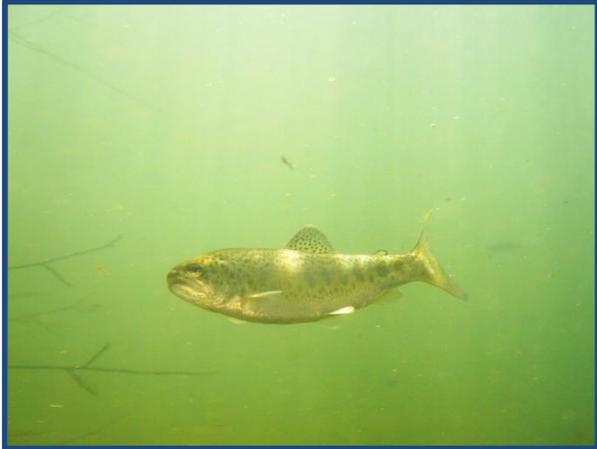
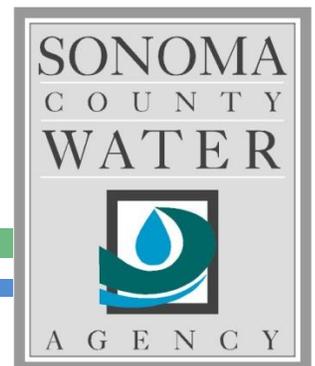


Russian River Biological Opinion Status and Data Report Year 2011-12



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1: Introduction

On September 24, 2008 the National Marine Fisheries Service (NMFS) issued a 15 year Biological Opinion for water Supply, flood control operations, and channel maintenance conducted by the U.S. Army Corps of Engineers (USACE), Sonoma County Water Agency (Water Agency), and Mendocino County Russian River Flood Control and Water Conservation Improvement District in the Russian River watershed (NMFS 2008). The Biological Opinion authorizes incidental take of threatened and endangered Chinook salmon, coho salmon, and steelhead pending implementation of a Reasonable and Prudent Alternative (RPA) to status quo management of reservoir releases, river flow, habitat condition, and facilities in portions of the mainstem Russian River, Dry Creek, and Russian River Estuary. Mandated projects to ameliorate impacts to listed salmonids in the RPA are partitioned among USACE and the Water Agency. Each organization has its own reporting requirements to NMFS. Because coho salmon are also listed as endangered by the California Endangered Species Act (CESA), the Water Agency is party to a Consistency Determination issued by the California Department of Fish and Game (CDFG) in November 2009. The Consistency Determination mandates that the Water Agency implement a subset of Biological Opinion projects that pertain to coho and the Water Agency is required to report progress on these efforts to CDFG.

Project implementation timelines in the Biological Opinion, and Consistency Determination, specify Water Agency reporting requirements to NMFS and CDFG and encourage frequent communication among the agencies. The Water Agency has engaged both NMFS and CDFG in frequent meetings and has presented project status updates on many occasions since early 2009. Although not an explicit requirement of the Biological Opinion or Consistency Determination, the Water Agency has elected to coalesce reporting requirements into one annual volume for presentation to the agencies. The following document represents the third report for year 2011-12. Previous annual reports can be accessed at <http://www.scwa.ca.gov>.

Water Agency projects mandated by the Biological Opinion and Consistency Determination fall into six major categories:

- Biological and Habitat Monitoring,
- Habitat Enhancement,
- California Environmental Quality Act (CEQA) Compliance and Permitting,
- Planning and Adaptive Management,
- Water and Fish Facilities Improvements, and
- Public Outreach.

This report contains status updates for planning efforts, environmental compliance, and outreach but the majority of the technical information we present pertains to monitoring and habitat enhancement. The Biological Opinion requires extensive fisheries data collection in the mainstem Russian River, Dry Creek, and Estuary to detect trends and inform habitat enhancement efforts. The report presents each data collection effort independently and the primary intent of this document is to clearly communicate recent results. However, because Chinook, coho, and steelhead have complex life history patterns that

integrate all of these environments, we also present a synthesis section to discuss the interrelated nature of the data. Some monitoring programs are extensions of ongoing Water Agency efforts that were initiated a decade or more before receipt of the Biological Opinion.

2: Public Outreach

Biological Opinion Requirements

The Biological Opinion includes minimal *explicit* public outreach requirements. The breadth and depth of the RPAs, however, *implies* that implementation of the Biological Opinion will include a robust public outreach program.

RPA 1 (Pursue Changes to D1610 Flows) mandates two outreach activities. First, it requires the Water Agency, with the support of NMFS staff, to conduct outreach “to affected parties in the Russian River watershed” regarding permanently changing Decision 1610. Second, the RPA requires the Water Agency to update NMFS on the progress of temporary urgency changes to flows during Section 7 progress meetings and as public notices and documents are issued.

RPA 2 (Adaptive Management of the Outlet Channel) requires that within six months of the issuance of the Biological Opinion the Water Agency, in consultation with NMFS, “conduct public outreach and education on the need to reduce estuarine impacts by avoiding mechanical breaching to the greatest extent possible.”

Finally, RPA 3 (Dry Creek Habitat Enhancements, refers to public outreach in the following mandate, “Working with local landowners, DFG and NMFS, Water Agency will prioritize options for implementation” of habitat enhancement.

The remaining RPAs do not mention public outreach.

Water Agency Public Outreach Activities – 2011/2012

Meetings

Public Policy Facilitating Committee meeting—The PPFC met in February 2012 for an update of the year’s activities. Notices for the meeting were sent out to approximately 800 individuals and agencies and a press release was issued. Approximately 50 people attended the meeting and heard presentations from Bill Hearn, NMFS; Erik Larson, CDFG; Mike Dillabough and Peter LaCivita, USACOE; and Pam Jeane, David Manning and Jessica Martini Lamb, Water Agency.

Community Meetings, Events & Tours -- No meetings were held regarding the estuary because of a lawsuit on the Lagoon Management Plan EIR. There were no meetings held regarding the Fish Flow Project, as Water Agency staff worked internally on modeling and analysis.

Several tours and events were held in Dry Creek. The USACE and the Water Agency co-hosted a ribbon-cutting at the new building housing the Russian River Coho Salmon Captive Broodstock Program on May 2. Approximately 75 people attended, including Representative Mike Thompson, Sonoma County Supervisors Efren Carrillo, Mike McGuire, David Rabbitt and Shirlee Zane. Several legislative staff and representatives from NMFS, CDFG, and the Corps were present, as were nonprofit partners and members of the public.

The USACE and the Water Agency co-hosted a Golden Shovel event at the Corps Dry Creek Demonstration project in October. Approximately 50 people attended and many of accompanied Water Agency staff on a tour of the Quivira demonstration project.

Several tours were held for public officials of the Coho Broodstock Program and of Dry Creek habitat enhancement sites. NMFS, DFG, Corps and Water Agency staff worked together on these tours, which included: NOAA Director Dr. Jane Lubchenco; Representative Mike Thompson; Assemblyman Wes Chesbro; California Senate Natural Resources Committee staff member Bill Craven; NOAA's Director of the Office of Habitat Restoration Buck Sutter; State Water Resources Control Board member Steve Moore; Nature Conservancy staff; and staff of the State Water Resources Control Board.

Stakeholder Process

The Dry Creek Advisory Group (Advisory Group), created in 2009, is a stakeholder group comprised of landowners and representatives from the Water Agency, the USACE, NMFS and DFG. The Advisory Group met in December 2011 to provide an opportunity for Advisory Group members and other members of the public to tour the Russian River Coho Salmon Captive Broodstock Program at the Congressman Don Clausen Fish Hatchery at Warm Springs Dam. Participants also heard updates about the work planned along Dry Creek.

While no meetings of the Advisory Group took place in 2012, a meeting is planned for spring 2013 to tour the habitat enhancement work completed thus far along Dry Creek.

Other Outreach

Free Media –Articles about the Biological Opinion appeared in The Press Democrat, the Russian River Times, the West County News and Review, and the Russian River Gazette. Press releases were issued on a NFWF grant for fish studies in the Russian River, board approval of the Dry creek Habitat Enhancement Project and environmental documentation for the project, the start of construction for the Quivira component of Dry creek habitat enhancement, the Corps appropriations for Dry creek habitat enhancement, the coho broodstock building completion, temporary urgency changes, Mirabel fish screen environmental documents, Chinook returns and two Public Policy Facilitating Committee meetings.

Electronic Media – The Water Agency continually updated its Biological Opinion webpage, including links on new documents and meetings. In addition, the Water Agency posted videos on YouTube regarding Chinook returns, Dry Creek winter backwater and the Grape Creek fish passage project, which can be accessed via the agency's website. Email alerts regarding activities in the estuary were issued about a dozen times in the last six months of 2011 and in 2012.

Materials – The Water Agency rewrote and redesigned its briefing papers to reflect new information and studies being conducted. A jetty FAQ was developed, along with a Dry Creek Demonstration Project flyer. These materials were distributed at meetings, conferences, statewide forums, outreach events and through the Water Agency website. In addition, a simple postcard handout was developed for events geared to the general public. A flyer was mailed to all Dry Creek Valley residents informing them of the demonstration projects being conducted by the Water Agency and the Corps.

Sonoma County Fair – The Biological Opinion was the focus of the Water Agency’s outreach efforts at the Sonoma County Fair in 2011 and 2012. In order to get a free gift, attendees needed to take a short “quiz” focused on aspects of the Biological Opinion (questions included “Name one of three fish in the Russian River that is on the endangered species list?” “Why are we asking people to conserve water this summer, even though we aren’t in a drought?” “Why is Dry Creek important to your water supply?” and “Can you tell us what an estuary is and whether the Russian River has one?”). These questions provided staff an opportunity to discuss the Biological Opinion with approximately 4,000 people.

3: Pursue Changes to Decision 1610 Flows

Two major reservoir projects provide water supply storage in the Russian River watershed: 1) Coyote Valley Dam/Lake Mendocino, located on the East Fork of the Russian River three miles east of Ukiah, and 2) Warm Springs Dam/Lake Sonoma, located on Dry Creek 14 miles northwest of Healdsburg. The Water Agency is the local sponsor for these two federal water supply and flood control projects, collectively referred to as the Russian River Project. Under agreements with the United States Army Corps of Engineers (USACE), the Water Agency manages the water supply storage space in these reservoirs to provide a water supply and maintain summertime Russian River and Dry Creek streamflows.

The Water Agency holds water-right permits¹ issued by the State Water Resources Control Board (SWRCB) that authorize the Water Agency to divert² Russian River and Dry Creek flows and to re-divert³ water stored and released from Lake Mendocino and Lake Sonoma. The Water Agency releases water from storage in these lakes for delivery to municipalities, where the water is used primarily for residential, governmental, commercial, and industrial purposes. The primary points of diversion include the Water Agency's facilities at Wohler and Mirabel Park (near Forestville). The Water Agency also releases water to satisfy the needs of other water users and to contribute to the maintenance of minimum instream flow requirements in the Russian River and Dry Creek established in 1986 by the SWRCB's Decision 1610. These minimum instream flow requirements vary depending on specific hydrologic conditions (normal, dry, and critical) that are based on cumulative inflows into Lake Pillsbury in the Eel River watershed.

NMFS concluded in the Russian River Biological Opinion that the artificially elevated summertime minimum flows in the Russian River and Dry Creek currently required by Decision 1610 result in high water velocities that reduce the quality and quantity of rearing habitat for coho salmon and steelhead. NMFS' Russian River Biological Opinion concludes that reducing Decision 1610 minimum instream flow requirements will enable alternative flow management scenarios that will increase available rearing habitat in Dry Creek and the upper Russian River, and provide a lower, closer-to-natural inflow to the estuary between late spring and early fall, thereby enhancing the potential for maintaining a seasonal freshwater lagoon that would likely support increased production of juvenile steelhead and salmon.

Changes to Decision 1610 are under the purview of the SWRCB, which retained under Decision 1610 the jurisdiction to modify minimum instream flow requirements if future fisheries studies identified a benefit. NMFS recognized that changing Decision 1610 would require a multi-year

¹ SWRCB water-right permits 12947A, 12949, 12950 and 16596.

² Divert – refers to water diverted directly from streamflows into distribution systems for beneficial uses or into storage in reservoirs.

³ Re-divert – refers to water that has been diverted to storage in a reservoir, then is released and diverted again at a point downstream.

(6 to 8 years) process of petitioning the SWRCB for changes to minimum instream flow requirements, public notice of the petition, compliance with the California Environmental Quality Act (CEQA), and a SWRCB hearing process. To minimize the effects of existing minimum instream flows on listed salmonids during this process, the Russian River Biological Opinion stipulated that the Water Agency “will seek both long term and interim changes to minimum flow requirements stipulated by D1610.” The permanent and temporary changes to Decision 1610 minimum instream flow requirements specified by NMFS in the Russian River Biological Opinion are summarized in Figure 3.1.

Permanent Changes

The Russian River Biological Opinion requires the Water Agency to begin the process of changing minimum instream flows by submitting a petition to change Decision 1610 to the SWRCB within one year of the date of issuance of the final Biological Opinion. The Water Agency filed a petition with the SWRCB on September 23, 2009, to permanently change Decision 1610 minimum instream flow requirements. The requested changes are to reduce minimum instream flow requirements in the mainstem Russian River and Dry Creek between late spring and early fall during normal and dry water years and promote the goals of enhancing salmonid rearing habitat in the upper Russian River mainstem, lower river in the vicinity of the Estuary, and Dry Creek downstream of Warm Springs Dam. NMFS’ Russian River Biological Opinion concluded that, in addition to providing fishery benefits, the lower instream flow requirements “should promote water conservation and limit effects on in-stream river recreation.” NMFS stated that the following changes, based on observations during the 2001 interagency flow-habitat study and the 2007 low flow season, may achieve these goals:

During Normal Years:

1. Reduce the minimum flow requirement for the Russian River from the East Fork to Dry Creek from 185 cubic-feet per second (cfs) to 125 cfs between June 1 and August 31; and from 150 cfs to 125 cfs between September 1 and October 31.
2. Reduce the minimum flow requirement for the Russian River between the mouth of Dry Creek and the mouth of the Russian River from 125 cfs to 70 cfs.
3. Reduce the minimum flow requirement for Dry Creek from Warm Springs Dam to the Russian River from 80 cfs to 40 cfs from May 1 to October 31.

During Dry Years:

1. Reduce the minimum flow requirement for the Russian River between the mouth of Dry Creek and the mouth of the Russian River from 85 cfs to 70 cfs.

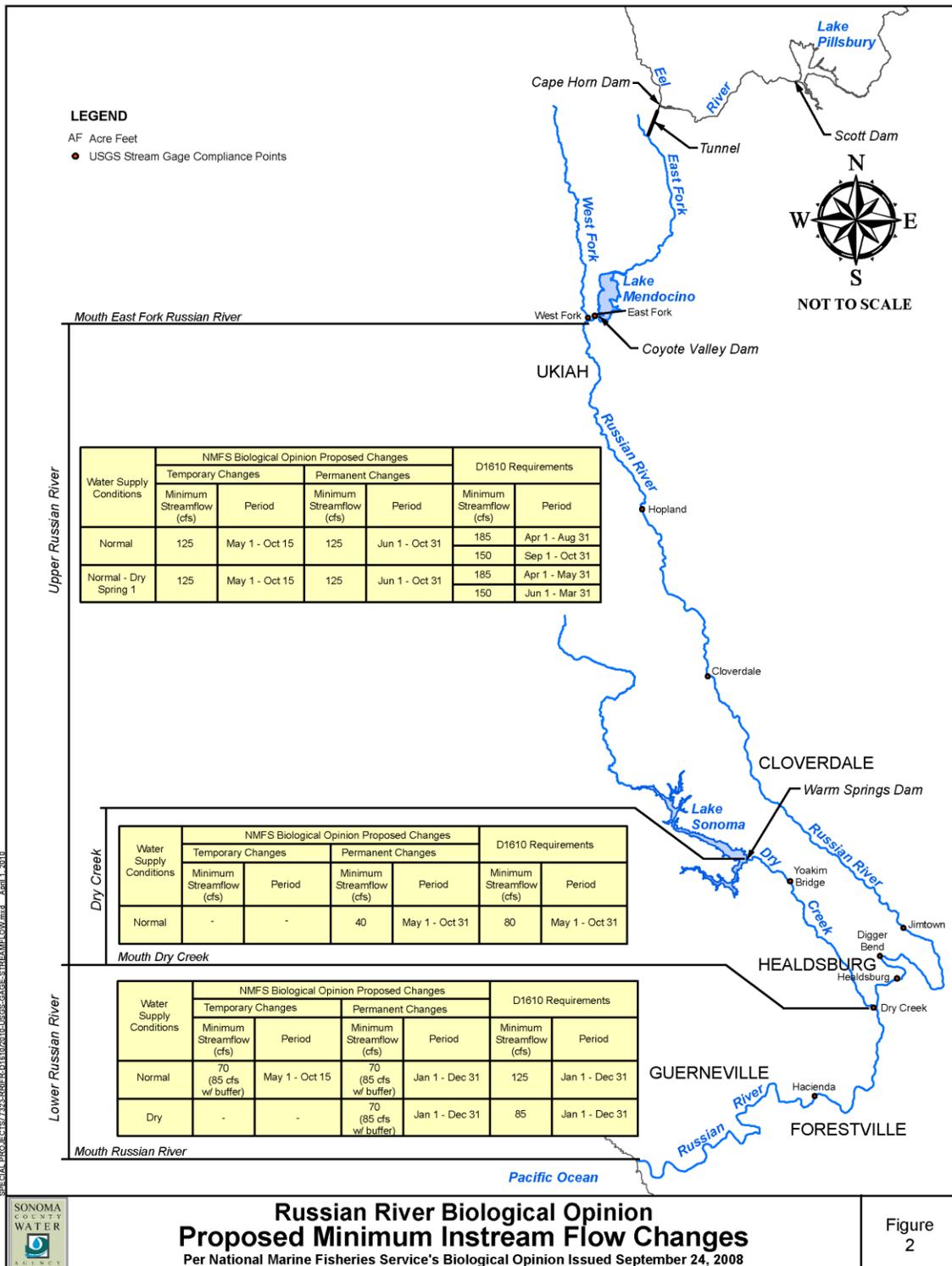


Figure 3.1. A summary of the permanent and temporary changes to Decision 1610 minimum instream flow requirements specified by NMFS in the Russian River Biological Opinion.

Summary Status

The SWRCB issued a second amended public notice of the Water Agency's petition to modify Decision 1610 for public comment on March 29, 2010. Following filing of the petition to change Decision 1610, the Water Agency issued a Notice of Preparation (NOP) of an Environmental Impact Report (EIR) for the Fish Habitat Flows and Water Rights Project (Fish Flow Project). Comments received during the NOP scoping process are being considered during current preparation of the Fish Flow Project Draft EIR.

Temporary Changes

Until the SWRCB issues an order on the petition to permanently modify Decision 1610, the minimum instream flow requirements specified in Decision 1610 (with the resulting adverse impacts to listed salmonids) will remain in effect, unless temporary changes to these requirements are made by the SWRCB. The Russian River Biological Opinion requires that the Water Agency petition the SWRCB for temporary changes to the Decision 1610 minimum instream flow requirements beginning in 2010 and for each year until the SWRCB issues an order on the Water Agency's petition for the permanent changes to these requirements. NMFS' Russian River Biological Opinion only requires that petitions for temporary changes "request that minimum bypass flows of 70 cfs be implemented at the USGS gage at the Hacienda Bridge between May 1 and October 15, with the understanding that for compliance purposes SCWA will typically maintain about 85 cfs at the Hacienda gage. For purposes of enhancing steelhead rearing habitats between the East Branch and Hopland, these petitions will request a minimum bypass flow of 125 cfs at the Healdsburg gage between May 1 and October 15."

Summary Status

The Water Agency petitioned the SWRCB for temporary changes to Decision 1610 on April 18, 2011 (Appendix A-1). The Water Agency filed a Temporary Urgency Change Petition (TUCP) to request that the SWRCB reduce the minimum instream flow requirements for the Russian River in the Water Agency's water-right permits in accordance with the recommendations in the Russian River Biological Opinion.

The Water Agency requested that the SWRCB make the following temporary changes to the Decision 1610 instream flow requirements:

- From May 1 through October 15, 2011, minimum instream flow requirements for the upper Russian River (from the confluence with the East Fork of the Russian River to its Confluence with Dry Creek) be reduced from 185 cfs to 125 cfs.
- From May 1 through October 15, 2011, minimum instream flow requirements for the lower Russian River (downstream of its confluence with Dry Creek) be reduced from 125 cfs to 70 cfs with the understanding the Water Agency will typically maintain approximately 85 cfs at the Hacienda Gauge as practicably feasible.

The SWRCB issued a public notice of the Water Agency's petition on May 18, 2011 (Appendix A-2). The SWRCB issued an Order approving the Water Agency's TUCP on June 1, 2011 (Appendix A-3). The order included several terms and conditions, including requirements for fisheries habitat monitoring (Terms 2 to 7), preparation of a water quality monitoring plan and summary data report (Terms 8 and 9), reporting of water conservation measures implemented during the term of the order (Term 11), relevant updates of estimated future water savings (Term 12) and maximum applied water allowance achieved by the Water Agency's contractors (Term 13). Reports to fulfill the terms of the order were prepared and submitted to the SWRCB and are provided in Appendices A-4 through A-8.

Provisions 2 through 7 of the State Water Board Order required the Water Agency to conduct and report on a number of fisheries monitoring projects. The Water Agency and State Water Board consulted with NMFS and the California Department of Fish and Game (DFG) regarding the fisheries monitoring objectives and methods. Projects included monitoring adult Chinook salmon returns at the Mirabel inflatable dam, dive surveys to monitor Chinook in the lower and upper Russian River, dive surveys to measure the relative abundance of juvenile steelhead and native freshwater fish in the upper Russian River, salmonid downstream migrant trapping operations in Dry Creek, the mainstem of the Russian River at Mirabel Dam and the Russian River estuary near Duncans Mills. Updates of fisheries monitoring data were sent to NMFS and DFG staff on a weekly basis per provision 7 of the State Water Board Order. While not a provision of the SWRCB Order, the Biological Opinion requires fish trap data collection in Austin Creek, Dutchbill Creek, and Green Valley Creek. Detailed results are provided in the *Results of the Fisheries Monitoring Plan for the Sonoma County Water Agency 2011 Temporary Urgency Change* (Appendix A-4). Additional analysis of fisheries habitat related to changes in minimum instream flows are provided in the water quality summary data report in Appendix A-6.

Water samples were collected from the following nine (9) surface-water sites in the mainstem of the Russian River: Diggers Bend; Camp Rose; Memorial Beach; below Memorial Beach and above Dry Creek confluence; ~1,500 feet below Dry Creek confluence; Riverfront Park; ~150 feet below Water Agency RDS; ~1,300 feet below Mark West Creek confluence; Steelhead Beach. All samples were analyzed for nutrients, chlorophyll a, standard bacterial indicators (total coliforms (multiple tube fermentation and colilert), e. coli, fecal coliform and enterococci), total and dissolved organic carbon, and total dissolved solids. Duplicate samples were taken at Steelhead Beach.

Bacteria analysis for the Water Agency was conducted by Alpha Laboratories in Ukiah, California. Total coliform was analyzed using multiple tube fermentation and Colilert to determine if there were significant differences between the two methods. Fecal coliform and enterococci were analyzed by multiple tube fermentation and e. coli was analyzed by the Colilert method. Monitoring results were posted to the Water Agency website and are provided in Appendix A-6. Water quality monitoring in the Russian River Estuary is further discussed in Chapter 4.

4: Estuary Management

The Russian River estuary (Estuary) is located approximately 97 kilometers (km; 60 miles) northwest of San Francisco in Jenner, Sonoma County, California. The Russian River watershed encompasses 3,847 square kilometers (km) (1,485 square miles) in Sonoma, Mendocino, and Lake counties. The Estuary extends from the mouth of the Russian River upstream approximately 10 to 11 km (6 to 7 miles) between Austin Creek and the community of Duncans Mills (Heckel 1994).

The Estuary may close throughout the year as a result of a barrier beach forming across the mouth of the Russian River. The mouth is located at Goat Rock State Beach (California Department of Parks and Recreation). Although closures may occur at anytime of the year, the mouth usually closes during the spring, summer, and fall (Heckel 1994; Merritt Smith Consulting 1997, 1998, 1999, 2000; Sonoma County Water Agency and Merritt Smith Consulting 2001). Closures result in ponding of the Russian River behind the barrier beach and, as water surface levels rise in the Estuary, flooding may occur. The barrier beach has been artificially breached for decades; first by local citizens, then the County of Sonoma Public Works Department, and, since 1995, by the Water Agency. The Water Agency's artificial breaching activities are conducted in accordance with the Russian River Estuary Management Plan recommended in the Heckel (1994) study. The purpose of artificially breaching the barrier beach is to alleviate potential flooding of low-lying properties along the estuary.

NMFS' Russian River Biological Opinion (NMFS 2008) found that artificially elevated inflows to the Russian River estuary during the low flow season (May through October) and historic artificial breaching practices have significant adverse effects on the Russian River's estuarine rearing habitat for steelhead, coho salmon, and Chinook salmon. The historical method of artificial sandbar breaching, which is done in response to rising water levels behind the barrier beach, adversely affects the estuary's water quality and freshwater depths. The historical artificial breaching practices create a tidal marine environment with shallow depths and high salinity. Salinity stratification contributes to low dissolved oxygen at the bottom in some areas. The Biological Opinion (NMFS 2008) concludes that the combination of high inflows and breaching practices impact rearing habitat because they interfere with natural processes that cause a freshwater lagoon to form behind the barrier beach. Fresh or brackish water lagoons at the mouths of many streams in central and southern California often provide depths and water quality that are highly favorable to the survival of rearing salmon and steelhead.

The Biological Opinion's Reasonable and Prudent Alternative (RPA) 2, Alterations to Estuary Management, (NMFS 2008) requires the Water Agency to collaborate with NMFS and to modify estuary water level management in order to reduce marine influence (high salinity and tidal inflow) and promote a higher water surface elevation in the estuary (formation of a fresh or brackish lagoon) for purposes of enhancing the quality of rearing habitat for young-of-year and age 1+ juvenile (age 0+ and 1+) steelhead from May 15 to October 15 (referred to hereafter as

the “lagoon management period”). A program of potential, incremental steps are prescribed to accomplish this, including adaptive management of a lagoon outlet channel on the barrier beach, study of the existing jetty and its potential influence on beach formation processes and salinity seepage through the barrier beach, and a feasibility study of alternative flood risk measures. RPA 2 also includes provisions for monitoring the response of water quality, invertebrate production, and salmonids in the estuary to the management of water surface elevations during the lagoon management period.

The following section provides a summary of the Water Agency’s estuary management actions required under the Russian River Biological Opinion RPA 2 in 2011.

Sandbar Management

RPA 2 requires the Water Agency, in coordination with NMFS, CDFG, and the USACE, to annually prepare barrier beach outlet channel design plans. Each year after coordinating with the agencies, the Water Agency is to provide a draft plan to NMFS, CDFG, and the USACE by April 1 for their review and input. The initial plan was to entail the design of a lagoon outlet channel cut diagonally to the northwest. Sediment transport equations shall be used by Water Agency as channel design criteria to minimize channel scour at the anticipated rate of Russian River discharge. This general channel design will be used instead of traditional mechanical breaching whenever the barrier beach closes and it is safe for personnel and equipment to work on the barrier beach. Alternate methods may include 1) use of a channel cut to the south if prolonged south west swells occur, and 2) use of the current jetty as a channel grade control structure (as described below) for maintaining water surface elevations up to 7-9 feet NGVD (NMFS 2008).

The Water Agency contracted with Philip Williams and Associates (ESA PWA) to prepare the Russian River Estuary Outlet Channel Adaptive Management Plan (Appendix B-1). The approach of the plan was to meet the objective of RPA 2 to the greatest extent feasible while staying within the constraints of existing regulatory permits and minimizing the impact to aesthetic, biological, and recreational resources of the site. It was recognized that the measures developed in the management plan, when implemented, potentially could not fully meet the objectives established by the RPA. The concept of this approach was developed in coordination with NMFS, CDFG, and California State Parks.

A monthly topographic survey of the beach at the mouth of the Russian River is also required under RPA 2. A topographic survey was not completed in February 2011 due to wet weather conditions. The beach topographic maps are provided in Appendix B-2.

The Water Agency did not perform any beach management, either artificial breaching or lagoon management, in 2011. Wave events caused a series of closures between the end of September and into November. However, the closures lasted a week or less, ending when rising lagoon water levels overtopped the beach berm and naturally scoured a new tidal channel. During the 2011 management period, May 15th to October 15th, Water Agency staff regularly monitored current and forecasted estuary water levels, inlet state, river discharge, tides, and wave

conditions to anticipate changes to the inlet's state. High river discharge in the first two months of the management period followed by the typical low wave energy conditions during the summer contributed to the inlet staying open for the first four months of the management period. Starting in late September, the inlet went through a succession of perched lagoon conditions and natural breaches, during which the Water Agency closely monitored estuary conditions and considered management options. The perched episodes were short-lived, lasting no more than a week, and included a small outlet channel flowing along and sometimes through gaps in the jetty. The perched episodes ended naturally when lagoon water levels increased, overtopped the beach berm, and scoured a new tidal channel. Since the perched lagoon episodes did not evolve to the point that management action was warranted, the Water Agency did not take any management actions to encourage formation of an outlet channel (ESA PWA 2012).

Jetty

RPA 2 includes a second step if adaptive management of the outlet channel as described, “is not able to reliably achieve the targeted annual and seasonal estuary management water surface elevations by the end of 2010, Water Agency will draft a study plan for analyzing the effects and role of the Russian River jetty at Jenner on beach permeability, seasonal sand storage and transport, seasonal flood risk, and seasonal water surface elevations in the Russian River estuary. That study will also evaluate alternatives for achieving targeted estuarine management water surface elevations via jetty removal, partial removal of the jetty, jetty notching, and potential use of the jetty as a tool in maintaining the estuary water surface elevations described above.”

ESA PWA, at the request of the Water Agency, developed a plan to study the effects of the Goat Rock State Beach jetty on the Estuary (Appendix B-3). In addition, it described the recommended approach for developing and assessing the feasibility of alternatives to the existing jetty that may help achieve target estuarine water surface elevations. As such, this study plan fulfills a portion of the Water Agency's obligations under the 2008 Biological Opinion (Biological Opinion) issued by the National Marine Fisheries Service (NMFS). The Biological Opinion directs the Water Agency to change its management of the Estuary's water surface elevations with the intent of improving juvenile salmonid habitat while minimizing flood risk. This plan was provided to NMFS and CDFG as required by the Biological Opinion and is provided in Appendix B-3.

Flood Risk Management

RPA 2 also includes a Flood Risk Reduction step if it proves difficult to reliably achieve raised water surface elevation targets based on implementation of a lagoon outlet channel or modification of the existing jetty. Should those actions be unsuccessful in meeting estuarine water surface elevation goals, RPA 2 states that the Water Agency “will evaluate, in coordination with NMFS and other appropriate public agencies, the feasibility of actions to avoid or mitigate damages to structures in the town of Jenner and low-lying properties along the estuary that are currently threatened with flooding and prolonged inundation when the

barrier beach closes and the estuary's water surface elevation rises above 9 feet. Such actions may include, but are not limited to, elevating structures to avoid flooding or inundation.”

The first effort to address flood risk management feasibility was compilation of a preliminary list of structures, properties, and infrastructure that would be subject to flooding/inundation as the result of sandbar formation and if the estuary were allowed to naturally breach. As required by Reasonable and Prudent Alternative (RPA) 2 in the Russian River Biological Opinion (NMFS 2008), the Water Agency submitted a preliminary list of properties, structures, and infrastructure that may be subject to inundation if the barrier beach at the mouth of the Russian River was allowed to naturally breach (Appendix B-3). Allowing Estuary water surface elevations to rise to between 10 and 12 feet NGVD (the estimated water surface elevation if the barrier beach was allowed to naturally breach per consultation with NMFS) may potentially inundate portions of up to 96 properties.

Permitting

In addition to compliance with the federal and California Endangered Species Acts, water level and beach management activities in the Estuary require compliance with numerous other federal and state regulations, as well as leases from several state agencies to perform management activities at Goat Rock State Beach and in the Russian River estuary. At the time of issuance of the Russian River Biological Opinion,⁴ the Water Agency held permits for artificial breaching from California State Parks, California State Lands Commission, California Coastal Commission, North Coast Regional Water Quality Control Board, California Department of Fish and Game, and the U.S. Army Corps of Engineers. Beginning in late 2008, the Water Agency began working with these state and federal agencies to either modify or receive clarification regarding the scope of activities allowed under existing permits to allow for creation of the lagoon outlet channel and compliance with RPA 2 of the Russian River Biological Opinion. Existing permits were either modified or clarification received to allow creation of the lagoon outlet channel, with the exception of the California Coastal Commission's Coastal Development Permit, which was modified in 2010.

The Water Agency began a CEQA process to obtain new regulatory permits that would allow for a change in the volume of sand excavated for creation of the lagoon outlet channel and to replace expiring permits. The Notice of Preparation (NOP) was released to local, state, and federal agencies, and to other interested parties on May 7, 2010. The NOP was circulated for a 45-day public review period, which ended on June 21, 2010. During the NOP review period, the Water Agency held two scoping meetings, in May at the Jenner Community Center and the Sonoma County Permit and Resource Management Department in Santa Rosa, to discuss the project and to solicit public input as to the scope and content of the EIR. On December 15, 2010, the Water Agency released the Draft EIR for public review. A 60-day public review and comment period on the Draft EIR ended February 14, 2011. A public hearing on the Draft EIR was held during the public review period on January 18, 2011, from 6:00 p.m. to 9:00 p.m. at

⁴ The previous NMFS biological opinion specific to estuary breaching activities was replaced with the Russian River Biological Opinion.

the Jenner Community Center. The Final EIR was certified by the Water Agency's Board of Director's on August 16, 2011. A lawsuit was subsequently filed by the Russian River Watershed Protection Committee under CEQA. The litigation was settled in 2012.

New permits for the Estuary Management Project have been issued by the California Department of Fish and Game (Streambed Alteration Agreement) and California State Lands Commission (General Lease), as well as right of entry provided by State Parks. Permits from the U.S. Army Corps of Engineers, California Coastal Commission, and North Coast Regional Water Quality Control Board are pending.

Following issuance of the Russian River Biological Opinion, the Water Agency was informed that a permit was also required under the Marine Mammal Protection Act (MMPA) as beach management activities occurred in the vicinity of a harbor seal haulout at the mouth of the Russian River. A new Marine Mammal Protection Act Incidental Take Permit was issued for the project by the National Marine Fisheries Service in April 2011.

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4.1 Water Quality Monitoring

Water quality monitoring was conducted in the lower, middle, and upper reaches of the Russian River estuary, including two tributaries and the maximum backwater area, between the mouth of the river at Jenner and Monte Rio (Figure 4.1.1). Water Agency staff continued to collect data to establish baseline information on water quality in the Estuary, gain a better understanding of the longitudinal and vertical water quality profile during the ebb and flow of the tide, and track changes to the water quality profile that may occur during periods of barrier beach closure, partial or full lagoon formation, lagoon outlet channel implementation, and artificial breaching.

Saline water is denser than freshwater and a salinity “wedge” (halocline) forms in the Estuary as freshwater outflow passes over the denser tidal inflow. During the Lagoon Management Period, the lower and middle reaches of the Estuary up to Sheephouse Creek are predominantly saline environments with a thin freshwater layer that flows over the denser saltwater. The upper reach of the Estuary transitions to a predominantly freshwater environment, which is periodically underlain by a denser, saltwater layer that migrates upstream to Duncans Mills during summer low flow conditions and barrier beach closure. Additionally, river flows, tides, topography, and wind action affect the amount of mixing of the water column at various longitudinal and vertical positions within the reaches of the Estuary. The maximum backwater area encompasses the area of the river between Duncans Mills and Monte Rio that is generally outside the influence of saline water, but within the upper extent of inundation and backwatering that can occur during tidal cycles and lagoon formation.

In 2011, the Estuary did not experience any closures during the lagoon management period, however there were several periods of perched conditions resulting in partial lagoon formation. Perched conditions occur when a barrier beach is incompletely formed and a small outlet channel remains, allowing water levels to rise while still providing outflow from the river. Perched conditions occurred for a period of 8 days from 22 September to 29 September, 5 days from 4 October to 8 October, and 5 days from 10 October to 14 October. During this time the Water Agency was able to monitor the partial development of a freshwater lagoon system as freshwater inflows increased the surface layer. The estuary also experienced a period of muted

tidal cycles, whereby the opening at the river mouth was somewhat isolated from ocean swells by the jetty, resulting in significantly reduced tidal action and salinity intrusion into the estuary.

Methods

Continuous Multi-Parameter Monitoring

Water quality was monitored using YSI Series 6600 multi-parameter datasondes. Hourly salinity (parts per thousand), water temperature (degrees Celsius), dissolved oxygen (percent saturation), dissolved oxygen (milligrams per liter), and pH (hydrogen ion) data were collected. Datasondes were cleaned and recalibrated periodically following the YSI User Manual procedures, and data was downloaded during each calibration event.

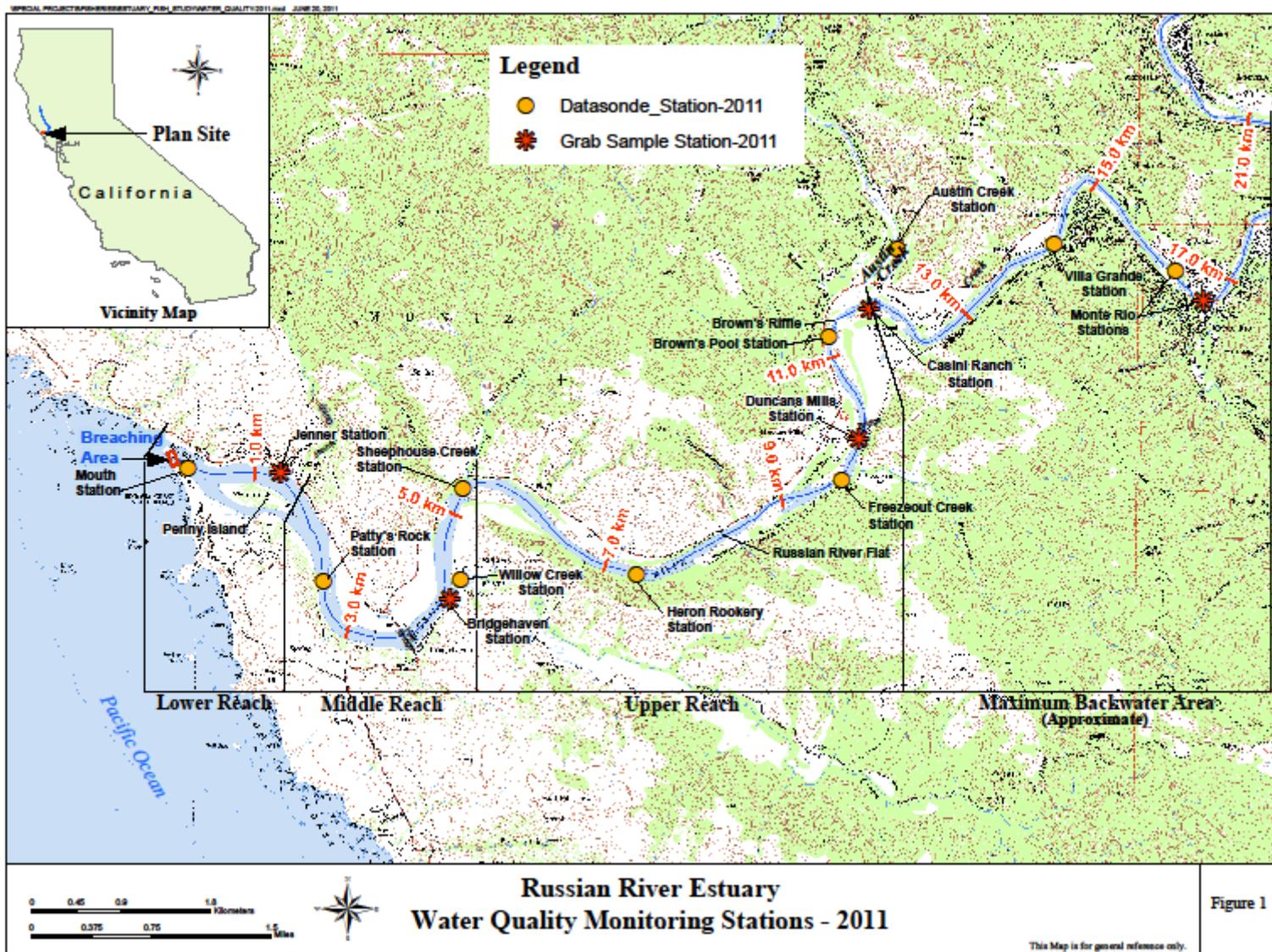


Figure 4.1.1. 2011 Russian River Estuary Water Quality Monitoring Stations

Ten stations were established for continuous water quality monitoring, including eight stations in the mainstem and two tributary stations (Figure 4.1.1). One mainstem station was located in the lower reach at the mouth of the Russian River at Goat Rock State Beach (Mouth Station). Two mainstem stations were placed in the middle reach: Patty's Rock upstream of Penny Island (Patty's Rock Station); and in the pool downstream of Sheephouse Creek (Sheephouse Creek Station). One tributary station was located in the mouth of Willow Creek, which flows into the middle reach of the estuary (Willow Creek Station). Three mainstem stations were located in the upper reach; a pool next to an area known as Heron Rookery located halfway between Sheephouse Creek and Duncans Mills (Heron Rookery Station), downstream of Freezeout Creek in Duncans Mills (Freezeout Creek Station), and downstream of Austin Creek in Brown's Pool (Brown's Pool Station). The other tributary station was located downstream of the first steel bridge in lower Austin Creek, which flows into the mainstem above Brown's Pool Station. Two mainstem stations were located in the maximum backwater area; a pool downstream of the community of Villa Grande (Villa Grande station) and in Monte Rio (Monte Rio Station).

The rationale for choosing mainstem Estuary sites, including the Brown's Pool Station, was to locate the deepest holes at various points throughout the Estuary to obtain the fullest vertical profiles possible and to monitor salinity circulation and stratification, hypoxic and/or anoxic events, and temperature stratification. Sondes were located near the mouths of Willow and Austin Creeks to collect baseline water quality conditions and monitor potential changes to water quality (e.g salinity intrusion) resulting from tidal cycling or inundation during partial or full lagoon formation. The Villa Grande and Monte Rio stations were established to monitor potential changes to water quality conditions in the maximum backwater area while inundated during lagoon formation (Figure 4.1.1). The Villa Grande station was also placed at the bottom of a deep hole to collect baseline data on hypoxic and/or anoxic events, and determine whether temperature stratification occurred or cold water refugia was present.

Mainstem estuary monitoring stations up to Freezeout Creek were comprised of a concrete anchor attached to a steel cable suspended from the surface by a large buoy (Figure 4.1.2). All mainstem estuary stations had a vertical array of two datasondes to collect water quality profiles, except Sheephouse Creek, which had one. Stations in the lower and middle reaches of the Estuary that are predominantly saline had sondes placed at the surface (~1m) and/or mid-depth (~3m) portions of the water column. The two stations in the upper reach of the Estuary, where water is predominantly fresh to brackish, were located in the lower half of the water column at mid-depth (~3-4m) and the bottom (~6-9m). Sondes were located in this manner to track vertical and longitudinal changes in water quality characteristics during periods of tidal circulation, barrier beach closure, lagoon formation, lagoon outlet channel implementation, and sandbar breach.

The monitoring station in the Maximum Backwater Area at Villa Grande was placed at the bottom of a deep pool (~6-9m), whereas the monitoring stations in the tributaries and at Monte Rio consisted of one datasonde suspended at approximately mid-depth (during open conditions) in the thalweg at each respective site.

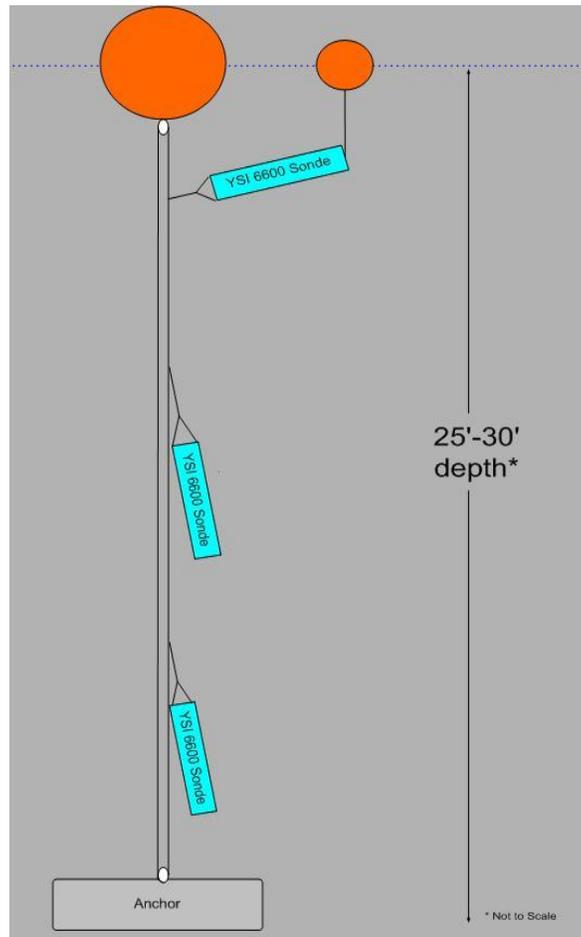


Figure 4.1.2. Typical Russian River Estuary monitoring station datasonde array.

The Austin Creek station was deployed from early April to early November, and the Monte Rio and Willow Creek stations were deployed from late April to early November. Monitoring stations at the Mouth, Heron Rookery, Freezeout Creek, and Villa Grande were deployed from early May to early November. The Patty's Rock and Brown's Pool stations were deployed from late June to early November, and the Sheephouse Creek Station was deployed from the first week of August to the middle of October. The Sheephouse Creek Station was deployed later and retrieved earlier than the other stations due to equipment malfunction.

Grab Sample Collection

In 2011, Water Agency staff continued to conduct nutrient and indicator bacteria grab sampling at the five stations established in 2010: the Jenner Boat Ramp (Jenner Station); Bridgehaven at the mouth of Willow Creek (Bridgehaven Station); Moscow Road Bridge in Duncans Mills (Duncans Mills Station); Casini Ranch across from the mouth of Austin Creek (Casini Ranch

Station); and just downstream of the Monte Rio Bridge (Monte Rio Station). Water Agency staff also collected duplicate samples at the Monte Rio Station during the monitoring period. Refer to Figure 4.1.1 for grab sampling locations.

Grab samples were collected once every two weeks from 17 May to 6 October. Additional focused sampling (collecting three samples over a ten-day period), was conducted following or during specific river management and operational events including: barrier beach closure and lagoon formation, lagoon outlet channel implementation, sandbar breach, or removal of summer recreational dams. All grab samples were analyzed at Alpha Labs in Ukiah, California.

Nutrient sampling was conducted for total organic nitrogen, ammonia, unionized ammonia, nitrate, nitrite, total Kjeldahl nitrogen, total nitrogen, and total phosphorus, as well as for *chlorophyll a*, which is a measurable parameter of algal growth that can be tied to excessive nutrient concentrations and reflect a biostimulatory response. Grab samples were collected for presence of indicator bacteria including total coliforms, fecal coliforms, *Escherichia coli* (*E. coli*) and *Enterococcus*. These bacteria are considered indicators of water quality conditions that may be a concern for water contact recreation and public health. The results of sampling conducted for total orthophosphate, dissolved organic carbon, total organic carbon, total dissolved solids, and turbidity are included as an appendix (Appendix A-5); however, an analysis and discussion of these constituents is not included in this report. Temperature and pH were recorded during grab sampling events and are included in the appendix.

Results

Water quality conditions in 2011 were similar to trends observed in sampling from 2004 to 2010. The lower and middle reaches are predominantly saline environments with a thin freshwater layer that flows over the denser saltwater layer. The upper reach transitions to a predominantly freshwater environment, which is periodically underlain by a denser, saltwater layer that migrates up and downstream and appears to be affected in part by freshwater inflow rates, tidal inundation, barrier beach closure, and subsequent tidal cycles following reopening of the barrier beach. The river upstream of Duncans Mills is considered predominantly freshwater habitat. The lower and middle reaches of the Estuary are subject to tidally-influenced fluctuations in water depth during open conditions and inundation during barrier beach closure, as is the upper reach and the maximum backwater area to a lesser degree.

Table 4.1.1 presents a summary of minimum, mean, and maximum values for temperature, depth, dissolved oxygen (DO), pH, and salinity recorded at the various datasonde monitoring stations. Data associated with malfunctioning datasonde equipment was removed from the data sets, resulting in the data gaps observed in the graphs presented as Figures 4.1.1 through 4.1.33. These data gaps may affect minimum, mean, and maximum values of the various monitored constituents, including at the Mouth Mid-depth Sonde in May, the Patty's Rock Bottom sonde in October, the Heron Rookery Bottom sonde in July, the Freezeout Creek Mid-depth sonde in October, the Brown's Pool Sonde in September and October, the Villa Grande

Table 4.1.1. Russian River estuary 2011 water quality monitoring results. Minimum, mean, and maximum temperature (degrees Celsius), depth (meters), dissolved oxygen (percent) saturation, dissolved oxygen (milligrams per Liter), hydrogen ion (pH), and salinity (parts per thousand).

Monitoring Station	Temperature	Depth	Dissolved Oxygen	Dissolved Oxygen	Hydrogen Ion	Salinity
<i>Sonde</i>	(°C)	(m)	(%) saturation	(mg/L)	(pH)	(ppt)
Mouth						
Surface						
May 12 - November 3						
Min	9.3	0.6	43.3	3.8	7.7	0.4
Mean	15.2	0.9	102.7	9.4	8.2	15.5
Max	22.2	1.1	245.4	21.1	9.3	30.7
Mid-Depth						
May 12 - November 3						
Min	8.9	2.8	22.7	1.9	7.5	4.8
Mean	12.4	3.2	90.1	8.0	7.9	28.8
Max	17.0	3.4	154.6	13.8	8.5	33.8
Patty's Rock						
Surface						
June 22 - November 3						
Min	11.2	0.7	55.0	4.9	7.6	0.3
Mean	16.6	0.9	107.2	9.4	8.0	17.7
Max	23.7	1.5	232.2	20.9	8.8	31.8
Mid-Depth						
June 22 - November 3						
Min	10.5	2.7	7.5	0.6	7.4	17.4
Mean	13.4	2.9	84.8	7.4	7.9	29.0
Max	20.3	3.1	155.8	13.4	8.3	33.0
Willow Creek						
Mid-Depth						
April 22 - November 14						
Min	9.4	0.4	0.0	0.0	6.8	0.1
Mean	16.3	0.7	64.1	6.0	7.4	11.0
Max	22.8	1.6	154.6	13.5	8.5	26.5
Sheephouse Creek						
Mid-Depth						
August 4 - October 13						
Min	13.7	2.3	34.1	2.8	7.6	17.4
Mean	15.8	3.3	86.7	7.3	7.9	26.6
Max	18.7	3.4	158.2	13.2	8.3	31.2
Heron Rookery						
Mid-Depth						
May 10 - November 3						
Min	13.2	4.3	0.0	0.0	6.7	0.1
Mean	19.4	4.6	81.8	7.3	8.0	6.8
Max	25.7	4.9	199.0	16.3	9.3	26.2
Bottom						
May 10 - November 2						
Min	13.2	7.1	0.0	0.0	6.2	0.1
Mean	18.3	8.7	40.8	3.8	7.5	12.5
Max	25.3	9.4	203.8	16.7	9.2	26.5

Monitoring Station Sonde	Temperature (°C)	Depth (m)	Dissolved Oxygen (%) saturation	Dissolved Oxygen (mg/L)	Hydrogen Ion (pH)	Salinity (ppt)
Freezeout Creek						
Mid-Depth						
May 10 - November 4						
Min	12.6	2.9	61.3	5.4	7.6	0.1
Mean	20.1	3.2	93.3	8.5	8.1	0.1
Max	25.3	5.3	150.5	12.5	9.1	1.1
Bottom						
May 10 - November 4						
Min	12.7	4.8	0.0	0.0	6.3	0.1
Mean	19.9	6.3	92.2	8.4	8.0	0.3
Max	25.3	7.1	152.7	13.3	8.9	4.8
Brown's Pool						
Bottom						
June 24 - November 3						
Min	13.8	0.3	50.6	4.5	7.4	0.1
Mean	20.7	5.4	98.0	8.7	8.0	0.2
Max	25.5	8.9	162.3	14.1	8.7	0.4
Austin Creek						
Mid-Depth						
April 8 - November 2						
Min	9.2	0.1	12.4	1.2	7.1	0.1
Mean	16.0	0.4	78.0	7.7	7.8	0.1
Max	22.4	0.9	110.3	11.3	8.2	0.2
Villa Grande						
Bottom						
May 9 - November 2						
Min	13.4	3.7	28.0	2.5	7.3	0.1
Mean	20.1	6.7	94.5	8.5	7.9	0.1
Max	25.9	7.9	155.1	13.3	8.8	0.2
Monte Rio						
Mid-Depth						
April 22 - November 2						
Min	13.4	0.6	71.9	6.3	7.5	0.1
Mean	20.1	0.8	95.4	8.7	7.9	0.1
Max	26.2	1.2	177.7	14.9	8.7	0.2

sonde in June, and the Monte Rio Sonde in May and August. The Sheephouse Creek surface sonde was not operational during the monitoring period and no data were collected.

Salinity

Full strength seawater has a salinity of approximately 35 ppt, with salinity decreasing from the ocean to the upstream limit of the Estuary, which is considered freshwater at approximately 0.5 ppt (Horne 1994). All of the mid-depth sondes in the lower and middle reaches were located in a predominantly saline environment, whereas the surface sondes were located at the saltwater-freshwater interface (halocline or salt wedge) and recorded both freshwater and saltwater conditions. In the middle reach of the Estuary, salinities can range as high as 30 ppt in the saltwater layer, with brackish conditions prevailing at the upper end of the salt wedge, to less than 1 ppt in the freshwater layer on the surface. The Willow Creek sonde was located just upstream of the confluence with the Russian River, where predominantly freshwater conditions observed in the creek during higher springtime flows transitioned to a brackish environment during lower dry season flows.

In the upper reach, the Estuary typically transitions from predominantly saline conditions to brackish and freshwater conditions in the Heron Rookery area. Upstream, the Freezeout Creek station is located in a predominantly freshwater environment; however, saltwater can occur in the lower half of the water column during open estuary conditions with lower in-stream flows, as well as during barrier beach closure or perched conditions. The Brown's Pool station is located in predominantly freshwater habitat in the upper reach of the Estuary, just downstream of the confluence with Austin Creek and the beginning of the maximum backwater area.

The Austin Creek, Villa Grande, and Monte Rio stations are located in the maximum backwater area in freshwater habitat that can become inundated during high tides, barrier beach closures, perched conditions, and lagoon formation. Salinity was not observed at any of the stations in the maximum backwater area during either open or perched conditions in 2011.

Lower and Middle Reach Salinity

The surface sondes at the Mouth and Patty's Rock stations were suspended at a depth of approximately 1 meter, and experienced frequent hourly fluctuations in salinity during open conditions. These fluctuations are influenced by freshwater inflows, tidal movement and expansion and contraction of the salt wedge. The freshwater layer was observed to be more persistent at the surface sondes during spring peak flows and under perched conditions. Concentrations ranged from 0.4 to 30.7 ppt at the Mouth surface sonde and 0.3 to 31.8 ppt at the Patty's Rock surface sonde (Table 4.1.1). The surface sondes at the Mouth and Patty's Rock had mean salinity values of 15.5 and 17.7 ppt, respectively.

The mid-depth sondes at the Mouth, Patty's Rock, and Sheephouse Creek stations were suspended at a depth of approximately 3 meters, and also experienced frequent fluctuations in salinity during open conditions, though to a lesser degree than their respective surface sondes. Concentrations ranged from 4.8 to 33.8 ppt at the Mouth, 17.4 to 33.0 ppt at Patty's Rock, and 17.4 to 31.2 ppt at Sheephouse Creek (Table 4.1.1). The mid-depth sondes at the Mouth, Patty's Rock, and Sheephouse Creek had mean salinity values of 28.8, 29.0, and 26.6, respectively. Minimum concentrations at the Mouth mid-depth sonde were observed to occur during high springtime flows in late-May and early June (Figure 4.1.3).

Salinity concentrations were observed to periodically decrease during muted tidal cycles in July and August and during perched conditions and partial lagoon formation in September and October (Figures 4.1.3 through 4.1.5). Muted tidal cycles occurred when the opening at the river mouth was somewhat isolated from ocean swells by the Jetty, resulting in reduced tidal action and salinity intrusion into the estuary (Figure 4.1.6).

Declines in salinity during perched conditions and partial lagoon formation were due to a combination of freshwater inflows increasing the depth of the freshwater layer over the salt layer, a reduction in tidal inflow, the compression and leveling out of the salt layer, and seepage

Russian River Mouth - Salinity and Flow 2011

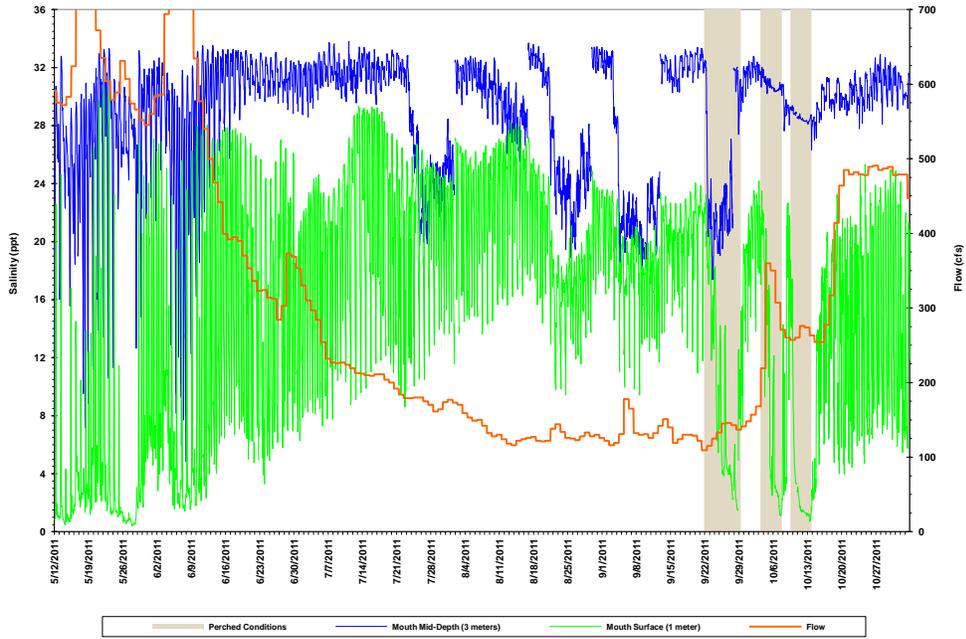


Figure 4.1.3. 2011 Russian River Mouth Salinity and Flow Graph

Russian River at Patty's Rock - Salinity and Flow 2011

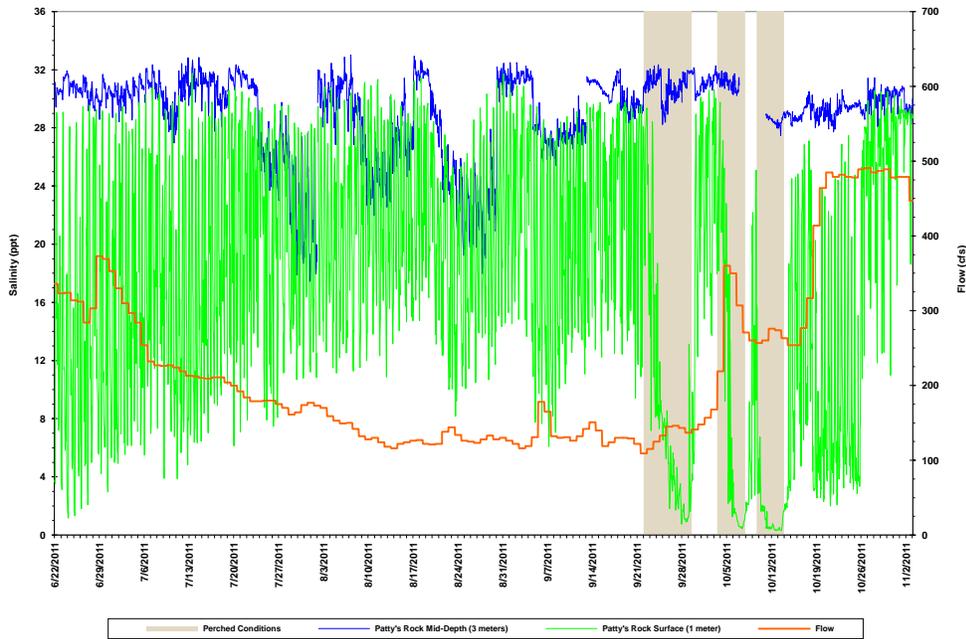


Figure 4.1.4. 2011 Russian River at Patty's Rock Salinity and Flow Graph

Russian River at Sheephouse Creek - Salinity and Flow 2011

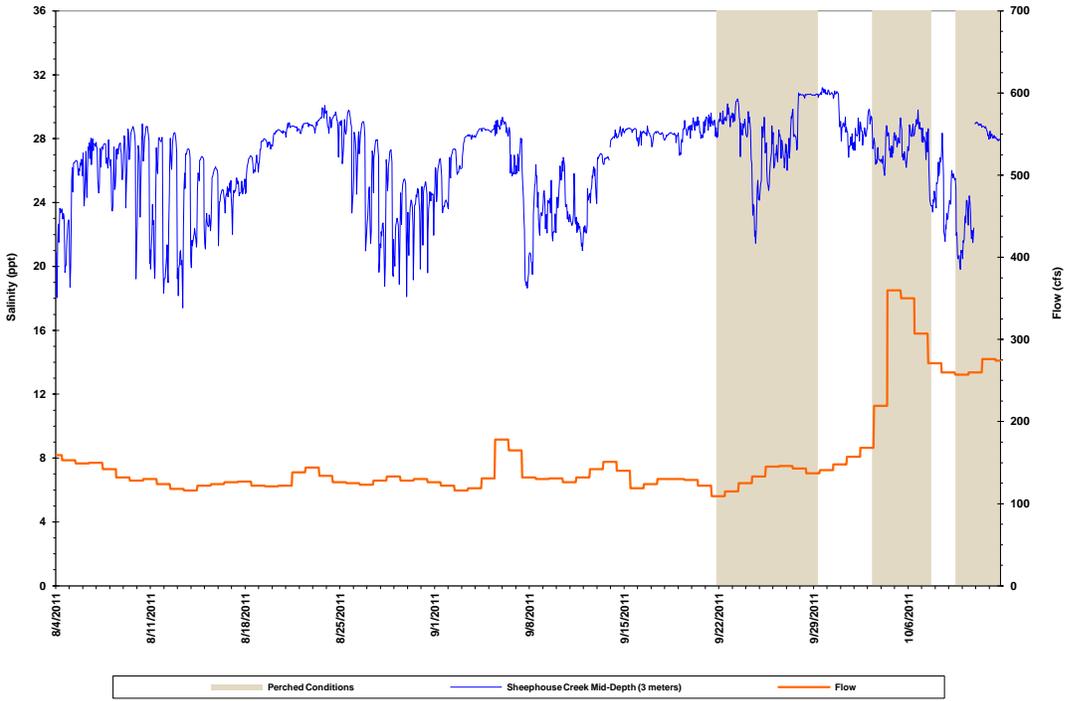


Figure 4.1.5. 2011 Russian River at Sheephouse Creek Salinity and Flow Graph



Figure 4.1.6. 2011 Russian River Mouth at Jetty Wall

of saline water through the barrier beach. Salinity returned to pre-perched levels after the mouth naturally reopened, although the time required to return to pre-perched conditions varied at each site and differed between perched events. This variability was related to the strength of subsequent tidal cycles, freshwater inflow rates, topography, relative location within the Estuary, and to a lesser degree, wind mixing.

The Willow Creek station was located in predominantly freshwater habitat during higher spring flows that persisted into early June. However, salt water was observed to migrate to this location and remain for the rest of the season once flows dropped in the creek and Russian River flows dropped below approximately 450 cfs (Figure 4.1.7). Salinity concentrations varied over the season with changing mainstem flows and tidal cycles, but remained primarily brackish in concentration. Mean salinity was observed to be 11.0 ppt, with a range of 0.1 to 26.5 ppt (Table 4.1.1).

Upper Reach Salinity

Two stations were monitored in the upper reach in 2011; Heron Rookery and Freezeout Creek. Both stations included a bottom sonde and a mid-depth sonde. Sondes were located in this manner to track changes in the presence and concentration of salinity in the water column.

The Heron Rookery station is located in a deep pool approximately 7.5 km upstream from the river mouth in an area where the Estuary begins to transition from predominantly saline conditions to brackish and freshwater conditions. The bottom and mid-depth sondes at Heron Rookery had mean salinity concentrations of 12.5 ppt and 6.8 ppt, respectively (Table 4.1.1). Salinity levels were observed to range from 0.1 to 26.5 ppt at the bottom sonde, and 0.1 to 26.2 ppt at the mid-depth sonde. (Figure 4.1.8).

The Freezeout Creek station is located approximately 9.5 km upstream from the river mouth in a pool approximately 300 meters downstream of the confluence of Freezeout Creek and the mainstem of the river. This station was located in a predominantly freshwater habitat that was occasionally subject to elevated salinity levels as the salt wedge migrated up the Estuary during both open and perched conditions (Figure 4.1.9). The bottom sonde at Freezeout Creek had a mean salinity concentration of 0.3 ppt and salinity levels that ranged from 0.1 to 4.8 ppt, while the mid-depth sonde at Freezeout Creek had a mean concentration of 0.1 ppt and a maximum concentration of 1.1 ppt (Table 4.1.1). Salinity concentrations at Freezeout Creek were significantly lower in 2011 than concentrations observed in 2009 or 2010 and were likely a result of the muted tidal cycles that occurred.

Willow Creek - Salinity and Russian River Flow 2011

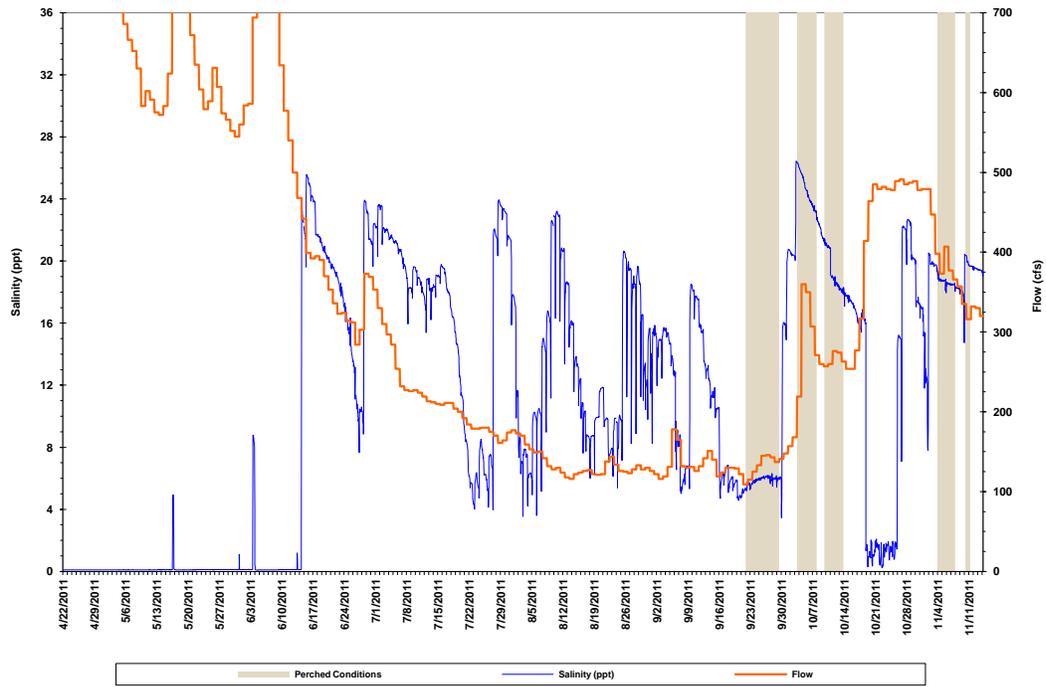


Figure 4.1.7. 2011 Willow Creek Salinity and Russian River Flow Graph

Russian River at Heron Rookery - Salinity and Flow 2011

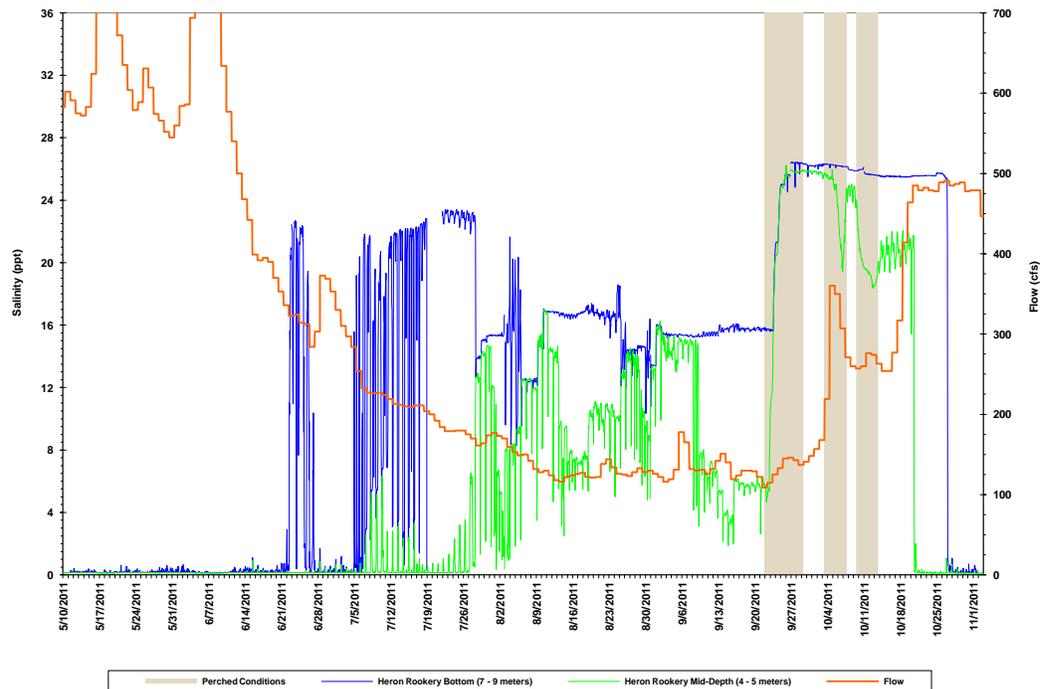


Figure 4.1.8. 2011 Russian River at Heron Rookery Salinity and Flow Graph

Russian River at Freezeout Creek - Salinity and Flow 2011

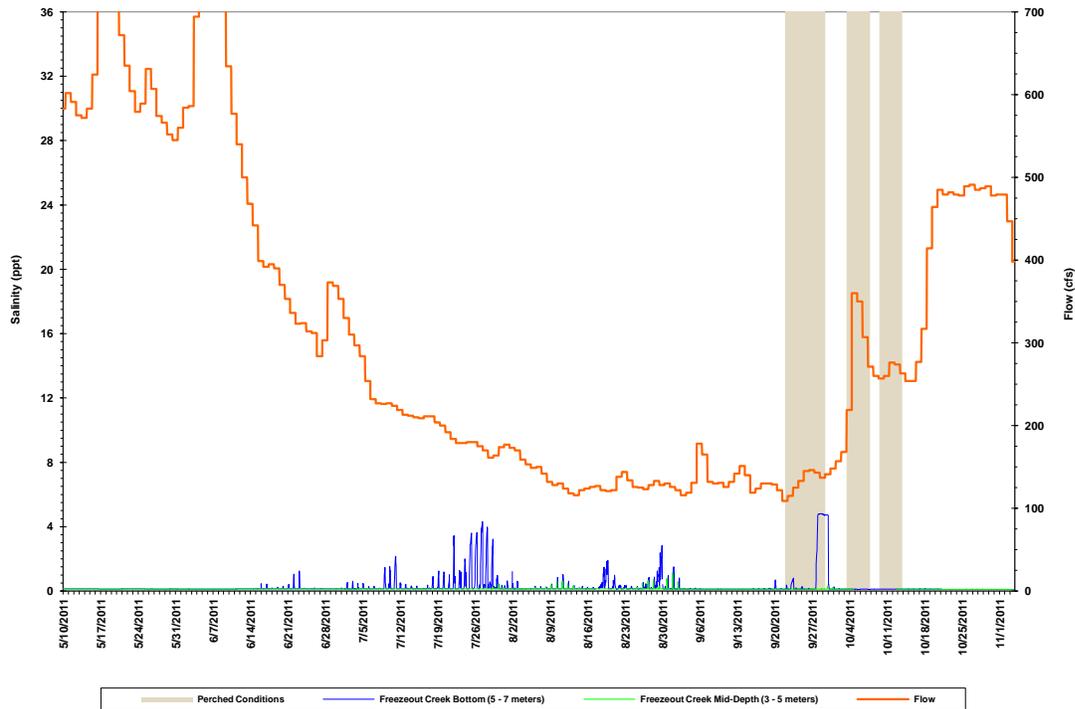


Figure 4.1.9. 2011 Russian River at Freezeout Creek Salinity and Flow Graph

The salt wedge migrated to the Heron Rookery station during open conditions in late-June when freshwater inflows decreased below approximately 350 cfs (Figure 4.1.8). A minor increase in salinity was observed at the Freezeout Creek station at the same time, but concentrations were only observed at the bottom sonde and only briefly increased to approximately 1 ppt before returning to fully fresh conditions. A brief surge in flow at the end of June pushed the salt wedge out of the Heron Rookery station until flows receded below 300 cfs on 5 July, at which point brackish conditions became persistent in the deep pool until late October. The salt wedge was also observed to periodically migrate into the bottom of the Freezeout Creek station as freshwater inflows decreased below 200 cfs in mid-July, and continued through August when flows were as low as 125 cfs. (Figure 4.1.9). However, salinity concentrations remained below 5 ppt during open conditions and were observed to return to freshwater levels on a daily basis, whereas salinity concentrations remained brackish at the Heron Rookery station during open conditions.

Salinity was observed to increase and persist at the Heron Rookery station during first perched event in September as the salt layer stratified and flattened out underneath the developing freshwater layer. Salinity remained elevated at the Heron Rookery bottom sonde during the second and third perching events, but was observed to fluctuate at the mid-depth sonde. Salinity was also observed to increase at the Freezeout Creek bottom sonde during during the first perched event, however concentrations remained below 5 ppt at the bottom sonde and 1 ppt at mid-depth sonde. Salinity was then observed to decrease to less than 1ppt (<1ppt) at

both Freezeout Creek sondes a day after the first perched event ended and remain fresh for the rest of the monitoring season, including the next two perched events (Figure 4.1.9). The mid-depth at Heron Rookery transitioned to freshwater habitat when flows increased to approximately 500 cfs following early season storms on 21 October, and the bottom became freshwater habitat six days later on 27 October as flows remained around 500 cfs (Figure 4.1.8).

The Brown's Pool sonde was located at the bottom of a deep hole in the mainstem just downstream of Austin Creek at the most upstream extent of the upper reach of the estuary. The mainstem above Brown's Pool is considered to be part of the maximum backwater area. Salinity was observed to increase slightly over the monitoring period, however the maximum concentration observed was only 0.4 ppt and the mean concentration was 0.2 ppt (Figure 4.1.10).

Maximum Backwater Area Salinity

Three stations were located in the maximum backwater area, including one tributary station located in lower Austin Creek and two mainstem Russian River stations, one located at Villa Grande and the other located in Monte Rio (Figure 4.1.1). None of the three stations in the maximum backwater area were observed to have salinity levels above normal background conditions expected in freshwater habitat, during both open and perched conditions. All three stations had mean salinity concentrations of 0.1 ppt, with concentrations ranging from 0.1 to 0.2 ppt (Table 4.1.1).

Temperature

During open estuary conditions, mainstem water temperatures were reflective of the halocline, with lower mean and maximum temperatures typically being observed in the saline layer at the bottom and mid-depth sondes compared to temperatures recorded in the freshwater layer at the mid-depth and surface sondes (Figures 4.1.11 through 4.1.16). The differences in temperatures between the underlying saline layer and the overlying freshwater layer can be attributed in part to the source of saline and fresh water. During open estuary conditions, the Pacific Ocean, where temperatures are typically around 10 degrees C, is the source of saltwater in the Estuary. Whereas, the mainstem Russian River, with water temperatures reaching as high as 26 degrees C in the interior valleys, is the primary source of freshwater in the Estuary.

