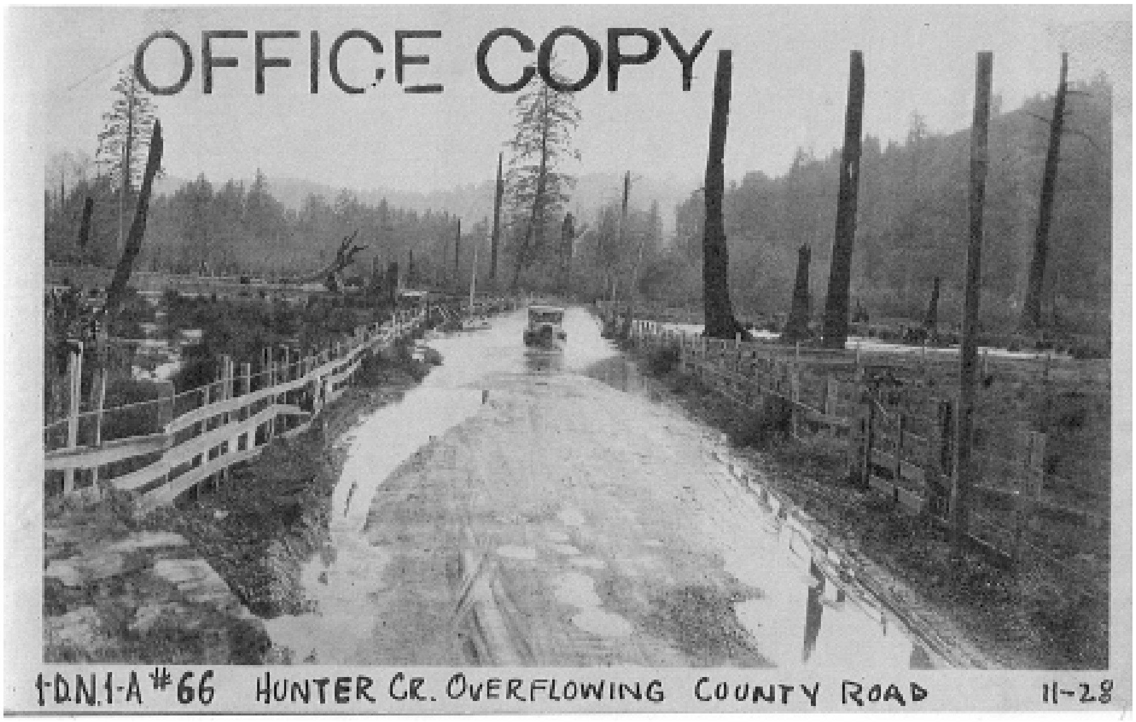


Figure 5. A historic photograph of lower Hunter Creek in the vicinity of Requa, Lower Klamath Sub-basin, California (Provided by the California Dept. of Transportation, November 1928).

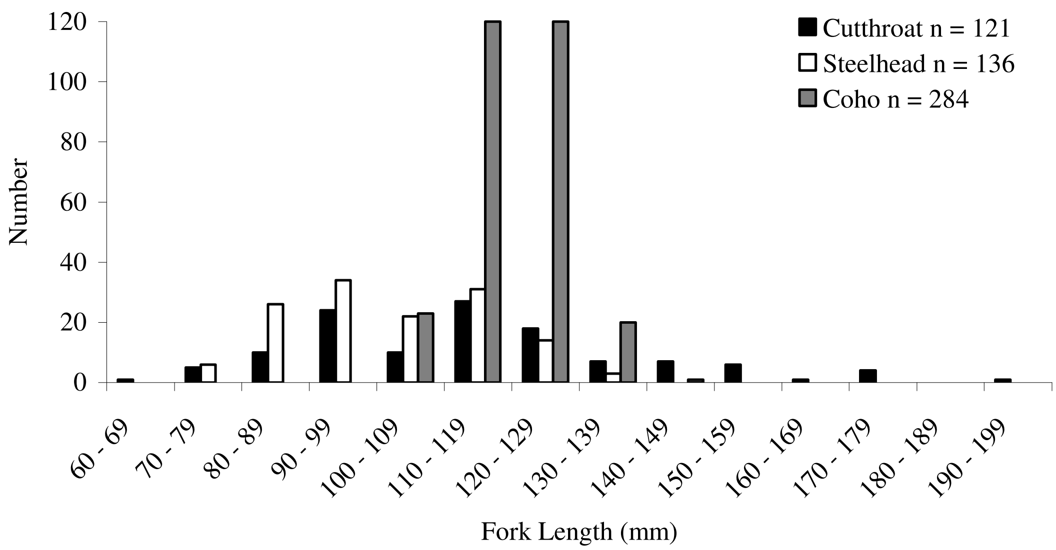


Figure 6. Length frequency for salmonids captured during April-May 2003 in a downstream migrant trap (26 sets) in lower Salt Creek, Lower Klamath River Sub-basin.

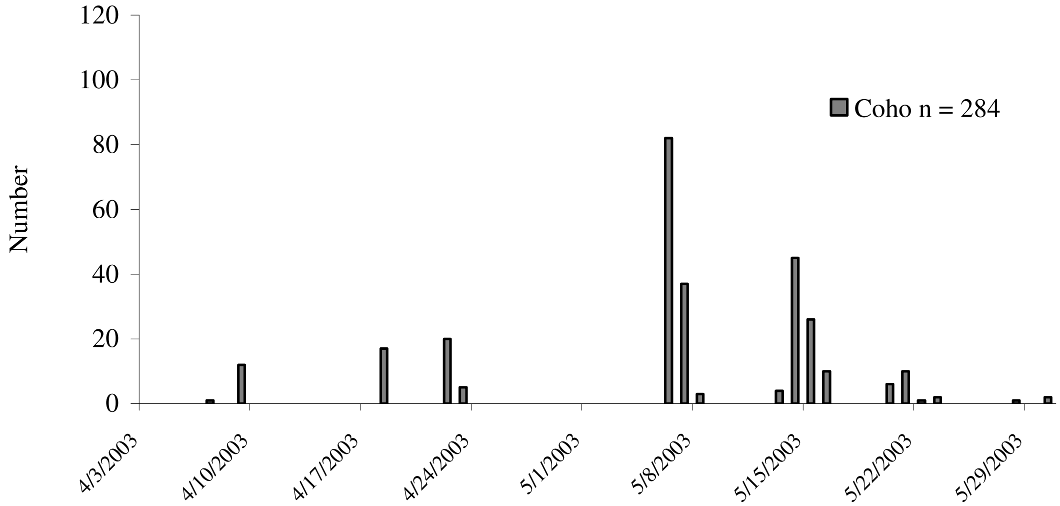


Figure 7. Number of juvenile coho salmon captured during April-May 2003 in a downstream migrant trap (26 sets) in lower Salt Creek, Lower Klamath River Sub-basin.

Sampling efforts in Salt Creek marsh in late March 2003 yielded juvenile coho smolts ranging from 97 – 127 mm (n = 7). As in lower Salt Creek, coastal cutthroat also dominated catches in this reach with fish ranging in size from 150 – 210 mm. Electrofishing surveys conducted in 2002, upstream of Salt Creek marsh, did not yield any coho salmon. Similarly, electrofishing surveys conducted in High Prairie Creek during 1997, 1999, and 2000 yielded no coho salmon. However, electrofishing surveys conducted in High Prairie during May 2002 yielded 43 young of the year (YOY) coho salmon (Figure 8). This was the first time that coho salmon were observed in this tributary. Repeat electrofishing surveys conducted in 2003 and 2004 did not yield any juvenile coho salmon in High Prairie Creek. However, juvenile coho ranging in size from 115 – 129 mm were captured during fish rescue efforts in lower High Prairie in May 2003. Forty juvenile coho salmon were rescued from this reach in 2002 (36 – 158 mm; ave. 60 mm).

Hunter Creek is a fourth order watershed draining to the Klamath River estuary just upstream from the Salt Creek confluence (Figure 1). The 28.7 mi^2 watershed supports anadromous populations of chinook and coho salmon, steelhead and coastal cutthroat trout. Lower Hunter Creek also provides critical rearing and staging habitat for non-natal fish migrating through the estuary. Hydrology of the Salt-Hunter valley is discussed in detail by Beesley and Fiori (2007 & 2008). In general, the valley is influenced by tributary flow events (winter flows driven by intense precipitation and low summer base flows); Klamath River flow events that back flood tributary habitats; ground water and sub-surface flow inputs (i.e. Panther Pond, Hunter Rd. wetland, lower Hunter Creek); and by the Pacific Ocean (tidal influence on lower-most reaches). During the low flow season, Hunter Creek flows sub-surface in reaches located upstream of Del Norte (DN) Highway 101 (Figure 10) (Beesley and Fiori 2007b). However; during this critical period, surface flows persist from upstream of the DN Highway 101 Bridge to the estuary.

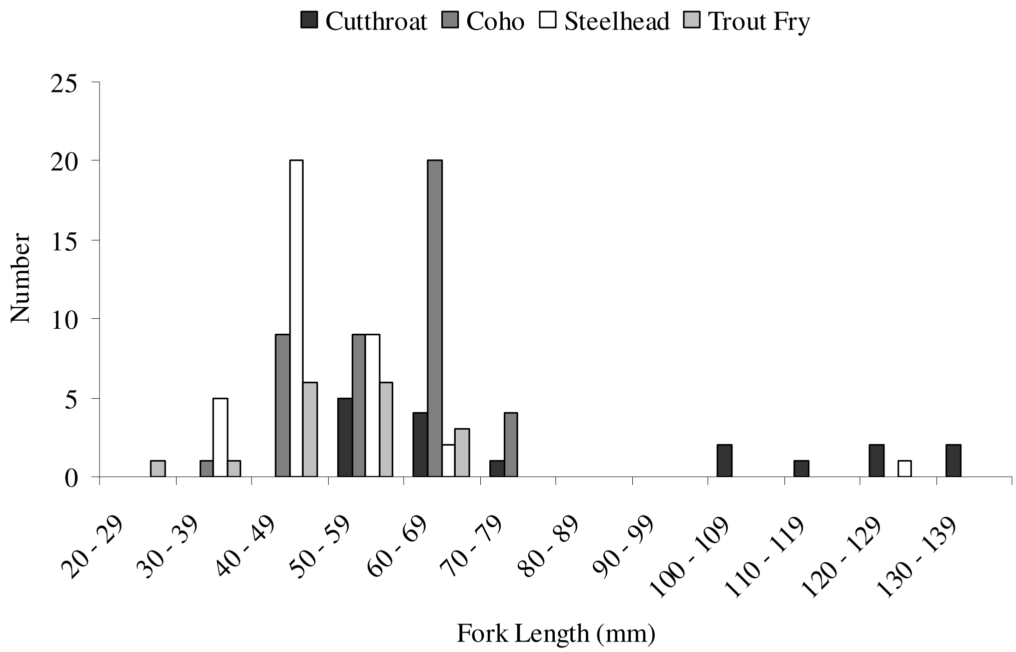


Figure 8. Length frequency of salmonids captured in four electrofishing reaches during May 2002 in High Prairie Creek, Lower Klamath River Sub-basin.

Figure 9. Photograph looking downstream at the lower Hunter Creek outmigrant trap operated by the Yurok Tribal Fisheries Program (1996 – 2001).

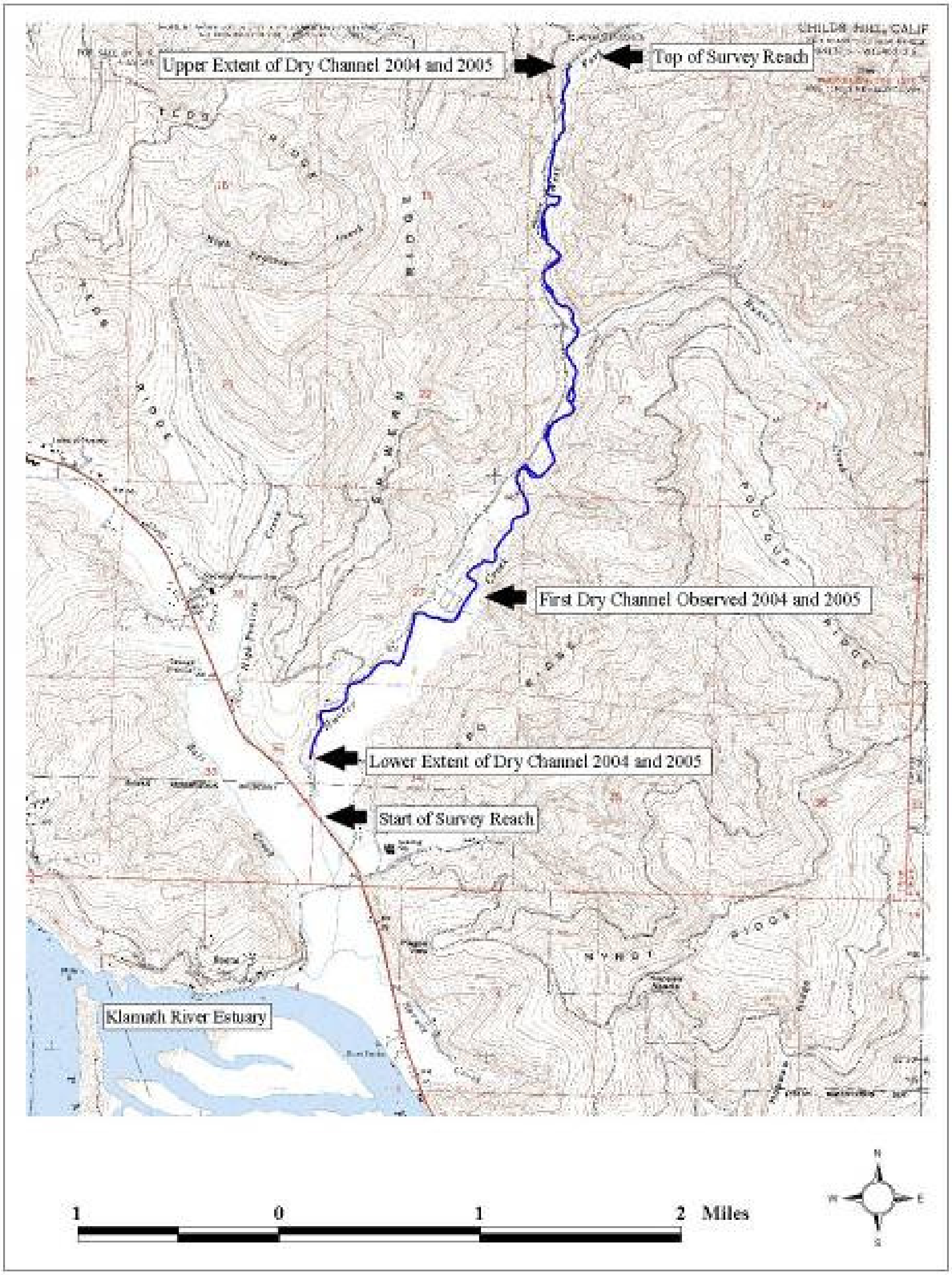


Figure 10. Map depicting the Hunter Creek channel and the reach surveyed for subsurface flow for the period 1 April 2004 – 31 December 2005, Lower Klamath River Sub-basin.

Spruce Creek and Panther Creek enter the eastern side of lower Hunter Creek (Figure 1). The dominant fish habitats in both tributaries are beaver influenced ponds and emergent wetlands (Figure 11). Spruce Creek enters Hunter Creek just upstream of the confluence with the Klamath River and therefore is greatly influenced by mainstem flow events and the Pacific Ocean (Beesley and Fiori 2008). The channel between DN Highway 101 and Hunter Creek is comprised mostly of beaver influenced ponds and sinuous channel reaches formed primarily by backwater processes. Spruce does not likely support spawning populations of salmon. The system does support spawning populations of coastal cutthroat and possibly steelhead. The Coho Ecology Study revealed that beaver ponds in lower Spruce provide critically important juvenile rearing habitat for non-natal coho and other salmonids (Soto et al. 2008; Hillemeier et al. 2010).

Panther Creek is primarily a spring fed system that enters Hunter Creek directly upstream of the Requa Road Bridge (Figure 1). Panther Creek Pond is located just upstream of the confluence with Hunter Creek and is comprised mostly of deep, open water habitat with complex edge habitats and interconnected emergent wetlands (Figure 11). This unique tributary provides critically valuable, high quality juvenile rearing habitat to non-natal salmonids and native wildlife (Soto et al. 2008; Hillemeier et al. 2010). Panther Creek does not likely support spawning populations of anadromous salmon or trout given the lack of spawning gravels.

Methods

Monthly mark-recapture fish surveys were performed in Spruce Creek, Panther Pond, and Salt Creek marsh. The Lincoln-Peterson estimator was used to estimate population size; allowing an assessment of trends in the populations of target species. YTFP conducted two trapping events each month; with each trapping event consisting of a 24 hour set with a cycle of a week between trapping events. The initial trapping event was the marking phase, where all captured fish of interest (coho and trout) were anesthetized with MS222 enumerated and identified by species, measured to fork length, weighed, scanned with an Allflex handheld scanner for detection of PIT tags, and marked with a freeze brand. Freeze branding is the process of using a letter shaped copper branding iron to freeze a mark on the epidermal of the fish. Freeze branding uses extreme cold produced by a combination of dry ice and acetone to kill the cells in the animal's skin that produce pigmentation or color. Every trapping cycle and monitored site had a different freeze brand mark. Marked fish were placed in holding pens to recover and then returned to the sampling area after they resumed a normal swimming pattern. A subset (n = 30) of non-target fish species caught during each event were identified to species, measured, and enumerated; all other non-target fish were enumerated. All amphibians caught were identified and enumerated.

The second trapping event was considered the first recapture event and traps were deployed in the same areas as during the marking event. All target fish captured were anesthetized with MS222, enumerated and identified by species, measured to fork length, weighed, scanned for a PIT tag, and checked for a freeze brand mark. All fish captured with the appropriate freeze brand mark from the marking cycle were recorded as a freeze brand recapture. If no PIT tag was detected, a 12 mm, 134.2 kHz, Super Tag 2 PIT tag was applied. PIT tags were applied by making a small surgical incision in the underside of the fish, near the pelvic fin, using a stainless steel, sterile surgical blade. PIT tags were sterilized in povidone/10% iodine hospital antiseptic

Figure 11. Photographs of an off-estuary beaver pond located in Spruce Creek (Top – February 2009); and Yurok Tribal Fisheries Program crews monitoring salmonid populations in Panther Creek Pond (Bottom – Spring 2008), Lower Klamath River Sub-basin.

solution before insertion into the body cavity. PIT tagged fish were scanned with the hand held scanner, the tag numbers were recorded, and the fish were identified as PIT tag marks. All sampled fish were allowed to recover in holding pens and were later returned to the sampling area after they resumed a normal swimming pattern. Non-target fish species and amphibians caught during recapture events were handled in the same manner as during the marking event.

Population estimates for coho and trout species were calculated using the mark-recapture data and the Bailey (1951) equation of the Lincoln-Peterson estimator. Coho salmon population estimates were based on both parr and presmolt data; whereas trout population estimates were based on parr, presmolt, and adult data. Cutthroat and steelhead data were lumped together to better facilitate population estimation (larger sample sizes).

This mark-recapture method assumes:

1. Animals marked in the initial trapping event have time to mix into the population prior to the recapture event so that marked and unmarked animals have an equal probability of being caught;

2. All marking must be conducted at the same time and the population size must remain the same between capture events; and

3. The number of marked animals does not change between capture events (no loss of marks, no mortality of marked animals, and no migration of marked individuals).

The Bailey Equation:

$$\hat{N} = \frac{(C+1)M_1}{M_2 + 1}$$

Where M_1 is the number of individuals marked in the first capture, M_2 is the number of marked individuals caught in the second capture, C is the total second catch, and N-hat is the estimated population size (N).

The 95% confidence interval was estimated by first calculating the standard error of N:

$$s_N = \sqrt{\frac{N^2(C - M_2)}{(C+1)(M_2 + 2)}}$$

Then the following equation was used to calculate the 95% confidence interval:

$$CI_{95\%} = N \pm 1.96(s_N)$$

Spruce Creek

For this study, sampling efforts were confined to areas located on either side of the DN Highway 101 culvert on Spruce Creek in the Caltrans right-of-way (Figures 1-2). The upstream area consisted of a shallow, confined stream bed with a mean width of 12 feet and a mean depth of 2.5 feet. The channel in this reach is heavily colonized by aquatic vegetation and dense willow branches overhang the reach. A prominent beaver dam exists approximately 30 yards upstream of the highway culvert (Figure 11). The area downstream of the DN Highway 101 culvert consisted of a deep pool with a maximum width of 20 feet and a maximum depth of 10 feet.

For the initial mark (06/10/09) and recapture trapping events (06/17/09), a 2.5 ft x 3 ft hooped fyke net (two trap compartments) with 2.5 ft x 25 ft wing block nets attached to either side of the opening was set in an upstream orientation in the area located upstream of the highway culvert. The downstream area was sampled using a 3 ft x 4 ft hooped fyke net (three trap compartments) with 3 ft x 25 ft wing block nets attached to either side of the opening. This trap was set near the pool tail in a downstream orientation. To help ensure a closed system during trap events, a block net (3 ft x 25 ft) was placed at the downstream end of the sampling reach. The beaver dam located upstream of the surveyed reach was presumed to impede immigration/emigration of fish.

For the remainder of the study (July-August), a 10 ft x 50 ft river seine and multiple baited minnow traps were used instead of the fyke net sets to reduce sampling stress during periods of poor water quality. These activities were conducted during periods of the day when dissolved oxygen levels were within the non-lethal range for salmonids. A 3 ft x 25 ft block net was set near the downstream end of the sampling reach and the river seine was set a total of four times in the pool located downstream of the DN Highway 101 culvert. Due to the aquatic vegetation and overhanging branches in the reach upstream of the highway culvert prevented seining efforts in this area. Instead, minnow traps were baited with cured Klamath River salmon roe and set on either side of the DN Highway 101 culvert for the duration of the seining event.

Panther Pond

In Panther Pond, fish sampling was performed throughout the available habitat (Figures 1-3). Areas were sampled using two 3 ft x 4 ft hooped fyke nets with a 3 ft x 50 ft lead block net and two 3 ft x 25 ft wing block nets attached (Figure 12). The lead block net was attached in the middle of the fyke opening and stretched to the waters perimeter and anchored. Each wing net was attached on either side of the fyke net opening and stretched out at or near a 45 degree angle and anchored. The back of each fyke net was tied off, stretched tight and anchored to keep the trap tight to the pond bottom and prevent it from collapsing. Both of the hooped fyke nets had three trap compartments. Trap sites were changed from one trapping period to the next to try and prevent familiarity of trap locations. All of the traps set near Panther Pond's primary outlet were set with an upstream orientation (Figure 12); all other traps were set with a downstream orientation or were set perpendicular to the primary flow line depending on the areas sampled.

To help ensure that mark-recapture estimator assumptions were not broken during surveys, downstream and upstream oriented hooped fyke nets (2.5 ft x 3 ft) were placed in Panther Creek ~ 30 yards downstream of Panther Pond in the first available reach with a confined channel.

Figure 12. A three-foot by four-foot hooped fyke net with lead block net (3 ft x 50 ft) and two wing block nets (3 ft x 50 ft) set in Panther Creek Pond, Lower Klamath River Sub-basin.

Two Biomark PIT tag antenna arrays also exist just upstream from the lower trapping location. The antenna arrays encompass the entire channel and detect full duplex PIT tagged fish and document directional movement of tagged fish. The traps allowed YTFP to document any loss of marked fish from the study area; while the PIT tag antennas continuously monitored lower Panther Creek for PIT tags. Traps were checked daily for any freeze branded or PIT tagged fish, and PIT tag monitoring data was downloaded and assessed regularly during the study.

Salt Creek Marsh

In the Salt Creek marsh (Figures 1 & 3), fish sampling was performed using two 3 ft x 4 ft hooped fyke nets. Attached to the opening on both fyke nets were a 3 ft x 50 ft lead block net and two 3 ft x 25 ft wing block nets. The lead block net was attached in the middle of the fyke opening and stretched to the stream bank and anchored. Wing nets were attached on either side of the fyke net opening and stretched out at or near a 45 degree angle and anchored. The back of each net was stretched tight, tied off, and anchored to keep the trap tight to the pond bottom and to prevent it from collapsing. Both of the fyke nets had three trap compartments. Trap locations were changed from one trapping period to the next to try and prevent familiarity of trap sites.

All trap locations near the downstream end of the marsh were oriented in an upstream fashion or perpendicular to the flow line. All trap locations upstream were oriented in a downstream fashion or perpendicular to the flow line. To help ensure that no assumptions were broken during mark-recapture surveys, downstream and upstream oriented hooped fyke nets (3 ft x 4 ft) were placed ~ 10 yards downstream of the beaver dam at the Salt Creek marsh outlet. Two

Biomark PIT tag antenna arrays also exist in lower Salt Creek to detect PIT tagged fish and document directional movement of tagged fish. This PIT tag monitoring station is located ~ 0.5 miles upstream from the Klamath River estuary and ~ 1.0 mile downstream of Salt Creek marsh. Traps were checked daily for any freeze branded or PIT tagged fish, and PIT tag monitoring data was downloaded and assessed regularly during the study.

Hunter Road Wetland

The Hunter Rd. wetland was sampled to assess fish presence and temporal trends of target species using minnow traps baited with cured Klamath salmon roe (Figures 1 & 3). A single minnow trap was baited and deployed on the downstream side of the DN Highway 101 culvert for a 24 hour period (trapping event). Due to the small size of the sampling area, the trap location remained the same for the entire study period. All target fish captured were anesthetized with MS222, identified by species and enumerated, measured to fork length, weighed, and scanned for a PIT tag. If no PIT tag was detected, a 12 mm, 134.2 kHz, Super Tag 2 PIT tag was applied. All captured fish were placed in holding pens to recover and then returned to the sampling area after they resumed a normal swimming pattern. A subset (n = 30) of non-target fish species caught during each event were identified to species, measured, and enumerated; all other non-target fish were enumerated. All amphibians caught were identified and enumerated.

Arbor Glen Wetland

The Arbor Glen wetland was sampled to assess fish presence and temporal trends of target species using minnow traps baited with cured Klamath salmon roe (Figures 1 & 3). Two baited minnow traps were deployed on each side of the DN Highway 101 culvert for a 24 hour period (trapping event). Traps were deployed in different areas within the Arbor Glen wetland for each trapping event. All target fish captured were anesthetized with MS222, identified by species and enumerated, measured to fork length, weighed, and scanned for a PIT tag. If no PIT tag was detected with the hand held scanner a 12mm, 134.2 kHz, Super Tag 2 PIT tag was applied. All captured fish were placed in holding pens to recover and then returned to the sampling area after they resumed a normal swimming pattern. A subset (n = 30) of non-target fish species caught during each event were identified to species, measured, and enumerated; all other non-target fish were enumerated. All amphibians caught were identified and enumerated.

Lower Hunter Creek

A 387 meter reach of Hunter Creek was monitored for the presence and temporal trends of target species (Figures 1-3). YTFP classified stream habitats in the survey reach using CDFG habitat mapping protocols (Flosi et al. 1998). For this study, units mapped were classified as shallow pool, deep pool, run, or riffle habitats. All habitat units were measured for length and maximum depth; stream width was measured at the bottom third, middle, and upper third of each unit.

Monthly snorkel surveys were performed in the survey reach by two trained fisheries biologists. When flows allowed, each unit was snorkeled by both divers and a consensus was made on observed fish numbers and species. During low flow periods, shallow pools were snorkeled by one of the divers who recorded the species and numbers observed. Snorkel surveys were performed by swimming from the bottom of the reach or unit to the top, except during the initial survey when stream flows inhibited the ability to swim upstream. That initial snorkel survey was conducted by both divers swimming downstream from the top of the reach. During each snorkel survey, divers measured water and air temperature and took notes regarding weather, discharge, and visibility conditions (ability of the diver to observe fish).

Salmonid Age-Length Criteria

Absent analysis of scales, age determination of fish can be difficult. For the purposes of this study, we used fork length information to categorize fish by age class (YOY and 1+). Based on Coho Ecology Study data collected in the Lower Klamath, the following criteria was used to separate YOY fish from age 1+ fish in this report. During June, juvenile coho less than 90 mm were considered YOY and coho greater than 90 mm were considered age 1+ fish. During July, juvenile coho less than 95 mm were considered YOY and coho greater than 95 mm were considered age 1+ fish. During August, juvenile coho less than 105 mm were considered YOY and coho greater than 105 mm were considered age 1+ fish. These size ranges were also used to determine ages for juvenile steelhead.

Coastal cutthroat tend to be smaller (5-10 mm) at age relative to coho and steelhead. During June, juvenile cutthroat less than 85 mm were considered a YOY; cutthroat from 85-139 mm was considered an age 1+ fish; and cutthroat greater than 140 mm were considered an age 2+ fish.