During perched conditions, increasing temperatures associated with fresh/saltwater stratification were observed to occur, though not as significantly as has been observed in past years under closed barrier beach conditions (Figures 4.1.11 through 4.1.13 and 4.1.15). Density and temperature gradients between freshwater and saltwater play a role in stratification and serve to prevent/minimize mixing of the freshwater and saline layers. When the estuary is closed, or the river mouth is perched and the supply of cool tidal inflow is reduced, solar radiation heats the underlying saline layer. In addition, the overlying surface freshwater layer restricts the release of this heat, which can result in higher water temperatures in the underlying saline layer than in the overlying freshwater layer. This effect was very minimal in 2011, due to a lack of complete barrier beach closures, and perched conditions that occurred late in the season when the effects of solar heating were reduced. In past years when the

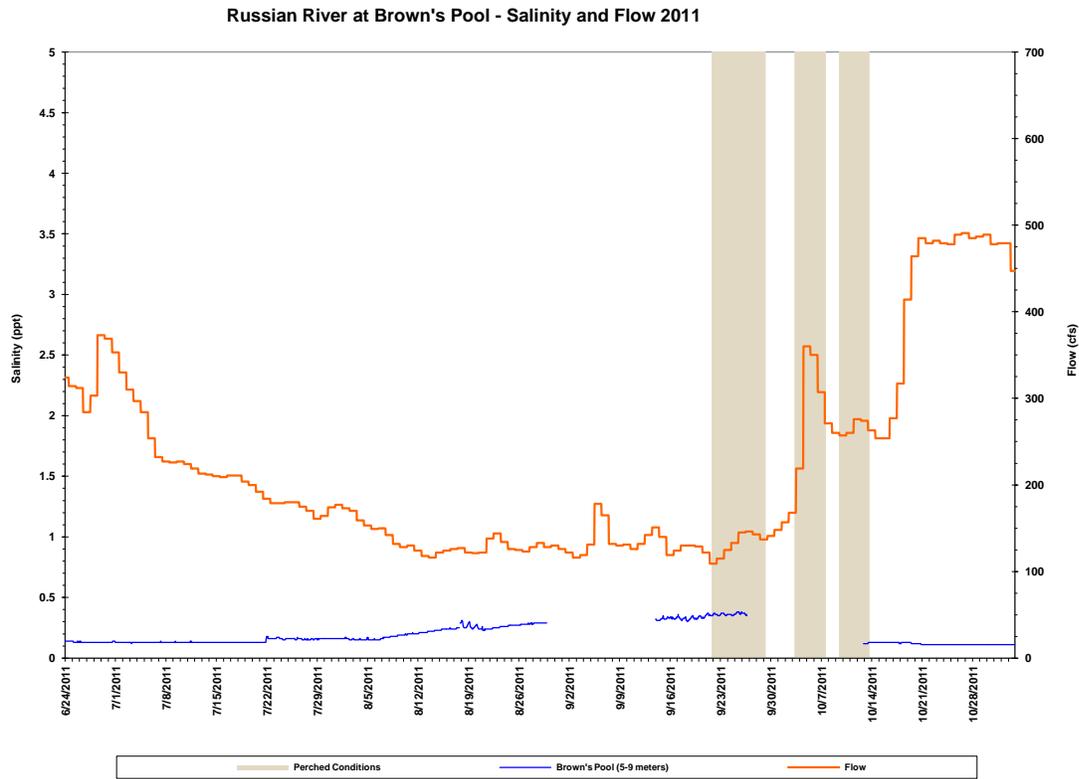


Figure 4.1.10. 2011 Russian River at Brown's Pool Salinity and Flow Graph

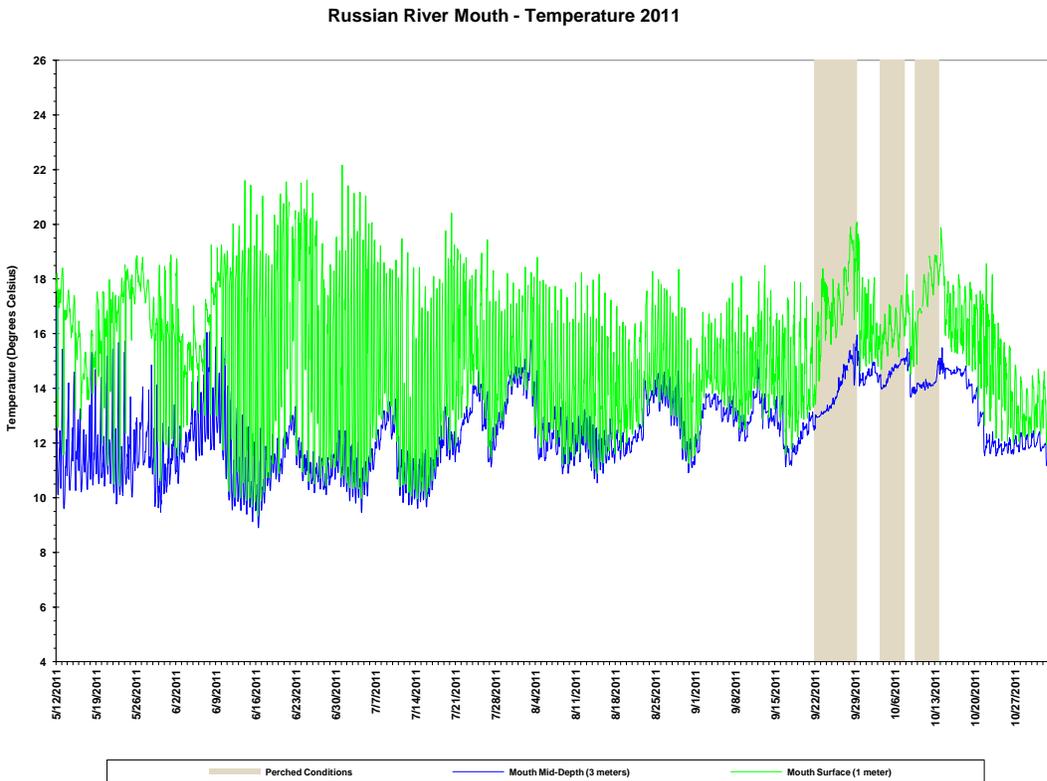


Figure 4.1.11. 2011 Russian River Mouth Temperature Graph

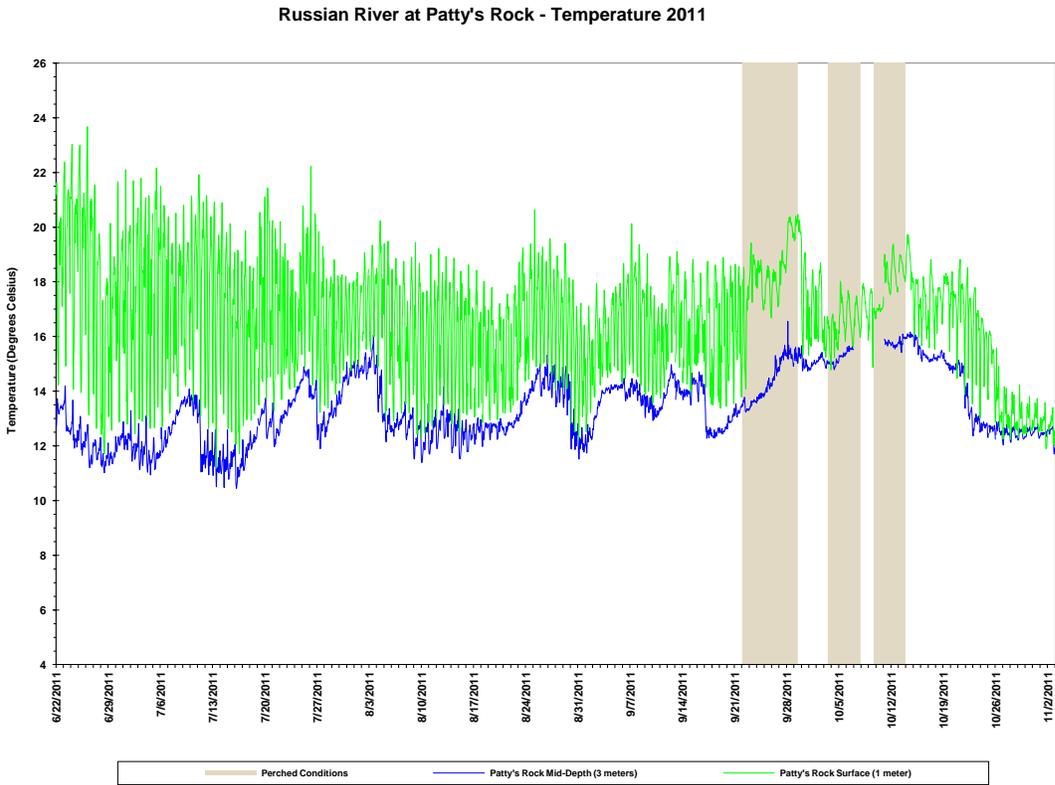


Figure 4.1.12. 2011 Russian River at Patty's Rock Temperature Graph

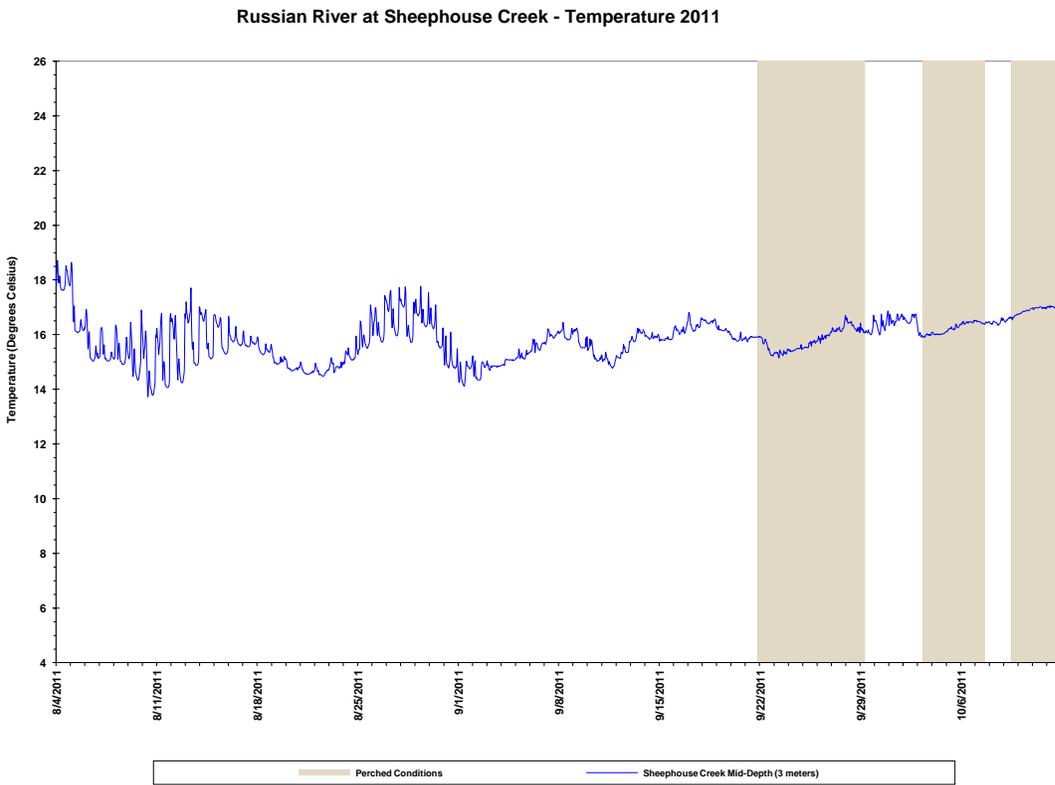


Figure 4.1.13. 2011 Russian River at Sheephouse Creek Temperature Graph

Willow Creek - Temperature with Salinity 2011

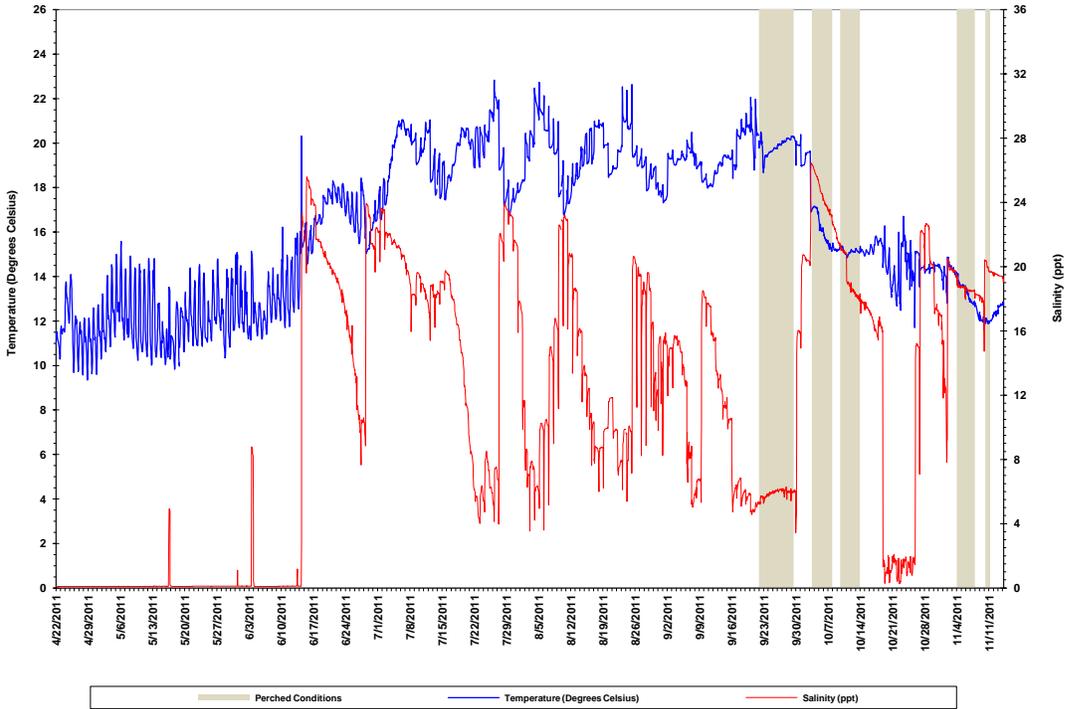


Figure 4.1.14. 2011 Willow Creek Temperature with Salinity Graph

Russian River at Heron Rookery - Temperature and Flow 2011

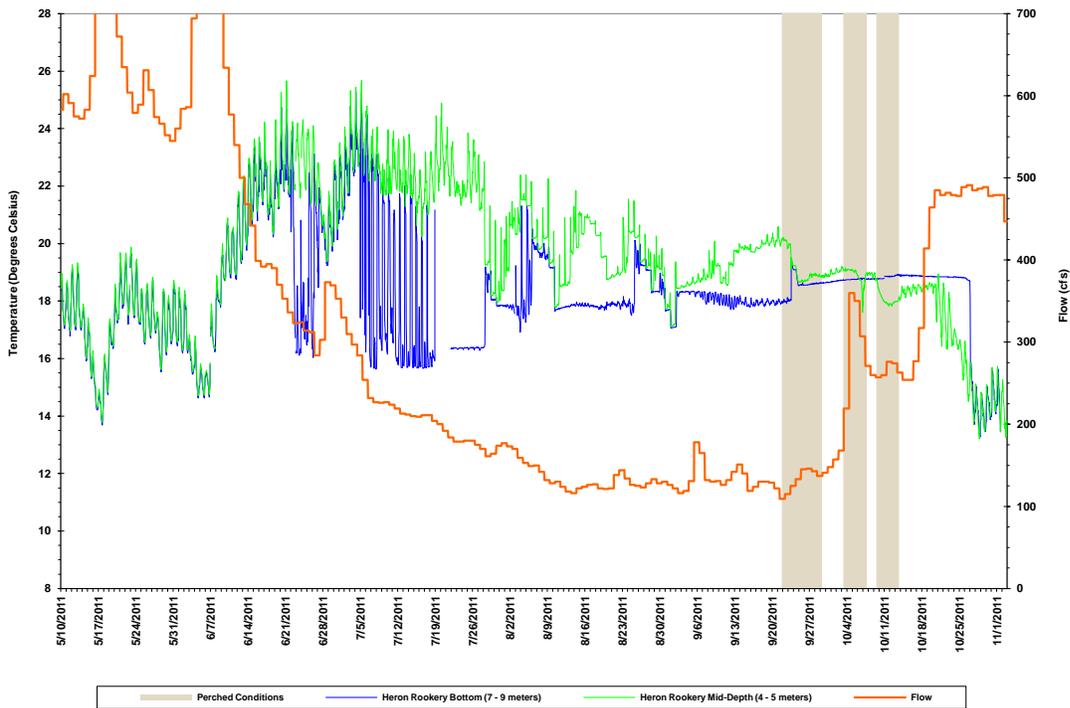


Figure 4.1.15. 2011 Russian River at Heron Rookery Temperature and Flow Graph

Russian River at Freezeout Creek - Temperature and Flow 2011

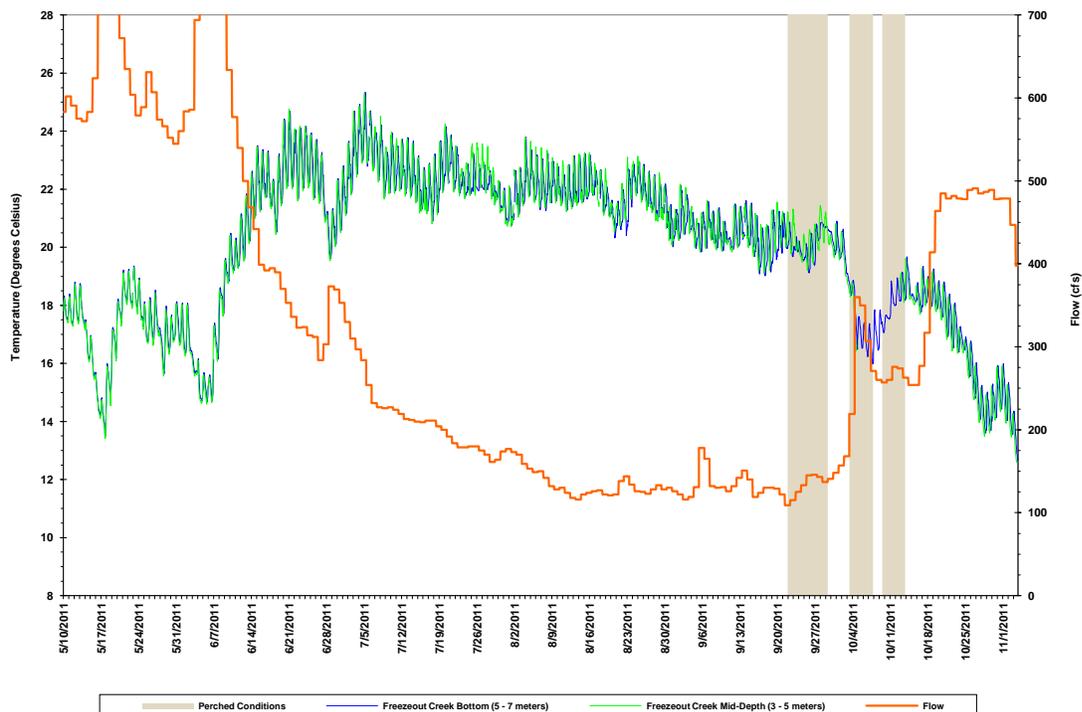


Figure 4.1.16. 2011 Russian River at Freezeout Creek Temperature and Flow Graph

barrier beach formed completely, stratification based heating was also observed to result in higher temperatures in the mid-depth saline layer compared to the bottom layer in deep pools, forming a three layered system. This stratification-based heating can also contribute to higher seasonal mean temperatures in the saline layer than would be expected to occur under open conditions.

Lower and Middle Reach Temperature

The surface sondes were located at the freshwater/saltwater interface and were observed to have maximum temperatures of 22.2 and 23.7 degrees C at the Mouth and Patty’s Rock, respectively. Whereas, the mid-depth sondes were located primarily in saltwater and had maximum temperatures of 17.0, 20.3, and 18.7 degrees C at the Mouth, Patty’s Rock, and Sheephouse Creek, respectively (Table 4.1.1). The surface sondes had mean temperatures of 15.2 and 16.6 degrees C and minimum temperatures of 9.3 and 11.2 degrees C at the Mouth and Patty’s Rock, respectively (Table 4.1.1). The mid-depth sondes had mean temperatures of 12.4, 13.4, and 15.8 degrees C, and minimum temperatures of 8.9, 10.5, and 13.7 degrees C at the Mouth, Patty’s Rock, and Sheephouse Creek, respectively (Table 4.1.1).

The Willow Creek sonde was located in predominantly freshwater habitat until flows dropped in the creek and flows in the Russian River dropped to approximately 450 cfs (measured at Hacienda) in mid-June. At this point, the station transitioned to a brackish system, with salinity levels fluctuating throughout the season associated with the tidal cycle. Although temperatures

were observed to increase, on average, through the summer season, temperatures were also observed to temporarily decrease when a given tidal cycle pushed a fresh source of cool saline water to the station (Figure 4.1.14). Conversely, the first significant migration of saline water to the station in mid-June was warmer than the freshwater it mixed with, resulting in a temporary spike in temperature from approximately 16 degrees C to almost 21 degrees C before returning to 16 degrees C. The Willow Creek Station had a maximum temperature of 22.8 degrees C, which occurred in brackish water during open conditions in late-July. The mean temperature at the site was 16.3 degrees C, and the minimum temperature recorded was 9.4 degrees C (Table 4.1.1). Minimum temperatures were observed at the beginning of the monitoring period during periods of cooler weather and elevated storm flows that contributed cooler freshwater into the system. Maximum temperatures were observed mid-season in brackish water. Temperature response to perched conditions was variable and dependent on the relative temperature of the saline layer migrating into and out of the station from the mainstem.

Upper Reach Temperature

Overall estuarine temperatures in both the saline layer and freshwater layer were typically hottest at the upper reach stations, as recorded at Heron Rookery and Freezeout Creek, and became progressively cooler as the water flowed downstream, closer to the cooling effects of the coast and ocean.

The bottom sondes at Heron Rookery and Freezeout Creek had maximum temperatures of 25.3 degrees C, minimum temperatures of 13.2 and 12.7 degrees C, and mean temperatures of 18.3 and 19.9 degrees C, respectively (Table 4.1.1). The mid-depth sondes at Heron Rookery and Freezeout Creek had maximum temperatures of 25.7 and 25.3 degrees C, minimum temperatures of 13.2 and 12.6 degrees C, and mean temperatures of 19.4 and 20.1 degrees C, respectively (Table 4.1.1). The lower mean temperatures at Heron Rookery were due in part to the presence of cooler saline water during open conditions that was not present at the Freezeout Creek station with as much frequency (Figures 4.1.15 and 4.1.16).

Heron Rookery experienced brackish conditions at both sondes beginning in early July, with higher concentrations typically observed at the bottom sonde. Temperatures at the station were affected by the presence of salinity and were typically cooler in the saline layer at the bottom of the water column during open conditions. Stratification related heating of the saline layer was observed during the series of perched events and temperatures at the bottom of Heron Rookery remained higher than at mid-depth as cool freshwater from early October storm flows mixed with the shallower salt layer (Figures 4.1.8 and 4.1.15). Storm flows eventually replaced the saline water with cooler freshwater and temperatures were observed to decrease at both sondes by the end of October.

Freezeout Creek remained primarily freshwater throughout the monitoring season, with only a few brief increases in salinity at the bottom sonde in July and August that did not exceed 5 ppt (Figure 4.1.9). These brief increases in salinity were not observed to result in any significant changes to water temperatures as temperatures were nearly identical at both sondes during these periods (Figure 4.1.16).

The Brown's Pool station had a maximum temperature of 25.5 degrees C, a mean temperature of 20.7 degrees C, and a minimum temperature of 13.8 degrees C. Perched conditions did not appear to have a significant effect on water temperatures at this station. Slight increases in water temperature during the first perched event coincided with increases in air temperatures, including a maximum air temperature of approximately 97 degrees Fahrenheit on 28 September. Likewise, decreases in water temperature during the second perched event were associated with a brief storm event, as temperatures were observed to increase after storm flows receded (Figure 4.1.17).

Maximum Backwater Area Temperature

Austin Creek had a maximum temperature of 22.4 degrees C, a mean temperature of 16.0 degrees C, and a minimum temperature of 9.2 degrees C. Perched conditions were not observed to have a significant effect on water temperatures at this station. Slight increases in water temperature during the first perched event coincided with increases in air temperatures. Likewise, decreases in water temperature during the second perched event were associated with a brief storm event, as temperatures were observed to increase to near pre-storm levels after flows receded. In addition, the diurnal cycle of heating and cooling was observed to increase during and after the second and third perched events when freshwater inflows increased from their lowest point (<2 cfs) of the season and the station was no longer in an isolated pool (Figure 4.1.18).

The Villa Grande station had a maximum temperature of 25.9 degrees C, a mean temperature of 20.1 degrees C, and a minimum temperature of 13.4 degrees C. Perched conditions were not observed to have a significant effect on water temperatures at this station. Slight increases in water temperature during the first perched event coincided with increases in air temperatures. Likewise, decreases in water temperature during the second perched event were associated with a brief storm event and temperatures were observed to increase after flows receded (Figure 4.1.19).

The Monte Rio station had a maximum temperature of 26.2 degrees C, a mean temperature of 20.1 degrees C, and a minimum temperature of 13.4 degrees C, with maximum temperatures being observed during open conditions (Figure 4.1.20). Perched conditions were not observed to have a significant effect on water temperatures at this station, similar to the other maximum backwater area stations. Slight increases in water temperature during the first perched event coincided with increases in air temperatures. Likewise, decreases in water temperature during the second perched event were associated with a brief storm event and temperatures were observed to increase after flows receded (Figure 4.1.20).

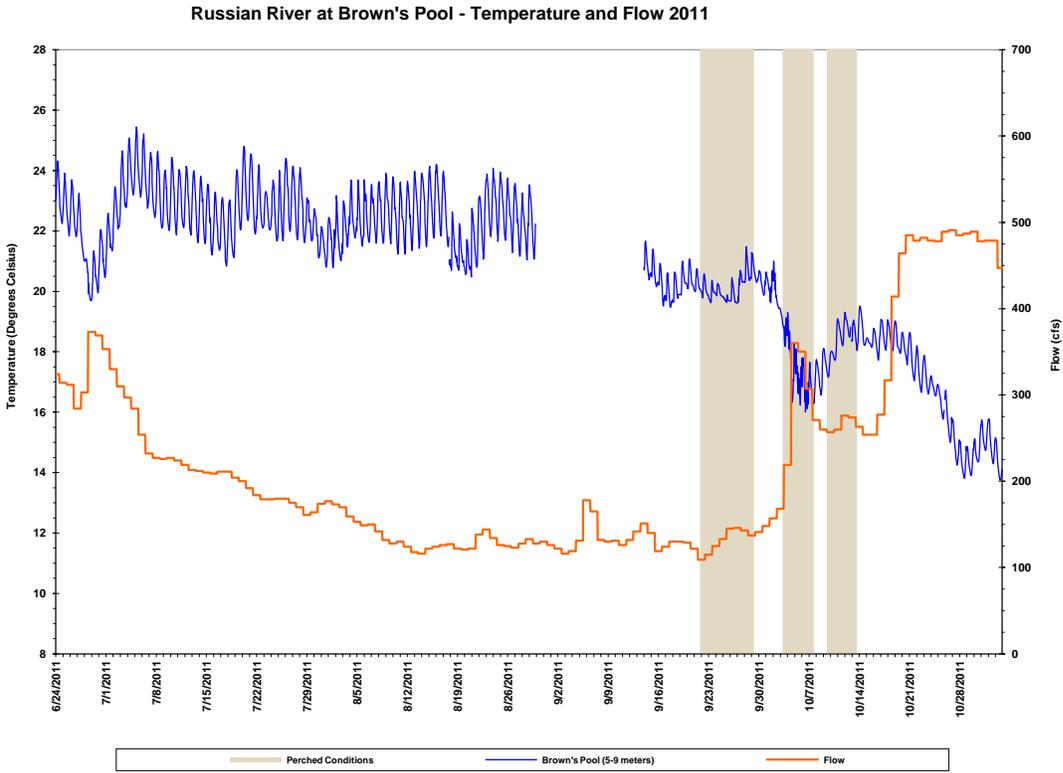


Figure 4.1.17. 2011 Russian River at Brown's Pool Temperature and Flow Graph

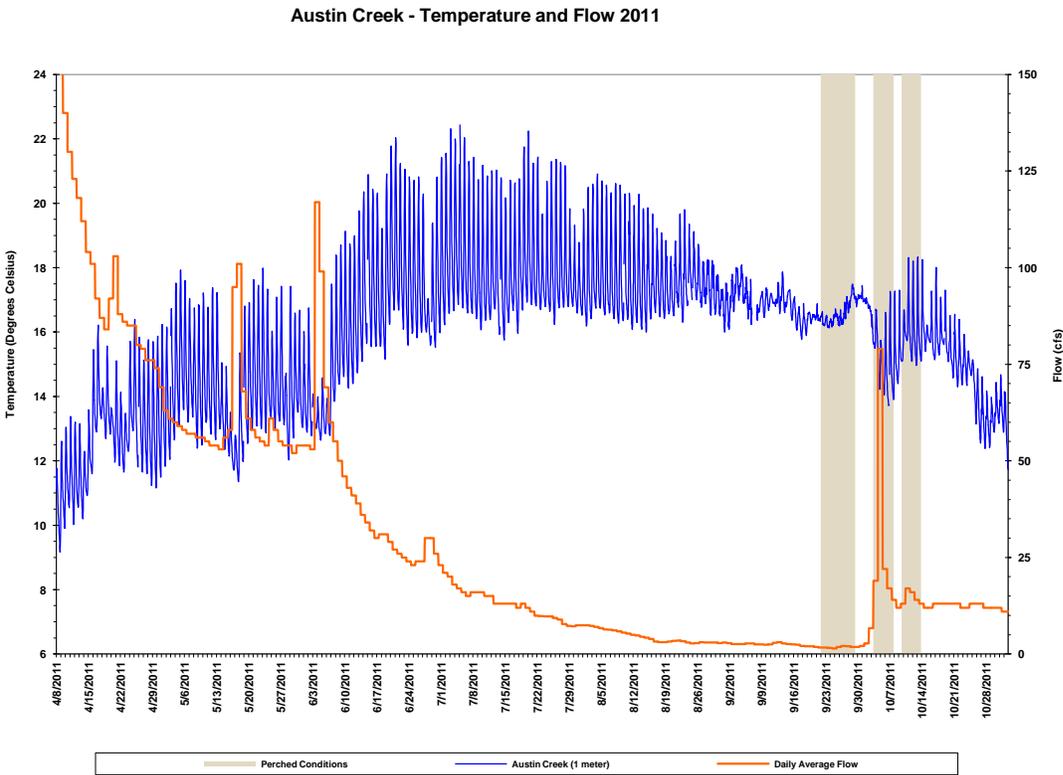


Figure 4.1.18. 2011 Austin Creek Temperature and Flow Graph

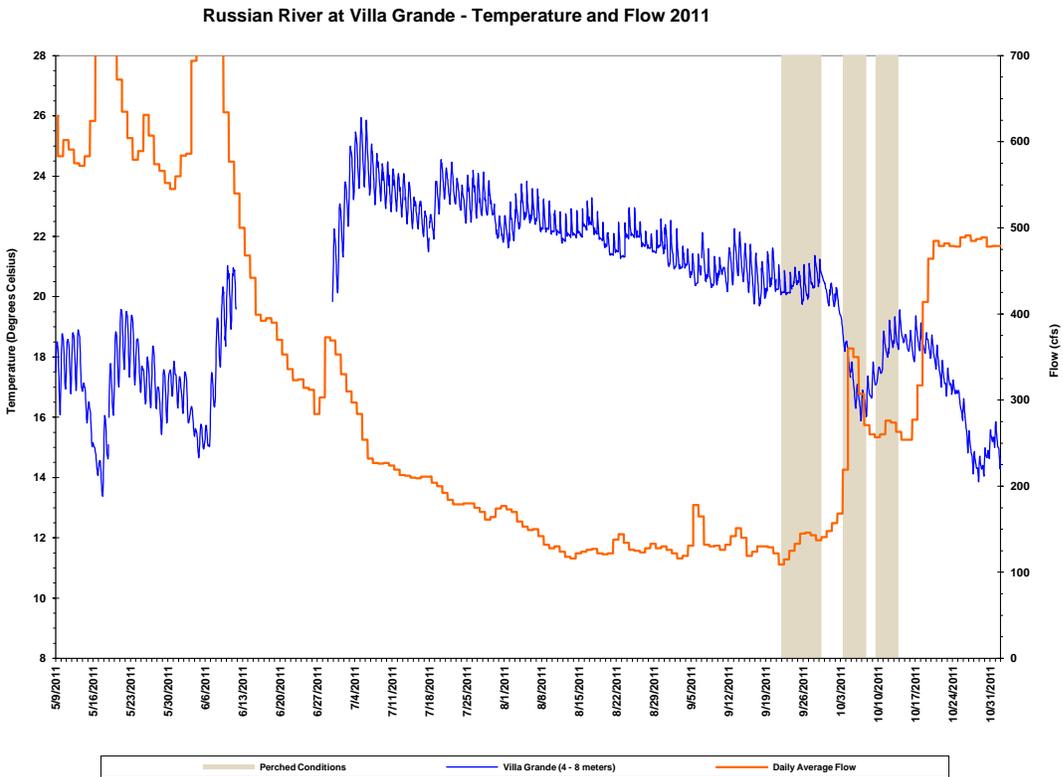


Figure 4.1.19 2011 Russian River at Villa Grande Temperature and Flow Graph

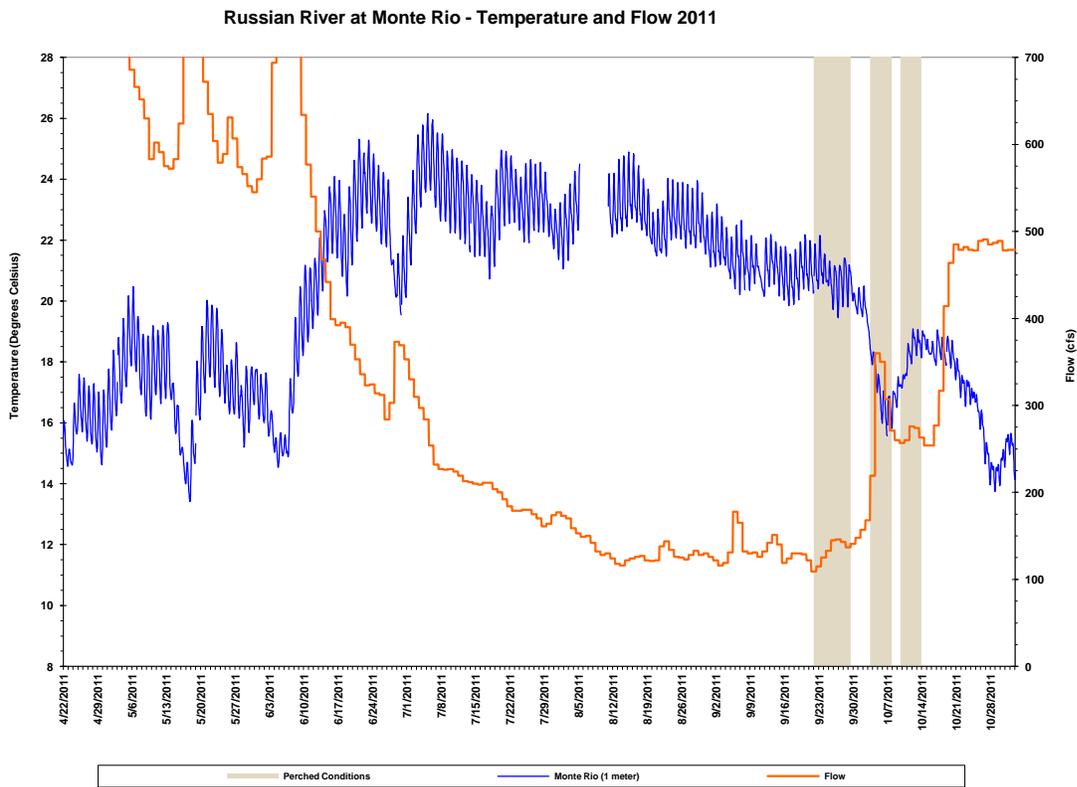


Figure 4.1.20. 2011 Russian River at Monte Rio Temperature and Flow Graph

Dissolved Oxygen

Dissolved oxygen (DO) levels in the Estuary, including the maximum backwater area, depend upon factors such as the extent of diffusion from surrounding air and water movement, including freshwater inflow. DO is affected by salinity and temperature stratification, tidal and wind mixing, abundance of aquatic plants, and presence of decomposing organic matter. DO affects fish growth rates, embryonic development, metabolic activity, and under severe conditions, stress and mortality. Cold water has a higher saturation point than warmer water; therefore cold water is capable of carrying higher levels of oxygen.

DO levels are also a function of nutrients, which can accumulate in water and promote plant and algal growth that both consume and produce DO during photosynthesis and respiration. Estuaries tend to be naturally eutrophic because land-derived nutrients are concentrated where runoff enters the marine environment in a confined channel⁵. Upwelling in coastal systems also promotes increased productivity by conveying deep, nutrient-rich waters to the surface, where the nutrients can be assimilated by algae. Excessive nutrient concentrations and plant, algal, and bacterial growth can overwhelm eutrophic systems and lead to a reduction in DO levels that can affect the overall ecological health of the Estuary.

Dissolved oxygen concentrations in the lower and middle reaches were generally higher at the surface sondes compared to the mid-depth sondes at a given sampling station (Table 4.1.1). Supersaturation conditions at the surface sondes and hypoxic conditions at the mid-depth sondes contributed to this difference. Supersaturation events were most significant during open conditions (Figures 4.1.21 through 4.1.23). Although the mid-depth sondes typically experienced less significant and less frequent supersaturation events than the corresponding surface sondes; mid-depth concentrations were observed to periodically exceed surface concentrations during both open and perched conditions (Figures 4.1.21 and 4.1.22).

Dissolved oxygen concentrations in Willow Creek were reflective of the presence of salinity, with higher mean values being observed in freshwater habitat and lower mean values being observed in saline conditions. DO concentrations were observed to remain relatively stable under freshwater conditions, whereas concentrations were observed to become hypoxic to anoxic in the presence of saline water, most significantly during perched conditions in late September and October (Figure 4.1.23).

Dissolved oxygen concentrations in the upper reach were also reflective of the presence of salinity, with lower minimum and mean concentrations in saline water and higher minimum and mean values in freshwater conditions. The Heron Rookery station transitioned from predominantly freshwater to saline conditions by early July, whereas the Freezeout Creek station remained predominantly freshwater all season (Figures 4.1.24 and 4.1.25). DO concentrations in the upper reach saline layer were also observed to be lower during both open and perched conditions, than DO concentrations observed in the saline layer in the lower and

⁵ *National Estuarine Eutrophication Assessment* by NOAA National Centers for Coastal Ocean Science (NCCOS) and the Integration and Application Network (IAN), 1999.

middle reaches. This effect was more pronounced at the bottom sondes with prolonged periods of hypoxia and anoxia observed to occur in the presence of salinity. This occurs as the saline layer becomes trapped at the bottom of deep holes where there is less circulation, especially further up in the estuary where the influence of the tidal cycle is reduced.

Lower and Middle Reach DO

The stations in the lower and middle reaches experienced significant fluctuations in DO concentrations during open and perched Estuary conditions, with supersaturation and/or hypoxic conditions being observed (Figures 4.1.21 through 4.1.23). The surface sondes were observed to have higher mean, maximum, and minimum DO concentrations when compared to the mid-depth sondes (Table 4.1.1). The surface sondes at the Mouth and Patty's Rock each had a mean DO concentration of 9.4 mg/L, whereas the mid-depth sondes had mean DO concentrations of 8.0, 7.4, and 7.3 mg/L at the Mouth, Patty's Rock, and Sheephouse Creek, respectively (Table 4.1.1).

The effect of perched conditions at the surface sondes was variable as DO concentrations were observed to remain unaffected, slightly decline, or increase in some instances. Although the surface sondes at the Mouth and Patty's Rock had minimum seasonal DO concentrations of 3.8 and 4.9 mg/L, these values did not coincide with any of the perching events (Table 4.1.1).

Short-term hypoxic and/or anoxic events observed during open conditions at some of the mid-depth sondes in 2009 were not observed to occur in 2011. However, DO concentrations at the mid-depth sondes were observed to decline during perched conditions in 2011 to hypoxic levels (Figures 4.1.21 and 4.1.22). Minimum concentrations were observed to be 1.9, 0.6, and 2.8 mg/L at the Mouth, Patty's Rock, and Sheephouse Creek, respectively (Table 4.1.1).

Interestingly, DO concentrations at all three mid-depth sondes were observed to initially increase and then decrease during the first perched event. This variability was associated with changes to circulation and/or stratification patterns in the saline layer at each given station (Figures 4.1.21 through 4.1.23). DO concentrations were observed to generally decrease at these stations during the second and third perched events and may have been partially affected by the downstream migration of hypoxic water from the Willow Creek and/or Heron Rookery areas between perching events. DO concentrations were generally observed to recover within a few days of the barrier beach reopening.

The lower and middle reach surface sondes, and mid-depth sondes to a lesser degree, also experienced hourly fluctuating supersaturation events. At times when oxygen production exceeds the diffusion of oxygen out of the system, supersaturation may occur (Horne, 1994). DO concentrations exceeding 100% saturation in the water column are considered supersaturated conditions. Because the ability of water to hold oxygen changes with temperature, there are a range of concentration values that correspond to 100% saturation. For instance, at sea level, 100% saturation is equivalent to approximately 11 mg/L at 10 degrees C, but only 8.2 mg/L at 24 degrees C. Consequently, these two temperature values roughly represent the range of temperatures typically observed in the Estuary.

Russian River Mouth - Dissolved Oxygen and Flow 2011

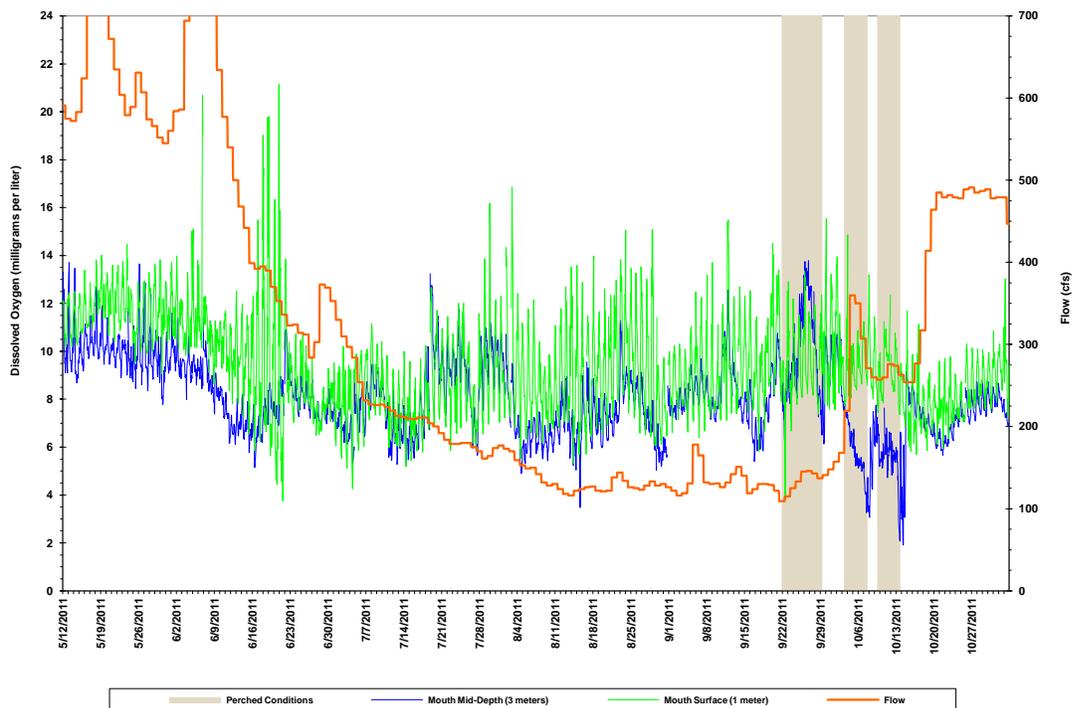


Figure 4.1.21. 2011 Russian River Mouth Dissolved Oxygen and Flow Graph

Russian River at Patty's Rock - Dissolved Oxygen and Flow 2011

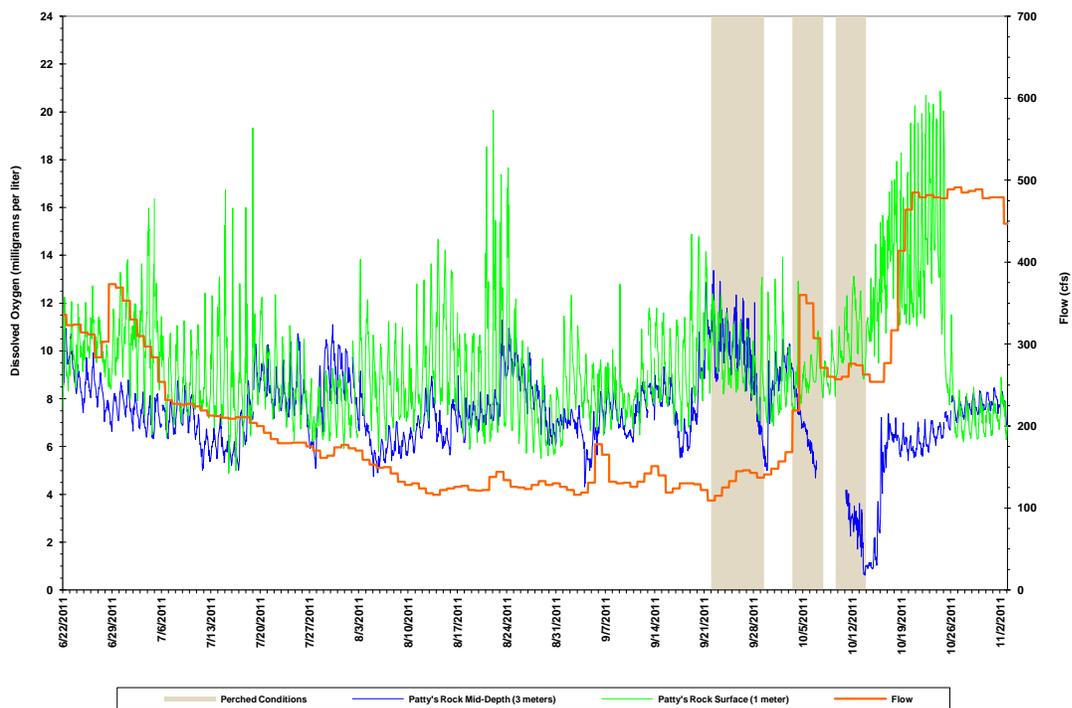


Figure 4.1.22. 2011 Russian River at Patty's Rock Dissolved Oxygen and Flow Graph

Russian River at Sheephouse Creek - Dissolved Oxygen and Flow 2011

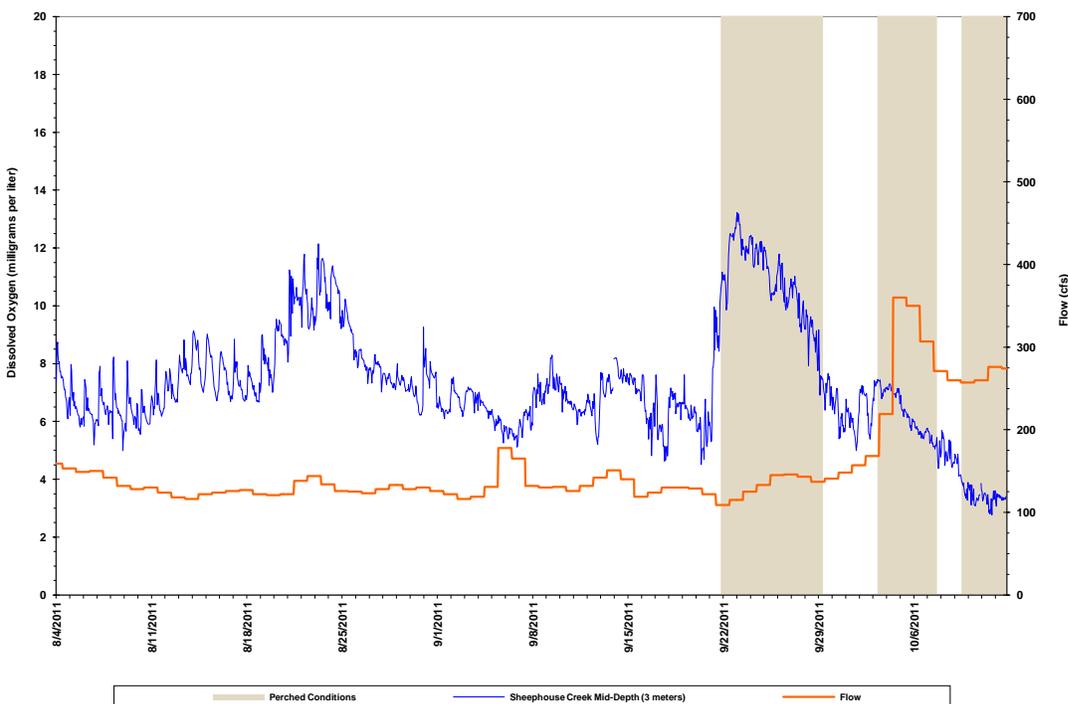


Figure 4.1.23. 2011 Russian River at Sheephouse Creek Dissolved Oxygen and Flow Graph

The most significant supersaturation events were observed at the surface sondes during open estuary conditions, with the most prolonged period occurring at Patty’s Rock (Figures 4.1.21 and 4.1.22). The maximum DO concentration at the Mouth Surface Sonde was approximately 21.1 mg/L, which corresponded to 245% saturation. The maximum DO concentration at the Patty’s Rock surface sonde was 20.9 mg/L, or 232% saturation (Table 4.1.1). Maximum DO concentrations at the Mid-Depth sondes were approximately 13.8 mg/L (155%) at the Mouth, 13.4 mg/L (156%) at Patty’s Rock, and 13.2 mg/L (158%) at Sheephouse Creek, respectively.

The Willow Creek sonde had a mean DO concentration of 6.0 mg/L, a maximum concentration of 13.5 mg/L (155%), and a minimum concentration of 0.0 mg/L (Table 4.1.1). Minimum values were observed to occur in brackish to saline water, with more pronounced hypoxic to anoxic conditions being observed during and between perched events (Figure 4.1.24).

Willow Creek - Dissolved Oxygen and Salinity 2011

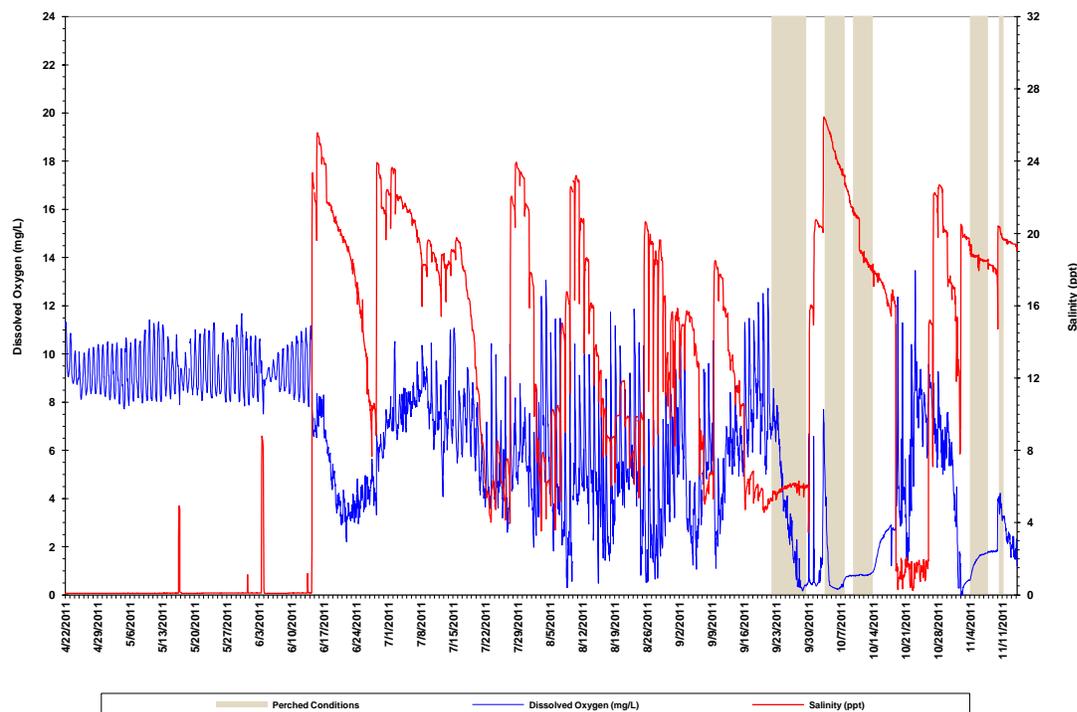


Figure 4.1.24. 2011 Willow Creek Dissolved Oxygen and Salinity Graph

Upper Reach DO

The mid-depth sondes at Heron Rookery and Freezeout Creek had mean DO concentrations of 7.3 and 8.5 mg/L, maximum concentrations of 16.3 and 12.5 mg/L (199% and 151%), and minimum concentrations of 0.0 mg/L (Table 4.1.1). The bottom sondes at Heron Rookery and Freezeout Creek had mean DO concentrations of 3.8 and 8.4 mg/L, maximum concentrations of 16.7 and 13.3 mg/L (204% and 153%), and minimum concentrations of 0.0 and 5.4 mg/L, respectively (Table 4.1.1).

Mean DO concentrations at the Heron Rookery mid-depth sonde were consistent with mean concentrations in the lower and middle reaches, however the mid-depth saline layer at Heron Rookery experienced more significant fluctuations, including supersaturation and anoxic conditions, than the mid-depth saline layer in the lower and middle reaches (Table 4.1.1). During open conditions, DO levels at Heron Rookery were observed to periodically become hypoxic and anoxic in the saline layer at the bottom sonde and at the mid-depth sonde to a lesser degree (Figure 4.1.25). DO was observed to decline as salinity increased and then increase when the salt wedge was replaced by or mixed with freshwater.

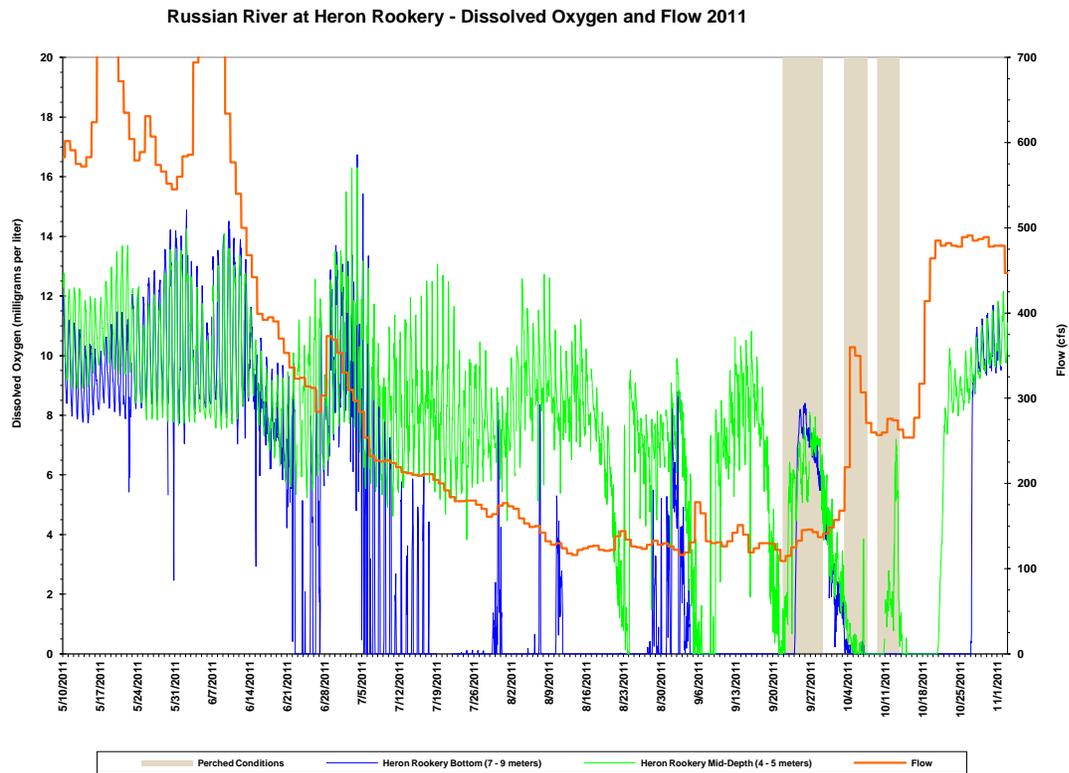


Figure 4.1.25. 2011 Russian River at Heron Rookery Dissolved Oxygen and Flow Graph

The Freezeout Creek mid-depth sonde had higher minimum and mean concentrations than mid-depth sondes in the lower and middle reaches, but lower maximum concentrations. As mentioned in the salinity section, the mid-depth sonde at Freezeout Creek was located in freshwater all season, which likely contributed to less frequent and significant hypoxic and anoxic events compared with those observed in the predominantly saline environment of the lower and middle reaches of the estuary. However, DO was observed to become hypoxic and anoxic at the Freezeout Creek bottom sonde during open conditions when saline water was present (Figure 4.1.26).

DO response to perched events was variable and dependent on the presence and movement of salinity. The presence of salinity would typically coincide with the presence of depressed DO levels, but not always, suggesting that variability is dependent on migration of the salt wedge, changes in the length of time of perched conditions, the timing of subsequent perched events, freshwater inflow rates and subsequent tidal inundation and mixing. During the first perched event, DO levels at Heron Rookery bottom and mid-depth sondes initially became hypoxic to anoxic before an oxygenated wedge of saline water migrated into the pool increasing both salinity and DO concentrations (Figures 4.1.8 and 4.1.25). Within a few days however, the saline layer began to stagnate and DO levels were observed to decline through the end of the first perched event and continue to remain hypoxic to anoxic through the second and third perched events. DO levels were not observed to recover at Heron Rookery until storm flows in mid-October pushed the salt layer out of the pool.

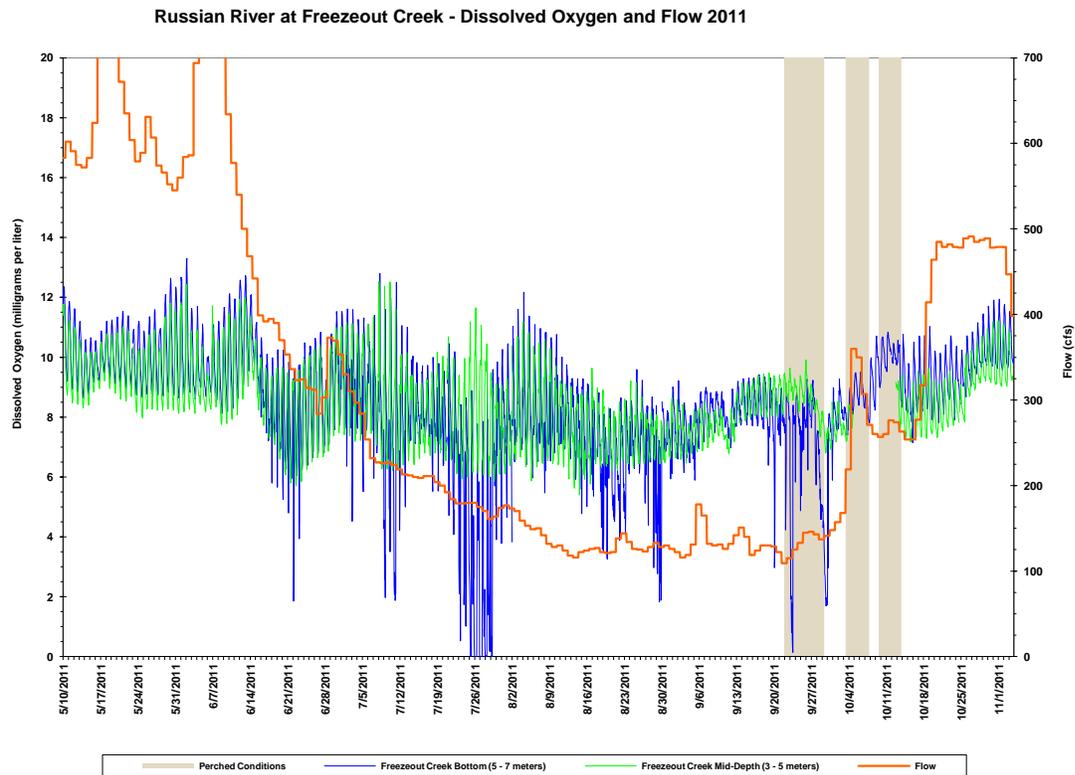


Figure 4.1.26. 2011 Russian River at Freezeout Creek Dissolved Oxygen and Flow Graph

The bottom sonde at Freezeout Creek experienced hypoxic conditions during the first perched event as saline water migrated to the station, whereas DO levels were observed to remain relatively unaffected in the presence of freshwater during the second and third perched events. DO levels were also observed to increase between and following perched events under freshwater conditions. Although the mid-depth sonde at Freezeout Creek was located in freshwater habitat through the entire monitoring season, DO levels were observed to decrease slightly during the first perched event as the underlying saline layer created hypoxic conditions at the bottom of the pool (Figures 4.1.9 and 4.1.26).

The Brown’s Pool station had a mean DO concentration of 8.7 mg/L, a maximum concentration of 14.1 mg/L (163%), and a minimum DO concentration of 4.5 mg/L (Table 4.1.1). The sonde was located in freshwater all season which likely contributed to the higher minimum values as compared to sondes located in saline water in the estuary. Dissolved oxygen concentrations were observed to remain relatively unaffected by perched conditions with minor increases observed during the first and third perched events. DO concentrations were also observed to initially increase during the second perched event until a brief increase in streamflow from approximately 160 cfs to 360 cfs occurred, at which point DO concentrations were observed to slightly decrease until flows receded (Figure 4.1.27).

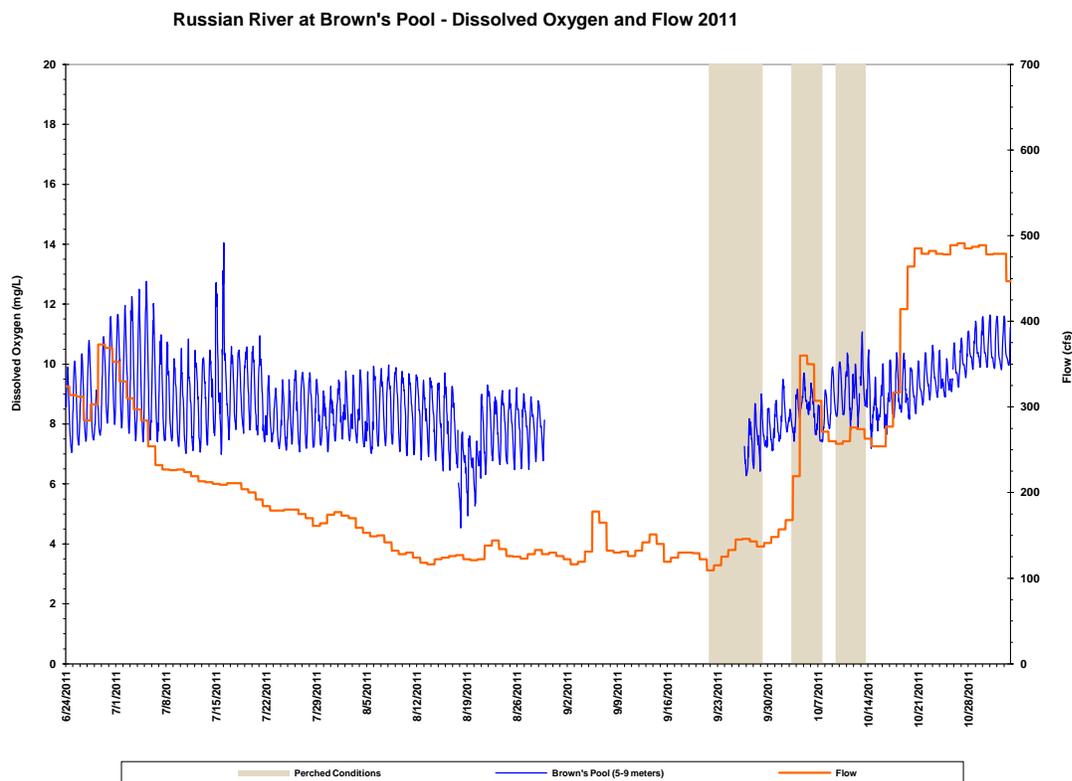


Figure 4.1.27. 2011 Russian River at Brown's Pool Dissolved Oxygen and Flow Graph

Maximum Backwater Area DO

The Austin Creek station had a mean DO concentration of 7.7 mg/L, a maximum concentration of 11.3 mg/L (110%), and a minimum concentration of 1.2 mg/L (Table 4.1.1). Minimum values were observed in late-September during both perched and open conditions while flow was intermittent (measured at less than 2 cfs at the upstream USGS gauging station) and the sonde was in a pool isolated from other pools (Figure 4.1.28). DO concentrations were observed to increase during the first perched event as the station became inundated, only to decrease back to hypoxic levels once perched conditions ended and the station became isolated from other pools. DO concentrations were then observed to increase to approximately 10 mg/L during the second perched event as storm flows briefly increased to about 80 cfs. Flows remained at about 15 cfs after the storm and DO concentrations were observed to remain above 6 mg/L through the end of the monitoring period, including during the third perched event (Figure 4.1.29).

The Villa Grande station had a mean DO concentration of 8.5 mg/L, a maximum concentration of 13.3 mg/L (155%), and a minimum concentration of 2.5 mg/L (Table 4.1.1). Supersaturation conditions were observed as spring flows receded in June. Minimum concentrations were observed during open conditions in August when flows decreased to approximately 125 cfs, however concentrations were observed to increase at the end of August, even though flows remained at about 125 cfs. DO concentrations did not appear to be significantly affected by perched conditions and remained above 7 mg/L, on average, during all three events (Figure

Austin Creek - Dissolved Oxygen and Flow 2011

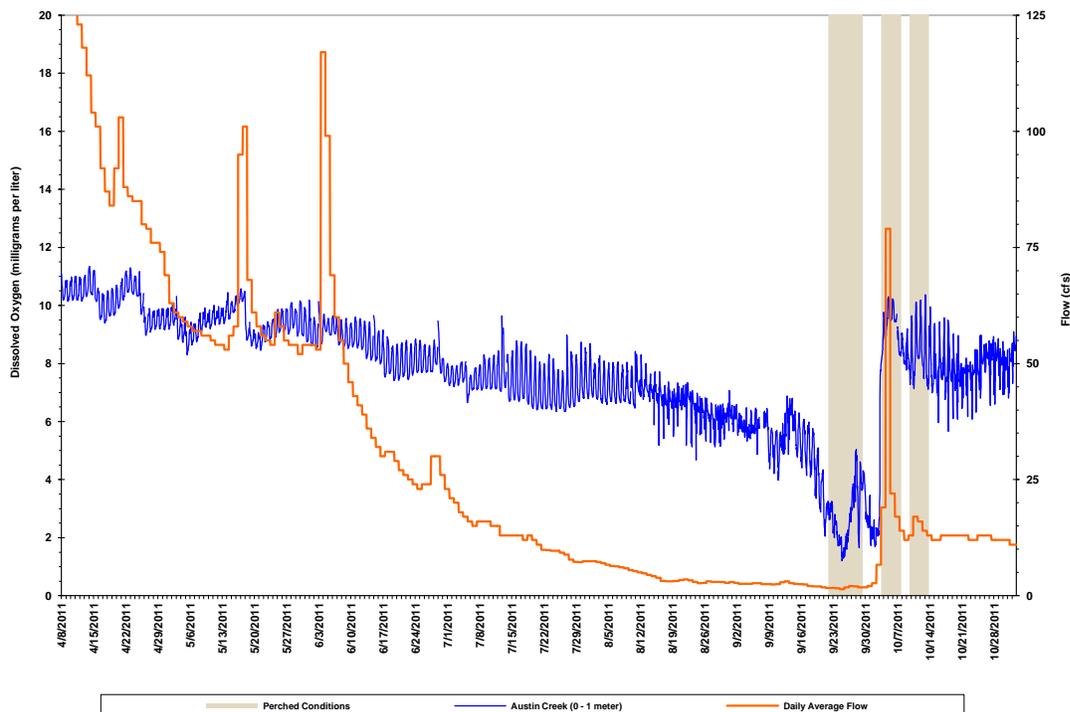


Figure 4.1.28. 2011 Austin Creek Dissolved Oxygen and Flow Graph

4.1.29). DO concentrations were also observed to increase between the second and third events following a brief storm that increased streamflows from approximately 150 to 250 cfs.

The Monte Rio Station had a mean DO concentration of 8.7 mg/L, a maximum concentration of 14.9 mg/L (178%), and a minimum concentration of 6.3 mg/L (Table 4.1.1). Supersaturation conditions were observed as storm flows receded in June. Minimum concentrations occurred during open conditions in July, when flows were approximately 250cfs. DO concentrations did not appear to be significantly affected by summer flows or perched conditions and remained above 8 mg/L, on average, during both open and perched conditions (Figure 4.1.30).

Russian River at Villa Grande - Dissolved Oxygen and Flow 2011

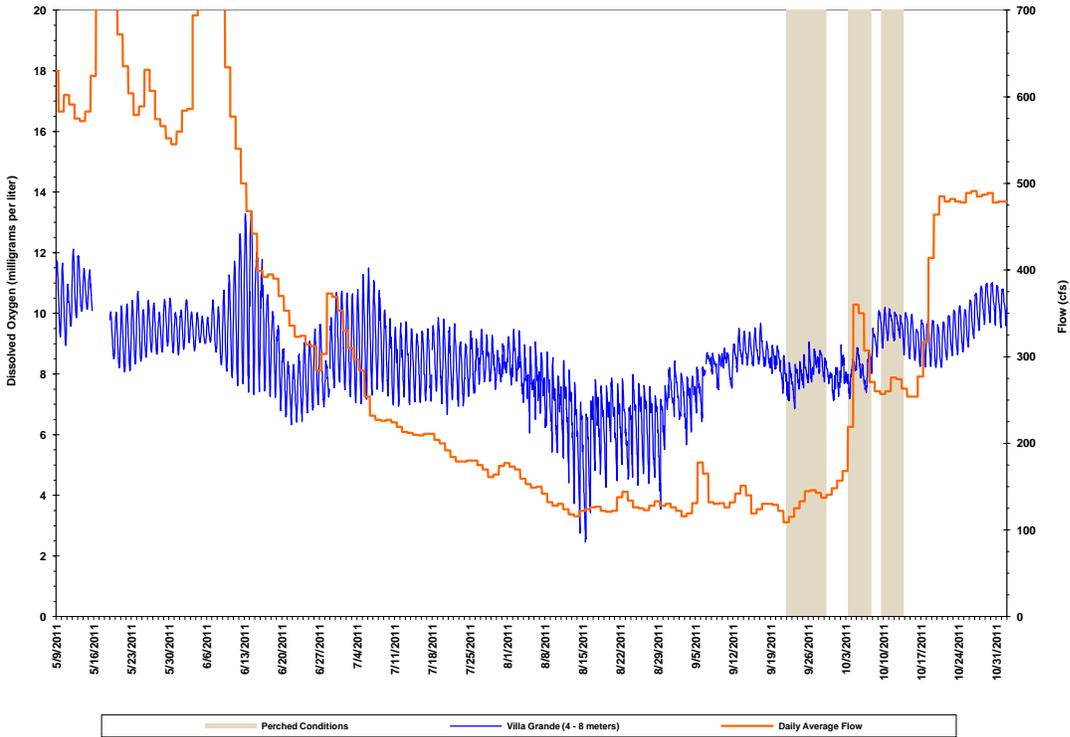


Figure 4.1.29. 2011 Russian River at Villa Grande Dissolved Oxygen and Flow Graph

Russian River at Monte Rio - Dissolved Oxygen and Flow 2011

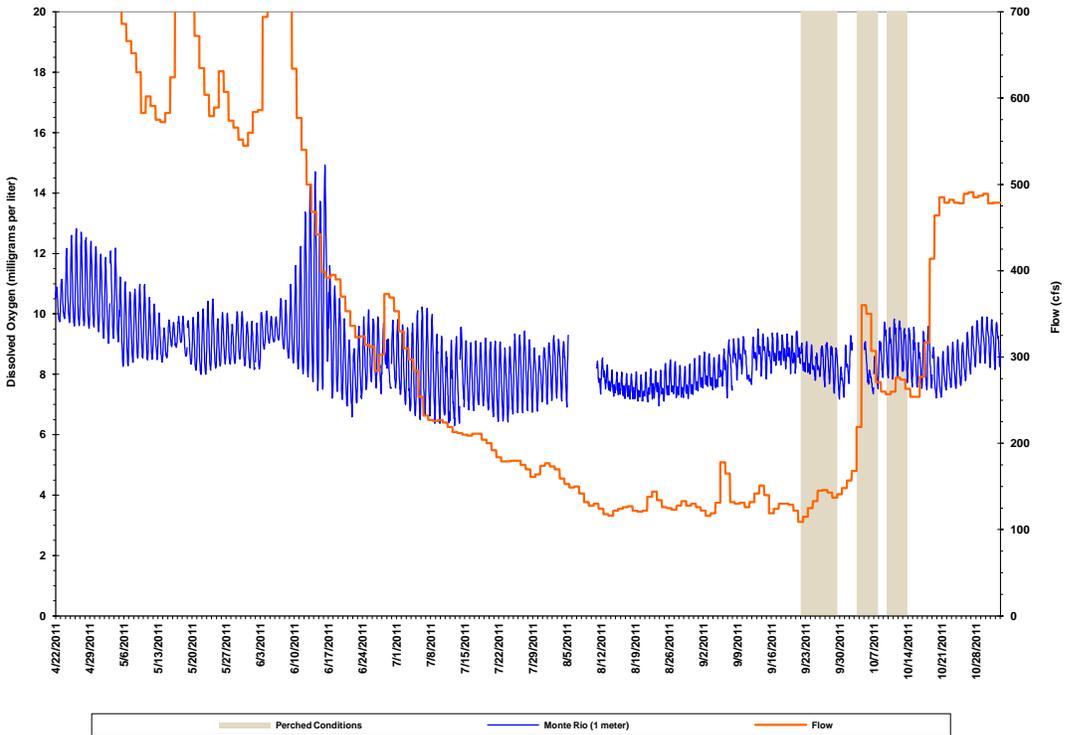


Figure 4.1.30. 2011 Russian River at Monte Rio Dissolved Oxygen and Flow Graph

Hydrogen Ion (pH)

The acidity or alkalinity of water is measured in units called pH, an exponential scale of 1 to 14 (Horne, 1994). Acidity is controlled by the hydrogen ion H^+ , and pH is defined as the negative log of the hydrogen ion concentration. A pH value of 7 is considered neutral, freshwater streams generally remain at a pH between 6 and 9, and ocean derived salt water is usually at a pH between 8 and 9. When the pH falls below 6 over the long term, there is a noticeable reduction in the abundance of many species, including snails, amphibians, crustacean zooplankton, and fish such as salmon and some trout species (Horne, 1994).

Lower and Middle Reach pH

Hydrogen ion (pH) values were fairly consistent among all stations at all depths in the lower and middle reaches, with mean values ranging from 7.9 pH at the Mouth, Patty's Rock, and Sheephouse Creek mid-depth sondes to 8.2 pH at the Mouth surface sonde (Table 4.1.1). Maximum pH values in the lower and middle reaches ranged from 8.3 to 9.3 and minimum pH values ranged from 7.4 to 7.7 (Table 4.1.1). Values were generally observed to be higher at the surface sondes, especially during open estuary conditions. The lower and middle reach stations had pH values that were observed to vary with increases and decreases of DO concentrations, with higher values observed during supersaturation conditions and lower values during hypoxic conditions.

The Willow Creek station had a mean pH value of 7.4, a maximum pH value of 8.5, and a minimum pH value of 6.8 (Table 4.1.1). The Willow Creek station also had pH values that were observed to vary with increases and decreases of DO concentrations, with higher values observed during supersaturation conditions and lower values during hypoxic conditions (Figure 4.1.31).

Upper Reach pH

Minimum, mean, and maximum pH values at the Heron Rookery and Freezeout Creek mid-depth sondes were fairly consistent with each other and with pH values observed in the lower and middle reaches of the estuary. Heron Rookery and Freezeout Creek had mean pH values of 8.0 and 8.1 at the mid-depth sondes and 7.5 and 8.0 at the bottom sondes, maximum pH values of 9.3 and 9.1 at the mid-depth sondes and 9.2 and 8.9 at the bottom sondes, and minimum pH values of 6.7 and 7.6 at the mid-depth sondes and 6.2 and 6.3 at the bottom sondes, respectively (Table 4.1.1).

The upper reach stations also had pH values that varied with increases and decreases of DO concentrations, with higher values observed during supersaturation conditions and lower values during hypoxic conditions (see Figures 4.1.28 and 4.1.32 for example). Lower minimum values observed at the Heron Rookery mid-depth station occurred during anoxic conditions in the presence of saline water (Table 4.1.1). Minimum pH values at the bottom sondes were generally lower than those observed at the mid-depth sondes and were also observed to occur during hypoxic and anoxic conditions in saline water (Figures 4.1.32 and 4.1.33).