Water Quality

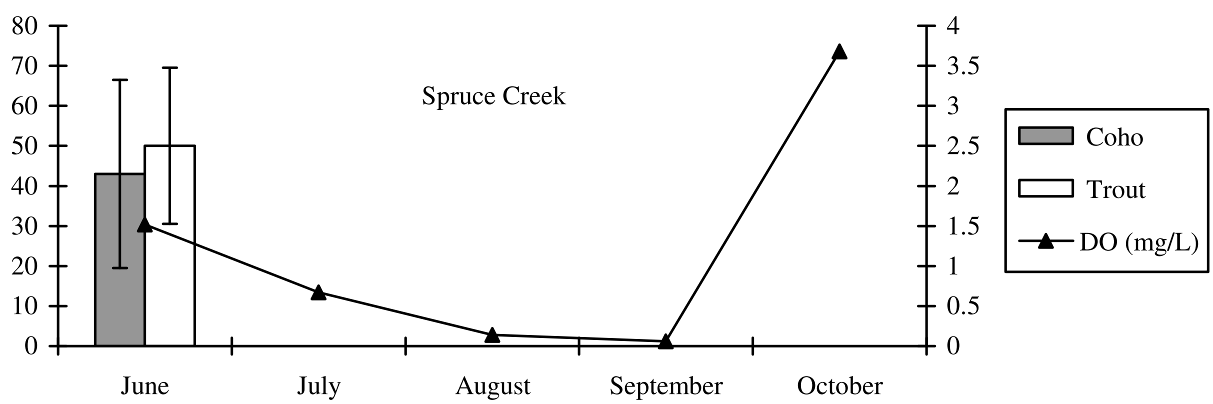
YTFP monitored water quality monthly in all six fish survey locations using HydroLab Datasondes. Before deployment, each datasonde was properly calibrated by a trained technician for temperature, specific conductivity, pH, and dissolved oxygen. At each site, water quality parameters were collected every 30 minutes for a minimum of 72 hours. Water quality readings were obtained with a hand held YSI 85 dissolved oxygen/conductivity instrument at each site just prior to deployment and retrieval to ensure proper calibration of the datasondes. After retrieval, datasondes were brought back to the laboratory to be downloaded and cleaned. During this study, datasondes were deployed in different areas of Spruce Creek, Panther Pond, Salt Creek marsh, and the Arbor Glen wetland to coincide with the trapping locations used during a given trapping event. Monitoring stations remained constant in both lower Hunter Creek and the Hunter Rd. wetland. Data was analyzed after each monitoring period to assess water quality conditions and ensure that sampling efforts would not result in overt stress or harm to fish.

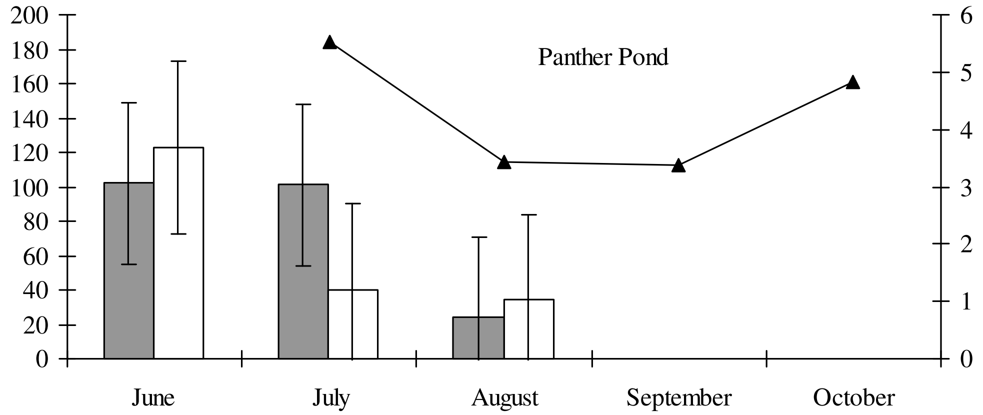
Results

Spruce Creek

The beaver dam located upstream of the Spruce Creek sampling site was breached sometime in mid- to late July. Rocco Fiori, Licensed Geologist for Fiori GeoSciences, estimated that draining the upper Spruce Creek beaver pond likely resulted in the release of at least 350,000 to 1,000,000 gallons of poor quality water. Velocities through confined channels may have been in excess of 9 ft/s and therefore capable of flushing juvenile fish downstream into Hunter Creek or the estuary. Prior to that event in late July, a population of 43 YOY and age 1+ coho salmon and 50 trout (primarily cutthroat trout) were estimated for the month of June (Figure 13) (Appendix A). Sampling efforts conducted after the dam breach (July-August), yielded hundreds of three-spine stickleback and zero coho and trout (Appendix B). Fork lengths for coho captured in Spruce Creek during June ranged from below 55 mm to above 130 mm (Figure 14); indicating the presence of two year classes rearing at this site. Non-target species captured in Spruce Creek during this study included several native fish species, a few native amphibian species, and two invasive aquatic species (Table 1) (Appendix B).

Water temperatures measured in Spruce Creek ranged from 13.06 to 18.74 degrees Celsius over the sampling period (Appendix C). The warmest temperatures were measured in July (range: 15.71 – 18.40 ℃) and August (range: 16.98 – 18.74 ℃) (Appendix C). Dissolved oxygen levels measured in Spruce Creek were extremely low at the start of the monitoring season with an average reading of 1.52 mg/L (Figures 13 & 15) (Appendix C). Dissolved oxygen levels below 3 mg/L are stressful to most aquatic vertebrates (Bjornn & Reiser 1991). Therefore, sampling efforts conducted in July and August were reduced to running a seine net during mid-day hours when water quality readings showed adequate dissolved oxygen levels. YTFP stopped survey efforts in Spruce Creek following the August event due to poor water quality conditions and the previous zero salmonid catches (Figures 13-15) (Appendix C).





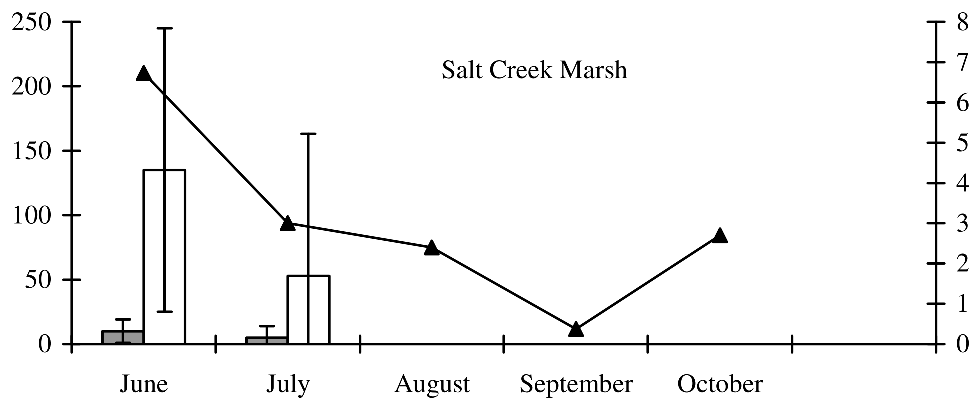


Figure 13. Mark-recapture population estimates in Spruce Creek, Panther Pond, and Salt Creek marsh (Left Axis); and average dissolved oxygen levels (mg/L) (Right Axis) for each site.

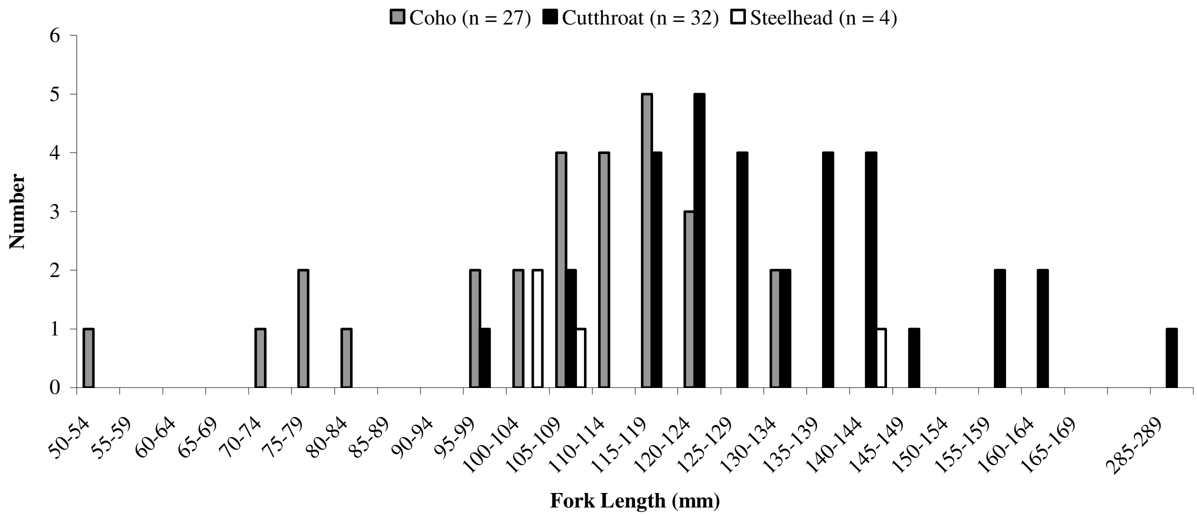
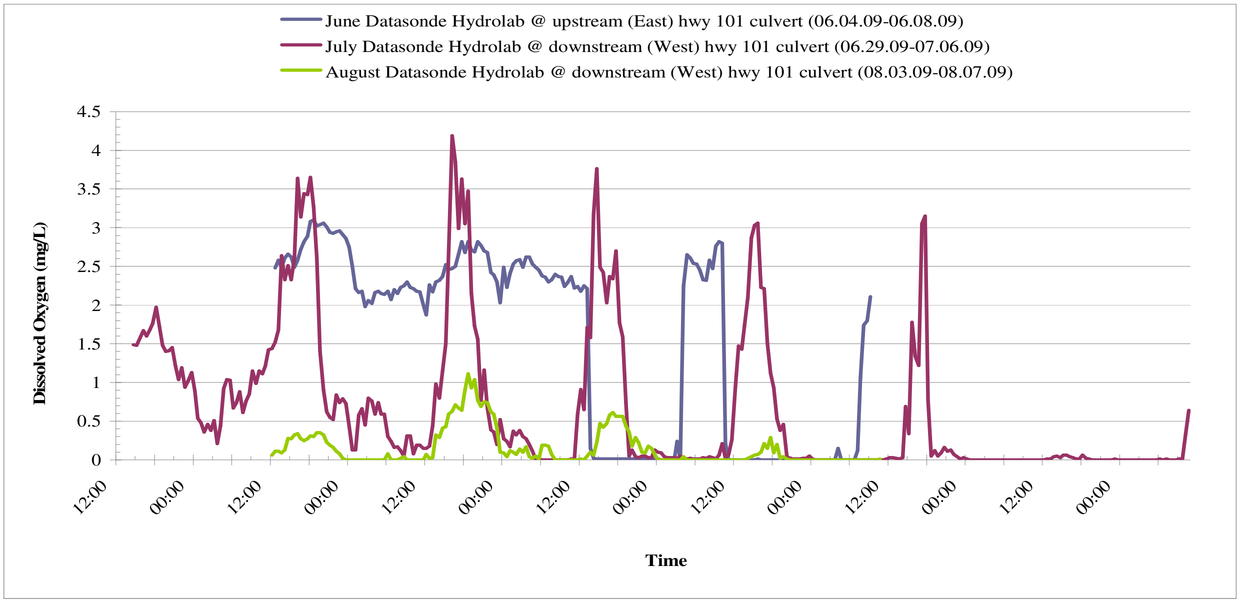


Figure 14. Length frequency for salmonids captured during mark-recapture sampling efforts conducted in Spruce Creek during June 2009.

Table 1. Non-salmonid species captured during fish monitoring activities conducted in several off-estuary habitats of the Klamath River ("x" indicates presence) (June – October 2009).

Species	**Spruce Creek**	**Panther Creek**	**Salt Marsh**	**Hunter Rd. Wetland**	**Arbor Glen Wetland**
Three Spine Stickleback	x	x	x	x	x
Prickly Sculpin	x	x	x	x	
Speckled Dace	x	x	x		
Klamath Small-Scale Sucker	x	x	x		
Golden Shiner	x				
Pacific Lamprey Ammocete	x	x	x	x	
Rough Skin Newt	x	x	x		
Northwest Salamander	x	x	x	x	x
Pacific Giant Salamander		x			
Reg Legged Frog - Tadpole					x
Green Sunfish	x	x			x
Brown Bullhead		x	x		
Bull Frog - Tadpole	x				



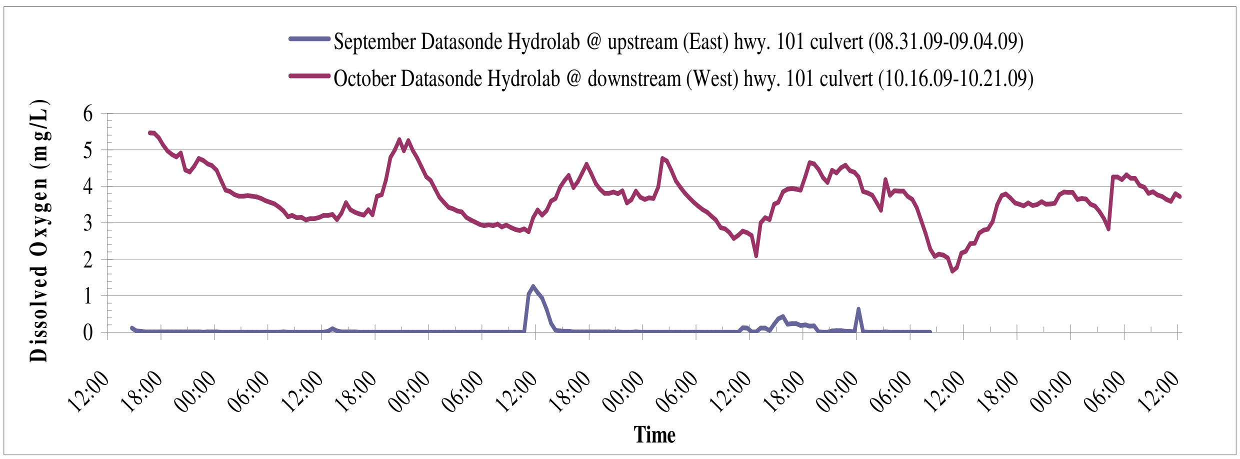


Figure 15. Dissolved oxygen levels measured at fish trapping locations within Spruce Creek during summer – fall 2009.

Panther Pond

Population estimates for June and July were relatively constant for coho, with estimates right around 100 fish (Figure 13) (Appendix A). By August, coho captures dropped significantly with no recaptures observed in the second trapping event (Appendix B). The drop in coho numbers may in part be attributed to trap familiarity since in July over 51% of coho captured were also captured in June. However this seems unlikely given that 56% of the coho caught in the recapture event had also been captured in June and 22% of those fish had been captured four times in fifty days. Trout population estimates dropped significantly from 123 fish in June to 40 fish in July (Figure 13) (Appendix A). The dominant trout species captured at this site was 1+ coastal cutthroat trout. The drop in trout captures could be related to the presence of otters and/or humans actively fishing the pond. Panther Pond is a popular sport fishing spot during summer and crews had observed people leaving the area with fishing poles and buckets. Trout numbers leveled out in August relative to the June - July estimates (Figure 13) (Appendix B).

By the first of September all salmonid catches dropped to zero. Three consecutive trapping efforts conducted in September yielded no salmonids (Figure 13) (Appendix B). Non-target species captured in Panther Pond included several native fish species, a few native amphibian species, and two invasive aquatic species (Table 1) (Appendix B). During the duration of the study, no fish were captured from the mark-recapture events in the downstream trap and the PIT tag antenna arrays did not detect any of the PIT tags applied during this study. This information gave us confidence that the system remained closed during this study.

Size frequency data for coho captured during this study indicated that juveniles using Panther Pond during summer were growing, with the largest fish (160-164 mm) captured in June and July (Figure 16). Size frequencies for coastal cutthroat captured during this study were much more variable with both YOYs and larger, older aged fish occurring throughout the study. In general, the size frequency data for coastal cutthroat also indicated a trend from smaller size fish in June to larger fish in August. No trends were observed in the size frequency data collected for steelhead; however, sample sizes for this species were very low in Panther Pond (Figure 16).

Water temperatures measured in Panther Pond ranged from 10.92 to 18.12 degrees Celsius over the sampling period (Appendix C). The warmest temperatures were measured in early September (range: 15.18 – 18.12 ℃); and the coolest temperatures were measured in October (range: 10.92 – 11.06 ℃) (Appendix C). Dissolved oxygen levels measured in Panther Pond were consistently low during the study (Figures 13 & 17) (Appendix C). In October, YTFP compared dissolved oxygen readings taken from just below the pond's surface, near the pond bottom, and at a site located close to the pond's outlet. Data collected during this assessment and the initial measures collected in early June indicated that dissolved oxygen levels in the column of water nearest the pond's bottom were stressful to most aquatic vertebrates. Levels measured in the upper water column were more similar to levels measured at the outlet rather than to levels measured near the pond's bottom (Figure 17) (Appendix C). Trapping efforts in Panther Pond also suggested that very few salmonids used the deepest areas of the pond located under the highway bridge.

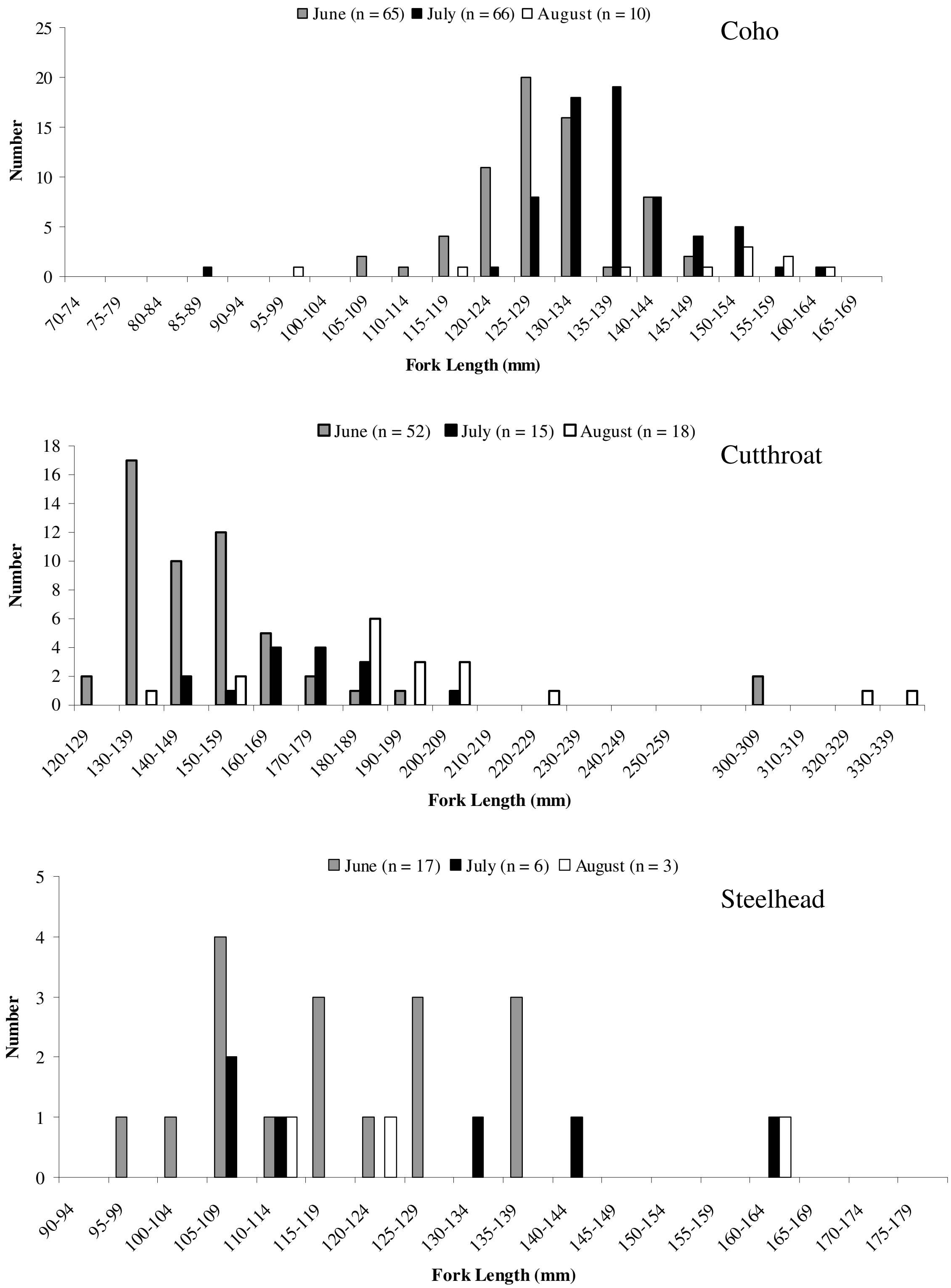


Figure 16. Length frequency for salmonids captured during monthly sampling efforts conducted in Panther Creek Pond during summer 2009.

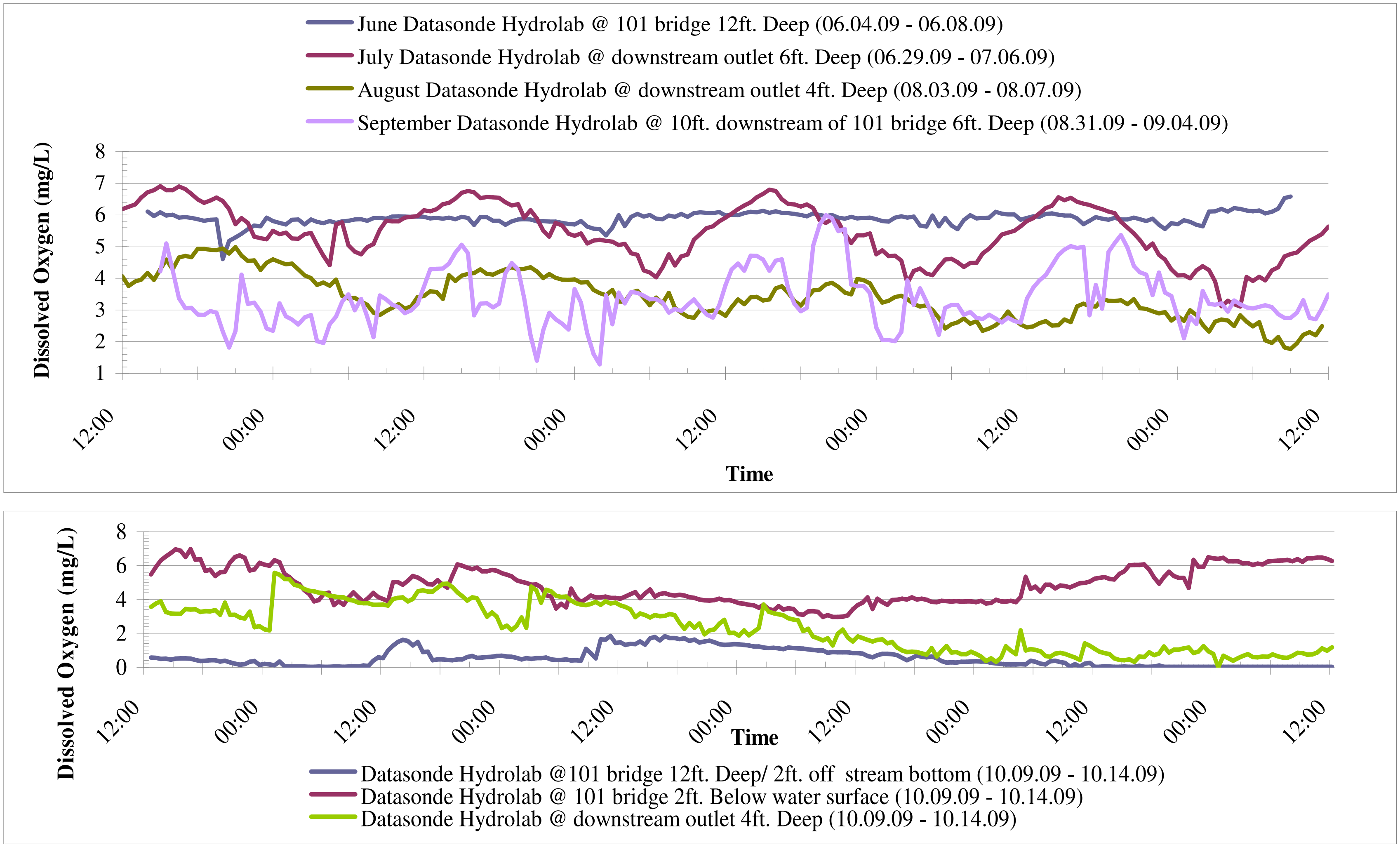


Figure 17. Dissolved oxygen levels measured at fish trapping locations within Panther Creek Pond during summer – fall 2009.

Salt Creek Marsh

Trapping efforts at this site resulted in the capture of very few coho during summer 2009 (Figures 13 & 18) (Appendix B). The limited coho catches inhibited the ability to generate reliable population estimates for the area. The estimates that were generated showed both coho and trout numbers dropped considerably from June to July (Figure 13) (Appendices A & B). The most frequently captured fish were adult coastal cutthroat. By August, all trapping was concluded due to poor water quality conditions in the marsh (i.e. prolonged periods of very low dissolved oxygen in August) (Figures 13 & 19) (Appendix C). Low dissolved oxygen levels likely resulted from plant decomposition and respiration dynamics rather than from high water temperatures. Water temperatures measured in Salt Creek marsh ranged from 10.08 to 14.72 degrees Celsius over the sampling period (Appendix C). In general, the warmest temperatures were measured in late July (range: 14.19 – 14.72 ℃); and the coolest temperatures were measured in late October (range: 10.08 – 12.39 ℃) (Appendix C). Two coho with marks from the 05/27/09 event were captured on 06/01/09 in the downstream trap located just downstream of the Salt Creek marsh beaver dam. These fish were removed from the marked population and a block net was placed in the marsh upstream of the beaver dam to help ensure a closed system during the mark-recapture period.

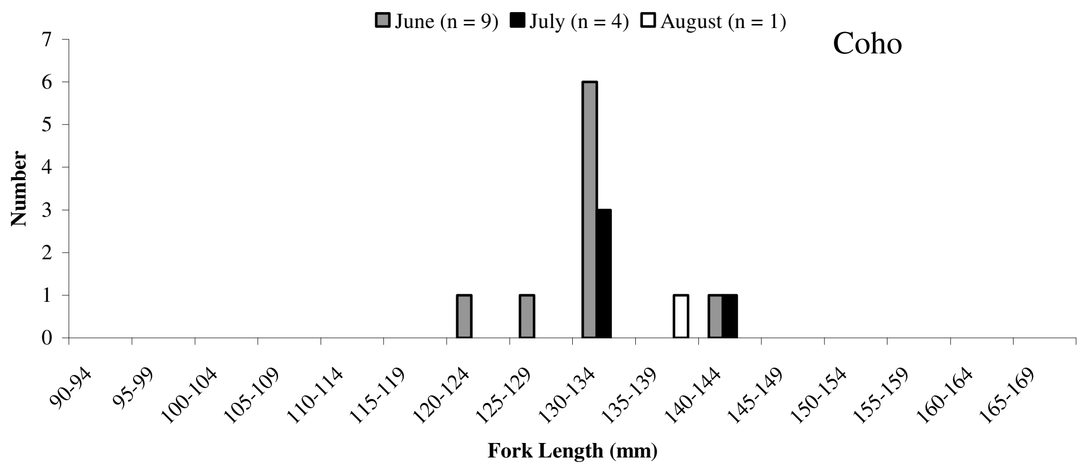
Hunter Road and Arbor Glen Wetlands

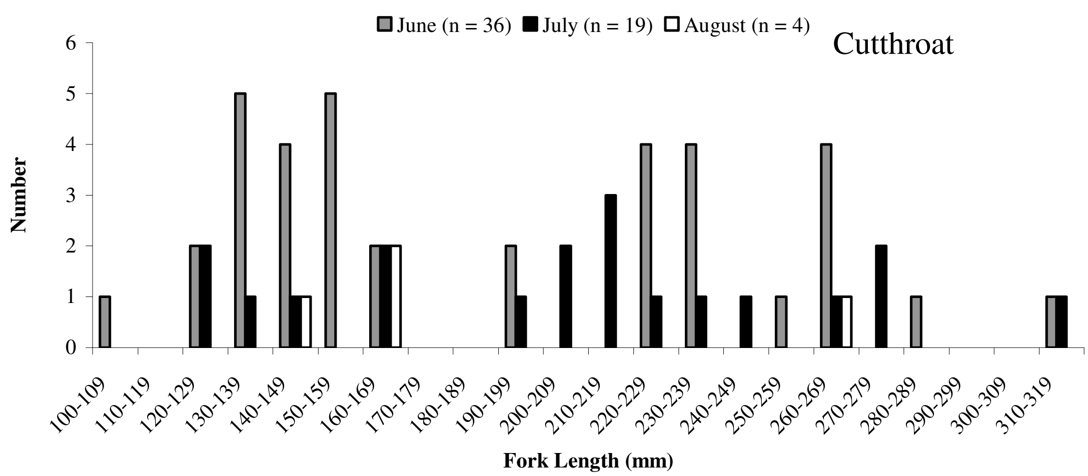
Sampling efforts conducted on the west side of the Hunter Rd. wetland yielded four age 1+ coastal cutthroat trout, one coho presmolt, three spine stickleback, prickly sculpin, and Northwest Salamanders (aquatic and terrestrial life stages) (Table 1) (Appendix B). This wetland maintained relatively good water quality until August when the water table dropped and significantly reduced inputs to the wetland. Average dissolved oxygen levels measured in August dropped below 1.0 mg/L and by October levels bottomed out (Figure 20) (Appendix C). Water temperatures measured in the Hunter Rd. wetland remained fairly constant from June through October (Appendix C). Water temperatures measured in this wetland complex ranged from 10.61 to 12.24 degrees Celsius over the sampling period (Appendix C). The warmest temperatures were measured in September (range: 11.71 – 12.24 ℃); and the coolest temperatures were measured in June (range: 10.61 – 11.02 ℃) (Appendix C).

Trapping efforts conducted in the Arbor Glen wetland yielded three spine stickleback, red legged frog tadpoles, rough skinned newts, Northwest salamanders, and a green sunfish (Table 1) (Appendix B). Water quality readings collected during this study indicated almost no dissolved oxygen on either side of the highway culvert (Figure 21) (Appendix C). Water temperatures measured in the Arbor Glen wetland ranged from 10.09 to 14.46 degrees Celsius over the sampling period (Appendix C). In general, the warmest temperatures were measured in late June (range: 13.98 – 14.46 ℃); and the coolest temperatures were measured in late October (range: 10.09 – 12.00 ℃) (Appendix C).

Lower Hunter Creek

A total of 11 habitat units were mapped in the lower Hunter Creek survey reach (Appendix F). Shallow pools dominated the survey reach during summer 2009. The DN Highway 101bridge was located ~ 200 meters downstream from the top of the survey reach and crossed Hunter Creek at habitat unit # 006 (Figures 1-3) (Appendix D). Monthly snorkel inventories conducted in the Hunter Creek survey reach revealed the presence of YOY and age 1+ coho, YOY trout and 1+ steelhead and coastal cutthroat trout, juvenile chinook salmon, brook lamprey, three spine stickleback, and sculpin (Table 2) (Appendix E). The most abundant age class and species





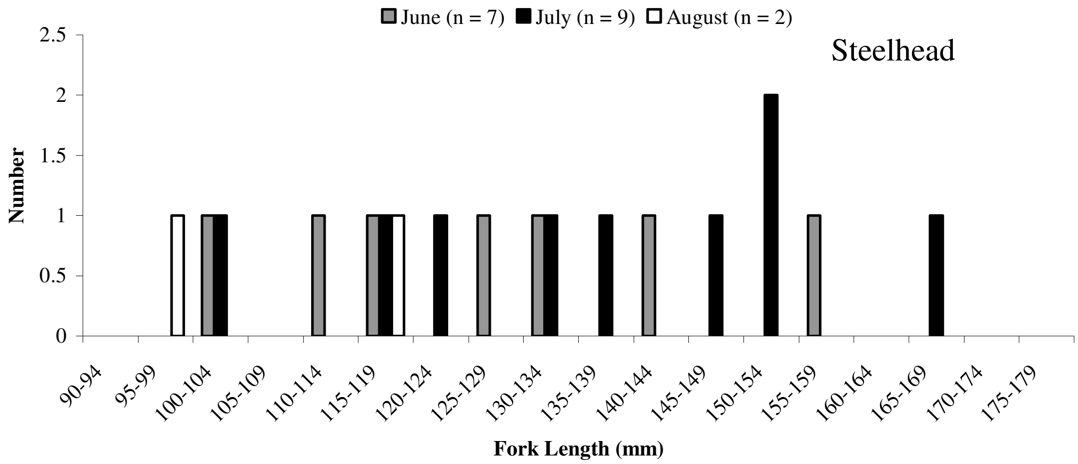


Figure 18. Length frequency for salmonids captured during monthly sampling efforts conducted in Salt Creek marsh during summer 2009.

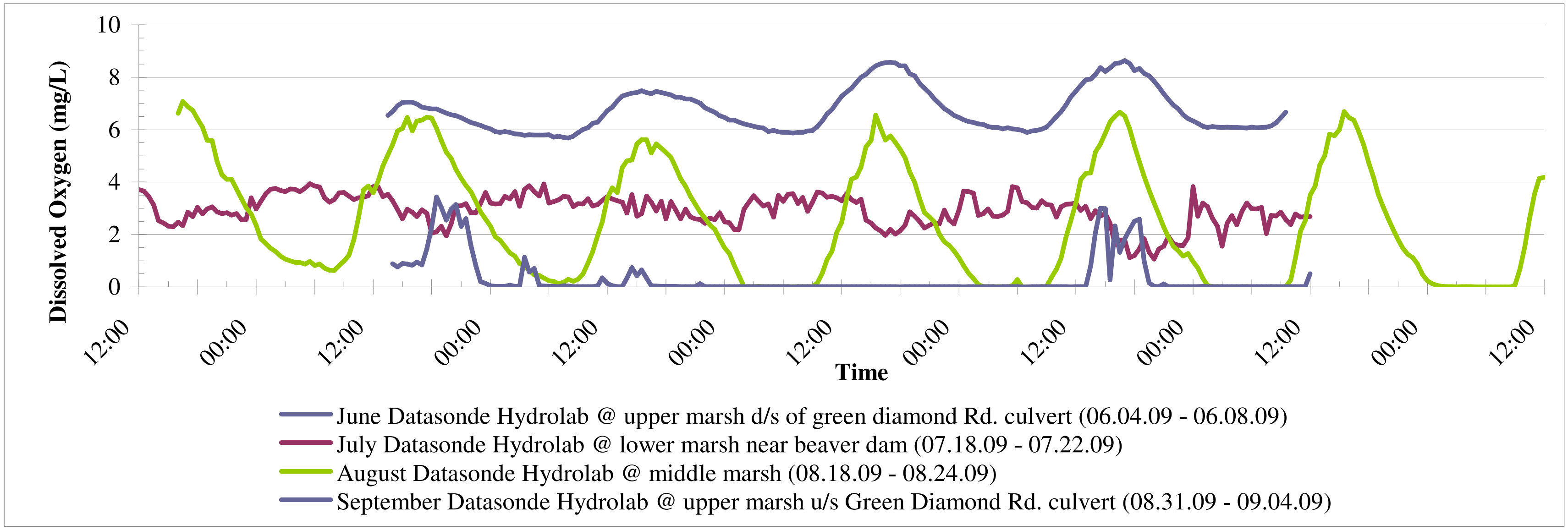
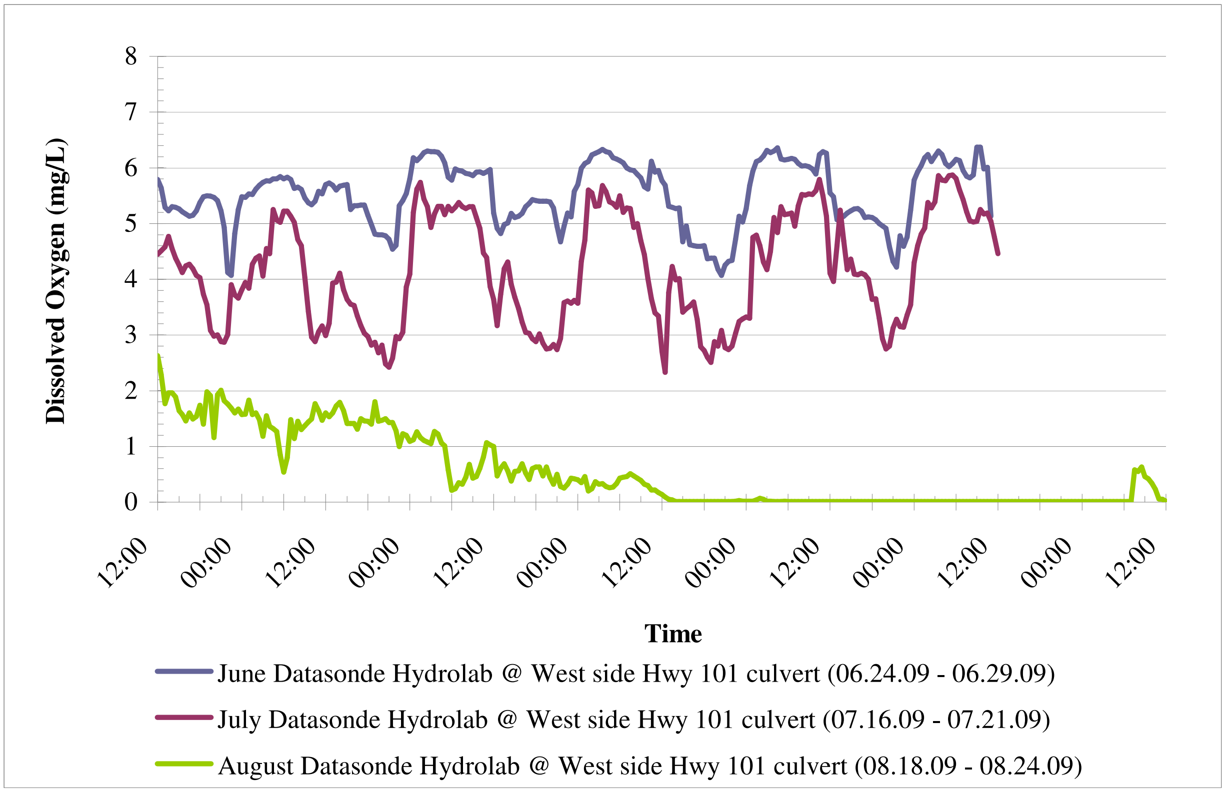


Figure 19. Dissolved oxygen levels measured at fish trapping locations within Salt Creek marsh during summer – fall 2009.



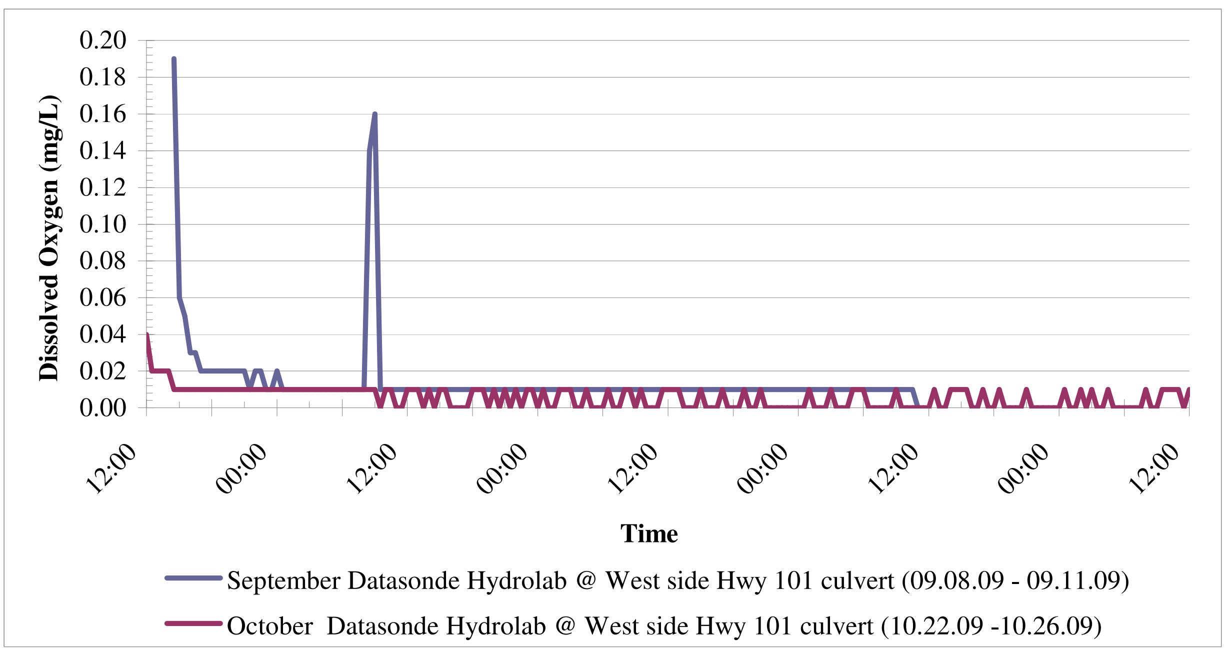


Figure 20. Dissolved oxygen levels measured at fish trapping locations within the Hunter Road wetland during summer – fall 2009.

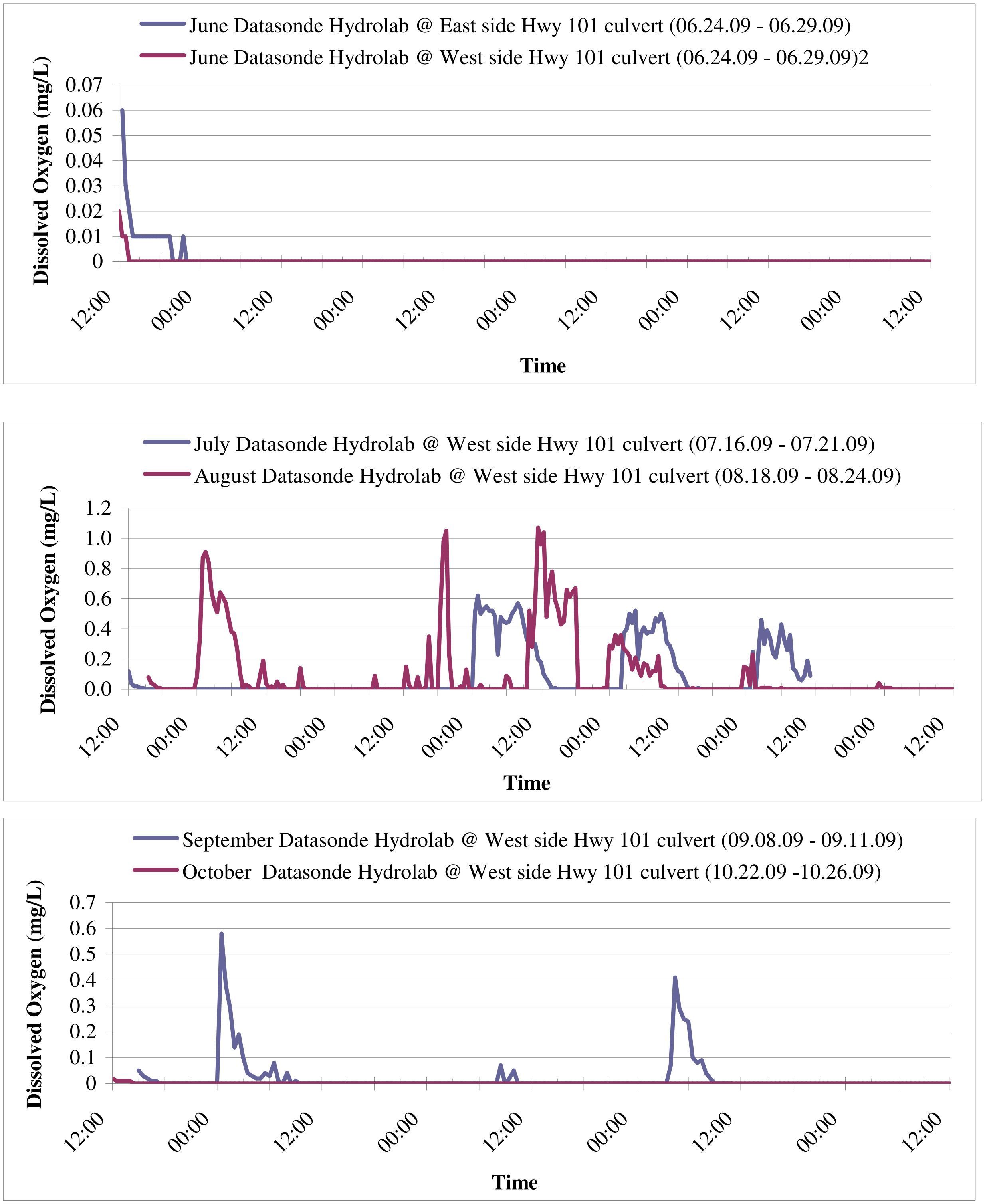


Figure 21. Dissolved oxygen levels measured at fish trapping locations within the Arbor Glen wetland during summer – fall 2009.

Table 2. Salmonid species observed during repeat snorkel inventories of a survey reach (387 meters) in lower Hunter Creek during summer 2009.

Species	May 13	June 24	July 29	Aug 25	Sept 30
Coho Salmon - Pre-smolt	2	1	0	0	0
Coho Salmon - Young of Year	1	2	2	1	2
Steelhead	106	135	178	141	144
Coastal Cutthroat	2	1	2	1	0
Chinook Salmon	0	2	0	0	0

observed in this reach was 1+ steelhead trout with only a few coho observations (Table 2) (Appendix E). Surface flows in this reach are maintained year-round; however, flows went subsurface upstream of the survey reach in early July. The quantity of fish in each unit stayed relatively consistent throughout the survey period (Table 2) (Appendix E).

Water quality for this reach was monitored just downstream of the highway bridge (Figures 1-3). Water temperatures measured in the Hunter Creek reach remained fairly constant from June through October (Appendix C). Water temperatures measured in this reach ranged from 10.24 to 12.27 degrees Celsius over the sampling period (Appendix C). Dissolved oxygen levels decreased slightly over the study period as the water table dropped (Figure 22) (Appendix D). However, levels measured at this site remained within an acceptable range for most aquatic vertebrates and other forms of aquatic life (Figure 22) (Appendix C).

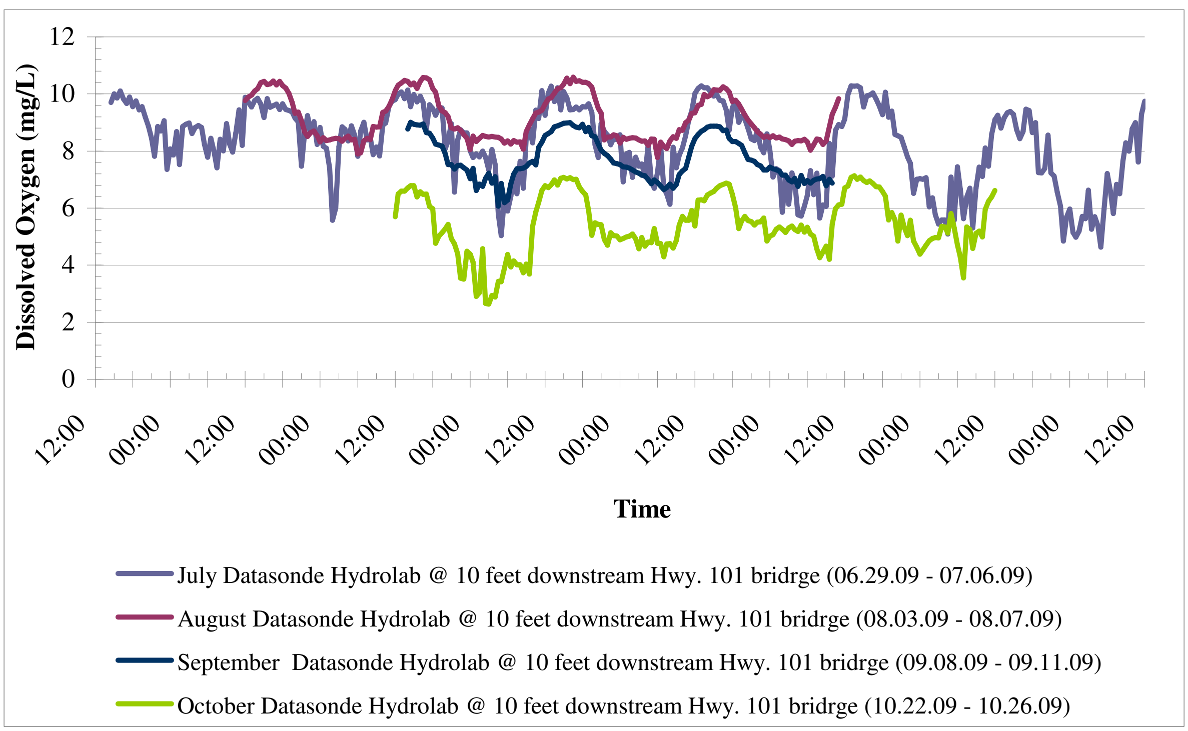


Figure 22. Dissolved oxygen levels measured in lower Hunter Creek during summer – fall 2009.

Longfin Smelt

Another primary species of concern for this study was the longfin smelt. These species use estuary and off-estuary habitats to spawn with larvae spending very little time residing in these habitats before initiating migration to the ocean. YTFP did not capture or observe any longfin smelt at any of the designated monitoring sites during this study. However, techniques used in this study were more appropriate for sampling salmonids than for sampling for longfin smelt.

Brood-year Analysis

The typical coho salmon life cycle is three years in length (one full year in freshwater habitats followed by two years in the ocean before returning to spawn). This typical life cycle leads to the concept of "brood years" (i.e. coho salmon populations using the Klamath Basin ecosystem can be divided into three relatively distinct populations or brood years. Further, each coho brood year may have a distinct population biology based on its response to environmental factors encountered during its current and previous brood year cycles. Increased knowledge regarding the relative strengths of coho brood years inhabiting the KGR Project area may provide useful information for developing project alternatives or construction scenarios that help minimize project impacts to coho salmon and their habitats.

Given that substantial non-natal rearing occurs in tributaries of the Lower Klamath Sub-basin (Soto et al. 2008; Hillemeier et al. 2010), including the KGR Project area; the number of juveniles rearing in these areas may be related to the abundance of adults that spawn in other areas of the Klamath-Trinity (K-T) Basin during the previous year. The number of coho that spawn in a given year is likely influences the abundance of juveniles that rear in the basin (whether in natal tributaries or elsewhere) the following spring/summer/winter, as well as the number of smolts that migrate to the ocean two springs after spawning. Unfortunately, adult coho escapement data from the K-T Basin is limited, especially relative to fall-run Chinook.

Extensive monitoring has been conducted by various entities throughout the K-T Basin to enumerate the escapement of fall Chinook, using various methods, such as: counting weirs, video weirs, redd surveys, live fish counts, march-recapture carcass surveys, snorkel surveys, harvest monitoring, and hatchery returns. However, due to funding limitations/priorities and adverse conditions related to increased precipitation and stream discharge during the time period that coho spawn; most spawning survey efforts do not cover the entire coho spawning season. Efforts have increased during recent years to enumerate coho salmon spawning escapement; however, long-term data sets to assess trends are limited. Areas with several years of data available include the Trinity River above the Willow Creek weir, Trinity River Hatchery, Iron Gate Hatchery, Scott River, and the Shasta River.

Trinity River

A primary long-term data set for coho salmon escapement has come from the Trinity Sub-basin, where a weir (located near the town of Willow Creek) has been used to estimate adult coho salmon run size since 1978. Since the construction of Trinity and Lewiston Dams during the early 1960's, the Trinity River coho population has been comprised mostly of hatchery production. For example, since mass-marking of hatchery coho production began in the mid-1990's, 89% of the adult coho salmon examined at the Willow Creek weir have been of hatchery origin on an annual basis (data obtained from Wade Sinnen, CDFG).

For the purpose of this analysis, of most interest is the annual number of coho that have spawned outside of the hatchery, regardless of the origin of these fish. The progeny of naturally spawned fish may rear as juveniles in habitats of the Lower Klamath; whereas progeny of hatchery fish are not released until they are smolts ready to emigrate to the ocean. Figure 23 shows the natural spawning escapement of adult coho salmon in the Trinity River from 1997 – 2008 (data obtained from Wade Sinnen, CDFG). As has been noted in other areas of the K-T Basin, there appears to be a cohort that was relatively more abundant during 1998, 2001, and 2004 (Table 3; Figure 24). Unlike populations in the other areas, the 2007 cohort was not relatively abundant in the Trinity.

Scott and Shasta Rivers

Efforts to monitor coho spawning escapement in the Scott and Shasta Rivers began in 2001; with a video weir operated in the Shasta River and live fish count surveys being conducted in the Scott River. As with naturally spawned Trinity coho (except in 2007), both of these populations have shown a relatively stronger cohort returning in 2001, 2004, and 2007; the strength of this cohort is most pronounced in the Scott River during 2004 & 2007 (Table 3; Figure 24).

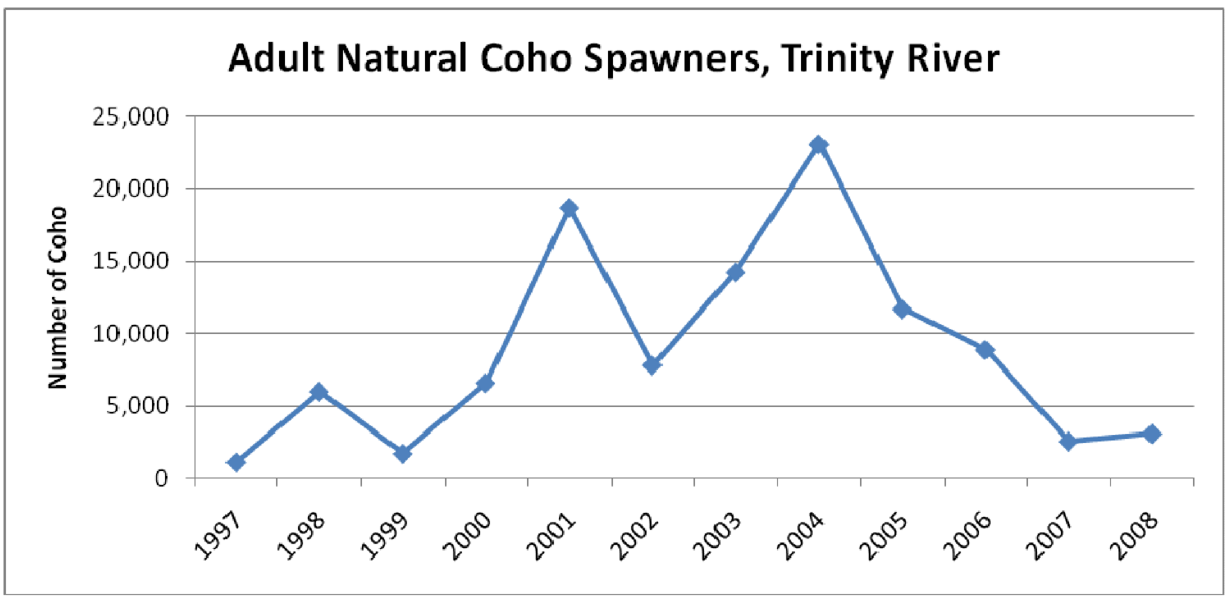


Figure 23. Natural spawning escapement of adult coho salmon in the Trinity River 1997 – 2008.

Table 3. Adult coho salmon returns to areas of the Klamath-Trinity Basin.

Year	Trinity Natural Spawning Areas	Trinity Hatchery	Shasta	Scott	Iron Gate Hatchery
1997	1,097	887			1,872
1998	5,995	4,014			511
1999	1,696	3,118			151
2000	6,585	3,461			723
2001	18,715	9,755	291	173	2,466
2002	7,812	6,495	86	17	1,193
2003	14,255	10,396	187	8	1,317
2004	23,117	9,906	373	1,577	1,495
2005	11,702	16,624	69	28	1,395
2006	8,870	9,839	47	5	263
2007	2,552	2,653	249	1622	625
2008	3,065	4,539	30	63	1,278
2009			9	81	46

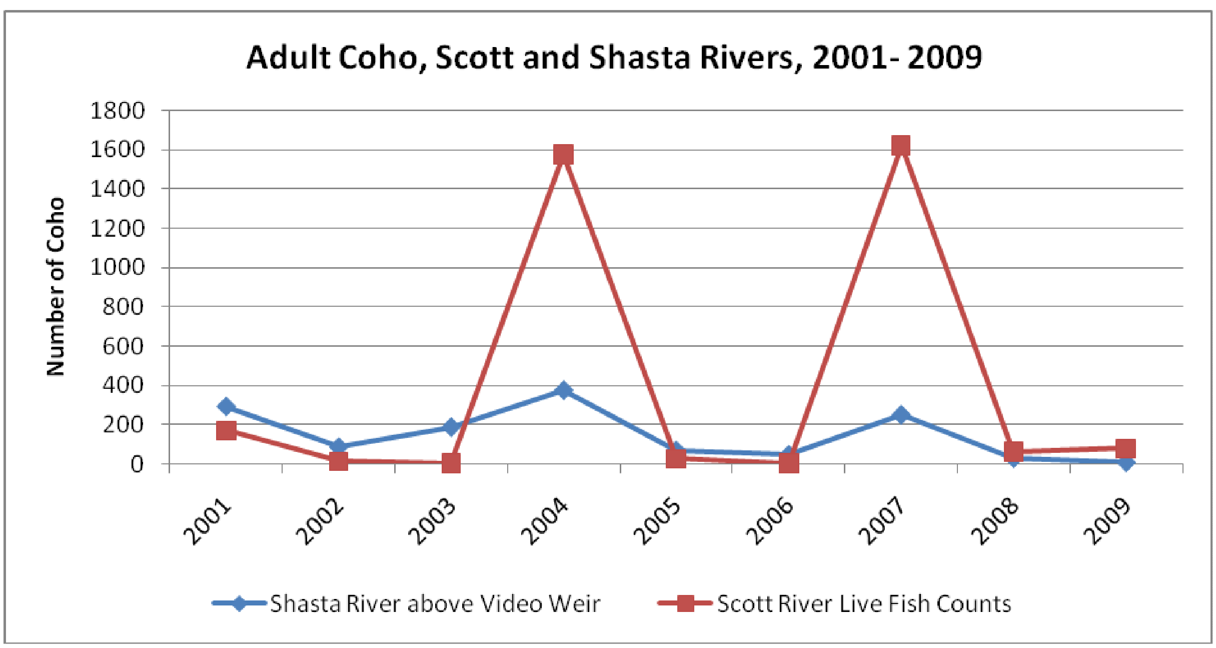


Figure 24. Estimates of adult coho spawning escapement in Scott and Shasta Rivers 2001-2009.

Juvenile Salmonid Monitoring

Various biological monitoring studies have been conducted in the Klamath River estuary and surrounding tributaries over the past couple decades. Some studies have focused primarily on juvenile fish species composition, relative abundance, emigration timing, and hatchery/natural composition in the estuary (Wallace 2001 & 2003; Hiner and Brown 2004; Hiner 2008); while others have focused on tributaries to the Lower Klamath River (Voight 2001-2004; YTFP 2009; Soto et al. 2008; Hillemeier et al. 2010; YTFP files). Most important for considerations related to the KGR Project, are biological monitoring efforts in Lower Klamath tributaries that assess species composition, timing, habitat use, and relative abundance over time (i.e. trends).

YTFP biological monitoring efforts in Lower Klamath tributaries have been conducted with various levels of funding. Some projects were grant funded and resulted in reports summarizing findings (Voight 2001-2004; YTFP 2009, Soto et al. 2008, Hillemeier et al. 2010); while other projects have consisted of under funded data collection efforts that are in various stages of data entry/analysis and reporting, some consisting primarily of data files and data summaries.