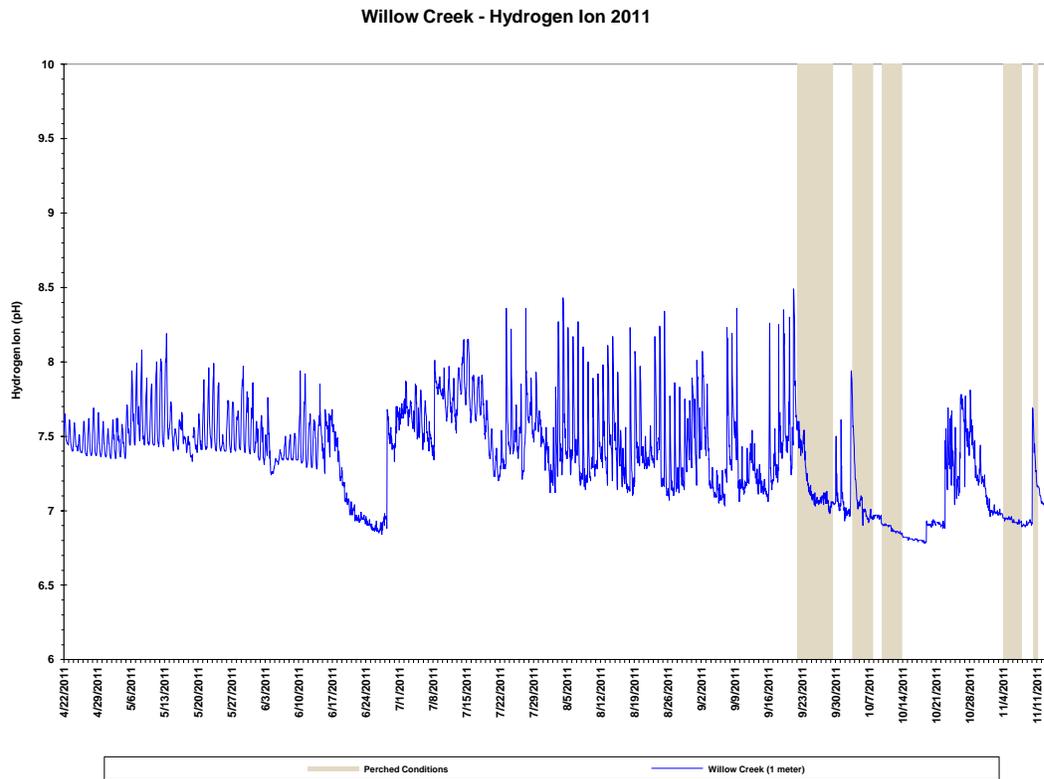


Figure 4.1.31. 2011 Willow Creek Hydrogen Ion Graph

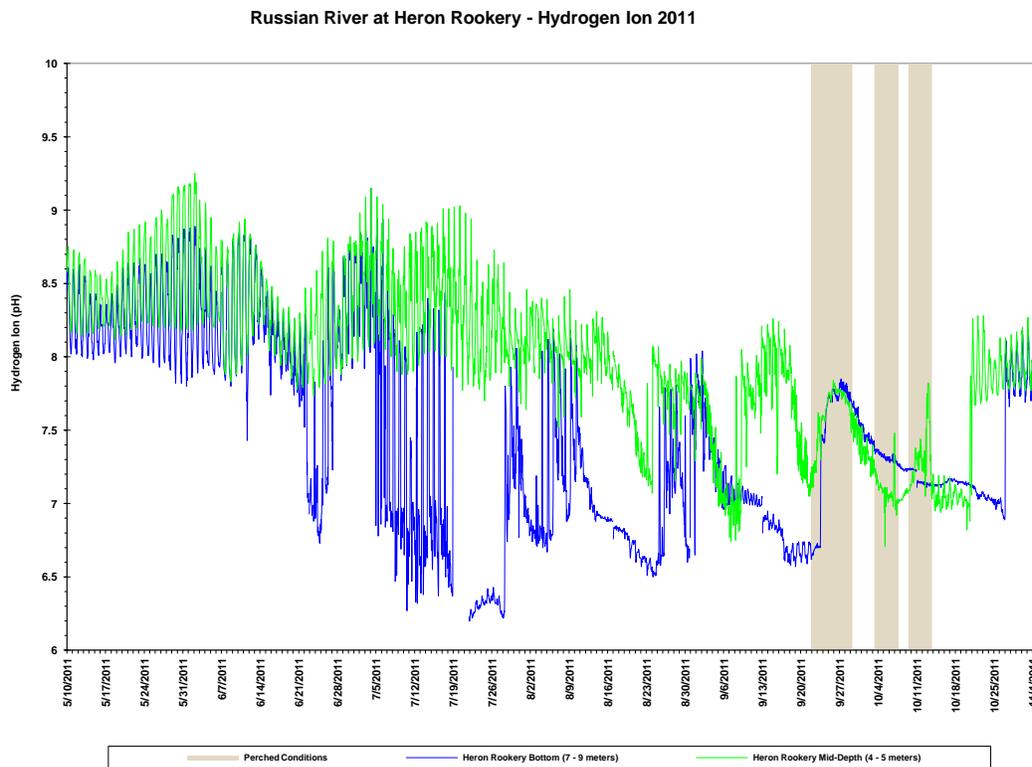


Figure 4.1.32. 2011 Russian River at Heron Rookery Hydrogen Ion Graph

Russian River at Freezeout Creek - Hydrogen Ion 2011

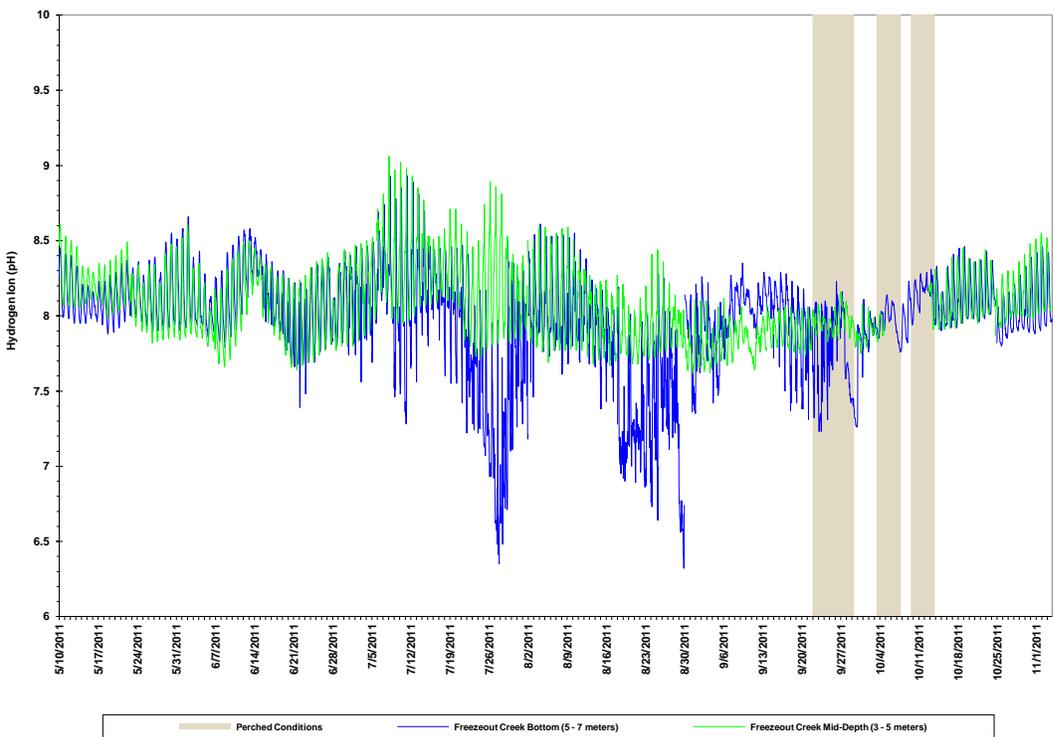


Figure 4.1.33. 2011 Russian River at Freezeout Creek Hydrogen Ion Graph

The Brown’s Pool station had a mean pH value of 8.0, a maximum pH value of 8.7, and a minimum pH value of 7.4. The Brown’s Pool station also had pH values that were generally observed to vary with increases and decreases of DO concentrations (Figure 4.1.27). Minimum values were observed when the sonde had been moved to shallow water by members of the public in early August and early October, and also when placed in the deepest part of the pool by Agency staff after recalibration in mid-August.

Maximum Backwater Area pH

The Austin Creek station had a mean pH value of 7.8, a maximum pH value of 8.2, and a minimum pH value of 7.1 (Table 4.1.1). The Austin Creek station also had pH values that were generally observed to vary with increases and decreases of DO concentrations (Figure 4.1.28). Minimum values were observed during both perched and open conditions in September while flow was intermittent and DO levels were depressed in the isolated pool.

The Villa Grande station had a mean pH value of 7.9, a maximum pH value of 8.8, and a minimum pH value of 7.3 (Table 4.1.1). This station had pH values that were generally observed to vary with increases and decreases of DO concentrations, with minimum values observed during open conditions in August when DO levels were depressed (Figure 4.1.29).

The Monte Rio station had a mean pH value of 7.9, a maximum pH value of 8.7, and a minimum pH value of 7.5 (Table 4.1.1). This station had pH values that were generally observed to vary

with increases and decreases of DO concentrations, with maximum values observed during supersaturation conditions in April and June (Figure 4.1.33).

Grab Sampling

Grab Sampling was conducted at five mainstem stations from Jenner to Monte Rio (Figure 4.1.1). Duplicate samples were also collected at the Monte Rio Station. Sampling was generally conducted every two weeks from 17 May to 6 October, when flows were above 125 cfs and the estuary was open. Sampling would have increased to every week if flows dropped below 125 cfs, but they remained above that level throughout the management period. Additional sampling was conducted during perched conditions and summer impoundment removal in late-September and October (Figures 4.1.2 to 4.1.8). Samples collected and analyzed for nutrients, *chlorophyll a*, and indicator bacteria are discussed below. Other sample results including organic carbon, dissolved solids, and turbidity are not analyzed, but are included as an appendix to the report.

Nutrients

The United States Environmental Protection Agency (USEPA) has established section 304(a) nutrient criteria across 14 major ecoregions of the United States. The Russian River was designated in Aggregate Ecoregion III (USEPA, 2011). USEPA's section 304(a) criteria are intended to provide for the protection of aquatic life and human health (USEPA, 2011). The following discussion of nutrients compares sampling results to these USEPA criteria. However, it is important to note that these criteria are established for freshwater systems, and as such, are only applicable to the freshwater portions of the Estuary. Currently, there are no numeric nutrient criteria established specifically for estuaries.

The USEPA desired goal for total nitrogen in Aggregate Ecoregion III is 0.38 mg/L for rivers and streams not discharging into lakes or reservoirs (USEPA, 2000). Calculating total nitrogen values requires the summation of the different components of total nitrogen; organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN), and nitrate/nitrite nitrogen (Appendix B-4). Often times, nitrogen constituent results were reported as less than the Method Detection Limit (MDL). In these instances, the MDL for the non-detected (ND) constituent is used for the purposes of calculating total nitrogen estimates, and the total nitrogen value is considered less than the estimate. Total nitrogen concentrations were observed to exceed levels recommended for the protection of aquatic habitats predominantly at Jenner and Bridgehaven, and periodically at Duncans Mills, Casini Ranch and Monte Rio (Tables 4.1.2 – 4.1.7). Exceedances of the total nitrogen criteria were observed to occur during open and perched conditions, with the majority of exceedances being observed at the Jenner Station. Exceedances were observed to occur throughout the monitoring period and under a variety of flows that ranged from a daily average of 129 cubic feet per second (cfs) to 767 cfs. Total nitrogen concentrations that exceeded the criteria were generally observed to be 0.5 mg/L or less, with a few exceptions. Jenner was observed to have three exceedances equal to or greater than 1 mg/L, with a high value of 1.7 mg/L on 23 August under open conditions (Table 4.1.2). Bridgehaven was observed to have a maximum concentration of 1.1 mg/L that

was collected on 6 September under open conditions (Table 4.1.3). The Monte Rio Duplicate Station was

Table 4.1.2. 2011 Jenner Station Grab Sample Results

Jenner Boat Ramp*	Temperature	Total Nitrogen	Phosphorus, Total	Chlorophyll-a	Total Coliforms (mtf***)	Total Coliforms (ColiIert)	Fecal Coliforms (mtf)	E. coli(ColiIert)	Enterococcus (mtf)	Hacienda	Estuary Condition
MDL**			0.020	0.00050	20	20	20	20	2.0	Flow Rate (cfs)	
Date	°C	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL		
5/17/2011	14.4	0.43	ND	0.001	900.0	2400	80.0	60	4.0	767	open
5/31/2011	16.0	0.24	0.029	0.00059	110.0	>2400	23.0	16	4.0	545	open
6/14/2011	19.4	0.14	0.048	0.00057	300	8300	ND	20	2.0	468	open
6/28/2011	18.2	1.00	0.043	0.00057	>16000	24000	170	150	170	303	open
7/12/2011	18.8	0.50	0.068	0.0016	340	10000	40	84	6.0	219	open
7/26/2011	19.1	0.47	0.048	0.0045	170	10000	ND	ND	2.0	180	open
8/9/2011	16.7	0.46	0.044	0.012	1100	>24000	20	72	14	132	open
8/23/2011	15.9	1.7	0.052	0.0034	170	8700	90	41	170	144	open
9/6/2011	16.5	1.6	0.048	0.0021	260	10000	40	52	4.0	178	open
9/20/2011	17.2	0.38	0.031	0.00047	170	>24000	ND	20	ND	129	open
9/29/2011	18.9	0.24	0.027	0.0015	3000	9100	40	98	17	137	perched
10/4/2011	16.3	0.35	0.039	0.0018	2500	24000	40	41	50	219	perched
10/6/2011	15.7	0.39	0.041	0.0011	>16000	17000	1500	320	1600	350	perched

* results are preliminary and subject to final revision.
 ** (MDL) Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors
 *** (mtf) Multiple Tube Fermentation

Recommended EPA Criteria based on Aggregate Ecoregion III:
 Total Phosphorus: 0.02188 mg/L (21.88 ug/L)
 Total Nitrogen: 0.38 mg/L
 Chlorophyll a: 0.00178 mg/L (1.78 ug/L)

CDPH Draft Guidance for Fresh Water Beaches - Single Sample Values:
 Beach posting is recommended when indicator organisms exceed any of the following levels:
 Total coliforms: 10,000 per 100 ml
 Fecal Coliforms: 400 per 100 ml
 Escherichia coli: 235 per 100 ml
 Enterococcus: 61 per 100 ml

Table 4.1.3. 2011 Bridgehaven Station Grab Sample Results

Bridgehaven*	Temperature	Total Nitrogen	Phosphorus, Total	Chlorophyll-a	Total Coliforms (mtf***)	Total Coliforms (Colilert)	Fecal Coliforms (mtf)	E. coli(Colilert)	Enterococcus (mtf)	Hacienda	Estuary Condition
MDL**		0.020	0.000050	20	20	20	20	2.0			
Date	°C	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	Flow Rate (cfs)	Estuary Condition
5/17/2011	11.5	0.43	0.2	0.0004	>1600	>2400	500.0	270	33	767	open
5/31/2011	16.5	0.22	0.035	0.00059	500.0	1400	70.0	5.2	2.0	545	open
6/14/2011	20.4	0.21	0.039	0.00023	170	1500	20	ND	7.0	468	open
6/28/2011	19.7	0.59	0.041	0.00047	1700	>24000	40	20	30	303	open
7/12/2011	20.7	0.41	0.065	0.00059	140	10000	40	140	14	219	open
7/26/2011	21.0	0.38	0.042	0.0079	140	10000	20	ND	ND	180	open
8/9/2011	19.5	0.14	0.071	0.022	320	>24000	ND	85	11	132	open
8/23/2011	17.4	0.84	0.060	0.0028	840	10000	90	10	4.0	144	open
9/6/2011	17.8	1.1	0.066	0.0031	1400	24000	ND	20	17	178	open
9/20/2011	17.4	0.48	0.057	0.0061	450	>24000	ND	ND	8.0	129	open
9/29/2011	18.4	0.44	0.037	0.00049	>16000	9600	700	74	500	137	perched
10/4/2011	16.3	0.49	0.067	0.00070	>16000	>24000	900	420	240	219	perched
10/6/2011	14.4	0.51	0.077	0.0015	>16000	9800	390	160	240	350	perched

* results are preliminary and subject to final revision.
 ** (MDL) Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors
 *** (mtf) Multiple Tube Fermentation

Recommended EPA Criteria based on Aggregate Ecoregion III:
 Total Phosphorus: 0.02188 mg/L (21.88 ug/L)
 Total Nitrogen: 0.38 mg/L
 Chlorophyll a : 0.00178 mg/L (1.78 ug/L)

CDPH Draft Guidance for Fresh Water Beaches - Single Sample Values:
 Beach posting is recommended when indicator organisms exceed any of the following levels:
 Total coliforms: 10,000 per 100 ml
 Fecal Coliforms: 400 per 100 ml
 Escherichia coli: 235 per 100 ml
 Enterococcus: 61 per 100 ml

Table 4.1.4. 2011 Duncans Mills Station Grab Sample Results

Duncans Mills*	Temperature	Total Nitrogen	Phosphorus, Total	Chlorophyll-a	Total Coliforms (mtf**)	Total Coliforms (Colilert)	Fecal Coliforms (mtf)	E. coli(Colilert)	Enterococcus (mtf)	Hacienda	Estuary Condition
MDL**		0.020	0.000050	20	20	20	20	2.0		Flow Rate (cfs)	
Date	°C	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL		
5/17/2011	14.4	0.40	0.034	0.0029	>1600	2000	240.0	120	80	767	open
5/31/2011	17.6	0.26	0.031	0.0015	500.0	1700	30.0	7.5	2.0	545	open
6/14/2011	21.2	0.24	0.047	0.0036	900	3500	ND	20	17	468	open
6/28/2011	21.0	0.48	0.043	0.0034	2200	1100	300	74	500	303	open
7/12/2011	22.3	0.37	0.063	0.00098	900	7200	70	41	ND	219	open
7/26/2011	22.0	0.36	0.038	0.0013	220	10000	ND	ND	2.0	180	open
8/9/2011	21.3	0.37	0.031	0.0011	170	>24000	40	10	ND	132	open
8/23/2011	21.8	0.38	0.039	0.00051	300	5200	20	10	240	144	open
9/6/2011	20.2	0.30	0.032	0.00074	240	1400	50	10	ND	178	open
9/20/2011	20.8	0.31	0.025	0.00071	110	1000	ND	ND	7.0	129	open
9/29/2011	20.3	0.33	0.027	0.000098	900	2200	80	74	130	137	perched
10/4/2011	18.5	0.46	0.024	0.00070	900	1500	70	84	70	219	perched
10/6/2011	16.8	0.37	0.036	0.00040	1400	1000	210	20	170	350	perched

* results are preliminary and subject to final revision.
 ** (MDL) Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors
 *** (mtf) Multiple Tube Fermentation

Recommended EPA Criteria based on Aggregate Ecoregion III:
 Total Phosphorus: 0.02188 mg/L (21.88 ug/L)
 Total Nitrogen: 0.38 mg/L
 Chlorophyll a: 0.00178 mg/L (1.78 ug/L)

CDPH Draft Guidance for Fresh Water Beaches - Single Sample Values:
 Beach posting is recommended when indicator organisms exceed any of the following levels:
 Total coliforms: 10,000 per 100 ml
 Fecal Coliforms: 400 per 100 ml
 Escherichia coli: 235 per 100 ml
 Enterococcus: 61 per 100 ml

Table 4.1.5. 2011 Casini Ranch Station Grab Sample Results

Casini Ranch*	Temperature	Total Nitrogen	Phosphorus, Total	Chlorophyll-a	Total Coliforms (mtf***)	Total Coliforms (Colilert)	Fecal Coliforms (mtf)	E. coli(Colilert)	Enterococcus (mtf)	Hacienda	Estuary Condition
MDL**		0.020	0.000050	20	20	20	20	2.0			
Date	°C	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	Flow Rate (cfs)	Estuary Condition
5/17/2011	14.5	0.40	0.025	0.0026	>1600	>2400	80.0	93	280	767	open
5/31/2011	17.6	0.35	0.044	0.00088	300.0	1200	8.0	14	7.0	545	open
6/14/2011	21.8	0.24	0.037	0.0023	140	960	ND	ND	2.0	468	open
6/28/2011	21.2	0.55	0.049	0.0042	3500	1400	ND	ND	26	303	open
7/12/2011	23.2	0.36	0.077	0.0016	370	3400	70	20	7.0	219	open
7/26/2011	22.9	0.36	0.034	0.0013	900	4400	40	ND	2.0	180	open
8/9/2011	22.4	0.33	0.037	0.00096	280	4600	ND	ND	4.0	132	open
8/23/2011	21.8	0.29	0.040	0.0013	500	1900	ND	20	4.0	144	open
9/6/2011	20.7	0.40	0.037	0.0012	140	990	20	ND	2.0	178	open
9/20/2011	20.9	0.37	0.021	0.00047	140	1100	40	ND	4.0	129	open
9/29/2011	21.0	0.37	0.033	0.00068	9000	1400	300	31	50	137	perched
10/4/2011	19.1	0.38	0.029	0.00050	900	1700	80	52	70	219	perched
10/6/2011	17.0	0.34	0.045	0.00040	800	1000	40	41	22	350	perched

* results are preliminary and subject to final revision.
 ** (MDL) Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors
 *** (mtf) Multiple Tube Fermentation

Recommended EPA Criteria based on Aggregate Ecoregion III:
 Total Phosphorus: 0.02188 mg/L (21.88 ug/L)
 Total Nitrogen: 0.38 mg/L
 Chlorophyll a : 0.00178 mg/L (1.78 ug/L)

CDPH Draft Guidance for Fresh Water Beaches - Single Sample Values:
 Beach posting is recommended when indicator organisms exceed any of the following levels:
 Total coliforms: 10,000 per 100 ml
 Fecal Coliforms: 400 per 100 ml
 Escherichia coli: 235 per 100 ml
 Enterococcus: 61 per 100 ml

Table 4.1.6. 2011 Monte Rio Station Grab Sample Results

Monte Rio*	Temperature	Total Nitrogen	Phosphorus, Total	Chlorophyll-a	Total Coliforms (mtf**)	Total Coliforms (Colilert)	Fecal Coliforms (mtf)	E. coli(Colilert)	Enterococcus (mtf)	Hacienda	
MDL**		0.020	0.00050	20	20	20	20	2.0			
Date	°C	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	Flow Rate (cfs)	Estuary Condition
5/17/2011	14.2	0.43	0.041	0.0045	900.0	2400	50.0	73	140	767	open
5/31/2011	17.1	0.32	0.071	0.0014	240.0	1600	30.0	6.2	13	545	open
6/14/2011	21.2	0.24	0.054	0.0073	220	1700	40	63	8.0	468	open
6/28/2011	21.5	0.54	0.048	0.0045	1100	2500	20	31	80	303	open
7/12/2011	22.7	0.40	0.053	0.0059	140	2000	20	20	11	219	open
7/26/2011	22.8	0.21	0.033	0.0019	210	2500	20	ND	4.0	180	open
8/9/2011	22.3	0.18	0.029	0.0013	520	1300	40	10	27	132	open
8/23/2011	21.6	0.30	0.043	0.0022	500	2200	ND	10	8.0	144	open
9/6/2011	20.5	0.29	0.033	0.0017	260	1300	ND	ND	4.0	178	open
9/20/2011	20.4	0.18	0.020	0.0014	2100	1400	ND	20	ND	129	open
9/29/2011	20.0	0.29	0.021	0.00039	2400	1900	80	31	30	137	perched
10/4/2011	18.1	0.29	0.028	0.00050	1200	1400	20	63	50	219	perched
10/6/2011	16.2	0.49	0.099	0.0014	>16000	16000	1400	150	13	350	perched

* results are preliminary and subject to final revision.

** (MDL) Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors

*** (mtf) Multiple Tube Fermentation

Recommended EPA Criteria based on Aggregate Ecoregion III:

Total Phosphorus: 0.02188 mg/L (21.88 ug/L)

Total Nitrogen: 0.38 mg/L

Chlorophyll a : 0.00178 mg/L (1.78 ug/L)

CDPH Draft Guidance for Fresh Water Beaches - Single Sample Values:

Beach posting is recommended when indicator organisms exceed any of the following levels:

Total coliforms: 10,000 per 100 ml

Fecal Coliforms: 400 per 100 ml

Escherichia coli: 235 per 100 ml

Enterococcus: 61 per 100 ml

Table 4.1.7. 2011 Monte Rio Duplicate Station Grab Sample Results

Monte Rio Duplicate*	Temperature	Total Nitrogen	Phosphorus, Total	Chlorophyll-a	Total Coliforms (mtf**)	Total Coliforms (ColiIert)	Fecal Coliforms (mtf)	E. coli(ColiIert)	Enterococcus (mtf)	Hacienda	Estuary Condition
MDL**		0.020	0.00050	20	20	20	20	2.0		Flow Rate (cfs)	
Date	°C	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL		
5/17/2011	14.2	0.43	0.038	0.001	>1600	>2400	80.0	74	50	767	open
5/31/2011	17.1	0.32	0.069	0.0013	140.0	2400	23.0	9.8	22	545	open
6/14/2011	21.2	0.32	0.055	0.015	1700	1400	ND	10	17	468	open
6/28/2011	21.5	0.54	0.049	0.0041	1700	2200	ND	31	50	303	open
7/12/2011	22.7	0.33	0.054	0.0063	750	1700	40	ND	22	219	open
7/26/2011	22.8	0.24	0.033	0.0018	170	2500	ND	ND	4.0	180	open
8/9/2011	22.3	0.26	0.039	0.0013	170	1500	ND	10	22	132	open
8/23/2011	21.6	0.34	0.040	0.0014	900	2200	ND	10	8.0	144	open
9/6/2011	20.5	0.33	0.033	0.0013	5400	1900	ND	10	8.0	178	open
9/20/2011	20.4	0.91	0.022	0.00094	170	1200	ND	20	7.0	129	open
9/29/2011	20.0	0.29	0.022	ND	300	1200	20	20	27	137	perched
10/4/2011	18.1	0.29	0.025	0.0020	2800	1500	ND	52	70	219	perched
10/6/2011	16.2	0.46	0.098	0.0012	>16000	24000	900	170	80	350	perched

* results are preliminary and subject to final revision.
 ** (MDL) Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors
 *** (mtf) Multiple Tube Fermentation

Recommended EPA Criteria based on Aggregate Ecoregion III:
 Total Phosphorus: 0.02188 mg/L (21.88 ug/L)
 Total Nitrogen: 0.38 mg/L
 Chlorophyll a: 0.00178 mg/L (1.78 ug/L)

CDPH Draft Guidance for Fresh Water Beaches - Single Sample Values:
 Beach posting is recommended when indicator organisms exceed any of the following levels:
 Total coliforms: 10,000 per 100 ml
 Fecal Coliforms: 400 per 100 ml
 Escherichia coli: 235 per 100 ml
 Enterococcus: 61 per 100 ml

observed to have a maximum concentration of 0.91 mg/L that was collected on 20 September under open conditions, whereas the primary Monte Rio Station had a concentration of 0.18 mg/L on the same day (Tables 4.1.6 and 4.1.7).

Chlorophyll a

In the process of photosynthesis chlorophyll *a*, a green pigment in plants, absorbs sunlight and combines carbon dioxide and water to produce sugar and oxygen. Chlorophyll *a* can therefore serve as a measureable parameter of algal growth. Qualitative assessment of primary production on water quality can be based on chlorophyll *a* concentrations. A U.C. Davis report on the Klamath River (1999) assessing potential water quality and quantity regulations for restoration and protection of anadromous fish in the Klamath River includes a discussion of chlorophyll *a* and how it can affect water quality. The report characterizes the effects of chlorophyll *a* in terms of different levels of discoloration (e.g., no discoloration to some, deep, or very deep discoloration). The report indicated that less than 10 µg/L (or 0.01 mg/L) of chlorophyll *a* exhibits no discoloration (Deas and Orlob, 1999). Additionally, the USEPA criterion for chlorophyll *a* in Aggregate Ecoregion III is 1.78 µg/L, or approximately 0.0018 mg/L for rivers and streams not discharging into lakes or reservoirs (USEPA, 2000). However, it is important to

note that the EPA criterion is established for freshwater systems, and as such, is only applicable to the freshwater portions of the Estuary. Currently, there are no numeric chlorophyll *a* criteria established specifically for estuaries.

Estimated Chlorophyll *a* concentrations were also observed to remain below the USEPA criteria of 0.0018 mg/L a majority of the time at all stations, however there were exceedances observed at each station including six of 14 samples at the Monte Rio Station (Tables 4.1.2 – 4.1.6). Exceedances at the Jenner, Bridgehaven, and Monte Rio stations were generally observed to occur during summer sampling events with open estuary conditions. However, the Jenner Station also had an exceedance on 4 October during perched conditions and elevated storm flows and the Monte Rio station had an exceedance on 17 May during open conditions and elevated storm flows (Tables 4.1.2 and 4.1.6). The Monte Rio Duplicate Station also had an exceedance on 4 October, but the primary Monte Rio Station did not. Exceedances at Duncans Mills and Casini Ranch were generally observed to occur in the spring during open conditions and elevated storm flows (Tables 4.1.4 and 4.1.5).

The Bridgehaven Station had the highest Chlorophyll *a* concentration of the season, with a value of 0.022 mg/L recorded on 9 August during open conditions and a flow of 132 cfs, whereas the Duncans Mills Station had the season low value of 0.000098 mg/L on 29 September during perched estuary conditions and a flow of 137 cfs (Figures 4.1.3 and 4.1.4).

Indicator Bacteria

The California Department of Public Health (CDPH) developed the "Draft Guidance for Fresh Water Beaches", which describes bacteria levels that, if exceeded, may require posted warning signs in order to protect public health (CDPH, 2011). The CDPH draft guideline for total coliform is 10,000 most probable numbers (MPN) per 100 milliliters (ml), 400 MPN per 100 ml for fecal coliforms, 235 MPN per 100 ml for *E. coli*, and 61 MPN per 100 ml for *Enterococcus*. However, it must be emphasized that these are draft guidelines, not adopted standards, and are therefore both subject to change (if it is determined that the guidelines are not accurate indicators). In addition, these draft guidelines were established for and are only applicable to fresh water beaches. Currently, there are no numeric guidelines that have been developed for estuarine areas.

Chlorophyll *a* concentrations were less than 0.01 mg/L at all stations during a majority of sampling events, the level recommended to prevent discoloration of surface waters, with a few isolated exceptions (Tables 4.1.2 – 4.1.6). This concentration was exceeded at the Jenner and Bridgehaven stations on 9 August during open conditions and a flow of 132 cfs, whereby Jenner had a concentration of 0.012 mg/L and Bridgehaven had a concentration of 0.022 mg/L (Tables 4.1.2 and 4.1.3). The Monte Rio Duplicate Station also exceeded this concentration with a value of 0.015 mg/L on 14 June during open conditions and elevated storm flows, whereas the primary Monte Rio Station only had a concentration of 0.0073 mg/L on the same day (Tables 4.1.6 and 4.1.7).

Total coliform was analyzed using multiple tube fermentation (mtf) and Colilert to determine if there were significant differences between the two methods. Fecal coliform and enterococci were analyzed by multiple tube fermentation and *e. coli* was analyzed by the Colilert method. Sampling results in 2011 indicate there is a large variation in indicator bacteria levels observed through the different sections of the Estuary (Tables 4.1.2 – 4.1.7). These variations occurred under both open and perched estuary conditions and a variety of flows, and may be seasonal as well.

Total coliform results varied between the multiple tube fermentation and Colilert analyses, with significantly higher values resulting from the Colilert method a majority of the time (Table 4.1.2 – 4.1.7). Total coliform counts analyzed using the mtf method were generally lower during open conditions from July to September under lower flows when compared to open conditions earlier in the season when flows were still elevated, and also when compared to perched conditions later in the season when flows were elevated. By contrast, total coliform counts using the Colilert method were often observed to be the highest during mid-season open conditions when flows were lower. The Jenner and Bridgehaven stations were observed to have the most exceedances of the total coliform guideline of 10,000 MPN/100 ml, with exceedances observed during open and perched conditions (Tables 4.1.2 and 4.1.3). The Casini Ranch Station was not observed to have any exceedances of the guideline. The Duncans Mills station had two exceedances during open conditions, but only with colilert results (Table 4.1.4). The Monte Rio and Monte Rio Duplicate stations both had exceedances on 6 October during perched conditions and elevated storm flows (Tables 4.1.6 and 4.1.7).

Fecal coliform counts were generally low during the monitoring season during open estuary conditions, whereas several sites did have at least one exceedance during perched conditions. The Duncans Mills and Casini Ranch stations had no counts above the CDPH recommended guideline of 400 MPN/100 ml. The Jenner, Monte Rio, and Monte Rio Duplicate stations had one high count each, of 1500 MPN, 1400 MPN, and 900 MPN, respectively that exceeded the recommended guideline during closed conditions on 6 October (Tables 4.1.2, 4.1.6, and 4.1.7). The Bridgehaven station had four exceedances of the recommended guideline. The first exceedance occurred on 17 May during open conditions and elevated storm flows. The next three exceedances occurred during perched conditions in late September and early October when flows were elevated by a storm event and summer dam removal.

The recommended *E. coli* guideline of 235 MPN/100 ml was only exceeded at the Jenner and Bridgehaven stations. Jenner had one count of 320 MPN that occurred on 6 October during perched conditions when flows were elevated by a storm event (Table 4.1.2). Bridgehaven had two exceedances, one on 17 May during open conditions with elevated storm flows, and another on 4 October during perched conditions and increasing storm flows (Table 4.1.3). All of the stations had at least one non-detect sample, which generally occurred during open conditions.

Enterococcus counts were generally higher during open conditions with elevated flows and during perched conditions in September and October with elevated flows (Table 4.1.2 – 4.1.7).

All stations, with the exception of the Monte Rio Station, were observed to exceed the recommended guidelines at least once during perched conditions. The draft guidance for freshwater beach posting identifies the potential for public health concerns when *Enterococcus* levels exceed 61 MPN/100ml. The Jenner Station had two counts of 170 MPN during open conditions on 28 June and 23 August, and a count of 1600 MPN during perched conditions on 6 October when flows were elevated (Table 4.1.2). The Bridgehaven Station had three exceedances of the guideline that all occurred during perched conditions in September and October, including a high count of 500 MPN on 29 September (Table 4.1.3). The Duncans Mills Station had six exceedances of the recommended guideline. These exceedances were observed during open and perched conditions and under a variety of flows (Table 4.1.4). Although the Duncans Mills Station had a high count of 500 MPN on 28 June during open conditions, it was also observed to have three non-detect samples collected during open conditions. The Casini Ranch Station had a high count of 280 MPN on 17 May during open conditions and elevated storm flows and another high count of 70 MPN on 4 October during perched conditions when flows were elevated by a storm event and summer dam removal (Tables 4.1.5). The Monte Rio Station had a high count of 140 MPN on 17 May and another high count of 80 MPN on 28 June (Table 4.1.6). Both exceedances occurred during open conditions and elevated flows. Whereas, the Monte Rio Duplicate Station had two high counts that occurred during the last two perched events on 4 October and 6 October when flows were elevated by a storm event and summer dam removal (Table 4.1.7).

Conclusions and Recommendations

Overall, water quality conditions observed during the 2011 monitoring season were similar to conditions associated with a dynamic estuarine system observed in previous years. There were a few notable observations associated with salinity and indicator bacteria that will be discussed further below.

Salinity concentrations were observed to periodically decrease during muted tidal cycles in July and August and during perched conditions and partial lagoon formation in September and October (Figures 4.1.3 through 4.1.5). Muted tidal cycles occurred when the opening at the river mouth was somewhat isolated from ocean swells by the jetty, resulting in reduced tidal action and salinity intrusion into the estuary (Figure 4.1.6). Salinity concentrations at Freezeout Creek were significantly lower in 2011 than concentrations observed in 2009 or 2010 and were likely a result of the muted tidal cycles that occurred.

During perched conditions, increasing temperatures associated with fresh/saltwater stratification were observed to occur, though not as significantly as has been observed in past years under closed barrier beach conditions

Density and temperature gradients between freshwater and saltwater play a role in stratification and serve to prevent/minimize mixing of the freshwater and saline layers. When the estuary is closed, or the river mouth is perched and the supply of cool tidal inflow is reduced, solar radiation heats the underlying saline layer. In addition, the overlying surface freshwater layer restricts the release of this heat, which can result in higher water

temperatures in the underlying saline layer than in the overlying freshwater layer. This effect was very minimal in 2011, due to a lack of complete barrier beach closures, and perched conditions that occurred late in the season when the effects of solar heating were reduced.

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4.2 Invertebrate Monitoring and Salmonid Diet Analysis

The University of Washington, School of Aquatic and Fishery Sciences' Wetland Ecosystem Team (UW-WET) is conducting studies of the ecological response of juvenile salmonids (*Oncorhynchus* spp.) and their potential prey resources to natural and alternative management actions at the mouth of the Russian River estuary. As described in the 2009-2010 Biological Opinion Annual Report (Manning and Martini-Lamb 2011), this component of the Estuary monitoring studies is designed to evaluate how different natural and managed ocean entrance conditions in the Russian River estuary affect steelhead (*O. mykiss*) and salmon (predominantly Chinook, *O. tshawytscha*) foraging and their potential prey resources over different temporal and spatial scales.

The current study is designed around systematic sampling coincident with juvenile salmon entrance to and residence in the estuary under opportunistic changes in estuary entrance conditions, whether by natural estuary entrance dynamics or managed opening of the barrier beach. Systematic sampling is intended to capture the natural ecological responses (prey composition and consumption rate) of juvenile salmon and availability of their prey resources (insect, benthic and epibenthic macroinvertebrates, zooplankton) under naturally variable, seasonal water level, salinity, temperature and dissolved oxygen conditions in the estuary. A second approach, event sampling, was originally proposed in 2009 to contrast juvenile salmonid foraging and prey availability changes over short-term estuary closure and re-opening events during managed opening of the estuary, as compared to more stochastic, dynamic opening of the estuary's entrance (controlled breaching of entrance barrier beach) anticipated in later years. However, due to limited barrier beach formation during the lagoon management season, the opportunity to sample closed or lagoon outlet events has been limited by the frequency and extent of estuary closures.

We are addressing four component tasks relative to estuary entrance conditions: (1) Diet Composition—documentation of diet composition of juvenile salmonids; (2) Prey Resource Availability—assessment of invertebrate (insect, benthos, epibenthos) prey resource availability from representative aquatic and riparian ecosystems and segments of the estuary; (3) Zooplankton Response—evaluation of zooplankton assemblages and dynamics; and (4) Bioenergetics Modeling and Synthesis—bioenergetic modeling of juvenile salmon performance and synthesis/interpretation. The first task is coordinated with the Water Agency sampling of

juvenile salmonids in the estuary and UW-WET samples derive from Water Agency protocols and schedule. Due to the extensive time required to complete the diet and prey availability sample processing, and that required for graduate student completion of their academic degree⁶, UW-WET reports on juvenile steelhead and Chinook salmon diet composition, epibenthic prey availability and bioenergetic modeling of juvenile steelhead potential growth; relative insect prey availability and zooplankton abundance and composition from 2011 will be available at a later date.

Methods

Sampling Sites

Sampling for fish diet and prey availability was designed to coincide with established Water Agency and other related sampling sites distributed in the lower, middle, and upper reaches of the estuary that were established by water quality measurements—dissolved oxygen, temperature and salinity (Figure 4.2.1; modified from Largier and Behrens 2010). Nine sites (three in each reach) were sampled for juvenile salmon by the Water Agency (see *Beach Seining* Section 4.4 in this report) – (1) River Mouth; (2) Penny’s Point; (3) Jenner Gulch; (4) Patty’s Rock; (5) Bridgehaven; (6) Willow Creek; (7) Sheephouse Creek; (8) Heron Rookery; (9) Freezeout Bar; (10) Moscow Bridge; (11) Casini Ranch; and, (12) Brown’s Riffle. When possible, samples were selected for diet analysis from the overall beach seine collections from Jenner Gulch, Bridgehaven and Moscow Bridge to represent the lower, middle, and upper estuary reaches, respectively. Incidental steelhead diet samples also originated from Penny’s Point (lower), Willow Creek (middle), and Sheephouse Creek, Freezeout Bar, and Casini Ranch (upper) sites when there were not sufficient samples from the primary reach sites. Most of the juvenile Chinook samples originated from the River Mouth, Jenner Gulch, and Penny’s Point beach seine sites in the lower reach until August-September, when they became abundant at Patty’s Rock and Bridgehaven in the middle reach. Invertebrate prey availability was sampled at three sites: (1) River Mouth; (2) Willow Creek; and, (3) Freezeout Creek (excluding insect fallout traps).

⁶ Erin Seghesio. 2011. M.S., Univ. Washington, Seattle, WA.

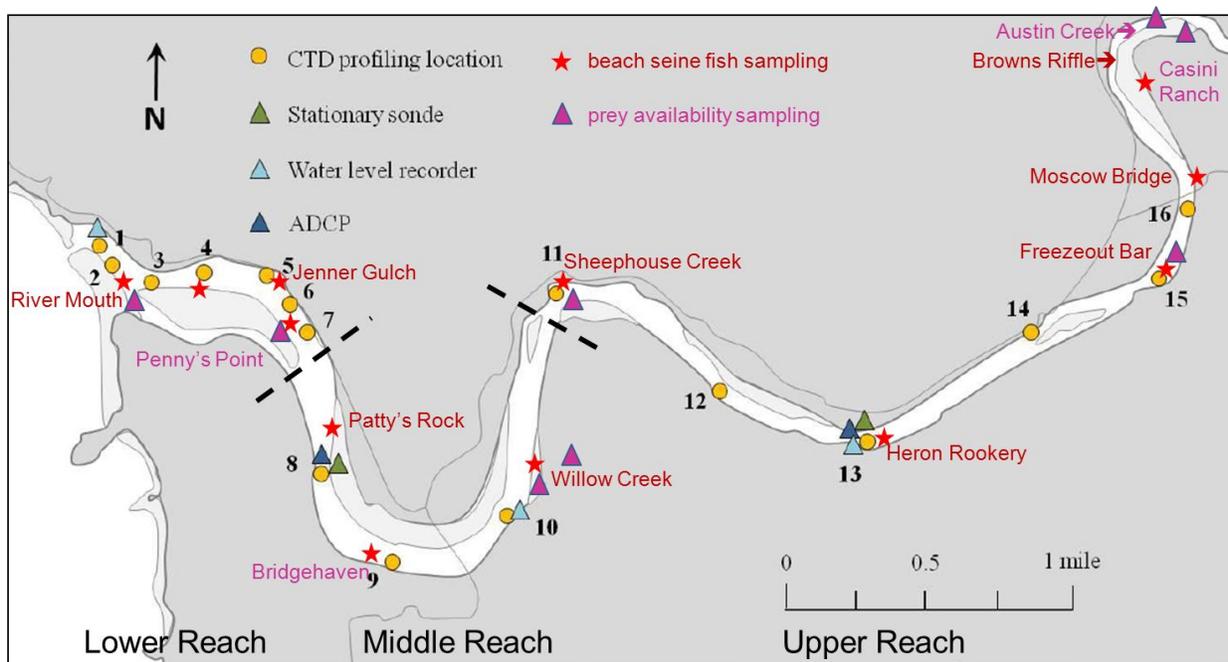


Figure 4.2.1. Locations of sampling stations for juvenile salmon diet (seining location) and prey resource availability (insect fall-out traps, benthic cores, epibenthic net and sled tows, zooplankton net hauls) in three reaches of the Russian River estuary in 2011.

Juvenile Salmon Diet Sampling

Diets of up to ten (although often even the minimum of five fish were difficult to procure) juvenile steelhead and Chinook salmon ≥ 55 mm FL derived from the monthly to semi-monthly Water Agency beach seine samples between July 10 and October 24, 2011. The availability of samples was not uniform across the estuary sites and reaches: the largest number of juvenile steelhead between July and October originated from the lower reach (predominantly Penny Gulch), but were distributed more uniformly across the reaches (with equal numbers of samples from the middle—Bridgehaven—and upper—Moscow Bridge—reaches from August through October; Chinook samples originated from predominantly the upper and middle reaches in June and at the mouth of the estuary in July and August.

During the 2011 study period (and similar to 2010), the estuary experienced very few and brief (4-7 days) perched or barrier beach-formed river mouth closures until late September. Due to strong river flow in spring and early summer, the berm morphology and over-flow and wave overwash, distinct perched river mouth conditions occurred only during September 22-29 and October 3-7 and 10-17. Samples of juvenile steelhead and Chinook salmon diets originated predominantly from periods when the estuary was either open (June 7-15; July 12-19; August 12-18; September 13-20), with only one collection explicitly after a closure (October 13-21, after closing October 3) (Figure 4.2.2). Few Chinook salmon were captured in the upper reach during the study period, and are not represented in these data. Fish length and weight

measurement, tag detection, and stomach lavage and preservation protocols were the same as for the 2009 and 2010 diet analyses (Manning and Martini-Lamb 2011).

Prey Resource Sampling

As in 2010, prey resource sampling during 2011 was conducted every three weeks, usually on the week following beach seine sampling between mid-July and late October (Figure 4.2.2). This corresponded to periods when the estuary was open (July 26-28; August 23-25) and perched (September 27-29; October 25-27). In terms of the state of the estuary's ocean exchange, the open periods during sampling spanned tidally-influenced elevations of -0.01 to 0.55 m (-0.04 to 1.82 ft) NGVD (at Jenner gage) while the closed or perched periods encompassed progressively higher water elevations from 1.38 to 2.14 m (4.54 to 7.01 ft) NGVD.

Sampling design, techniques and protocols for epibenthic organisms, emergent and drift insects, and zooplankton were as described in Manning and Martini-Lamb 2011, with the addition of a modification to accommodate changes in water volumes and cross-channel wetting as a function of the estuary mouth closure and opening (Figures 4.2.3 and 4.2.4).

Benthos—Replicate core samples (0.0024-m² PVC core inserted 10 cm in to the sediment) were taken at each transect of each site. The location of each core sample is consistent with each sled pull and epibenthic net pull, but no core samples are taken in between transects. This sample is repeated four times per transect (twelve times per site).

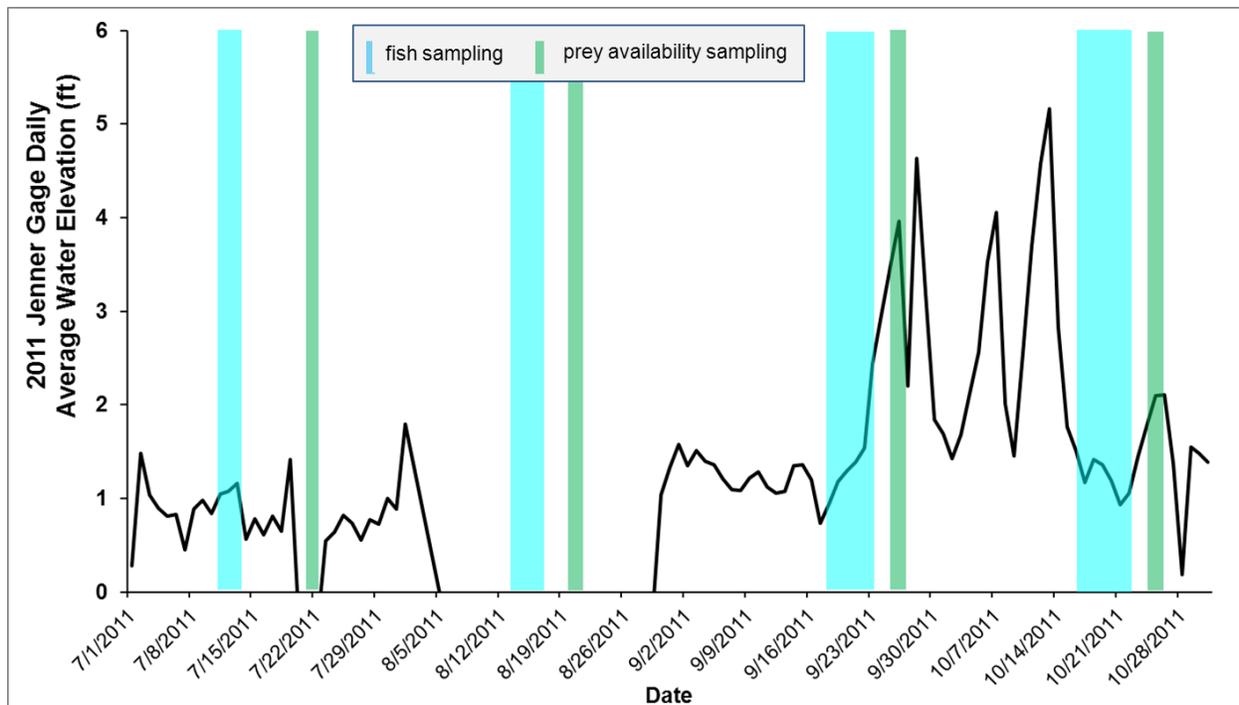


Figure 4.2.2. Timeframe of sampling for juvenile salmon diet and prey resource availability relative to variation in average daily water surface elevation (m, Jenner Gage) in the Russian River estuary in 2011.

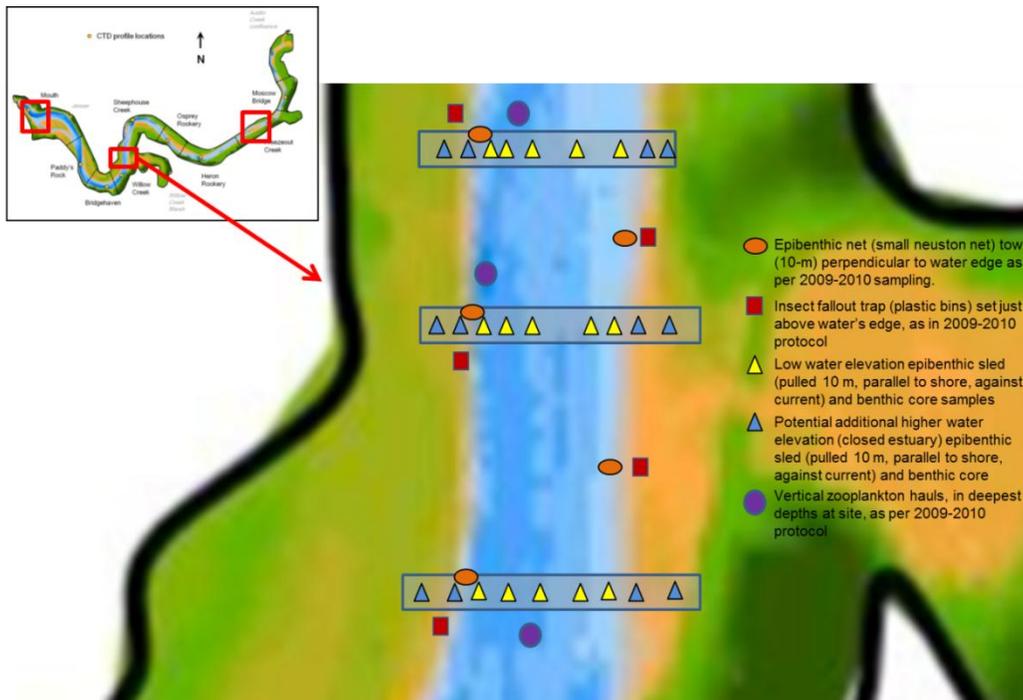


Figure 4.2.3. Schematic of general sampling design to document prey availability of juvenile salmon in the Russian River estuary in 2011.



(a)



(b)

Figure 4.2.4. Distribution of juvenile salmonid prey availability sampling (a) and sites of different prey sampling techniques within study reaches (b-f) in the Russian River estuary in 2011.



(c)



(d)

Figure 4.2.4 (cont.). Distribution of juvenile salmonid prey availability sampling (a) and sites of different prey sampling techniques within study reaches (b-f) in the Russian River estuary in 2011.



(e)



(f)

Figure 4.2.4 (cont.). Distribution of juvenile salmonid prey availability sampling (a) and sites of different prey sampling techniques within study reaches (b-f) in the Russian River estuary in 2011.

Epibenthos—Epibenthic organisms at the sediment-water interface were sampled with two methods: (1) epibenthic net; and (2) epibenthic sled. The epibenthic net is a 0.5-m x 0.25-m rectangular net, equipped with 106- μm Nitex mesh, that is designed to ride along the surface of the estuary bottom. It is deployed 10 m perpendicular to shore and then pulled along the bottom back to shore by an individual onshore. This is replicated five times per site (once at each transect and then once between Transects 1 and 2 and also between Transects 2 and 3). The epibenthic sled is equipped with a 0.125-m² opening, 1-m long 500- μm Nitex mesh net towed behind the boat against the current. The sled is dropped off of the bow of the boat and allowed to sink to the bottom. Once the boat has finished towing the sled (in reverse) 10 m against the current, it will be retrieved back onto the boat. This is replicated five times per site (once at each transect and then once between Transects 1 and 2 and also between Transects 2 and 3). The sled is used to obtain three samples per transect (nine per site under open conditions).

Fallout Insects—Insects that settle on the estuary surface are sampled by fallout traps. These traps are 51.7-cm x 35.8-cm x 14-cm plastic bins filled with $\frac{1}{2}$ biodegradable soapy water and set atop PVC frames (when the land is uneven) with a PVC anchor pole attached to the bin with a monofilament line with additional PVC guide poles allowing the bins to float at high tide and not tip or drift away. Fallout traps are deployed and collected 48 hours later.

Zooplankton—Zooplankton are sampled at the same location as water quality (the deepest available depth per site) using a 0.33-m ring net, 73- μ m Nitex mesh and cod end cup. The zooplankton is lowered until the top ring of the net is just above the benthos and then pulled by hand vertically to the surface to obtain a sample of the entire water column. This sample set is repeated three times per site.

In 2011, we modified this fixed sampling design to better address the potential redistribution or expansion of prey resources during estuary closure (Figure 4.2.3). When a closure event occurs, the standard monthly sampling was to be augmented to include additional sampling events both seven and fourteen days after a closure in each reach (Figure 4.2.4 a-f). Additional repetitions of the epibenthic sled were to be added spatially in place of previous epibenthic net samples (as described above) and the epibenthic net sampling regime moved to stay consistent with the shoreline to 10m offshore sampling area.

Sample Processing and Analyses

Stomach contents from juvenile salmon collected in 2011 were processed under the same procedures and protocols as for the 2009-2010 samples, which provided numerical, gravimetric and frequency of occurrence for prey taxa identified to the species, except for insects which were identified to family. Additional data derived from this procedure was relative consumption rate (“instantaneous” ration) for individual fish and a summary total Index of Relative Importance (%Total IRI) that incorporates all three metrics of prey contribution to the diet. The diet is described comprehensively as %Total IRI to indicate the relative importance of the three factors but describe differences among fish size intervals, sites and reaches over time in terms of gravimetric composition because of the importance of that variable to fish growth. See Manning and Martini-Lamb 2011 for further details.

Multivariate analyses were also utilized to organize fish diet sample compositions and prey availability samples into statistically distinct categories. All statistical analyses were performed using the PRIMER v6.0 multivariate statistics analysis package (Clarke and Gorley 2006). These analytical tools, and the PRIMER package in particular, are used extensively in applied ecology and other scientific inquiries where the degree of similarity in organization of multivariate data (e.g., species, ecosystem attributes) is of interest.

Results

As described in earlier in this report, distinct or prolonged closure events did not occur in the estuary during the lagoon management season in 2011, and occurred only briefly and episodically through October. As a result, the fixed sampling design to document potential estuary closure-induced changes in juvenile steelhead and Chinook salmon foraging and the relative availability of their primary prey organism did not provide the opportunity to test these effects from an explicit, prolonged closure event.

Juvenile Steelhead and Chinook Salmon Diet Composition and Consumption Rate

Overall diet composition of 65 steelhead, varying in length from 94 to 324 mm FL, captured in the estuary between July 10 and October 24, 2011 (Figure 4.2.5). represented a somewhat

similar dominance of epibenthic and benthic amphipods (*Eogammarus confervicolus*, *Ameriocolopium spinicorne*) and epibenthic isopods (*Gnorimosphaeoma insulare*), with considerably lesser contributions of early life stages or emerging (e.g., Ephemeroptera, Chironomidae) or adult insects (Corrixidae) and mysids (*Neomysis mercedis*) as found in 2009-2010. Among the most commonly (60-80% frequency of occurrence) preyed upon macroinvertebrates, *E. confervicolus* was the most numerically (>50% of total prey consumed) dominant prey and both amphipods and *G. insulare* contributed relatively equal (25-30%) of the total prey biomass.

From July through September, *E. confervicolus* dominated the prey biomass (gravimetric composition) except in the upper reach of the estuary, where corixids or *G. insulare* dominated (Figure 4.2.6). In October, the proportional biomass of *G. insulare* was higher in the lower and middle reach, but *E. confervicolus* dominated in the middle reach and *A. spinicorne* constituted almost all the prey biomass in the upper reach. However, some of these patterns need to be considered with some uncertainty due to low sample sizes (e.g., middle reach in July and October, upper reach in August and October).

Multivariate (NMDS) analysis of the gravimetric composition of the diets illustrated that there were no strong similarities (groups) of diet composition within month and estuary reach (Figure 4.2.7), although there was some distinction in the diets of juvenile steelhead captured in the upper reach compared to the lower and middle reaches. When the 2011 diet data were combined with the 2009 and 2010 data, there is much more cohesive evidence of greater similarity in the diets of juvenile steelhead from the lower and middle reach than in the upper reach, irrespective of month (Figure 4.2.8). Based on partitioning of these data by estuary reach and year, it is evident that, while diet composition in the lower and middle reaches were not substantially different among the three years, juvenile steelhead diets were different in the upper reach in 2010 compared to 2009 and that diets of fish in the upper reach in 2011 were

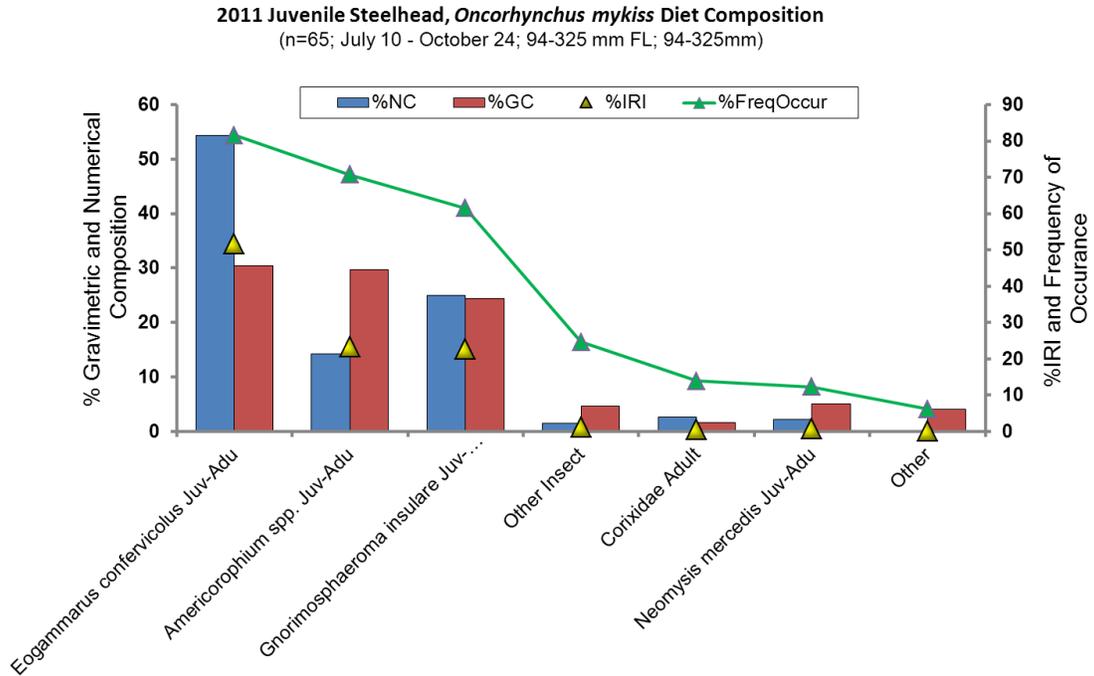


Figure 4.2.5. Index of Relative Importance (IRI) diet composition of 65 juvenile steelhead, 94-325 mm FL, in Russian River estuary in 2011.

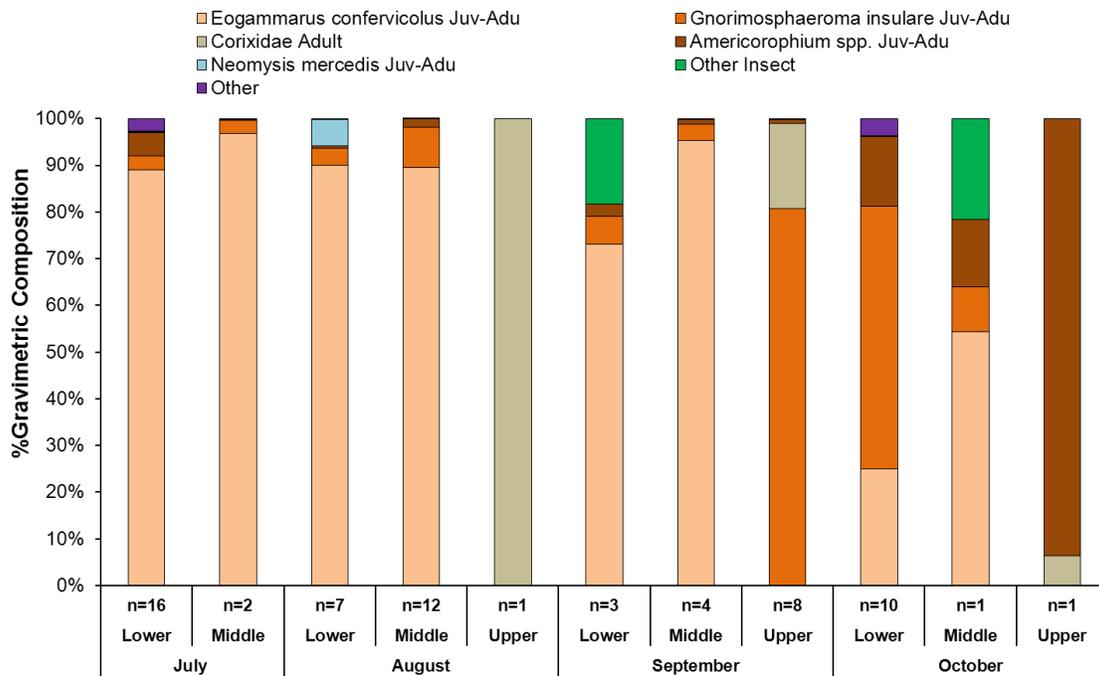


Figure 4.2.6. Gravimetric composition (%) of juvenile steelhead in three reaches of the Russian River estuary, July-October 2011.

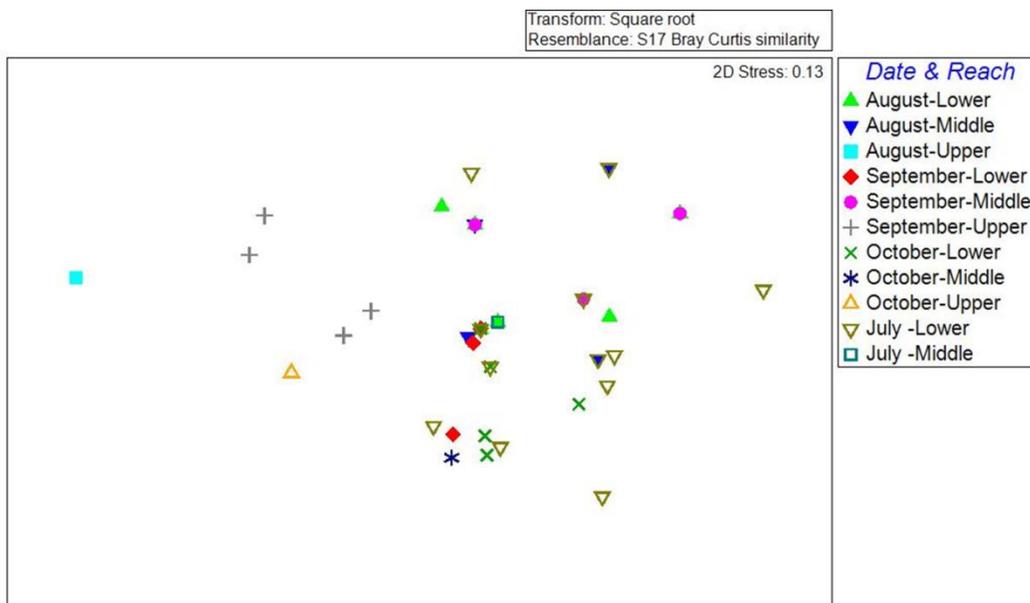


Figure 4.2.7. Non-metric Multi-Dimensional Scaling plot of juvenile steelhead diets (% gravimetric) in three reaches of the Russian River estuary, July-October 2011.

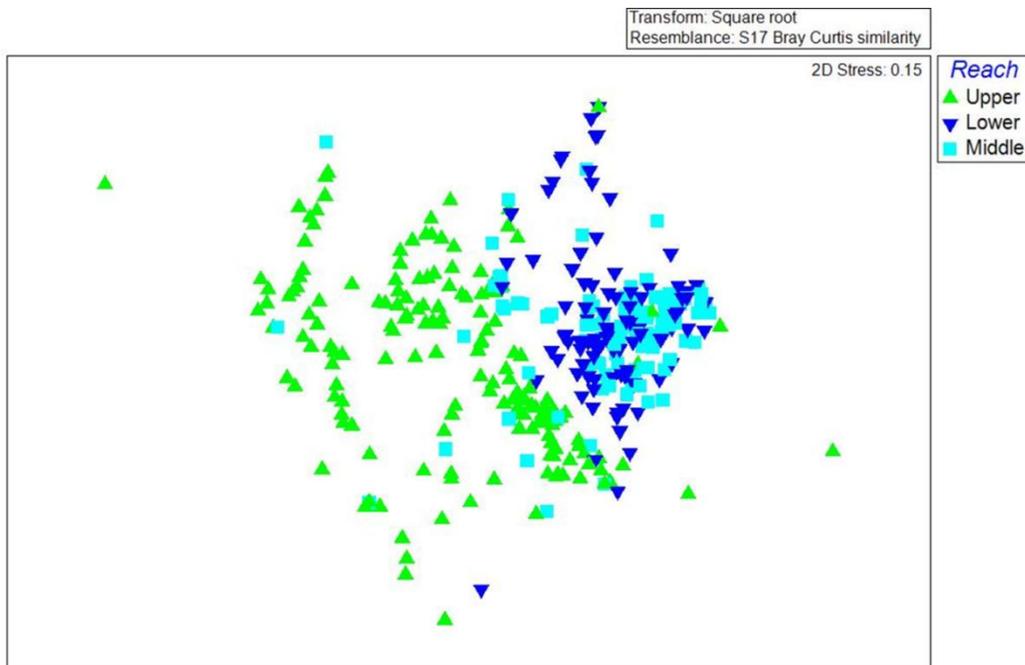


Figure 4.2.8. Non-metric Multi-Dimensional Scaling plot of juvenile steelhead diets (% gravimetric) in three reaches of the Russian River estuary pooled by month in 2011.

somewhat more similar to the middle and lower reach diet compositions (Figure 4.2.9). The sample design is not explicitly intended to test for differences in fish consumption rate because there is some uncontrolled variation in the times that fish are captured in the different estuary reaches. However, trends in consumption may still be instructive if controlling for other factors that might influence prey availability and foraging success. Taking into account fish size (which is a major factor), juvenile steelhead appeared to have more prey biomass in their stomachs in lower and middle reaches than upper reach, and perhaps maximum in lower reach (Figure 4.2.10).

The diet composition of 36 juvenile Chinook salmon caught concurrently with steelhead between July 10 and October 24 was generally similar to steelhead except for less predation on *G. insulare* and more on the mysid *N. mercedis*, but considerably less predation on insects than in 2010 (Figure 4.2.11). Based on NMDS analysis, there were no distinct differences in diet composition among reaches between 2010 and 2011 (Figure 4.2.12). In addition, there was no detectable difference in juvenile Chinook salmon instantaneous ration between lower and middle reach; however, the relative foraging rate appeared to increase with individual fish size, the opposite trend as found for juvenile steelhead (Figure 4.2.13).

Prey Resource Availability

Samples of macroinvertebrates potentially available as prey for juvenile steelhead and Chinook salmon have been analyzed for epibenthic net and sled samples from July through October 2010. Processing and analysis of the benthic macroinvertebrate, insect fallout trap and zooplankton samples is on-going, but the final database will include all available samples as they are completed.

Epibenthic Net—Epibenthic net samples from 2011 indicated that typical crustacean prey of juvenile steelhead and Chinook salmon in the shallow, marginal habitats of the estuary were most prevalent and dense in the lower reach (Figure 4.2.14). *Amerocorophium* spp., *E. confervicolus*, and *G. insulare* were available throughout the study period, but maximally (due to densities of *Amerocorophium* spp. $\sim 1000 \text{ m}^{-2}$) in August; conversely, corixid insects were the only prominent prey organism in the upper reach of the estuary, and were most dense from July to August.

Multivariate analysis of the epibenthic net macroinvertebrate compositions among reaches and between the years 2010 and 2011 suggest that these assemblages were relatively distinct between 2010 and 2011 (Figure 4.2.15). Reflecting to some degree the patterns observed in interannual comparison of the juvenile steelhead and Chinook salmon diet compositions, samples from the lower and middle reaches were more similar (while not overlapping) than with the upper reach.

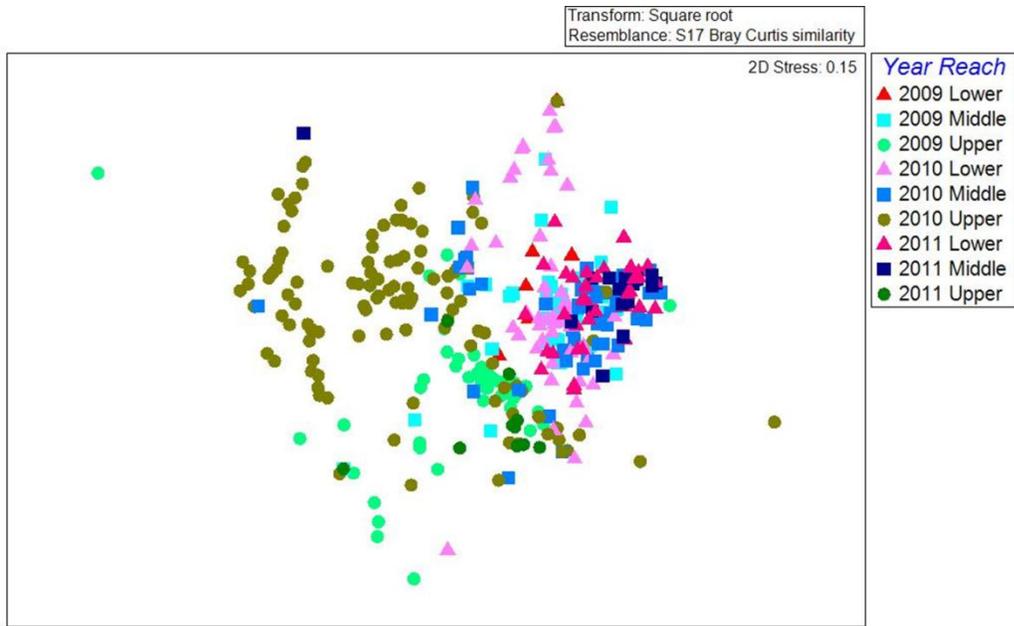


Figure 4.2.9. Non-metric Multi-Dimensional Scaling plot of juvenile steelhead diets (% gravimetric) in three reaches of the Russian River estuary in 2009, 2010 and 2011.

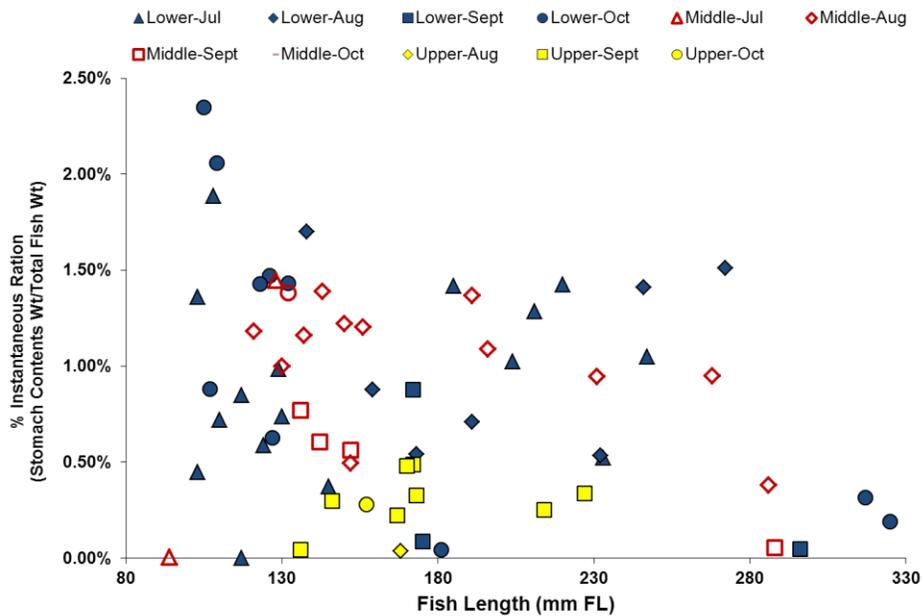


Figure 4.2.10. Instantaneous ration (stomach contents weight/total fish weight) of juvenile steelhead as a function of individual fish length (mm FL) in three reaches of the Russian River estuary in 2011.

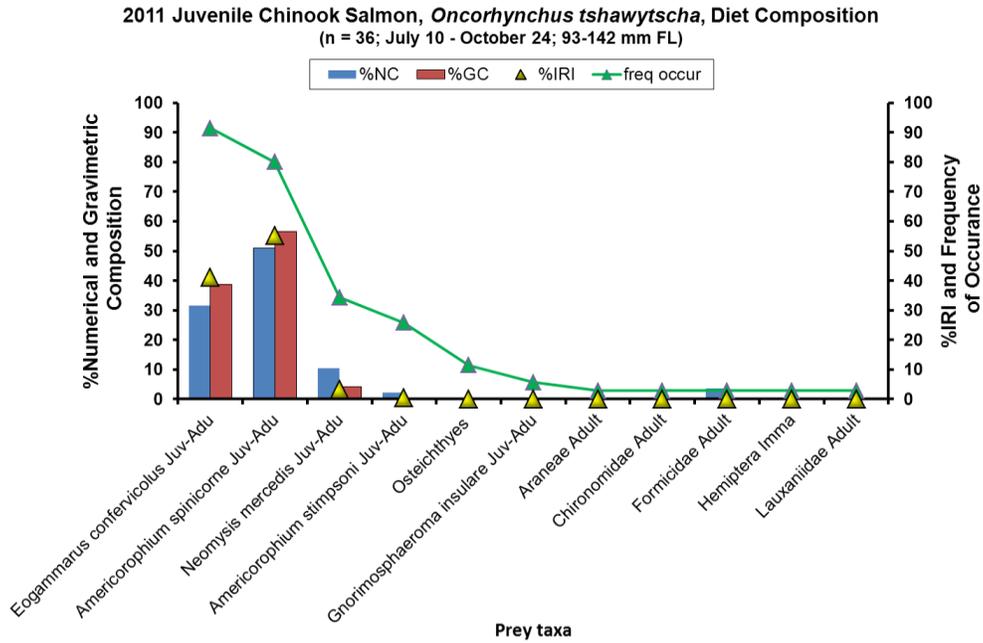


Figure 4.2.11. Index of Relative Importance (IRI) diet composition of 36 juvenile Chinook salmon, 93-142 mm FL, in Russian River estuary in 2011.

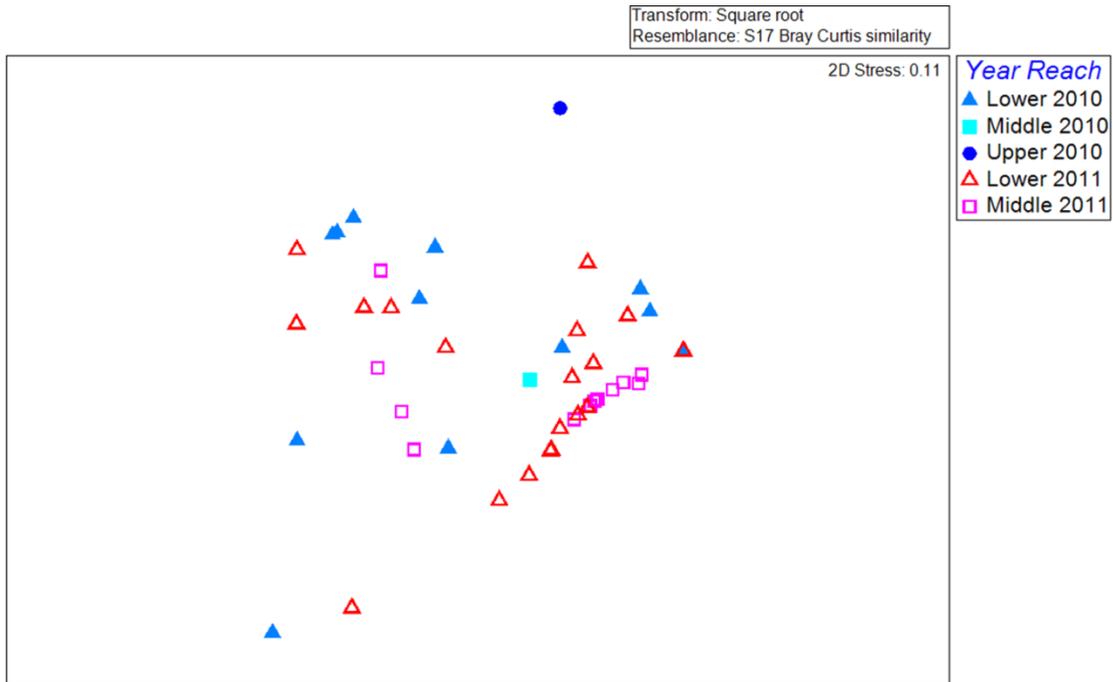


Figure 4.2.12. Non-metric Multi-Dimensional Scaling plot of juvenile Chinook salmon diet composition (% gravimetric) in three reaches of the Russian River estuary, 2010 and 2011.

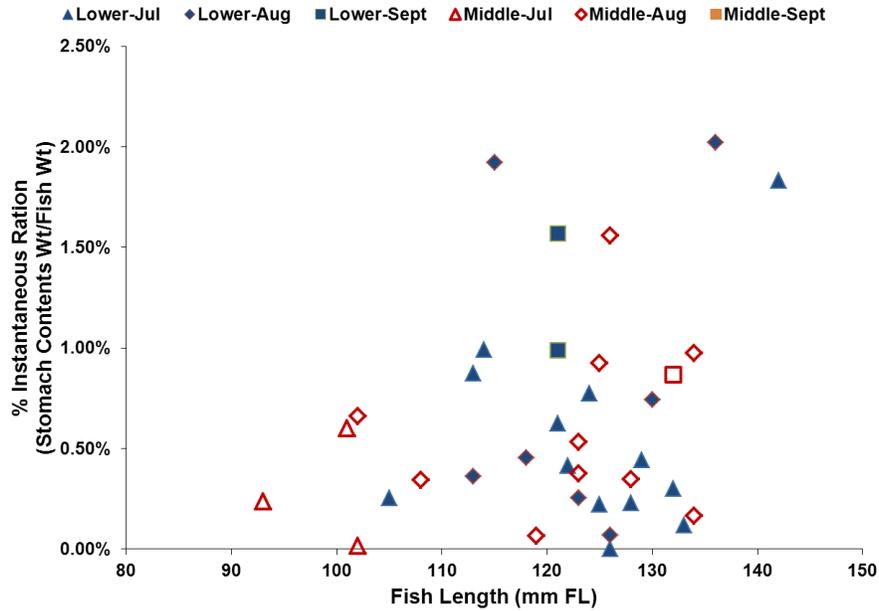


Figure 4.2.13. Instantaneous ration (stomach contents weight/total fish weight) of juvenile Chinook salmon as a function of individual fish length (mm FL) in three reaches of the Russian River estuary in 2011.

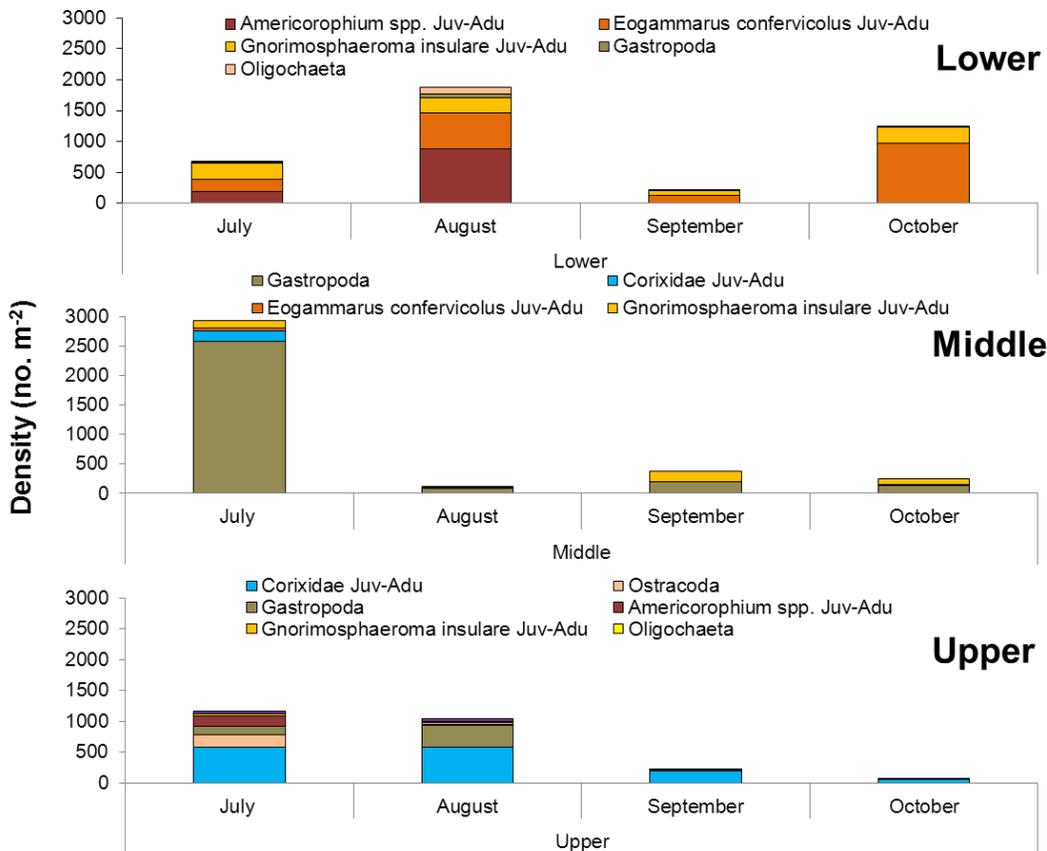


Figure 4.2.14. Density (no. m⁻²) of macroinvertebrates in epibenthic net samples from three reaches of the Russian River estuary, July-October, 2011.