Downstream migrant trapping (either via screw traps, fyke net traps, or pipe traps) have been conducted by YTFP during various years in Hunter Creek (1996-2001), Terwer Creek (2001-2004), and McGarvey Creek (since 1997) (Table 4). Amongst tributaries near the estuary, McGarvey Creek has been the most intensively monitored for juvenile salmonid emigration (Table 4; Figure 25) (YTFP 2009). Seasonal movements of juvenile salmonids past the trap sites are available upon request from YTFP files.

Table 4. Estimated number of coho yearlings emigrating past downstream migrant traps in McGarvey, Terwer, and Hunter Creeks during the years traps were operated from 1997 – 2008.

Year	McGarvey Creek	Terwer Creek	Hunter Creek
1997	916		1,224
1998	613		595
1999	146		100
2000	572		5,154
2001	849	710	196
2002	1,461	1,164	
2003	1,283	289	
2004	749	314	
2005	678		
2006	2,085		
2007	329		
2008	1,212		
Average	908	619	1454

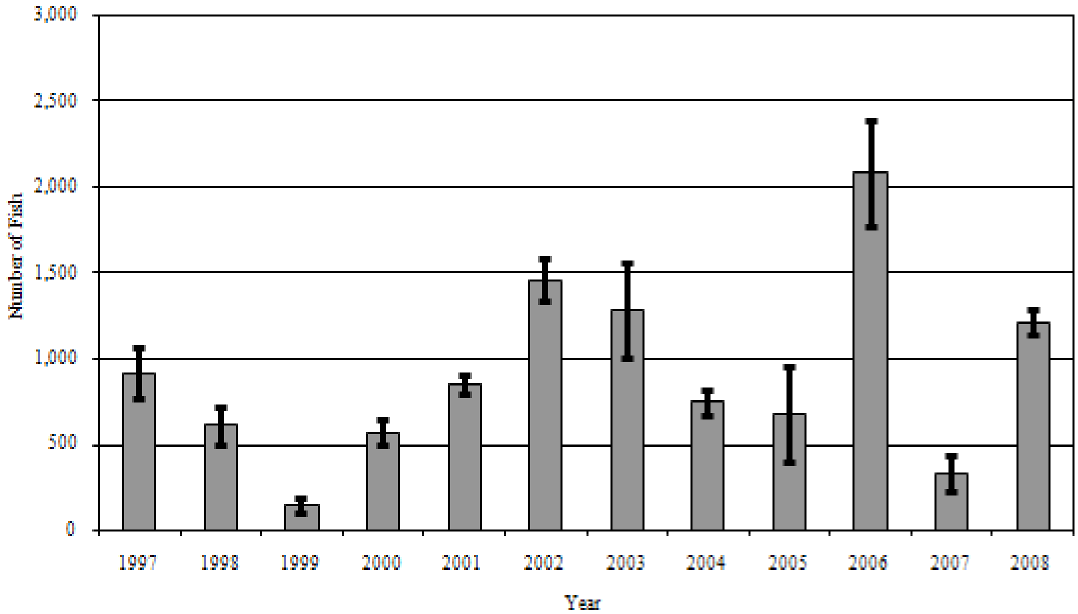


Figure 25. Estimated number of coho smolts (+/- S.D.) migrating past the outmigrant trap in McGarvey Creek, 1997 – 2008.

The number of coho smolts estimated to leave these creeks during the period of record does not appear to be consistently related to the relatively strong coho broods observed elsewhere in the K-T Basin (1998, 2001 & 2004). This observation was based on smolt emigration occurring in the springs of 2000 (brood year 1998), 2003 (brood year 2001), and 2006 (brood year 2004) (Table 4; Figures 25-26). Coho smolts from the 1998 brood were exceptionally abundant in Hunter Creek and several times larger relative to coho captured during the other four years this trap was operated. However, this pattern was not observed in McGarvey Creek during 2000. The 2001 brood resulted in an above average number of smolts leaving McGarvey Creek. Large numbers of coho smolts were also observed migrating past the lower Salt Creek trap in May 2003 (Figures 6-7); but the pattern was not observed in Terwer Creek (Table 4). The 2004 brood resulted in the largest number of smolts emigrating from McGarvey Creek during the period of record (Table 4; Figure 25).

Regional abundance surveys for YOY coho salmon were conducted in the Lower Klamath Sub-basin (downstream of Weitchpec, excluding Pine Creek) from 2000-2004 (Voight 2001-2004) (Table 5). YTFP also conducted single-stream estimates in McGarvey Creek in 2001-2004 and 2006-2008; and in the Crescent City Fork of Blue Creek (CC Fork) during 2001-2003 (Table 5; Figure 27). For the years surveyed, YOY coho abundance in the Lower Klamath and the CC Fork was greatest in summer 2002 following the relatively strong 2001 brood return (Table 5). There were substantially more YOY coho in McGarvey Creek following the years of relatively strong brood returns (2001 & 2007); with the largest numbers of YOY coho observed during summers 2002 & 2008 (Figure 27 – no estimate is available for summer 2005). Summer 2002 was also the first time YOY coho were documented in High Prairie Creek (Figure 8).

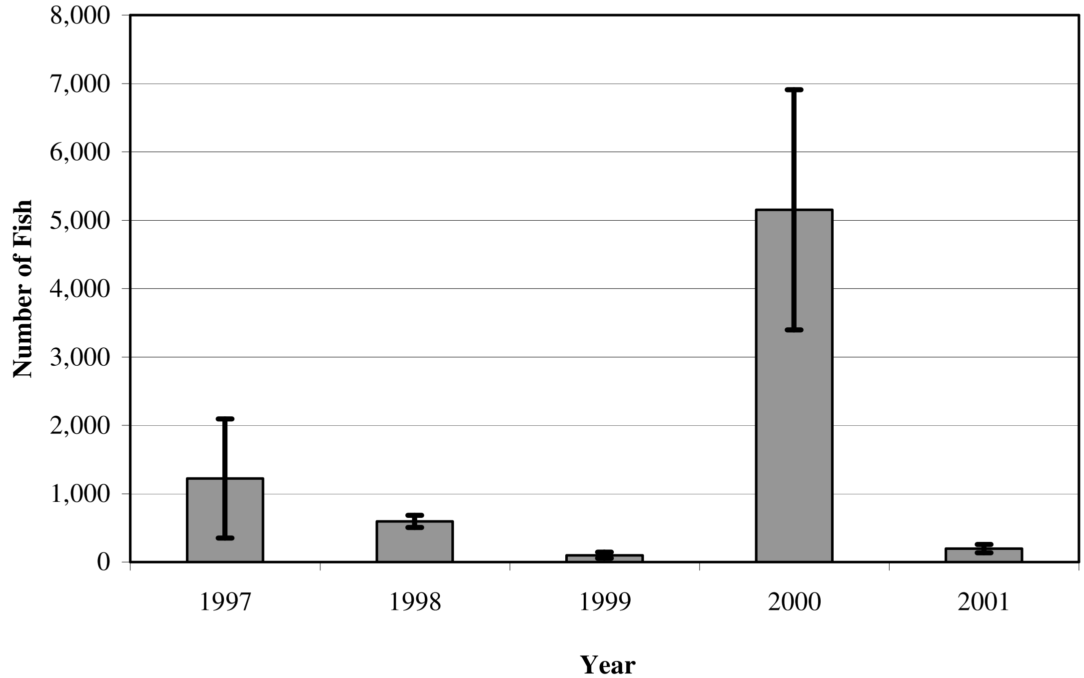


Figure 26. Estimated number (+/- S.D.) of coho salmon yearlings emigrating past the Hunter Creek outmigrant trap located downstream of Requa Road, Lower Klamath River Sub-basin.

Table 5. Summary of estimated abundance of age 0+ coho residing in the Lower Klamath River: regional and single stream surveys, with 95% confidence intervals (CI), Yurok Tribal Fisheries Program, 2000-2004 surveys.

Year	All Regional Reaches	95% CI	McGarvey Single Stream	95% CI	CCFK Single Stream	95% CI	Overall Lower Klamath Estimate	95% CI
2000	322	+/- 306	NS1	--	NS	--	322	+/- 306
2001	5,943	+/- 4,917	1,928	+/- 773	5,217	+/- 706	13,089	+/- 5,026
2002	16,497	+/- 12,257	4,767	+/- 1,458	12,359	+/- 917	33,812	+/- 12, 379
2003	12,901	+/- 10,615	2,748	+/- 822	5,539	+/- 495	21,188	+/- 10,659
2004	5,625	+/- 6,680	1,563	+/- 345	NS	--	7,188	+/- 6,689

NS= not surveyed

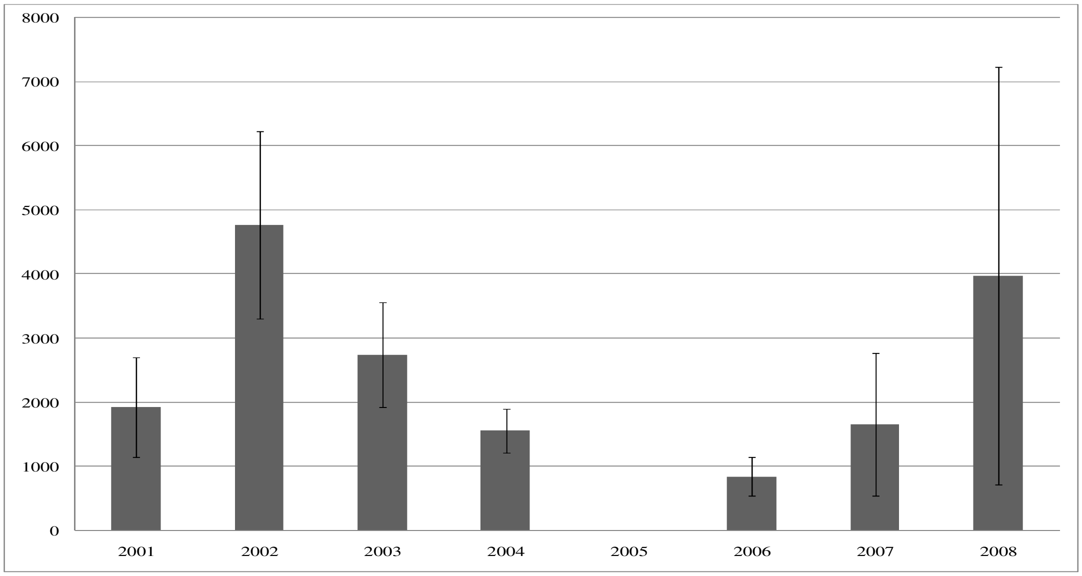


Figure 27. Estimated abundance of young of the year juvenile coho salmon in McGarvey Creek (all reaches combined) for 2001 – 2004 and 2006 – 2008.

Juvenile Coho Ecology Study

A primary goal of the Coho Ecology Study project is to assess life history traits of Klamath Basin juvenile coho, especially in regard to use of the mainstem corridor and lower portions of tributaries (Soto et al. 2008; Hillemeier et al. 2010). Ancillary objectives include: development of a conceptual life history model regarding life history stage verse habitat use (types of habitat used and their spatial distribution) which will be used to guide restoration efforts; an assessment of the importance of various life history strategies; and an assessment of restoration efforts. This project has involved marking (primarily with freeze brands and PIT tags) YOY coho in various locations of the Klamath Basin and tracking their presence, by life stage, throughout the Basin.

Intensive sampling conducted in areas of the Lower Klamath (Waukell, Salt, and Panther Creeks), indicate that juvenile coho salmon (and likely steelhead) from throughout the Klamath Basin (especially mid-Klamath) rely on these habitats for overwinter rearing; particularly in beaver influenced ponds and off-estuary wetlands such as those found in Spruce and Panther Creeks (Table 6; Appendix F). Junior Creek is a tributary of Waukell Creek, which enters the south side of the Klamath River estuary near the DN Highway 101 Klamath River Bridge (Figure 1). Junior Creek Pond (Jr. Pond) is a small, open water wetland that provides extremely valuable overwinter habitat to non-natal salmonids before drying out in mid-summer. In 2008, ~2,500 coho smolts were captured in the downstream trap or during fish rescue efforts in Jr. Pond. YTFP also calculated winter 2008-2009 population estimates for yearling coho using mark-recapture techniques in Panther Pond, Salt Creek marsh, and Jr. Pond (Figures 28-29).

Table 6. The number of tagged fish by site (Mid-Klamath) that were recaptured one or more times in the Lower Klamath study area from May 2007 - May 2008.

Stream	RM	No. tagged	No. recap in lower Klamath	% recap in lower Klamath
Aikens Creek	49.6	201	4	2.0%
Big Bar (Klamath R)	50.0	50	4	8.0%
Camp Creek	57.1	96	3	3.1%
Stanshaw Creek	76.9	72	3	4.2%
Sandy Bar Creek	77.6	116	3	2.6%
Dillon Creek	84.1	44	3	6.8%
Independence Creek	94.0	756	23	3.0%
Titus Creek	96.7	49	0	0.0%
Bulk Plant (Klamath R)	111.5	37	0	0.0%
Cade Creek	112.5	32	0	0.0%
China Creek	117.9	302	3	1.0%
(Little) Horse Creek	118.1	25	0	0.0%
Thompson Creek	123.0	51	1	2.0%
Fort Goff Creek	128.0	72	1	1.4%
Tom Martin Creek	144.2	55	0	0.0%
Beaver Creek	161.0	1	0	0.0%
Total		1959	48	2.5%

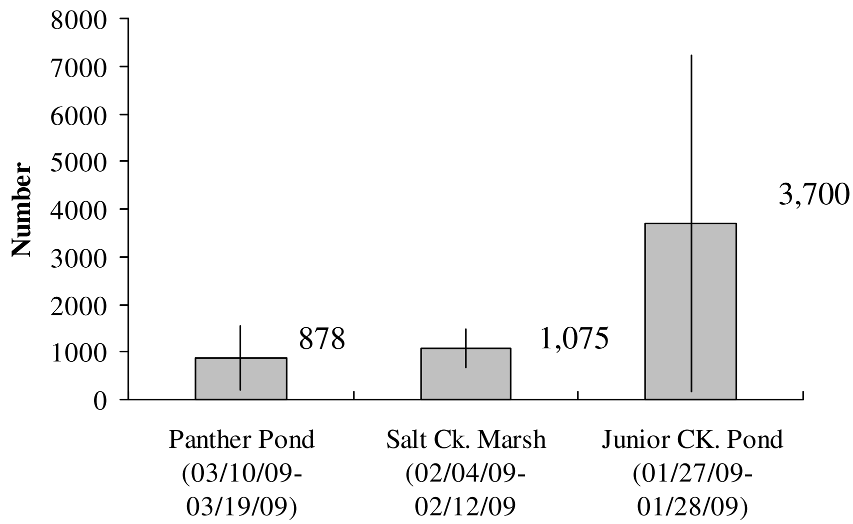


Figure 28. Mark-recapture population estimates in Panther Creek Pond, Salt Creek marsh, and Junior Creek Pond (coho brood year 2008-2009) (Dates listed under site names are the date of the marking event (Top), and the date of the recapture event (Bottom)).

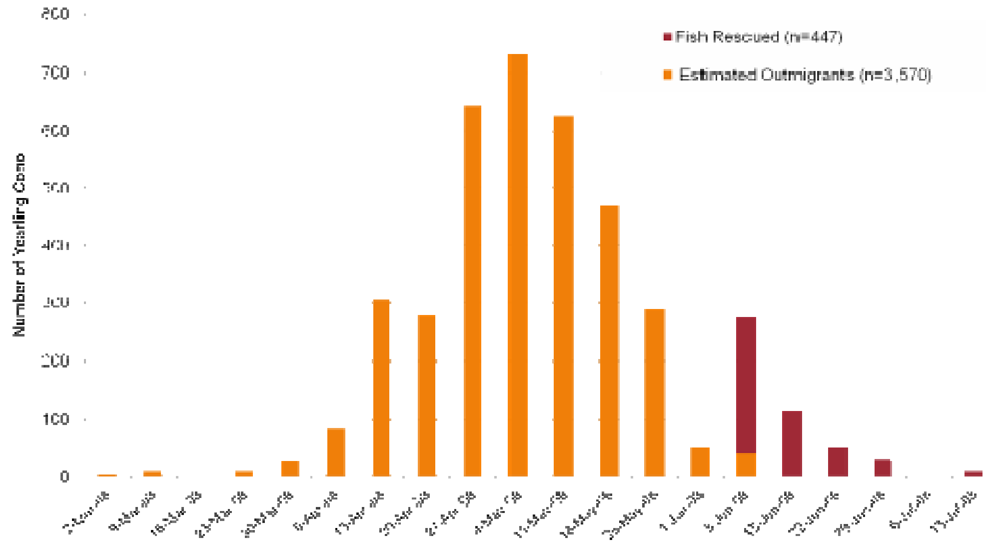


Figure 29. Coho outmigration estimate for Junior Pond for 2008 (Refer to Hillemeier et al. 2010 for a description of methods), Lower Klamath Sub-basin, California.

The onset of the first substantial late fall-early winter precipitation, and associated river discharge, typically initiates the beginning of the upstream migration (following their emigration down the mainstem Klamath corridor) of non-natal juvenile coho salmon (and steelhead) into Lower Klamath tributaries (Figures 30-38). During 2007-2008, the late fall-early winter upstream migration was less substantial than during the previous year; however, there was significant upstream movement of juvenile coho (0+ and 1+) into Lower Klamath tributaries during spring of 2008. Length frequency data collected during spring 2008 showed that while many of the upstream migrants were large (easily large enough to be smolts), they were somewhat smaller than the yearling fish moving seaward at the same time (Figures 39-40).

The life history strategy of non-natal juvenile coho salmon rearing in the Lower Klamath Sub-basin can have several survival benefits: 1) these fish are occupying under-seeded habitat due to relatively low spawning in some of the off-channel habitats; 2) much of the downstream emigration in the mainstem occurs during late fall-early winter, when predation rates are relatively low; 3) growth in these Lower Klamath habitats is substantial during winter months (Figure 41) relative to most inland tributaries, because of warm winter water temperatures resulting from marine and ground water influences and high productivity of beaver ponds; and 5) following their freshwater rearing, smolts only have a short distance to travel before reaching the ocean, which substantially minimizes exposure to disease, predation, and other potential threats. Therefore, the survival rates of juvenile coho (and steelhead) that rear in Lower Klamath habitats are likely quite high relative to fish from other parts of the basin, which underscores the importance of these habitats to populations from throughout the Klamath Basin.

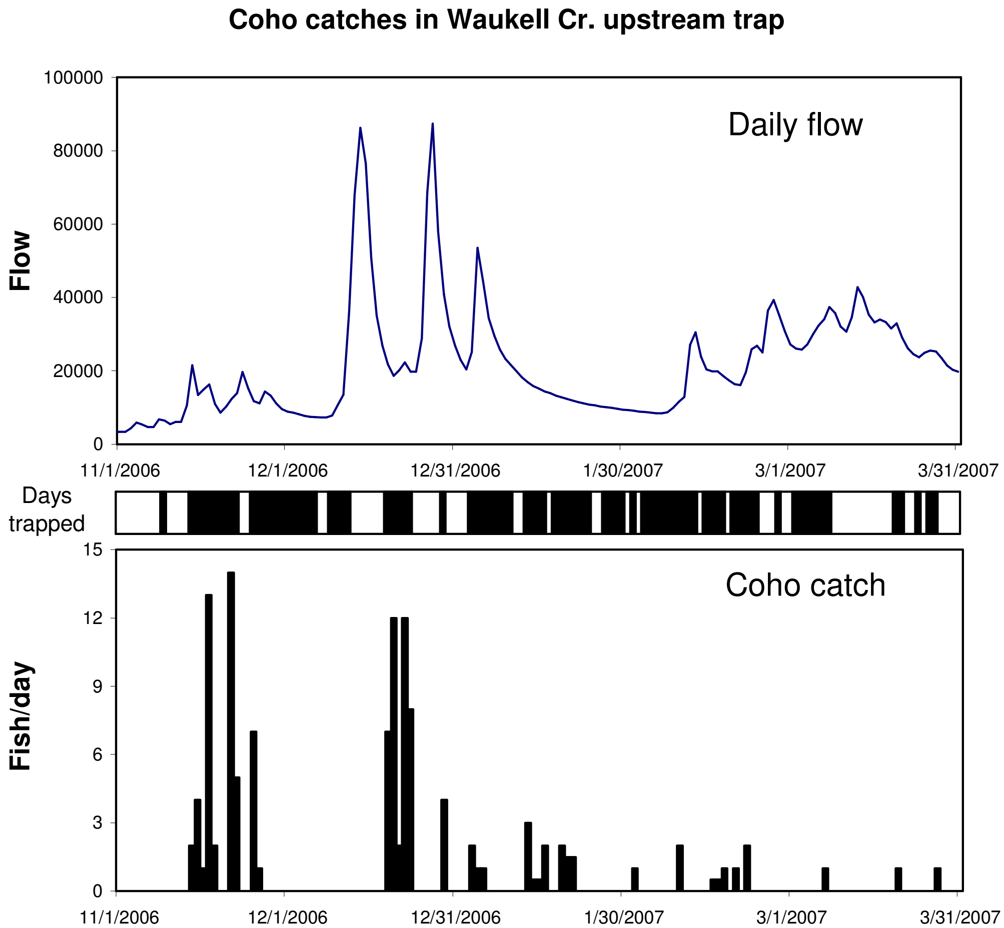


Figure 30. Catch per day of juvenile coho in the upstream trap in lower Waukell Creek, days fished, and flow in the Klamath River (Terwer gauge near Highway 101) between November 1, 2006 and March 31, 2007.

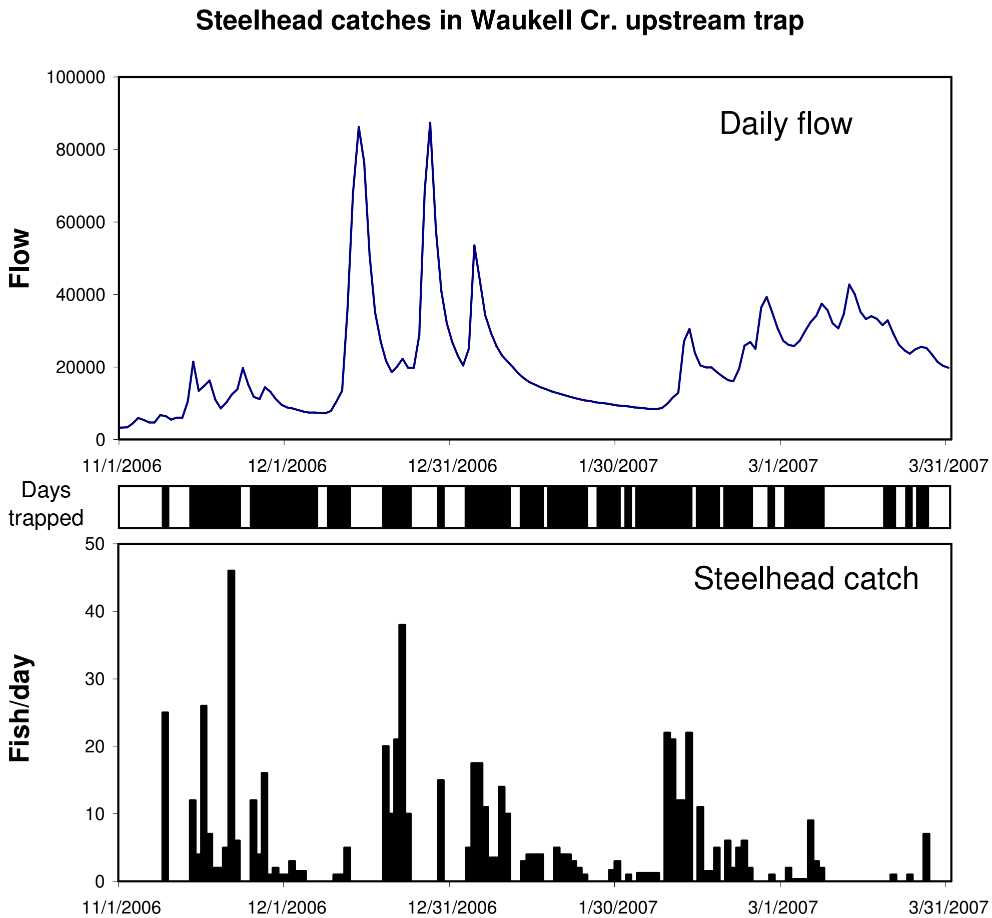


Figure 31. Catch per day of juvenile steelhead in the upstream trap in lower Waukell Creek, days fished, and flow in the Klamath River (Terwer gauge near Highway 101) between November 1, 2006 and March 31, 2007.

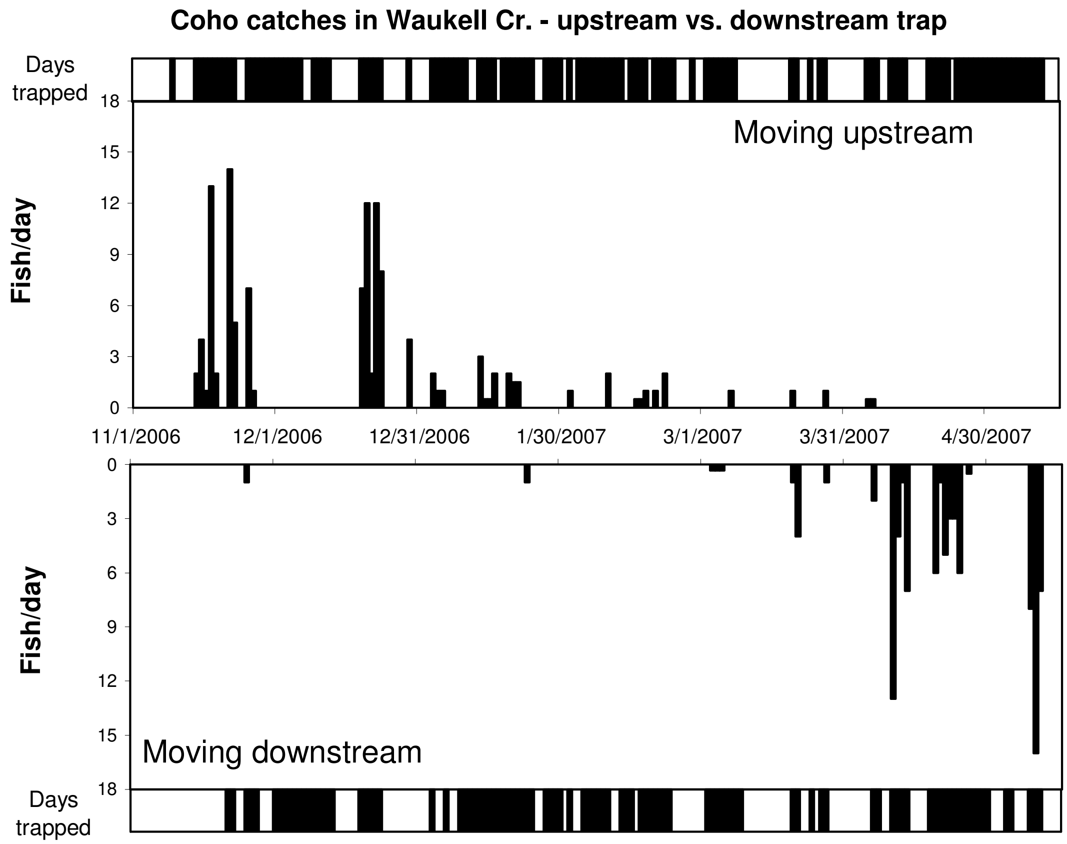


Figure 32. Upstream and downstream catches of juvenile coho and days fished in lower Waukell Creek between mid November 2006 and mid May 2007

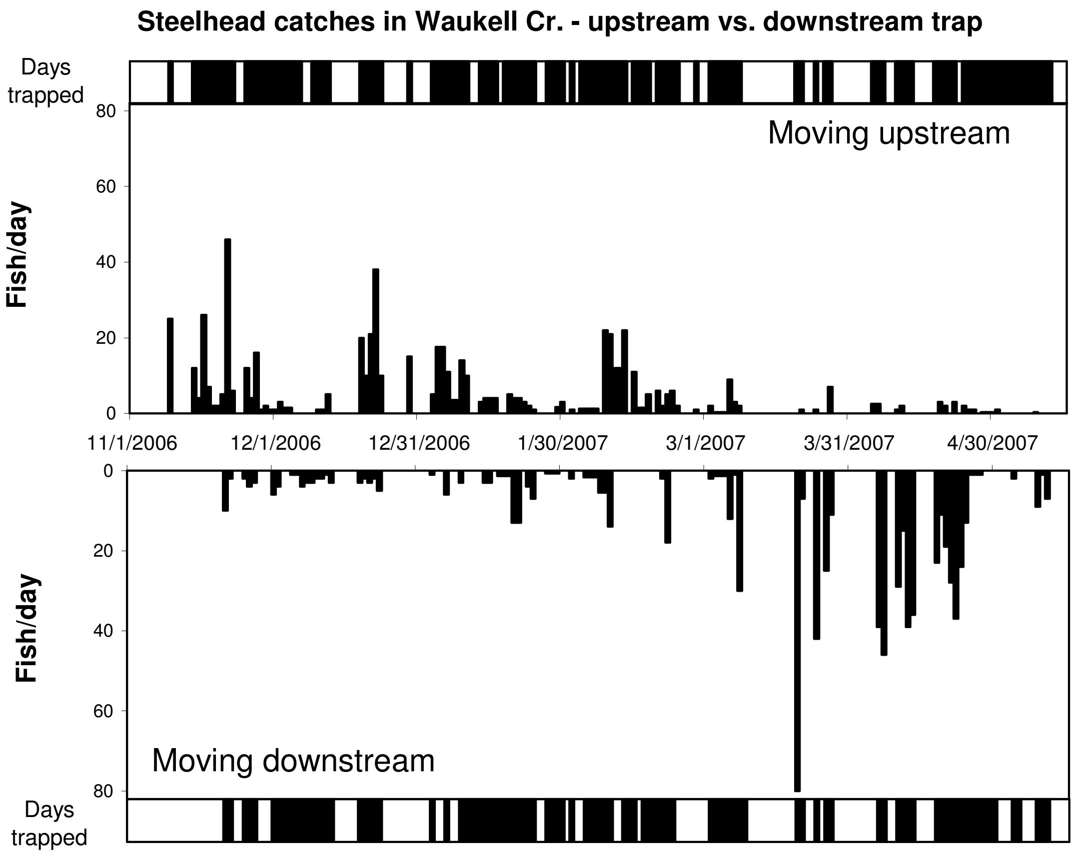
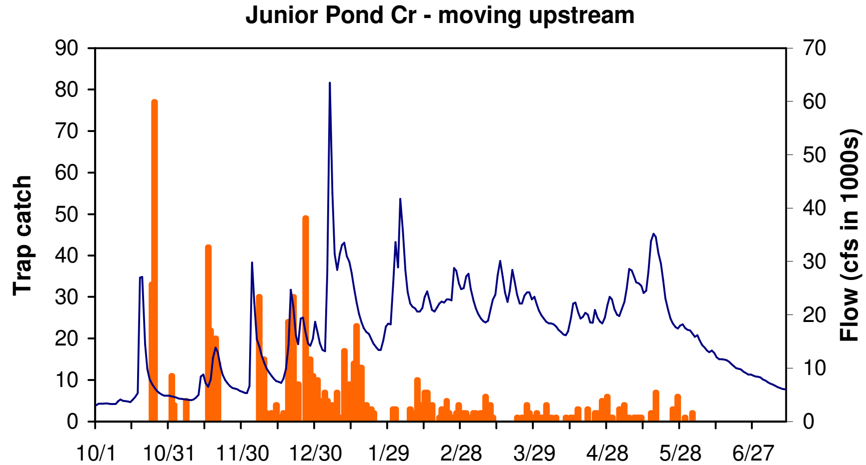


Figure 33. Upstream and downstream catches of juvenile steelhead and days fished in lower Waukell Creek between mid November 2006 and mid May 2007.



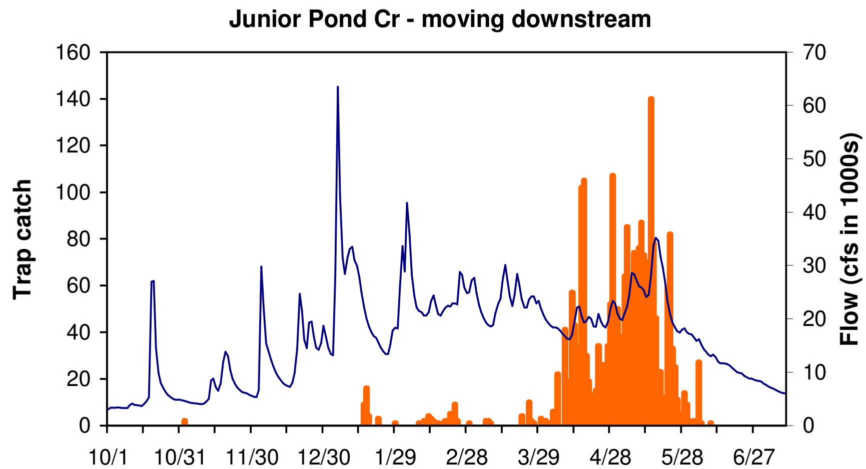


Figure 34. Daily catches (orange bars) of juvenile coho in the upstream (top) and downstream (bottom) directional fyke traps in Junior Pond Creek located a short distance downstream of Junior Pond between October 1, 2007 and July 15, 2008. Klamath River flow data (solid line) from the USGS Klamath River near Klamath CA Station is also shown.

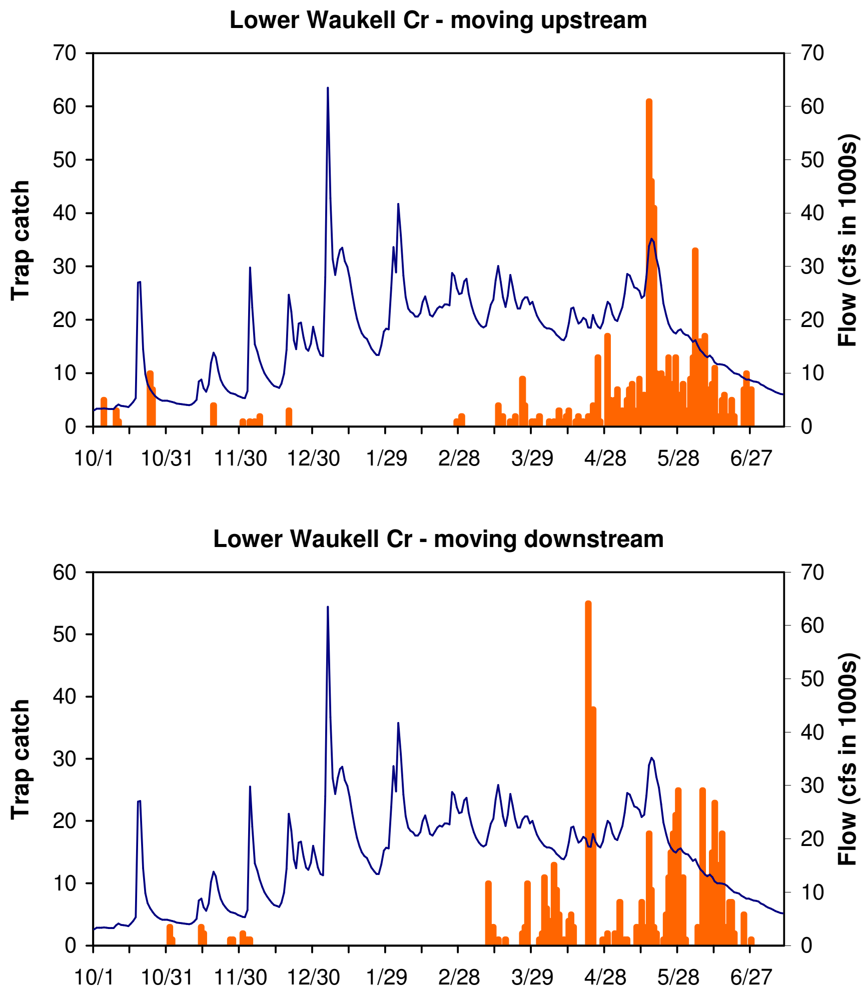


Figure 35. Daily catches (orange bars) of juvenile coho in the upstream (top) and downstream (bottom) directional fyke traps in lower Waukell Creek between early November, 2007 and the end of July, 2008. Klamath River flow data (solid line) from the USGS Klamath River near Klamath CA Station is also shown.

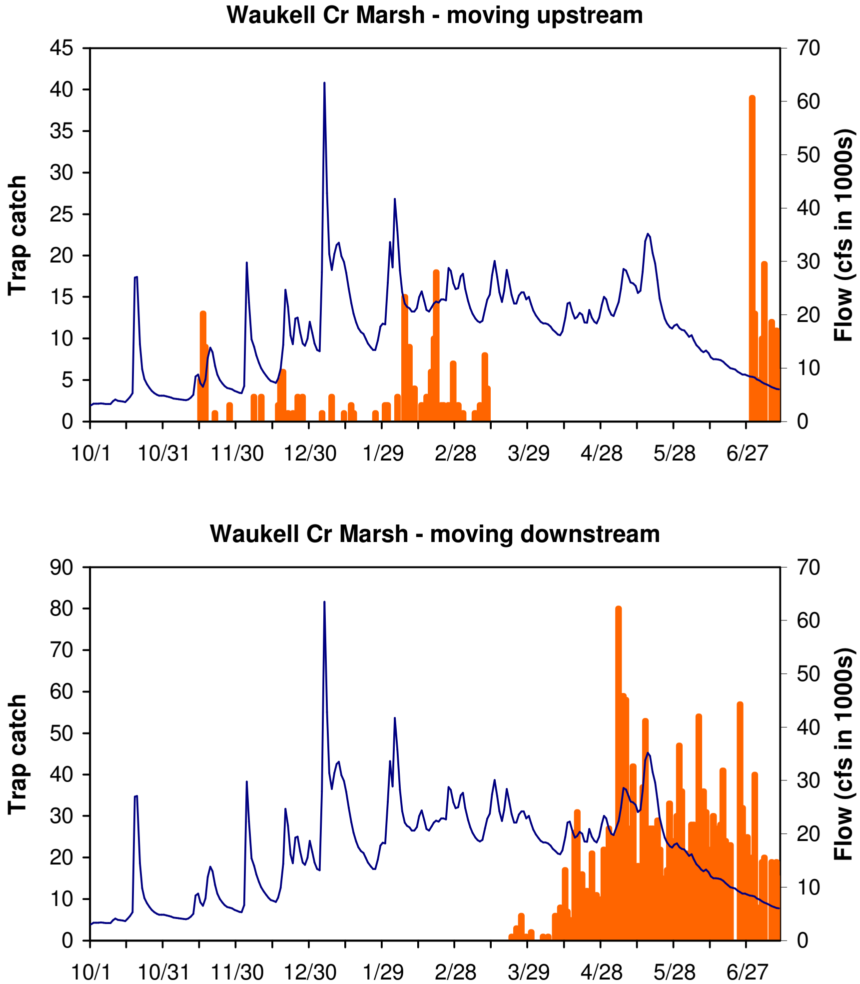
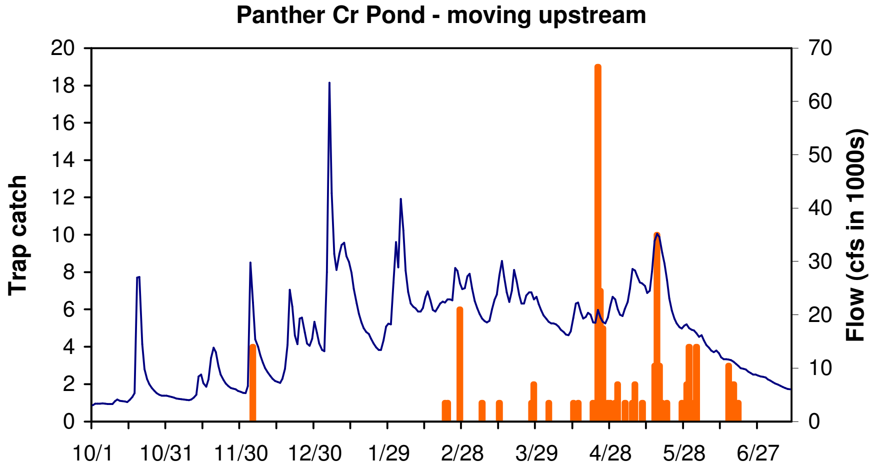


Figure 36. Daily catches (orange bars) of juvenile coho in the upstream (top) and downstream (bottom) directional fyke traps in the upper Waukell Creek marsh site between early November, 2007 and mid July, 2008. Klamath River flow data (solid line) from the USGS Klamath River near Klamath CA Station is also shown.



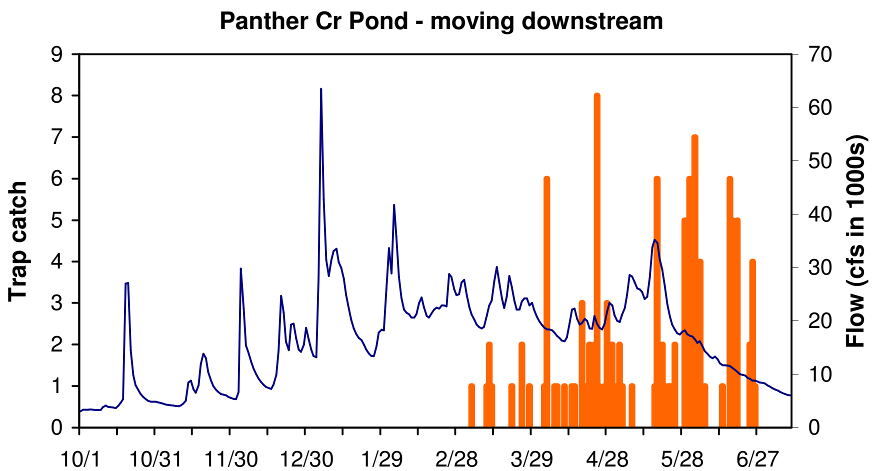


Figure 37. Daily catches (orange bars) of juvenile coho in the upstream (top) and downstream (bottom) directional fyke traps in Panther Creek between early December, 2007 and the end of June, 2008. Klamath River flow data (solid line) from the USGS Klamath River near Klamath CA Station is also shown.

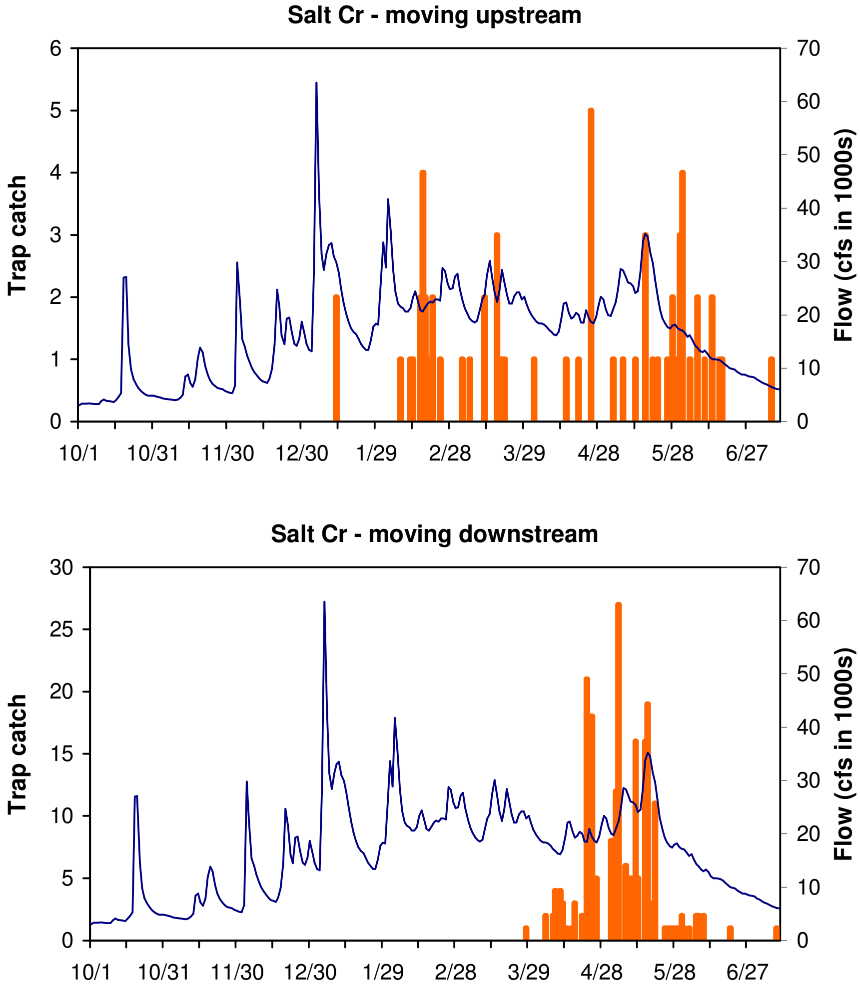


Figure 38. Daily catches (orange bars) of juvenile coho in the upstream (top) and downstream (bottom) directional fyke traps in Salt Creek between mid January, 2008 and the end of June, 2008. Klamath River flow data (solid line) from the USGS Klamath River near Klamath CA Station is also shown.

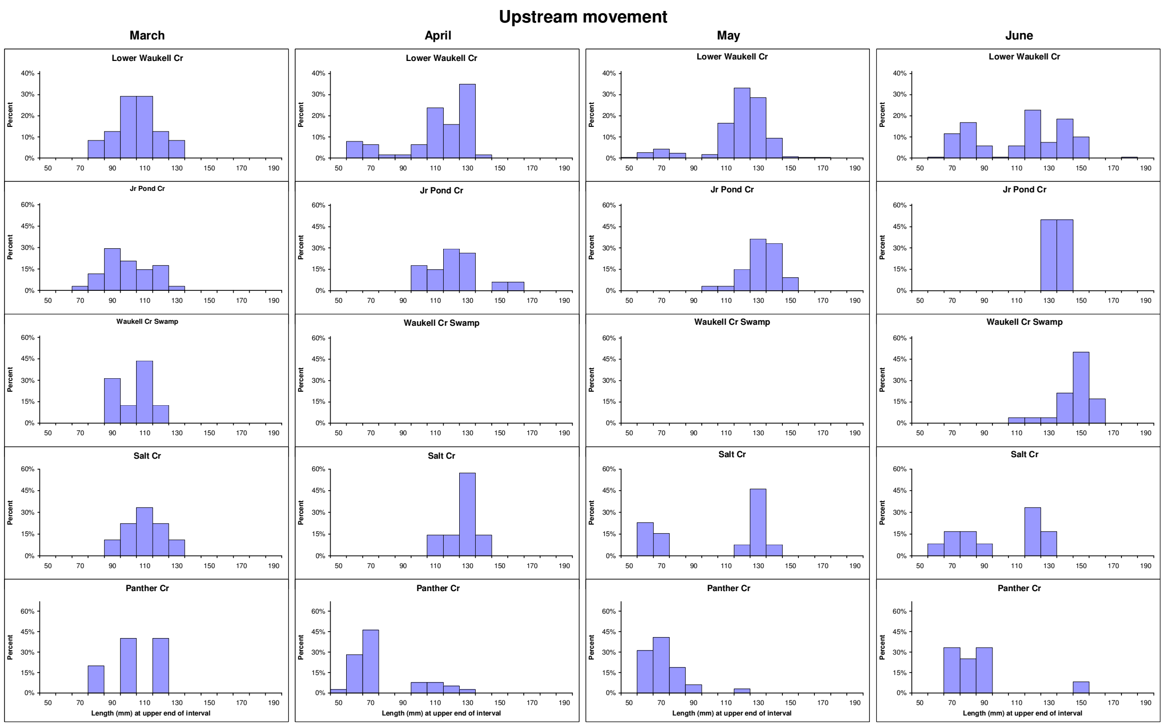


Figure 39. Length frequency charts for juvenile coho captured in upstream directional fyke traps during fall, winter, spring, and early summer of 2007-2008 in lower Waukell Creek, Junior Pond Creek, upper Waukell Creek swamp, Salt Creek, and Panther Creek.

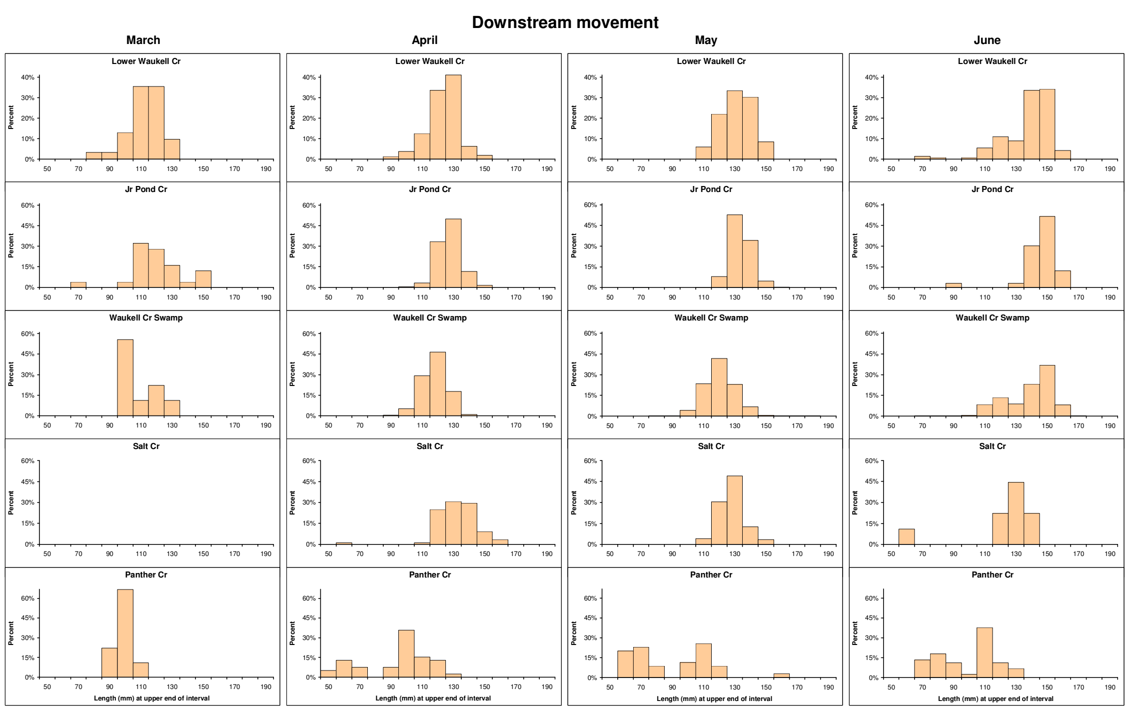


Figure 40. Length frequency charts for juvenile coho captured in downstream directional fyke traps during fall, winter, spring, and early summer of 2007-2008 in lower Waukell Creek, Junior Pond Creek, upper Waukell Creek swamp, Salt Creek, and Panther Creek.

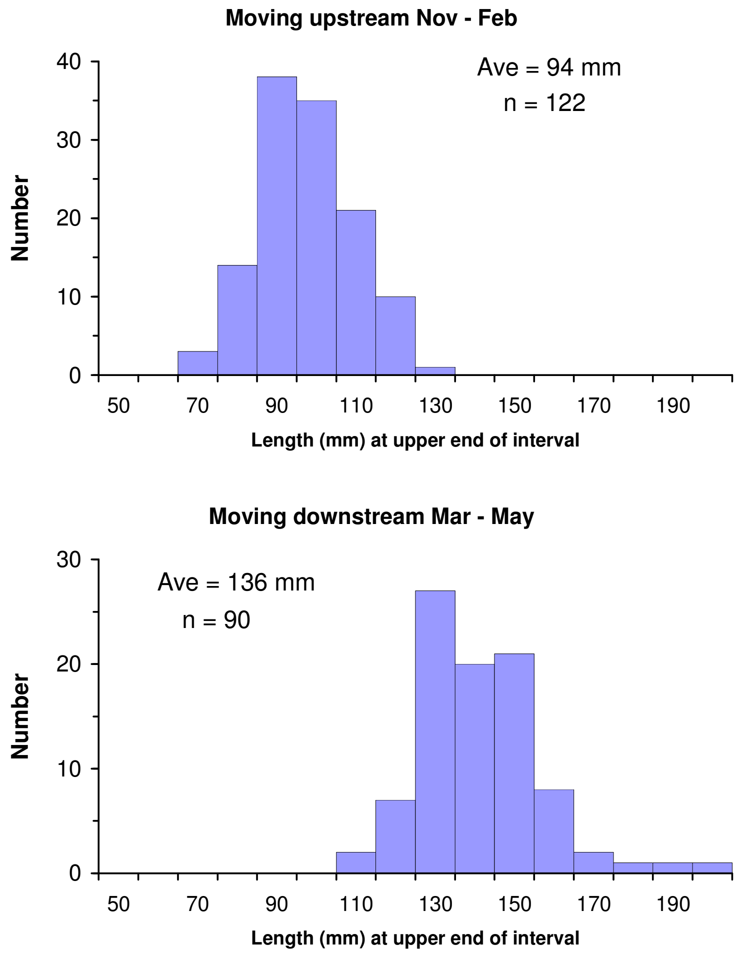


Figure 41. Length frequencies of juvenile coho captured in lower Waukell Creek moving upstream between November - February and moving downstream between March – May.

Discussion

The beaver (*Castor Canadensis*) has been a "keystone species" (Naiman et al. 1986) throughout the Pacific Northwest with its ability to greatly modify the structure and dynamics of their surroundings. Pollock and others (2003) compiled research pertaining to the geomorphic effects of beaver dams and their influence on water quality and fish populations in North America. They found that beaver ponds prolong stream flows during late-summer, expand floodplains, increase ground water recharge, and dissipate the erosive power of floods. They found that beaver ponds tended to be more productive in terms of number and size of fish, especially for juvenile coho, than free-flowing stream reaches. They further stated that larger coho (age 1+) consistently used beaver pond habitats over all other available habitats. Beaver activity in the Lower Klamath appears to be increasing during the last few decades following fur trapping activities and dramatic hydrologic alterations (i.e. diking and draining of wetlands/streams) occurring in off-estuary habitats in the early 1900s (Beesley and Fiori 2004; 2007; & 2008).

Nickelson and others (1992) studied habitat use by juvenile coho in 14 Oregon coastal streams during spring, summer, and winter seasons. They found that juvenile coho were most abundant in alcoves and beaver ponds; and that beaver ponds supported more fish (mean = 456/pond) and higher densities of fish (1.28 fish/m^2) than other types of dammed pools (mean = 96/pool and density = 0.49 fish/m^2). Pollock and others (2004) studied the effects of extensive removal of beaver and their dams on coho salmon in the Stillaguamish River Basin of Washington. They assessed current and historic distributions of beaver ponds and other coho rearing habitats and reported that the greatest reduction in coho smolt production capacity was related to the loss of beaver ponds. Historically, most of the coho smolt production occurred in beaver ponds (61% for summer - 86% for winter); whereas currently tributary habitats accounted for 62% of summer production and beaver ponds only accounted for 38% of winter production (Pollock et al. 2004).

Similar shifts in habitat use by juvenile coho have likely occurred in the Klamath Basin given the substantial loss of beaver ponds and other high quality, wetland habitats in the estuary (Beesley and Fiori 2004 & 2008). It is likely that a primary limitation to Klamath Basin coho runs is the loss of critically valuable coastal wetlands, beaver ponds, and alcove/slough habitats. Although beaver activity occurs in the Salt-Hunter valley, the amount of beaver influenced habitat available to juvenile salmonids remains extremely low relative to historic conditions.

Fur trapping activities nearly drove many Pacific Northwest populations of beaver to extinction; however, the greatest impact to coastal beaver populations is the historic (early 1900s) loss of habitat through wetland clearing/draining, and stream diking (Figures 4-5) (Sedell and Luchessa 1982; Pollock et al. 2004). Beaver populations in the Lower Klamath remain extremely low because their habitat continues to be lost and simplified through agricultural and other land use activities (Beesley and Fiori 2004, 2007 & 2008). Additionally, beaver is considered a nuisance species in California and may be hunted from November – February with no bag limit. As a result of these policies, the beaver pond located upstream of DN Highway 101 in Spruce Creek has been drained and altered several times in the last few years even though it provided high quality and preferred rearing habitat to coho salmon, a state and federally listed species.

Although water temperatures were well within tolerable ranges for salmonids and other aquatic dependent species during the study, low dissolved oxygen levels persisted in a majority of the sites during the low flow period (Appendix C). Every site, except lower Hunter Creek, experienced prolonged periods with dissolved oxygen levels at or below the threshold for sustaining salmonids.

YTFP established water quality monitoring sites in several off-estuary tributaries and the South Slough to better characterize the range of water quality conditions present in these critically valuable habitats (Hiner 2006; Hiner and Brown 2004; Beesley 2007; Beesley and Fiori 2004 & 2008) (Figure 42). Data collected in the Salt-Hunter valley since 2000 has revealed water quality conditions in the lower reaches of Salt Creek, Hunter Creek, and Spruce Creek are greatly influenced by Klamath River flows and tide cycles during most of the year (Figures 43-44). While water quality at sites located upstream (Mynot Creek and Panther Creek) appear less influenced by tides or river conditions, especially in spring - fall (Figures 43-44). Water temperatures in off-estuary tributary habitats remain well within tolerable levels for salmonids year-round, except at sites that are flooded by mainstem flows during high tides in late summer - fall (Figures 43-50).