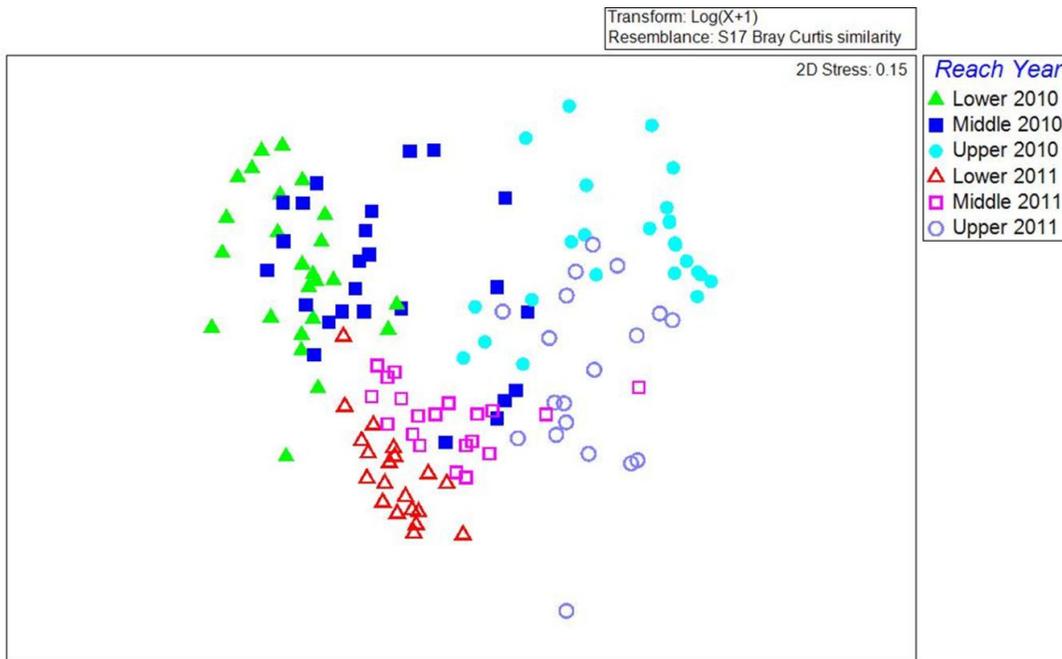


Figure 4.2.15. Non-metric Multi-Dimensional Scaling plot of epibenthic net composition (% numerical) of macroinvertebrates in three reaches of the Russian River estuary, 2010 and 2011.

Epibenthic Sled— Densities of macroinvertebrates in the aggregated (across all cross-channel transects) samples were somewhat lower than the marginal epibenthic net macroinvertebrates, although the taxa composition was generally similar (Figure 4.2.16). There were more *G. insulare* in the middle reach, amphipods in lower reach sled samples, and fewer *N. mercedis* overall. Except for July in the upper reach, when corixids and cladoceran larvae (*Eurycercus* spp.) contributed most of the ~2000 m⁻² organisms, densities averaged at or below 500 m⁻² organisms, comparable to epibenthic net densities in 2010.

Although the composition of macroinvertebrates did not vary radically among the cross-channel epibenthic sled transects within a reach and month, there were several cases where a taxa appeared conspicuously (Figure 4.2.17). For example, gastropods appeared prominently only at the upper reach (Freezeout), and particularly dense along the marginal transects; the mysid *N. mercedis* occurred in highest density only in the lower reach, and particularly in the channel thalweg in July and August, but became dense in both the thalweg and marginal transects and the upper reach as well in October. However, there were no consistent patterns in spatial distribution of the prominent juvenile steelhead and Chinook salmon prey among the three (one thalweg, two marginal) transects among the three reaches over the four months. The highest densities of epibenthic organisms in the sled samples occurred slightly more densely (particularly amphipods and isopods) in the thalweg than in the marginal transects in

the lower and middle reaches, but more often (particularly corixids and mysids) in the marginal transects in the upper reach.

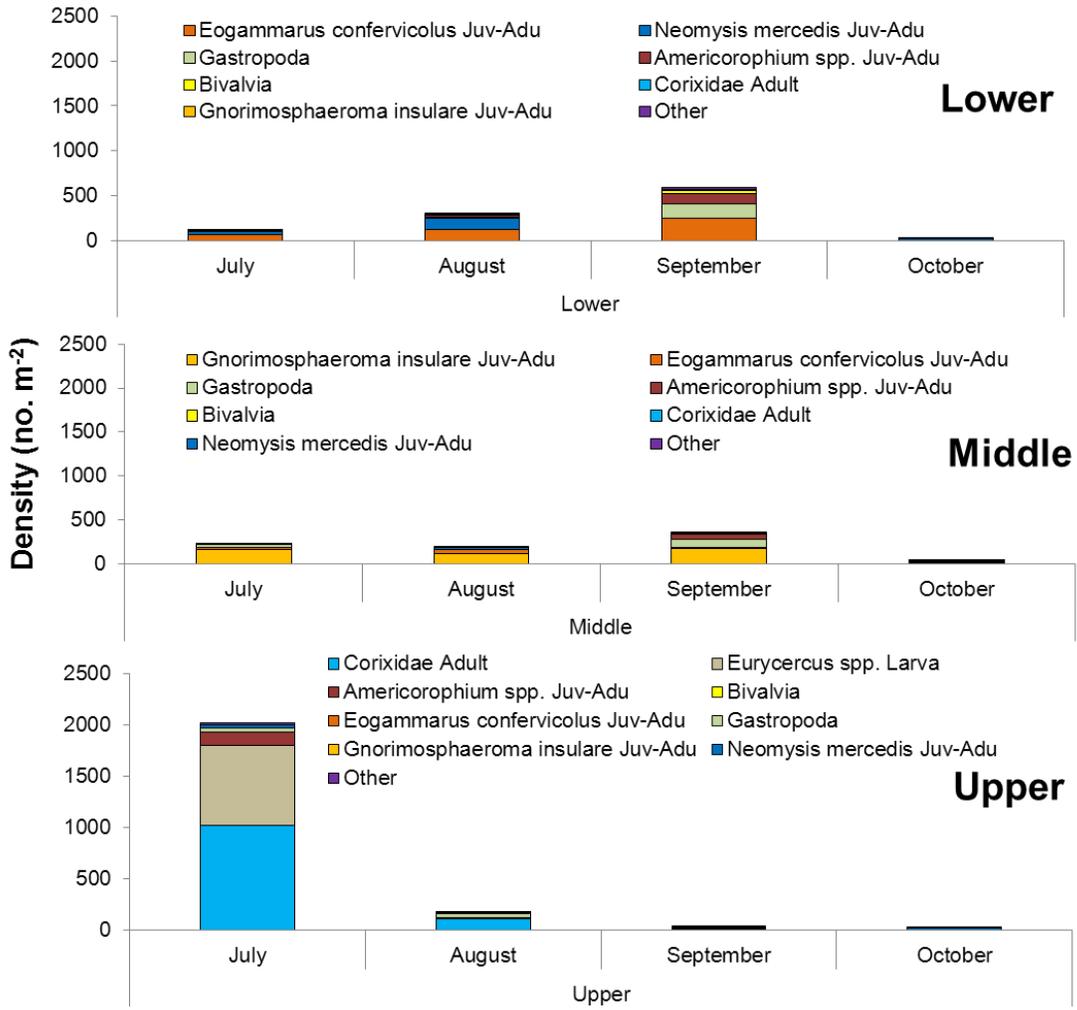


Figure 4.2.16. Mean aggregate density (no. m⁻²) of macroinvertebrates in epibenthic sled samples from three reaches of the Russian River estuary, July-October, 2011.

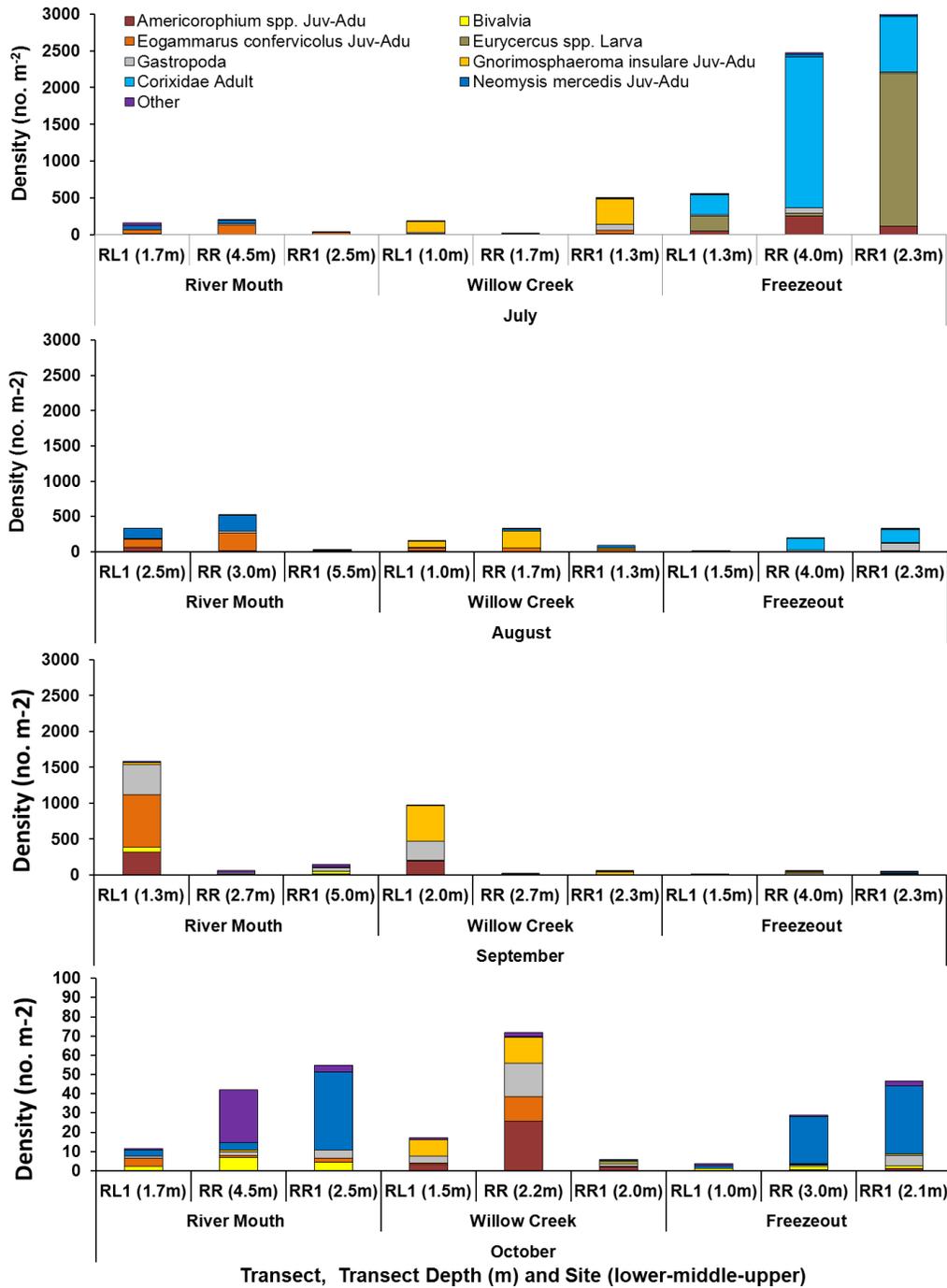


Figure 4.2.17. Mean density (no. m⁻²) of macroinvertebrates in epibenthic sled samples from marginal (RL1, RR1) and thalweg (RR) transects in three reaches of the Russian River estuary, July-October, 2011; note density scale change from July-September to October.

Preliminary Conclusions

Juvenile Steelhead and Chinook Salmon Diet Composition

As documented for 2009-2010, epibenthic crustaceans (*Ameriocolopium* spp., *Eogammarus confervicolus*, *Gnorimospheroma insulare*, *Neomysis mercedis*), and insects (corixids [water boatmen]) dominated all diet aspects of juvenile steelhead and Chinook salmon foraging in the Russian River estuary. *E. confervicolus* were the most common prey in juvenile steelhead diets overall, particularly the contribution to prey biomass; conversely, corixids and *N. mercedis* were more incidental, particularly to diets of steelhead in the upper reach. *E. confervicolus* was also prevalent in the diets of juvenile Chinook salmon, but *A. spinicorne* and *N. mercedis* were also common dietary constituents. In the case of both fish species, the very minor contributions of chironomids and other insects in 2011 contrasted with the greater contributions in 2010. In the present absence of the completed insect fallout trap data; there is no obvious explanation for this pattern, although it may relate to the decreased duration and extent of flooding of the upper intertidal zone during the more extended closure events in 2010.

While not designed to statistically test foraging performance in the different reaches of the estuary, size-specific instantaneous ration of juvenile steelhead suggested that prey availability and foraging opportunity might be higher in the lower and middle reaches than in the upper reach, or that environmental conditions are less conducive to efficient foraging.

Prey Availability

Initial results (limited to the epibenthos sampling) from sampling of prey availability does not allow interpretation of estuary entrance status because limited estuary closure events did not coincide with the fixed epibenthos sampling. Alterations in the original (2009) sampling design and protocol in 2010 and 2011 to take greater advantage of prolonged estuary closure events to (1) be more reactive to closing/opening events to deploy sampling beyond the fixed schedule and (2) deploy integrated epibenthic sled sampling across (perpendicular to) the channel to determine uniformity of prey distribution in depth/habitat zones (“hypsometric habitat” sampling) under different water level (estuary or lagoon) conditions could not be implemented for that reason. However, epibenthic sled sampling in the channel thalweg and along the channel margins did not indicate any obvious trends in the distribution of prey organisms. At a minimum, this suggests that under open tidal estuary conditions the prominent epibenthic prey resources are not specifically concentrated in either the thalweg or the marginal shallows of the estuary, but may shift (or be passively concentrated) according to cross-channel variation in physicochemical conditions. It remains to be seen, under prolonged lagoon conditions, how the changes in water quality and expanded prey habitat availability will influence the distribution and productivity of the prominent prey and their availability as prey for juvenile steelhead and Chinook salmon.

Considerations and Recommendations for 2012 Sampling

There is no reason that the present sampling design and protocol would not present a viable test of the redistribution of available prey under a closure event. However, rather than depend opportunistically on an event, it would be extremely advantageous to focus on a dedicated closure event and conduct selected (e.g., epibenthic sled, benthic) sampling daily or otherwise

frequently enough to capture the potential redistribution and density variation of epibenthic and benthic prey over increasing water levels.

As recommended in earlier reports, experiments to evaluate the feasibility of deploying depth- and/or temperature-logging or transmitting acoustic tags on juvenile steelhead would certainly be a move toward resolving many questions about the diel behavior under varying estuary status conditions.

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Clarke, K.R., and R.N. Gorley. 2006. PRIMER v6: User Manual/Tutorial. PRIMER-E, Plymouth, United Kingdom.

Largier, J., and D. Behrens. 2010. Hydrography of the Russian River estuary Summer-Fall 2009, with special attention on a five-week closure event. Unpubl. Rep. to Sonoma County Water Agency, Bodega Mar. Lab., Univ. Calif. Davis. 72 pp.

Manning, D., and J. Martini-Lamb, editors. 2011. Russian River Biological Opinion status and data report year 2009-2010. Sonoma County Water Agency, Santa Rosa, CA. 200 p.

4.3 Downstream Migrant Trapping

Part of the Reasonable and Prudent Alternative (RPA) in the Russian River Biological Opinion relative to the estuary is to provide information about the timing of downstream movements of juvenile steelhead, their relative abundance and the size/age structure of the population. The sampling design implemented by the Water Agency and described in this section specifically targets the detection and capture of anadromous salmonid young-of-the-year (YOY, age-0) and parr (\geq age-1) (collectively referred to as juveniles) as well as smolts. In order to help accomplish the objectives listed above, the Water Agency undertook a variety of fish detection activities in the estuary at Duncans Mills and at selected sites upstream of the estuary (Austin, Dutch Bill, Green Valley Creeks and the mainstem Russian River at Wohler-Mirabel, Figure 4.1.1). Implementation of the monitoring activities described here represent a slight departure from the original RPA in the Russian River Biological Opinion; however, after consultation with NMFS and CDFG all parties agreed to evaluate the approach presented here. Descriptions and data from other monitoring activities conducted in the estuary (e.g., water quality monitoring, beach seining) as well as fish trapping operations in Dry Creek are presented elsewhere in this report.

Methods

As in 2010, in 2011 we again employed a combination of remote monitoring methods at sites where fish were not physically captured (underwater video and PIT antennas were used

instead) and fish traps at sites where fish were physically captured (rotary screw trap, funnel trap or pipe trap), sampled for biological data and released. In the following sections, we describe the sampling methods and analyses conducted for data collected at each site.

Estuary video camera and PIT antenna systems

On April 28, we constructed a fyke net at the same location as the 2009 and 2010 fyke net on a low gradient riffle between the Cassini Ranch campground and the Moscow Road Bridge at river km 10.5 (Figure 4.3.2; see Manning and Martini-Lamb 2011 for additional details on gear and installation). A remote detection system consisting of an underwater video/DVR system and a small racket-style PIT antenna around the cod end of the fyke net. This allowed fish to move through a viewing chamber which facilitated identification of individual fish to species and life stage on digitally-recorded video footage as well as be detected if they were PIT-tagged (tagged at upstream locations) as they moved downstream through the PIT antenna. Date and time were recorded for all PIT-tagged fish that were detected and date, time and direction of movement (upstream or downstream) were noted for each fish observed passing through the viewing chamber. In order to estimate fish lengths from the video footage, vertical lines spaced 10 mm and 50 mm apart were drawn on the viewing chamber so that lengths could be estimated from the line spacing (Figure 4.3.2). As in 2010, a mammal/bird excluder was also installed. The video camera and PIT antenna were operated 24 hours per day during the late spring through mid-summer except for periods described below.



Figure 4.1.1. Map of downstream migrant detection sites in the lower Russian River, 2011. Numbered dots along stream courses represent distance (km) from the mouth of each stream.

After approximately one month of operating the fyke net, wing walls and remote monitoring gear (video and PIT antenna systems) in the manner described above, filamentous algae clogging the cod end of the fyke net and associated ponding of water upstream of the fyke net (perpetual problems in 2010 as well) led us to consider changes to the configuration of the net apparatus and monitoring gear beginning in late May. On May 26, we installed a 16 foot wide by 2 foot high swim-through antenna at the upstream end of the river left (outer) wing wall in order to evaluate the possibility that fish were skirting the fyke net entirely. When we discovered that this was indeed the case, on June 1 we began a series of steps to reconfigure the wing walls and fyke net. These steps included moving the wing walls farther upstream and placing the 16 foot by 2 foot swim-through antenna at the downstream end of the wing walls (the apex of the "V" formed by the wing walls). We also installed a chute consisting of two nets attached to the downstream end of the wing walls, but not attached to the mammal/bird excluder (Figure 4.3.3). The lack of attachment to the mammal/bird excluder was intended as a means to allow debris, mainly filamentous algae, to spill out the downstream ends of the chute thus reducing the potential to clog the fyke net and video chamber. During the period when the net was being reconfigured, the camera and both antennas were turned off to avoid damage to the cables. We began operating the antennas and camera again on June 8.

On July 19, 2011 the video camera and racket PIT antenna were removed along with the viewing chamber, net chute and mammal/ bird excluder. The wing walls and large antenna remained in place and were operated until August 29 when all remaining equipment was removed.

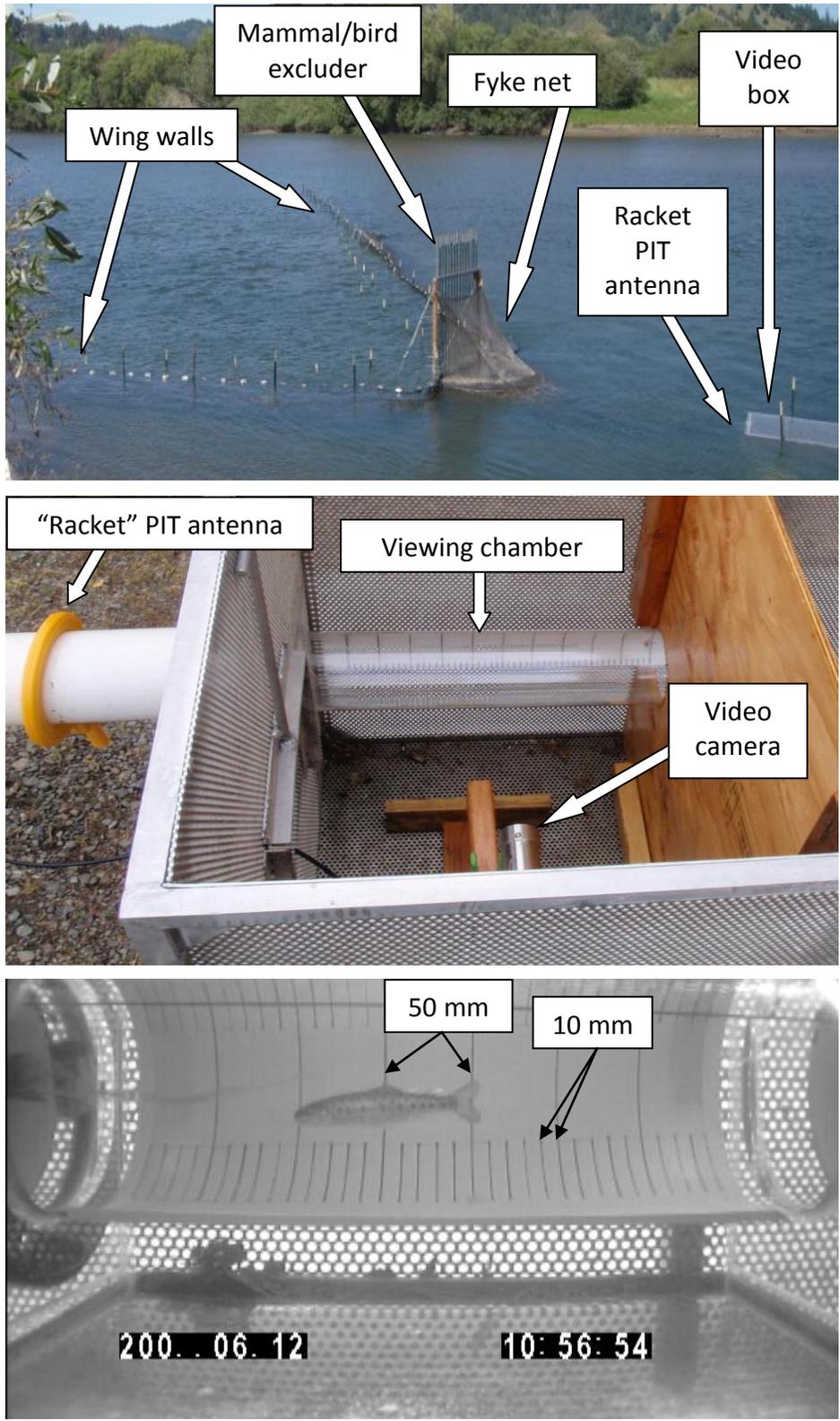


Figure 4.3.2. Video box, PIT antenna and example image from continuous underwater video footage at the Duncans Mills fyke net (RiverKm=10.5), 2010 and 2011.

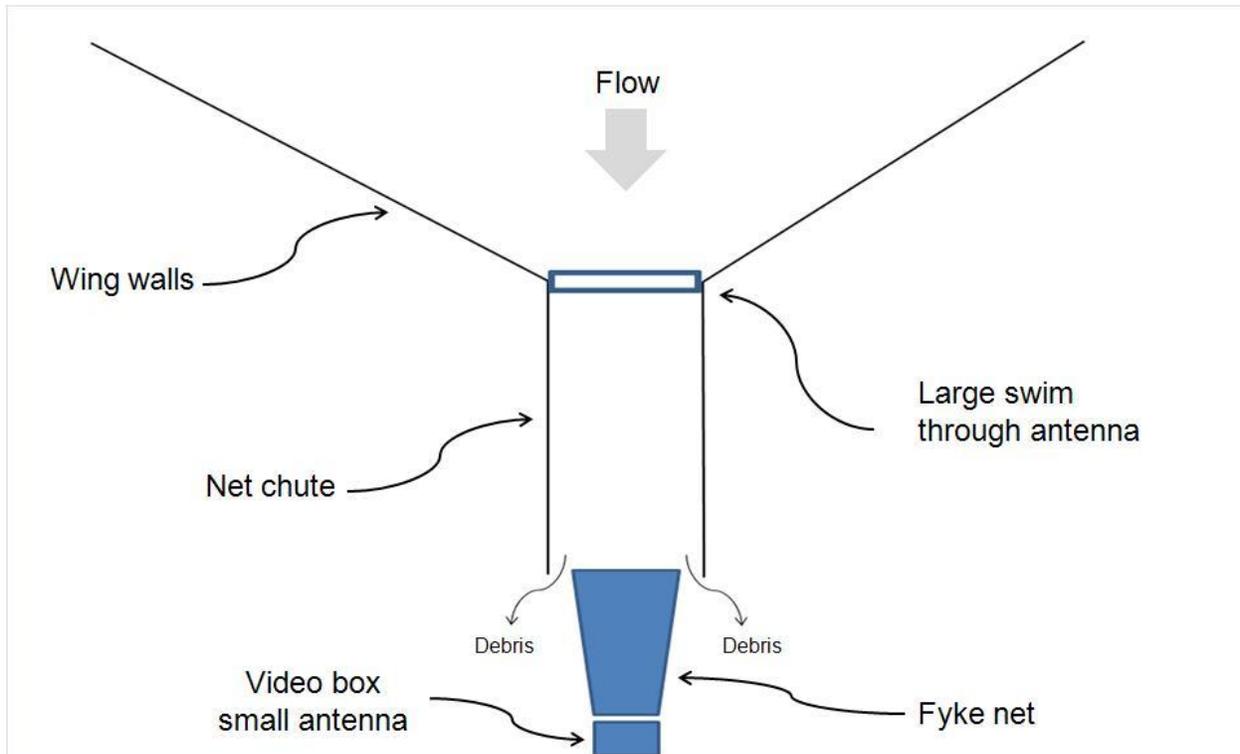


Figure 4.3.3. Diagram of the estuary fyke net at Duncans Mills (overhead view). Configuration shown is the second of two configurations evaluated in 2011 (see text for description of configurations evaluated).

Lower River fish trapping and PIT tagging

As a result of consultation with NMFS and DFG, the Water Agency identified three lower River tributaries (Green Valley Creek, Dutch Bill Creek and Austin Creek) in which to operate fish traps as a way to supplement data collected from the PIT antenna and video monitoring system at the estuary fyke net (Figure 4.3.4). In 2011 the Water Agency operated three types of downstream migrant traps in these tributaries; a rotary screw trap, funnel traps and pipe traps (Figure 4.3.5). In addition, juvenile steelhead were captured and PIT-tagged at the Water Agency's downstream migrant trapping site at Wohler-Mirabel; this resulted in a total of four possible sources of PIT-tagged fish that we could monitor as they entered the tidal portion of the estuary (Figure 4.3.4). Growth data collected from fish originally PIT-tagged in lower river traps then recaptured during beach seining surveys is covered in the Syntheses chapter of this report. Water Agency rotary screw trap methods are detailed in Chase (2005) and Manning and Martini-Lamb (2011). For detailed methods on pipe and funnel net trapping in Russian River tributaries see Obedzinski *et al.* (2006, 2007, 2008). Fish traps were checked daily by Water Agency staff during the trapping season (April through July). Captured fish were enumerated and identified to species and life stage at all traps. Fork length (± 1 mm) and weight (± 0.1 g) was measured on a subset of all non-PIT-tagged individuals each day. PIT tags were implanted in a portion of the total capture of steelhead YOY and parr ≥ 60 mm in fork length; all PIT-tagged fish were measured for fork length and weight (± 0.1 g).

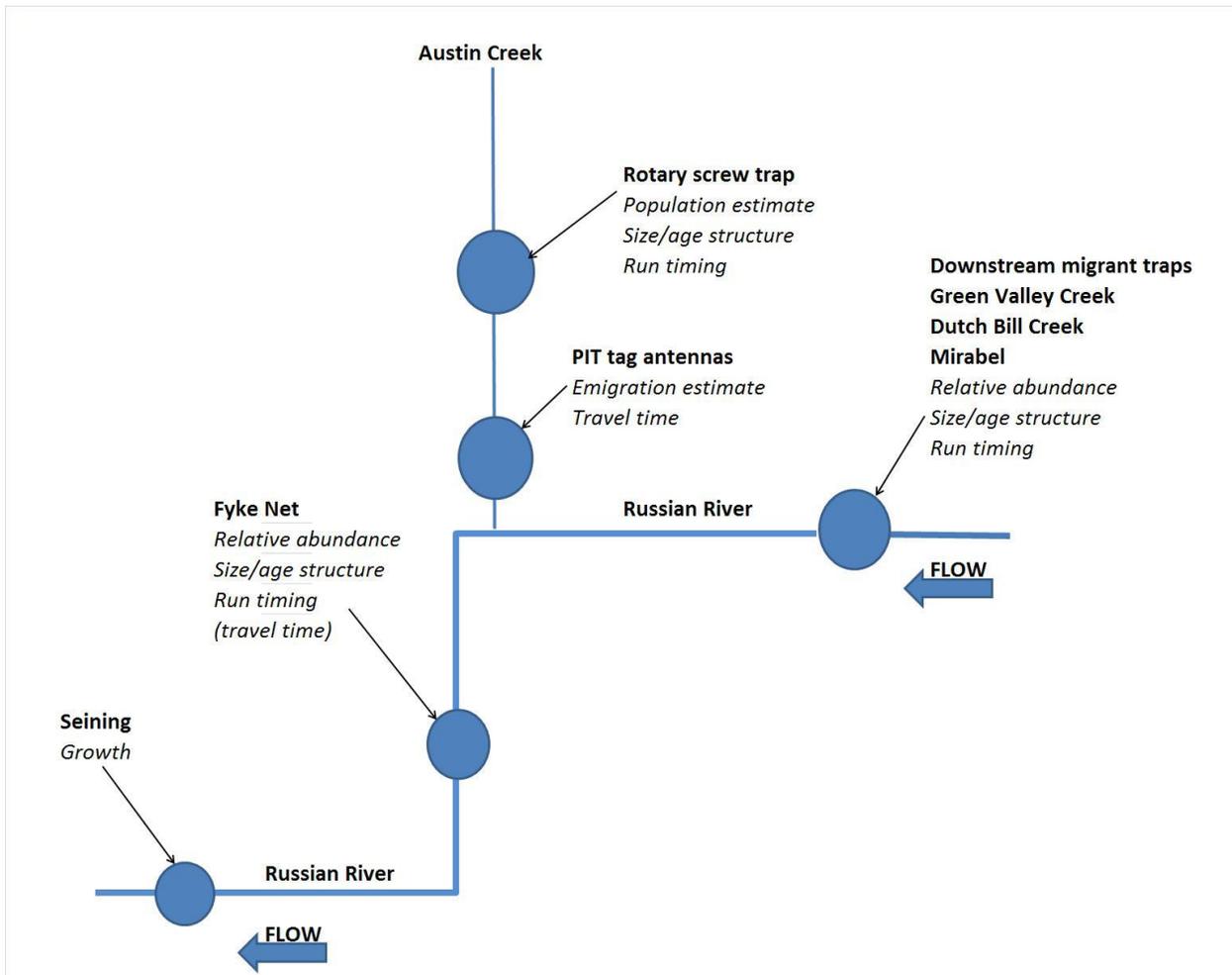


Figure 4.3.4. Diagram showing the relationship of the lower river downstream migrant traps (Wohler-Mirabel, Green Valley Creek, Dutch Bill Creek and Austin Creek) to the estuary fyke net and to the beach seining surveys. Also shown are the types of monitoring data that were collected at each of these locations.

Rotary screw trap on Austin Creek



Pipe trap on Dutch Bill Creek



Funnel net on Green Valley Creek



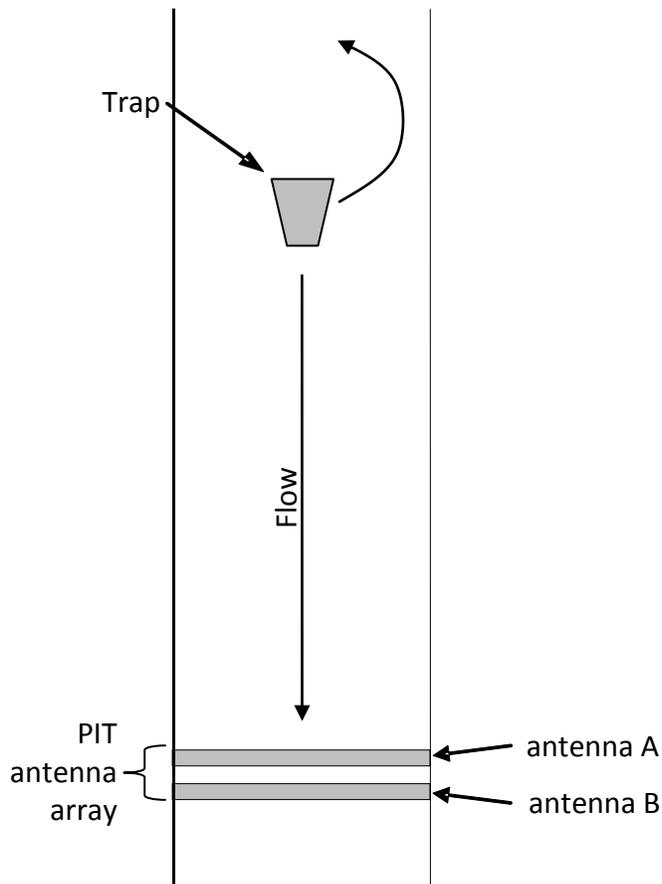
Figure 4.3.5. Photographs of downstream migrant traps operated by the Water Agency (Austin, Dutch Bill and Green Valley Creeks). The Green Valley Creek photograph is courtesy of UCCE.

Austin Creek- A rotary screw trap was installed on Austin Creek on April 14, 2011. As a way to increase trap efficiency, wood-frame/plastic-mesh weir panels and a metal-mesh ramp were installed to direct fish into the screw trap. By late May, the rotary screw trap was not fishing effectively due to low stream velocities; therefore, on May 27 we replaced the screw trap with a funnel trap that was fished through the end of the trapping season. The funnel trap consisted of wood-frame/plastic-mesh weir panels, a funnel net and a wooden live box; it was located on a riffle approximately 200 m downstream of the rotary screw trap site. Trapping continued until surface flow in Austin Creek was no longer contiguous and daily catches of steelhead dropped rapidly (Table 4.3.1).

A portion of the steelhead PIT-tagged at the Austin Creek fish trap were released upstream of the trap in order to estimate trap efficiency. Trap efficiencies are commonly calculated by releasing fish that are highly motivated to move downstream (e.g., smolts) upstream of a fish trap (Bjorkstedt 2000). Because not all juvenile steelhead are necessarily motivated to move downstream, this is not necessarily a suitable life stage to use for estimating trap efficiency. Therefore, although failure to recapture a juvenile steelhead released upstream of the trap may be due to trap inefficiency (e.g., fish passage but failure to capture), it may also be due to some fish remaining upstream of the trap where it may take up residence or die.

To help distinguish between failure to capture due to trap inefficiency vs. failure to re-emigrate, a dual antenna PIT antenna array was installed on April 19, 2011 approximately 0.6 km downstream of the rotary screw trap in order to detect PIT-tagged steelhead. The PIT antenna array was located approximately 0.5 km from the mouth of Austin Creek just upstream of the area that can be inundated by the Russian River during closure of the barrier beach; therefore, we assumed that once fish passed the antenna array they had effectively entered the estuary/lagoon.

To gain estimates of the number of fish emigrating from Austin Creek, trap efficiencies were calculated by using the total number of PIT-tagged steelhead that were released upstream of the trap, recaptured in the trap and detected on the downstream antennas. Because the antenna array consisted of two antennas, we could estimate antenna efficiency using a similar approach (Figure 4.3.6; Zydlewski et al. 2006).



1. Methods:

Capture and PIT-tag juvenile steelhead, then release newly tagged fish upstream while releasing previously-tagged fish (recaptures) downstream.

2. Estimating trap efficiency:

Of the PIT-tagged fish released upstream of the trap, how many were recaptured in the trap before being detected on the downstream antenna array?

3. Estimating antenna efficiency:

Of the PIT-tagged fish detected on the downstream antenna in the array (antenna B), how many were also detected on the upstream antenna (antenna A).

Figure 4.3.6. Diagram illustrating the relative location of the downstream migrant trap and PIT antenna array operated on Austin Creek and outline of how trap and antenna efficiencies were estimated.

Dutch Bill Creek- A funnel trap was installed on Dutch Bill Creek adjacent to the park in downtown Monte Rio (approximately 0.3 km upstream of the creek mouth) on April 6, 2011. On May 6, the trap was converted to a pipe trap because of low water velocities. The trap was fished until the completion of trapping operations on July 5 when stream flow in lower Dutch Bill Creek became disconnected (Table 4.3.1).

Green Valley Creek- A funnel trap was installed on Green Valley Creek approximately 2.1 km upstream of the mouth on April 12, 2011. Trapping operations were suspended on May 5 due to unexpected capture in the trap of freshwater shrimp, a state and federally listed species (Table 4.3.1). The Water Agency is working with the NMFS, DFG, and USFWS to resolve this issue.

Mainstem Russian River at Mirabel- A rotary screw trap was operated on the mainstem Russian River immediately downstream of the Water Agency’s inflatable dam site at Wohler-Mirabel (approximately 39.7 km upstream of the river mouth) from April 15, 2011 to July 19 (Table 4.3.1). The purpose of this trap was to fulfill a broader set of objectives in the Russian River Biological Opinion than what is described in the current section of this report. However,

one of the objectives was to provide a source of PIT-tagged steelhead juveniles that may enter the estuary and be detected during downstream monitoring efforts. Therefore, we report the number of steelhead that we applied PIT tags to at the Wohler-Mirabel downstream migrant trapping site in the Results section. Other methods and results related to the Wohler-Mirabel fish trapping effort in 2011 are detailed in the Mirabel Downstream Migrant Trapping section of this report.

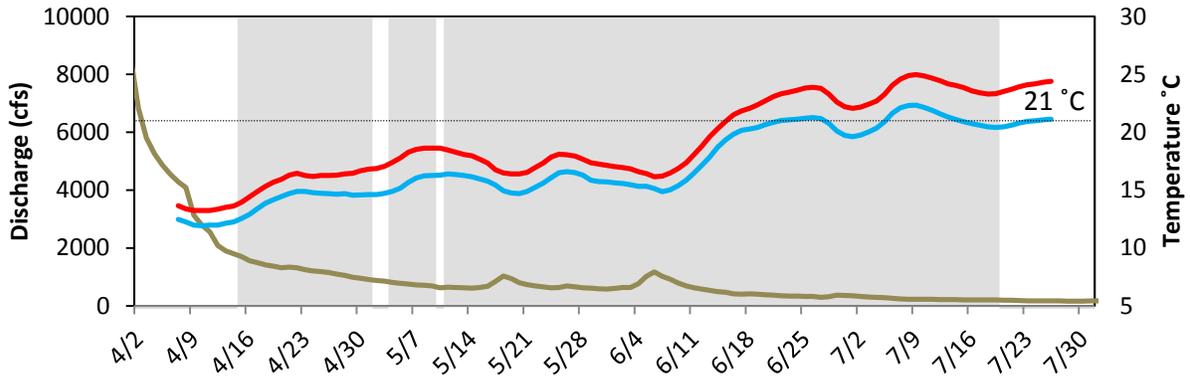
Table 4.3.1. Installation and removal dates, and total number of days fished for lower river downstream migrant traps operated by the Water Agency (Dutch Bill, Green Valley Austin Creeks, and Mirabel on the mainstem Russian River).

Trap	Installation date	Removal date	Number of days fished
Duncans Mills (video / PIT antenna)	4/28/2011	7/19/2011	63
Austin Creek	4/14/2011	7/5/2011	74
Dutch Bill Creek	4/6/2011	7/5/2011	87
Green Valley Creek	4/12/2011	5/5/2011	24
Wohler-Mirabel	4/15/2011	7/19/2011	93

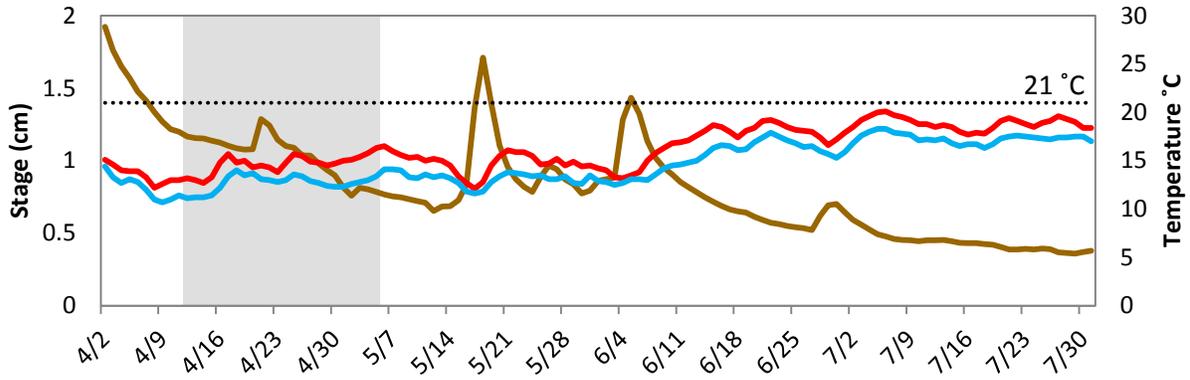
Results

Because of high flow conditions in 2011, downstream migrant monitoring stations on the lower river and in tributaries to the Russian River could not be installed earlier than April 6 (Table 4.3.1). Although this meant we missed the earlier portion of the downstream migrant season for salmonid smolts, our sampling period did encompass a high portion of the juvenile steelhead movement period (Figure 4.3.7). Water temperatures in tributary trapping sites were low enough to safely handle and PIT tag fish throughout the 2011 downstream migrant season, but water temperatures at Wohler-Mirabel (as measured at Hacienda) became too warm to handle fish in mid-June.

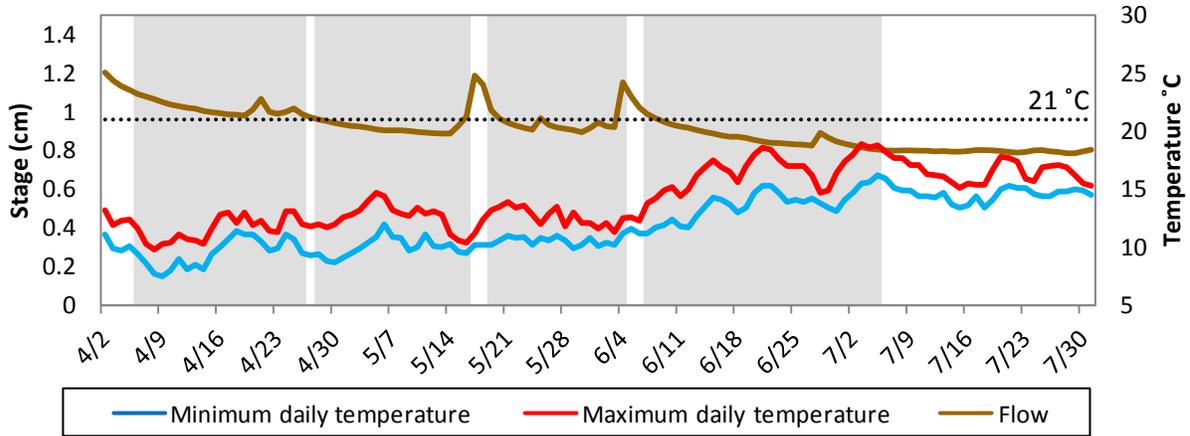
Mainstem (Wohler-Mirabel, 38.57)



Green Valley (Martinelli Bridge)



Dutch Bill (near Grub Creek)



— Minimum daily temperature — Maximum daily temperature — Flow

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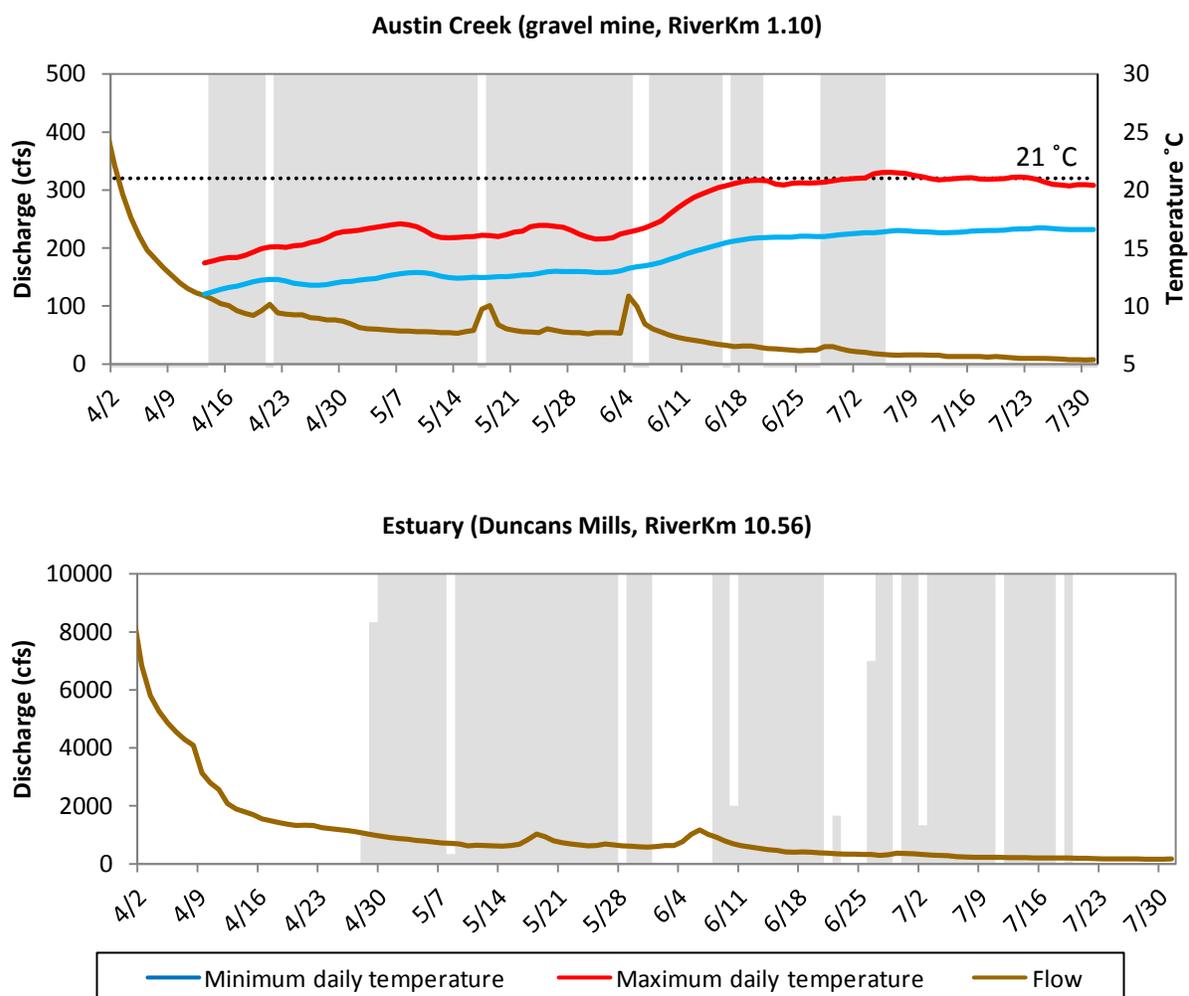


Figure 4.3.7. Environmental conditions at downstream migrant detection sites from April 1, 2011 to July 31, 2011 to July 31. Gray shading indicates the proportion of each day that each facility was operated and discharge data are from the USGS gauge at Hacedinda (mainstem and estuary, 11467000), the USGS gauge at Cazadero (Austin, 11467200), the SWRCB gauge at Martinelli bridge (Green Valley Creek) or stage height from a data logger operated by CEMAR (Dutch Bill Creek). Temperature data are from the USGS gauge at Hacienda (mainstem and estuary), data loggers at the same site (Green Valley, Dutch Bill), or a Water Agency data logger located at the trap site (Austin).

Estuary video camera and PIT antenna systems
Steelhead

The six day (May 26-31) evaluation of whether clogging and associated ponding upstream of the fyke net in Duncans Mills was limiting downstream movement of fish through the fyke net revealed that 13 PIT-tagged salmonids swam around the fyke net while only two salmonids swam through the video box during the same period. By reconfiguring the net as a chute and installing the 16 foot swim-through antenna (Figure 4.3.3), PIT detections increased but the increase came as a result of the 16 foot antenna as opposed to the racket antenna around the cod end of the fyke net (Figure 4.3.8). A total of 1,096 salmonids were recorded on the video system in 2011 as compared to 1,706 in 2010; however, only 9.7% (n=165) could not be identified to species in 2010, whereas almost 25% (n=253) could not be identified to species in 2011. We believe that higher water velocity through the viewing chamber (resulting in fewer frames per fish) in 2011 was the primary reason for differences in proportions of unidentifiable salmonid species between years.

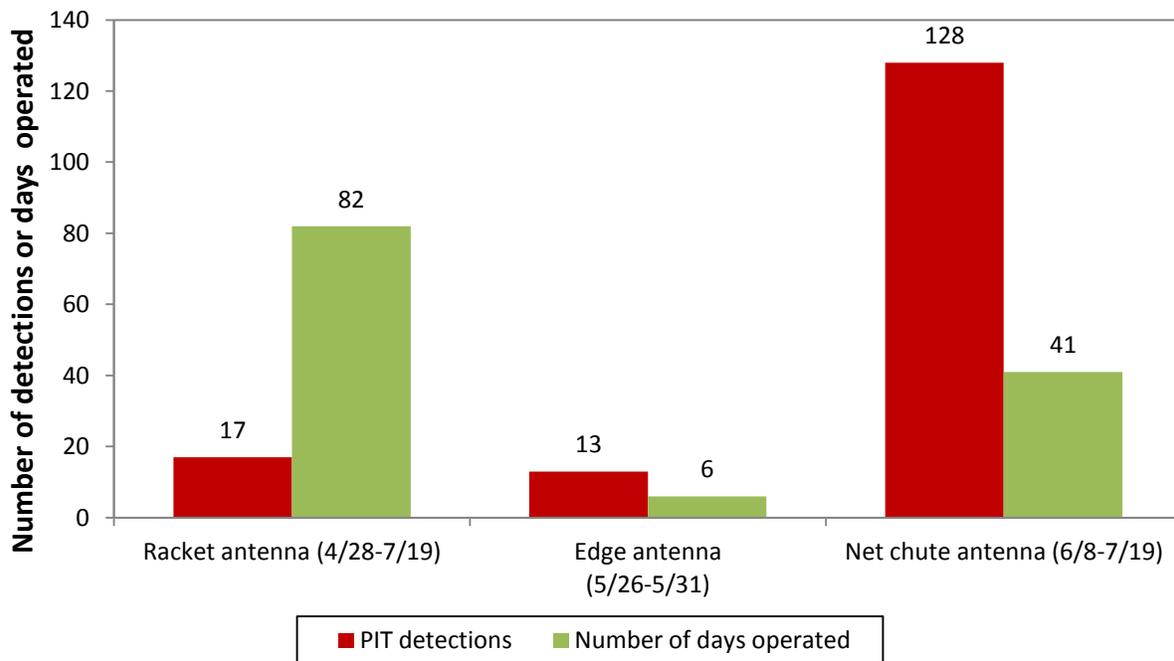


Figure 4.3.8. The number of salmonids detected on each PIT antenna/fyke configuration at the Duncans Mills fyke net during the period of time that the video camera system was operating.

The problems associated with debris clogging the with fyke net as well as attempts to reconfigure the net undoubtedly hindered our ability to accurately detect the number of juvenile salmonids moving into the estuary even in a relative sense. The 98 juvenile and smolt steelhead detected on the video in 2011 (Figure 4.3.9) was relatively lower than the 956 detected in 2010 and similar to the number detected in 2009 (64) when the fyke net was operated as a trap. Unfortunately, it is impossible to say with any certainty what proportion of the reduction in detection from 2010 to 2011 was due to an actual reduction in the number of

fish moving into the estuary as opposed to reductions in trapping efficiency. Fork lengths could be estimated from the video for 95 steelhead (Figure 4.3.11).

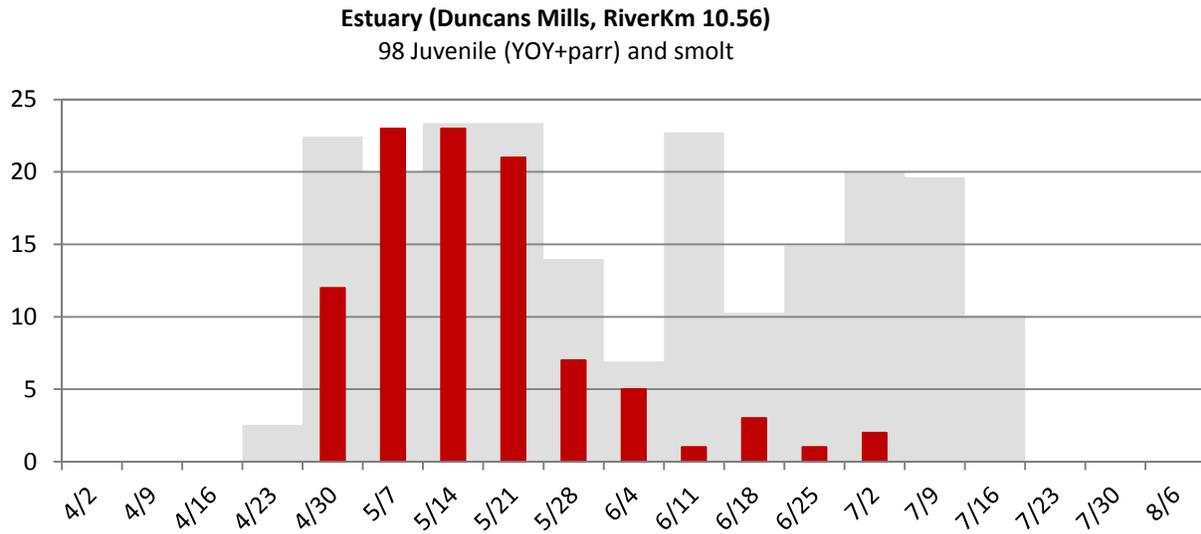


Figure 4.3.9. Weekly detection of juvenile and smolt steelhead at the Duncans Mills fyke net, 2011. Gray shading indicates portion of each week video was operational.

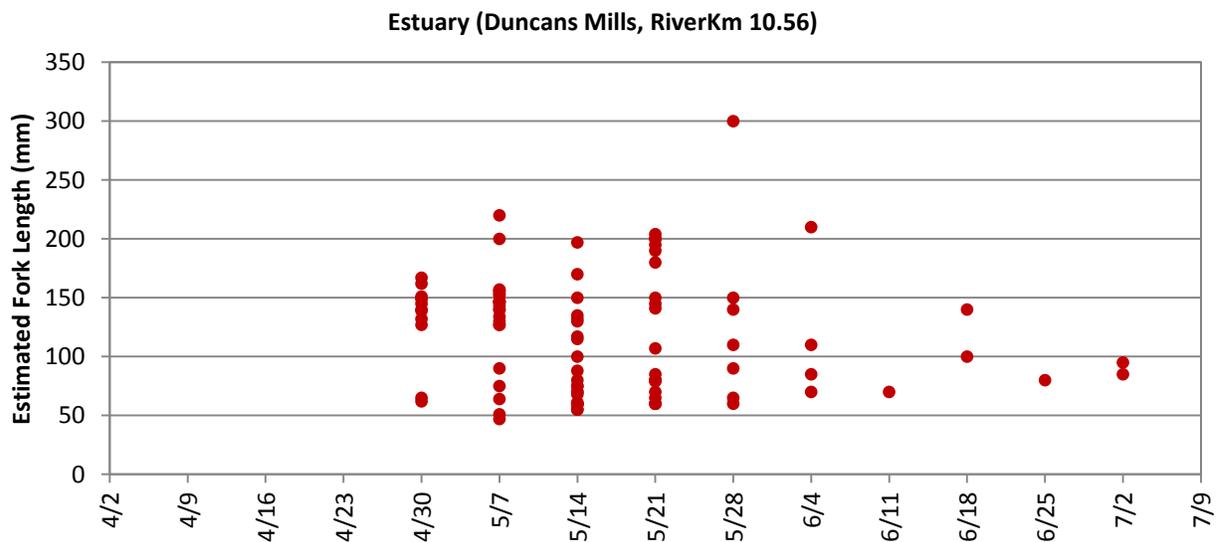


Figure 4.3.10. Estimated fork lengths of steelhead by week recorded on the estuary fyke net video camera, Duncans Mills, 2011. See text for description of fork length estimation method.

Trapping operations in Austin, Dutch Bill and Green Valley Creeks, allowed us to PIT tag more steelhead in 2010 and 2011 (total=1,139 and 622 respectively, Table 4.3.2) as compared to 2009 (total=9) when the only fish PIT-tagged were at Wohler-Mirabel and the fyke net (the fyke net was operated as a trap only in 2009). Of the sites monitored in 2011, steelhead were most frequently encountered in Austin Creek. Over the course of the season, 1,974 steelhead were

captured of which 1,287 were YOY, 513 were parr (\geq age-1) and 174 were smolts (Figure 4.3.11). The Water Agency applied PIT tags to 500 individuals; based on their size, 326 of this total were estimated to be YOY. In total, 324 PIT-tagged steelhead were released upstream of the trap (Table 4.3.3). Of those 326, we have high certainty that at least 131 moved downstream because they were detected on the downstream PIT antenna array. Of the individuals detected on the downstream PIT antenna array, 8 were first recaptured in the trap resulting in an estimated trap efficiency of 6.1% (8/131). Based on this trap efficiency, we estimate that the population size of YOY steelhead moving past (or in the vicinity of) the trap was approximately 7,426. Of the 178 individuals detected on the downstream antenna in the array, 93 were also detected on the upstream antenna in the array resulting in an estimated antenna efficiency of 52.2 % (93/178). This resulted in an estimate of 77.7 % (251/324) of the PIT-tagged population that moved downstream. By inference, we assume that a similar proportion of the entire YOY steelhead population (\geq 60 mm) estimated at the trap site also moved downstream. Therefore, we estimate that approximately 5,755 steelhead YOY from Austin Creek emigrated into the tidal portion of the estuary in 2011. The Austin Creek trap catch and population estimate in 2011 was lower relative to 2010, but the estimated emigration rate (proportion of PIT-tagged YOY that emigrated) was fairly similar between the two years (Table 4.3.3).

In 2011, relatively few steelhead were caught at Wohler-Mirabel, Dutch Bill and Green Valley Creek fish traps as compared to Austin Creek. In total, 528, 3 and 31 steelhead juveniles were caught at Wohler-Mirabel, Green Valley and Dutch Bill Creeks, respectively (Figure 4.3.11). During 2011, PIT tags were applied to 100, 0 and 23 juvenile steelhead at Wohler-Mirabel, Green Valley and Dutch Bill Creeks, respectively (Table 4.3.2). Fork lengths of fish caught at these traps show at least 3 year classes with steelhead YOY present at each of the trapping locations (Figure 4.3.12). We assume that the few steelhead smolts captured at any of the trap sites in 2011 was likely due to a large portion of the smolt outmigration occurring before trap installation and the generally low trap efficiencies for steelhead smolts that is well-documented in the Russian River and elsewhere. The season total catches of steelhead at Wohler-Mirabel show an increasing trend since 2009 (Figure 4.3.13), with no apparent similar trend in Dutch Bill, Green Valley and Austin Creek trap catches (Figure 4.3.14 through 4.3.16).

Table 4.3.2. The number of PIT-tagged steelhead juveniles tagged at downstream migrant monitoring locations in the lower river in 2009-2011.

Site	2009	2010	2011
Mainstem (Wohler-Mirabel)	5	96	100
Green Valley Creek	no PIT tagging	0	0
Dutch Bill Creek	not fished	46	23
Austin Creek	not fished	997	500
Estuary fyke net	4	no trapping	no trapping

Table 4.3.3. PIT tag and trap capture metrics and values for YOY steelhead in Austin Creek. Note that 2010 numbers differ from Martin-Lamb and Manning (2011) because they have been adjusted to only include YOY.

Metric	2010	2011
Number PIT-tagged YOY released upstream of trap	765	324
Number PIT-tagged YOY released downstream of trap	195	2
Number PIT-tagged YOY detected on antenna array that were tagged in Austin Creek	547	131
Number PIT-tagged YOY released upstream & detected on antenna array	389	131
Number released upstream & recaptured in trap & detected on antenna	47	8
ESTIMATED TRAP EFFICIENCY	12.1%	6.1%
Number YOY+parr detected on both antennas in array	241	93
Number YOY+parr detected on downstream antenna only	288	178
ESTIMATED ANTENNA EFFICIENCY	83.6%	52.2%
Number YOY captured and PIT-tagged	960	324
Total number of YOY captured (≥ 60 mm only)	2,617	453
ESTIMATED NUMBER OF PIT-TAGGED YOY EMIGRANTS (≥ 60 mm only)	632	251
ESTIMATED PROPORTION OF PIT-TAGGED YOY THAT EMIGRATED (≥ 60 mm only)	65.8%	77.5%
ESTIMATED POPULATION SIZE OF YOY AT TRAP	21,628	7,426
ESTIMATED NUMBER OF YOY IN POPULATION THAT EMIGRATED	14,231	5,755

Chinook

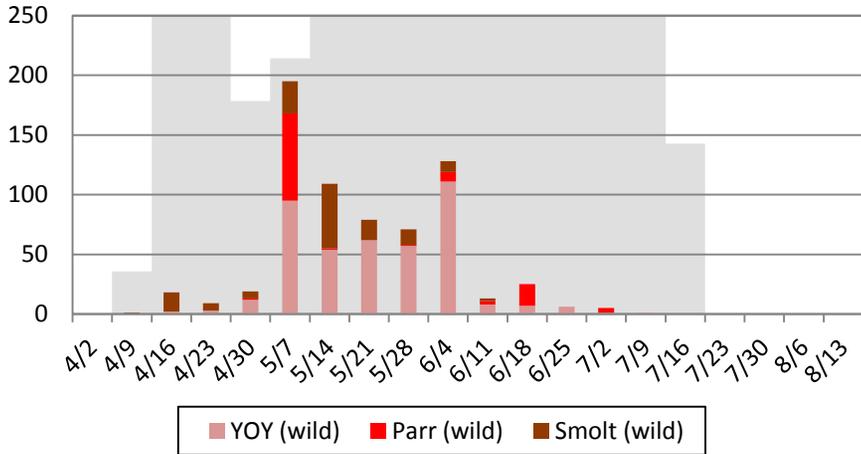
During the 2011 sampling season a total of 149 Chinook smolts were observed on the estuary fyke video. In 2011 relatively few Chinook smolts were captured in Austin Creek, Dutch Bill Creek, and Green Valley Creek (48, 34 and 16 respectively). For the number of Chinook smolts captured see the Mirabel Downstream Migrant trapping section of this report.

Coho

In 2011, 45 coho (YOY and smolt combined) were observed on the fyke net video. Capture of hatchery coho smolts were relatively greater in 2011 at Wohler-Mirabel and Dutchbill Creek than in 2010, but relatively similar between years at Green Valley and Austin Creeks (Figure 4.3.13 through 4.3.16). At Wohler-Mirabel 872 hatchery smolts, 15 wild smolts, and 10 wild parr were captured (Figure 4.3.13 and 4.3.17). At Green Valley Creek 229 hatchery coho smolts, 2 wild coho smolts, and 1 wild coho parr were detected at the trap (Figure 4.3.14 and 4.3.17). The Dutch Bill Creek trap captured the most coho salmon smolts of the traps operated. A total 2,904 hatchery and 2 wild coho smolts as well as 5 wild coho parr were captured at the Dutch Bill Creek trap site (Figure 4.3.15 and 4.3.17). At Austin Creek 335 hatchery coho smolts, 45 hatchery parr, and 14 wild parr were detected at the fish trap (Figure 4.3.16 and 4.3.17). Based on length data collected at the lower river traps there were at least two age groups (YOY: age-0 and parr/smolt: \geq age-1) of coho were captured (Figure 4.3.18). For a more detailed analysis of downstream migrant trapping catches of coho in the Russian River see UCCE Coho Salmon Monitoring Program results for 2011.

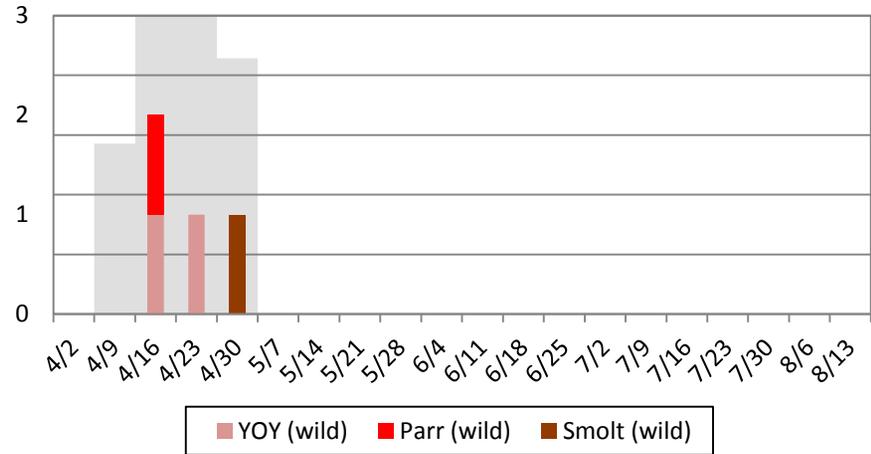
Mainstem (Wohler-Mirabel, RiverKm 38.57)

419 YOY, 109 Parr, 151 Smolt



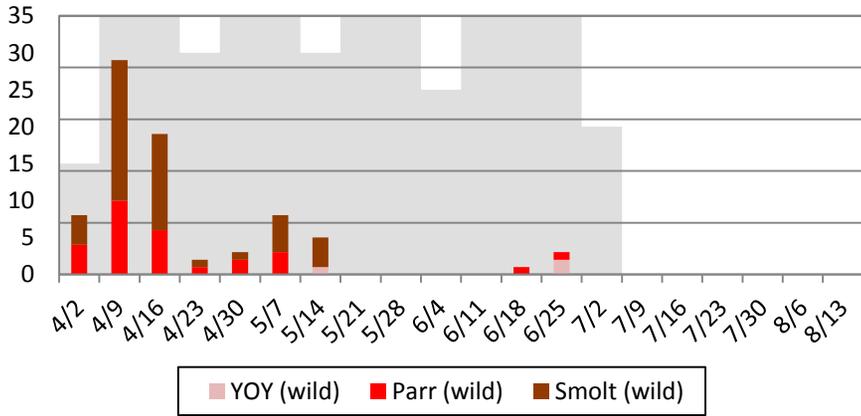
Green Valley Creek (lower trap site, RiverKm 2.07)

2 YOY, 1 Parr, 1 Smolt



Dutch Bill Creek (Monte Rio Park, RiverKm 0.28)

3 YOY, 28 Parr, 47 Smolt



Austin Creek (gravel mine, RiverKm 1.10)

1287 YOY, 513 Parr, 174 Smolt

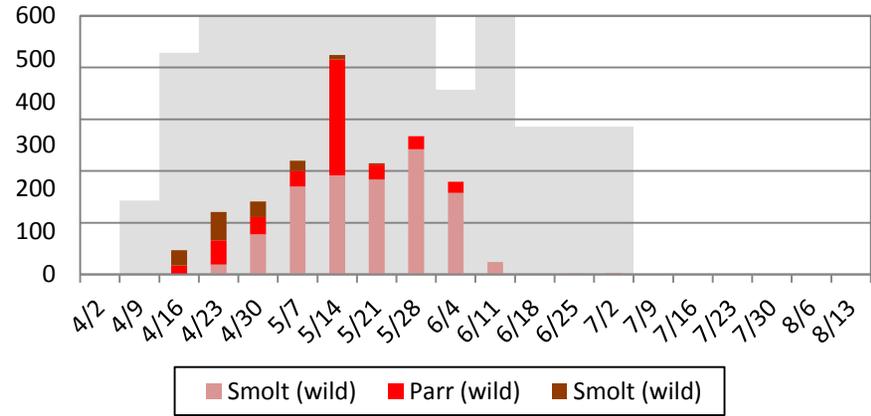


Figure 4.3.11. Weekly capture of steelhead by life stage at lower river downstream migrant trapping sites, 2011. Gray shading indicates portion of each week trap was fishing. Note the different vertical scale among plots for each site.

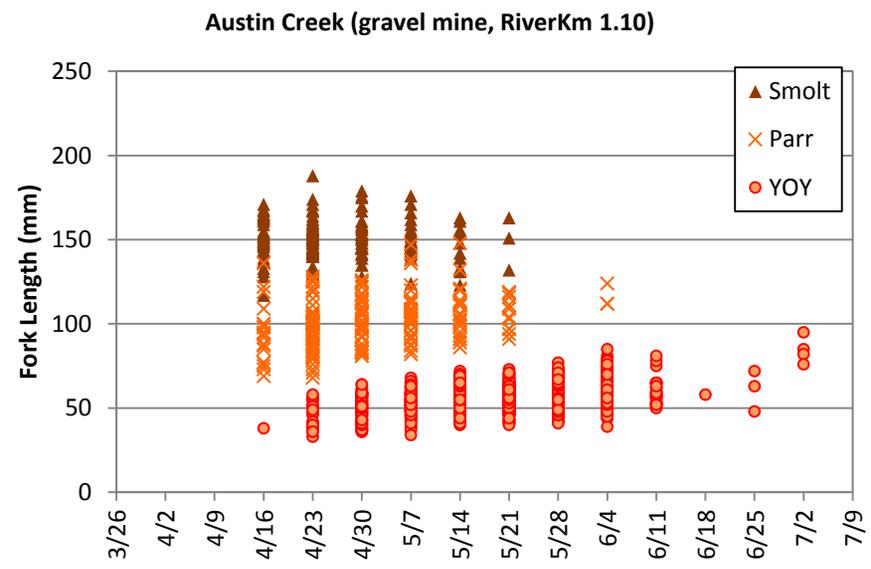
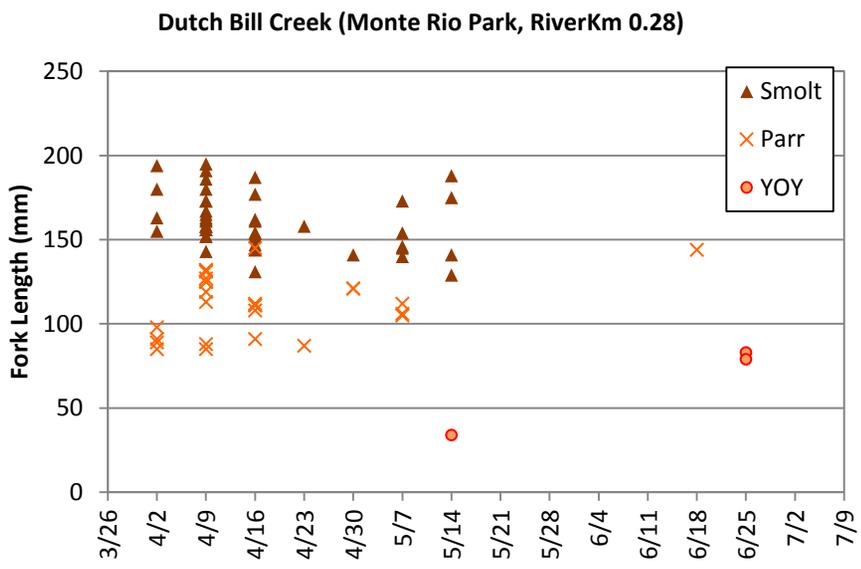
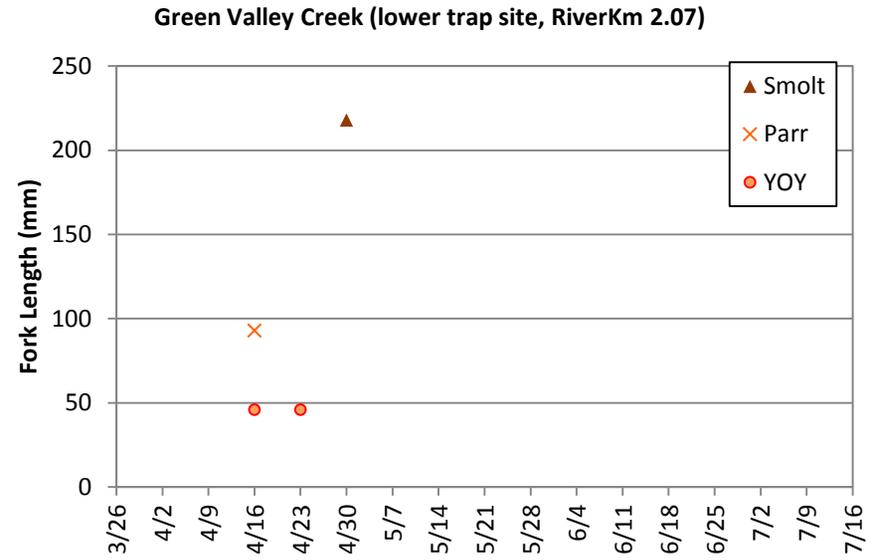
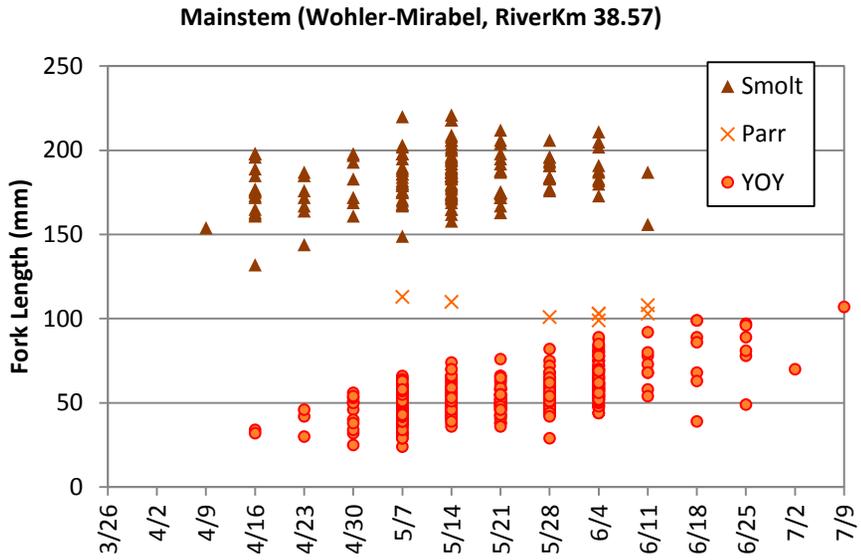


Figure 4.3.12. Weekly fork lengths of steelhead captured at lower river downstream migrant trap sites, 2011.

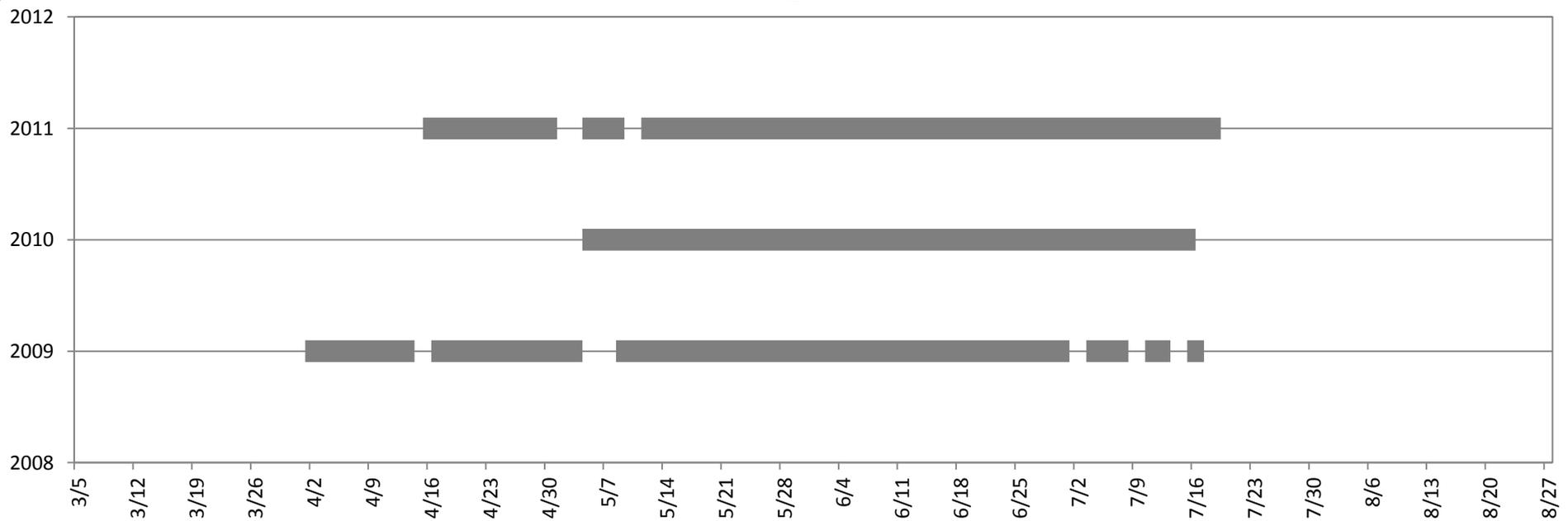
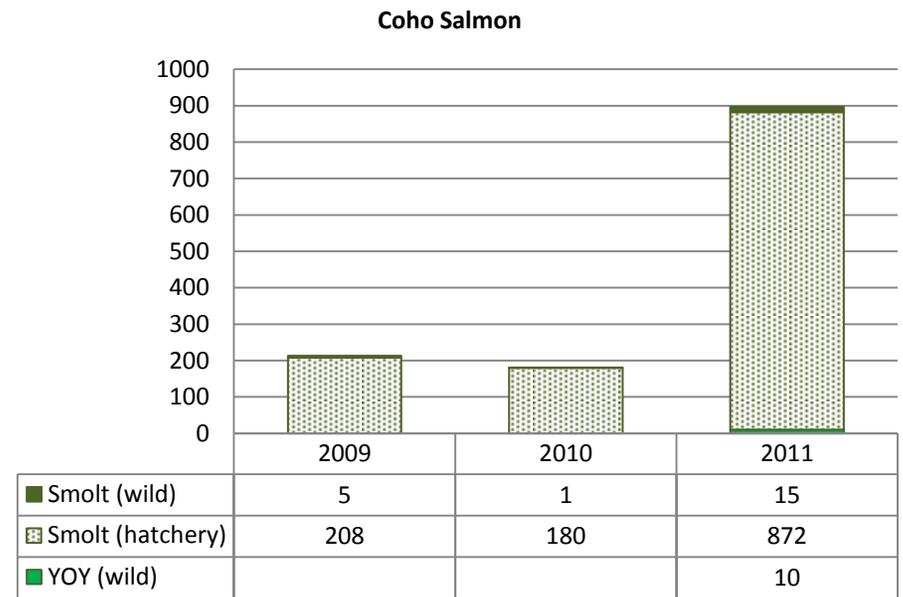


Figure 4.3.13. Number of steelhead and coho salmon captured by life stage and origin at the mainstem Russian River (Wohler-Mirabel) downstream migrant trap, (upper panels) and duration and timing of trap operation (lower panel), 2009-2011.