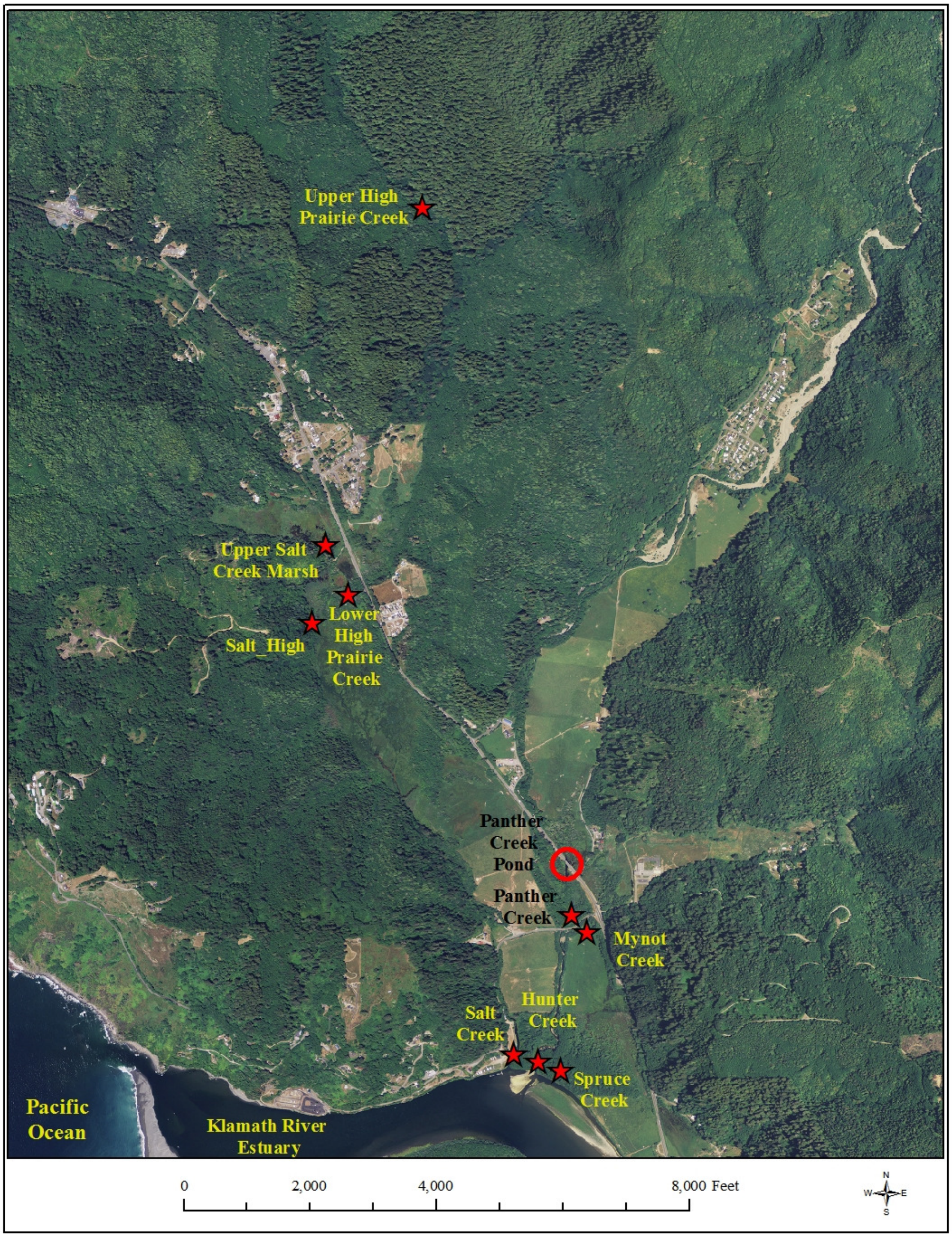
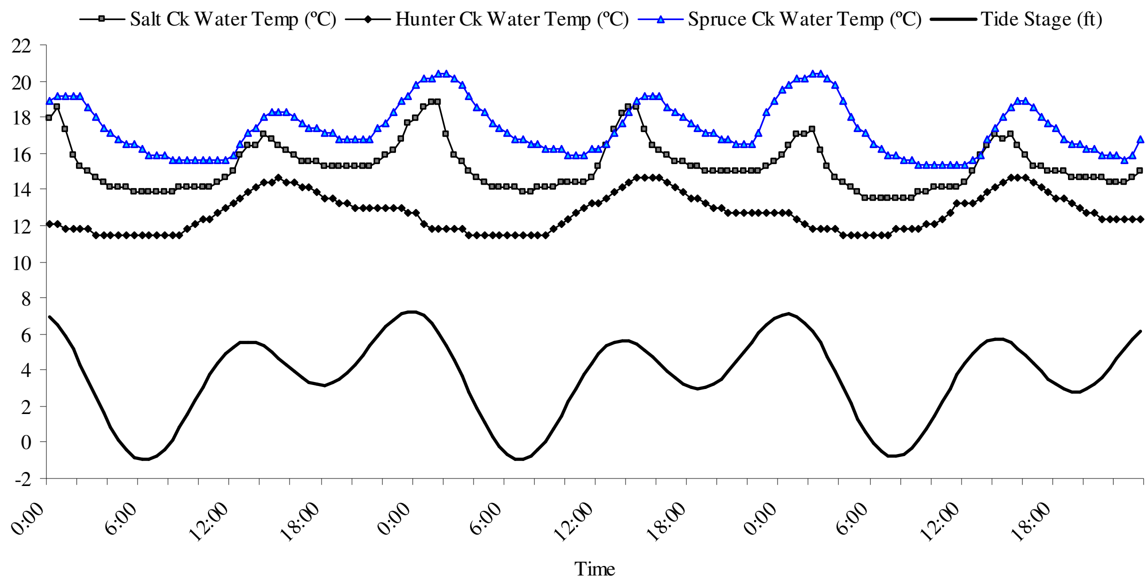


Figure 42. Map depicting several water quality monitoring stations located in off-estuary tributary habitats of the Klamath River, California.



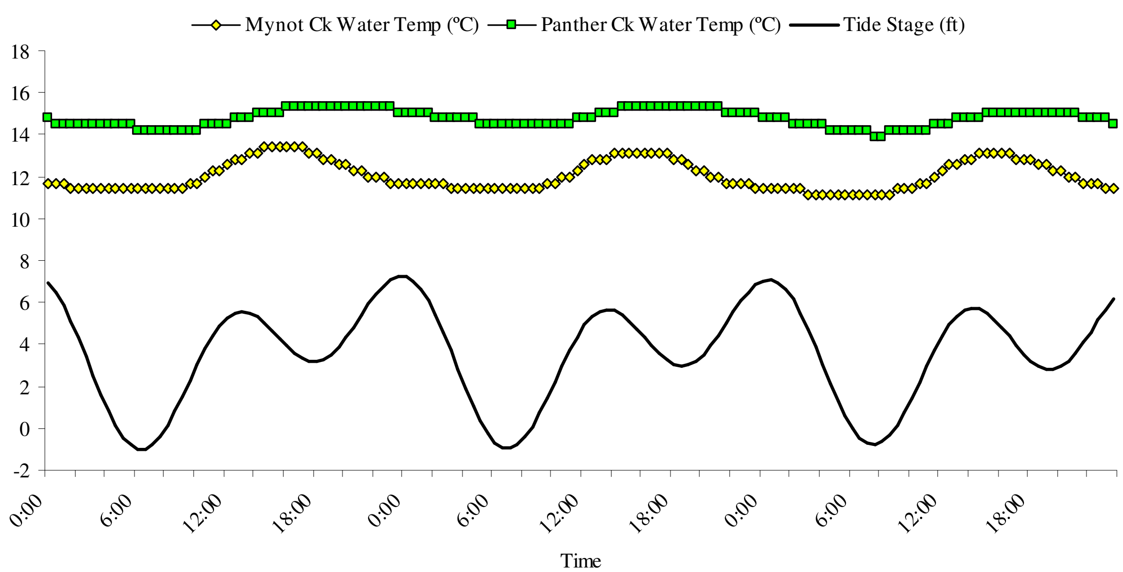


Figure 43. Water temperature recorded at several stations located in tributaries of the Klamath River estuary and predicted tide stage from the National Oceanic and Atmospheric Administration for Crescent City, California, for the period 24 – 26 July 2006.

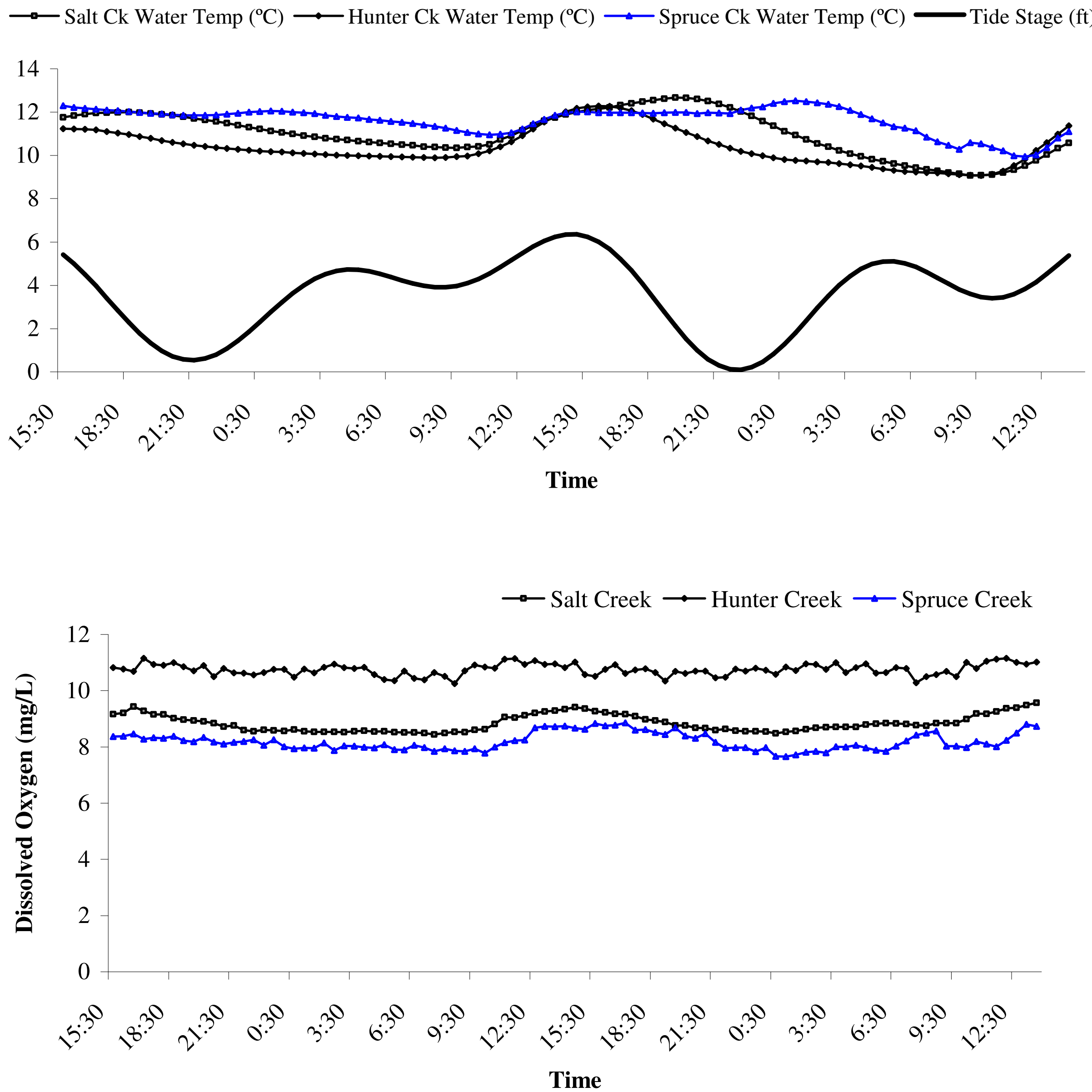


Figure 44. Water quality data measured at several stations located in tributaries of the Klamath River estuary and predicted tide stage from the National Oceanic and Atmospheric Administration for Crescent City, California (Monitoring period: 13 – 15 March 2007).

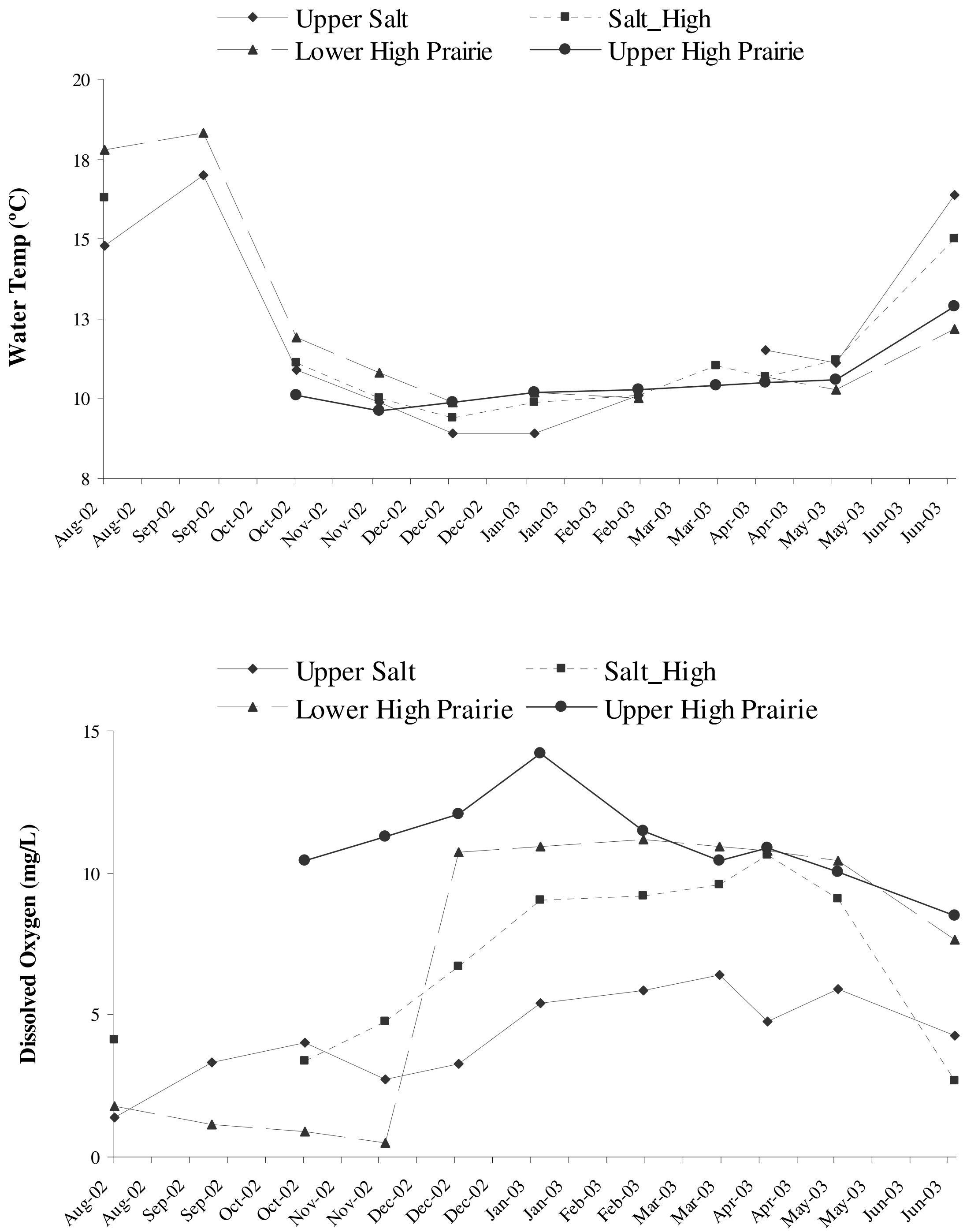
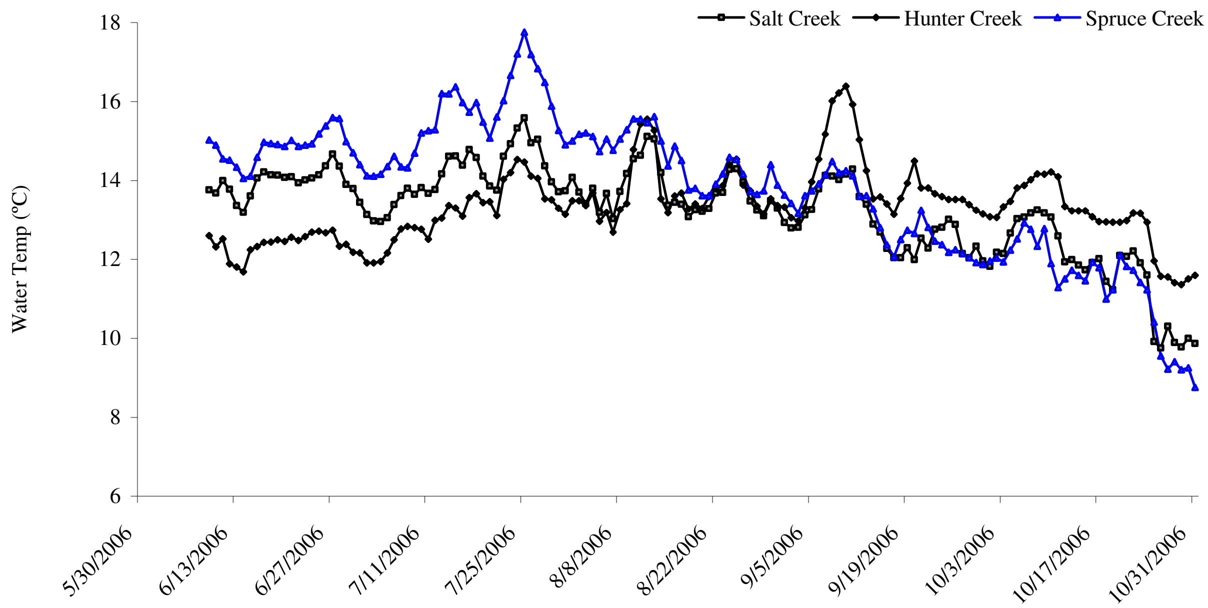


Figure 45. Water temperatures (Top) and dissolved oxygen (Bottom) measured at four monitoring locations in the Salt Creek watershed using a hand-held YSI Meter.



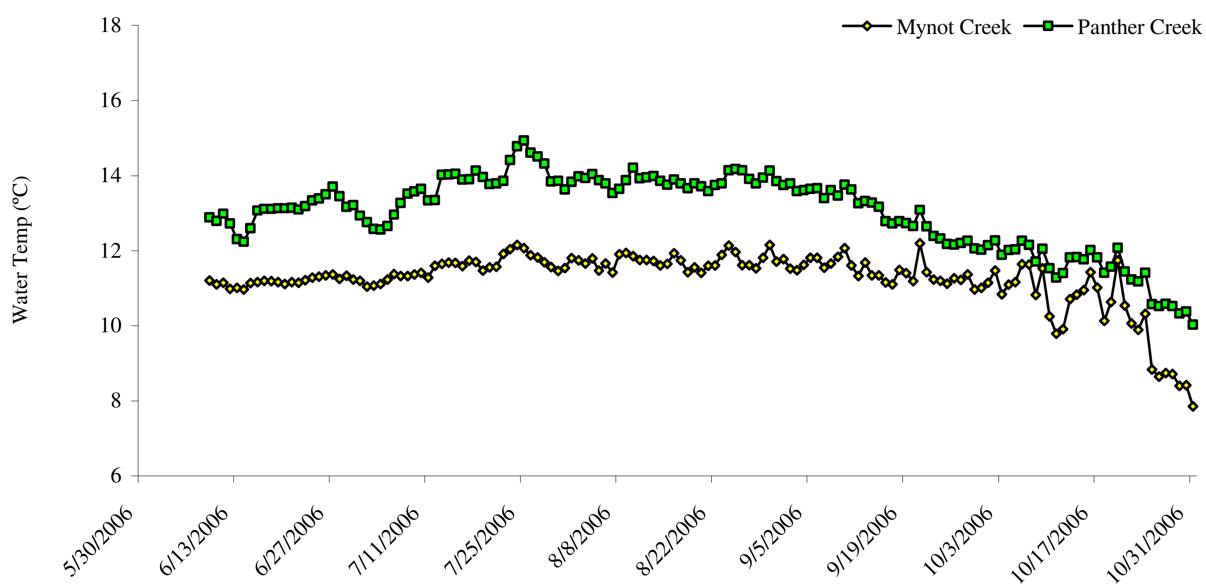
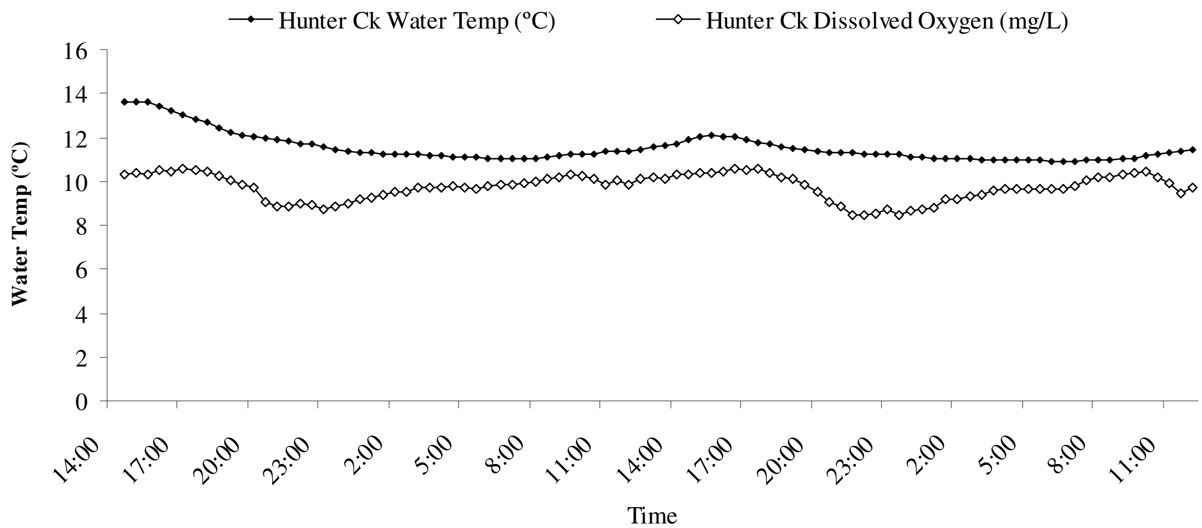


Figure 46. Daily mean water temperatures recorded at several stations located in tributaries of the Klamath River estuary, California.



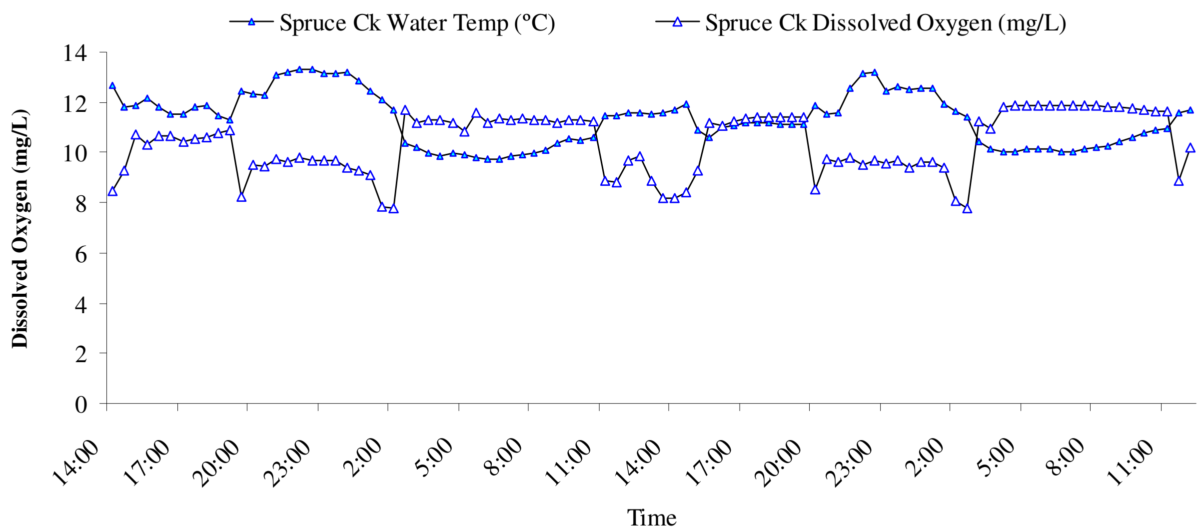
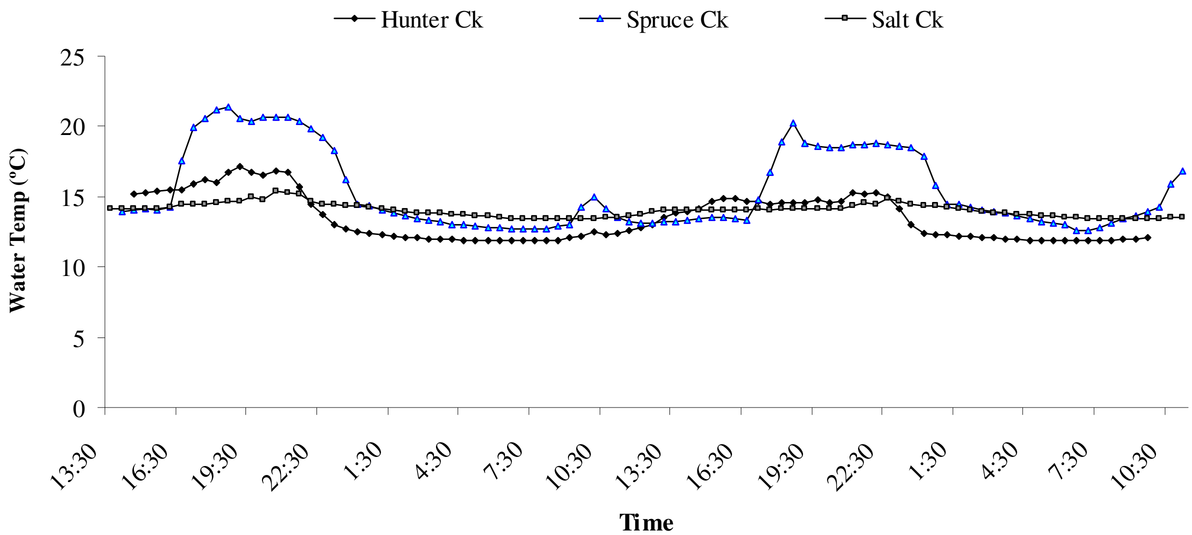


Figure 47. Water quality data measured at several stations located in tributaries of the Klamath River estuary, California (Monitoring period: 29 – 31 May, 2007).



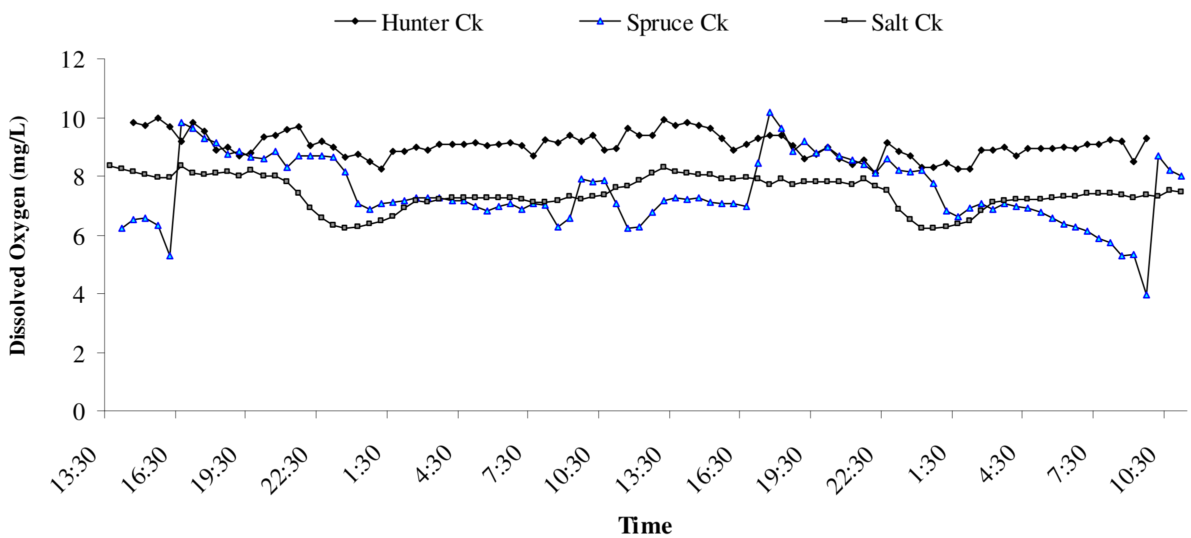


Figure 48. Water quality data measured at several stations located in tributaries of the Klamath River estuary, California (Monitoring period: 9 – 11 July, 2007).

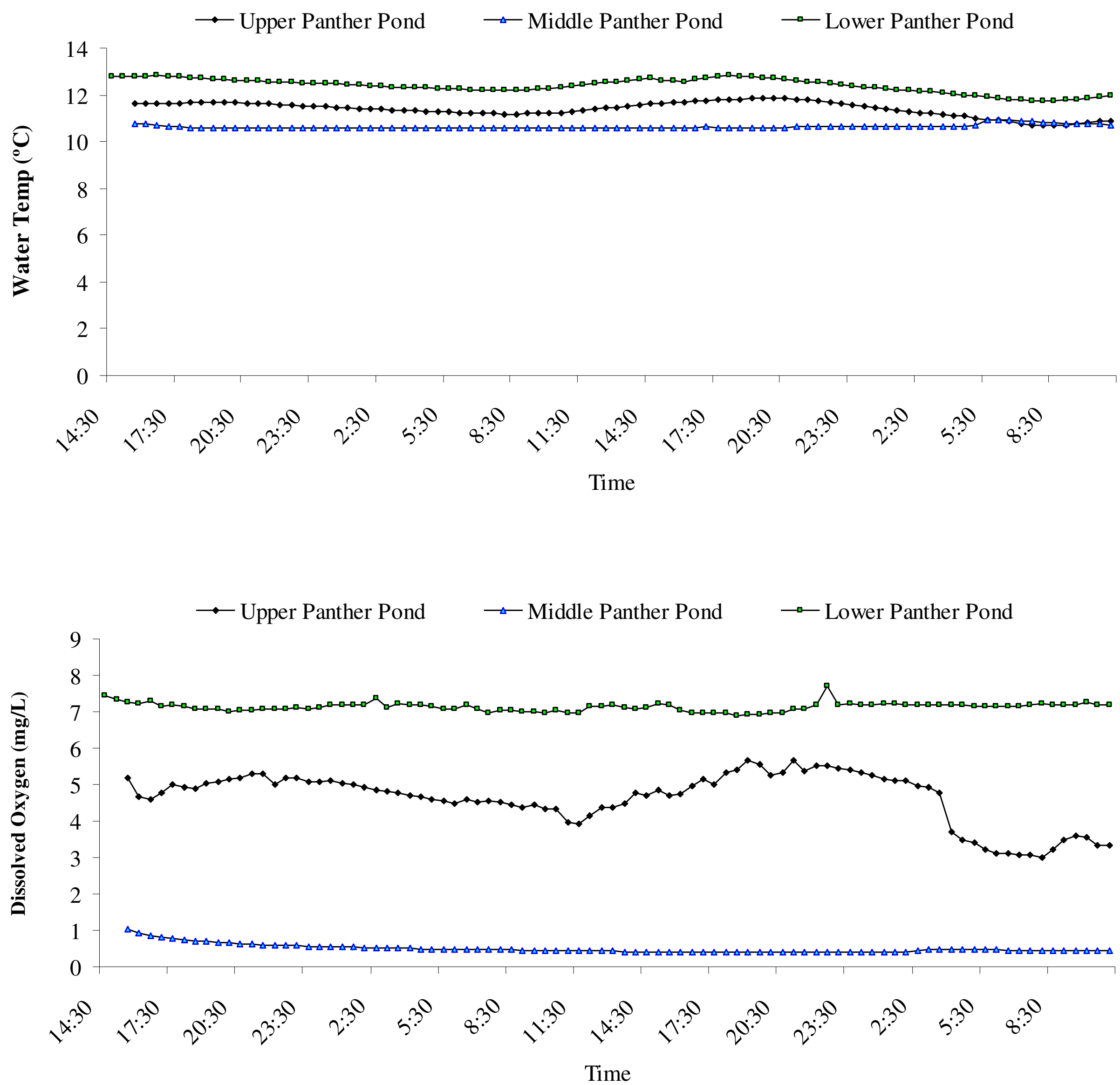
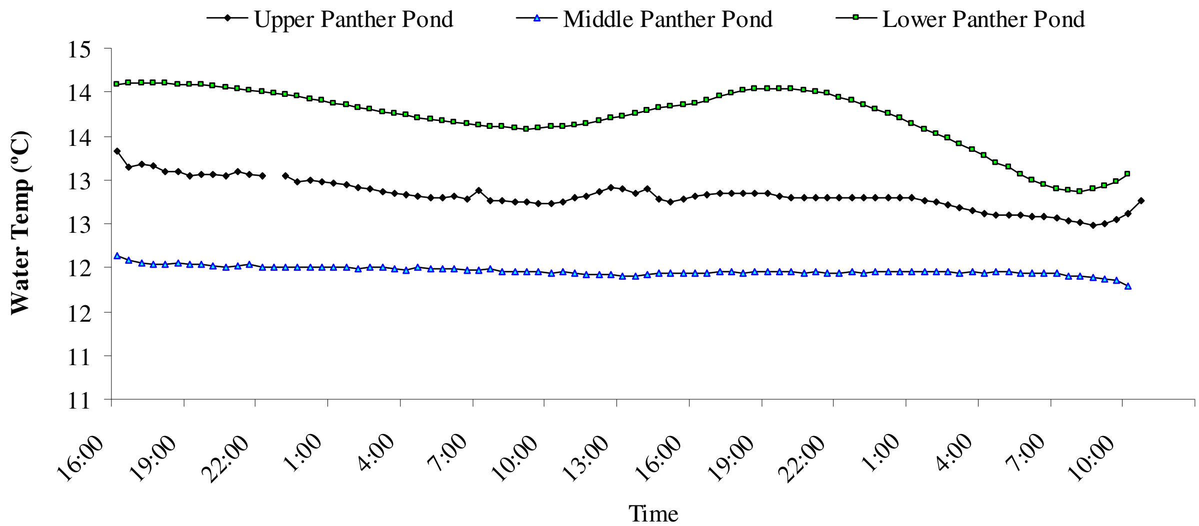


Figure 49. Water quality data measured at three stations located in Panther Creek Pond, Lower Klamath River, California (Monitoring period: 04 – 06 June, 2007).



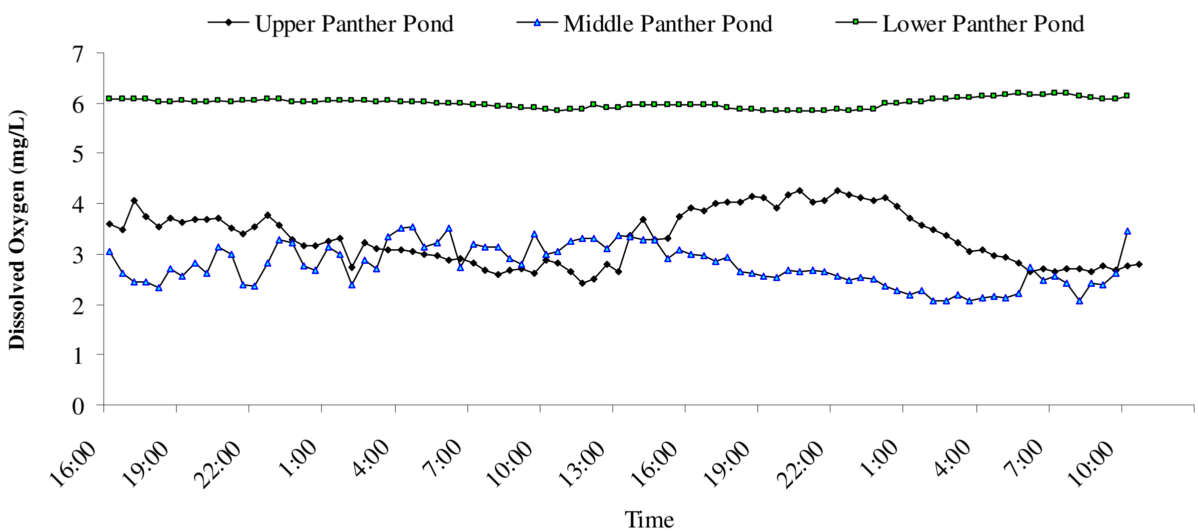


Figure 50. Water quality data measured at three stations located in Panther Creek Pond, Lower Klamath River, California (Monitoring period: 11 – 13 July, 2007).

This was the first time that YTFP monitored Spruce Creek water quality in the vicinity of the DN Highway 101 culvert. Hydrology and water quality at this site is most influenced by 1) tributary surface and ground water inputs, 2) beaver dams (impounding surface and ground water inputs), and 3) land use activities (i.e. removal and/or continued modification of existing beaver dams; colonization of the area by invasive plant species). The long-term monitoring site for Spruce Creek is located upstream of the confluence of Hunter Creek and the estuary; thus conditions at this site were more influenced by the river and tide cycles. Summer dissolved oxygen levels in the lower-most reach appear to be more favorable to juvenile coho and other salmonids (Figures 44 & 47-48) than the study area (Figure 15; Appendix C).

In 2007, three stations were monitored in Panther Pond rather than in the flowing reaches located downstream as was monitored previously. The stations were located upstream of the highway bridge, at the bridge, and near the pond's primary outlet. Water temperatures in June and July were fairly similar at the three sites with readings remaining well within tolerable levels for salmonids (Figures 49-50). Both water temperature and dissolved oxygen levels were the highest at the lower-most site in the pond. The upper two sites had the lowest water temperatures as well as the lowest dissolved oxygen levels in both June and July (Figures 49-50). Similar dissolved oxygen patterns were observed in Panther Pond in summer - fall 2009, with the highest levels occurring in the upper third of the water column and near the outlet (Figure 17).

Juvenile coho populations in Panther Pond went from 878 coho during peak residency in March to ~100 fish in June and July (Figures 13 & 28). Catches then dropped off significantly with no salmonids captured during August – October (Figure 13; Appendix A). Although salmonids were not captured from August – October, water quality data collected in Panther Pond suggests juvenile coho could likely find areas within the pond with adequate dissolved oxygen levels, even in late summer (Appendix C; Figures 49-50). Low and zero catches were likely a result of sampling limitations rather than fish not being present within the sampling area. For this study, traps were set along the pond's bottom where dissolved oxygen levels appeared to be the lowest.

YTFP investigations conducted over the last decade indicate that off-estuary habitats within the Salt-Hunter valley support native fish populations, including salmonids, year-round. We believe year-round survival in these habitats is possible due to the high quality ground and surface water inputs; and because native fish species are adapted to continuously seek out areas with sustainable levels of dissolved oxygen. The best supporting evidence of year-round residency of these habitats by juvenile salmonids was collected during mark-recapture surveys conducted during spring 2010. Although YTFP is still analyzing fyke trap data and PIT tag antenna data collected during winter – spring 2010; several coho and cutthroat that had a freeze brand and/or PIT tag applied during the KGR study in summer – fall 2009 were recaptured in Panther Creek and Salt Creek marsh during spring 2010 (Table 7; Figures 51-52). Recapture data collected in spring 2010 highlights the variability in rearing patterns expressed by Klamath Basin coho populations; and strongly suggests that off-estuary habitats such as Panther Pond, lower Hunter Creek, lower Spruce Creek, and Salt Creek provide critically valuable rearing habitat for natal and non-natal salmonids during the entire year not just during winter-spring.

Twenty-three coho captured in Panther Pond during the KGR study in summer 2009 were recently captured during mark-recapture surveys conducted in Panther Pond during spring 2010

Table 7. Mark-recapture data for salmonids using off-estuary habitats located on the north side of the Klamath River 2008-2010.

Species	Freeze Brand	Date Marked	Location	Fork Length (mm)	Weight (g)	Pit tag #	Date Marked	Location	Fork Length (mm)	Weight (g)	Recapture Date	Location	Fork Length (mm)	Weight (g)	applied Pit tag #	Scales (Y/N)
coho	RPH	8/11/09	Panther Pond								3/19/10	Panther Pond	151	42.4	985121016704868	Y
coho	LAH	7/9/09	Panther Pond								3/19/10	Panther Pond	167	49.9	985121016523602	Y
coho	LAH	7/9/09	Panther Pond	139	26.7	985121016416409	6/3/09	Panther Pond	138	27.1	3/26/10	Panther Pond	168	52.7		Y
coho	LAH	7/9/09	Panther Pond								3/26/10	Panther Pond	160	43.5	985121016705617	Y
coho	LAH	7/9/09	Panther Pond	128	20.0	985121016671003	1/15/09	Panther Ck.-u/s	86	6.5	3/26/10	Panther Pond	162	42.0		Y
coho	LPV-D	6/10/09	Spruce Creek	116	18.3	985121014807240	3/14/09	Panther Ck.-u/s	69	3.8	3/26/10	Panther Pond	156	41.4		Y
coho	LPH	5/26/09	Panther Pond			985121016219545	7/14/09	Panther Pond	129	21.5	3/26/10	Panther Pond	163	46.7		Y
coho	LPH	5/26/09	Panther Pond								3/26/10	Panther Pond	173	55.1	985121015717580	Y
coho	LPH	5/26/09	Panther Pond			985121016220411	7/14/09	Panther Pond	126	21.9	3/26/10	Panther Pond	162	46.5		Y
coho	LPH	5/26/09	Panther Pond			985121016503485	7/14/09	Panther Pond	144	33.0	3/26/10	Panther Pond	176	56.2		Y
coho	LPH	5/26/09	Panther Pond			985121016491085	7/14/09	Panther Pond	134	26.4	3/26/10	Panther Pond	165	46.4		Y
coho	LAH	7/9/09	Panther Pond								4/9/10	Panther Pond	175	54.7	985121016706442	Y
coho	LAH	7/9/09	Panther Pond			985121016501847	7/14/09	Panther Pond	129	21.8	4/9/10	Panther Pond	159	49.6		Y
coho	LAH	7/9/09	Panther Pond								4/9/10	Panther Pond	172	52.1	985121016498225	Y
coho	LAH	7/9/09	Panther Pond								4/9/10	Panther Pond	177	54.4	985121015686883	Y
coho	LAH	7/9/09	Panther Pond			985121016494561	7/14/09	Panther Pond	142	28.4	4/9/10	Panther Pond	179	57.5		Y
coho	LPH	5/26/09	Panther Pond								4/9/10	Panther Pond	151	37.1	985121015690451	Y
coho	LAH	7/9/09	Panther Pond			985121016506417	7/14/09	Panther Pond	135	24.3	4/9/10	Panther Pond	176	53.3		Y
coho	LPH	5/26/09	Panther Pond								4/9/10	Panther Pond	174	43.8	985121016219545	N
coho	LAH	7/9/09	Panther Pond								4/9/10	Panther Pond	160	41.6	985121015715298	Y
coho	LPH	5/26/09	Panther Pond	130	21.9	985121015330504	11/21/08	Panther Ck.-u/s	85	7.4	4/9/10	Panther Pond	158	38.4		Y
coho						985121016494801	7/14/09	Panther Pond	134	26.3	3/26/10	Panther Pond	168	52.4		N
coho						985121016483814	7/14/09	Panther Pond	123	24.0	3/26/10	Panther Pond	155	40.8		N
coho						985121014803682	1/15/09	Panther Ck.-u/s	86	6.5	3/26/10	Panther Pond	159	41.6		N
coho						985121016494801	7/14/2009	Panther Pond	134	26.3	3/30/10	Panther Ck.-d/s	168	50.5		Y
Cutthroat	LAH	7/9/09	Panther Pond			985120024722724	8/19/09	Panther Pond	196	71.7	3/19/10	Panther Pond	270	236.0		N
Cutthroat	LPH	5/26/09	Panther Pond								3/19/10	Panther Pond	235	137.4		N
Cutthroat	LPH	5/26/09	Panther Pond								3/19/10	Panther Pond	230	121.2		N
Cutthroat	RPH	8/11/09	Panther Pond								3/19/10	Panther Pond	258	169.6		N
Cutthroat	LPH	5/26/09	Panther Pond								3/19/10	Panther Pond	235	130.2		N
Cutthroat	LPH	5/26/09	Panther Pond								3/26/09	Panther Pond	228	123.5		N
Cutthroat	LPH	5/26/09	Panther Pond								3/26/09	Panther Pond	225	110.5		N
Steelhead	LPH	5/26/09	Panther Pond								3/26/09	Panther Pond	189	70.2		N
Cutthroat						985120024722285	7/14/09	Panther Pond	157	37.1	4/9/10	Panther Pond	240	135.0		N
Cutthroat	LAI	3/11/09	Panther Pond								3/18/10	Salt Ck marsh	262	195.0		N
Cutthroat	LPI	5/27/09	Salt Ck. Marsh								3/25/10	Salt Ck marsh	264	189.0		N
Cutthroat	LAT	2/5/09	Salt Ck. Marsh								4/1/10	Salt Ck marsh	196	78.3		N
Cutthroat						985121016512012	7/14/09	Panther Pond	178	57.6	5/3/10	Panther Ck.-u/s	265	166.0		N

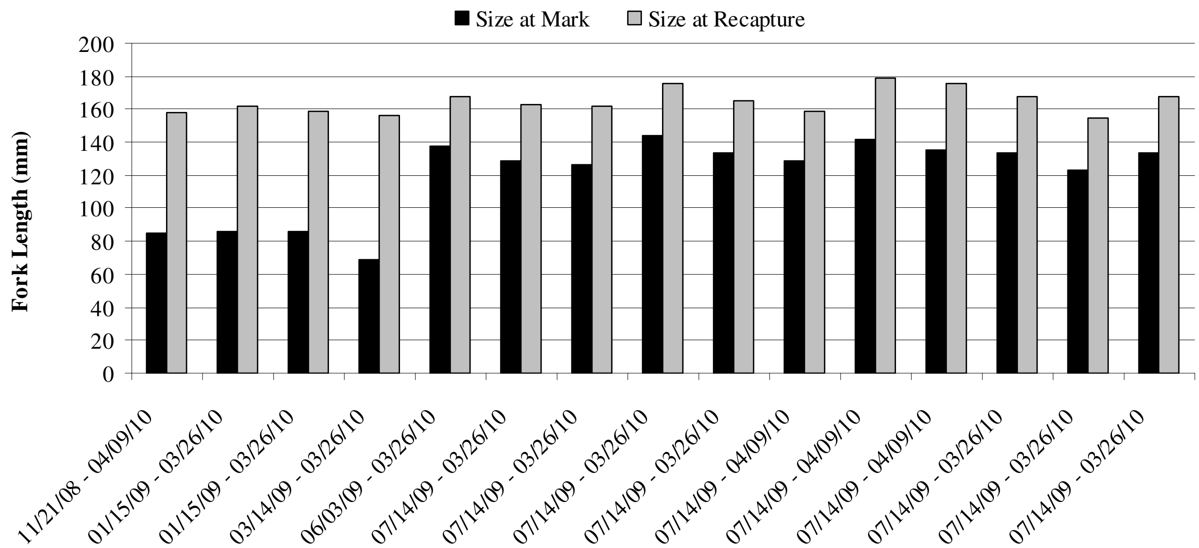


Figure 51. Fork length data collected for 15 juvenile coho salmon monitored in off-estuary habitats (Spruce and Panther Creeks) located on the north side of the Klamath River (Dates along the X axis are the date of the initial marking event and the date of recapture).

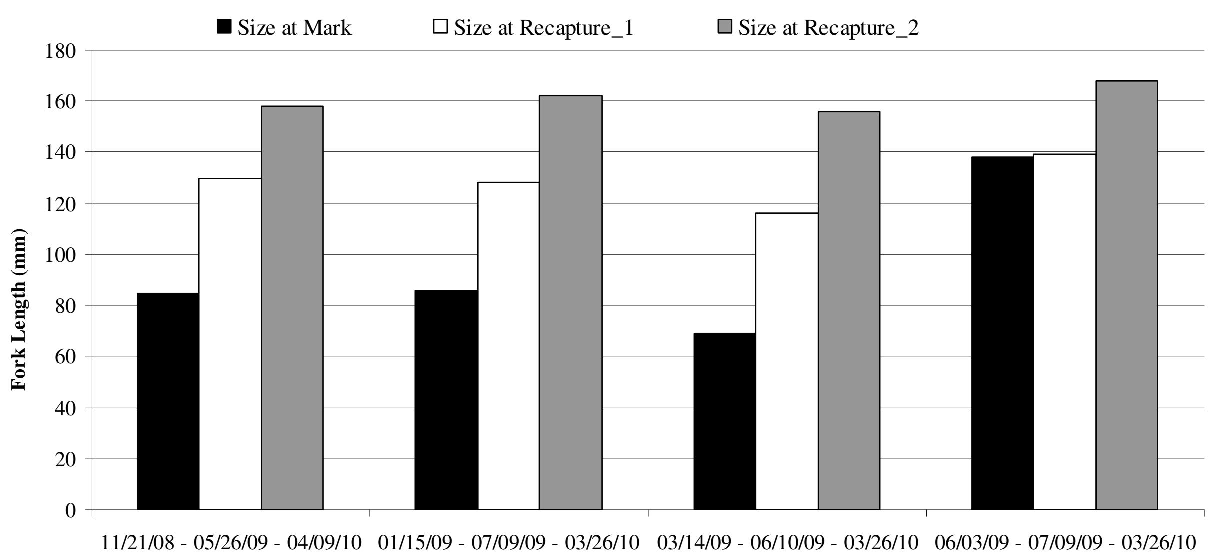


Figure 52. Fork length data collected on four juvenile coho salmon monitored in off-estuary habitats (Spruce and Panther Creeks) located on the north side of the Klamath River (Dates along the X axis are the date of the initial marking event followed by the two recapture dates).

(Table 7; Figure 51). Eight coho captured and freeze branded in Panther Pond on 05/26/09 were recaptured during trap sets in Panther Pond in Panther Pond in late March (n=5) and in early April (n=3), 2010 (Table 7; Figure 51). One of these fish was initially PIT tagged after being caught in the upstream migrant trap in Panther Creek in November 2008. Eleven coho marked (freeze band) in Panther Pond on 07/09/09 were recaptured in Panther Pond in late March (n=4) and in early April (n=7), 2010. Five of these fish also had PIT tags applied either before or during the KGR fish study. On 07/14/09, an additional three coho captured in Panther Pond were marked with PIT tags and subsequently recaptured in Panther Pond (n=2) and in the downstream migrant trap (n=1) in late March, 2010. One other coho marked (freeze band) in Panther Pond on 08/11/09 was recaptured on 03/10/10 in Panther Pond (Table 7; Figure 51).

Furthermore, several of the coho that held in Panther Pond exhibited a 2+ life history trait; not migrating to the ocean until at least their third spring in fresh water (i.e. brood year 2007 fish were captured in Panther Pond during the spring of 2010). The average size of coho recaptured in Panther Pond or Panther Creek during spring 2010 was 165 mm (range: 151-179 mm). As documented in the literature, this extremely large size results in relatively high survival rates to adult spawners; further indicating the importance of these habitats to Klamath Basin coho. Data collected from PIT tagged coho during these studies revealed that substantial growth of juvenile coho occurs in beaver influenced habitats during spring-summer (Figure 52).

Another interesting rearing pattern was observed by a coho that was captured in the upstream migrant trap in lower Panther Creek and PIT tagged on 03/14/09 (Table 7; Figures 51-52). This fish was later recaptured in Spruce Creek on 06/10/09 and a freeze brand was applied for the KGR study. At some point after the KGR study, this coho moved upstream into Panther Pond and was recaptured on 03/26/09 (Table 7; Figures 51-52). This PIT tagged coho was then detected moving downstream at the Panther Creek antenna arrays on 04/13/10 at 01:50 am.

In addition to coho, nine coastal cutthroat and one steelhead marked in Panther Pond in summer 2009 were also recaptured in Panther Pond or in the outmigrant trap during spring 2010 (Table 7). Two coastal cutthroat that were marked with freeze brands in Salt Creek marsh on 02/05/09 and on 05/27/09, were recaptured in Salt Creek marsh in late March – early April 2010. Two of the cutthroat captured in Panther Pond on 07/14/09 had PIT tags applied. During the time between capture events, one of the coastal cutthroat marked in February grew 83 mm in length by April 2010 and gained an additional 97.9 mg in body weight (Table 7). The other cutthroat trout marked in May 2009 in Panther Pond grew 87 mm in length and gained an additional 108.4 mg in body weight by March 2010 (Table 7).

For this and previous studies, water quality was measured at a single location or at a very limited number of sites within each sampling area. Most, if not all, of the pond sites studied (Spruce, Panther, Salt Creek marsh, Hunter Rd. wetland, and Arbor Glen wetland) are influenced and/or supplied with ground water (i.e. springs) and small surface water inputs that influence dissolved oxygen conditions to varying degrees. Based on the data collected in Panther Creek and Salt Creek marsh during spring 2010, off-estuary habitats of the Klamath River provide high quality rearing habitat to juvenile coho and other salmonids during both winter and summer (Table 7).

Recommendations

Based on the data collected during this study and other related investigations, YTFP recommends conducting more fish related studies within the proposed KGR project area; as well as expanding the studies into other off-estuary tributary habitats of the Klamath River. Future efforts should focus on generating population estimates for salmonids rearing during winter, spring, and summer in Spruce Creek and Panther Creek. If feasible, fish population surveys should also be conducted in other off-estuary tributaries such as Waukell Creek, Richardson Creek, Hoppaw Creek, Hunter Creek, Salt Creek, and the South Slough of the estuary (Figure 1). Presence-absence surveys in High Prairie Creek should be conducted regularly during summer months to document coho spawning activities in this priority watershed. In addition to these efforts, long-term operation of outmigrant traps in lower Salt Creek and Hunter Creek would greatly improve our knowledge of natal and non-natal population dynamics and seasonal use of target fish species within the proposed KGR Project area. However, the ability to fund such long-term fish monitoring efforts has and remains very difficult.

Most related to the proposed KGR Project would be continued population studies in Spruce Creek and Panther Pond. YTFP recommends conducting successive mark-recapture efforts at each site in February or March, during peak residency, to improve our understanding of Klamath coho brood year strength; as well as provide important information pertaining to use of coastal habitats by natal and non-natal coho salmon, cutthroat, and steelhead. Population estimates should be repeated in late May and June, when fish emigration slows down, to further assess summer rearing trends. Continued population studies in these areas would help to establish regional trends in Klamath Basin coho brood year strength; and greatly improve our understanding of non-natal rearing patterns occurring in off-estuary tributaries of the Klamath River. Understanding these trends is directly relevant to the proposed KGR and information gained would help determine when and how the proposed work should occur to best minimize impacts to ESA listed coho salmon and other Klamath Basin salmonid populations.

Although fyke trapping methods used during the KGR study appear sufficient for sampling salmonid populations in off-estuary habitats during winter-spring (peak residency); these methods do not appear effective during periods where dissolved oxygen is limited (summer-fall) (Figure 13; Appendices A-C). The other methods employed included seining in Spruce Creek and the use of baited minnow traps in Spruce Creek and in Hunter Rd. and Arbor Glen wetlands. Employing these alternative methods in late summer 2009 also did not result in the capture of any salmonids from these areas (Appendix B). More effective sampling methods will need to be developed to enumerate salmonid populations in these habitats during late summer – early fall. One alternative would be to install additional PIT tag antenna arrays in these habitats and to rely on recapture data collected at the antennas to assess fish populations during this critical period.

Along with additional fisheries studies, YTFP recommends conducting more intensive water quality studies within the proposed KGR project area, especially in Panther Pond and the Hunter Rd. wetland. Water quality and quantity in both of these areas are greatly influenced by ground water inputs. Future studies should employ the use of multiple sensors and depth integrated sampling techniques to allow for a better characterization of the range of water quality conditions occurring in these wetlands over the summer season. The bridge over Panther Creek is proposed for replacement as part of the KGR project; and the highway is scheduled to be widened in the vicinity of the Hunter Rd. wetland. Bridge replacement activities will likely result in the construction of an expansive network of temporary and permanent pilings within Panther Pond. At this time, short- and long-term impacts to the quality and quantity of ground water and spring inputs related to this type of construction scenario are unknown. As mentioned, year-round survival of fish in these areas likely depends on the quality and quantity of ground and surface water inputs. Therefore, in addition to more extensive water quality studies, YTFP recommends studies be developed and implemented that will improve our understanding of how the proposed KGR construction activities, especially bridge replacement at Panther Pond, will affect ground water and spring inputs on short- and longer-term timescales.

Highway widening activities will decrease the size of the Hunter Rd. wetland and likely impact the springs that feed this fragile wetland. Historic information suggests that Hunter Creek and this area were once connected to lower Salt Creek (Beesley and Fiori 2008). This wetland is likely a remnant channel segment that has persisted because of continuous ground water inputs. This study revealed that juvenile coho already use this wetland prior to ocean entry; and that protection and minimal restoration (i.e. enhancing the outlet draining to Salt Creek) would greatly enhance the function of this wetland and increase the amount of high quality winter-spring rearing habitat available for non-natal salmonids. Therefore, future off-estuary restoration efforts should include enhancing the outlet of the Hunter Rd. wetland to facilitate improved hydrologic and geomorphic function, and increase fish access to this valuable wetland. Once again, more intensive water quality and ground water studies should be conducted at this site.

Several priority areas within the proposed KGR project area were not sampled during this study due to a lack of landowner support. One of the areas not studied included the wetland complex located between Spruce and Mynot Creeks (Old Mynot wetlands) (Figure 1). These wetlands drain to lower Hunter Creek, just upstream from Spruce Creek and the confluence with the estuary. As is the case with most off-estuary wetlands of the Klamath River, this area has been severely degraded and simplified (Beesley and Fiori 2004 and 2008). Lower Hunter and Mynot Creeks are currently confined by levees that inhibit floodplain and wetland connectivity and thereby limit productivity and survival of Klamath Basin salmonids. Restoration focused on increasing hydrologic connectivity to the Old Mynot wetlands could dramatically increase the amount of quality rearing habitat available to non-natal salmonids, especially juvenile coho.

YTFP is currently working with the Yurok Tribe Environmental Program (YTEP) and other pertinent basin stakeholders to develop a prioritized restoration plan for the Klamath River estuary and its associated tributary, wetland, and slough habitats. For now YTFP is focusing on the Coho Ecology Study; as well as conducting and planning for future restoration in the Waukell Creek watershed and in Salt Creek in the vicinity of High Prairie Creek. Given the importance of the Salt-Hunter valley for Klamath Basin coho populations, YTFP strongly encourages managers to direct any wetland and fisheries mitigation that may result from KGR activities to habitats draining the north side of the Klamath River estuary. This approach would more directly address or help mitigate for impacts to aquatic resources resulting from the KGR project. YTFP and YTEP have considerable knowledge of the Klamath River estuary and its associated off-estuary habitats; therefore Caltrans and state/federal agencies should continue working closely with the Yurok Tribe to ensure that current and future land use activities will not result in excessive harm to ESA listed species, and other Tribal Trust fish and wildlife.

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Appendix A. Mark-recapture population estimates for Spruce Creek, Panther Creek Pond, and Salt Creek marsh, Lower Klamath River Sub-basin (summer – fall 2009).

Population Estimates

Location	Month (sampling dates)	Coho Salmon	95% Confidence Interval	Trout (Steelhead/ Cutthroat)	95% Confidence Interval	Gear	Comments:
Spruce Creek	June (6/10 & 6/17)	43	67 & 20	50	70 & 31	two fyke nets w/ wings	
	July (7/30 & 7/31)	0	N/A	0	N/A	River seine	water released from upper beaver pond prior to sampling effort
	August (8/19)	0	N/A	0	N/A	River seine, 2 minnow traps	minnow traps (baited) placed on east/west side of culvert to hwy 101
	September	N/A	N/A	N/A	N/A		all trapping efforts were halted due to poor water quality
	October	N/A	N/A	N/A	N/A		all trapping efforts were halted due to poor water quality
Panther Pond	June (5/26 & 6/4)	102	149 & 54	123	173 & 73	two fyke nets w/ lead & wings	
	July (7/9 & 7/15)	101	137 & 65	40	75 & 4	two fyke nets w/ lead & wings	
	August (8/11 & 8/19)	24	N/A	34	54 & 13	two fyke nets w/ lead & wings	No marked coho recaptures in second sampling effort
	September (9/1 & 9/2)	0	N/A	0	N/A	two fyke nets w/ lead & wings	no salmonids captured during trapping efforts
	October (9/29)	0	N/A	0	N/A	two fyke nets w/ lead & wings	no salmonids captured during trapping efforts
Salt Marsh	June (5/27 & 6/18-19)	10	19 & 1	135	245 & 25	two fyke nets w/ lead & wings	
	July (7/23 & 7/31)	5	7 & 2	53	85 & 21	two fyke nets w/ lead & wings	
	August	N/A	N/A	N/A	N/A	two fyke nets w/ lead & wings	First trapping effort had to many mortalities, seized trapping
	September	N/A	N/A	N/A	N/A		all trapping efforts were halted due to poor water quality
	October	N/A	N/A	N/A	N/A		all trapping efforts were halted due to poor water quality

Appendix B. Fish capture data collected in several off-estuary habitats of the Klamath River (2009).