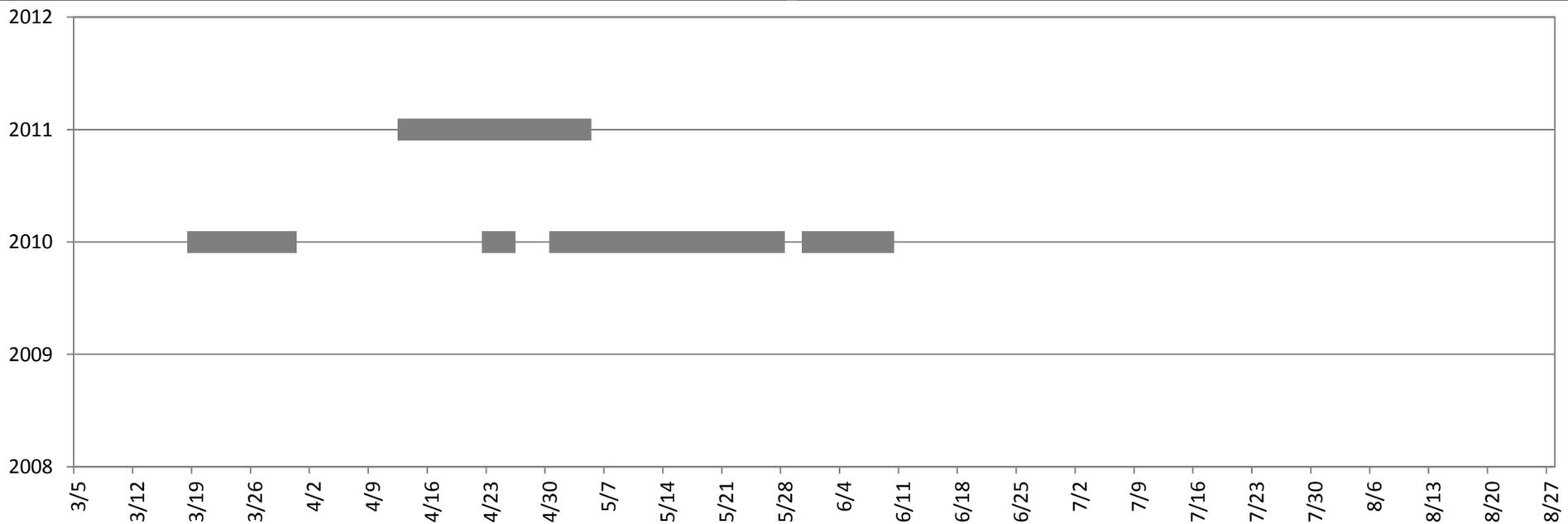
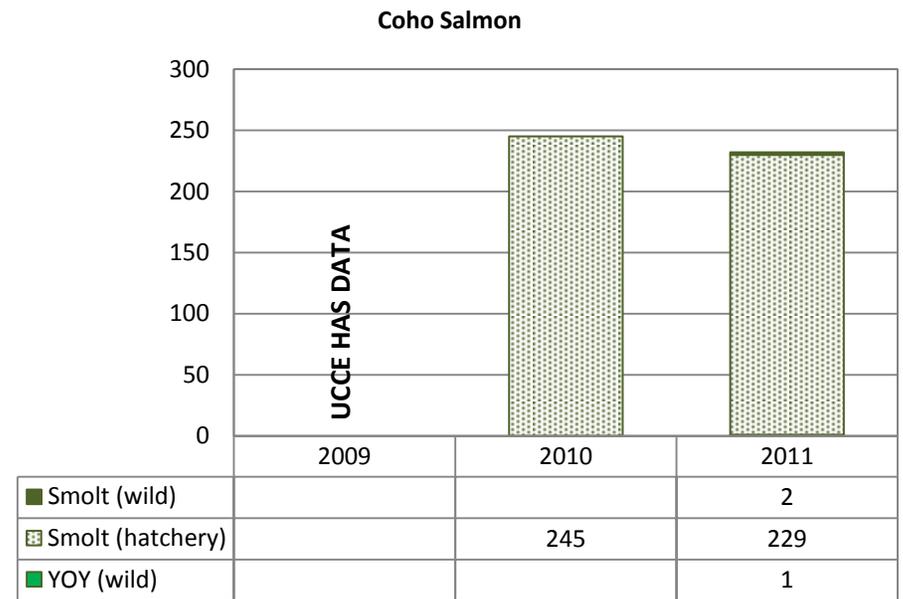
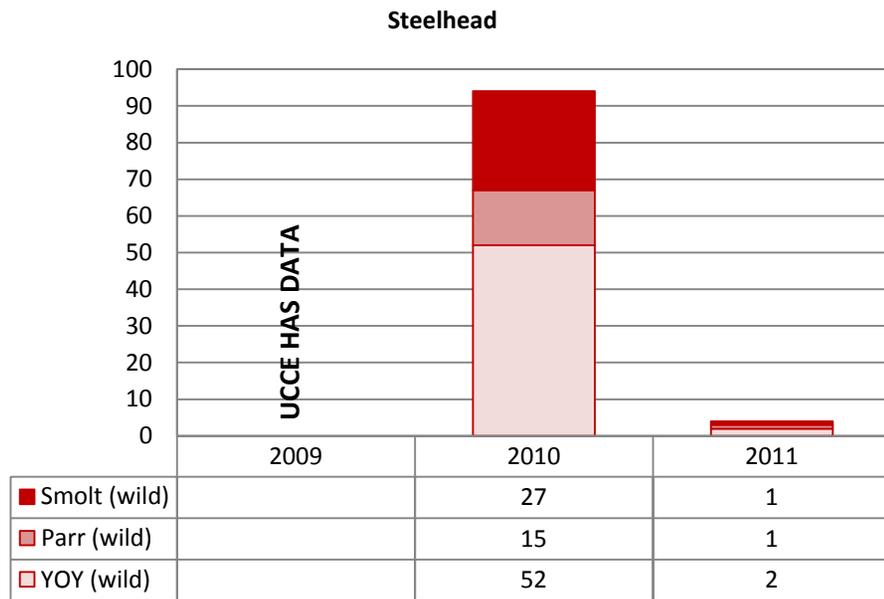


Figure 4.3.14. Number of steelhead and coho salmon captured by life stage and origin at the Green Valley Creek downstream migrant trap, (upper panels) and duration and timing of trap operation (lower panel), 2010-2011.

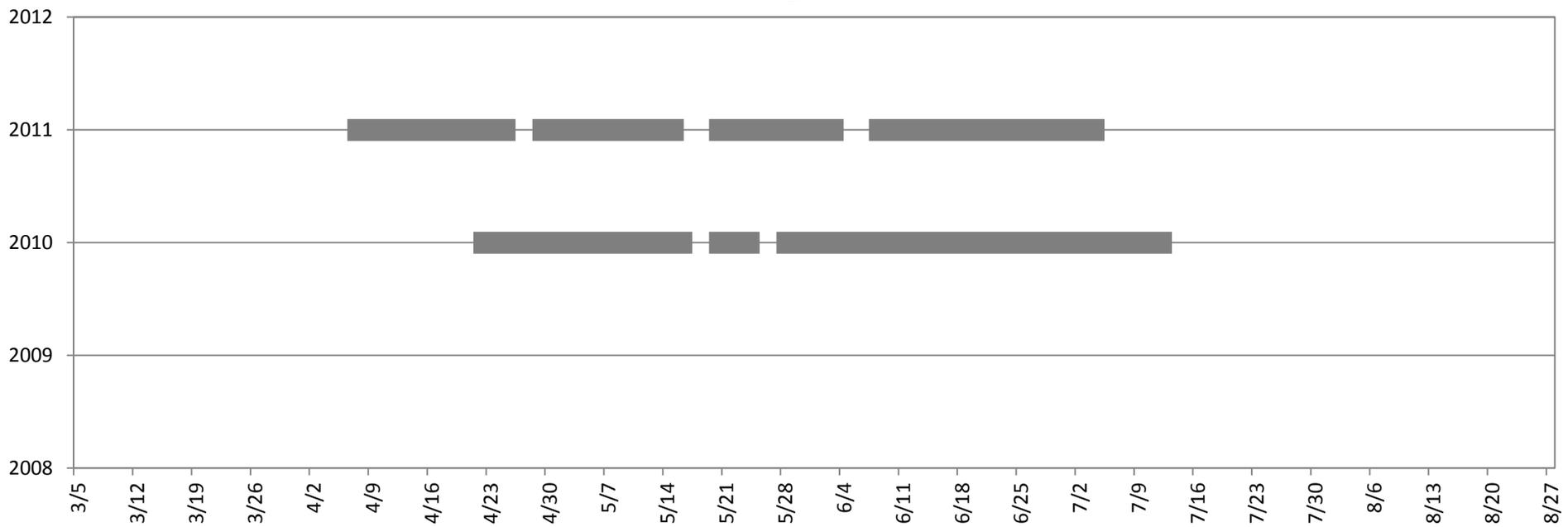
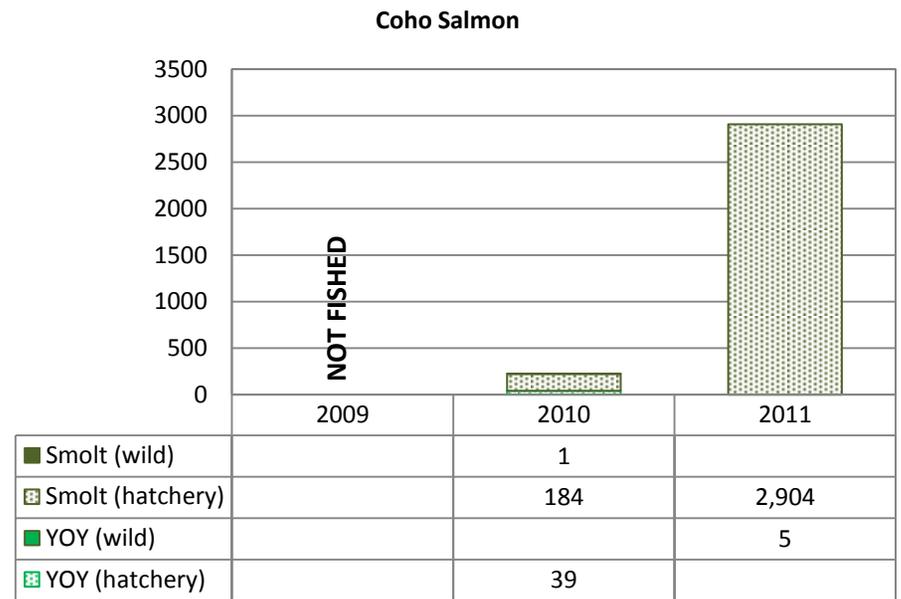


Figure 4.3.15. Number of steelhead and coho salmon captured by life stage and origin at the Dutch Bill Creek downstream migrant trap, (upper panels) and duration and timing of trap operation (lower panel), 2010-2011.

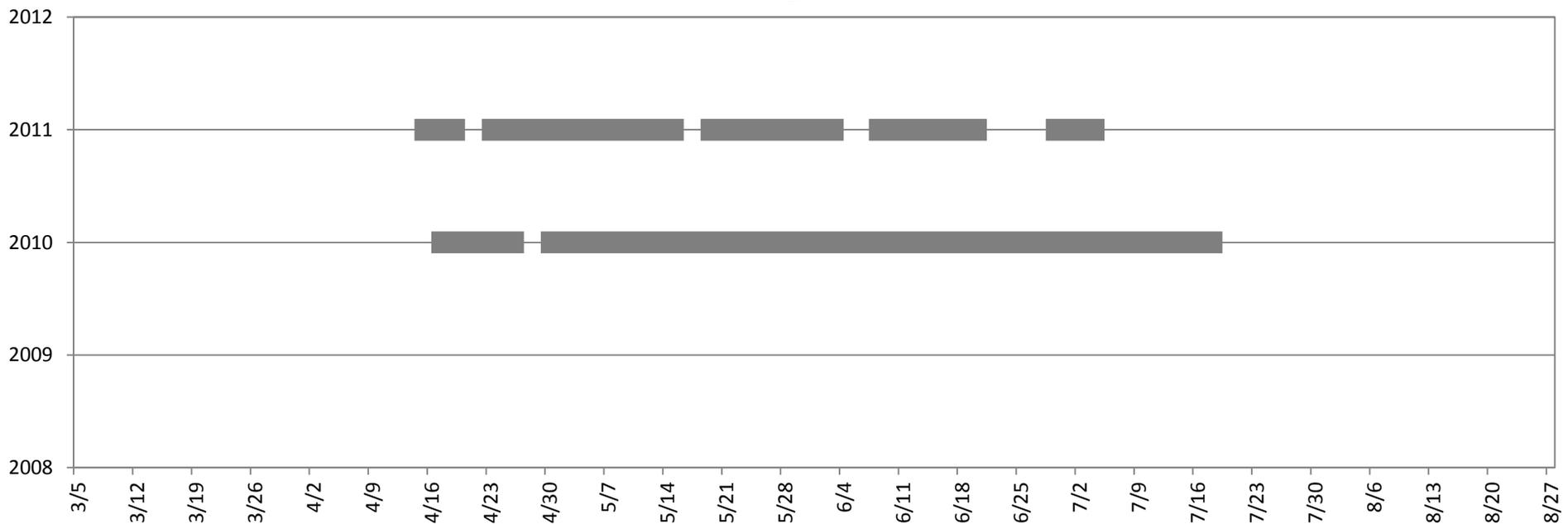
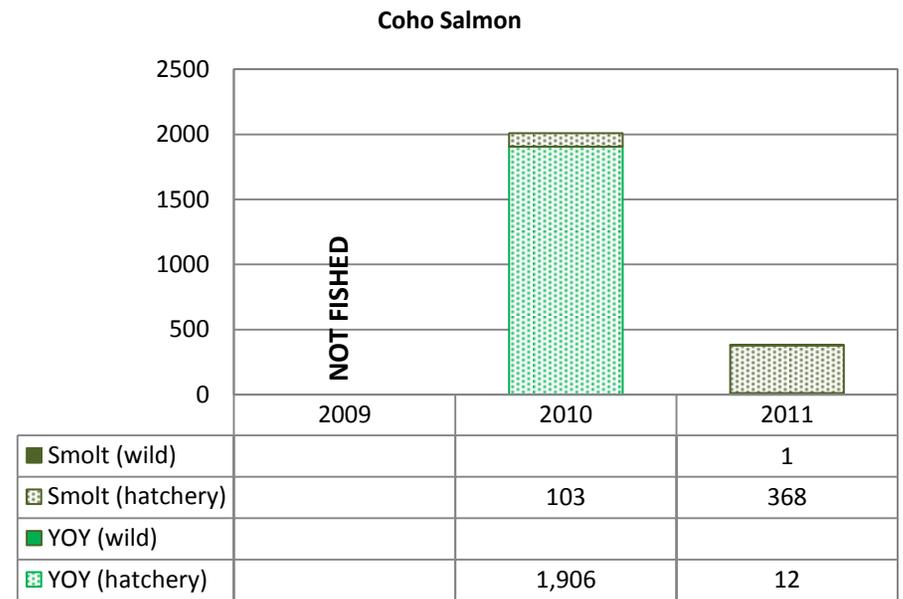
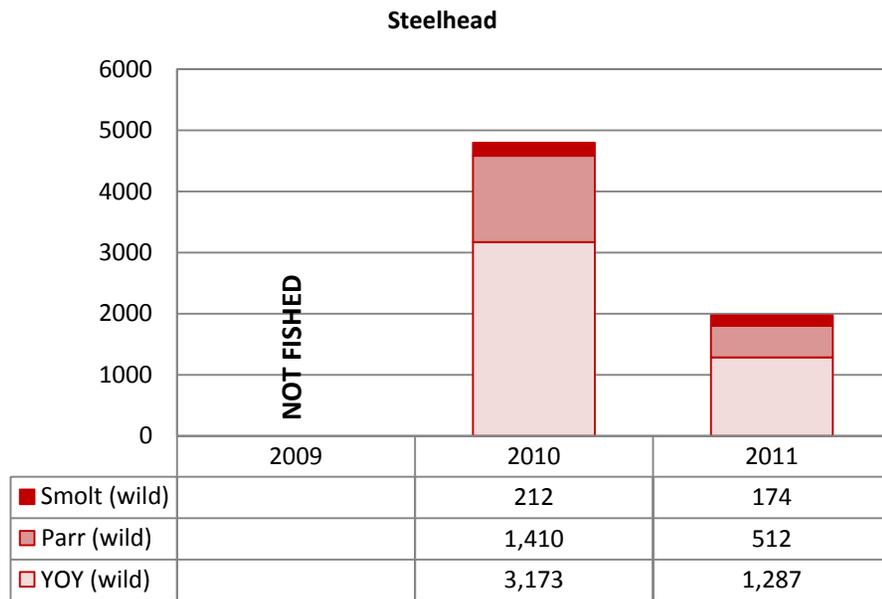
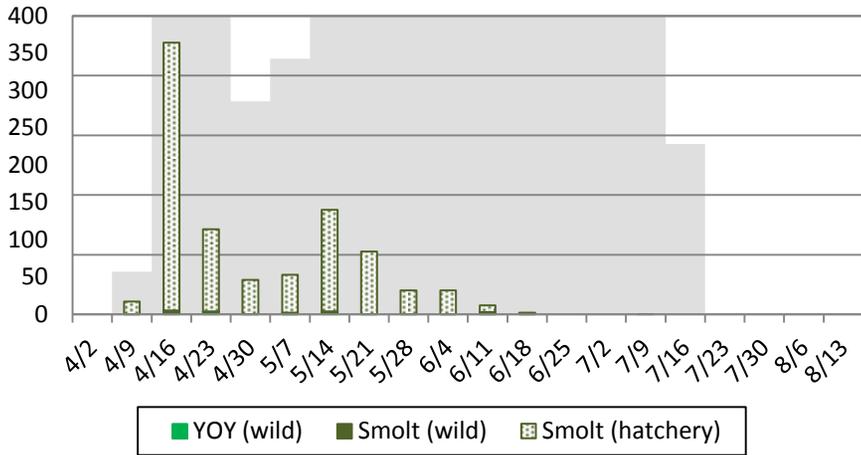
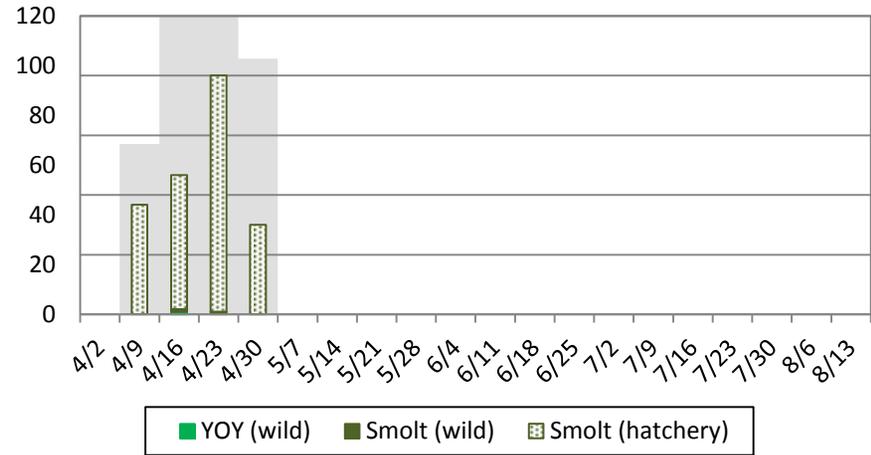


Figure 4.3.16. Number of steelhead and coho salmon captured by life stage and origin at the Austin Creek downstream migrant trap, (upper panels) and duration and timing of trap operation (lower panel), 2010-2011.

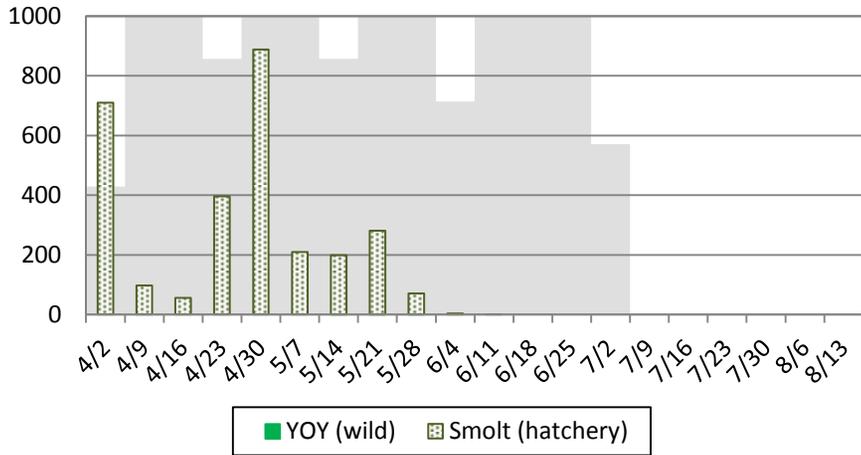
Mainstem (Wohler-Mirabel, RiverKm 38.57)
 10 YOY (wild), 15 Smolt (wild), 872 Smolt (hatchery)



Green Valley Creek (lower trap site, RiverKm 2.07)
 1 YOY (wild), 2 Smolt (wild), 229 Smolt (hatchery)



Dutch Bill Creek (Monte Rio Park, RiverKm 0.28)
 5 YOY (wild), 2904 Smolt (hatchery)



Austin Creek (gravel mine, RiverKm 1.10)
 14 YOY (wild), 45 YOY (hatchery), 335 Smolt (hatchery)

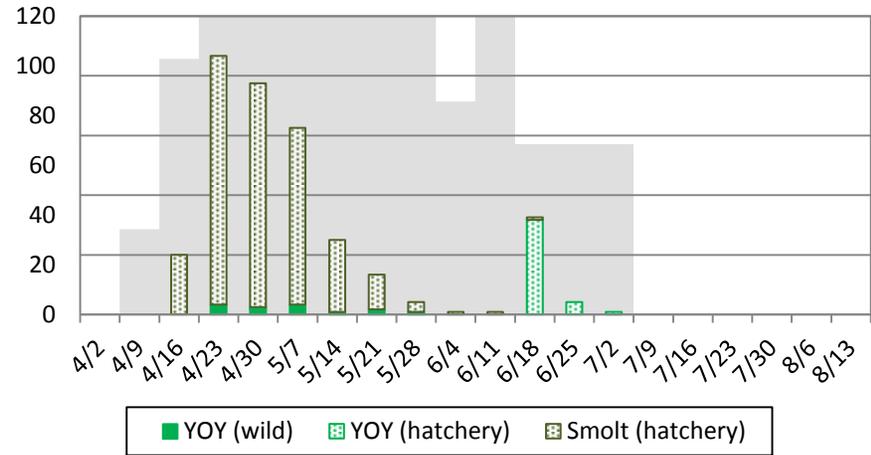


Figure 4.3.17. Weekly capture of coho salmon by life stage at lower river downstream migrant trapping sites, 2011. Gray shading indicates portion of each week trap was fishing. Note the different vertical scale among plots for each site.

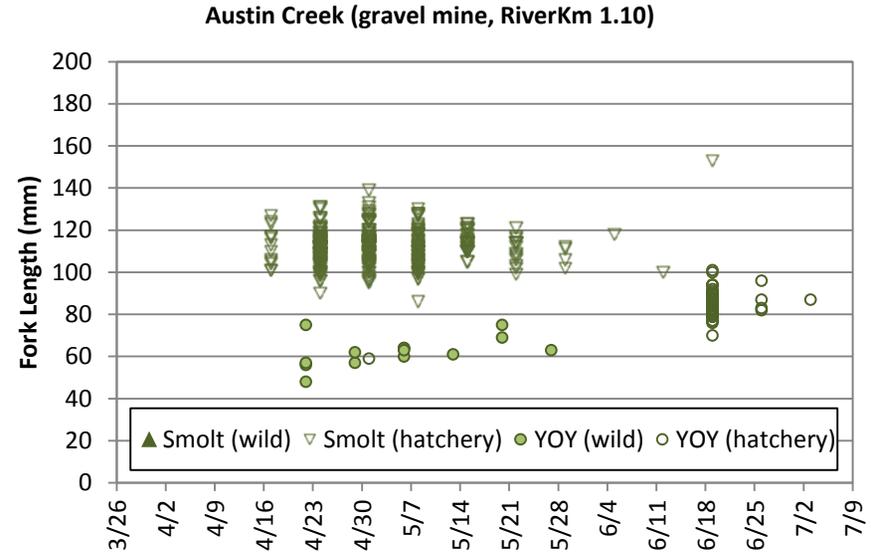
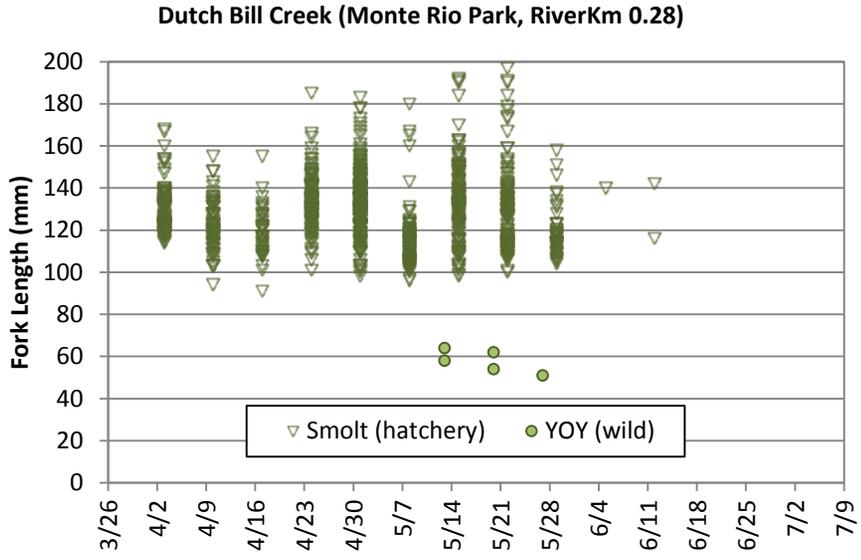
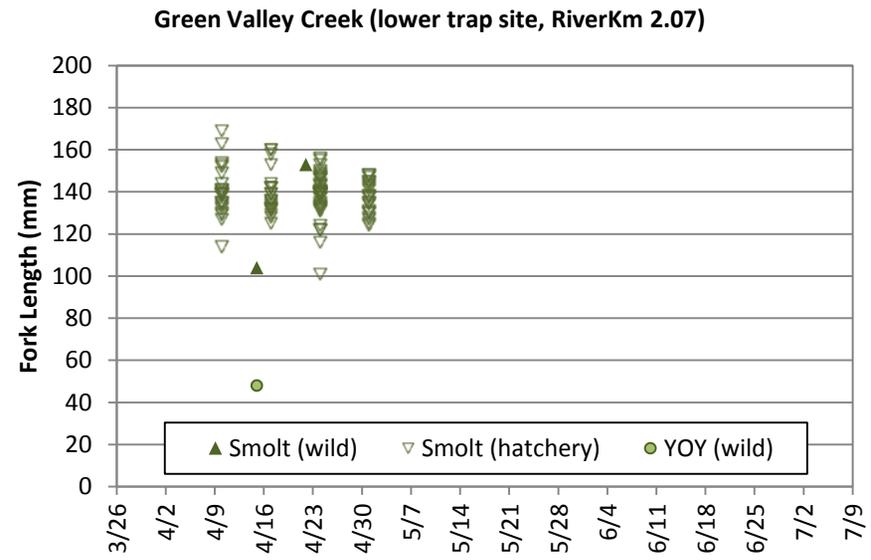
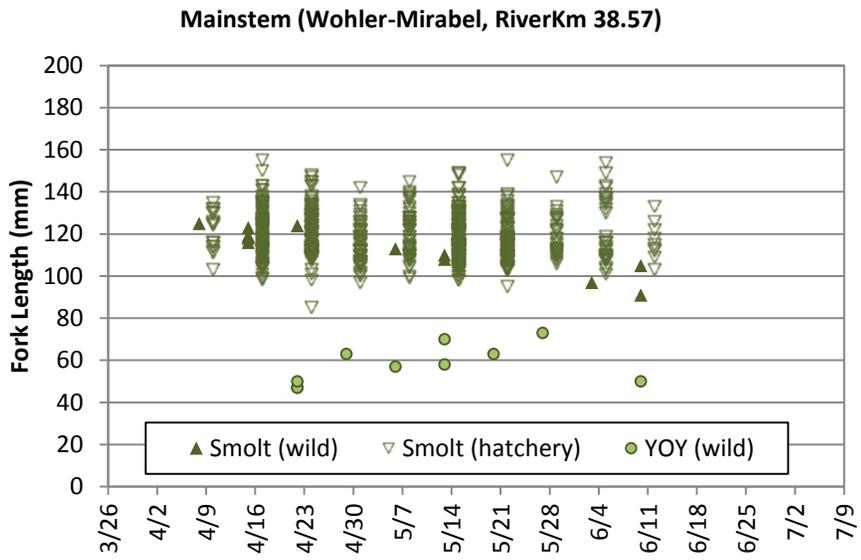


Figure 4.3.18. Weekly fork lengths of coho salmon captured at lower river downstream migrant trap sites, 2011.

Conclusions and Recommendations

Estuary video camera and PIT antenna systems

The relatively low number of fish detected on the estuary fyke net video in 2011 as compared to 2010 was likely due to a combination of low efficiency and gaps in the sampling period because of poor performance of the fyke net and wing walls and associated reconfiguration. As described in the Methods and Results sections, these problems were unavoidable because they were related to environmental conditions. Qualitatively, the main problem appeared to be an increased amount of filamentous algae in 2011 as compared to 2010. The configuration of the fyke net used in the later portion of the 2011 trapping season created beneficial fish passage conditions by increasing velocity through the racket PIT antenna while allowing for a portion of debris to pass around the entrance of the fyke net. Unfortunately, this new configuration also allowed fish to pass through the 16 foot net chute PIT antenna without necessarily having to pass through the fyke net or racket antenna/video chamber. The increased velocity in the viewing chamber also resulted in increased uncertainty in accurately identifying species and life stage simply because fish were passing through the video chamber faster leaving less time and fewer frames for the video reviewer to use for analyses. Algae build-up on the net wing walls accentuated velocity in the video chamber even more by blocking flow through the wing walls thereby forcing more water through the viewing chamber. Although reflection off the sides of passing fish and backscatter from artificial lighting used to illuminate the viewing chamber was not a problem that was unique to 2011, it resulted in degraded image quality and further hindered our ability to accurately identify species/life stage.

Accurate estimation of fish size from the fyke net video continued to present challenges in 2011. Based on detections of PIT-tagged fish that were tagged in Austin Creek and observed a short time later on the fyke net video, there was some error in fork length obtained from the fyke video but the error did not appear to be biased (i.e., no consistent pattern in over- or under-estimation of fish size). The main contributor to this error was most likely the distance of the fish from the camera lens which could vary by as much as 15 cm (the inside dimension of the viewing chamber). A secondary contributor was the orientation of the fish to the camera lens (i.e., straight vs. flexed or angled).

Because of the problems with accuracy of life stage identification, we ultimately abandoned our attempts to identify the life stage of salmonids observed on the camera. In future years we will explore alternative lighting and measurement methods to help alleviate problems with reflection and backscatter. Nevertheless, we remain confident that provided the uncertainties outlined above are acknowledged, the remote monitoring systems used by the Water Agency to detect fish movements into the tidal portion of the estuary in 2010 and 2011 are superior to trapping fish in the tidal portion of the estuary as was attempted in 2009.

Lower River fish trapping and PIT tagging

Based on the extremely small number and size of steelhead YOY trapped in the downstream migrant traps in the early part of the trapping season (Figure 4.3.11 and 4.3.12) and because low streamflow in tributaries in the late spring and summer often disconnects these tributaries from the mainstem, it is likely that most of the YOY steelhead emigration period for Austin and Dutch Bill Creeks was encompassed by our trap operation period. The same can not be said of Green Valley Creek which had a truncated trapping season due to the capture of freshwater shrimp. Over a decade worth of downstream migrant trapping at Wohler-Mirabel shows wide variability in the number of fish captured (see Mirabel Downstream Migrant Trapping section). Some of this could be due to naturally variability, but some may be due to trap efficiency which we are unable to measure for this life stage without additional monitoring tools (e.g., PIT antenna; Table 4.3.3). The Synthesis chapter relates detections of downstream migrants in the lower river tributaries that were monitored in 2011 to the objectives in the Russian River Biological Opinion.

Operating downstream migrant traps in lower river tributaries in conjunction with remote monitoring methods in the estuary accomplishes the monitoring goals in the Russian River Biological Opinion. The Russian River Biological Opinion calls for monitoring YOY steelhead as they enter the Russian River estuary in order to determine the timing of these movements, as well as the relative abundance and the size/age structure of steelhead entering the estuary. Without the ability to measure efficiency at the fyke net it is not possible to determine if the difference between the numbers of steelhead observed between years is related to the differences in sampling season, a change in the number of steelhead entering the estuary, or simply a difference in detection rates. Russian River Biological Opinion objectives regarding the timing of estuary entry are met by using PIT tag detections on antennas in lower Austin Creek and at the fyke net; both of these methods provide clear information about seasonal movements of juvenile steelhead into the estuary as well as the travel time associated with those movements.

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4.4 Fish Sampling – Beach Seining

The Water Agency has been sampling the Russian River Estuary since 2004 - prior to issuance of the Biological Opinion. An Estuary fish survey methods study was completed in 2003 (Cook 2004). To provide context to data collected in 2011, we present and discuss previous years of data in this report. Although survey techniques have been similar since 2004, some survey locations and the sampling extensity changed in 2010 as required in the Biological Opinion. The distribution and abundance of fish in the Estuary are summarized below. In addition to steelhead, coho salmon, and Chinook salmon, we describe the catch of several common species to help characterize conditions in the Estuary.

Methods

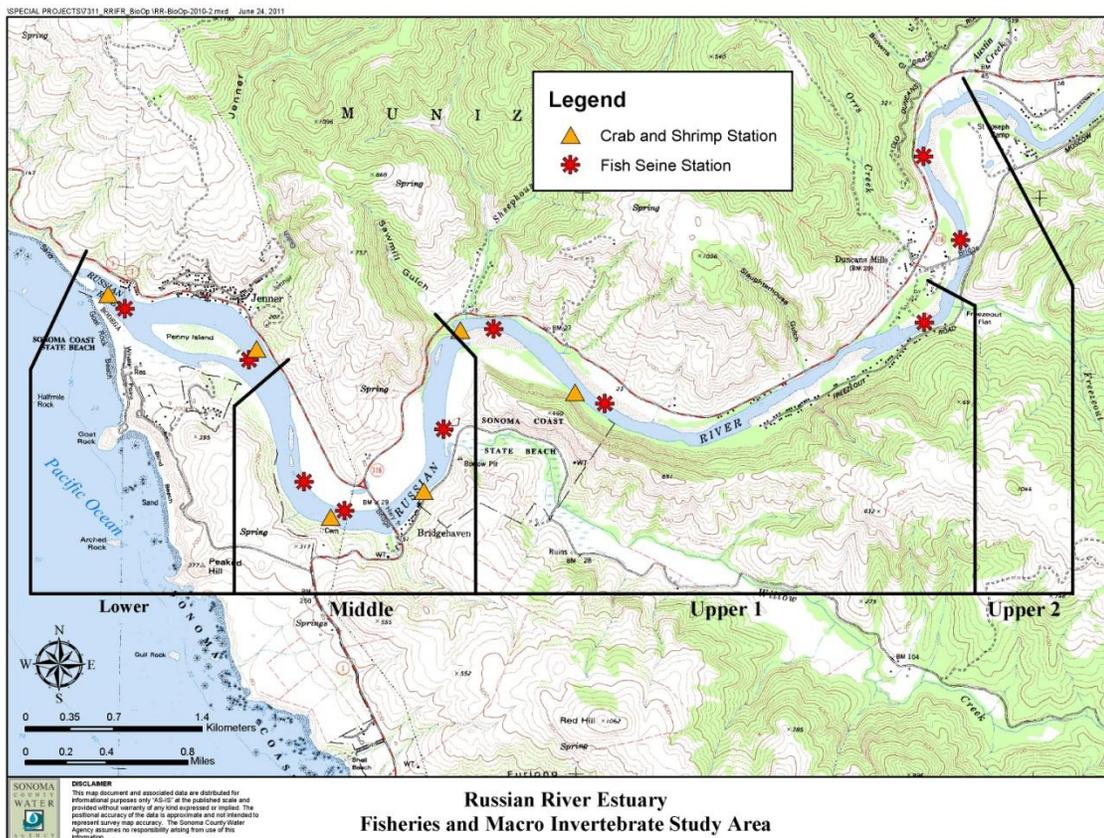
Study Area

The Estuary fisheries monitoring area included the tidally influenced section of the Russian River and extended from the sandbar at the Pacific Ocean to Duncans Mills, located 9.8 km (6.1 mi) upstream from the coast (Figure 4.4.1).

Fish Sampling

A beach-deployed seine was used to sample fish species, including salmonids, and determine their relative abundances and distributions within the Estuary. The rectangular seine consisted of approximately 5 mm ($\frac{1}{4}$ inch) mesh netting with pull ropes attached to the four corners. Floats on the top and weights on the bottom positioned the net vertically in the water. During 2004-2006 a 30 m long (100 feet) by 3 m deep (10 feet) purse seine was used. This seine was replaced in 2007 with a conventional seine (dimensions 46 m (150 ft) long by 4 m (14 ft) deep). The seine was deployed with a boat to pull an end offshore and then around in a half-circle while the other end was held onshore. The net was then hauled onshore by hand. Fish were placed in aerated buckets for sorting, identification, and counting prior to release. A few non-salmonid voucher specimens were preserved in ethanol to verify identification.

Salmonids were anesthetized with Alka-seltzer tablets or MS-222 anesthetic and then measured, weighed, and examined for general condition, including life stage (i.e., parr, smolt). Salmonids were identified as wild or hatchery stock (indicated by a clipped adipose fin). Tissue and scale samples were collected from some steelhead. Fish were allowed to recover in aerated buckets prior to release. Also, juvenile steelhead greater than 60 mm fork length were marked by surgically implanting a passive integrated transponder (PIT) tag. PIT tags provide a unique identification to each fish. All captured steelhead were scanned with a PIT tag receiver to detect recaptured fish. This data was used to better understand the movement patterns and growth rates of steelhead in the Estuary.



From 2004 to 2009 eight seining stations were located throughout the Estuary in a variety of habitats based on substrate type (i.e., mud, sand, and gravel), depth, tidal, and creek tributary influences. Three seine sets adjacent to each other were deployed at each station totaling 24 seine sets per sampling event. Stations were surveyed approximately every 3 weeks from late May through September or October. Total annual seine pulls ranged from 96 to 168 sets.

Starting in 2010 fish seining sampling was doubled in effort with 300 sets completed for the season. Surveys were conducted monthly from May to October. Between 3 and 7 seine sets were deployed at 10 stations for a total of 50 sets for each sampling event. Twenty-five sets were in the lower and middle Estuary and 25 in the upper Estuary. During 2011, a total of 297 seine sets were completed. Three of the seven standard seine sets were not completed at the river mouth during October due to restricted property access. Aerial photographs showing the locations of seining stations and each seine site are in Appendix c-1.

For data analysis the Estuary study area was divided into three reaches, including Lower, Middle, and Upper, which is consistent with study areas for water quality and invertebrate studies (Figure 4.4.1). For the fish seining study, the Upper Reach of the Estuary was divided into Upper1 and Upper2 sub-reaches to improve clarity on fish patterns. Fish seining

stations in 2010 were located at previous stations or placed in areas that could be sampled during open and closed river mouth conditions. Suitable seining sites are limited during closed mouth conditions due to flooded shorelines. Capture per unit effort (CPUE), defined as the number of fish captured per seine set (fish/set), was used to compare the relative abundance of fish among Estuary reaches and study years.

The habitat characteristics and locations of study reaches, fish seining stations, and number of monthly seining sets are below.

Lower Estuary

- River Mouth (7 seine sets): sandbar separating the Russian River from the Pacific Ocean, sandy substrate with a low to steep slope, high tidal influence.
- Penny Point (3 seine sets): shallow water with a mud and gravel substrate, high tidal influence.

Middle Estuary

- Patty's Bar (3 seine sets): large gravel and sand bar with moderate slope, moderate tidal influence.
- Bridgehaven (7 seine sets): large gravel and sand bar with moderate to steep slope, moderate tidal influence.
- Willow Creek (5 seine sets): shallow waters near the confluence with Willow Creek, gravel and mud substrate, aquatic vegetation common, moderate tidal influence.

Upper Estuary

Upper1 Sub-Reach

- Sheephouse Bar (5 seine sets): opposite shore from Sheephouse Creek, large bar with gravel substrate and moderate to steep slope, low to moderate tidal influence
- Heron Rookery Bar (5 seine sets): gravel bank adjacent to deep water, low to moderate tidal influence.
- Freezeout Bar (5 seine sets): opposite shore from Freezeout Creek, gravel substrate with a moderate slope, low tidal influence.

Upper2 Sub-Reach

- Moscow Bridge (5 seine sets): steep to moderate gravel/sand bank adjacent to shallow to deep water, aquatic vegetation common, low tidal influence.
- Casini Ranch (5 seine sets): moderate slope gravel/sand bank adjacent to shallow to deep water, upper end of Estuary at riffle, very low tidal influence.

Results

Fish Distribution and Abundance

Fish captures from seine surveys in the Russian River Estuary for 2011 are summarized in Table 4.4.1. During the 8 years of study, over 150,000 fish comprised of 50 species were caught in the Estuary. In 2011, seine captures consisted of 29,795 fish comprised of 33

species. In comparison, during 2009 there were 46,051 fish caught comprised of 37 species. Fish studies in the 1990s detected 18 to 28 species/year for a total of 49 species (Sonoma County Water Agency and Merritt Smith Consulting 2001). No new fish species were detected in the Estuary during 2011 fish seining.

The distribution of fish in the Estuary is, in part, based on a species preference for or tolerance to salinity (Figure 4.4.2). In general, the influence of cold seawater from the ocean results in high salinity levels and cool temperatures in the Lower Reach transitioning to warmer freshwater in the Upper Reach from river inflows (Figure 4.4.3). For more detail please refer to water quality in Chapter 4.1. Fish commonly found in the Lower Reach were marine and estuarine species including topsmelt (*Atherinops affinis*), surf smelt (*Hypomesus pretiosus*), staghorn sculpin (*Leptocottus armatus*), and starry flounder (*Platichthys stellatus*). The Middle Reach had a broad range of salinities and a diversity of fish tolerant of these conditions. Common fish in the Middle Reach included those found in the Lower Reach and shiner surfperch (*Cymatogaster aggregata*). Freshwater dependent species, such as the Sacramento sucker (*Catostomus occidentalis*), Sacramento pikeminnow (*Ptychocheilus grandis*), and Russian River tule perch (*Hysterocarpus traskii pomu*), were predominantly distributed in the Upper Reach. Anadromous fish, such as steelhead (*Oncorhynchus mykiss*) and American shad (*Alosa sapidissima*), which can tolerate a

Table 4.4.1: Total fish captured by beach seine in the Russian River Estuary from May to October 2011. Each station was sampled monthly from May to October. Seine sets per station are shown in parentheses.

Life History	Species	Seining Station										Total
		River Mouth (39)	Penny Point (18)	Patty's Bar (18)	Bridge-haven (42)	Willow Creek (5)	Sheep-house Bar (5)	Heron Rookery Bar (6)	Freeze-out Bar (4)	Moscow Bridge (5)	Casini Ranch (5)	
Anadromous	American shad		1	1	157		1	1	279	34	236	710
	Chinook salmon	36	9	7	146		4	111	161	2	19	495
	coho salmon	7	1	191	11	1	1	8	29	7	7	263
	steelhead	4	3	7	17	2	11	3	3	15	42	107
Estuarine	bay pipefish	8	8	2	4	4						26
	shiner surfperch	2	122	671	30	1273	150	2				2250
	staghorn sculpin	41	6	32	13	45	11	2		1		151
	starry flounder	3		4	3			5	1	7	21	44
	topsmelt	1	56	11	6	213						287
Freshwater	bluegill									1	2	3
	California roach							5	13	116	4	138
	common carp								1	6	11	18
	cyprinid sp								3	25		28
	green sunfish								1			1
	hardhead									1	3	4
	hitch					2		3	2	107		114
	largemouth bass								3	23		26
	Russian River tule perch			3	3	7		1	20	632	5	671
	Sacramento pikeminnow		1	1		8	1	66	8	109	34	228
Sacramento sucker	1	1	17	9	96	404	3081	707	707	785	5808	
Marine	buffalo sculpin	14										14
	cabezon	41										41
	northern anchovy				1							1
	Pacific herring	64	1	15	86							166
	saddleback gunnel	4	3									7
	<i>Sebastes</i> sp.	52	2									54

Life History	Species	Seining Station										Total
		River Mouth (39)	Penny Point (18)	Patty's Bar (18)	Bridge-haven (42)	Willow Creek (5)	Sheep-house Bar (5)	Heron Rookery Bar (6)	Freeze-out Bar (4)	Moscow Bridge (5)	Casini Ranch (5)	
	sharpnose sculpin	4		1								5
	surf smelt	495	38	78	37	104						752
	kelp greenling	3										3
	lingcod	31	1									32
	Pacific sand sole	3										3
	penpoint gunnel	2										2
	smelt sp	273		11			1					285
Generalist	prickly sculpin*	37	131	532	320	1080	349	180	122	110	51	2912
	sculpin species*	26					1			1		28
	threespine stickleback	3	110	924	340	4439	1454	2481	965	2835	567	14118
Total	33	1155	494	2508	1183	7274	2388	5949	2318	4739	1787	29795

*Prickly Sculpin counts may include small numbers of the freshwater-resident Coast Range sculpin (*Cottus aleuticus*) and riffle sculpin (*Cottus gulosus*), although neither of these species has been reported from the Estuary.

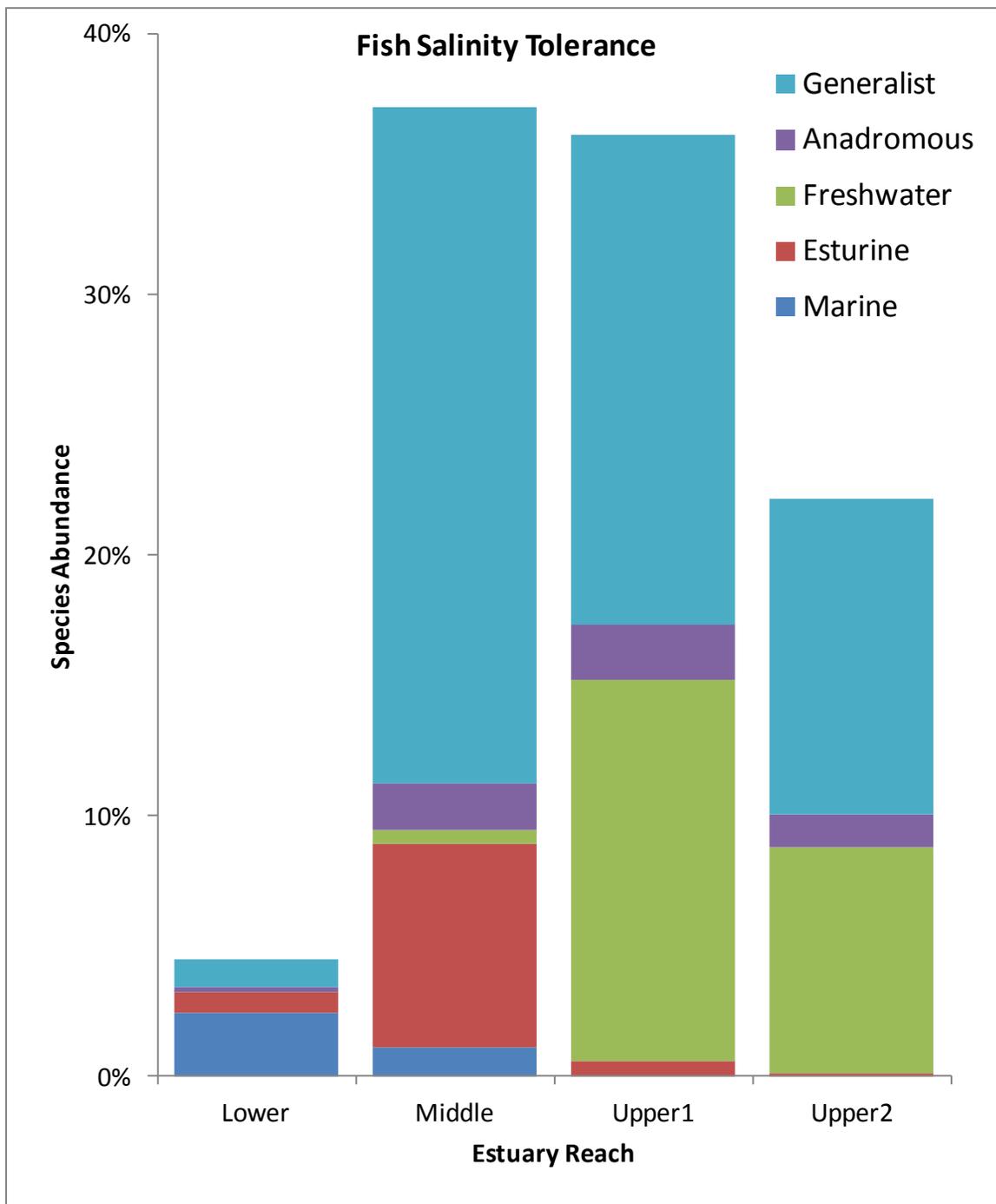


Figure 4.4.2. Distribution of fish captured by beach seine in the Russian River Estuary based on salinity tolerance and life history, 2011. Groups include: generalist species that occur in a broad range of habitats (threespine stickleback and prickly sculpin); species that are primarily anadromous; freshwater resident species; brackish-tolerant species that complete their lifecycle in estuaries; and species that are predominantly marine residents. See Table 4.4.1 for a list of species in each group.

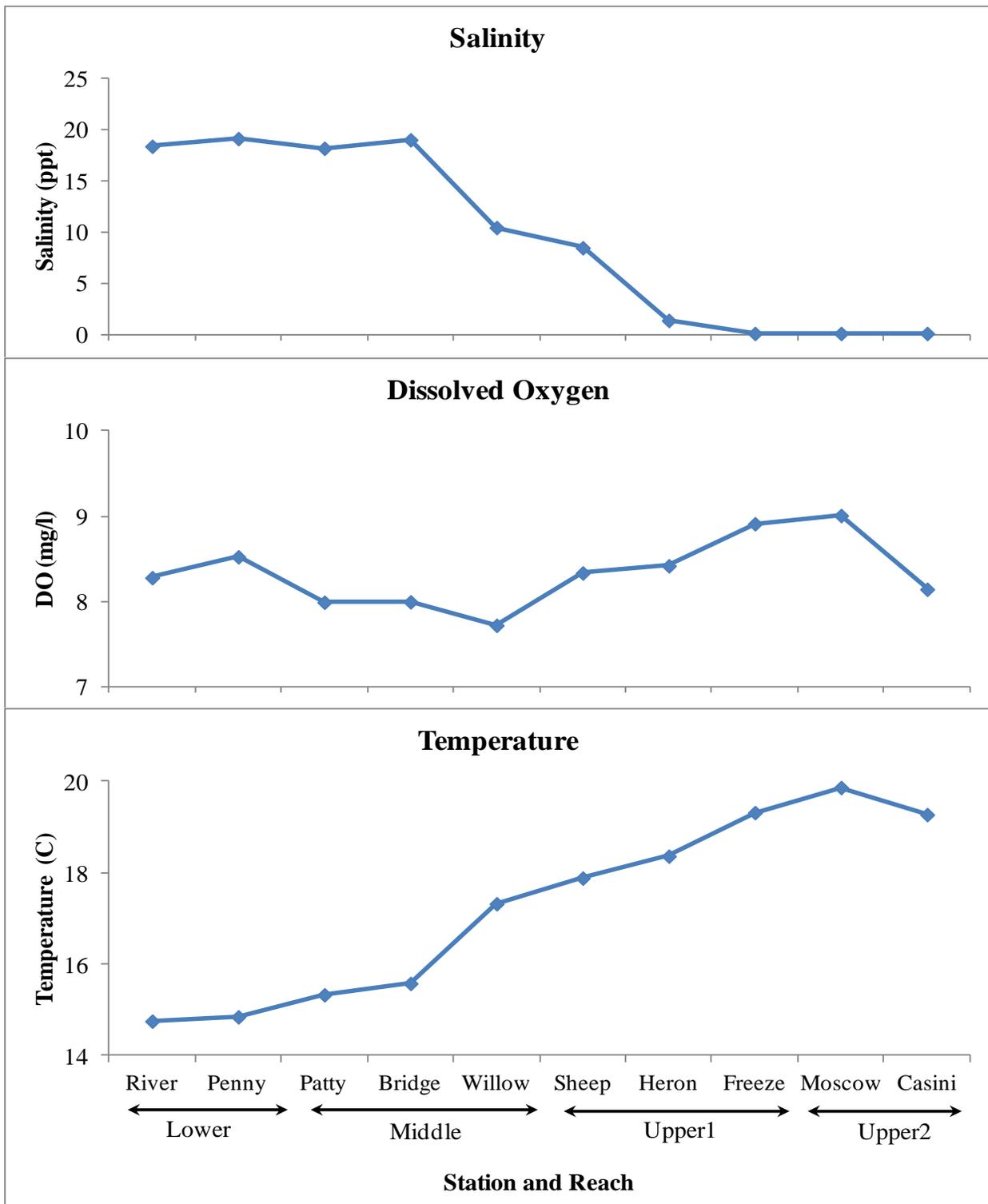


Figure 4.4.3. Generalized water quality conditions at fish seining stations in the Russian River Estuary, 2011. Values are averages collected at 0.5 m intervals in the water column during beach seining events from May to October. Salinity values are in parts per thousand (ppt), dissolved oxygen (DO) are in milligrams per liter, and water temperature is in degrees Celsius (C).

broad range of salinities, occurred throughout the Estuary. Habitat generalists, such as threespine stickleback (*Gasterosteus aculeatus*) and prickly sculpin (*Cottus asper*), occurred in abundance in the Estuary, except within full strength seawater in the Lower Reach.

Steelhead

During 2011, a total of 107 steelhead were captured (Table 4.4.1) in 297 seine sets. The resulting Catch per Unit Effort (CPUE) was 0.36 fish/set (Figure 4.4.4). In comparison, during 2010, a total of 257 steelhead were captured for a CPUE of 0.86 fish/set. The highest CPUE for all study years was 1.7 fish/set in 2008. All steelhead captured in 2011 were wild, except two hatchery steelhead caught in the Lower Reach on July 18, 2011.

The seasonal abundance of steelhead captured varied annually in the Estuary (Figure 4.4.5). Juvenile steelhead were captured during all survey months from May through October. The highest steelhead abundances are typically in June and August. During 2011 steelhead captures were highest during August at 0.68 fish/set. The highest capture abundance among all study years was in August at 4.3 fish/set and June at 4.2 fish/set in 2008.

Since seining surveys began in 2004, steelhead appear to have a patchy distribution and vary in abundance in the Estuary (Figure 4.4.6). In 2004 and 2006, relatively low numbers of steelhead were captured and only in the Middle and Upper1 Reaches (Upper2 Sub-Reach sampling began in 2010). While in 2005, juvenile steelhead were caught throughout most of the Estuary. Over all years surveyed, captures were typically highest in the Upper Reach with a high of 6.9 fish/set in the Upper1 Sub-Reach in 2008. During 2011 steelhead were captured in all study reaches in relatively moderate to low numbers. Captures were highest in the Upper2 Sub-Reach at 1.1 fish/set, followed on 0.5 fish/set in the Middle Reach.

The temporal and spatial distribution of juvenile steelhead in the Estuary in 2011 was strongly influenced by large captures in the Upper2 Reach from May to August (Figure 4.4.7). Fewer steelhead were captured in the Upper1 to Lower Reaches. Most captured juvenile steelhead were age 0+ parr or age 1+ smolts and ranged in size from 52 mm to 288 mm fork length. The seasonal sizes of juvenile steelhead are shown in Figure 4.4.8. Estuary steelhead in May appear to consist of age 1+ smolts or pre-smolts and a few young-of-the-year less than 70 mm fork length (Figure 4.4.8). In June there was a broad range of juvenile steelhead sizes and two age groups appeared present. During July and August steelhead grew rapidly but distinct size/age groups were less apparent. In September steelhead continued to grow rapidly but there was a marked decrease in the numbers of fish. Only two relatively small steelhead were captured during the last seining event in October. This general pattern of rapid growth of juvenile steelhead from May to September then a decrease in numbers and size in October suggests that once fish obtain a large size they disperse to the ocean or move upstream out of the Estuary. Also, cooler river temperatures in October likely facilitate the upstream movement of steelhead.

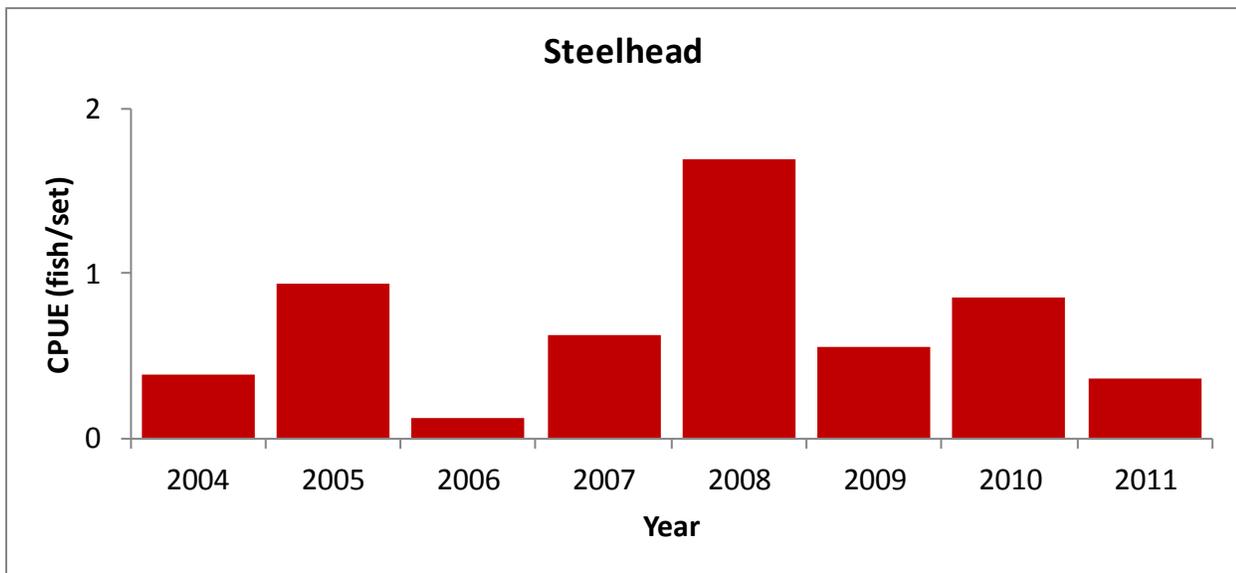


Figure 4.4.4: Annual abundance of juvenile steelhead captured by beach seine in the Russian River Estuary. Samples are from 96 to 300 seine sets conducted yearly between May and October.

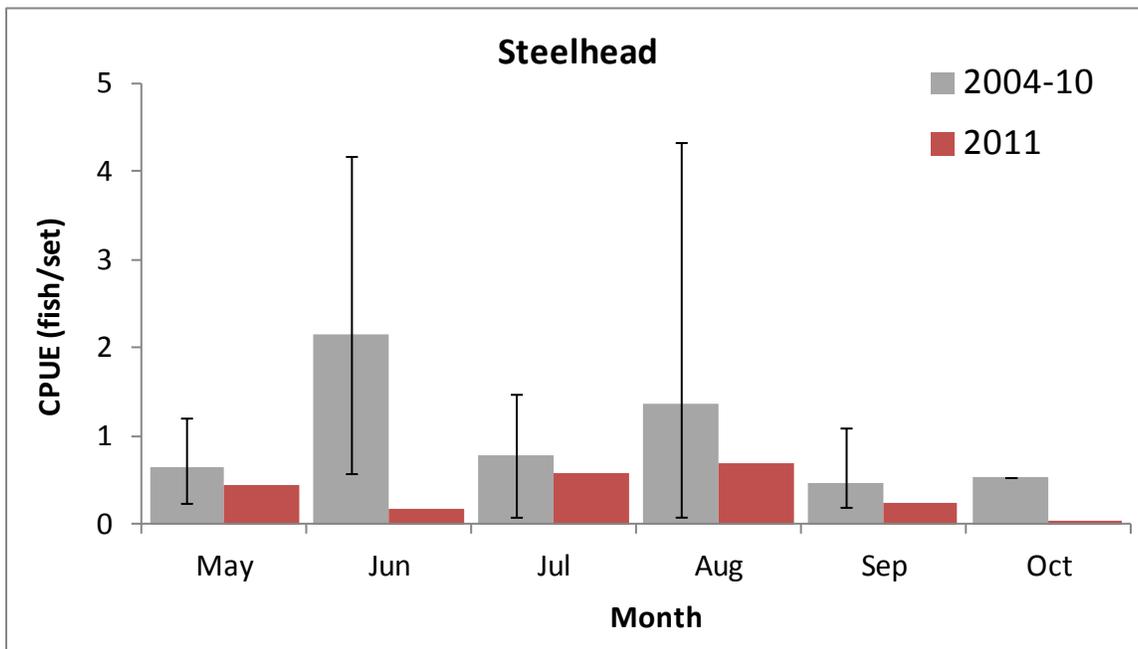


Figure 4.4.5. Seasonal abundance of juvenile steelhead captured by beach seine in the Russian River Estuary, 2004-2011. Seining events consisted of 21 to 50 seine sets approximately monthly. October surveys began in 2010. Data from 2004 to 2010 were averaged and whiskers indicate minimum and maximum values.



Figure 4.4.6. Distribution of juvenile steelhead captured by beach seine in the Russian River Estuary, 2004-2011. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the Upper2 Sub-Reach (Casini Ranch and Moscow Bridge stations) from 2004 to 2009.

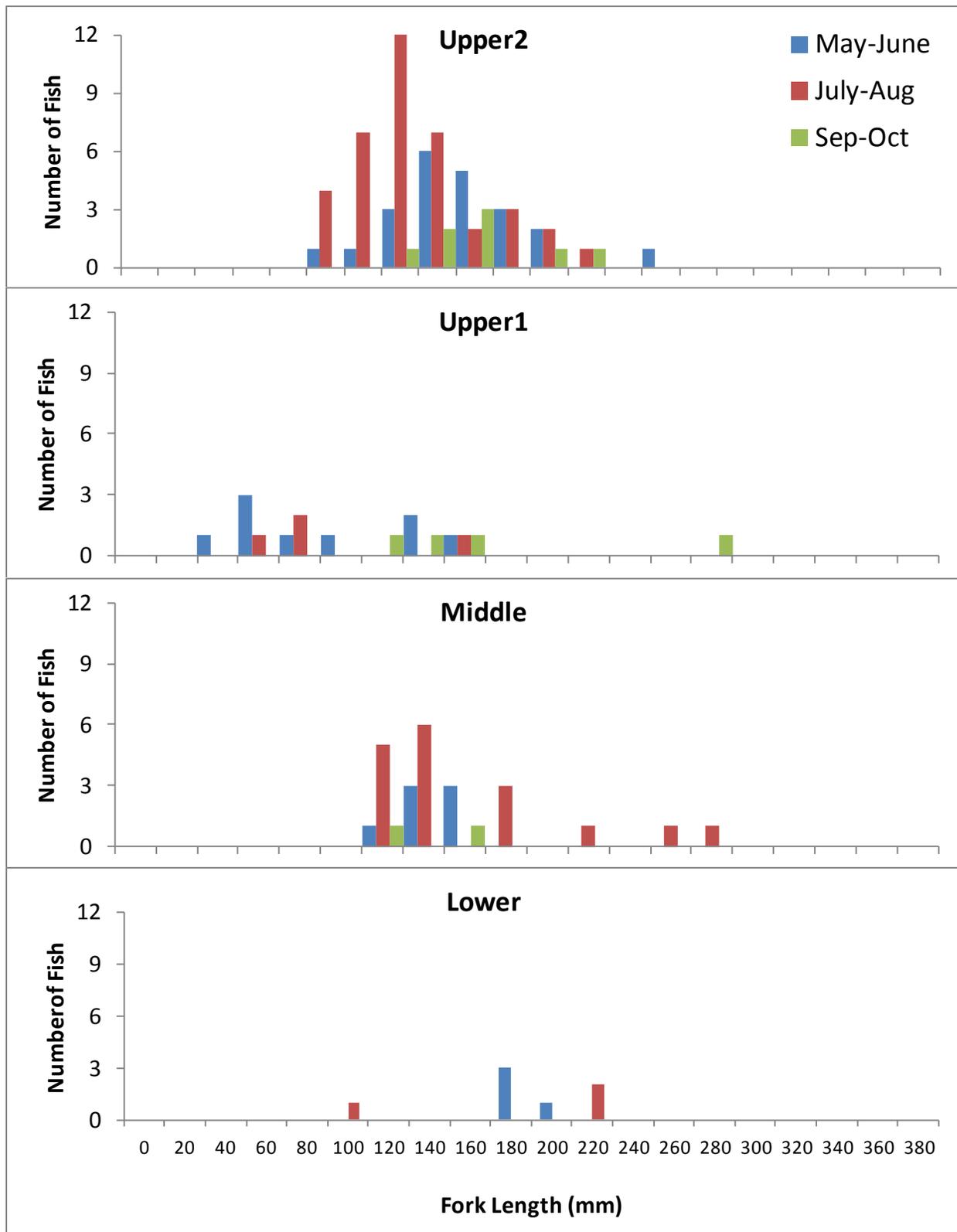
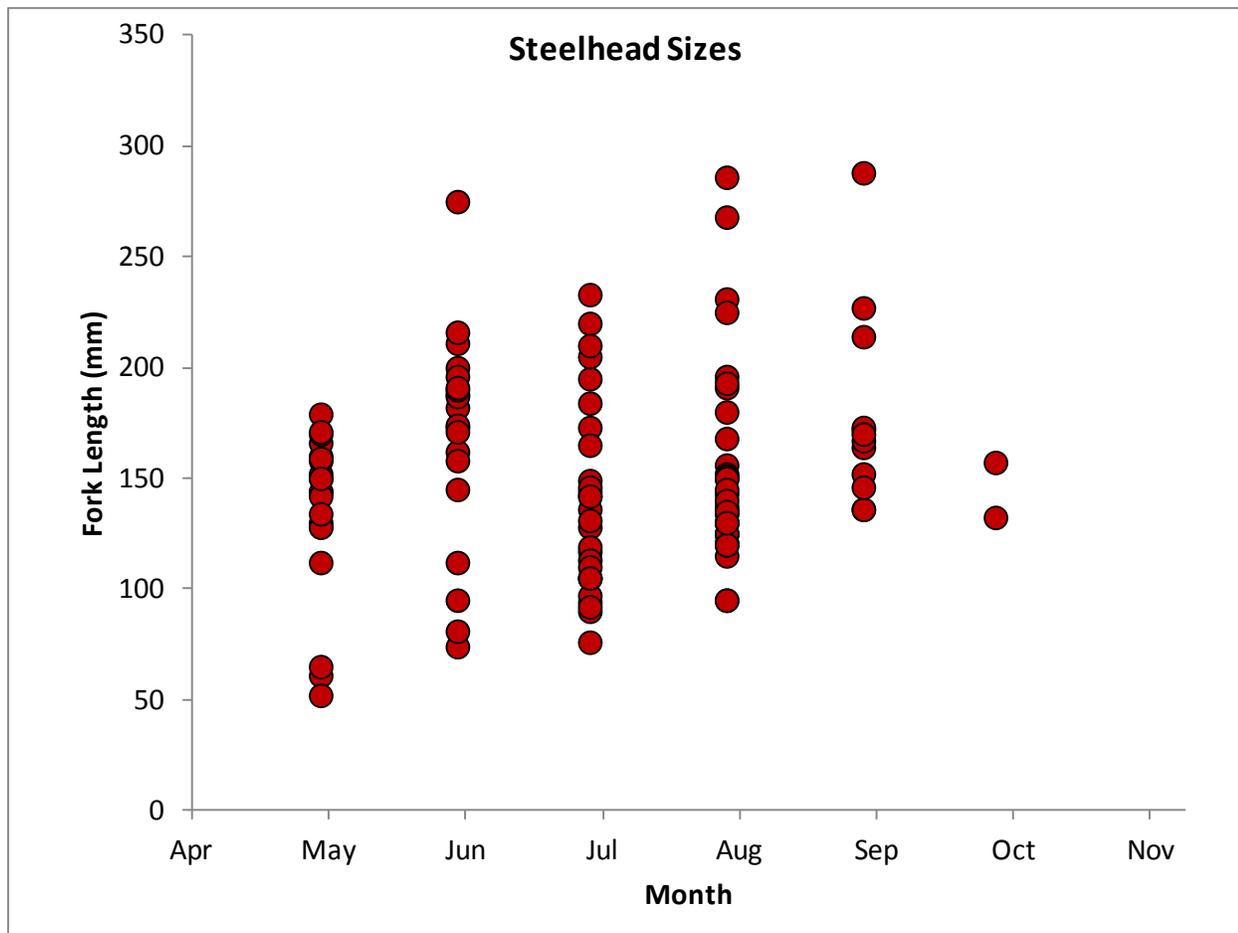


Figure 4.4.7: Length frequency of juvenile steelhead captured by beach seine in the Russian River Estuary, 2011. Fish captures are grouped by Estuary reach and month.



Figure

4.4.8 Juvenile steelhead sizes captured by beach seine in the Russian River Estuary, 2011.

In 2011, 77 juvenile steelhead captured during Estuary seining surveys were implanted with a PIT tag. An additional 10 steelhead were tagged during fish diet studies conducted in collaboration with the University of Washington prey availability study (see Chapter 4.2). Also, 497 juvenile steelhead were PIT-tagged in Austin Creek during downstream migrant trapping studies (see Chapter 10 – Synthesis). Of the total 584 tagged fish, 13 were later recaptured in the Estuary. Of these recaptured steelhead 7 were tagged and recaptured during fish diet studies in the Lower Estuary at Jenner Gulch. One fish was captured a total of four times at Jenner Gulch. Six fish were tagged in Austin Creek and then recaptured in the Upper, Middle, or Lower reaches of the Estuary.

The growth rates of PIT-tagged steelhead are shown in Figure 4.4.9. The average growth rate of steelhead throughout the Estuary in 2011 was 1.14 mm/day. The fastest growth rate at 1.8 mm/day was a steelhead tagged in Austin Creek on May 9th with a fork length of 105 mm and then recaptured 36 days later on June 14th at the Casini Ranch seining station with a fork length of 171 mm.

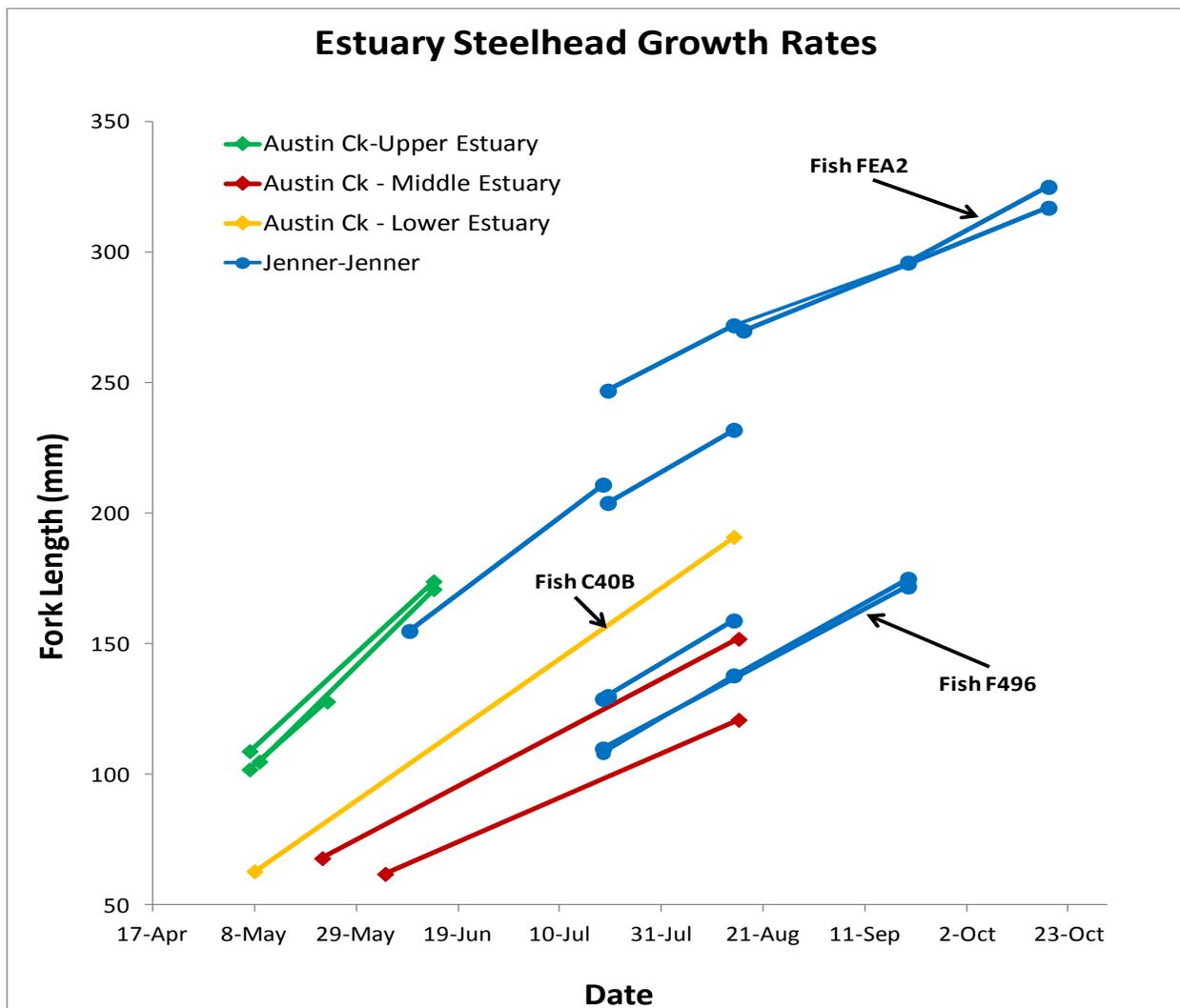


Figure 4.4.9. Growth rates of juvenile steelhead in the Estuary, 2011. Thirteen PIT-tagged fish were later recaptured. Blue lines are fish tagged and always recaptured at Jenner Gulch (Lower Reach). Green, red, and orange lines are fish tagged in Austin Creek, a tributary to the Upper Estuary, and recaptured in the Estuary.

All Estuary PIT-tagged steelhead were photographed during every capture. This provided monthly comparisons of a few individual steelhead growth and life stage. Figures 4.4.10 and 4.4.11 show two examples of sequential photographs of steelhead tagged and recaptured multiple times at Jenner Gulch. Fish F496 was tagged as a parr with a fork length of 108 mm on July 19 and recaptured as a smolt on September 20 with a growth rate of 1.0 mm/d. Fish FEA2 was captured four times between July 20 and October 19. This fish appeared to be an age 1+ smolt that resided in the Lower Estuary from at least late-summer to early-fall. During 91 days of capture Fish FEA2 increased in fork length from 247 mm to 325 mm and had an average growth rate of 0.9 mm/d. The steelhead with the longest duration between captures (Fish C40B) at 99 days was tagged in Austin Creek on May 8th at 63 mm and then was recaptured on August 15th at 171 mm in the Lower Estuary at Jenner Gulch for a growth rate on 1.3 mm/d (Figure 4.4.9 and 4.4.12).



Figure 4.4.10. Juvenile steelhead F496, Russian River Estuary 2011. Steelhead captured by seine three times at the Lower Estuary at Jenner Gulch. Fish PIT-tagged on July 19 with a fork length of 108 mm, then recaptured on August 15 at 138 mm and September 20 at 175 mm.



Figure 4.4.11. Juvenile steelhead FEA2, Russian River Estuary 2011. Steelhead captured by seine four times in the Lower Estuary at Jenner Gulch. FEA2 PIT-tagged on July 20 at a fork length of 247 mm. Then recaptured August 15 at 272 mm, September 20 at 296 mm, and October 19 at 325 mm.



Figure 4.4.12. Juvenile steelhead C40B, Russian River Estuary 2011. Steelhead captured in rotary screw trap in Austin Creek on May 8 with a fork length of 63 mm (this photograph is of another steelhead parr of a similar size proportioned to 63 mm). C40B was recaptured on August 15 in the Lower Estuary at Jenner Gulch at 191 mm for a growth rate of 1.3 mm/d.

Chinook Salmon

A total of 495 Chinook salmon smolts were captured by beach seine in the Estuary during 2011 (Table 4.4.1). The abundance of smolts in the Estuary appear to be on a 3-4 year cycle since studies began in 2004 (Figure 4.4.13). Chinook salmon abundance was lowest in 2005 at 0.7 fish/set and reached a peak in 2008 at 4.6 fish/set. Then decreased through 2010 at 0.9 fish/set. The 2011 CPUE of 1.7 fish/set appears to be a trend toward increased abundance. Chinook salmon smolts were usually most abundant during May and June (Figure 4.4.14) and rarely encountered after July. Monthly smolt captures in 2011 were highest during May (5.8 fish/set). Very few or no smolts were captured late in the survey season in September and October. Chinook salmon smolts were distributed throughout the Estuary with captures at most sample stations and all reaches annually (Figure 4.4.15).

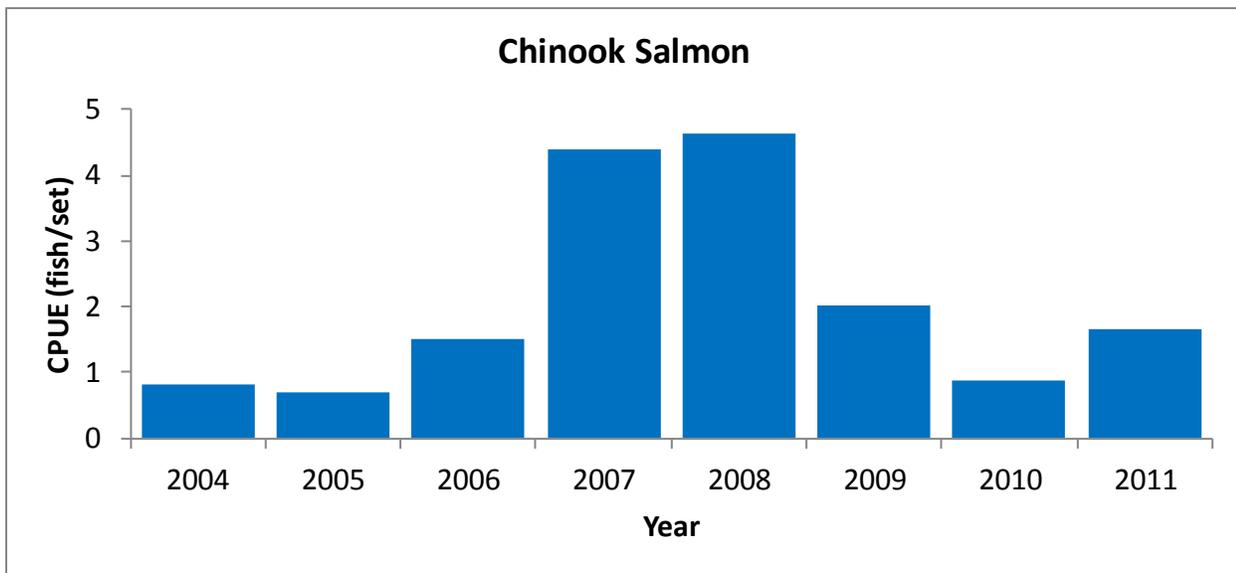


Figure 4.4.13. Annual abundance of Chinook salmon smolts captured by beach seine in the Russian River Estuary. Samples are from 96 to 300 seine sets yearly between May and October.

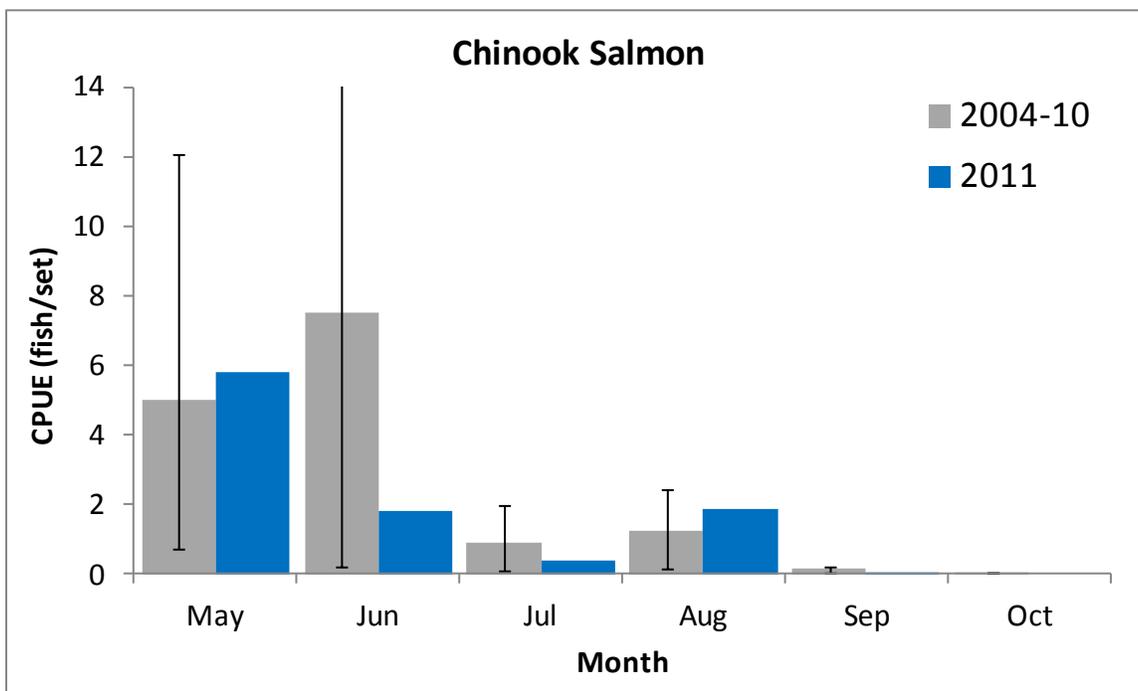


Figure 4.4.14. Seasonal abundance of Chinook salmon smolts captured by beach seine in the Russian River Estuary, 2004-2011. Seining events consisted of 21 to 50 seine sets approximately monthly. October surveys began in 2010. Data from 2004 to 2010 were averaged and whiskers indicate minimum and maximum values above the below the average. The June maximum value whisker is not shown at 25.5 CPUE.

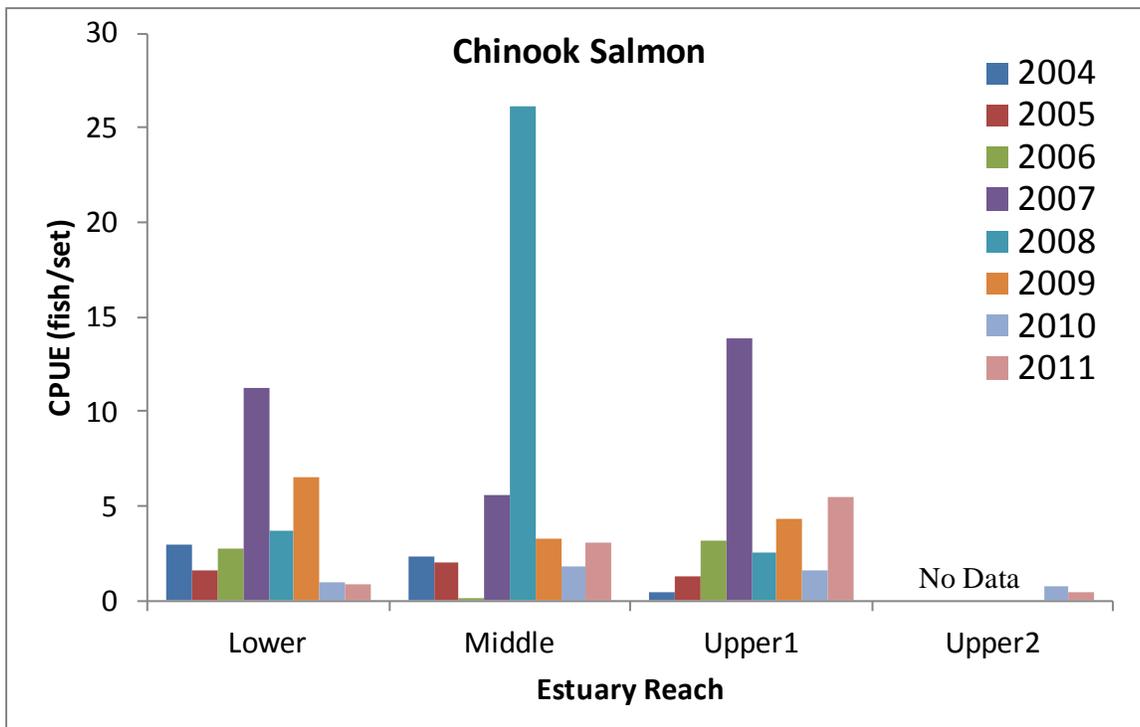


Figure 4.4.15. Spatial distribution of Chinook salmon smolts in the Russian River Estuary, 2004-2011. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the Upper2 Sub-Reach (Casini Ranch and Moscow Bridge stations) from 2004 to 2009.

Coho Salmon

There have been relatively few coho salmon smolts captured in the Estuary during our beach seining surveys, although their numbers have been increasing (Table 4.4.1; Figure 4.4.16). The first coho smolt captured in the Estuary was a single fish in 2006. As of 2010 there had been a total of 159 smolts captured. In 2011 there was a marked increase in captures at 263 coho smolt; however, 187 of these smolts were captured during a single seine set on May 17th at Patty’s Bar station in the Middle Reach. During previous study years coho abundance was as high as 0.2 fish/set. Then during 2011 the CPUE was 0.9 fish/set, an over 4-fold increase. The relatively low coho captures in the Estuary are related to their low numbers in the Russian River watershed, but also the timing of our seining surveys that begin in late-May or June when most smolts have already migrated to the ocean. Nearly all smolts were captured during May (Figure

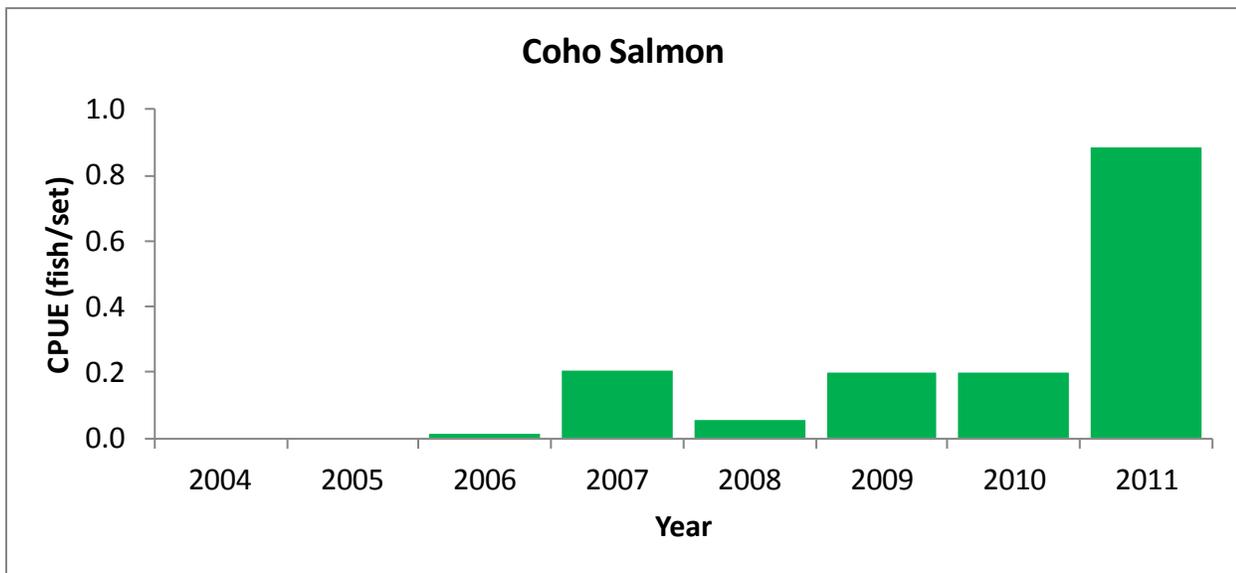


Figure 4.4.16. Annual abundance of coho salmon smolts captured by beach seine in the Russian River Estuary. Samples are from 96 to 300 seine sets yearly from May to October.

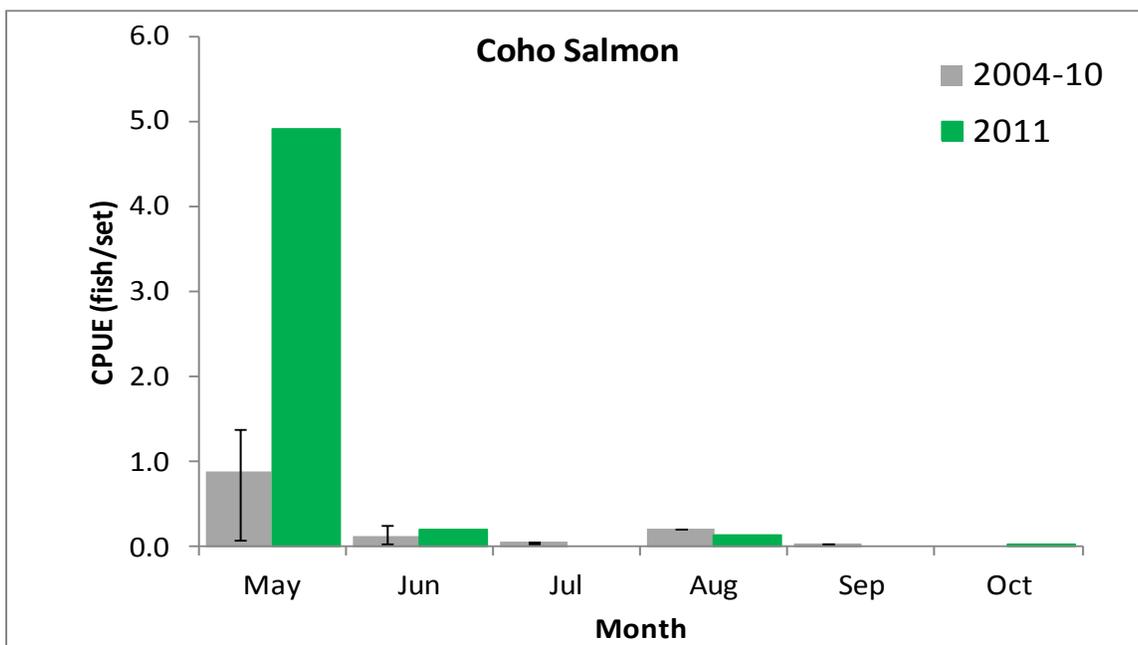


Figure 4.4.17. Seasonal abundance of coho salmon smolts captured by beach seine in the Russian River Estuary, 2004-2011. Seining events consisted of 21 to 50 seine sets approximately monthly. October surveys began in 2010. Data from 2004 to 2009 were averaged and whiskers indicate minimum and maximum values above the below the average.

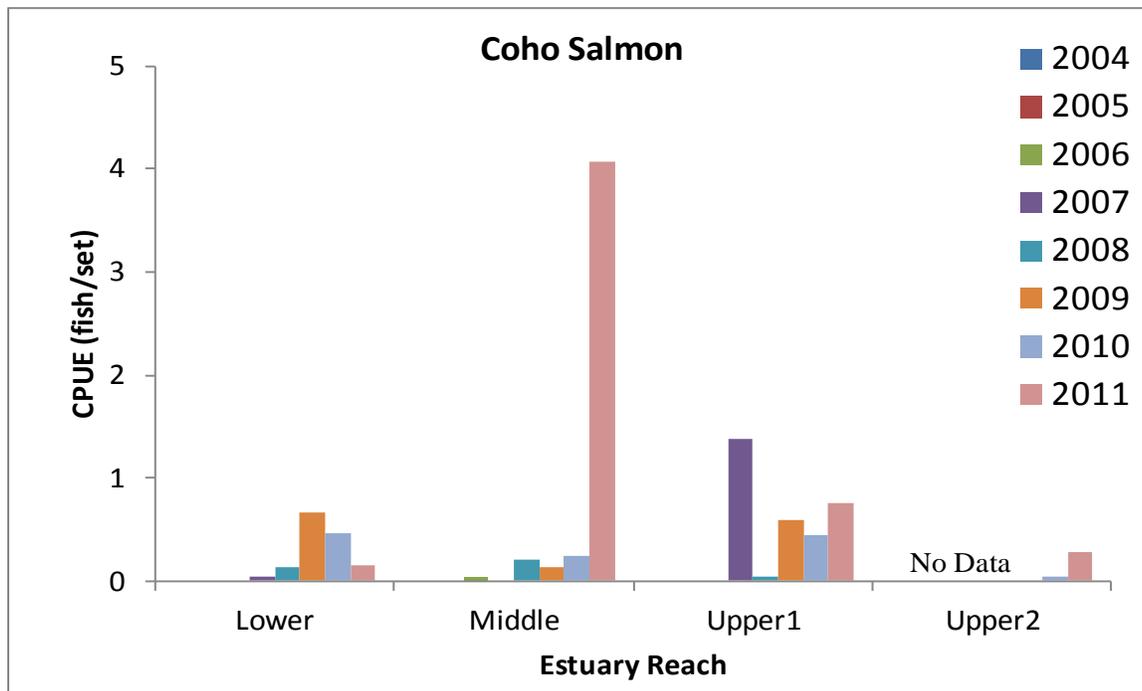


Figure 4.4.18. Spatial distribution of coho salmon smolts in the Russian River Estuary, 2004-2011. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the Upper2 Sub-Reach (Casini Ranch and Moscow Bridge stations) from 2004 to 2009.

4.4.17). The spatial distribution of coho smolts has varied annually (Figure 4.4.18). During 2007 most coho were captured in the Upper1 Sub-Reach, while from 2009 to 2011 smolts appeared to occur throughout the Estuary. Most captured smolts had a clipped adipose fin indicating they originated from the Coho Salmon Captive Broodstock Hatchery Program. This program began stocking coho in local streams in 2004. Two wild coho smolts were captured in the Estuary in 2011.

American Shad

American shad is an anadromous sportfish, native to the Atlantic coast. It was introduced to the Sacramento River in 1871, and within two decades, was abundant locally and had established populations from Alaska to Mexico (Moyle 2002). Adults spend from 3 to 5 years in the ocean before migrating upstream to spawn in the main channels of rivers. Juveniles spend the first year or two rearing in rivers or estuaries.

The annual abundance of American shad in the Estuary has ranged from 0.3 fish/set in 2005 to 24.3 fish/set in 2006 (Figure 4.4.19). During 2011, the shad CPUE was 2.4 fish/set. The seasonal occurrence of juvenile American shad followed a recurring seasonal pattern. They first appear in relatively large numbers in July and the catch usually peaks in August. Shad were distributed throughout the Estuary but were most abundant in the Upper1 and Upper2 Sub-Reaches where slightly brackish waters occur (Figure 4.4.20).

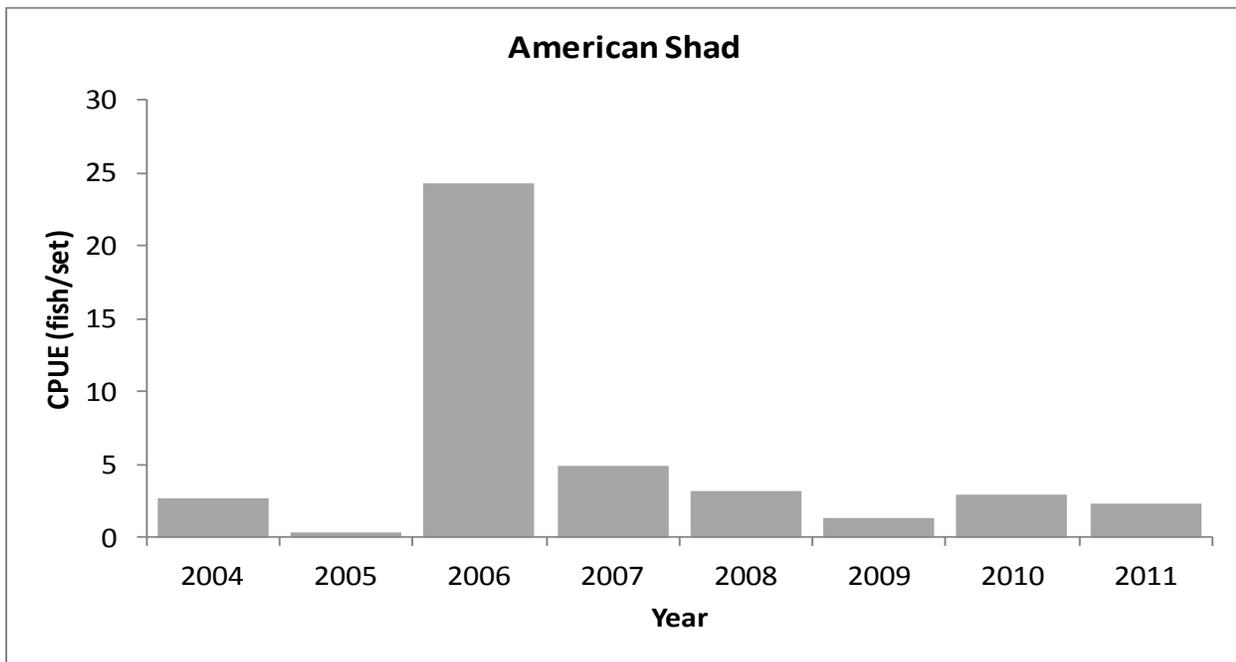


Figure 4.4.19. Annual abundance of juvenile American shad captured by beach seine in the Russian River Estuary. Samples are from 96 to 300 seine sets yearly from May to October.

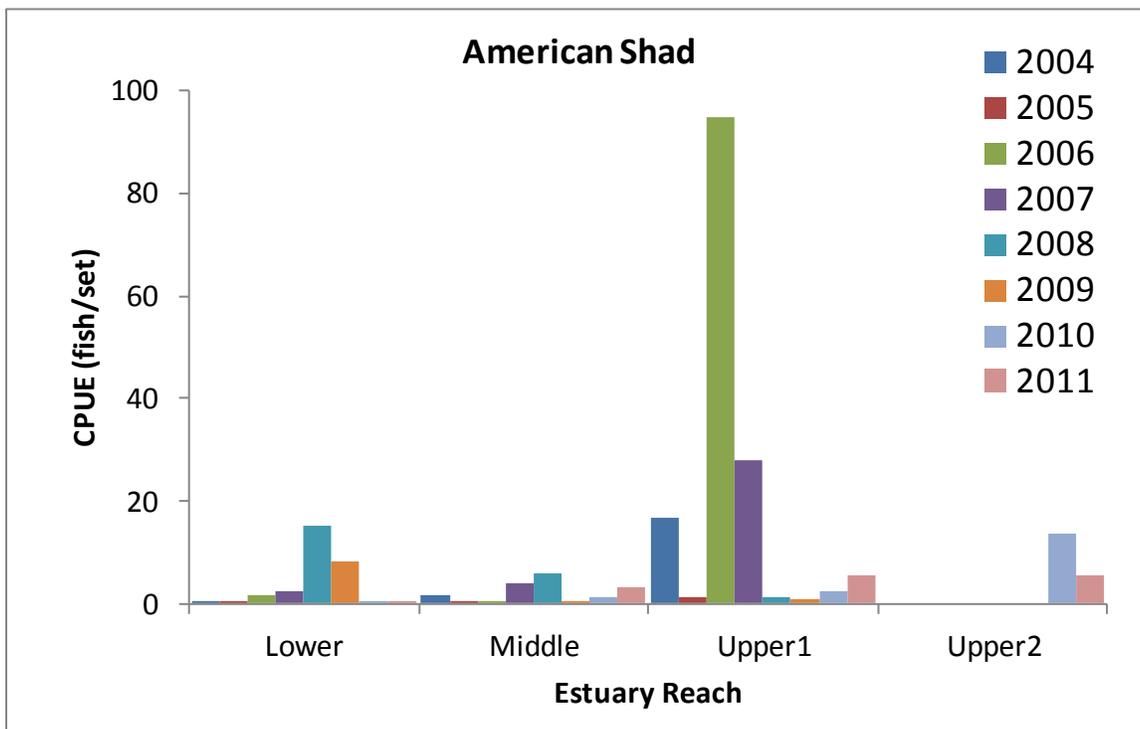


Figure 4.4.20. Spatial distribution of juvenile American shad in the Russian River Estuary, 2004-2011. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the Upper2 Reach during 2004 and 2009.

Topsmelt

Topsmelt are one of the most abundant fish in California estuaries (Baxter et al. 1999) and can tolerate a broad range of salinities and temperatures, but are seldom found in freshwater (Moyle 2002). They form schools and are often found near the water surface in shallow water. Sexual maturity is reached in 1 to 3 years and individuals can live as long as 7 to 8 years. Estuaries are used as nursery and spawning grounds and adults spawn in late-spring to summer.

Topsmelt is a common fish in the Russian River Estuary. However, the abundance of topsmelt in the Estuary has decreased since a peak in 2006 with a CPUE of 13.4 fish/set (Figure 4.4.21). The CPUE in 2011 was 1.0 fish/set. The catch of topsmelt peaked in July and August. Topsmelt were distributed in the Lower and Middle Reaches, where brackish water conditions are common, and were seldom captured upstream where tidal influences are low (Figure 4.4.22). The highest occurrence of topsmelt was in the Middle Reach in 2006 with a CPUE of 32.9 fish/set. During 2011, the highest CPUE was in the same reach at 7.4 fish/set.

Starry Flounder

Starry flounder range from Japan and Alaska to Santa Barbara in coastal marine and estuarine environments. In California, they are common in bays and estuaries (Moyle 2002). This flatfish is usually found dwelling on muddy or sandy bottoms. Males mature during their second year and females mature at age 3 or 4 (Baxter et al. 1999). Spawning occurs during winter along the coast, often near the mouths of estuaries. Young flounders spend at least their first year rearing in estuaries. They move into estuaries during the spring and generally prefer warm, low-salinity water or freshwater. As young grow, they shift to using brackish waters.

The abundance of juvenile starry flounder in the Estuary has generally decreased since 2004 (Figure 4.4.23). Juvenile flounder have been at relatively low abundance since 2006. Seasonal changes in river outflow in combination with changing ocean conditions likely affect the strength of year classes (Baxter et al. 1999). The Estuary appears to be utilized primarily by young-of-the-year fish where most flounder captures are less than 100 mm fork length. The seasonal occurrence of starry flounder was typically highest in May and June, and then gradually decreased through September and October when few were caught. Starry flounder were distributed throughout the Estuary ranging from the River Mouth in the Lower Reach, with cool seawater conditions, to the Upper Reach, with warm freshwater (Figure 4.4.20). Starry flounder have been detected as far as Austin Creek at the upstream end of the Estuary (Cook 2006).

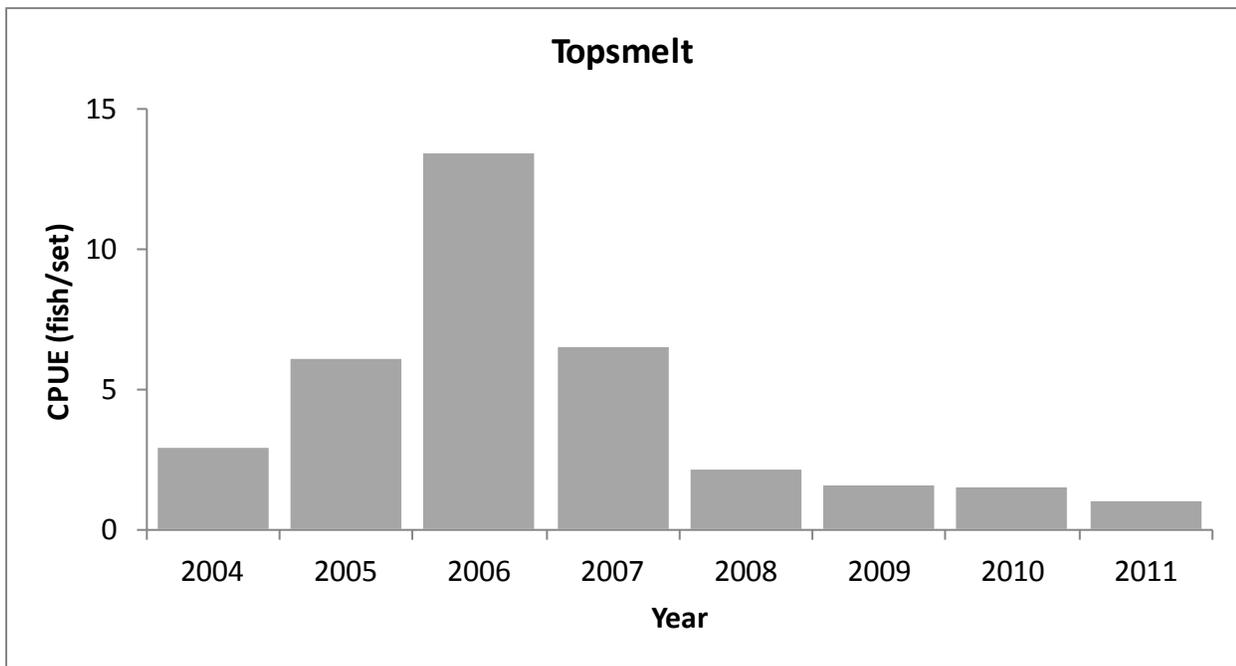


Figure 4.4.21. Annual abundance of topsmelt captured by beach seine in the Russian River Estuary. Samples are from 96 to 300 seine sets yearly from May to October.

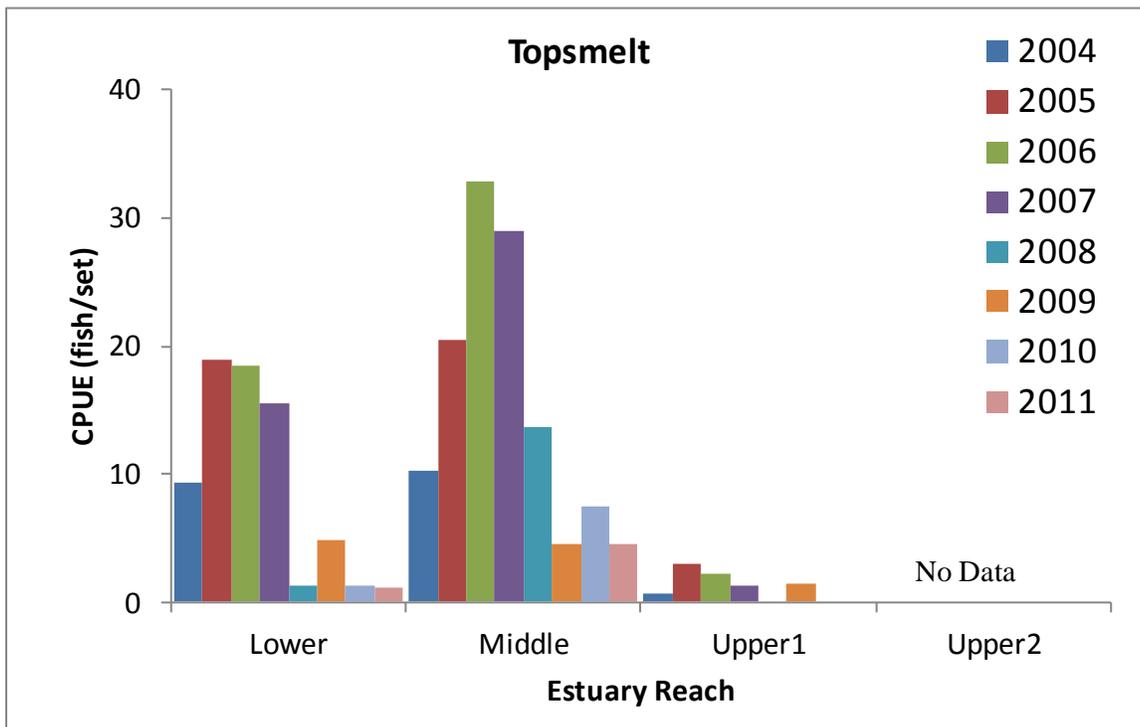


Figure 4.4.22. Spatial distribution of topsmelt in the Russian River Estuary, 2004-2011. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the Upper2 Reach during 2004 and 2009.

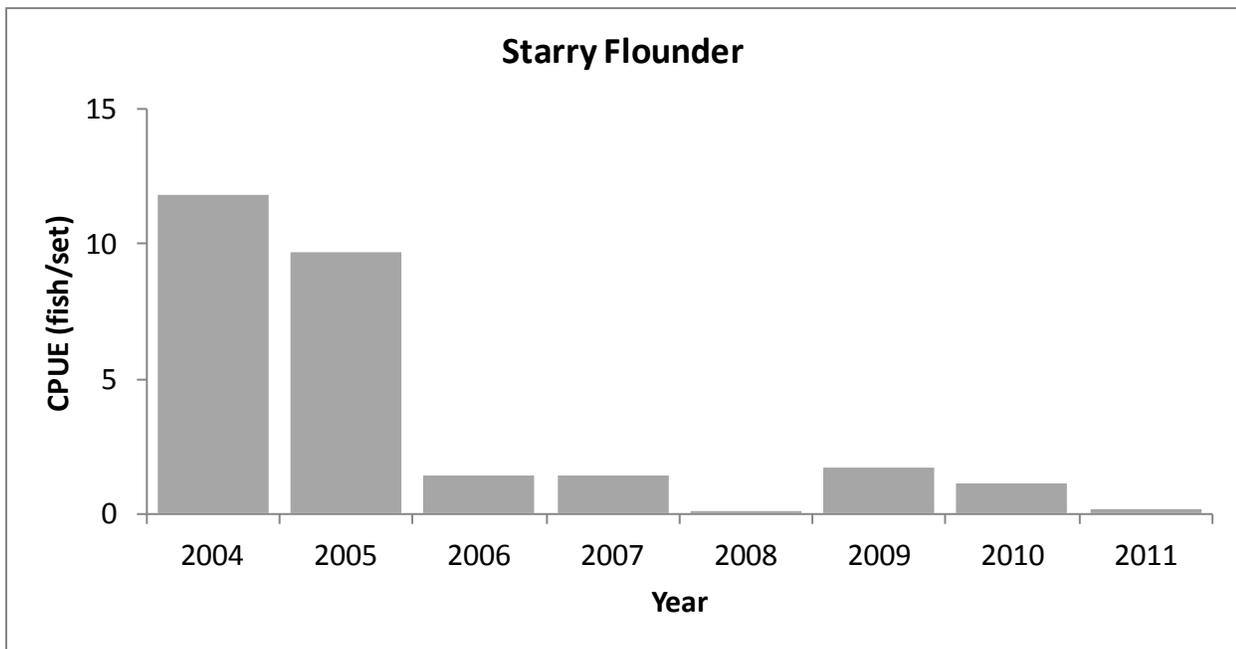


Figure 4.4.23. Annual abundance of juvenile starry flounder captured by beach seine in the Russian River Estuary. Samples are from 96 to 300 seine sets yearly from May to October.

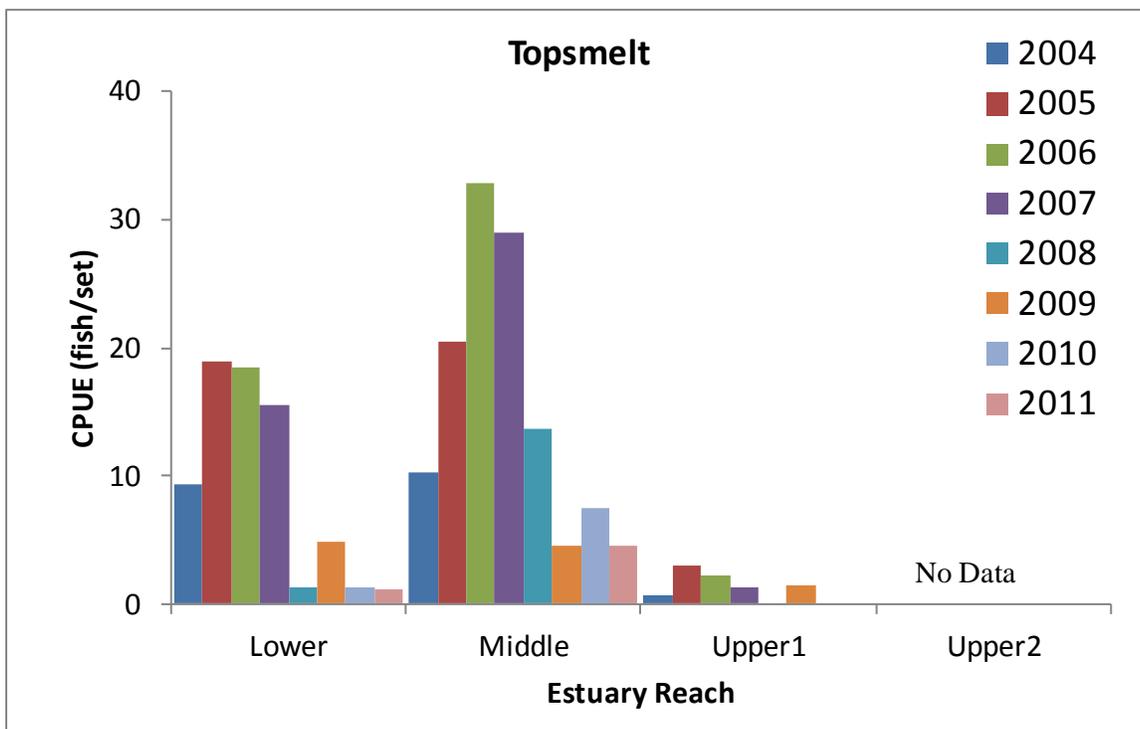


Figure 4.4.24. Spatial distribution of juvenile starry flounder in the Russian River Estuary, 2004-2011. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the upper Estuary during 2004 and 2009.

Conclusions and Recommendations

Fish Sampling - Beach Seining

The results of fish surveys from 2004 to 2011 found a total of 50 fish species from marine, estuarine, and riverine origins. The distribution of species was strongly influenced by the salinity gradient in the Estuary that is typically cool seawater near the mouth of the Russian River and transitions to warmer freshwater at the upstream end. Exceptions to this distribution pattern were anadromous and generalist fish that occurred throughout the Estuary regardless of salinity levels. All fish seining studies were conducted under open river conditions allowing daily tidal circulation in the Estuary. The results of the 2011 fish studies contribute to our knowledge of a tidal brackish system. This baseline data will be used to compare with a closed mouth lagoon system.

Although beach seining is widely used in estuarine fish studies, beach seines can only be used effectively near shore in relatively open water habitats free of large debris and obstructions that can foul or snag the net. Consequently, there is inherent bias in seine surveys (Steele et al. 2006). By design, our seining stations were located in areas with few underwater obstructions (i.e., large rocks, woody debris, etc) and this likely influenced our assessment of fish abundance and habitat use. However, the spatial and temporal aspects of our sampling do allow comparison among reaches and years.

The distribution and abundance of salmonids in the Estuary differed spatially, temporally, and by species. Steelhead were captured from May to October during each study year. Also, PIT-tagged steelhead showed strong site fidelity to specific sites in the Estuary. This indicates that steelhead rear in the Estuary under current river mouth management conditions. The synthesis in Chapter 10 provides a discussion about trends in abundance but the fluctuation in abundance of steelhead annually is likely attributed to the variability in adult spawner population size (i.e. cohort abundance), residence time of young steelhead before out-migration, and schooling behavior that affects susceptibility to capture by seining. Chinook salmon smolts spent less than half the summer rearing in the Estuary and were usually absent after July. Based on the detection of these smolts at most seining stations, they appear to use most estuarine habitats as they migrate to the ocean. In comparison, steelhead were found during the entire summer and were often found in the Upper Reach of the Estuary. However, there are sites in the Middle and Lower Estuary (e.g., Jenner Gulch confluence) where steelhead are consistently found. There have been relatively low, but increasing, numbers of coho salmon smolts in the Estuary since studies began in 2004. Most coho were caught early in the season and were hatchery-born fish.

4.5 Crab and Shrimp Trapping

Trapping surveys were used to determine the relative abundance and distribution of macro-invertebrates in the Estuary. These surveys focused on marine species, began in 2004, and have been conducted annually. Surveys from 2004 to 2010 determined the distribution of marine crabs within reaches of the Estuary and the relative abundance of age classes (SCWA, 2011). These studies showed that most macro-invertebrates in the Estuary were Dungeness crab (*Metacarcinus [Cancer] magister*) consisting of 99.2% of the catch. The Lower and Middle reaches of the Estuary are used predominantly by rearing juvenile and a few adult crabs. Juveniles appeared to prefer shallow warmer brackish waters, while adult crabs were found in deeper cold seawater; however, most trapping was in deep water. Studies in 2011 evaluated the occurrence of Dungeness crab at varied depths and water conditions to better understand microhabitats used by crab age classes.

Methods

Studies conducted in 2011 were directed at understanding the abundance of Dungeness crabs based on water quality in the Lower Reach of Estuary. Water conditions in this reach are highly stratified with seawater at the bottom and brackish water at the surface. Seven oval-shaped crab traps (dimensions 28 X 20 X 13 inches, 0.5 inch mesh) baited with fish parts were placed along a transect crossing the river. The first trap was placed near the shore in shallow water (1-2 m) and the last trap at maximum depth. Deployed traps were retrieved 24 hours later. Trap transects were set twice, once near the river mouth and once near Penny Point. Captured invertebrates were identified to species, measured, and released. Age classes of Dungeness crabs were separated by an evaluation of size frequency data. For age class determination, we used ranges of carapace widths to incorporate summer growth of a cohort. Age class and carapace width categories were: age 0+/young-of-the-year (<60-75 mm); age 1+ (60-75 mm to 90-100 mm); and adult (\geq 90-100 mm). Water quality data was collected using a YSI 85 meter near the Estuary bottom at the site of each trap. Measurements consisted of temperature, dissolved oxygen, and salinity.

Results

Dungeness crab prefers sandy to sandy-mud bottoms and range from the intertidal zone to depths greater than 100 m. Adult Dungeness crabs spawn in the open ocean. The shrimp-like larvae are planktonic and drift with offshore currents (Morris et al. 1980). Larvae metamorphose into juvenile crabs from April to June and have a similar appearance as adults. Juveniles are bottom dwellers and rear in near-shore coastal waters, including estuaries (Wild and Tasto 1983). At least 2 years of age is required for sexual maturity.

The Lower Reach of the Russian River Estuary is highly stratified with very little mixing between water layers. A warm brackish layer occurred at the surface to approximately 2 m in depth. Below was a denser layer of cold seawater. Figures 4.5.1 and 4.5.2 show water conditions along the trap transects and crab captures. Juvenile Dungeness crabs were usually trapped in the upper brackish water layer near or at the thermocline that usually coincided with trap numbers 1-3 on Figures 4.5.1 and 4.5.2. Most adults were found in the deeper cold seawater in trap numbers 4-7.

Conclusions and Recommendations

Crab and Shrimp Surveys

The Russian River Estuary has shown a bust or boom pattern of abundance for rearing juvenile Dungeness crabs (SCWA 2011). Since 2004, the river mouth has been predominantly open during the spring suggesting that access to the Estuary does not affect the annual change in abundance of juvenile crabs. Changing winter ocean temperatures and currents, and low ocean productivity, are likely important factors. These ocean conditions can affect larval Dungeness crab survival and migration to inshore areas and estuaries.

The profile distribution studies conducted in 2011 showed a spatial separation between Dungeness crab age groups that correlated with the strong stratification in the Estuary. Juvenile Dungeness crab used the shallower warmer brackish waters and adults used the deep cold seawater. This pattern occurred during open mouth conditions. Further studies should focus on how short-term and long-term changes in water conditions from mouth closures could affect the use of Estuary by Dungeness crab age groups.

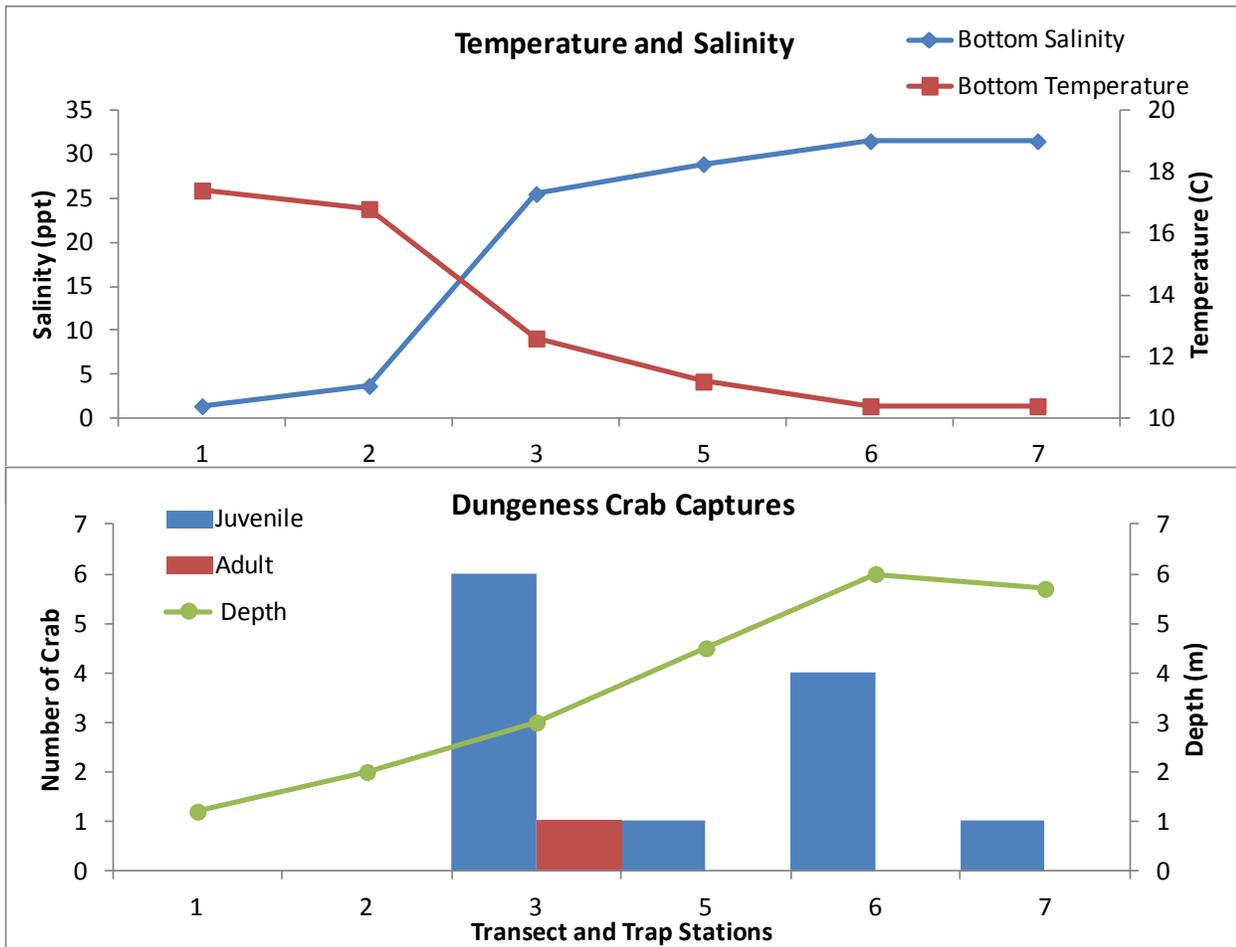


Figure 4.5.1. Dungeness crab captures and bottom water conditions near the river mouth, Russian River Estuary, May 25, 2011. Traps were placed along a transect crossing the Estuary in depths ranging from 1.2 to 6.0 m. A total of 15 crabs were captured in seven traps during a one day period. Age classes are based on carapace widths.

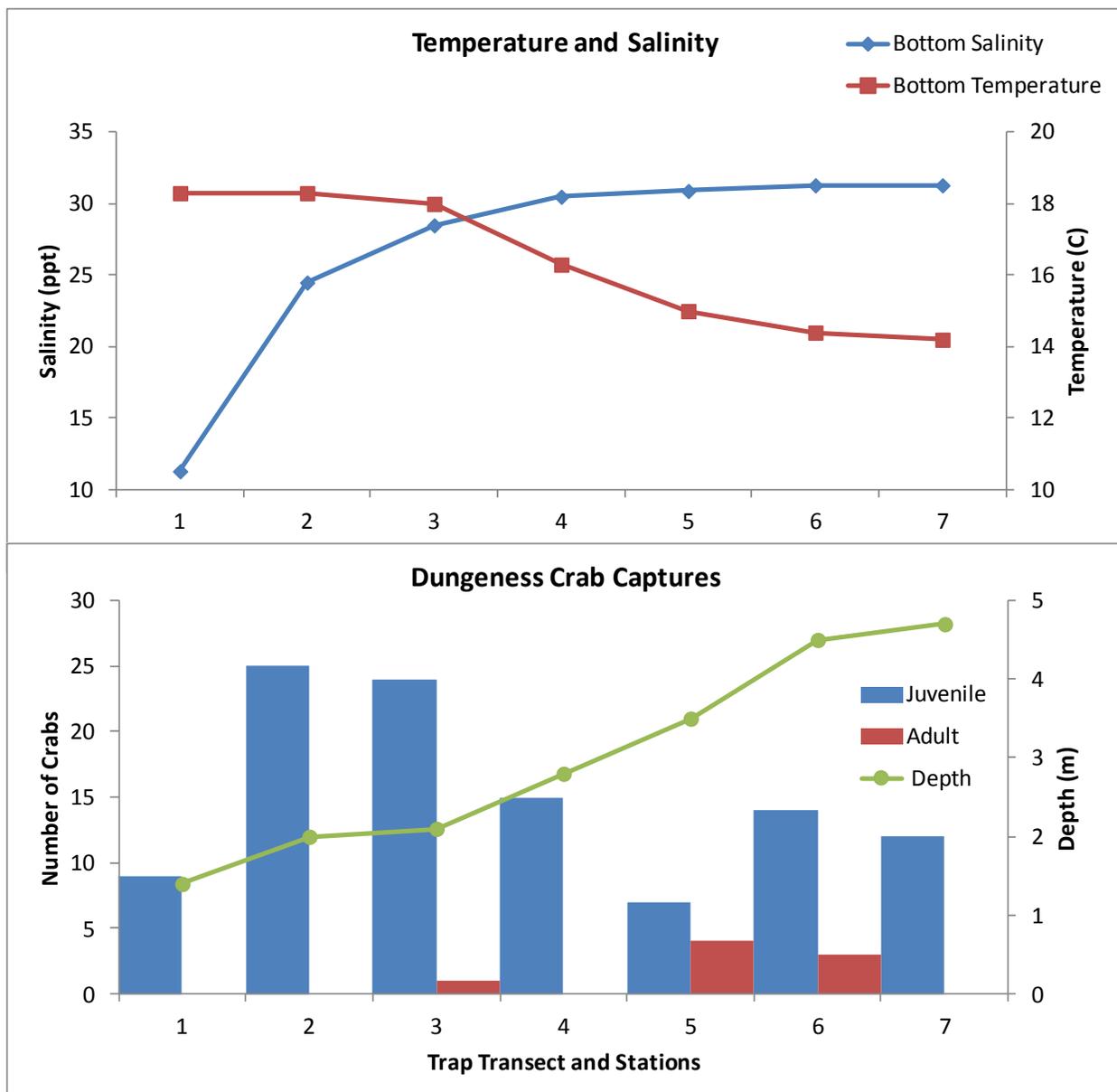


Figure 4.5.2. Dungeness crab captures and bottom water conditions near upper Penny Island, Russian River Estuary, September 27, 2011. Traps were placed along a transect crossing the Estuary in depths ranging from 1.4 to 4.7 m. A total of 114 crabs were captured in seven traps during a one day period. Age classes are based on carapace widths.

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5: Dry Creek Habitat Enhancement, Planning, and Monitoring

5.1 Dry Creek Habitat Enhancement

The Biological Opinion contains an explicit timeline that prescribes a series of projects to improve summer and winter rearing habitat for juvenile coho salmon and steelhead in Dry Creek (Figure 5.1.1). During the initial three years of implementation, 2008 to 2011, the Water Agency is charged with improving fish passage and habitat in selected tributaries to Dry Creek and the lower Russian River. The status of those efforts is described in Chapter 6 of this report. For the mainstem of Dry Creek, during this initial period, the Water Agency is directed to perform fisheries monitoring, develop a detailed adaptive management plan, and conduct feasibility studies for large-scale habitat enhancement and a potential water supply bypass pipeline. The pipeline feasibility study was completed in 2011 and is reported in Martini-Lamb and Manning 2011.

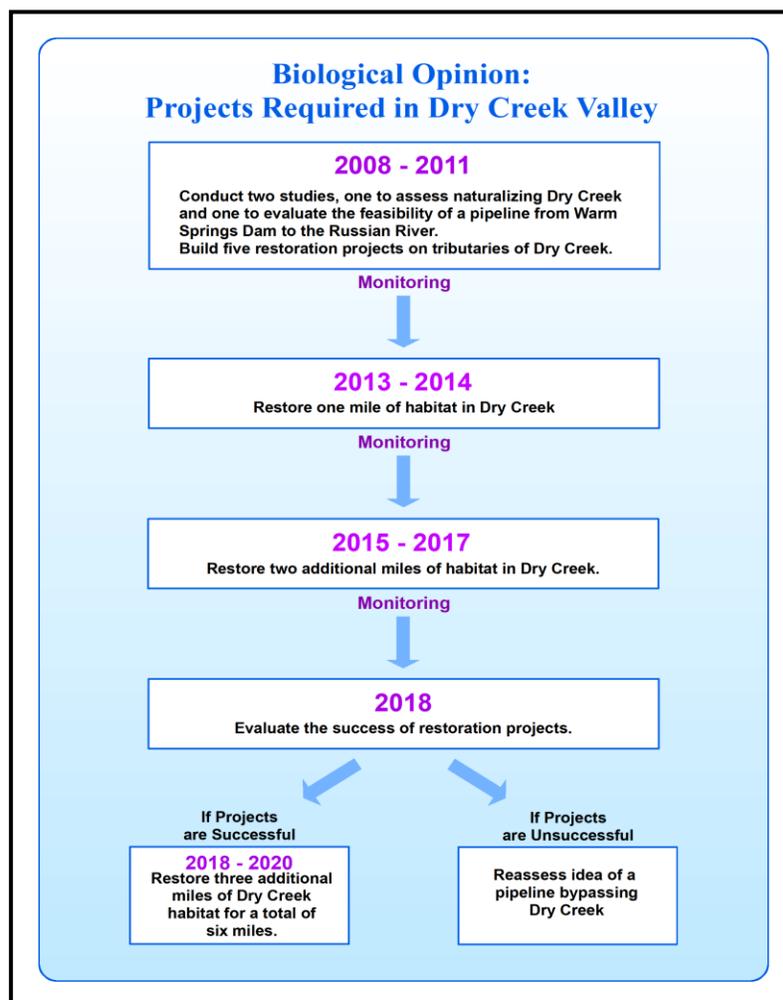


Figure 5.1.1. Timeline for implementation of Biological Opinion projects on Dry Creek.

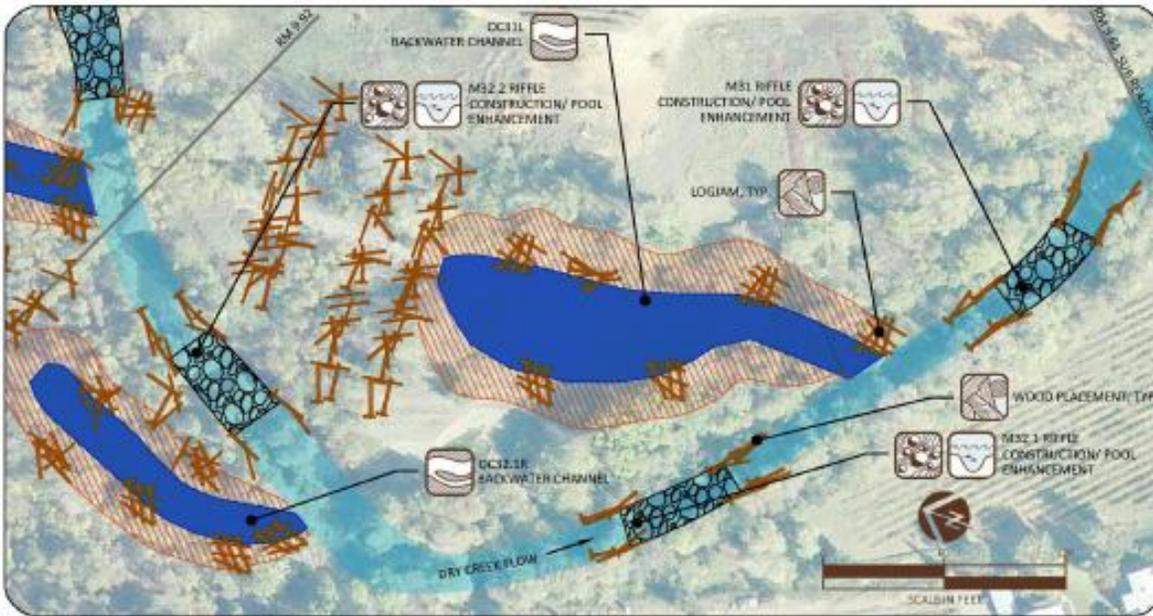
Habitat Enhancement Feasibility Study

The Water Agency regulates summer releases from Warm Springs Dam along a 14 mile reach of Dry Creek from Lake Sonoma to the Russian River. This abundant, cool, high quality water has tremendous potential to enhance the Russian River's coho and steelhead population but it flows too swiftly to provide maximum habitat benefit. By modifying habitat conditions to create refugia from high water velocities along 6 miles of Dry Creek, NMFS and DFG assert that water supply releases can continue at current discharge levels of approximately 100 cubic feet per second (cfs) and potentially historic discharge levels up to 175 cfs.

To plan large scale enhancement of the Dry Creek channel, the Water Agency has retained Inter-Fluve, Inc. to conduct extensive field surveys and produce a series of reports detailing habitat enhancement opportunities along Dry Creek. Interfluve's work is being conducted in three phases: 1) inventory and assessment of current conditions; 2) feasibility assessment of habitat improvement approaches; and 3) conceptual design of habitat approaches deemed feasible. All three reports have been completed and can be viewed at <http://www.scwa.ca.gov/drycreek/>.

During 2011, Interfluve developed the Dry Creek Fish Habitat Enhancement Conceptual Design Report (Appendix D-1). The final report was released to the public in July 2012 and identifies 26 sub reaches along Dry Creek as potential areas for construction of low velocity habitat with depth and cover characteristics conducive to rearing juvenile coho salmon and steelhead. The opportunities identified in the report are distributed throughout the 14 mile length of Dry Creek. However, different reaches of Dry Creek present unique geomorphic and hydrologic constraints and Interfluve divided the stream into upper, middle, and lower segments. In the upper segment (mile 11 to 13.7), the influence of Warm Springs Dam on streamflow, substrate, and channel dimensions is most pronounced. The stability of this reach provides opportunities for long lasting "constructed" habitat features such as side channels, backwaters, and log structures. In the lower segment between Westside Road Bridge and the confluence with the Russian River (mile 0 to 3), conditions are amenable to constructing projects designed to let natural river processes develop habitat over time. The middle segment between Pena Creek and Westside Road (mile 3 to 11), has opportunities for both constructed habitat and river process based approaches.

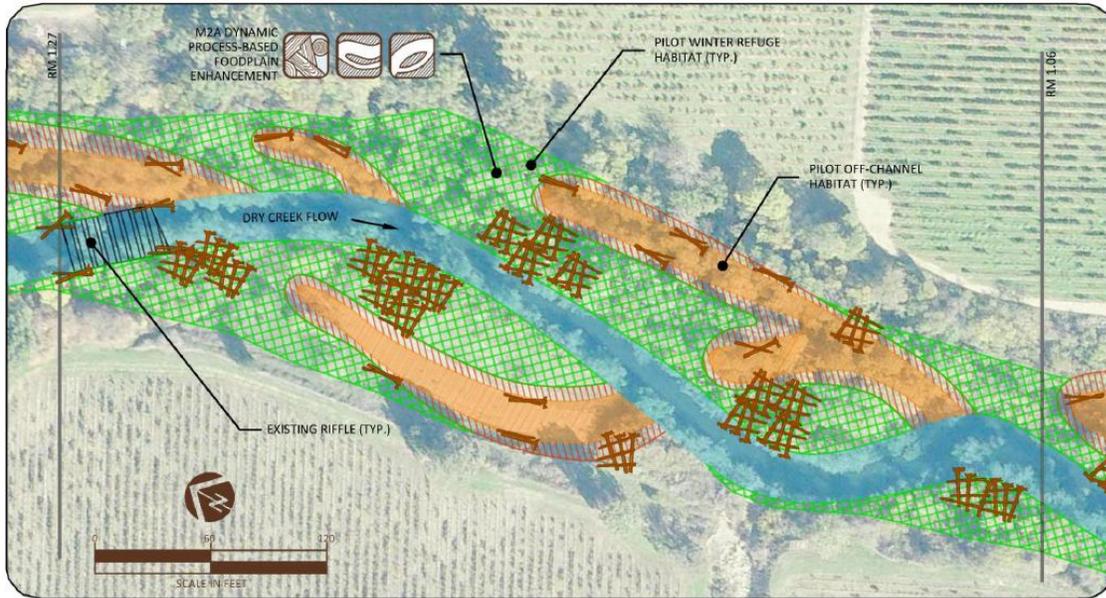
The Concept Design report includes a description of current habitat conditions, modeled inundations at high flow, maps and graphics depicted proposed summer and winter habitat features, and a preliminary cost estimate for each of the 26 enhancement sub reaches along Dry Creek (Figure 5.1.2). All of the sub reaches are ranked according to the potential quantity of summer and winter coho rearing habitat they provide (Table 5.1.1). This ranking does not, however, include implementation considerations such as relative cost, landowner willingness and accessibility, and continuity or predicted longevity of constructed features. Figure 5.1.3 illustrates the two step process that will be employed to select enhancement reaches on Dry Creek.



LEGEND

- MAIN CHANNEL AT 110 CFS
- OFF CHANNEL HABITAT
- GRADING LIMIT
- RIFFLE CONSTRUCTION/ ENHANCEMENT

SUB REACH 10 A
CONCEPT DESIGN
1 OF 2



LEGEND

- MAIN CHANNEL AT 110 CFS
- PILOT OFF CHANNEL HABITAT
- GRADING
- EXISTING RIFFLE
- PILOT WINTER REFUGE HABITAT

SUB REACH 2 A
CONCEPT DESIGN
3 OF 4

Figure 5.1.2. Examples of habitat enhancement conceptual designs for two Dry Creek subreaches. The top panel, Reach 10A, illustrates proposed summer habitat enhancements using a static “constructed” habitat approach. Reach 2A, lower panel, is close the confluence of Dry Creek and the mainstem Russian River. In this highly dynamic environment, a “process” based approach that creates pilot habitat features the stream can adjust over time is proposed.

Table 5.1.1. Ranking of enhancement subreaches in Dry Creek organized by Upper, Middle, and Lower segments.

Segment	Ranking Tier	(Sub) Reach	Coho Potential Coho Rearing Habitat Score	Winter Refuge & Rearing Habitat Score	Total Potential Habitat Score	Predicted Continuity Score
Upper	Tier I	14a	High	Medium	High	High
		13b	Medium	Medium	Medium	High
		15	Medium	Low	Low	High
		14b	Medium	Low	Low	High
	Tier II	12b	Low	High	Medium	High
		13a	Low	Low	Low	High
12a		Low	Low	Low	High	
Middle	Tier I	8b	High	Medium	High	Medium
		4a	High	Low	High	High
		5a	High	Low	High	Medium
		4b	High	Low	Medium	Medium
		8a	Medium	High	High	High
		5b	Medium	Medium	High	Medium
		10a	Medium	Low	Medium	High
		10b	Medium	Low	Medium	Medium
	Tier II	4c	Medium	Low	Low	High
		6	Low	High	High	Medium
		11	Low	Medium	High	Medium
		9b	Low	Medium	Low	Medium
		9a	Low	Low	Low	Medium
Lower	Tier I	2b	High	High	High	Low
		2a	High	High	High	Low
		1	High	High	High	Low
	Tier II	3b	Medium	Low	Medium	Medium
		3a	Medium	Low	Medium	Medium

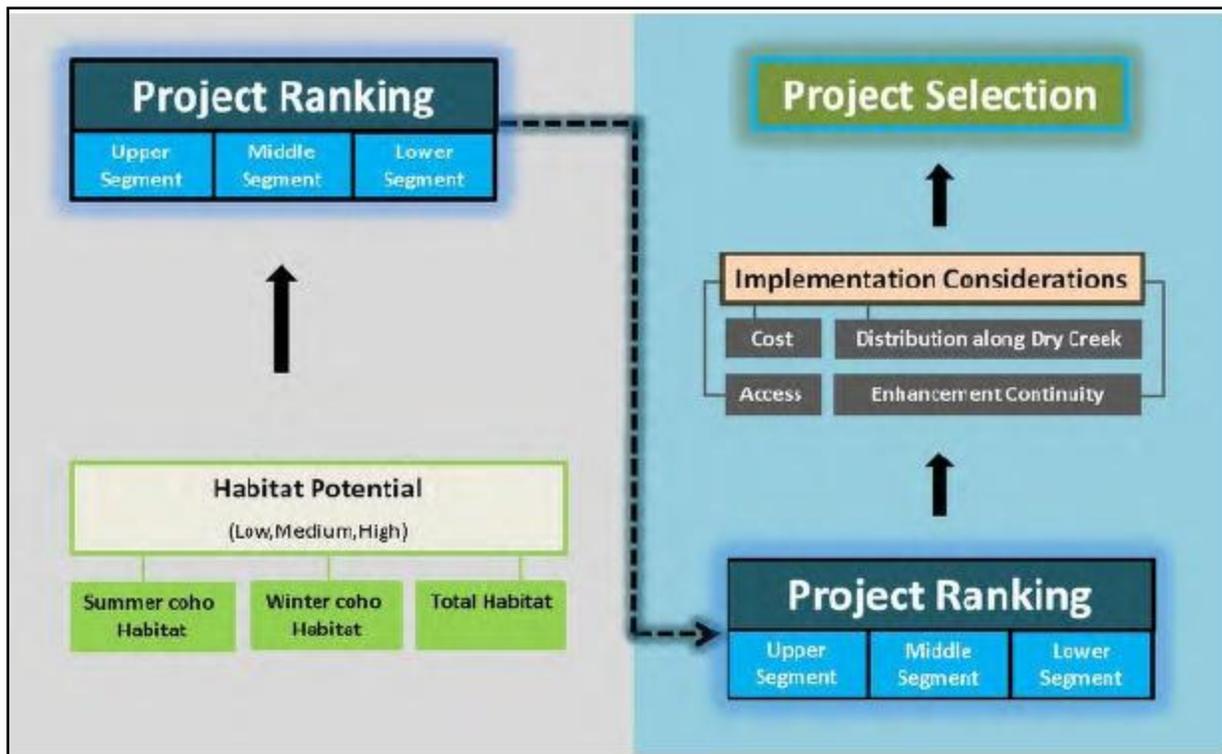


Figure 5.1.3. Conceptual depiction of habitat project prioritization approach. The left side of the figure represents the first phase of the prioritization process which includes ranking of the enhancement subreaches based solely on their inherent potential for habitat enhancement. The second phase, project selection, includes implementation considerations such as access, distribution, and cost.

Demonstration Project

As described in the Public Outreach Chapter of this report, the Water Agency must engage a diverse group of stakeholders to implement the Biological Opinion. Dry Creek is held almost entirely in private ownership and Water Agency staff must work in concert with landowners of more than 170 parcels to study, plan, and construct habitat enhancements. The Biological Opinion's 5 year timeline prior to construction of the first mile of habitat enhancement acknowledges this challenge and the depth of study, planning, and environmental compliance required for implementation. A forward looking group of property owners along a one mile stretch of the stream near Lambert Bridge, in the middle of Dry Creek Valley, approached the Water Agency with the opportunity to advance the schedule and demonstrate habitat enhancement techniques in their reach of the stream (Figure 5.1.4). The Water Agency has welcomed this opportunity, and worked throughout 2011 and 2012 to develop the Dry Creek Habitat Enhancement Demonstration Project. The U.S. Army Corps of Engineers is planning similar habitat enhancement on a 0.3 mile reach of Dry Creek immediately below Warms Springs Dam (Figure 5.1.4).

The Demonstration Project has four goals and objectives:

1. Maximize the general ecological lift to the reach to the extent practicable within the current geomorphic and hydraulic function of the stream,

2. Increase the availability of high quality summer rearing and winter refugia habitat for salmonids (specifically coho and steelhead), given the current physical function of the system,
3. Stabilize areas of problem erosion using techniques that also enhance habitat conditions for fish, and
4. Demonstrate enhancement techniques that may be utilized elsewhere in Dry Creek in order to meet the habitat requirements of the Biological Opinion.

In close consultation with NMFS and DFG, InterFluve advanced the Demonstration Project engineering design to the 90 percent complete phase in 2011. A CEQA Initial Study and Mitigated Negative Declaration for the project was approved by the Agency’s Board of directors on November 15, 2011. In 2012, InterFluve completed a 100 percent design for a winter backwater habitat feature located on property owner by Quivira Winery. Construction on this first component of the Demonstration Project was initiated in September 2012. Pre and Post project data are being gathered and the results of the project will be reported in the 2012-13 annual report.

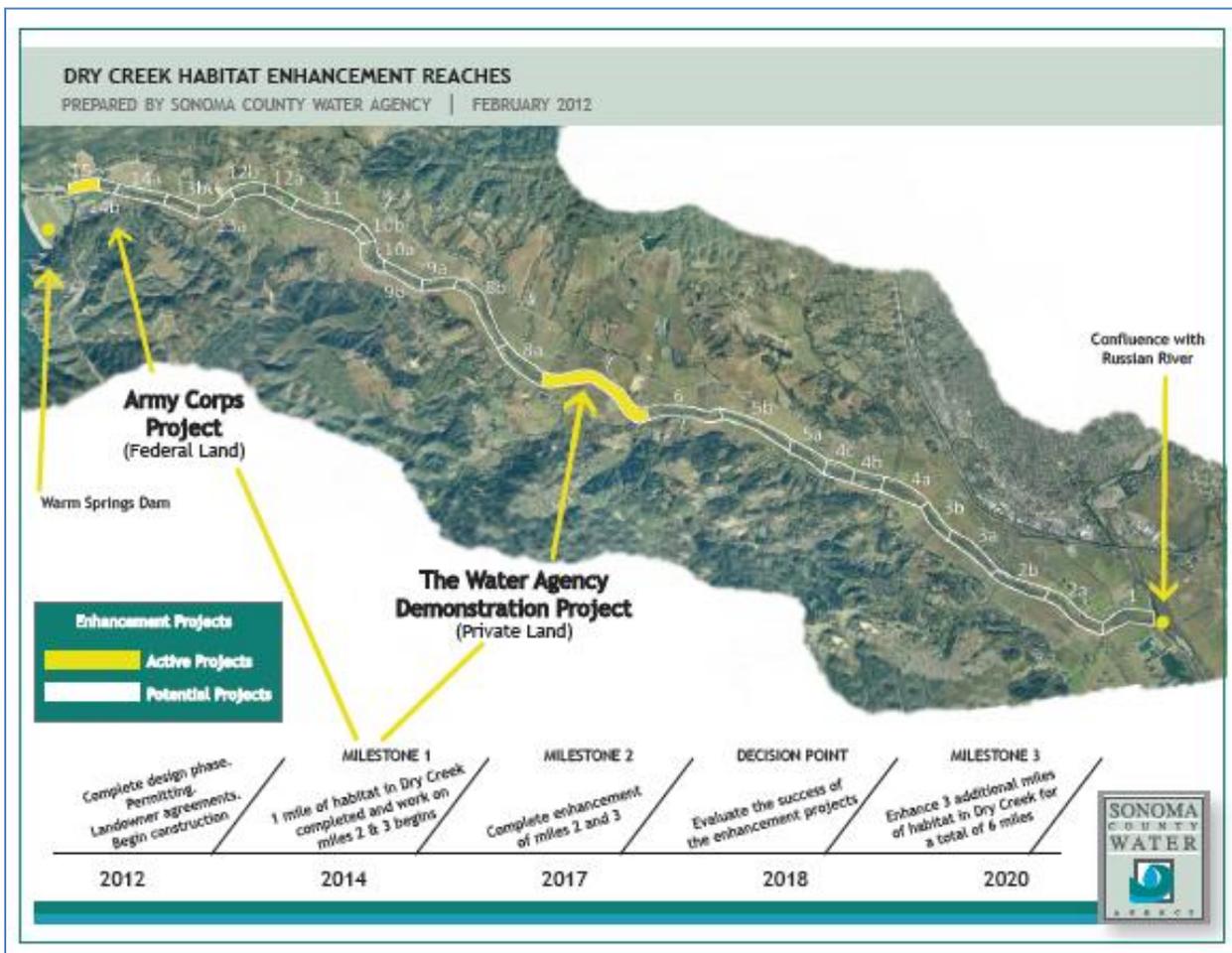


Figure 5.1.4. The location of Water Agency and Army Corps of Engineers Dry Creek habitat enhancement projects to meet Biological opinion milestones.

Adaptive Management and Monitoring Plan

A multi-entity effort to develop an adaptive management plan (AMP) for validating the effectiveness of habitat enhancement in mainstem Dry Creek is currently underway. The group is facilitated by ESSA Technologies Ltd. (an independent consulting firm from Vancouver Canada) and it consists of the Sonoma County Water Agency, NMFS, CDFG, USACE and Inter-Fluve, Inc. The Water Agency intends to use the AMF developed through this process as the basis for the adaptive management plan described in the Russian River Biological Opinion. The plan will include criteria and approaches for evaluating project implementation (implementation monitoring), changes in habitat (effectiveness monitoring) and biological responses (validation monitoring).

During 2011 and 2012, ESSA is held a series of workshops with the agencies, including USACE, to build the decision trees and guidelines for a state-of-art adaptive management plan. Planning for work in the Demonstration Project mile is being used to develop an adaptive management framework that can be applied to subsequent phases of the Dry Creek Habitat Enhancement Project. The final AMP will be completed in early 2013.

Validation Monitoring

As described in Martini-Lamb and Manning (2011) a multi-entity effort to develop an adaptive management framework (AMF) for validating the effectiveness of eventual habitat enhancement in mainstem Dry Creek is currently under development. The current section of this report focuses on the results of validation monitoring for juvenile and smolt salmonid populations in mainstem Dry Creek in 2011. These data are part of an ongoing pre-construction (baseline) monitoring effort begun in 2008 and outlined in NMFS' Russian River Biological Opinion (RRBO). Some preliminary effectiveness monitoring data have been collected; however those data will be reported in future reports. Plans for additional effectiveness monitoring are being developed as part of the AMF document that will result from AMF workshops held over the past 23 months and attended by NMFS, CDFG, the Water Agency and USACE.

In the Russian River Biological Opinion status and data report year 2009-10 (Manning and Martini-Lamb 2011), the Water Agency outlined six possible metrics that could be considered for validation monitoring of juvenile salmonids with respect to eventual habitat enhancements in the mainstem of Dry Creek: habitat use, abundance (density), size, survival, growth and fidelity. In 2009 and 2010, a major focus of validation monitoring in Dry Creek was on evaluating the feasibility of sampling methods to accurately estimate each of those metrics while simultaneously attempting to understand how limitations in sampling approaches may affect our ability to validate project success. These same validation metrics and associated limitations and uncertainties have been discussed in the context of the results of those evaluations and are being incorporated into the adaptive management plan described above (Porter et al. 2011). The methods we employed in 2011 are largely based on the outcome of that work (Manning and Martini-Lamb 2011; Martini-Lamb and Manning 2011).

In the most recent draft of the AMF, three spatial scales of validation monitoring for juvenile salmonids for mainstem Dry Creek have been identified: site/feature, reach, and entire mainstem. The draft further suggests the appropriate target life stage and temporal scale of monitoring for each spatial

scale (**Table 5.1..2**). During the current pre-construction monitoring phase, validation monitoring has been at the reach scale in the form of juvenile sampling to estimate size and growth, survival, emigration and population density for steelhead as well as at the stream (mainstem Dry Creek) scale to begin the task of establishing long term smolt population trends for coho salmon. Following project construction, we plan to begin implementing finer spatial scale sampling to estimate use of newly constructed features by juvenile salmonids.

Table 5.1.2. Proposed target life stages, validation metrics, spatio-temporal scale and monitoring tools for validation monitoring in mainstem Dry Creek.

Spatial scale	Target life stage	Target metric(s)	Temporal scale	Primary monitoring tool(s)
Site/feature	Juvenile (non-smolt)	Habitat use, abundance (density), size, growth	Post-construction	Snorkeling, electrofishing, PIT tags and antennas
Reach	Juvenile (non-smolt)	Abundance (density), size, survival, growth, fidelity	Pre-construction (baseline) vs. post-construction	Electrofishing, PIT tags and antennas
Mainstem Dry Creek	Smolt	Abundance	Ongoing to capture long-term trend	Downstream migrant trap, PIT antennas

Methods

Juvenile sampling

In 2011, we continued the focus begun in 2009 and continued in 2010 of sampling at the reach scale by making multiple backpack electrofishing passes through relatively long stream sections in an attempt to estimate over-summer survival, emigration and size/growth for juvenile steelhead in the upper, middle and lower reaches of mainstem Dry Creek. As in 2008-2010, we also sampled shorter sections within the middle reach stream section that has been targeted for the first mile of habitat enhancements in mainstem Dry Creek (the “demonstration project”) in order to estimate over-summer growth and population density in early autumn (Figure 5.1.5). All of the stream sections sampled in 2011 were similar to those sampled in previous years (Figure 5.1..5). Although our primary target species for the eventual habitat enhancement work is coho salmon, steelhead juveniles are also federally threatened in the Russian River and are currently the only species present in the summer that are abundant enough to estimate the aforementioned parameters in a meaningful way.

Reach-scale sampling- We adopted the geomorphically-based reach designations identified by Inter-Fluve (2011) for our reach-scale sampling. Those reaches are: lower reach (Dry Creek mouth to just downstream of the lowest grade control sill; river km 0.00 to 4.83), middle reach (just downstream of the lowest grade control sill to the confluence of Pena Creek; river km 4.83 to 11.00) and upper reach (river km 11.00 to 22.00).

Reach-scale sampling involved selecting stream sections that could be reasonably sampled with a backpack electrofishing unit. Sampling began by first bounding the downstream end of selected stream sections with a paired PIT antenna array from mid-summer to early autumn, capturing individual juvenile salmonids with a backpack electrofisher and dipnets in late July/early August, PIT-tagging fish that were ≥ 60 mm and re-sampling the same sections with a backpack electrofisher in each section in late September/early October. Both antenna arrays consisted of two antennas in close proximity to one another so that efficiency for each array could be estimated. For PIT-tagged

individuals that were captured in late July then again in autumn (i.e., recaptured), we calculated over-summer growth rates (mm of change in fork length per day). We used the multistate-robust-design model in program MARK (White and Burnham 1998) to estimate over-summer survival and emigration as well as population abundance in early fall by simultaneously estimating the efficiency of each PIT antenna array (Horton et al. 2011). Fall re-sampling actually consisted of two passes through each section. Because these two re-sampling passes were spaced close together in time (2 days apart), we could reasonably assume that survival and emigration between these two passes was 1 and 0, respectively. Another important assumption of the multistate-robust-design model is that all fish are equally available for recapture on subsequent sampling occasions; in other words, all fish must remain in the section. If this assumption is violated, section fidelity would remain confounded with true survival meaning that the parameter being estimated would be apparent survival as opposed to true survival. In order to decouple emigration from mortality paired PIT antenna arrays were located immediately adjacent to the downstream boundary of the stream section sampled so that PIT-tagged fish moving downstream out of the section could be detected. A consequence of this design requirement on Dry Creek, however, was that in particularly deep or swift habitat where the sampling efficacy of backpack electrofishing gear is often low and wading conditions are often unsafe, the choice of contiguous sample sections where PIT antenna arrays could be located at downstream section boundaries was also limited. As a result, we were unable to find a section in the upper reach that was suitable for applying the reach-level sampling possible for the lower and middle reaches. In the middle reach, we sampled a 320 m long section extending from river km 9.48 to 9.80; in the lower reach, we sampled a 526 m long section extending from river km 2.80 to 3.33 (Figure 5.1..5). Within each section, the location of capture for each individual was recorded to the nearest 46 m.