Site	Date	# of traps	Coho 0+	Coho 1+	Steelhead 0+	Steelhead 1+	Cutthroat 0+	Cutthroat 1+	Other Species present:	Comments:
Spruce CK	6/10	2	3	13	3	0	1	24	Pacific Lamprey Ammo., Three Spine Stickleback, Prickly Sculpin, Speckled Dace, Sucker, Rough Skin Newt, NW Salamander, Golden Shiner, Green Sunfish	2 fyke nets (3ft X 4ft & 2ft X 3ft) w/ wings
Spruce CK	6/17	2	3	13	0	1	0	16	Pacific Lamprey Ammo., Three Spine Stickleback, P. Sculpin, S. Dace, Sucker, Rough Skin Newt, NW Salamander, Green Sunfish	2 fyke nets (3ft X 4ft & 2ft X 3ft) w/ wings
Spruce CK	7/30	1+	0	0	0	0	0	0	Three Spine Stickleback, Bullfrog-tadpole	4 sets w/ beach seine & fyke net (3ft X 4ft) w/ wings & block net
Spruce CK	7/31	1+	0	0	0	0	0	0	Three Spine Stickleback, NW Salamander-aquatic, Rough Skin Newt	4 sets w/ beach seine & fyke net/ 2 wings blocker (3ft X 4ft)
Spruce CK	8/19	2+	0	0	0	0	0	0	Three Spine Stickleback	2 baited minnow traps/salmon roe and 4 sets w/ seine & block net
Panther Ck. Pond	5/26	2	0	61	2	10	0	38	Pacific Lamprey Ammo., Three Spine Stickleback, Prickly Sculpin, Speckled Dace, Sucker, Rough Skin Newt, Green Sunfish, amphibian egg masses	2 fyke nets (3ft X 4ft) w/ lead and wings
Panther Ck. Pond	6/4	2	0	9	0	9	0	22	Three Spine Stickleback, P. Sculpin, S. Dace, Sucker, Rough Skin Newt, Pacific Giant Salamander, Unk. Tadpole, Amphibian egg masses	2 fyke nets (3ft X 4ft) w/ lead and wings
Panther Ck. Pond	7/9	2	0	41	1	1	0	5	Three Spine Stickleback, P. Sculpin, S. Dace, Sucker, Rough Skin Newt, N.W. Salamander-aquatic	2 fyke nets (3ft X 4ft) w/ lead and wings
Panther Ck. Pond	7/15	2	1	40	0	4	0	12	Pacific Lamprey Ammo., Three Spine Stickleback, P. Sculpin, S. Dace, Sucker, Rough Skin Newt, N.W. Salamander.-aquatic, Brown Bullhead	2 fyke nets (3ft X 4ft) w/ lead and wings
Panther Ck. Pond	8/11	2	1	7	0	2	0	12	Pacific Lamprey Ammo. 3S. Stickleback, P. Sculpin, S. Dace, Sucker, Rough Skin Newt, N.W. Salamander.-aquatic	2 fyke nets (3ft X 4ft) w/ lead and wings
Panther Ck. Pond	8/19	2	0	2	0	0	0	11	Pacific Lamprey Ammo., Three Spine Stickleback, P. Sculpin, S. Dace, Sucker, Rough Skin Newt, N.W. Salamander.-aquatic	2 fyke nets (3ft X 4ft) w/ lead and wings
Panther Ck. Pond	9/1	2	0	0	0	0	0	0	Three Spine Stickleback, P. Sculpin, S. Dace, Sucker, Rough Skin Newt, N.W. Salamander-aquatic	2 fyke nets (3ft X 4ft) w/ lead and wings
Panther Ck. Pond	9/2	2	0	0	0	0	0	0	Rough Skin Newt	2 fyke nets (3ft X 4ft) w/ lead and wings
Panther Ck. Pond	9/29	2	0	0	0	0	0	0	Three S. Stickleback, P. Sculpin, S. Dace, Sucker, Rough Skin Newt, N.W. Sal.-aquatic	2 fyke nets (3ft X 4ft) w/ lead and wings

Appendix B. Continued.

Site	Date	# of traps	Coho 0+	Coho 1+	Steelhead 0+	Steelhead 1+	Cutthroat 0+	Cutthroat 1+	Other Species present:	Comments:
Salt Ck. Marsh	5/27	2	0	6	1	5	0	12	Pacific Lamprey Ammo., Three Spine Stickleback, P. Sculpin, S. Dace, Sucker, Rough Skin Newt, Green Sunfish, amphibian egg masses	2 fyke nets (3ft X 4ft) w/ lead & wings
	6/18	1	0	0	0	0	1	12	Pacific Lamprey Ammo., Three Spine Stickleback, P. Sculpin, S. Dace, Sucker, N.W. Sal.-aquatic, amphibian egg masses	1 fyke net (3ft X 4ft) w/ lead & wings
	6/19	1	0	4	0	3	0	13	Pacific Lamprey Ammo., Three Spine Stickleback, P.Sculpin, S.Dace, Sucker, Rough Skin Newt, N.W.Sal.-aquatic, amphibian egg masses, Brown Bullhead	1 fyke net (3ft X 4ft) w/ lead & wings
	7/23	2	0	3	1	6	0	13	Pacific Lamprey Ammo., Three Spine Stickleback, P. Sculpin, S. Dace, Sucker, Rough Skin Newt, N.W. Salamander-aquatic	2 fyke nets (3ft X 4ft) w/ lead & wings
	7/31	2	0	2	1	3	0	7	Three Spine Stickleback, Prickly Sculpin, S. Dace, Sucker, Rough Skin Newt, N.W. Salamander-aquatic	2 fyke nets (3ft X 4ft) w/ lead & wings
	8/25	2	0	1	1	1	0	4	Pacific Lamprey Ammo., Three Spine Stickleback, Prickly Sculpin, Speckled Dace, Sucker, Rough Skin Newt, N.W. Salamander.-aquatic	2 fyke nets (3ft X 4ft) w/ lead & wings
Hunter Rd. Wetland	6/24	1	0	0	0	0	0	0	Three Spine Stickleback, NW Salamander-aquatic	Baited minnow trap w/ salmon roe
	7/30	1	0	0	0	0	0	4	Three Spine Stickleback	Baited minnow trap w/ salmon roe
	8/18	1	0	1	0	0	0	1	Three Spine Stickleback, Prickly Sculpin	Baited minnow trap w/ salmon roe
	9/2	1	0	0	0	0	0	0	Three Spine Stickleback, NW Salamander, P. Lamprey ammo.	Baited minnow trap w/ salmon roe
Arbor Glen Wetland	6/24	2	0	0	0	0	0	0	Three Spine Stickleback, NW Salamander-aquatic, Red Legged Frog-tadpole, Green Sunfish	Baited minnow trap w/ salmon roe
	7/29	2	0	0	0	0	0	0	Three Spine Stickleback	Baited minnow trap w/ salmon roe

Appendix C. Water quality data collected at several fish monitoring sites located in off-estuary habitats of the Klamath River during summer 2009.

Site/ Datasonde	Length of Record	Temperature (*C)			Specific Conductivity (uS/cm)			Dissolved Oxygen (mg/l)			PH	
	12:00p.m.- 12:00p.m.	avg.	low	high	avg	low	high	avg.	low	high	low	high
Spruce-east 101/ 40026	06/04-06/08/09	15.11	14.64	15.83	95.0	74.8	184.1	1.52	0.00	3.08	6.59	6.82
Spruce-west 101/ 38794	06/29-07/06/09	16.87	15.71	18.40	101.6	87.5	121.1	0.67	0.00	4.19	6.31	6.48
Spruce-west 101/ 38794	08/03-08/07/09	17.67	16.98	18.74	81.5	76.5	92.6	0.14	0.00	1.11	6.38	6.43
Spruce-east 101/ 40026	08/31-09/04/09	16.03	15.08	16.14	79.9	73.1	102.2	0.06	0.00	1.25	6.58	6.85
Spruce-west 101/ 38794	10/16-10/20/09	14.22	13.06	15.98	117.4	111.7	121.6	3.68	2.04	5.47	6.31	6.45
Panther - bridge/ 38793	06/04-06/08/09	15.10	14.64	15.83	98.5	74.8	182.7	1.53	0.00	3.08	6.69	6.82
Panther - outlet/ 38793	06/29-07/03/09	11.70	11.07	12.09	58.5	57.4	59.4	5.53	3.85	6.92	6.04	6.15
Panther - outlet/ 38793	08/03-08/07/09	12.95	12.56	13.41	61.0	59.9	61.9	3.42	1.77	4.98	6.10	6.14
Panther-east 101/ 38793	08/31-09/04/09	16.24	15.18	18.12	67.1	64.0	71.1	3.38	1.40	5.99	6.17	6.42
Panther - outlet/ 38793	10/09-10/14/09	11.53	11.00	12.28	63.9	61.3	67.3	2.33	0.32	5.57	6.44	6.59
Panther-bridge/top/ 38794	10/09-10/14/09	11.97	11.19	13.34	65.2	63.4	67.5	4.82	2.96	6.97	6.73	6.89
Panther -bridge/bot./ 40026	10/09-10/14/09	10.98	10.92	11.06	67.5	66.7	69.2	0.55	0.01	1.85	6.48	6.58
Salt-upper marsh/ 38794	06/04-06/08/09	11.00	10.32	11.99	69.1	67.6	71.2	6.73	5.68	8.63	6.37	6.53
Salt-lower marsh/ 38794	07/16-07/21/09	14.51	14.19	14.72	73.1	71.8	74.5	3.00	1.06	3.94	6.21	6.32
Salt- mid marsh/ 38794	08/18-08/24/09	12.92	12.62	13.39	72.7	70.5	77.3	2.40	0.00	7.08	6.23	6.37
Salt-upper marsh/ 38794	08/31-09/04/09	11.30	11.00	11.51	74.3	70.5	81.1	0.37	0.00	3.43	6.13	6.39
Salt-upper marsh/ 38793	10/16-10/21/09	10.90	10.08	11.58	85.6	76.6	97.9	2.70	1.09	4.15	5.90	6.06
Salt-lower marsh/ 40026	10/16-10/21/09	11.96	11.13	12.39	100.8	88.7	122.8	0.54	0.01	1.61	6.27	6.38
Hunter Rd. wetland/ 40026	06/24-06/29/09	10.83	10.61	11.02	62.9	62.3	64.5	5.56	4.07	6.36	6.91	7.05
Hunter Rd. wetland/ 40026	07/16-07/21/09	10.92	10.83	11.00	63.1	62.1	66.2	4.17	2.33	5.87	6.71	6.82
Hunter Rd. wetland/ 40026	08/18-08/24/09	11.24	11.02	11.59	66.2	64.1	69.2	0.51	0.01	2.01	6.77	6.87
Hunter Rd. wetland/ 40026	09/08-09/11/09	11.95	11.71	12.24	91.6	81.3	97.7	0.01	0.01	0.06	6.66	6.71
Hunter Rd. wetland/ 38794	10/22-10/26/09	11.13	10.97	11.28	115.8	103.7	122.3	0.00	0.00	0.02	6.27	6.36

Appendix C. Continued.

Site/ Datasonde	Length of Record	Temperature (*C)			Specific Conductivity (uS/cm)			Dissolved Oxygen (mg/l)			PH	
	12:00p.m.- 12:00p.m.	avg.	low	high	avg	low	high	avg.	low	high	low	high
Arborglen-east101/ 38794	06/24-06/29/09	14.16	13.98	14.46	80.6	76.7	82.8	0.00	0.00	0.01	6.09	6.14
Arborglen-west101/ 38793	06/24-06/29/09	13.07	12.35	13.85	92.8	84.4	114.3	0.11	0.00	0.62	6.26	6.52
Arborglen-west101/ 38793	07/16-07/21/09	13.33	13.11	13.48	137.9	107.4	151.7	0.00	0.00	0.00	6.24	6.51
Arborglen-west101/ 38793	08/18-08/24/09	13.03	11.68	14.20	93.0	86.6	101.3	0.08	0.00	1.07	6.27	6.43
Arborglen-west101/ 38793	09/08-09/11/09	12.26	11.32	13.20	127.3	121.4	134.4	0.03	0.00	0.58	6.42	6.63
Arborglen-west101/ 38793	10/22-10/26/09	11.43	10.09	12.00	185.1	122.6	244.0	0.00	0.00	0.01	6.20	6.39
Hunter Ck-bridge/ 40026	06/29-07/06/09	10.91	10.24	12.00	58.7	58.2	60.2	8.15	4.85	10.28	7.03	7.29
Hunter Ck-bridge/ 40026	08/03-08/07/09	11.15	10.84	11.69	59.4	59.0	59.9	9.16	7.77	10.59	6.97	7.07
Hunter Ck-bridge/ 38794	09/08-09/11/09	11.53	10.89	12.27	59.9	59.4	60.6	7.70	6.07	8.95	6.41	6.5
Hunter Ck-bridge/ 40026	10/22-10/26/09	11.14	10.45	11.65	61.3	60.7	61.9	5.33	2.63	7.13	6.51	6.69

Appendix D. Habitat units mapped on 05/12/09 in a survey reach located in lower Hunter Creek.

Habitat Type*	Unit Length*	Wetted Width			Maximum
		Bottom	Middle	Top	Water Depth
1. Shallow Pool	67	32	36	29	4.1
2. Riffle-low gradient	240	37	46	26	1.7
3. Shallow Pool	148	28	30	36	2.7
4. Shallow Pool	116	45	32	35	4.3
5. Shallow Pool	86	46	28	23	4.0
DN Highway 101 Bridge					
6. Shallow Pool	137	35	24	23	3.0
7. Shallow Pool	63	43	40	32	3.0
8. Shallow Pool	132	37	47	40	4.4
9. Shallow Pool	74	30	31	27	2.7
10. Shallow Pool	98	30	39	29	4.3
11. Shallow Pool	108	31	27	31	3.6

*Units are numbered from upstream to downstream - #1 is the most upstream unit in the reach.

*Measurements taken are in 10th of feet

*Riffles developed between pool units 6 & 7, and 10 & 11 as summer base flows receded.

Appendix E. Snorkel inventory data collected in a survey reach (387 meter) located in lower Hunter Creek during summer – fall 2009.

Hunter Creek Snorkel Inventories- Klamath Grade Raise Project 2009
Coho and Chinook are considered age 0+ (YOY), steelhead and cutthroat are ≥1+ (parr).

Date	Diver	Weather	Water vis.	Discharge	Water temp(F)	Air temp(F)
5/13/09	SS/AA	cloudy-2	2	1	54	50

Unit #	Hab. Type	species	count	Comments: Dive upstream to downstream- discharge high 2 diver/unit
9	SP (Rb)	SH	2	
8	SP/run	SH	6	
7	SP	SH	17	15-1+ / 2-2+ age class
		CO	1	Presmolt
		B.Lamprey	2	
6	SP	SH	8	
5	SP	SH	9	Bridge unit
4	SP	SH	9	unit above bridge
3	SP	SH	30	24-1+ / 6-2+ age class
		CO	1	
2	SP	SH	24	21-1+ / 3-2+ age class
		CT	2	
		CO	1	Presmolt
1	SP	SH	1	

Date	Diver	Weather	Water vis.	Discharge	Water temp(F)	Air temp(F)
6/24/09	SS/AA	sunny-3	3	3	54	61

Unit #	Hab. Type	species	count	Comments: Dive downstream to upstream 2 diver/unit
1	SP	SH	24	4-1+ / 20-2+ age class
2	SP	SH	9	5-1+ / 5-2+ age class
3	SP	SH	15	8-1+ / 7-2+ age class
		CO	1	Presmolt
4	SP	SH	3	3-1+ age class
		CO	1	
5	SP	SH	14	7-1+ / 7-2+ age class
		CT	1	age 2+
6	SP	SH	21	8-1+ / 13-2+ age class
7	SP	SH	23	18-1+ / 5-2+ age class
		CO	1	yoy
8	SP	SH	6	
9	SP	SH	20	15-1+ / 5-2+ age class

Appendix E. Continued.

Date	Diver	Weather	Water vis.	Discharge	Water temp(F)	Air temp(F)
7/29/09	SS/AA	Clear-3	3	3	54	65

Unit #	Hab. Type	species	count	Comments: Dive downstream to upstream 2 diver/ unit
1	SP (Lb)	SH 0+	5	
		SH 1+	28	
		CO 0+	1	
2	Riffle			no dive
3	SP (Lb)	SH 0+	10	
		SH 1+	18	
		CHnk	2	
4	SP (Rb)	SH 0+	2	
		SH 1+	15	
5	SP (Rb)	SH 1+	7	
6	SP	SH 0+	1	Bridge unit
		SH 1+	12	
7	Riffle			no dive
8	SP (Lb)	SH 1+	10	
9	SP (Lb)	SH 0+	5	
		SH 1+	28	
		CO 0+	1	
		CT 2+	2	
10	SP (Lb)	SH 1+	6	
11	Riffle			no dive
12	SP (Rb)	SH 0+	3	
		SH 1+	28	

Date	Diver	Weather	Water vis.	Discharge	Water temp(F)	Air temp(F)
8/25/09	SS/AA	Clear- 3	3	3	56	66

Unit #	Hab. Type	species	count	Comments: Dive downstream to upstream 1 diver/ unit
1	SP (Lb)	SH 0+	10	
		SH 1+	35	
		CO 0+	1	
2	Riffle			no dive
3	SP (Lb)	SH 0+	10	
		SH 1+	5	
4	SP (Rb)	SH 0+	8	
		SH 1+	2	
5	SP (Rb)	SH 0+	1	
		SH 1+	4	
6	SP	SH 0+	5	Bridge unit
		SH 1+	7	

Appendix E. Continued.

Date	Diver	Weather	Water vis.	Discharge	Water temp(F)	Air temp(F)
8/25/09	SS/AA	Clear- 3	3	3	56	66

Unit #	Hab. Type	species	count	Comments: Dive downstream to upstream 1 diver/ unit
7	Riffle			no dive
8	SP (Lb)	SH 0+	1	
		SH 1+	5	
9	SP (Lb)	SH 0+	7	
		SH 1+	18	
		CT 2+	1	
10	SP (Lb)	SH 1+	2	
11	Riffle			no dive
12	SP (Rb)	SH 0+	3	
		SH 1+	18	

Date	Diver	Weather	Water vis.	Discharge	Water temp(F)	Air temp(F)
9/30/09	SS/WM	Clear- 3	3	4	56	56

Unit #	Hab. Type	species	count	Comments: Dive downstream to upstream 1 diver/unit
1	SP (Lb)	SH 0+	5	
		SH 1+	35	
		CO 0+	1	
2	Riffle			no dive
3	SP (Lb)	SH 0+	1	
		SH 1+	4	
4	SP (Rb)	SH 0+	1	
		SH 1+	11	
5	SP (Rb)	SH 0+	1	
		SH 1+	6	
		CO 0+	1	
6	SP	SH 0+	8	Bridge unit
		SH 1+	14	
7	Riffle			no dive
8	SP (Lb)	SH 0+	1	
		SH 1+	10	
9	SP (Lb)	SH 0+	12	
		SH 1+	6	
10	SP (Lb)	SH 1+	1	
11	Riffle			no dive

Appendix E. Continued.

Date	Diver	Weather	Water vis.	Discharge	Water temp(F)	Air temp(F)
9/30/09	SS/WM	Clear- 3	3	4	56	56
Unit #	Hab. Type	species	count	Comments: Dive downstream to upstream 1 diver/unit		
12	SP (Rb)	SH 0+	18			
		SH 1+	10			

Weather:	1=Poor	Water Visibility:	1=Poor	Discharge:	1=Poor
	2=Fair		2=Fair		2=Fair
	3=Good		3=Good		3=Good
	4=Excellent		4=Excellent		4=Excellent

note: Weather rating is based on how diver think the weather is effecting their ability to see fish

Discharge rating is based on how diver thinks the flow effects their ability to see fish

Divers: SS=Scott Silloway-YTFP biologist 1

AA=Andrew Antonetti-YTFP biologist 1

WM=William Mitchell-Jones & Stokes fish biologist

Appendix F. Listing of the recapture incidents for the 48 fish tagged in the Mid Klamath study area and subsequently recaptured at sites within the Lower Klamath study area between May 2007 and May 2008. Table is continued onto multiple pages.

Tagging site	Date tagged	Tag code	Tagging length (mm)	Recap incident	Date recap	Recap site	Recap length (mm)
Aikens Cr	10-Sep-07	487770564A	81	1	29-May-08	Panther Cr	115
Aikens Cr	10-Sep-07	487770564A	81	2	30-May-08	Panther Cr	116
Aikens Cr	17-Sep-07	48762E4358	75	1	07-Dec-07	Jr Pond Cr	83
Aikens Cr	17-Sep-07	48762E4358	75	2	04-Apr-08	Jr Pond	105
Aikens Cr	17-Sep-07	48762E4358	75	3	11-May-08	Jr Pond Cr	128
Aikens Cr	17-Sep-07	48762E4358	75	4	20-May-08	Jr Pond Cr	130
Aikens Cr	17-Sep-07	48762E4358	75	5	27-May-08	Waukell Cr	130
Aikens Cr	17-Sep-07	48780F6C32	68	1	10-May-08	Jr Pond Cr	127
Aikens Cr	17-Sep-07	48780F6C32	68	2	04-Jun-08	Jr Pond	145
Aikens Cr	05-Dec-07	486A646E05	89	1	16-Jan-08	Jr Pond Cr	92
Big Bar (KR)	08-Nov-07	486A37282C	82	1	04-Jun-08	Jr Pond	141
Big Bar (KR)	05-Dec-07	48767C3F6A	90	1	20-Jun-08	Salt Cr	131
Big Bar (KR)	11-Dec-07	4877063829	94	1	21-Dec-07	Jr Pond Cr	93
Big Bar (KR)	18-Dec-07	486A7A5274	99	1	04-May-08	McGarvey Cr	106
Camp Cr	21-Aug-07	4875204C3C	85	1	16-Apr-08	Jr Pond Cr	125
Camp Cr	21-Aug-07	4875204C3C	85	2	17-Apr-08	Jr Pond Cr	124
Camp Cr	21-Aug-07	4875377620	69	1	22-May-08	Salt Cr	131
Camp Cr	28-Aug-07	470457056D	73	1	02-Apr-08	Waukell Cr	97
Camp Cr	28-Aug-07	470457056D	73	2	03-Apr-08	Waukell Cr	98
China Cr	14-Aug-07	134427450A	68	1	02-Jan-08	Jr Pond Cr	92
China Cr	14-Aug-07	134427450A	68	2	10-Jun-08	Jr Pond	145
China Cr	14-Aug-07	134427450A	68	3	12-Jun-08	Waukell Cr	145
China Cr	14-Aug-07	134427450A	68	4	13-Jun-08	Waukell Cr	145
China Cr	14-Aug-07	134427450A	68	5	25-Jun-08	Waukell Cr	146
China Cr	27-Aug-07	48757D7671	73	1	30-Mar-08	Jr Pond Cr	118
China Cr	27-Aug-07	48780A712B	65	1	20-May-08	Salt Cr	105
Dillon Cr	05-Oct-07	486B121919	75	1	29-Apr-08	Waukell Cr	117
Dillon Cr	05-Oct-07	487674454B	85	1	08-May-08	Jr Pond Cr	125
Dillon Cr	05-Oct-07	487674454B	85	2	24-May-08	Waukell Cr	125
Dillon Cr	05-Oct-07	48777D6B07	81	1	18-Apr-08	Jr Pond Cr	118
Fort Goff Cr	18-Sep-07	4708010373	82	1	10-May-08	Salt Cr	140
Indepen. Cr	03-Jul-07	133531393A	68	1	25-May-08	Jr Pond Cr	135
Indepen. Cr	03-Jul-07	133531393A	68	2	27-May-08	Jr Pond Cr	134
Indepen. Cr	03-Jul-07	133531393A	68	3	05-Jun-08	Waukell Cr	136
Indepen. Cr	10-Jul-07	134659450A	71	1	04-Jun-08	Jr Pond	158
Indepen. Cr	18-Jul-07	133568477A	66	1	21-Apr-08	Waukell Cr	120

Tagging site	Date tagged	Tag code	Tagging length (mm)	Recap incident	Date recap	Recap site	Recap length (mm)
Indepen. Cr	18-Jul-07	133636144A	77	1	06-May-08	Jr Pond Cr	126
Indepen. Cr	18-Jul-07	133636144A	77	2	05-Jun-08	Jr Pond	142
Indepen. Cr	12-Sep-07	486A404241	83	1	27-May-08	McGarvey Cr	130
Indepen. Cr	12-Sep-07	486A687452	73	1	08-May-08	Jr Pond Cr	125
Indepen. Cr	12-Sep-07	486B111A7D	74	1	15-Jun-08	Waukell Cr	139
Indepen. Cr	12-Sep-07	4875192A50	80	1	17-Apr-08	Salt Cr	110
Indepen. Cr	12-Sep-07	48752E134C	88	1	08-Nov-07	McGarvey Cr	90
Indepen. Cr	12-Sep-07	4875341841	86	1	16-May-08	Waukell Cr	106
Indepen. Cr	12-Sep-07	487545123D	78	1	18-Apr-08	Jr Pond Cr	118
Indepen. Cr	12-Sep-07	487545123D	78	2	01-May-08	Jr Pond	118
Indepen. Cr	12-Sep-07	487545123D	78	3	03-Jun-08	Jr Pond	138
Indepen. Cr	12-Sep-07	4876751827	78	1	16-May-08	Waukell Cr	112
Indepen. Cr	12-Sep-07	48770C3752	69	1	26-Dec-07	Jr Pond Cr	80
Indepen. Cr	12-Sep-07	48770C3752	69	2	19-Feb-08	Jr Pond Cr	78
Indepen. Cr	26-Sep-07	487629780B	73	1	07-Jun-08	Waukell Cr	114
Indepen. Cr	26-Sep-07	487629780B	73	2	08-Jun-08	Waukell Cr	114
Indepen. Cr	26-Sep-07	487629780B	73	3	16-Jun-08	Waukell Cr	114
Indepen. Cr	26-Sep-07	487629780B	73	4	24-Jun-08	Waukell Cr	114
Indepen. Cr	26-Sep-07	487629780B	73	5	25-Jun-08	Waukell Cr	114
Indepen. Cr	26-Sep-07	4878062F1F	73	1	09-Jun-08	Waukell Cr	119
Indepen. Cr	26-Sep-07	4878062F1F	73	2	10-Jun-08	Waukell Cr	121
Indepen. Cr	26-Sep-07	4878062F1F	73	3	24-Jun-08	Waukell Cr	121
Indepen. Cr	12-Oct-07	486A2F6511	77	1	16-Jan-08	Jr Pond Cr	88
Indepen. Cr	12-Oct-07	486A2F6511	77	2	16-Apr-08	Jr Pond Cr	127
Indepen. Cr	12-Oct-07	486A2F6511	77	3	17-Apr-08	Jr Pond Cr	125
Indepen. Cr	12-Oct-07	486B0A674E	78	1	11-Jan-08	Jr Pond Cr	83
Indepen. Cr	12-Oct-07	486B0A674E	78	2	24-May-08	Jr Pond Cr	139
Indepen. Cr	12-Oct-07	486B12741C	78	1	17-Jan-08	Jr Pond Cr	95
Indepen. Cr	12-Oct-07	486B12741C	78	2	04-Apr-08	Jr Pond	108
Indepen. Cr	12-Oct-07	486B12741C	78	3	06-May-08	Jr Pond Cr	124
Indepen. Cr	12-Oct-07	486B12741C	78	4	08-May-08	Jr Pond Cr	122
Indepen. Cr	12-Oct-07	4876335408	74	1	05-May-08	Jr Pond Cr	128
Indepen. Cr	27-Nov-07	4875305F39	77	1	13-Apr-08	Jr Pond Cr	125
Indepen. Cr	27-Nov-07	48762F4B0A	87	1	21-May-08	Jr Pond Cr	143
Indepen. Cr	27-Nov-07	48762F4B0A	87	2	27-May-08	Waukell Cr	143
Indepen. Cr	27-Nov-07	487744063A	72	1	29-Dec-07	Jr Pond Cr	78
Sandy Bar Cr	27-Dec-07	486A694102	102	1	23-May-08	Jr Pond Cr	141
Sandy Bar Cr	29-Dec-07	4877257834	93	1	07-May-08	Waukell Cr	108
Sandy Bar Cr	02-Jan-08	48765C4F79	113	1	20-Apr-08	Waukell Cr	117
Stanshaw Cr	18-Dec-07	486A652E68	102	1	07-May-08	Jr Pond Cr	123

Tagging site	Date tagged	Tag code	Tagging length (mm)	Recap incident	Date recap	Recap site	Recap length (mm)
Stanshaw Cr	18-Dec-07	486A652E68	102	2	19-May-08	Jr Pond Cr	122
Stanshaw Cr	18-Dec-07	486A652E68	102	3	24-May-08	Waukell Cr	121
Stanshaw Cr	18-Dec-07	4876316C54	100	1	14-Apr-08	Jr Pond Cr	115
Stanshaw Cr	04-Jan-08	48746D1D52	96	1	16-May-08	Waukell Cr	127
Thomp. Cr	04-Sep-07	4877797862	70	1	21-May-08	Waukell Cr	110