Site-scale sampling- Site-scale sampling involved defining two relatively shorter (270 and 180 m) contiguous sites within the demonstration project area (located in the middle reach of Dry Creek), capturing individual juvenile steelhead with a backpack electrofisher in late July/early August, PIT-tagging fish that were ≥ 60 mm and re-sampling the same sections in late September/early October followed 2 days later by a recapture pass through each section. We used this same sampling approach on a 93 m long section in the upper reach (a paired PIT antenna array was located approximately 440 m downstream of the sampling section in the upper reach). For PIT-tagged individuals that were captured in late July then again in autumn, we calculated over-summer growth rates (mm of change in fork length per day). From the paired sampling events in early autumn, we used the Petersen mark recapture model to estimate end of summer abundance at these three sites. Provided recapture probability, mortality and the proportion of fish leaving the section between the marking and recapture events is the same for the marked group as it is for the unmarked group, the abundance estimates from the paired mark and recapture events in early autumn should be unbiased.

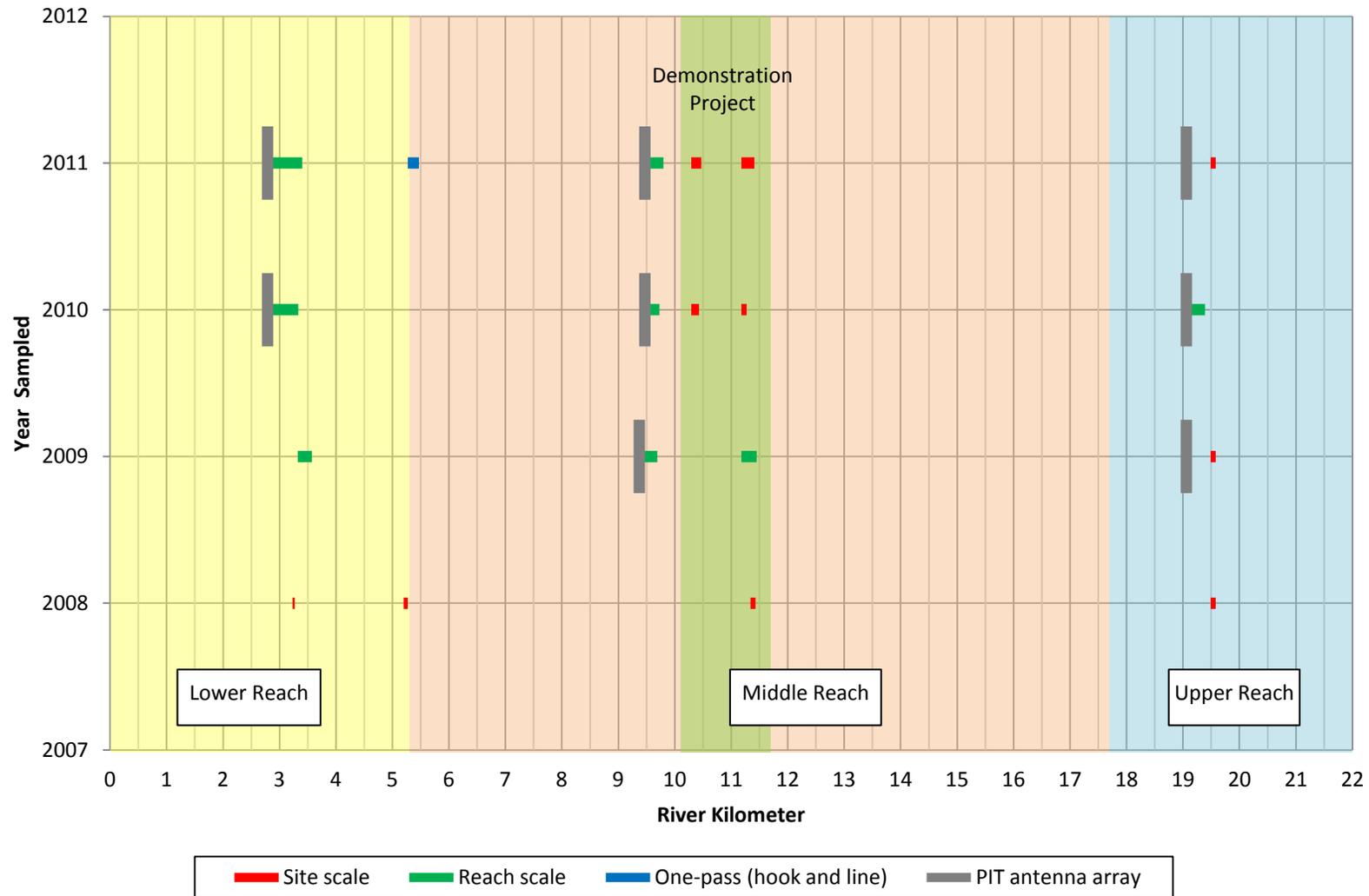


Figure 5.1.5. Years sampled and river kilometer (from the mouth) where juvenile steelhead populations were sampled in mainstem Dry Creek, 2008-2011. Line length for each site is scaled to the length of stream sampled. Data collected at the site scale were analyzed using mark-recapture (either a multiple-pass depletion or Petersen model) and reach scale data collected in 2009 was analyzed with the core-sampling approach (see Manning and Martini-Lamb 2011 for details) while reach scale data collected in 2010 was analyzed with the multistate model using program MARK (White and Burnham 1998). The green-shaded area indicates the stream section that has been targeted to receive the first mile of habitat enhancements (“demonstration project”).

Smolt sampling

A rotary screw trap with a 1.5 m diameter cone was anchored to the Westside Road bridge, located 3.3 km upstream from the confluence of Dry Creek and the Russian River. Weir panels were installed adjacent to the rotary screw trap in order to divert downstream migrating salmonids into the trap that may have otherwise avoided the trap.

Fish handling methods and protocols were similar to those used in previous years (see Manning and Martini-Lamb 2011). Fish captured in the trap were identified to species and enumerated. A subsample of each species was anesthetized and measured for fork length each day, and a subsample of salmonid species was weighed each week. With the exception of up to 50 Chinook salmon smolts each day, all fish were released downstream of the first riffle located downstream of the trap. Each day, up to 50 Chinook smolts (≥ 60 mm) were finclipped and released approximately 100 m upstream of the trap for the purpose of estimating population abundance using program DARR (Bjorkstedt 2005). Finclipped fish that were recaptured in the trap were noted and released downstream (the lengths and weights of recaptured fish were not recorded a second time). We applied the weekly trap efficiency estimates generated from the annual Chinook salmon mark-recapture abundance estimates to weekly trap catches of coho salmon and steelhead juveniles so that we could begin an examination of annual trends in abundance for these two species.

Fry sampling

For the third straight year in 2011, we also installed and fished fry traps at Westside Road (river km 3.2) just downstream of the rotary screw trap site and at Yoakim Bridge just upstream of Yoakim Bridge (river km 17.1). Two fry traps at each at Yoakim Bridge and Westside Road were installed on May 5, 2011. Traps were fished throughout the period at both sites with the exception of weekends and during periods of high flows until they were removed on June 11, 2011. Traps were checked in the morning each day the traps fished.

Results

Juvenile sampling

We captured a total of 33 wild coho YOY in the five stream sections sampled in 2011. Although the total number was low, fish were found from river km 2.8 to river km 19.5 indicating that they were relatively spread out and probably not from redd(s) at a single location.

Densities of juvenile steelhead in 2011 ranged from less than 0.03 fish/m² to 0.11 fish/m² (Figure 5.1.6.) When averaged for all sites within a year, densities in 2011 were the lowest of the four years of data collected from 2008 to 2011 (Figure 5.1.7).

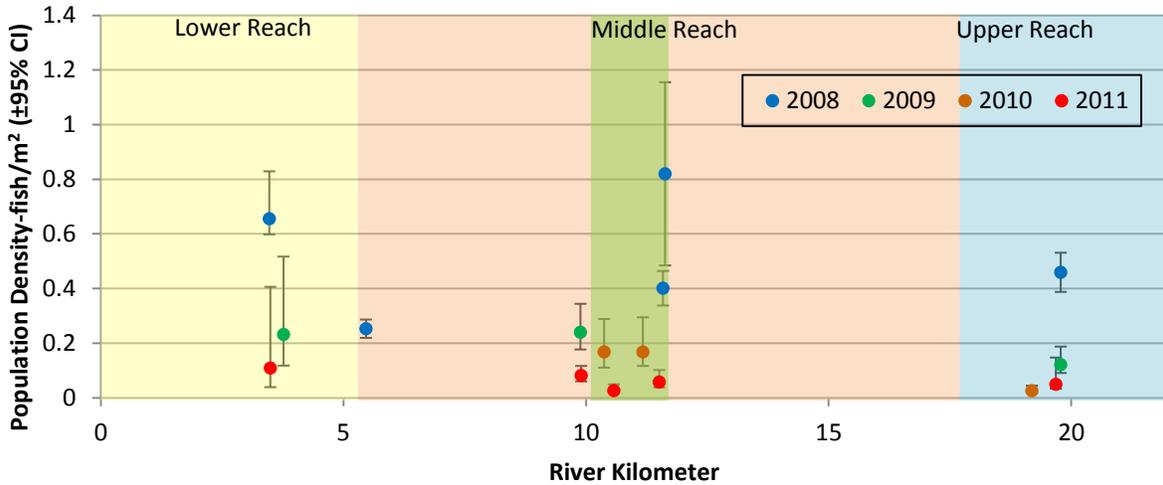


Figure 5.1.6. Estimated density of juvenile steelhead in mainstem Dry Creek, 2008-2011. Estimates are from a variety of approaches all based on mark-recapture models.

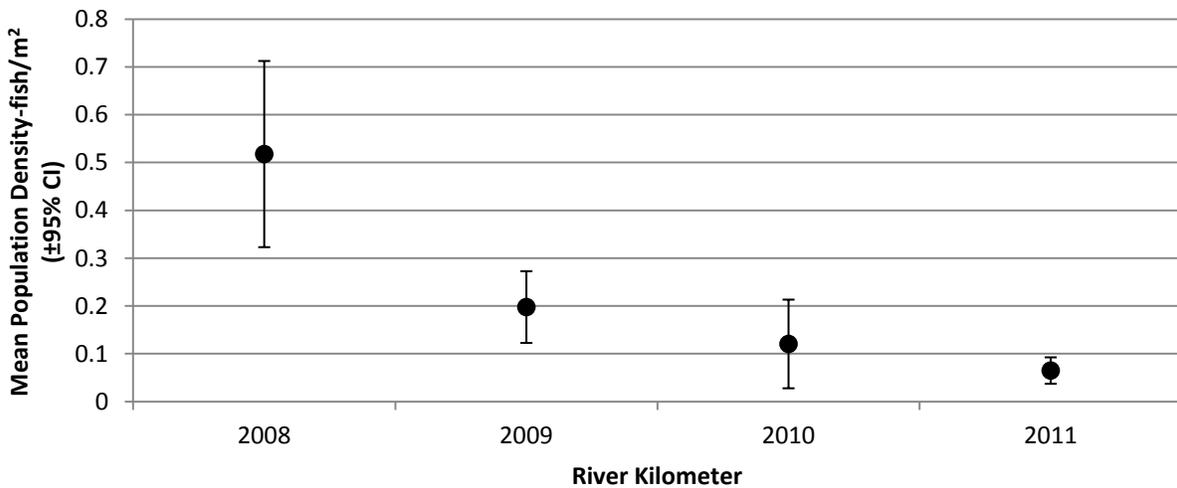


Figure 5.1.7. Mean density among all sites sampled within a year in mainstem Dry Creek, 2008-2011.

Monthly survival estimates of juvenile steelhead in 2011 varied between 0.45 (lower reach) and 0.77 (upper reach) and average monthly survival among all three reaches was slightly higher in 2011 (0.62) as compared to 2010 (0.55, Figure 5.1.8). In 2011, overall emigration between the end of July and the end of September varied between 0.05 (middle and upper reaches) and 0.14 (lower reach) and the average overall emigration for the three reaches was higher in 2011 (0.08) as compared to 2010 (0.04, Figure 5.1.9).

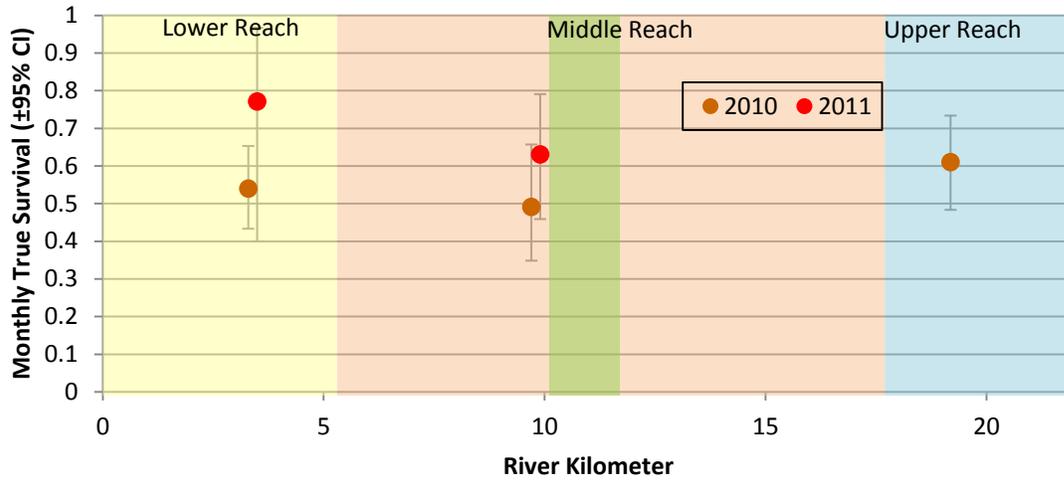


Figure 5.1.8. Estimated monthly true survival of juvenile steelhead from mainstem Dry Creek, 2010-2011.

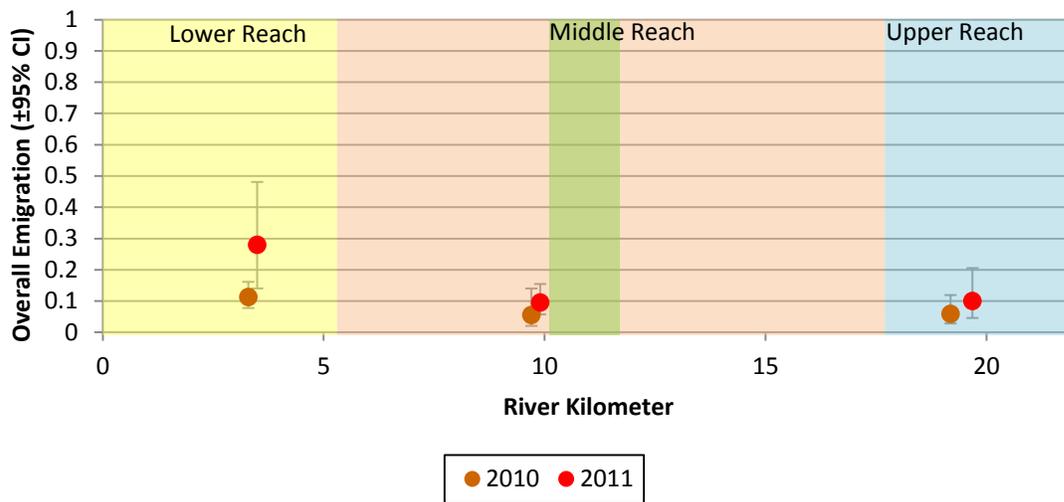


Figure 5.1.9. Estimated overall reach-specific emigration of juvenile steelhead from mainstem Dry Creek, 2010-2011.

The overall mean size of coho salmon YOY captured in 2011 was 88 mm (SD: 9.56). Sample size (n=30) was too low to evaluate the data for differences in mean size among reaches.

Mean individual growth rates of juvenile steelhead in 2011 were significantly lower in the upper reach as compared to the middle and lower reaches (Figure). These data help to explain a similar trend in size data (smaller-sized fish in the upper reach) evident in data from 2008-2010 as well (Manning and Martini-Lamb 2011; Martini-Lamb and Manning 2011).

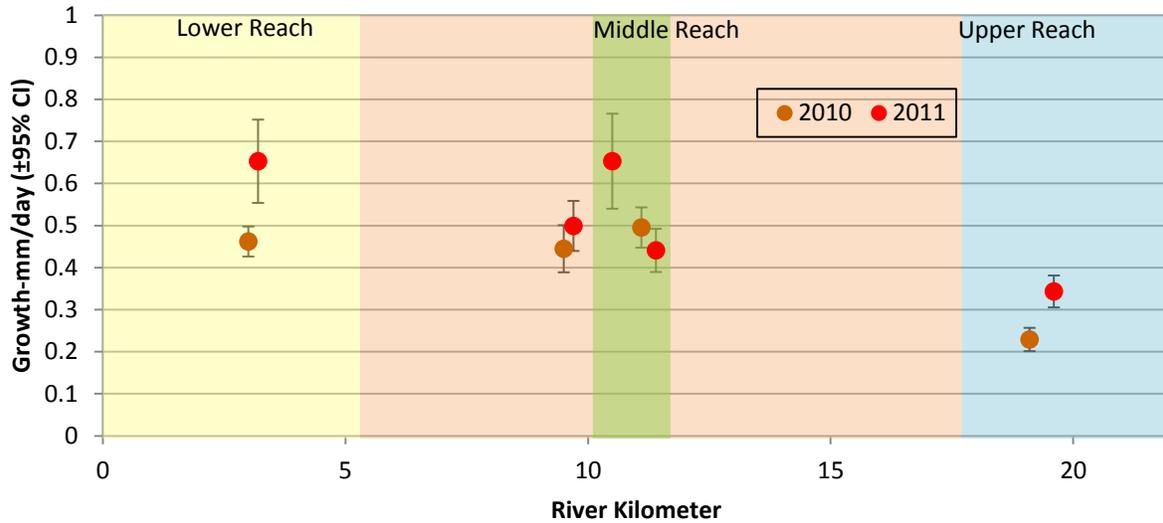


Figure 5.1.10. Estimated growth rates of juvenile steelhead from mainstem Dry Creek, 2011. Estimates are from individual growth rates calculated as the change in fork length (mm) per day of PIT-tagged fish between initial tagging in July and recapture in late September/early October.

Smolt sampling

Because of high flows in Dry Creek, we were unable to install the rotary screw trap until April 12. The trap was checked daily during operation from April 13 until it was removed on August 10 (Figure 5.1.11).

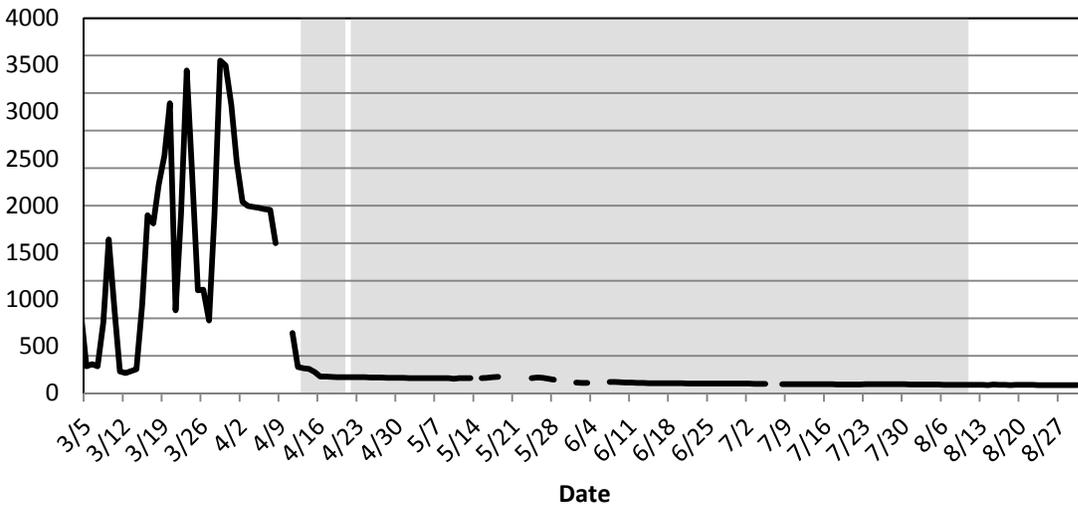


Figure 5.1.11. Discharge (CFS) at Yoakim Bridge (USGS gauge 11465200), and the days the Dry Creek rotary screw trap fished, 2011 (shaded area).

The peak capture of Chinook smolts (5,052) occurred during the week of 5/28 (Figure 5.1.12). Based on the estimated average weekly capture efficiency (range: 4% to 29%, Figure 5.1.13 upper panel), the resulting population size of Chinook salmon smolts passing the Dry Creek trap between April 13 and August 9, 2011 was 225,391 (95% CI: $\pm 29,834$, Figure 5.1.13 lower panel).

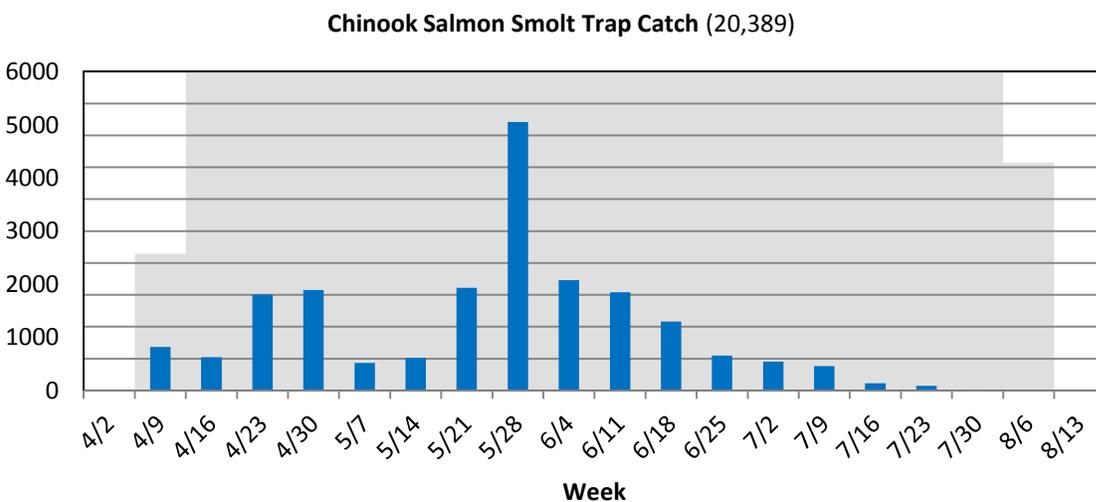


Figure 5.1.12. Weekly trap catch of Chinook salmon smolts in the Dry Creek rotary screw trap and the proportion of each week the trap was fished, 2011 (shaded area).

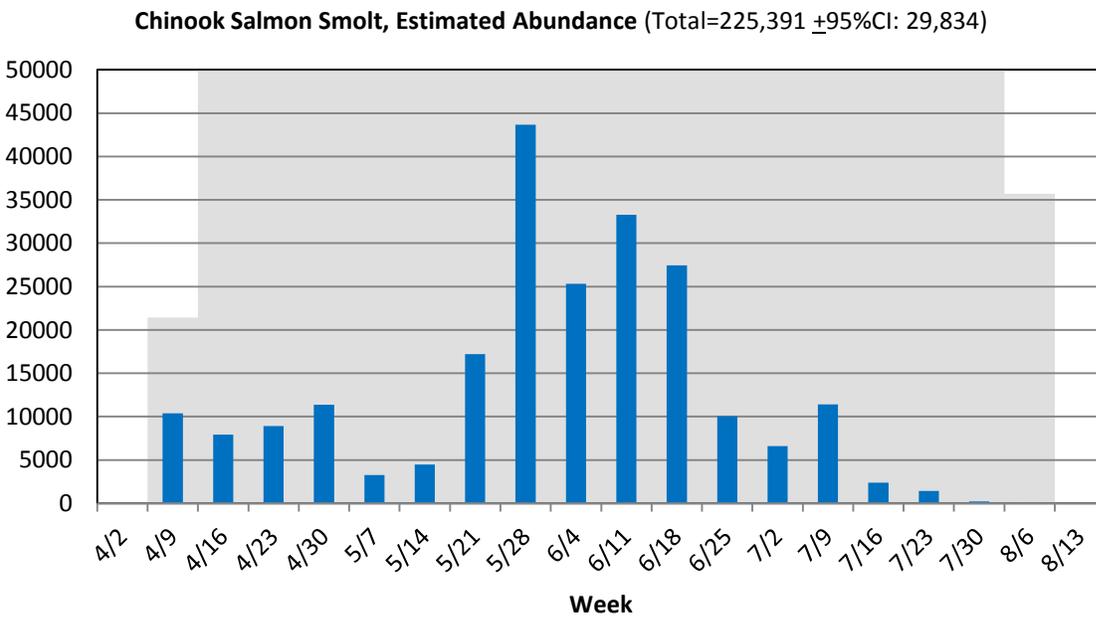
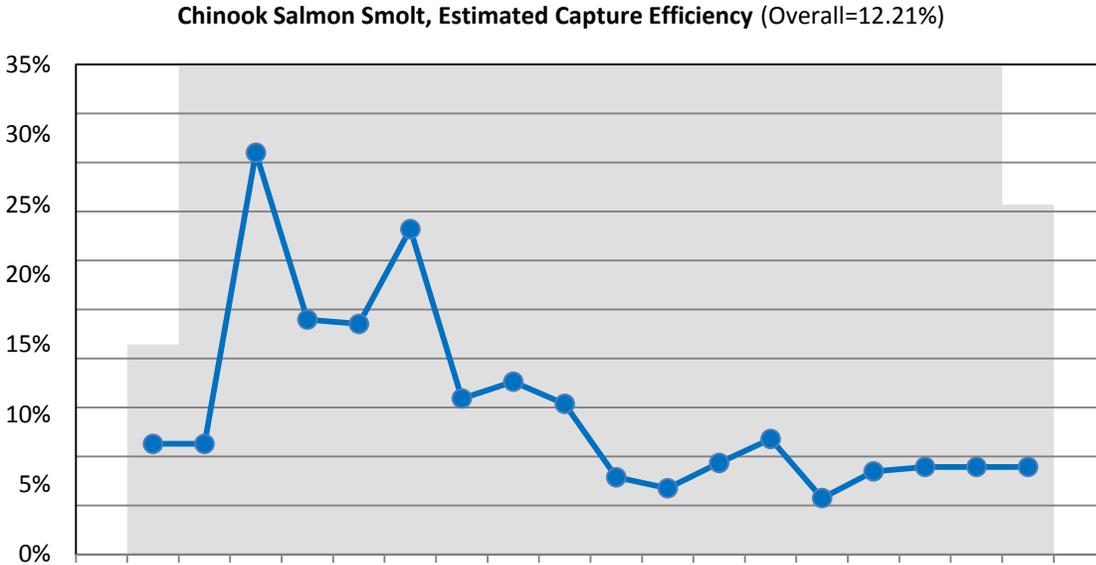


Figure 5.1.13. Estimated average weekly capture efficiency (upper panel) and population estimate of Chinook salmon smolts in the Dry Creek rotary screw trap (lower panel), 2011. Estimates are from DARR (Bjorkstedt 2005). The proportion of each week the trap was fished is represented by the shaded area.

The estimated trap efficiency and trend in weekly trap efficiency was similar among the three years of trap operation (range 8% to 12%). Abundance, however, varied by over 2.5-fold from a low of 84,785 in 2010 to a high of 225,392 in 2011.

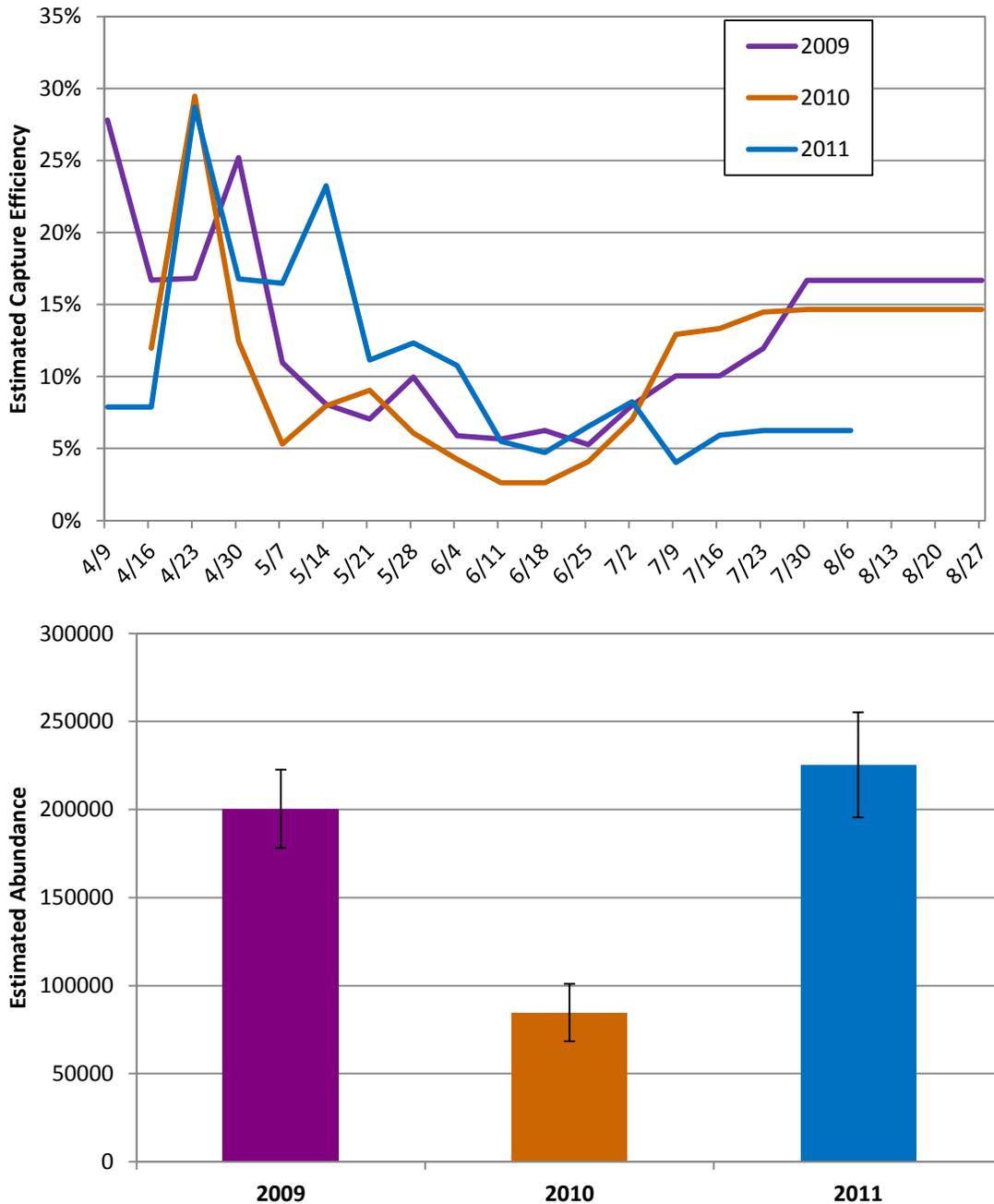


Figure 5.1.14. Estimated average weekly capture efficiency (upper panel) and population estimate of Chinook salmon smolts in the Dry Creek rotary screw trap (lower panel), 2009-2011.

Coho were the least abundant of the 3 salmonid species captured and Steelhead YOY and parr capture peaked in late May-early June with a season total of 1,493 YOY and 1,386 parr (Figure 5.1.15).

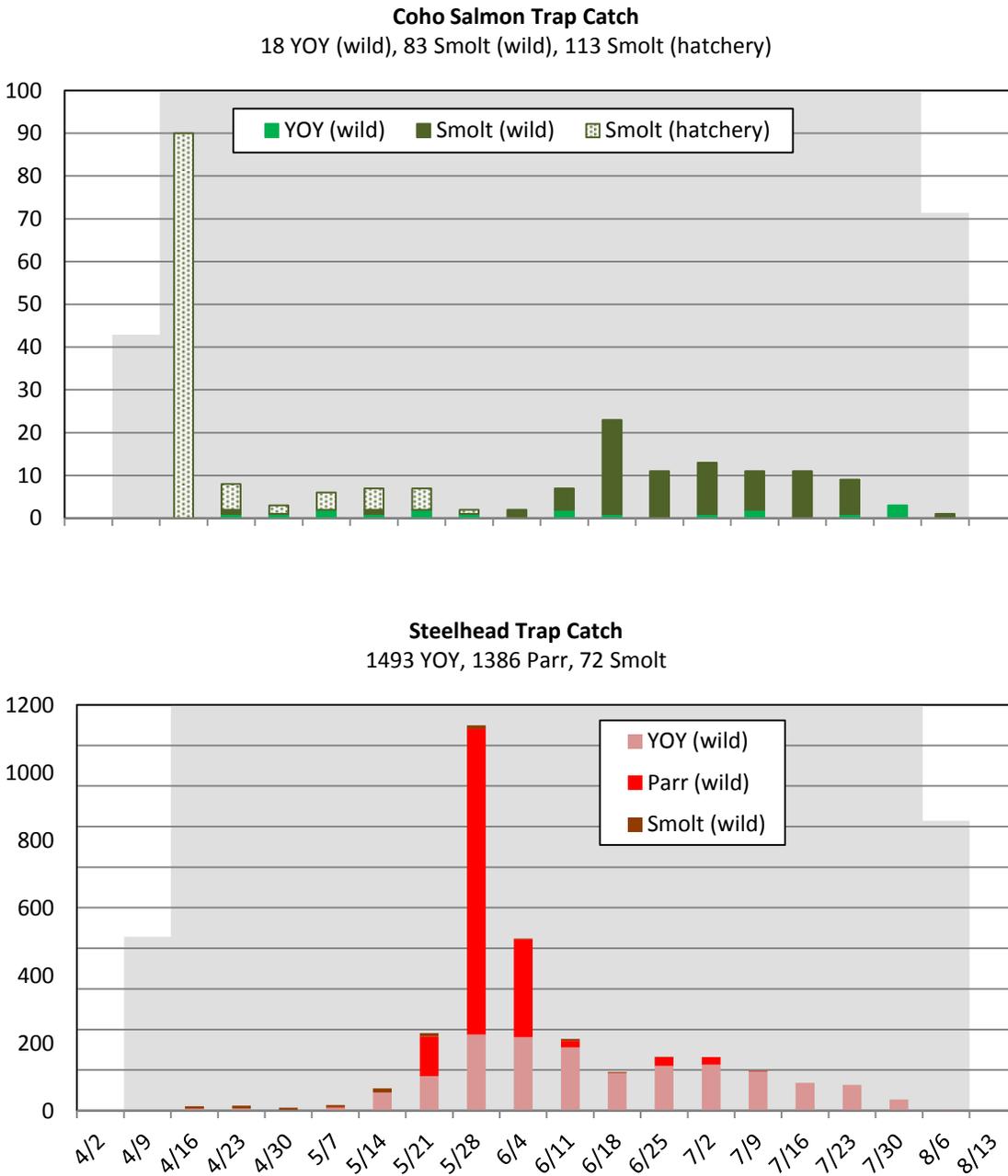


Figure 5.1.15. Weekly trap catch of juvenile coho salmon and steelhead in the Dry Creek rotary screw trap, 2011.

The annual abundance estimates for coho and steelhead at the Dry Creek trap (calculated by applying the weekly trap efficiency estimates from the annual Chinook salmon smolt mark-recapture abundance estimates) suggest that there is a decidedly upward trend in coho abundance from 2009 to 2011 with a downward trend in steelhead abundance during the same time period (Figure 5.1.16).

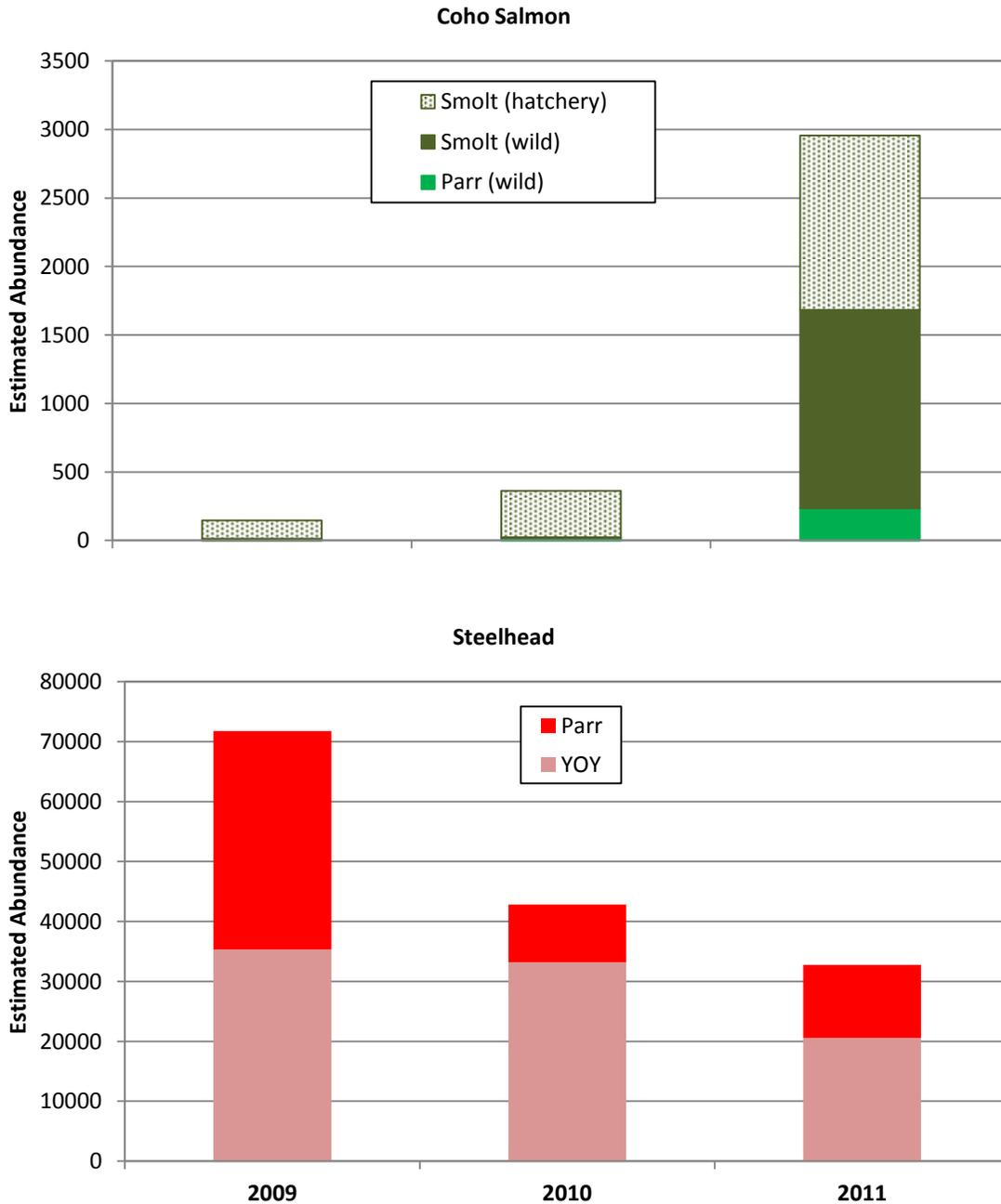


Figure 5.1.16. Estimated abundance of coho salmon (YOY and smolts) and steelhead (YOY and parr), 2009-2011.

The weekly sizes of all salmonids captured at the Dry Creek trap all showed evidence of growth during the course of the trapping season in 2011 (Figure 5.1.17).

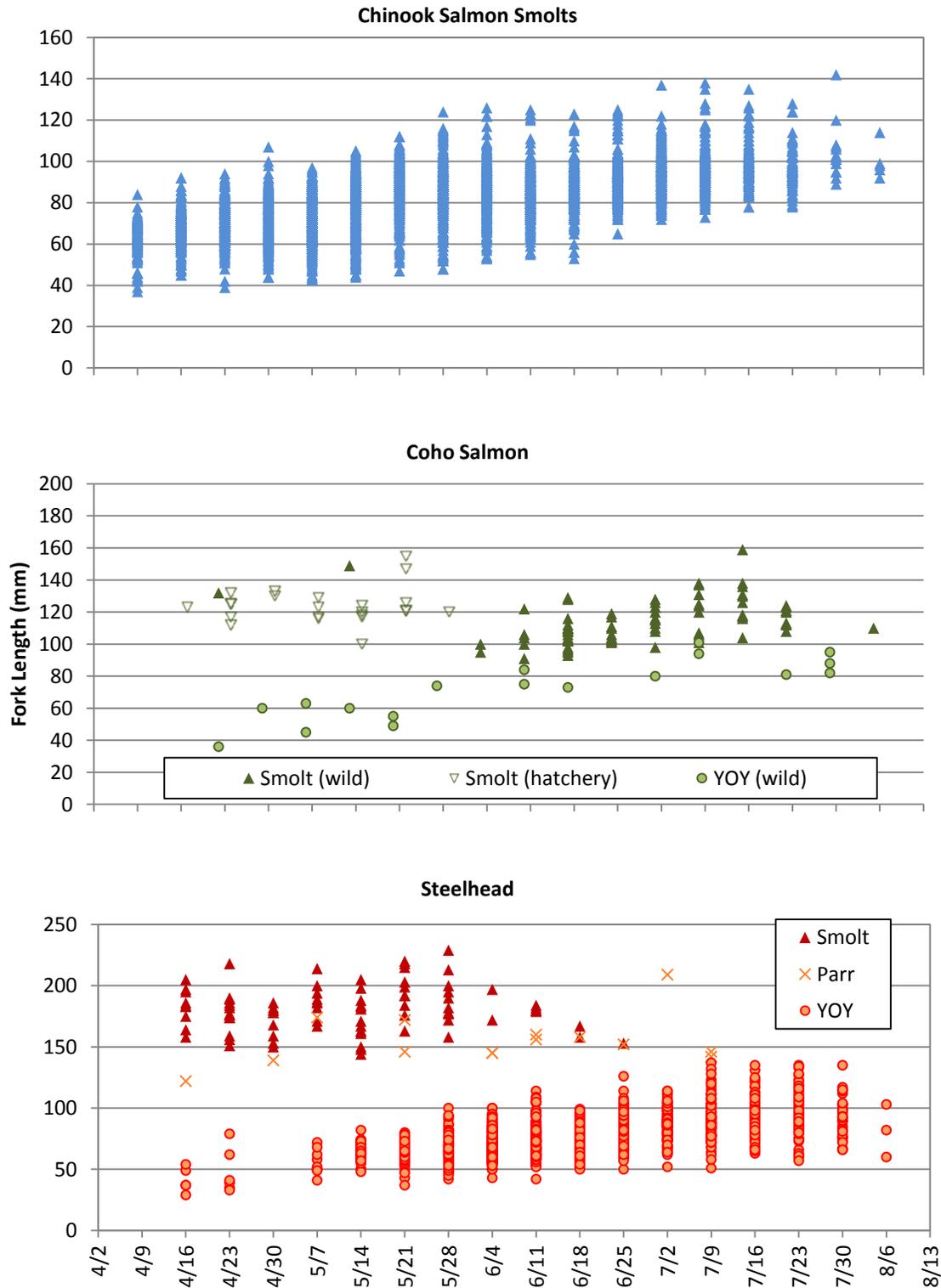


Figure 5.1.17. Fork lengths of juvenile salmonids captured in the Dry Creek rotary screw trap by week, 2011.

Fry sampling

Fry traps at Westside Road and Yoakim Bridge were fished for 21 days during a portion of the downstream migrant trapping season in May. Capture of salmonid fry at the traps was once again low with 29 captured at Yoakim Bridge and 11 captured at Westside Road. As in previous years, we observed dozens of fry milling about on the stream margins in the vicinity of fry trap locations on several occasions. All fry captured appeared to be in good condition with no mortality observed. We were unable to identify individuals to species given their small size (sizes were generally in the 25-35 mm range).

Conclusions and Recommendations

Understanding natural spatial- and temporal-scale variation in salmonid populations will be critical as we attempt to discern whether changes in population levels in mainstem Dry Creek are responses to improved habitat conditions from habitat enhancements or the consequence of natural variability from external drivers. The fish data collected in 2011 in Dry Creek as well as population indicators at other monitoring stations in the Russian River watershed should help us along that path.

Just as in mainstem Dry Creek, indicators of steelhead population abundance in other locations suggest that populations in the basin were lower as compared to previous years. In Austin Creek and the estuary for example, the steelhead abundance estimate (Austin Creek, downstream migrant trap) and CPUE estimate (estuary, beach seining) was approximately one-half the magnitude of these same indicators in 2010 (see Synthesis chapter). This pattern is consistent with the fact that the range in adult returns to Warm Springs hatchery for the three year period 2008/2009-2010/2011 was an average of 75% lower (870-2,122) than in the three year period 2005/2006-2007/2008 (3,841-6,785). This is just one illustration of the type of information that we will consider when interpreting data from validation monitoring on Dry Creek.

In 2012, we recommend continuation of monitoring at the reach-scale (electrofishing/PIT tagging) and stream-scale (downstream migrant trapping) over time so that we can understand whether changes in population metrics are due to eventual habitat enhancements as opposed to natural population variability from external drivers. We also recommend continued efforts to develop approaches for monitoring at the site/feature scale so that once habitat enhancements are implemented we are prepared immediately to begin evaluating fish responses to those projects in a meaningful way.

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6: Tributary Habitat Enhancements

One component of the reasonable and prudent alternative (RPA) identified in the Biological Opinion is the enhancement of salmonid rearing habitats in tributaries to Dry Creek and the Russian River. A total of ten potential tributary enhancement projects are listed in the Biological Opinion with the requirement that the Water Agency implement at least five of these projects by the end of year 3 of the 15 year period covered by the Russian River Biological Opinion. The five projects that the Water Agency intends to complete are 1) Grape Creek Habitat Improvement Project; 2) Willow Creek Fish Passage Enhancement Project; 3) Grape Creek Fish Passage Project; 4) Wallace Creek Fish Passage Project; and 5) Crane Creek Fish Passage Access Project. The Water Agency entered into an agreement with the Sotoyome Resource Conservation District on December 16, 2008 to coordinate and implement the Grape Creek Habitat Improvement Project, Mill Creek Fish Passage Project, and the Crane Creek Fish Passage Access Project. In December 2010, after efforts to secure landowner access for the Mill Creek Fish Passage Improvement Project were unsuccessful, the Water Agency abandoned efforts on the Mill Creek Fish Passage Improvement Project and directed the Sotoyome Resource Conservation District to move forward with the Crane Creek Fish Passage Access Project. The Water Agency is coordinating with the County of Sonoma Department of Public Works, Permit and Resource Management Department, California Department of Fish and Game, and National Marine Fisheries Service on the design and implementation of the Grape Creek Fish Passage Project and the Wallace Creek Fish Passage Project. On January 26, 2011, the Water Agency provided \$100,000 to Trout Unlimited towards the construction of the Willow Creek Fish Passage Enhancement Project.

Grape Creek Habitat Improvement

Phase 1

The Grape Creek Phase 1 portion of the project consisted of installing 8 complex log and boulder structures along a 1,200 foot reach of Grape Creek upstream of the Wine Creek Road Crossing (Figure 6.1). Implementation of this work took place in July and August of 2009. All areas where vegetation was disturbed by heavy equipment were replanted with native plants prescribed by restoration staff from the RCD. Additional plantings were also installed per the request of DFG, and permission of the landowner, in areas outside the active construction area in an effort to eventually expand the width of the riparian area. A total of 248 native trees and shrubs were planted along this reach of the project. During 2011, maintenance and weeding of the plantings was conducted. General observations of the log structures during and after high creek flows of 2011-2012 have not shown any changes or failures in any of the Phase 1 reach structures. The first post-construction monitoring efforts occurred during the summer of 2011 (Figure 6.2).



Figure 6.1. Grape Creek – Phase 1. In-Stream Large Woody Debris Structure Example



Figure 6.2. Grape Creek – Phase 1. 2011 Post-Construction Monitoring



Figure 6.3. Grape Creek – Phase 1. February 2012.

Phase 2

The Grape Creek Phase 2 portion of the project consisted of installing 9 complex log and boulder structures and 2 bank layback areas along a 700 foot reach of Grape Creek upstream of the West Dry Creek Road Crossing (Figure 6.4). Implementation of this work took place over two construction seasons, in 2009 and 2010. Construction began in early October 2009 and was cut short due to rain. Revegetation took place in January 2010. In February 2010, portions of one structure (Site 5) were removed as an emergency measure to avoid bank erosion on the opposite bank as a result of the structure's movement during high flows. Construction resumed in late August 2010, with heavy equipment work completed in the first week of September, and final touches placed on erosion control in early October. The remaining vegetation was installed in early 2011 when the soil is sufficiently moist. General observations of the log structures during and after high creek flows of 2011-2012 have not shown any changes or failures in any of the Phase 2 reach structures. The first post-construction monitoring efforts occurred during the summer of 2011 (Figure 6.5).

The 2011 post-construction effectiveness monitoring report for Phase 1 and Phase 2 of the Grape Creek Habitat Improvement Project is attached as Appendix E-1.



Figure 6.4. Grape Creek – Phase 2. Large Woody Debris and Bank Layback Example.



Figure 6.5. Grape Creek – Phase 2. 2011 Post-Construction Monitoring.



Figure 6.6. Grape Creek – Phase 2. February 2012.



Figure 6.7. Grape Creek – Phase 2. February 2012.

Willow Creek Fish Passage Enhancement Project

Willow Creek is a tributary to the lower Russian River that once supported an abundant subpopulation of coho salmon. The creek continues to support significant potential spawning and rearing habitat; however, access to that habitat is blocked by impassable road culverts and a shallow braided channel that passes through forested wetland. To implement the Willow Creek Fish Passage Enhancement Project, the Water Agency has contributed \$100,000 in funding to Trout Unlimited towards the removal of a complete barrier in Willow Creek. On October 19, 2010, the Water Agency's Board of Directors approved the funding agreement with Trout Unlimited for the Willow Creek Fish Passage Enhancement Project. The \$100,000 in funding was provided by the Water Agency to Trout Unlimited on January 26, 2011. During the summer of 2011, construction was completed for the Willow Creek Fish Passage Enhancement Project (Figures 6.8 and 6.9) Attached in Appendix E-2 is a copy of the Final Report provided to the Water Agency by Trout Unlimited for the Willow Creek Fish Passage Enhancement Project.



Figure 6.8. Willow Creek Bridge Installation. September 2011.



Figure 6.9. Willow Creek Bridge Installation. September 2011.

Crane Creek Fish Passage Project

The Water Agency originally intended to implement the Mill Creek Fish Passage Project. The Mill Creek Fish Passage Project required landowner permission from two property owners in order to design and construct the project. One of the property owners was willing to enter into an agreement to allow the project to move forward; however, the second landowner gave multiple indications that they would allow the project to move forward, but ultimately failed to ever sign any access agreements to allow project design to move forward. Multiple attempts at obtaining the necessary permissions from this landowner were made by the Stoyome Resource Conservation District and the National Marine Fisheries Service. Still seeing no progress with this landowner, the Water Agency directed the Sotoyome Resource Conservation District in December 2010 to abandon its efforts on the Mill Creek Fish Passage Project and instead implement the Crane Creek Fish Passage Access Project (Figure 6.10). The Crane Creek Fish Passage Access Project consists of the removal of a barrier to fish passage caused by a bedrock outcropping at the lower end of Crane Creek near its confluence with Dry Creek. The proposed project design developed by Prunuske Chatham, Inc., consists of creating a series of step pools through the bedrock outcropping to create sufficient depth and flow to allow fish

passage. Design approval was obtained from National Marine Fisheries Service and the landowners in September of 2011. Construction began on October 1, 2011 and was completed on October 18, 2011.



Figure 6.10. Crane Creek Fish Passage Access Project. Bedrock outcropping.



Figure 6.11. Crane Creek Fish Passage Access Project. Chiseling pools in bedrock outcropping.



Figure 6.12. Crane Creek Fish Passage Access Project. Expanded pools in bedrock outcropping (February 2012).

Grape Creek Fish Passage Project

The Grape Creek Fish Passage Project consists of the modification of a concrete box culvert where Grape Creek flows under West Dry Creek Road (Figure 6.13). As part of the permit review and design approval process, the National Marine Fisheries Service noted that the project design did not meet their maximum allowable 0.5-foot drop height for barrier passage. In October 2010, the Water Agency proposed re-designing the project to cut into the culvert bottom instead of placing curbs on top of the culvert bottom in order to meet the 0.5-foot maximum drop height requirement. Because the culvert-bottom is a structural portion of the bridge and culvert, cutting into the culvert bottom substantially increases the design complexity and costs of implementing the project. Between October 2010 and March 2011, the Water Agency coordinated with the Sonoma County Department of Public Works on the proposed re-design of the project. In April 2011, National Marine Fisheries Service indicated that the proposed re-design provided by the Sonoma County Department of Public Works was acceptable. Because of the increased complexity, the revised project design will require that the project be put out to bid as a general construction contract. Putting the project out to bid requires detailed project drawings and construction specifications. The Water Agency is working with a consultant through the Sotoyome Resource Conservation District to prepare the project construction drawings and specifications. It is anticipated that the project will be constructed in the fall of 2012.



Figure 6.13. Grape Creek Fish Passage Project – Flat culvert invert proposed for modification.

Wallace Creek Fish Passage Project

Wallace Creek Fish Passage Project consists of the modification of a concrete box culvert where Wallace Creek flows under Mill Creek Road (Figure 6.14). Engineering designs have been completed for the Wallace Creek Project. The National Marine Fisheries Service has approved the engineering designs for the project. The County of Sonoma Permit and Resource Management Department has submitted permit applications and has coordinated site visits with California Department of Fish and Game, National Marine Fisheries Service, U.S. Army Corps of Engineers, and the North Coast Regional Water Quality Control Board. The Water Agency is continuing to work on obtaining the necessary landowner permissions for constructing the project. There are three landowners within the project area. The Water Agency has obtained permission from one of the landowners, is in negotiations with a second landowner, and has not been able to illicit any response from the third landowner. If the necessary landowner permissions are obtained, the project will be advertised for construction during the summer of 2012.



Figure 6.14. Wallace Creek Fish Passage Project – Flat culvert invert proposed for modification.

7: Coho Salmon Broodstock Program Enhancement

The Biological Opinion and Consistency Determination require the Water Agency to increase production of coho salmon smolts from the Russian River Coho Salmon Broodstock Hatchery Program (Coho Program). The Coho Program is located at the Don Clausen Fish Facility (Warm Springs Hatchery) at the base of Lake Sonoma on Dry Creek. Initiated in 2001, this innovative program is a multi-partner effort involving USACE, CDFG, NMFS, University of California Cooperative Extension (UCCE)/California Sea Grant (CSG), and the Sonoma County Water Agency. Native Russian River coho salmon and neighboring Lagunitas (Lagunitas and Olema) Creek coho salmon stock are bred according to a genetic matrix (provided by NMFS Southwest Fisheries Science Center) and progeny are released to more than 20 streams in the Russian River watershed. Fish are released in spring as fry, in fall as fingerlings, and during winter and early spring as smolts. The Biological Opinion requires USACE to fund most hatchery operations and monitoring, but also requires the Water Agency to provide resources to CDFG to produce 10,000 coho smolts for release directly to Dry Creek.

In spring 2010, the Water Agency purchased 15 tanks for the Coho Program and they were installed by USACE in fall 2010. These tanks were operational by January of 2011, and have since been used to increase space for juvenile rearing, as well as for holding adult returns, and for the streamside acclimation tanks used on Dutch Bill Creek and Green Valley Creek. The Water Agency also hired a technician in spring 2010 and she began working full time at the hatchery in summer 2010. The technician's primary duties at the hatchery include daily feeding and cleaning, seasonal inventories of Broodstock, and special projects as they relate to the spawning, rearing, tagging and release of all coho salmon Broodstock and progeny.

In 2010 the Broodstock program initiated streamside imprinting and smolt releases to the suite of release strategies used to introduce fish to tributaries. The Water Agency's senior technician, Francis Hourigan, played a principal role in developing and implementing streamside-imprinting techniques. One such special project was a cooperative assignment with a USACE employee in which an imprinting tank was fabricated and installed at Westminster Woods on Dutch Bill Creek. In the spring of 2012 another imprinting tank was fabricated and installed at the Green Valley Village property on Green Valley Creek. These tanks used pumps to circulate creek water through the tank, and were used to hold three groups of 2,000 coho smolts for three to four weeks at a time - allowing them time to imprint on the water of their release streams. The technician has also assisted the lead biologist in program with data processing and annual report writing and is coordinating the work of other Water Agency technicians for activities such as tagging and marking.

The current release plan for Coho Program smolts includes more than 10,000 fish for release into Dry Creek (Table 7.1)

Table 7.1. Russian River Coho Program 2011-12 smolt releases (B. White, USACE, personal communication).

Release Date(s)	Release Stream	Number Released	Mean Fork Length (mm)	Mean Weight (g)	Tagging/Release Strategy
6/13/2011	Mill Creek	1,014	68 ± 6	3.9 ± 1.2	PIT-tag only
6/13/2011	Grape Creek	1,019	69 ± 6	4.0 ± 1.2	PIT-tag only
6/14/2011	Dutch Bill Creek	1,016	69 ± 6	3.9 ± 1.1	PIT-tag only
6/14/2011	Green Valley Creek	1,018	69 ± 6	4.0 ± 1.2	PIT-tag only
6/15/2011	Palmer Creek	7,059	70 ± 6	4.2 ± 2.0	CWT (+ 716 PIT)
6/15/2011	Angel Creek	2,058	71 ± 7	4.4 ± 1.5	CWT (+ 210 PIT)
6/16/2011	Black Rock Creek	7,059	71 ± 6	4.4 ± 1.4	CWT (+ 719 PIT)
6/20/2011	Thompson Creek	3,358	71 ± 7	4.5 ± 1.5	CWT (+ 314 PIT)
6/20/2011	Gilliam Creek	3,061	72 ± 6	4.8 ± 1.3	CWT (+ 314 PIT)
6/21/2011	Devil Creek	4,049	73 ± 6	4.9 ± 1.4	CWT (+ 404 PIT)
6/22/2011	Gray Creek	5,056	71 ± 6	4.5 ± 1.4	CWT (+ 510 PIT)
2011 Spring Release Total:		35,767			
10/18/2011	Willow Creek	11,062	96 ± 8	11.5 ± 3.2	CWT (+ 804 PIT)
10/19/2011	Freezeout Creek	3,046	98 ± 6	12.0 ± 2.3	CWT
10/20/2011	Sheephouse Creek	3,047	100 ± 8	12.6 ± 3.3	CWT
10/21/2011	Pena Creek	9,046	99 ± 8	12.1 ± 3.3	CWT (+ 897 PIT)
10/25/2011	Mark West Creek	9,047	102 ± 9	13.9 ± 4.5	CWT
10/26/2011	Porter Creek (MW)	4,047	99 ± 9	13.1 ± 3.6	CWT
10/27/2011	Porter Creek (RR)	9,122	100 ± 8	12.5 ± 3.4	CWT
11/1/2011	Green Valley Creek	9,046	100 ± 8	12.2 ± 2.9	CWT (+ 900 PIT)
11/2/2011	Purrington Creek	3,079	101 ± 7	12.0 ± 2.6	CWT (+ 300 PIT)
11/3/2011	Dutch Bill Creek	9,052	102 ± 8	13.1 ± 3.6	CWT (+ 897 PIT)
11/4/2011	Grape Creek	3,050	101 ± 9	13.8 ± 4.0	CWT (+ 449 PIT)
11/8 & 11/9/2011	Mill Creek	25,014	102 ± 10	13.3 ± 4.1	CWT (+ 2,536 PIT)
11/10 & 11/17/2011	Walker Creek (Marin)	11,784	100 ± 9	12.3 ± 3.4	CWT
2011 Fall Release Total:		109,442			
3/13/2012	Dry Creek	10,081	125 ± 13	23.9 ± 8.6	CWT + PIT
4/30/2012	Mill Creek	3,990	127 ± 13	25.9 ± 9.0	Imprinted for 26 days in pond prior to release / CWT + PIT
5/29/2012		1,915	137 ± 12	29.8 ± 7.6	Imprinted for 22 days in pond prior to release / CWT + PIT
4/16/2012	Dutch Bill Creek	1,999	126 ± 12	24.5 ± 7.7	Imprinted for 27 days in tank prior to release / CWT + PIT
5/10/2012		1,994	132 ± 10	26.7 ± 6.3	Imprinted for 24 days in tank prior to release / CWT + PIT
5/29/2012		1,773	141 ± 15	32.1 ± 12.0	Imprinted for 18 days in tank prior to release / CWT + PIT
5/2/2012		1,998	128 ± 11	26.2 ± 7.2	Imprinted for 15 days in tank prior to release / CWT + PIT
5/12/2012	Green Valley Creek	1,316	139 ± 16	30.1 ± 8.5	Imprinted for 9 days in tank prior to release / CWT + PIT
5/17/2012		955	139 ± 13	30.9 ± 8.3	No imprinting--released directly into creek / CWT + PIT
5/29/2012		951	141 ± 12	31.9 ± 8.6	Imprinted for 12 days in tank prior to release / CWT + PIT
2012 Smolt Release Total:		26,972			
2011-12 Release Total:		172,181			

8: Wohler-Mirabel Water Diversion Facility

The Water Agency diverts water from the Russian River to meet residential and municipal demands. Water is stored in Lake Sonoma and Lake Mendocino, and releases are made to meet downstream demands and minimum instream flow requirements. The Water Agency's water diversion facilities are located near Mirabel and Wohler Road in Forestville. The Water Agency operates six Ranney collector wells (large groundwater pumps) adjacent to the Russian River that extract water from the aquifer beneath the streambed. The ability of the Russian River aquifer to produce water is generally limited by the rate of recharge to the aquifer through the streambed. To augment this rate of recharge, the Water Agency has constructed several infiltration ponds. The Mirabel Inflatable Dam (Inflatable Dam) raises the water level and allows pumping to a series of canals that feed infiltration ponds located at the Mirabel facility. The backwater created by the Inflatable Dam also raises the upstream water level and submerges a larger streambed area along the river. Three collector wells, including the Agency's newest and highest capacity well, are located upstream of Wohler Bridge. These wells benefit substantially from the backwater behind the Dam.

8.1 Mirabel Fish Screen and Ladder Replacement

To divert surface water from the forebay of Mirabel Dam, The Water Agency operates a pump station on the west bank of the river. The pump station is capable of withdrawing 100 cfs of surface flow through two rotating drum fish screens in the forebay. The fish screens have been functioning since the dam was constructed in the late 1970's. However, they fail to meet current velocity standards established by NMFS and CDFG to protect juvenile fish. The Biological Opinion requires the Water Agency to replace the antiquated fish screens with a structure that meets modern screening criteria. In 2009, the Water Agency employed the engineering firm of Prunuske Chatham, Inc. to prepare a fish screen design feasibility study. The report was completed in December 2009.

The feasibility study was conducted to develop a preferred conceptual design that meets many of the project objectives while ensuring that the fish screening facilities adhere to contemporary fish screening design criteria. A Technical Advisory Committee composed of the Water Agency engineering and fisheries biologist staff, NMFS, and CDFG provided guidance in refining the objectives and identifying alternatives. Six concept alternatives were evaluated for meeting the project objectives. Schematic designs and critical details were developed for these concept alternatives to assess physical feasibility and evaluate alternatives relative to the objectives. The preferred concept design alternative was determined through an interactive evaluation and was selected because it meets or exceeds the project objectives.

In 2010, the Water Agency solicited qualifications from engineering firms, and a list of qualified consultants was created from the responses. The Water Agency selected HDR Engineering (HDR) because of its demonstrated experience with this type of work and the strength of their proposed project manager, who has a proven track record with fish passage and screening projects. The Water Agency and HDR entered into an Agreement for Engineering Design Services for the Mirabel Fish Screen and Fish Ladder Replacement Project in June of 2011. In 2011 and 2012, HDR completed work on preliminary engineering, geotechnical analysis, hydraulic modeling, development of construction drawings and specifications. HDR's final construction drawings and specifications are anticipated in early 2013. HDR will also provide engineering support during bidding and construction. HDR's design process included consultation at different design steps with the Technical Advisory Committee described above.

Because the fish ladder enhancement identified in the feasibility study is not required by the Biological Opinion, the Water Agency applied for funds from CDFG's Fishery Restoration Grant Program (FRGP) in 2010 to help defray costs associated with fish ladder design. The Director of CDFG awarded the grant to the Water Agency in February 2011. The Water Agency also submitted a second application for FRGP funds in 2012 to help defray costs associated with fish ladder construction. A decision from CDFG on the Water Agency's 2012 FRGP grant application is expected in early 2013.

The Water Agency is in the process of completing California Environmental Quality Act (CEQA) documentation for the project. On December 10, 2012, the Water Agency released for public review an Initial Study and Mitigated Negative Declaration for the Mirabel Fish Screen and Fish Ladder Replacement Project. This document will be available for public review through January 18, 2013 and will then be brought before the Water Agency's Board of Directors for their consideration on January 29, 2013.

The CEQA document for the project consists of a discussion of potential environmental impacts related to the construction, operation, and maintenance of the proposed fish screen and fish ladder modifications. Project construction activities would require isolating the work area from the active flow of the Russian River, demolishing the existing fish screen/intake and fish ladder structures on the western bank of the Russian River, and constructing the new fish screen and fish ladder structures. The new facilities would extend approximately 40 feet farther upstream and approximately 100 feet farther downstream than the existing facilities. This larger footprint is necessary to meet contemporary fish screen and fish passage design criteria. Figure 8.1.1 shows a plan view of the proposed project design. Figure 8.1.2 shows a conceptual design drawing of the proposed project components.

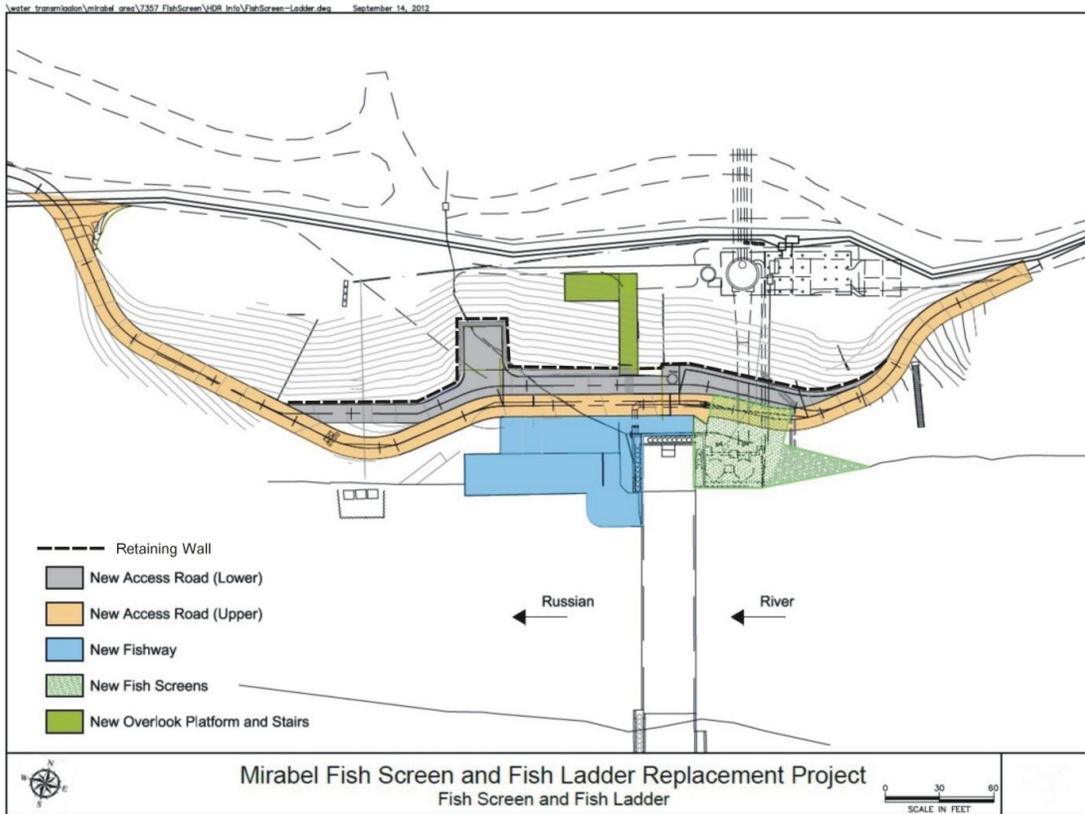


Figure 8.1.1. Planned modifications of Mirabel diversion facility and fish ladders.



Figure 8.1.2. Conceptual design of modified Mirabel diversion facility showing new fish screens upstream of the dam, a vertical slot fishway below the dam, and a new access road to the site.

Fish Screen

The proposed intake screen would consist of six 12-foot tall by 6-foot wide panels, with a total area of 432 square feet. The new fish screen would also incorporate a cleaning system to ensure that the screen material does not become clogged. Clogged screens result in higher flows through unclogged portions of the screen, which can lead to fish getting trapped against the screen. The cleaning mechanism is anticipated to be an electric motor-driven mechanical brush system that periodically moves back and forth to clean the intake screen structure.

Fish Ladder

A vertical slot type fish ladder was selected as the recommended design to provide passage for upstream migrating salmonids. Vertical slot fish ladders are commonly used for salmon and steelhead (among other fish species) throughout the world. A vertical slot fish ladder consists of a sloped, reinforced concrete rectangular channel separated by vertical baffles with 15-inch wide slots that extend down the entire depth of the baffle. The baffles are located at even increments to create a step-like arrangement of resting pools.

The design would be self-regulating and provide consistent velocities, flow depths, and water surface differentials at each slot throughout a range of operating conditions. It is anticipated that the ladder would be configured to accommodate a range of fish passage conditions while the Mirabel Dam is up and river flows ranging from 125 to 800 cubic feet per second. Fish passage while the Mirabel Dam is down would also be accommodated, but is not the primary focus of design. The fish ladder would extend approximately 100 feet further downstream than the existing fish ladder at the site.

Fisheries Monitoring Components

The Water Agency currently conducts a variety of fisheries monitoring activities at its Mirabel Dam facilities. The new fish ladder design would support these monitoring activities by providing a dedicated viewing window and video equipment room and a fish trapping and holding area built into the fish ladder. The monitoring information collected by Water Agency staff is critical in tracking population trends and movement of different species in the Russian River system.

Education Opportunities

The existing facility at Mirabel is visited every year by approximately 3,000 schoolchildren as part of the Water Agency's water education efforts. The existing facility allows schoolchildren to see a critical component of the Water Agency's water supply system, but the views of the top of the existing fish ladder do not offer much opportunity for observing and learning about the fisheries of the Russian River system. The proposed project would include a viewing area, separate from the video monitoring viewing window, which would allow visitors to see into the side of the fish ladder. The educational experience for schoolchildren would be improved by having the opportunity to actually see fish travelling up or down the fish ladder.

Additional Features

The project design would also include a variety of other components that would support the primary fish screen and fish ladder aspects of the project. These other components consist of items such as replacement of the buoy warning line upstream of the Mirabel Dam, modification of the existing access road to the project site, and the installation of a viewing platform to allow visitors a safe location to view the overall facility. The existing access road down to the Mirabel Dam is a steep one-way road. Vehicles going down to the Mirabel Dam area must be turned around or backed up the road down to the project site. The proposed project includes a modification of the access road so that the road will not be as steep and will include both an entrance and exit ramp from the Mirabel Dam site. Because the site is a major component of the Water Agency's water education program where several thousand schoolchildren are brought out to the site each year, the design for the new access road also includes a parking area at the Mirabel Dam that is compliant with Americans with Disabilities Act access standards. The viewing platform would be a deck area at the elevation of the existing upper levee road above the Mirabel Dam that would allow visitors to the site to view the facility. A stairway from the top of bank down to the Mirabel Dam would allow visitor access from the upper levee road area down to the Mirabel Dam.

8.2 Wohler Infiltration Pond Decommissioning

The Wohler Infiltration Ponds 1 and 2 (originally built to assist with water supply operations) are located on the east side of the Russian River at the Water Agency's Wohler facility. The Decommissioning Project is part of the Reasonable and Prudent Measure (RPM) 6 Terms and Conditions (Item C). The Water Agency was required to decommission or modify Infiltration Ponds 1 and 2 to prevent fish entrapment in the ponds during flood events. During 2010, the Water Agency received all necessary state and federal agency permits to allow construction during the low-flow season when the infiltration ponds are dry. Construction commenced in July 2011 and was completed in October 2011.

To decommission the ponds, crews removed two manual valves at the inlet/outlet channel of each pond, imported fill, and graded the fill at a slope of 1 percent toward the river. The 1% slope allowed the ponds to fill with water during flood events but drain gradually at the same rate as the receding river.

Figure 8.2.1 through Figure 8.2.12 show pre and post construction condition of the ponds. Before they were decommissioned, the ponds retained residual water after high winter flows and entrapped hundreds to thousands of fish annually. Post construction monitoring showed that little residual water remained in the ponds and they filled and drained at rates similar to natural overbank areas along the river.

To monitor inundation and recession of flood waters in the ponds, the Water Agency installed a time lapse camera on pond two in spring 2012. The camera was installed on March 29 and removed on April 2. During this time period, a significant storm event increased flows in the

Russian River from 7,000 cfs to over 10,000 cfs. Based on photos collected from the time lapse camera it appears that the river inundated the ponds at a flow between 7,500 cfs and 9,200 cfs. During this event, the river filled the ponds at night and the camera was not able to capture a precise time, and therefore flow, when the ponds were inundated. However, it was possible to determine that the ponds drained relatively quickly following the receding river stage. Once the ponds were drained, a few inches of standing water remained. Agency biologists used seine nets to sample ponds one and two after this event and only observed one fish, a live juvenile Chinook salmon, in pond two. This fish was found in a small, approximately 1 m³, depression in the bottom of the pond. This dramatic decline in the number of entrapped fish is encouraging and the Water Agency will continue to monitor the ponds for fish entrapment after flood events and rescue any listed salmonids that become stranded.



Figure 8.2.1. Pond 1 Pre construction Photographs



Figure 8.2.2. Pond 1 outlet Pre construction Photographs



Figure 8.2.3. Pond 2 Pre construction Photographs



Figure 8.2.4. Pond 2 outlet Pre construction Photographs



Figure 8.2.5. Pond 1 Post Construction Photographs



Figure 8.2.6. Pond 1 outlet Post Construction Photographs



Figure 8.2.7. Pond 2 Post Construction Photographs



Figure 8.2.8. Pond 2 outlet Post Construction Photographs



Figure 8.2.9. Pond 2 pre-flood



Figure 8.2.10. Pond 2 flooding



Figure 8.2.11. Pond 2 flooding



Figure 8.2.12. Pond 2 receding

8.3 Mirabel Fisheries Monitoring

2011 marked the 12th year that fishery studies have been conducted at the Wohler-Mirabel site. Although this report details the findings of the 2011 sampling season, data from previous years will be included to provide historical context. Fisheries studies at Mirabel Dam were developed in cooperation with the National Marine Fisheries Service and the California Department of Fish and Game to assess the potential for the dam to adversely impact listed species through: 1) altering water temperature and water quality in the lower river, 2) impeding downstream migration of juveniles, 3) impeding upstream migration of adults, and 4) altering habitat to favor predatory fish. The results of the initial 5-year study are presented in Chase *et al.* 2005, and Manning *et al.* 2007. Since 2005, the studies have focused on providing a long-term record of adult Chinook salmon escapement and juvenile salmonid emigration, as well as collecting basic life history information on all salmonids and other species migrating past the Inflatable Dam.

Mirabel Downstream Migrant Trapping

The Water Agency has collected juvenile emigration data below the Inflatable Dam since 2000. Two rotary screw traps are generally fished below the dam from approximately April 1 through mid-July, depending on annual flow conditions. Data collected includes run timing, species composition, relative abundance, age, and size at emigration.

Methods

The rotary screw trap site is located approximately 40 m downstream of the Inflatable Dam. In 2011, two rotary screw traps (one 1.5-m diameter and one 2.5-m diameter) were operated. Trapping is initiated during the spring when streamflows decrease to levels suitable to safely and efficiently operate the traps. In 2011, the traps were deployed on April 15 at a flow of 1,540 cfs (Hacienda Gauge), and fished through the morning of July 19.

Fish captured by the screw traps were netted out of the live well and placed in an insulated ice chest supplied with freshwater. Aerators were operated to maintain DO levels in the ice chest. Prior to data collection, fish were transferred to a 19-liter bucket containing water and Alka-seltzer, which was used as an anesthetic. Fish captured were identified to species and measured to the nearest mm (FL). After data collection, fish were placed in a bucket containing fresh river water. Dissolved oxygen levels in the recovery buckets were also augmented with aerators to insure that the DO level remained near saturation. Once equilibrium was regained, the fish were released into the river downstream of the screw traps. In accordance with Water Agency's NMFS Section 10 Research Permit, once water temperatures exceeded 21.1°C, salmonids were not anesthetized, but were netted from the live well, identified, enumerated, and immediately released below the traps.

In 2011, a mark-recapture study was initiated on April 15 (first day of trapping) and conducted through June 19 in an attempt to estimate the number of juvenile Chinook salmon emigrating past the dam. The study has been initiated each year since 2001⁷ once the majority of juvenile Chinook salmon captured reach a minimum length of 60 mm FL (juveniles less than 60 mm FL are too small to safely mark). Chinook salmon captured in the traps were sub sampled, and up to 50 fish daily were marked with a small caudal clip. Marked fish were held in an ice chest equipped with aerators, and transported and released approximately 1.2 km above the dam. The proportion of marked to unmarked fish captured in the traps was then used to calculate a weekly estimate of the number of Chinook smolts emigrating past the dam (Bjorkstedt 2000).

Results

In 2011, two rotary screw traps were operated for 93 days (Table 8.3.1). A total of 29 species including 28,457 individual fish were captured (excluding larval suckers). The catch included 15 species native to the Russian River. Two species, Chinook salmon and young-of-the-year (30-90 mm FL) largemouth bass, accounted for 76 percent of the total catch.

Chinook salmon

A total of 13,349 juvenile Chinook salmon were captured in 2011. Chinook smolts were captured from the first day of sampling through the last day (April 15 – July 19) (Table 8.3.2). The total juvenile Chinook catch in 2011 was the second highest during 12 years of sampling. Excluding 2009 and 2010, overall trapping efficiency has ranged from 6.2 to 11.4 percent. In 2011, 2,763 Chinook salmon smolts were marked and released upstream of the dam. Of these, 172 (6.2 percent) were recaptured. Based on the DARR estimator (Bjorkstedt 2000), the 2011 mark-recapture estimate was 305,361 ($\pm 84,891$) juvenile Chinook salmon migrating past the trapping site during the mark-recapture study (Table 8.3.3).

Trapping efficiency varied substantially during the season. In terms of efficiency, there were three different phases during the trapping season: 1) early season with the dam deflated (April 15 through May 9), 2) mid-season with the dam inflated (May 11 through June 7), and 3) a late season low flow period with the dam inflated (June 8 through June 19). Trapping efficiency with the dam deflated was 2.4 percent, but increased to 11.4 percent after the dam was raised. After June 8, trapping efficiency declined to 0.7 percent.

In most years, the juvenile Chinook salmon emigration has peaked during the month of May and decreases rapidly during June. In 2011, the weekly catch followed this general trend, but the estimated catch remained high into mid-June (a function of the low trapping efficiency (Figure 8.3.1). Weekly catches of juvenile Chinook salmon in Dry Creek during June were also relatively high in 2011, suggesting that the outmigration period in 2011 did extend later in the season compared to most years.

⁷ Excluding 2005 and 2006 when high streamflows curtailed downstream migrant trapping

The weekly average measured fork length for Chinook salmon captured below the Inflatable Dam ranged from approximately 69 mm in mid-April to approximately 97 mm in mid-July (Figure 8.3.2).

Table 8.3.1. Summary of Mirabel Dam rotary screw operations from 2000 to 2011.

Year	Deployment date	End date	Dam Inflated	Dates on non-operation	Number of days operated
2000	April 8	June 29	May 2	April 18, 19	82
2001	April 20	June 7	April 21	April 22 May 28, 29	46
2002	March 1	June 27	April 16	April 16	118
2003	March 1	July 3	May 23	March 15 – 19 April 13 – 21; April 24- May 11 May 23	92
2004	April 1	July 1	April 8	April 8	91
2005	April 15	June 30	May 26	May 19-23; May 27 - 31	72
2006	May 4	May 24	May 11	May 12 - 15	18
2007	March 21	June 28	March 28	March 30 May 30	99
2008	March 20	June 26	April 11	April 11 – 13 May 17 – 18 June 10 June 16 June 24	104
2009	April 1	July 17	July 8	April 15 May 5-7 July 2, 9, 14	93
2010	May 4	July 16	June 11	--	74
2011	April 15	July 19	May 9	May 2, 3, 10	93

Table 8.3.2. Weekly capture of Chinook salmon at the Wohler trapping site, 2000 – 2011.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
26-Feb			45	332								
5-Mar			74	841								
12-Mar			319	89								
19-Mar			181	169				257	114			
26-Mar			797	346				940	80	6		
2-Apr	41		908	377	82			730	224	257		
9-Apr	158		757	176	115	446		564	100	236		263
16-Apr	154	122	2,279	17	672	848		1,011	866	190		815
23-Apr	204	720	2,992	60	1,911	618		759	1,161	159		269
30-Apr	169	1,338	4,337	0	1,845	353		1,148	315	67	86	628
7-May	121	1,154	1,780	50	1,631	132	69	782	258	149	451	1,732
14-May	174	226	2,056	508	552	222	46	880	381	123	187	2,820
21-May	106	76	1,755	690	158	35	217	698	91	55	158	2,967
28-May	92	64	704	1,461	150	419	67	503	107	64	268	1,802
4-Jun	66	22	192	530	125	541		857	60	42	145	924
11-Jun	47		93	374	31	136		268	94	30	155	372
18-Jun	19		46	186	88	156		45	19	9	324	437
25-Jun	10		4	86	26	55		38	8	2	441	226
2-Jul				3						8	71	49
9-Jul										1	72	33
16-Jul										1	10	12
Total	1,361	3,722	19,319	6,295	7,386	3,961	399	9,480	3,878	1,399	2,368	13,349

Table 8.3.3. Estimated number of juvenile Chinook salmon that passed the Mirabel Dam site, based on mark-recapture trap efficiency testing, from 2001 to 2011.

Year ¹	Number of days studied	Number marked	Number recaptured	Overall efficiency	Seasonal estimate ²	95% CI
2001	34	525	60	11.4	19,473	5,022
2002	76	2,778	253	9.1	225,135	37,028
2003	26	1,072	90	8.4	45,699	18,218
2004	40	1,631	120	7.4	91,352	17,652
2005	0	N/A	N/A	N/A	N/A	N/A
2006	0	N/A	N/A	N/A	N/A	N/A
2007	76	3,201	203	6.3	149,329	28,722
2008	42	1,321	88	6.7	43,774	16,768
2009	51	709	20	2.8	41,663	10,208
2010	69	1,881	76	4.0	109,540	47,463
2011	62	2,763	172	6.2	305,361	84,941

¹ Includes fish captured outside of the mark-recapture study period

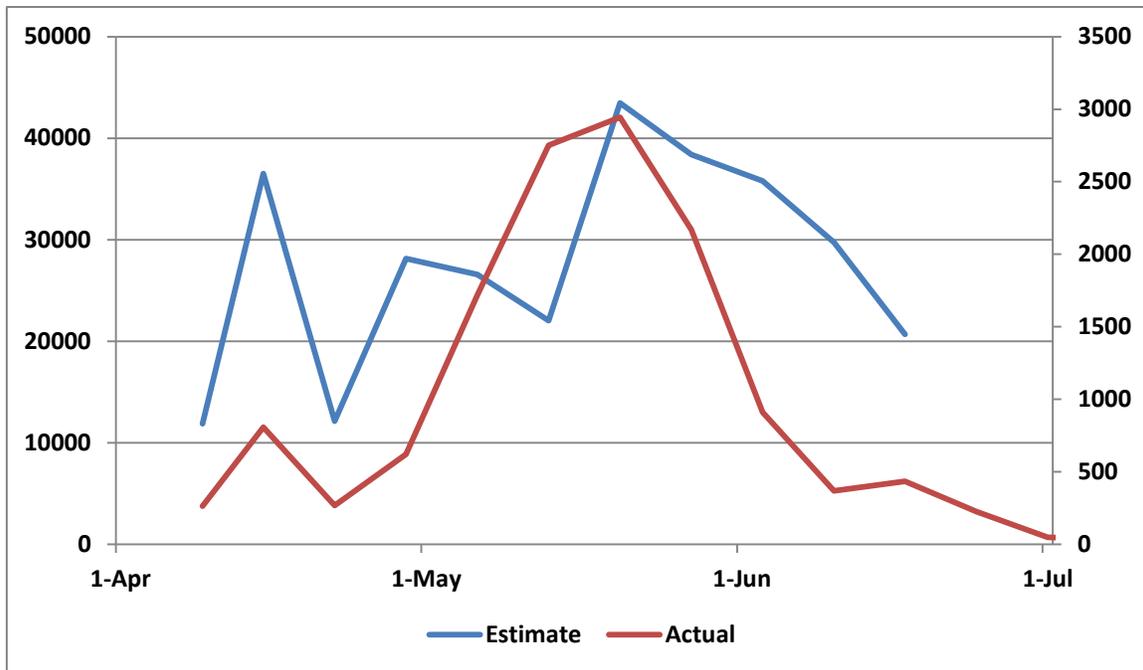


Figure 8.3.1. Weekly estimated and actual catches at the Mirabel Dam downstream migrant trap, 2011.

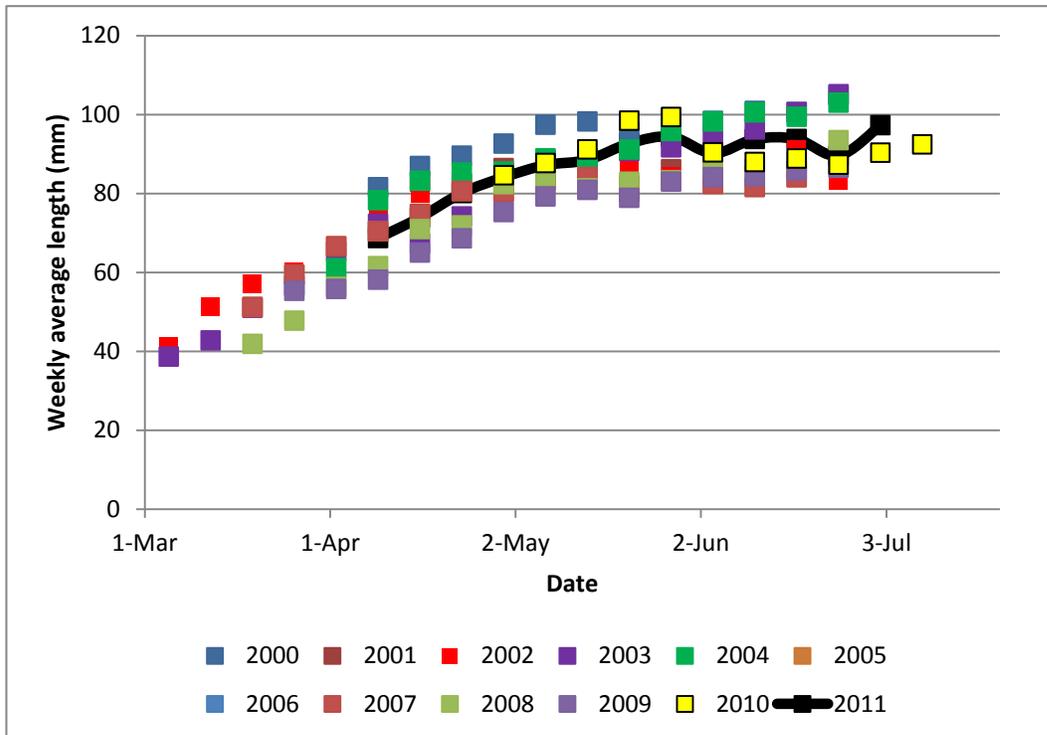


Figure 8.3.2. Weekly average fork lengths of Chinook salmon smolts measured at the Mirabel Dam trap site in 2011 (black line) compared to years 2000-2011.

Steelhead

For the season, 528 wild (natural origin) steelhead parr were captured, most of which were likely YOY based on length-frequency data (Table 8.3.4, Figure 8.3.3). In addition, 151 wild origin steelhead smolts were captured between April 15 and June 16 (Table 8.3.5). Based on previous data collection efforts at the Wohler-Mirabel fish trapping station, the steelhead migration season runs from at least March through June, with peak numbers occurring between mid-March and mid-May. Steelhead smolts ranged in length from 132 to 221 mm FL, averaging 184 mm FL overall. Since 2000, the average size of steelhead smolts has ranged from 161 to 185 mm FL.

Coho salmon

Coho smolts were captured between April 15 (first day of sampling) and June 22. For the season, 15 wild smolts and 872 hatchery coho salmon smolts were captured (Table 8.3.6). In addition, 10 wild parr were captured. Although data are limited, coho appear to migrate past the Inflatable Dam primarily in April and May (although see the discussion for coho out migrants in Dry Creek where the peak of the outmigration season appeared to occur much later than what was reported at the Wohler traps). Wild coho smolts ranged in length from 91 to 125 mm FL, averaging 113 mm. Hatchery coho smolts ranged from 85 to 155 mm FL, averaging 119 mm FL (Figure 8.3.4).

Conclusions and Recommendations

This project is an essential component of the overall Russian River fisheries monitoring program and provides valuable information necessary for the management of all three listed species. Information collected at the Mirabel trapping site provides long term trends in smolt emigration past the Wohler-Mirabel facility, as well as insights into their life history strategies.

Based on 12 years of sampling, juvenile Chinook salmon are present in the river by late-February, with peak captures at Mirabel typically occurring between mid-April and mid-May. After the mid-May peak, the catch declines with relatively few Chinook smolts being captured after approximately mid-June. By mid-July, the capture of juvenile Chinook approaches zero. The timing of salmonid smolt emigration through the lower river is significant because of water temperatures in the mainstem Russian during the late spring can reach levels stressful to smolts. Water temperatures recorded at the Diggers Bend and at the Hacienda gauges generally exceed 20°C by mid-to-late-May. Increasing water temperatures in the upper river likely stimulate mainstem rearing fish to emigrate. However, in Dry Creek water temperatures are controlled by releases from the dam, and remain cold even during the heat of summer.

This modified temperature regime likely dampens natural thermal cues motivating juvenile salmonids to migrate earlier in the season. The Spring of 2011 was cool and wet), and the average water temperature at Diggers Bend was 16.8°C on May 30, but increased to 22.1°C by June 15. The rise in water temperature at Diggers Bend would likely have sparked salmonids rearing in the upper river to begin migrating. Conversely, in Dry Creek the average water temperature on June 15 was 14.8°C. The significance of this is that water temperature in the lower Russian River may increase to stressful levels by mid-June (On June 15th, 2011, the water temperature at Hacienda was 22.0°C).

Table 8.3.4. Weekly catch of steelhead young-of-the year (age 0+) and parr (age 1+) at the Mirabel Dam trapping site, 2000 – 2011.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
26-Feb	0	0	0	1	0	0	0	0	0	0		
5-Mar	0	0	0	5	0	0	0	0	0	0		
12-Mar	0	0	1	3	0	0	0	0	0	0		
19-Mar	0	0	8	13	0	0	0	1	1	0		
26-Mar	0	0	3	67	0	0	0	27	7	0		
2-Apr	0	0	56	170	3	0	0	8	14	4		
9-Apr	3	0	51	132	14	86	0	12	35	4		
16-Apr	20	1	447	4	12	100	0	39	34	4		2
23-Apr	33	17	81	20	16	97	0	136	74	8		3
30-Apr	224	4	658	0	10	523	14	58	118	11	33	13
7-May	30	13	756	22	3	354	12	164	133	7	36	168
14-May	49	23	976	74	1	75	182	157	52	3	39	55
21-May	80	34	1315	246	1	25	26	185	101	8	81	62
28-May	74	32	806	223	2	110	0	173	59	6	60	58
4-Jun	102	26	467	55	2	136	0	684	76	2	26	119
11-Jun	40	0	164	29	1	40	0	176	50	8	41	11
18-Jun	58	0	60	28	10	29	0	5	26	4	22	25
25-Jun	50	0	1	2	7	9	0	22	10	4	25	6
2-Jul	0	0	0	1	0	0	0	0	0	1	8	5
9-Jul	0	0	0	0	0	0	0	0	0	0	2	1
16-Jul	0	0	0	0	0	0	0	0	0	0		
23-Jul	0	0	0	0	0	0	0	0	0	0		
Total	763	150	5,850	1,095	82	1,584	234	1,847	790	74	373	528

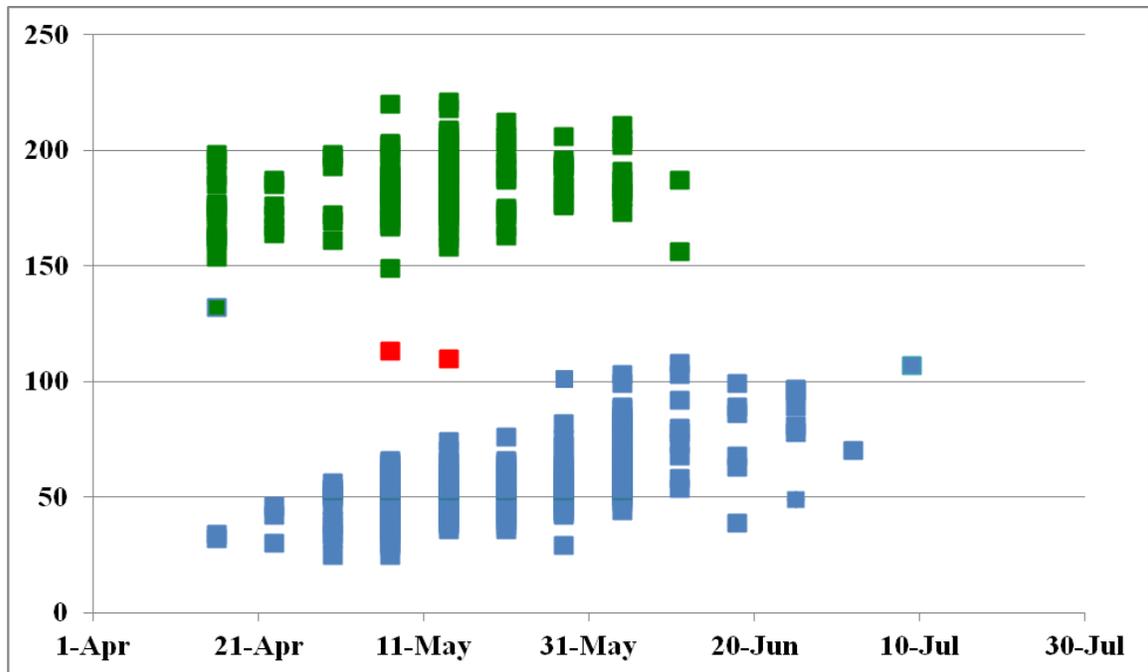


Figure 8.3.3. Length of steelhead captured in 2011, grouped by week of capture. Blue squares represent young-of-the-year (age 0+), red squares represent parr (age 1+), and green squares represent smolts (primarily age 2+).

Table 8.3.5. Weekly catch of steelhead smolts at the Mirabel trapping site, 2000 – 2011.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
26-Feb			1	4								
5-Mar			1	3								
12-Mar			38	5								
19-Mar			15	3				24	0			
26-Mar			24	39				99	1			
2-Apr			31	39	3			24	3	12		
9-Apr	19		33	18	14	0		25	0	5		1
16-Apr	24	7	30		11	18		43	4	5		16
23-Apr	24	16	23		14	9		61	8	2		6
30-Apr	21	16	23		10	7	9	14	12	1	4	6
7-May	8	9	7		3	3	10	17	4	1	8	27
14-May	14	4	9	26	1	1	5	11	0	2	14	54
21-May	9	0	9	16	1	3	6	3	1	2	9	17
28-May	6	0	3	6	1	0		2	0	0	4	13
4-Jun	1	1	0	2	2	3		1	0	0	1	9
11-Jun	4		1	1	1	2		0	0	0	4	2
18-Jun	2		0	0	2	1		0	0	2		
25-Jun	2		0	0	0	1		0	0	0		
2-Jul										1		
9-Jul										0		
16-Jul										0		
23-Jul										0		
Total	134	53	248	162	63	48	30	324	33	33	44	151

Table 8.3.6. Weekly catch of coho salmon smolts at the Mirabel Dam trapping site, 2006 – 2011. Most fish were marked from the Russian River Coho Salmon Hatchery Broodstock Program.

	2006	2007	2008	2009	2010	2011
26-Feb						
5-Mar						
12-Mar						
19-Mar		3	1			
26-Mar		1	6	4		
2-Apr		0	6	23		
9-Apr		2	2	35		16
16-Apr		9	10	38		362
23-Apr		8	16	33		111
30-Apr	1	15	17	3	38	45
7-May	1	38	23	26	53	51
14-May	1	24	9	23	30	138
21-May	0	7	1	9	15	83
28-May		1	0	7	21	31
4-Jun		0	0	1	19	32
11-Jun		0	0	4	0	11
18-Jun		0	0	0	3	2
25-Jun		0	0	0	1	0
2-Jul				0	0	0
9-Jul				0	1	1
16-Jul				0		
Total	3	108	91	206	181	891

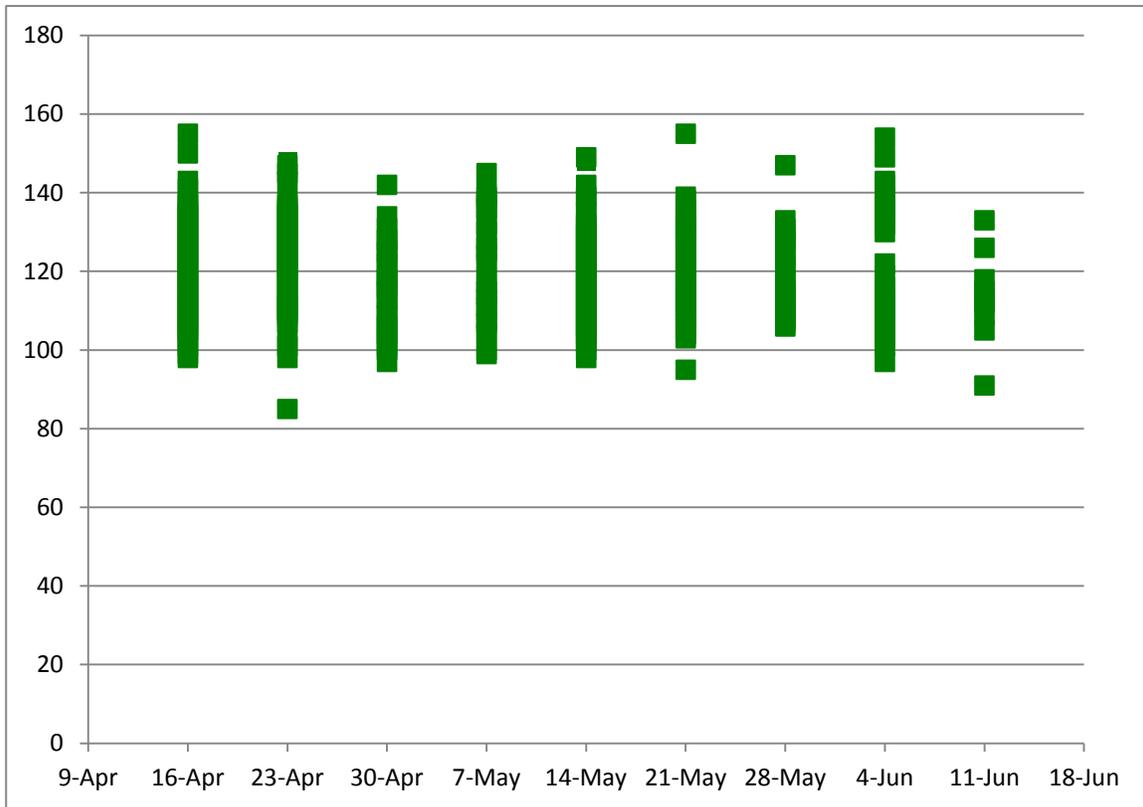


Figure 8.3.4. Lengths of hatchery coho salmon captured in 2011 grouped by week of capture.

Juvenile salmonids leaving Dry Creek during the end of the migration period would be exposed to these stressful conditions.

Juvenile steelhead (mainly young-of-the-year) captures at the Wohler-Mirabel traps peak in May, with few being caught after the first week of June. Juvenile steelhead abundance likely reflects the timing of emergence as well as flow and water temperature conditions at the trap. Rearing in the lower river is likely limited by water temperatures during the late spring/early summer period. At Mirabel, water temperatures typically exceed 21°C by mid-June. Although we have observed low numbers of steelhead rearing above and below the dam during the summer, conditions are stressful (mid-summer temperatures approach or exceed 25.0°C), and few steelhead have been observed rearing in this reach of the river.

Prior to 2011, few largemouth bass were captured during annual screw trap operations or during boat electrofishing surveys conducted upstream of the Inflatable Dam. In 2011, 8,304 YOY largemouth bass (30 to 90 mm FL) were counted at the screw traps. We speculate that a farm pond may have been drained into the Russian River resulting in the high number of YOY largemouth bass encountered in 2011.

Mirabel Fish Ladder Video Monitoring

The Inflatable Dam is approximately 4.0-meter high, 45-m wide, and when fully inflated forms a barrier to upstream migrating fish. To provide upstream passage, the dam is equipped with two Denil-type fish ladders. The dam is typically inflated from early spring through late-fall, depending on water demand and streamflow. During years with low rainfall in the fall and early winter, the dam may also be inflated during portions of the coho salmon and steelhead migration periods.

The video counting system has been in operation at the Inflatable Dam since 2000 primarily to document Chinook salmon escapement. The upstream migration period for Chinook salmon overlaps the time period when the dam is most likely to be inflated. Conversely, a large portion of the coho salmon and steelhead runs generally occur after the dam is deflated during the high flow period. Since the vast majority of Chinook salmon spawning habitat lies above the dam, the counting station provides a good estimate of the overall run in the Russian River. However, during periods of high turbidity (generally associated with high streamflows), the cameras are ineffective and some portion of the run is missed in most years. As a result, the numbers presented for years prior to 2011 should be viewed as minimum counts. In 2011, a DIDSON (dual-frequency identification sonar) was installed at the upstream ends of both fish ladders. These units effectively detect and record images of fish passing upstream of the fish ladders during periods of high turbidity.

Methods

In 2011, passage of adult salmonids through the fish ladders was assessed using digital underwater video cameras from September 1 until January 17, 2012, when high stream flows resulted in the deflation of the dam for the season. Each year, metal housings (camera boxes) are installed at the upstream end of each fish ladder. Underwater cameras and lighting systems are located in the boxes, and are operated 24 hours a day, 7 days a week. Video data are stored on a hard drive located in a nearby building. Each morning, data stored on the hard drive are downloaded directly to the office where it is reviewed. Once viewed, the video footage is copied to 8 GB DVDs for archival purposes.

Fish were counted as moving upstream once they exited the upstream end of the camera box. For each adult salmonid observed, the reviewer recorded the species (when possible), date, and time of passage out of the ladder. During periods of low visibility it was not always possible to identify fish to species, although identification to family (e.g., Salmonidae) was often possible, and such fish were lumped into a general category called "unknown salmonid." Fish that were identified as a salmonid, but could not be identified to species were partitioned into Chinook, coho or steelhead in an attempt to better estimate the number of each of these species observed in the fish ladders. Salmonids were partitioned by taking the proportion of each species identified in the ladder each day, and multiplying the number of salmonids by these proportions. On days when no salmonids could be identified to species, an average ratio from adjacent days was used to categorize the unidentified salmonids.

In most years, high turbidity events associated with rainstorms reduces visibility to the point where the cameras become inoperable. In 2011, the Water Agency deployed a DIDSON (on loan from the Department of Fish and Game) at the exit to each fish ladder in order to count fish passing during periods of high turbidity. The DIDSON can “see through” turbidity and record images of fish passing out of the fish ladders. The DIDSON was run continuously as a backup for the video cameras. However, the winter of 2011 was exceptionally dry, river flow was low, water remained clear and the DIDSON was required for only a few hours of operation.

Results

In 2011, the cameras were in operations continuously from September 1 to January 17, 2012 (Table 8.3.7). During the majority of the season, the image quality of the videos was sufficient to identify and count fish passing through the fish ladder. Species observed in the last 10 years include, but are not limited to Chinook and coho salmon, steelhead, Pacific lamprey, American shad, Sacramento pikeminnow, hardhead, Sacramento sucker, common carp, and channel catfish.

Unknown Salmonids

In 2011, 209 fish were categorized as an “unknown salmonid” (i.e., these fish possessed the general body shape of an adult salmonid, but could not be identified to species). Of these, 162 were estimated as Chinook salmon, 15 as coho salmon, and 32 as steelhead.

Chinook

In 2011, 3,172 adult Chinook salmon (including “unknown salmonids”) were counted at the Mirabel fish counting station. The number of adult Chinook salmon counted each year has ranged from 1,138 to 6,103 (Table 8.3.8).

The date that the first Chinook salmon was observed during video monitoring has ranged from August 20 to October 7 during the 12 years of video monitoring. In 2011, the first Chinook salmon was observed on September 25, and the run began in earnest on October 1. Sixty-two percent of the run was observed between 15 October and 15 November (Table 8.3.8, Figure 8.3.5). Approximately 1 percent of the run was counted after the end of November.

In 2011, the first Chinook salmon was observed at the counting station when the mean daily temperature (MDT) was 20.1°C and the first significant pulse of adult Chinook salmon occurred on October 2 (126 fish) at a MDT of 19.0°C. In 2011, 61 percent of the run occurred after the MDT declined to $\leq 16.0^{\circ}\text{C}$.

In 2011, the lowest flow recoded at Hacienda gauge after Chinook salmon were first observed at the fish counting station was 133 cfs. On October 2 when the first significant pulse of Chinook were detected passing the dam, flow measured 157 cfs. Streamflow did not appear to be effect migration in 2011.

Table 8.3.7. Deployment and removal dates for the Mirabel underwater video system, 2000 – 2011.

Year	Date Deployed	Date Removed
2000	May 12	January 10 (2001)
2001	August 7	November 13
2002	August 12	December 11
2003	September 3	December 2
2004	August 1	December 8
2005	August 1	December 1
2006	August 14	November 26
2007	April 1	June 27
2007	August 15	December 15
2008	August 15	December 22
2009	August 15	December 16
2010	September 1	December 5
2011	September 1	January 17 (2012)

Table 8.3.8. Weekly count of adult Chinook salmon at the Mirabel Dam fish ladders, 2000 – 2010. Dashes indicate that no sampling occurred during that week.

Week	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1-Aug	0	0	0	--	0	0	--	--	--	--	--	--
8-Aug	0	0	0	--	0	0	--	--	--	--	--	--
15-Aug	0	0	1	--	0	0	0	0	0	0	--	--
22-Aug	1	0	8	--	0	1	0	0	0	0	--	--
29-Aug	0	3	7	2	1	2	0	0	1	0	0	0
5-Sep	9	1	18	7	1	5	0	0	0	0	0	0
12-Sep	38	7	19	20	3	11	2	0	1	0	0	0
19-Sep	23	12	65	23	8	13	3	0	14	0	3	1
26-Sep	50	17	1,223	181	16	20	7	1	65	0	1	157
3-Oct	31	240	113	146	42	34	120	7	122	21	669	534
10-Oct	115	51	628	515	51	114	255	38	109	394	896	390
17-Oct	81	10	272	232	585	403	531	28	11	362	154	1070
24-Oct	466	300	153	532	2284	332	83	87	21	305	286 ¹	273
31-Oct	63	661	505	2969	183	632	1169	250	243	75	95 ²	223
7-Nov	24	81	2,337	1289	1164	735	696	115	427	217	174	90
14-Nov	182	--	20	47	217	172	472	475	13	229	43	120
21 Nov	200	--	37	95	57	91	53	60	24	63	113	266
28 Nov	111	--	14	45	59	40	18	105	15	84	76	6
5-Dec	19	--	54	--	15	0	--	770	21	20	5	1
12-Dec	14	--	--	--	--	--	--	22	8	31	--	2
19-Dec	17	--	--	--	--	--	--	0	13	0	--	10
26-Dec	1	--	--	--	--	--	--	--	--	0	--	15
2-Jan	0	--	--	--	--	--	--	--	--	--	--	2
9-Jan												10
16-Jan												1
Total	1,445	1,383	5,474	6,103	4,788	2,572	3,410	1,963	1,125	1,801	2,516	3,172

¹Dam was deflated for 3 days of this week

²Dam was deflated for 2 days of this week

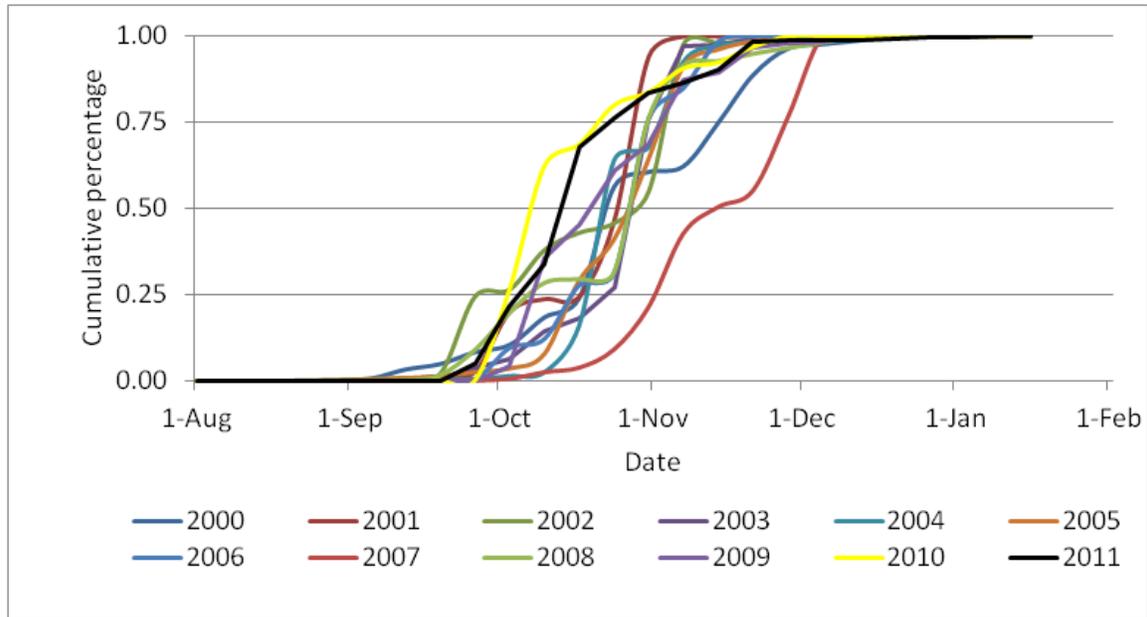


Figure 8.3.5. Cumulative percentage of the total number of adult Chinook salmon counted at the Mirabel Dam fish ladders each year from 2000 to 2011.

Pulsed Flows

The USACE evacuates water from Lake Mendocino in the fall to increase storage for flood control operations. Recently, these planned releases have been modified to improve flow conditions for upstream migrating adult Chinook salmon. Based on the hydrograph, there were two “pulsed flows” in 2011 (Figure 8.3.6). The first was a natural event that occurred when an early season rainstorm dropped 1.43 inches of rain (measured in Santa Rosa) on October 3-4, and increased flow from approximately 150 cfs to 360 cfs (Hacienda Gauge). There did not appear to be an immediate response by Chinook to the increased flow in terms of the number of fish migrating upstream during this rain event. On October 2, 126 Chinook salmon were counted at the fish counting station, and 131 were counted the day after the event occurred. However, water temperature declined from 19.4°C on October 1 to 15.8°C on October 6. On October 15 the USACE began its pulsed flow release from Coyote Valley Dam. Flow was increased from approximately 150 cfs on October 15 to approximately 480 cfs five days later. The pulsed flow took approximately 4 days to reach Hacienda. A run of Chinook salmon was detected at the Inflatable Dam beginning on October 15, and continued through October 20. While this pulse of fish began prior to the enhanced flows reaching the lower river, these fish would have benefitted from the higher flows in terms of migration and improved water temperature (water temperature measured at Hacienda decreased from 18.1°C on October 19 to 17.0°C on October 22).

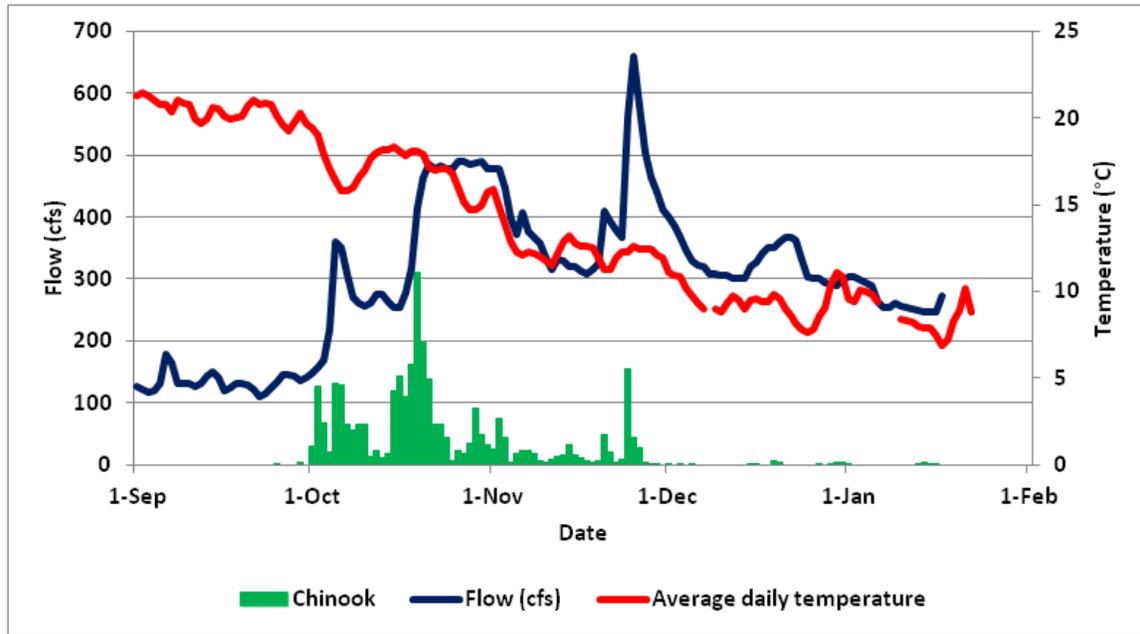


Figure 8.3.6. Daily Chinook salmon counts at Wohler, daily streamflow recorded at the Hacienda gauge, and the daily average water temperature recorded at the Hacienda gauge, September, 2011 through January 17, 2012.

Coho

In 2011, 128 coho salmon were identified on the video system. These images were reviewed by multiple fisheries biologist from the Water Agency, NMFS, and University of California Cooperative Extension (UCCE). Including the 15 coho salmon estimated from the “unknown salmonid” category, the total run of coho salmon passing the Wohler Dam was 153. Most of the coho salmon that were positively identified on the video system (124 of 128 fish) were adipose fin clipped indicating that they were returns from the Russian River coho salmon broodstock program. Coho were observed migrating past the counting stations from October 17 through January 6, 2012. Although data are limited, the peak of the coho run at Mirabel Dam appeared to occur in late-November.

Steelhead

Since the majority of the adult steelhead run in the Russian River occurs after Mirabel Dam is deflated, fall counts from the video system are not representative of run size and cannot be used to compare steelhead runs between years. In 2011, 634 adult steelhead were counted at Mirabel Dam (8.3.9). Steelhead were categorized by being of wild, hatchery, or unknown origin. Of the 634 steelhead that could be categorized by origin, 74 percent were identified as hatchery fish. Since 2000, few adult steelhead were observed prior to the last week of November.

Table 8.3.9. Fall steelhead counts at the Mirabel Dam fish counting station in the fall of 2000-2011.

Date	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
8/1	0	0	0	0	0	0	0	0	--	--	--	--
8/8	0	0	0	0	0	0	0	0	--	--	--	--
8/15	0	0	0	0	0	0	0	0	0	0	--	--
8/22	0	0	0	0	0	0	0	0	0	0	--	--
8/29	0	0	0	0	0	0	0	0	0	0	0	0
9/5	0	0	0	0	0	0	0	0	0	1	0	0
9/12	0	0	0	0	0	1	0	0	0	0	0	0
9/19	0	0	0	0	0	0	0	0	0	0	0	0
9/26	0	0	0	0	0	0	0	0	0	0	0	1
10/3	1	0	2	0	0	1	0	0	2	0	0	9
10/10	0	0	0	1	0	2	0	1	1	9	8	10
10/17	0	0	3	0	1	3	0	0	0	19	8	8
10/24	2	0	1	2	6	3	1	0	1	1	0	5
10/31	2	0	3	0	0	2	0	0	9	2	5	8
11/7	1	0	18	4	3	12	6	0	5	8	2	11
11/14	7	--	10	18	14	9	25	4	15	2	22	8
11/21	11	--	1	17	34	21	--	15	4	12	36	110
11/28	56	--	9	36	97	14	--	194	35	18	72	36
12/5	43	--	55	--	52	--	--	46	18	33	10	23
12/12	178	--	--	--	--	--	--	--	112	51	--	60
12/19	87	--	--	--	--	--	--	--	55	--	--	78
12/26	24	--	--	--	--	--	--	--	--	--	--	105
1/2	45	--	--	--	--	--	--	--	--	--	--	66
1/9	56	--	--	--	--	--	--	--	--	--	--	80
TOTAL	513	0	102	78	207	68	32	260	256	156	163	635

¹Wild, hatchery, and unknown origin combined.

Conclusions and Recommendations

The 2011 count of 3,172 Chinook salmon ranks as the 5th highest out of the 12 years monitored to date. A direct comparison of population size between years is limited because the sampling periods are not necessarily equal. Although the counting system is operated throughout the majority of the Chinook salmon run in most years, the date that the dam has been deflated has ranged from November 13 to January 17. In addition, in some years prolonged periods of high turbidity prevent the cameras from operating for a significant amount of time. For example, in 2010, high flows and associated high turbidity levels resulted in a loss of data over a 7-day period compared to 2011, when no more than a few hours of data were lost to poor visibility. Thus, the annual counts should be viewed as minimum escapements. With the loan of two DIDSON units from the CDFG, the loss of data due to high turbidity events can be greatly reduced in future years.

Few Chinook salmon have been counted at the dam prior to October in any year sampled. Based on video monitoring, the typical Chinook salmon run in the Russian River begins in mid-September, peaks between the last week of October and mid-November, and tails off rapidly by late-December (Figure 8.3.5). The first Chinook salmon was observed at Mirabel on September 25, and the first significant pulse of fish occurred on October 2. In 2011, migration occurred earlier than normal, with the peak counts occurring during the week of October 15th to the 21st (Figure 8.3.5).

Although Chinook salmon have been observed migrating past the Mirabel Dam at temperatures ranging to 22.6°C, in most years approximately 90 percent of the adult Chinook salmon have been observed at the fish counting station after the mean daily temperature (MDT) declined below 17.1°C (Table 8.3.10). Annually, 73 to 97 percent of the fish counted at the Mirabel Dam pass after the MDT declines below 15.5°C. The 15.5°C threshold is significant because exposure of migrating adults to temperatures above this point can result in decreased survival of developing embryos (Hinze 1959, cited by DW Kelly and Associates and 1992). In 2011, the run appeared to occur earlier in the year and MDT during the peak of the run was 17.7°C (October 15 – 24) when 42 percent of the run passed the dam.

The Mirabel video monitoring system continues to provide excellent data on Chinook salmon escapement to the Russian River. In addition, with the recent rebound in coho salmon numbers resulting from the coho broodstock program (see Chapter 7 in this report), the Mirabel Fish Counting Station is providing information on at least the first half of the coho run. 2011 marks the third year that coho salmon have been observed migrating upstream during the fall spawning run. Although the numbers counted have been very low (9 in 2009 and 38 in 2010), the system does not detect fish that return to lower Russian River tributaries and is inoperable during a significant portion of the migration period during some years. The steelhead run occurs primarily after the dam is deflated rendering the video system inoperative. Still, the video information is useful in defining the beginning of their run.

Table 8.3.10. Date that the mean daily water temperature declined below 17.1 and 15.5°C and the percentage of the run that occurred after this date, 2000-2011.

Year	Date temp ≤ 17.1°C	Percentage of Chinook salmon counted on days when temp ≤17.1°C	Date temp ≤ 15.5°C	Percentage of Chinook salmon counted on days when temp ≤15.5°C
2000	Oct 11	86.5	Oct 22	76.4
2001	Oct 7	75.4	Oct 21	72.6
2002	Oct 9	97.7	Oct 16	59.4
2003	Oct 16	83.2	Oct 30	75.3
2004	Oct 10	98.4	Oct 13	96.7
2005	Oct 9	96.2	Oct 27	91.8
2006	Oct 11	99.6	Oct 18 ¹	82.2 ¹
2007	No data ²	No data	No data	No data
2008	Oct 4	87.3	Oct 10	79.7
2009	Sept 30	93.9	Oct 28	62.2
2010	Oct 14	91.3	Oct 17	62.3
2011	Oct 24	52.0	Oct 27	28.9

¹Temperature data collection ended on October 18, 2006 when the MDT = 15.8°C. For this analysis it was assumed that the temperature would have declined below 15.5°C on October 19.

²Temperature probed failed, no temperature data collected in 2007.

We recommend that the video system continue to be augmented with the DIDSON technology. The loss of video images due to episodic turbidity events is an ongoing issue with video technology. The inclusion of the DIDSON units will significantly reduce the loss of data and increase the total counts of fish migrating past the dam. Although it may not be possible to accurately identify species from the DIDSON images it should be possible to estimate the numbers of each species migrating past the dam by partition the DIDSON images by the percentage of each species identified on video.

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9: Chinook Spawning Ground Surveys

Although not an explicit requirement of the Biological Opinion, the Water Agency has continued to perform spawning ground surveys for Chinook salmon in the mainstem Russian River and Dry Creek. This effort compliments the required video monitoring of adult fish migration and has been stipulated in temporary D1610 flow change orders issued by the State Water Resources Control Board to satisfy the Biological Opinion (see Pursue Changes to D1610 flow chapter of this report). The Water Agency began conducting Chinook salmon spawning surveys in fall 2002 to address concerns that reduced water supply releases from Coyote Valley Dam (Lake Mendocino) may impact migrating and spawning Chinook salmon (Cook 2003). Spawner surveys in Dry Creek began in 2003.

This report summarizes 2011 field studies on Chinook salmon spawning activity. Surveys were curtailed due to poor water visibility for detecting redds in the upper reaches of the Russian River. Hence, spawner surveys were only conducted in Dry Creek and in the Russian River mainstem from Cloverdale to below Healdsburg. Background information on the natural history of Chinook salmon and findings from 2002 to 2010 are presented in the 2011 Russian River Biological Opinion annual report (SCWA 2011). The primary objectives of the spawning ground surveys are to (1) characterize the distribution and relative abundance of Chinook salmon spawning sites, and (2) compare annual results with findings from previous study years. In addition, in 2011 studies of the construction of redds at selected riffles over the spawning season were conducted.

Methods

Chinook salmon redd (spawning bed) surveys were conducted in the Russian River from fall 2002 to 2011. Typically, the upper Russian River basin and Dry Creek are surveyed (Figure 9.1). The study area includes approximately 114 km of the Russian River mainstem from Riverfront Park (40 rkm), located south of Healdsburg, upstream to the confluences of the East and West Forks of the Russian River (154 rkm) near Ukiah. River kilometer (rkm) is the meandering stream distance from the Pacific Ocean upstream along the Russian River mainstem and for Dry Creek the distance from the confluence with the Russian River upstream. In 2003, the study area was expanded to include 22 rkm of Dry Creek below Warm Springs Dam at Lake Sonoma to the Russian River confluence. In 2011 Chinook salmon spawner surveys were not completed from Ukiah to Cloverdale due to high turbidity levels that limited visual observations of redds.

Distribution and Abundance

Surveys were conducted to determine the distribution and relative abundance of Chinook salmon redds and the habitats utilized for spawning. This study consisted of a single-pass survey during the estimated peak of Chinook salmon fall spawning. The Dry Creek and the Russian River study area was surveyed on November 30 and December 5, 7, and 8, 2011. A crew of two biologists in kayaks visually searched for redds along the streambed. The locations of redds were recorded using a global positioning system (GPS). Also, to better understand the ability to

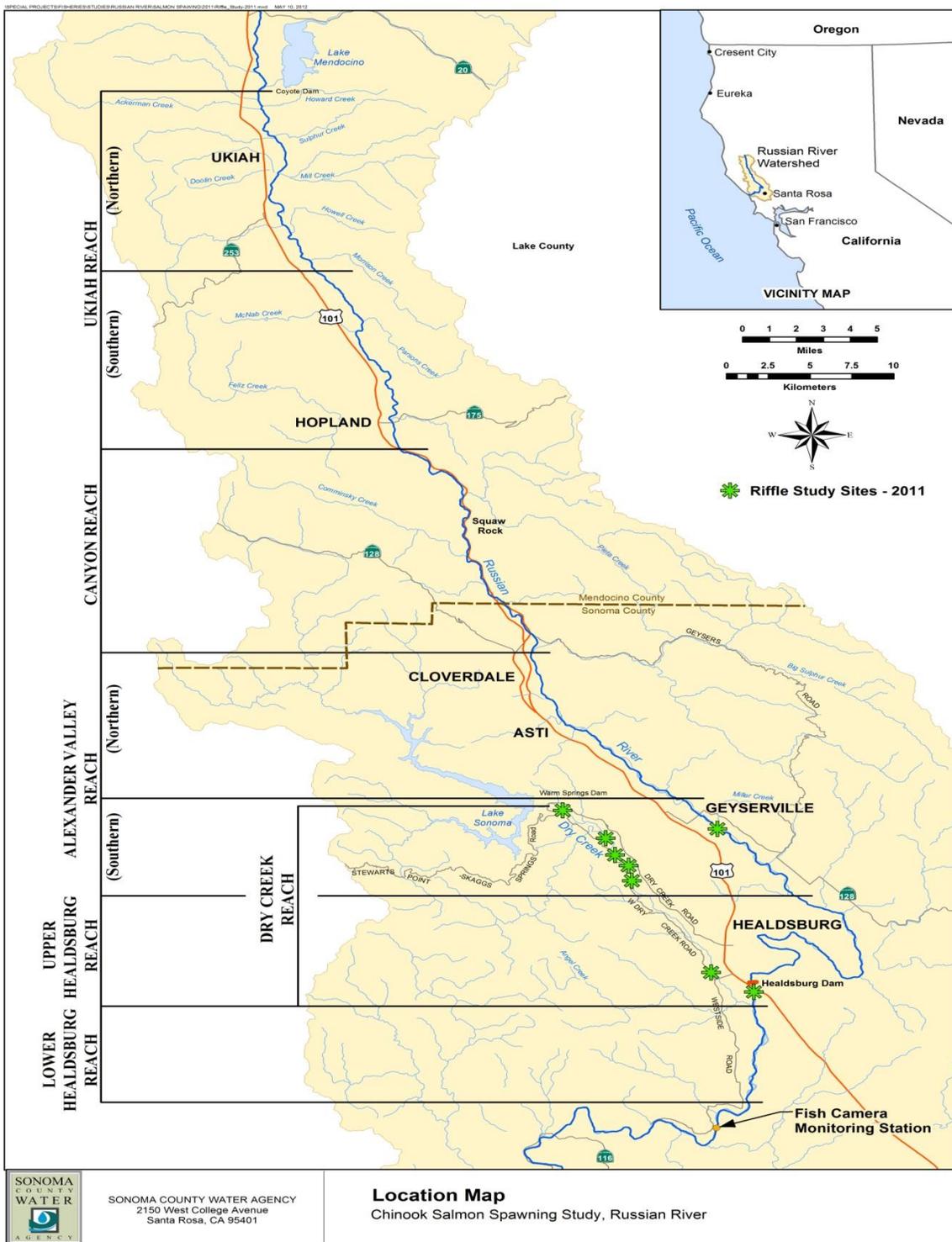


Figure 9.1. Chinook salmon spawning survey reaches. Ukiah and Canyon Reaches were not surveyed in 2011.

judge the peak of salmon spawning weekly single-pass surveys along Dry Creek were completed from November 15 to December 21, 2011. During each survey a redd was recorded as either newly constructed or an older redd that did not show activity since the previous visit. This allowed a comparison of redd numbers and their condition throughout Dry Creek during most of the Chinook salmon spawning period. See below for additional studies of timing of redd construction.

Redd Construction and Timing

Several riffles were selected in the Russian River mainstem and Dry Creek to monitor the timing of Chinook salmon spawning and redd construction. Riffles were selected based on previous spawning observations (SCWA 2011) including six sites in Dry Creek and two in the Russian River (Figure 9.1). Weekly surveys were conducted from November 15 to December 15-21, 2011. During each visit the study riffle was searched for salmon and redds. Each observed redd was marked by placing a painted numbered rock upstream of the redd pit (Figure 9.2). (A redd consists of a shallow excavation and a mound of loose gravel where eggs are deposited downstream of the pit). A map of the location and size of redds was drawn by hand onsite and then revised during weekly visits. Missing marker rocks were replaced as needed during subsequent site visits. The condition of each redd was recorded weekly using the following categories: 1) newly constructed “fresh” redd with clean gravel, 2) well defined pit and mound but gravel slightly discolored from algae, 3) pit and mound of the redd apparent but not well defined and gravel covered with algae, 4) redd no longer visible. These data were used to compare spawning activity of salmon and to determine the ability of survey crews to detect aging redds over the 5-6 week study period.

Results

Most of the Chinook salmon spawning typically occurs in the upper Russian River mainstem and Dry Creek (Table 9.1). The three reaches surveyed during 2011 in the Russian River showed a similar pattern of relative abundance of redds as in previous study years with a general increase in redd numbers in an upstream direction. During 2011, Alexander Valley Reach had the highest frequency of redds in the mainstem at 3.7 redds/rkm, followed by Upper Healdsburg and Lower Healdsburg at 2.6 and 0.97 redds/rkm, respectively. During peak spawning activity, there were a maximum of 229 redds recorded from Dry Creek at a frequency of 10.6 redd/rkm. Redd counts in Dry Creek have ranged from 65 to 342 redds since surveys began in 2003.

During weekly redd surveys along Dry Creek in fall 2011 a peak of observed redds occurred on December 6 with a total count of 229 redds (Figure 9.3). Chinook salmon spawning probably started in early November based on our observation of only new redds on November 15. There was a decline in new redds after December 6 but new redds were recorded through the end of the study on December 21.



Figure 9.2. Chinook salmon redd at study riffle, Dry Creek, 2011. Flow direction is from right to left in the photograph. The redd is the clean lighter substrate with a painted numbered rock marker placed upstream of the pit (center right side of photograph). The inset shows a close up of the marker.

There was a similar activity pattern of redd construction between the upper and lower reaches of Dry Creek (Figure 9.4). However, the upper reach contained approximately twice as many redds compared to the lower reach.

The changes in condition of marked redds at study riffles in the Russian River and Dry Creek are shown in Figures 9.5 and 9.6. A total of 16 redds in Russian River and 98 redds in Dry Creek were monitored over the 5-6 week study period. The number of redds peaked at the Dry Creek and Russian River riffle study sites on December 6-7. At the Russian River study riffles all marked redds were visible until the last visit on December 15, except for two previously marked redds that were not found. Missed detections at the Dry Creek study riffles ranged from 1 redd on the second visit to 24 undetected redds on the sixth visit on December 21, 2011.

Table 9.1. Chinook salmon redd abundances by reach, upper Russian River and Dry Creek, 2002-2011. Redd counts are from a single pass survey conducted during the peak of fall spawning activity. *Survey either not completed or incomplete. Dry Creek value for 2008 is an estimate.

Reach	Reach (rkm)	Redd Observations									
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Redd Count											
Ukiah (Forks-Hwy101)	33.1	511	458	284	*	248	118	20	38	*	*
Canyon (Hwy101-SulphurCr)	20.8	277	190	169	*	68	88	36	38	*	*
Alexander (SulphurCr-AV Rd)	26.2	163	213	90	*	62	131	65	129	*	97
Upper Healdsburg (AV Rd-Dry Cr)	25.6	79	40	8	*	23	67	48	38	*	66
Lower Healdsburg (Dry Cr-Wohler Bridge)	8.2	6	0	7	*	1	2	9	30	*	7
Russian River Subtotal	113.9	1036	901	558	*	402	406	178	273	*	170
Dry Creek (Dam-River)	21.7	*	256	342	*	201	231	65	223	268	229
Total	135.6		1157	900	*	603	637	243	496	268	399
Relative Contribution of Redds											
Russian River (%)	84.0	*	77.9	62.0	*	66.7	63.7	73.3	55.0	*	*
Dry Creek (%)	16.0	*	22.1	38.0	*	33.3	36.3	26.7	45.0	*	*
Total	100.0		100.0	100.0		100.0	100.0	100.0	100.0		

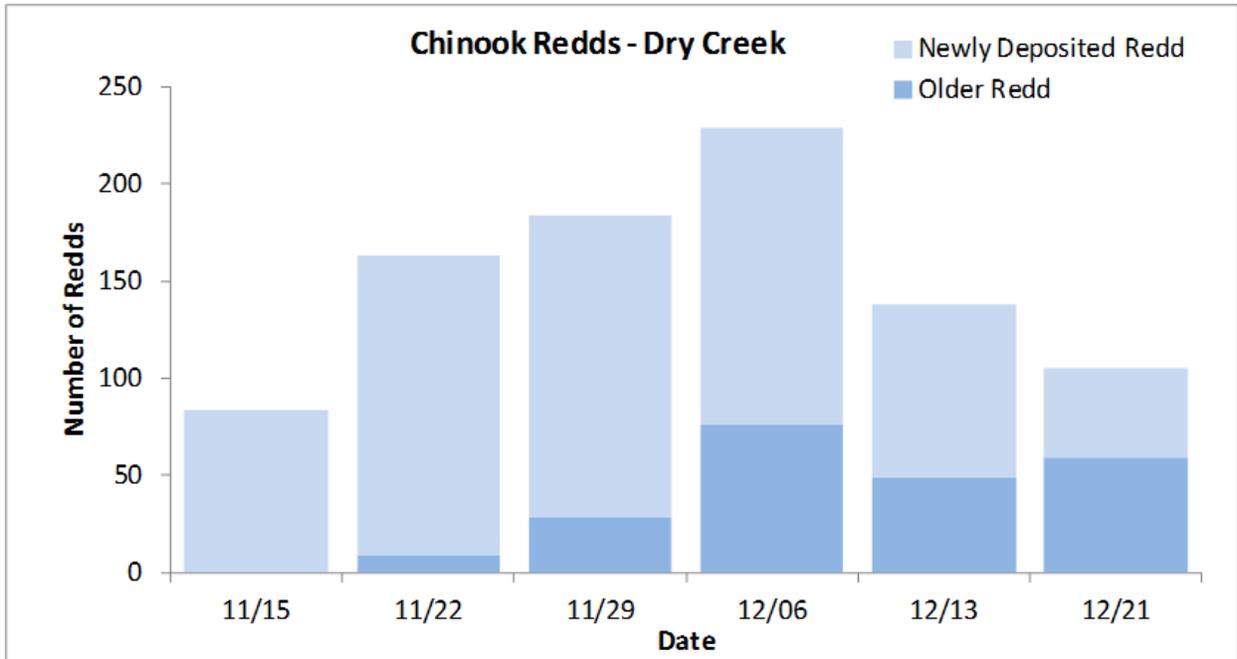


Figure 9.3. Weekly counts of Chinook salmon redds in Dry Creek, 2011. Redds were identified as either newly constructed redds or older redds.

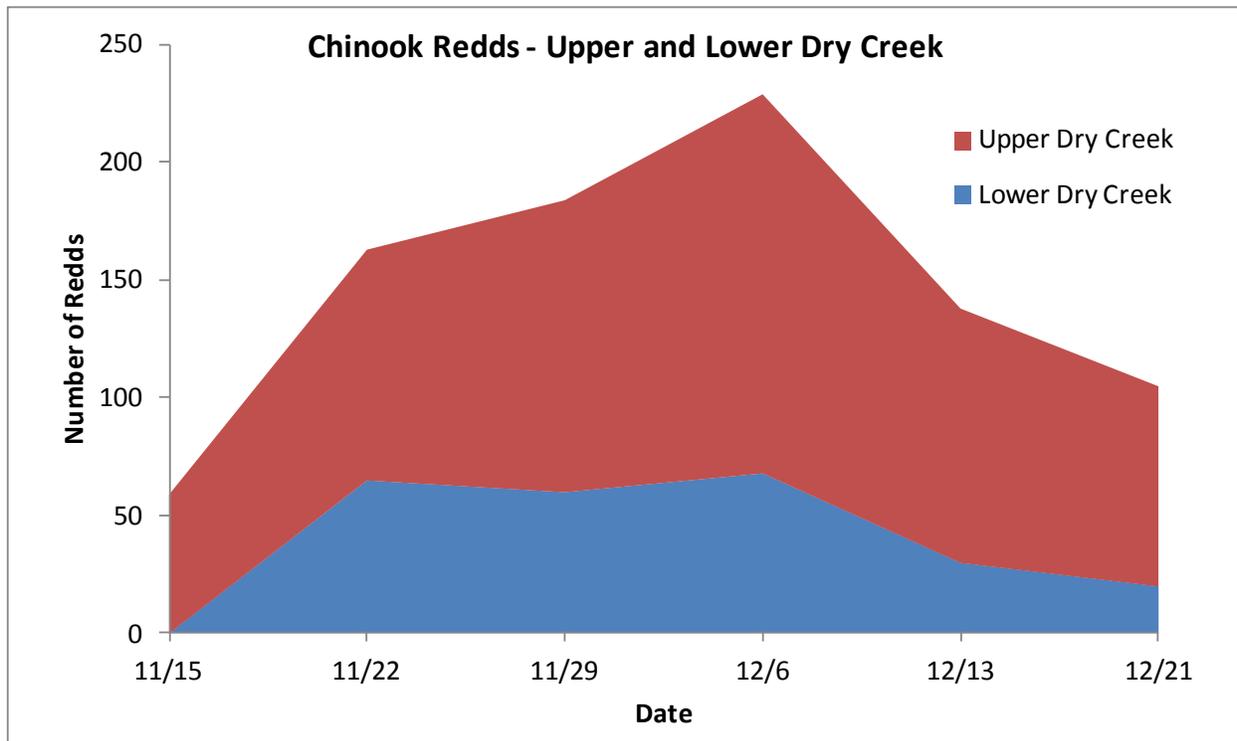


Figure 9.4. Chinook salmon redds in reaches of Dry Creek, 2011. The number of redds observed during 6 weekly surveys are shown. Reaches are the upper Dry Creek from Warm Springs Dam to Lambert Bridge and lower Dry Creek from Lambert Bridge to the Russian River confluence.

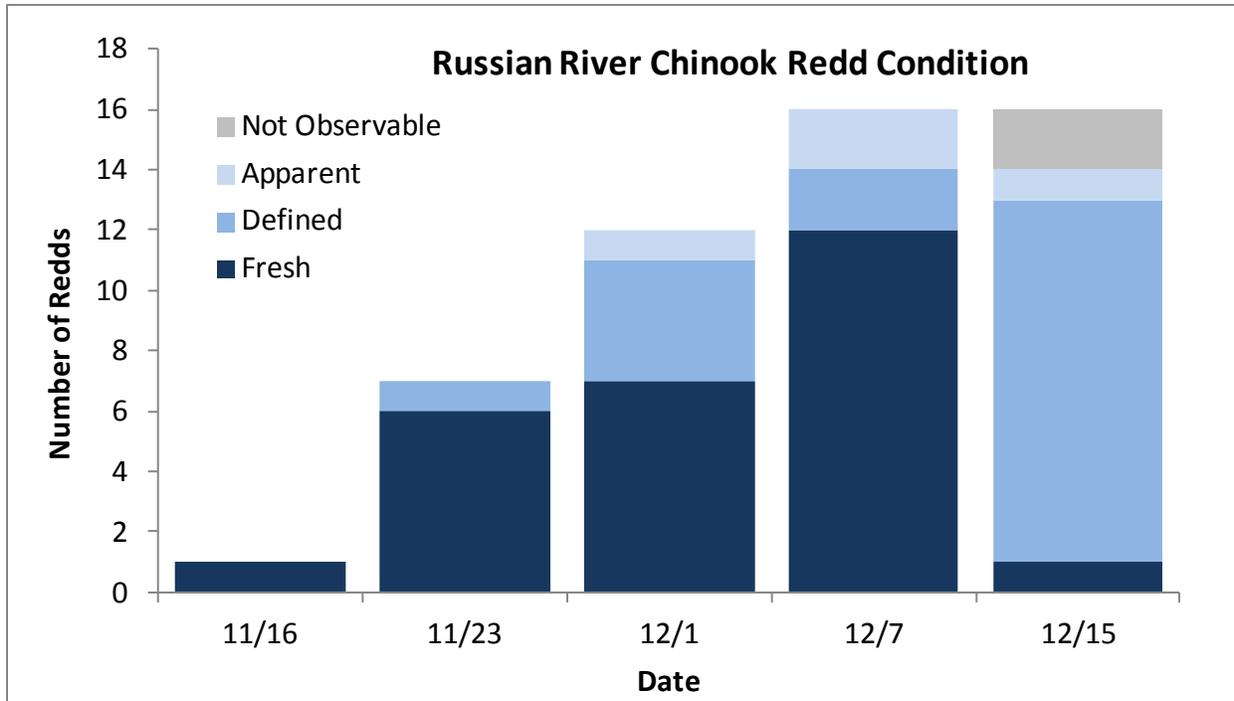


Figure 9.5. Chinook salmon redd condition in the Russian River. Two study riffles were monitored weekly in 2011. Blue bar sections indicate varied condition of observed redds. Gray bar sections are redds no longer detected but recorded during a previous visit.

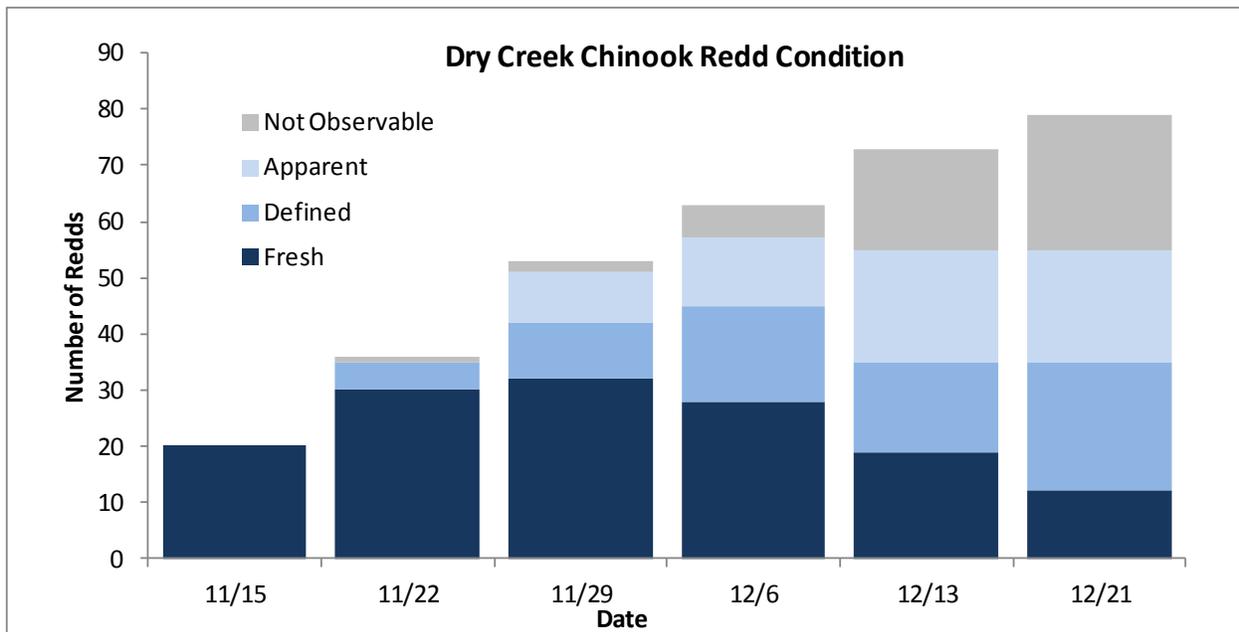


Figure 9.6. Chinook salmon redd condition observed in Dry Creek study riffles during six weekly visits, 2011. Bar sections with blue indicate varied condition of redds that were detected. Gray bar sections are redds no longer detected but recorded during a previous visit.

Conclusions and Recommendations

The primary Chinook salmon spawning areas in the Russian River basin are located from Alexander Valley upstream to Ukiah Valley and in Dry Creek (SCWA 2011). During previous study years redds were least abundant in the Lower Healdsburg and Upper Healdsburg reaches. This same abundance pattern was observed in 2011, although no spawner surveys were conducted in the Canyon and Ukiah Reaches in the upper Russian River watershed due to poor water visibility.

At the peak of Chinook salmon spawning there were 229 redds found in Dry Creek during 2011, which is close to the eight-year average of 226.9 redds. This suggests there was a moderate run of spawning Chinook salmon during fall 2011 and confirms observations from the Mirabel Dam video monitoring of adult Chinook salmon (see Chapter 8).

The weekly sampling of study riffles in the Russian River and weekly redd surveys in Dry Creek found a similar peak in redd numbers and corresponded to the timing of our single-pass redd survey. Previously the timing of single-pass surveys to count redds was based on adult Chinook salmon counts from the Mirabel camera monitoring station. This suggests that single-pass surveys since 2002 were likely conducted during the peak of spawning activity and may serve as an accurate index of spawning activity. Because Russian River and Dry Creek flow was low during the survey period in 2011, we were able to assess how our ability to detect redds was influenced by algal growth on the substrate and changes in redd morphology due to spawning activity. Weekly monitoring surveys indicated that most redds can be detected for up to 3-4 weeks before they are obscured by algal growth or their topography redd changes due to activity of newly arriving fish.

References

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10: Synthesis

An increased understanding of baseline salmonid population dynamics in the Russian River watershed is necessary if we are to understand the consequences of changes to estuary management, flow regimes and habitat enhancement measures compelled by the Russian River Biological Opinion. Additional data and connections in these data will be necessary if we are to understand the mechanisms underlying the dynamics of growth and mortality particularly as it relates to habitat transitions as fish move out of headwater tributaries to larger tributaries, the mainstem, estuary and ultimately the ocean.

The Sonoma County Water Agency has collected a variety of fish and water quality monitoring data relevant to fulfilling the overall objectives in the Russian River Biological Opinion. Those efforts have been detailed in portions of this report leading to this chapter. The objectives specific to this synthesis chapter are to relate these data sets to one another first by illustrating the spatial and temporal extent of monitoring activities in the basin and second by presenting and discussing emerging trends in juvenile salmonid abundance, movement and growth in streams encompassed by the Reasonable and prudent Alternative (RPA) section of the Russian River Biological Opinion.

In 2011 we collected data from a broad spatial (Figure 10.19) and temporal (Figure 10.20) extent in the Russian River Basin. Between April 6, 2011 and January 17, 2012, we collected fish data from 24 sites. We also conducted six spawner surveys every seven to eight days for Chinook salmon on the 22 km of stream length in mainstem Dry Creek downstream of Warm Springs Dam as well as five spawning surveys every six to eight days on one spawning riffle on the mainstem Russian in Alexander Valley. Sites, gear types, and target life stages monitored included: downstream migrant trapping with rotary screw traps on Dry Creek, the mainstem Russian River at Mirabel and Austin Creek as well as a funnel net on Dutch Bill Creek and Green Valley Creek; operation of an underwater PIT antenna and underwater video camera to detect both PIT-tagged and non-PIT-tagged salmonids near the upstream extent of the tidal portion of the estuary in Duncans Mills; juvenile salmonid sampling using beach seining at ten fixed locations in the estuary; juvenile sampling using backpack electrofishing, PIT tags and PIT antennas at multiple sites in Dry Creek; adult Chinook surveys using underwater video at Mirabel and from spawner surveys in Dry Creek and mainstem Russian River. Complementary data on water quality were collected by means of continuously-recording datasondes at 10 sites throughout the estuary/lagoon and from bimonthly grab samples at five additional sites. Monthly invertebrate sampling in the estuary was conducted at six sites in May and June and four sites in July-October. Details regarding the specifics of these monitoring activities are covered in individual chapters of this report.

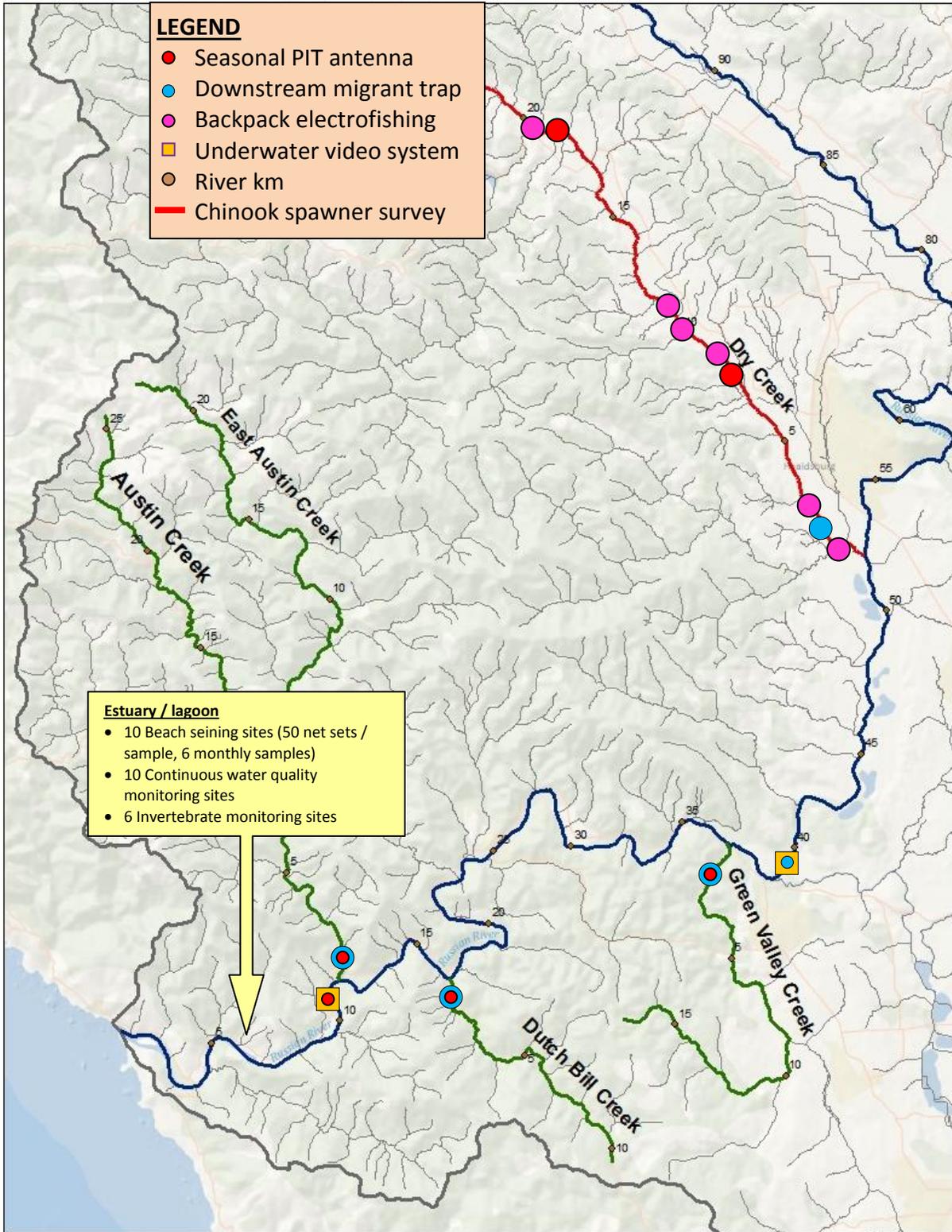


Figure 10.19. Spatial extent of fisheries and water quality monitoring related to the Russian River Biological Opinion, 2011. Numbered dots along stream courses represent distance (km) from the mouth of each stream.

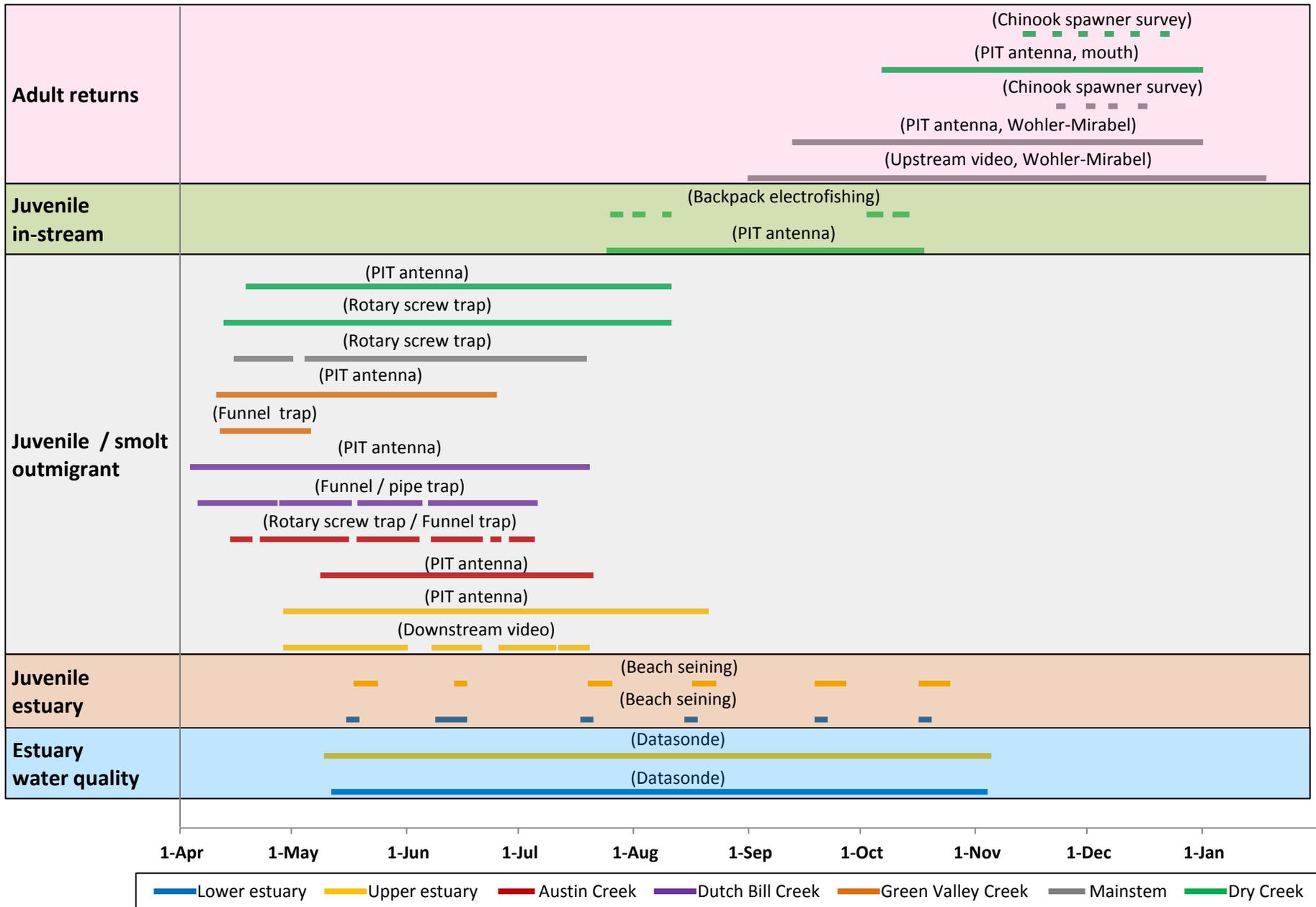


Figure 10.20. Temporal and life stage extent of sampling at fisheries and water quality monitoring sites related to the Russian River Biological Opinion, 2011.

In the sections that follow, we summarize abundance, movement and growth dynamics of juvenile and smolt salmonids based on data from tributary and mainstem sites sampled in 2011. The Water Agency used PIT tags and fin-clipping as primary tools for characterizing these metrics. As described in other sections of this report and reports from prior years, PIT-tagged and/or fin-clipped fish were detected at downstream trapping locations and during beach seining sampling bouts in the estuary as well as at downstream migrant traps and stationary PIT-tag antennas located throughout the system (Figure 10.19). In the first section below, we broadly summarize available abundance information to describe some general temporal trends in abundance and variability in abundance. Following that, we focus specifically on the movement of juvenile steelhead from the Mirabel trap site on the mainstem Russian River and “lower river tributaries” (i.e., Green Valley Creek, Dutch Bill Creek, Austin Creek) into the lower mainstem and estuary. Next we describe efforts based on a combination of PIT tags and site-specific fin-clipping (upper caudal clip at Dry Creek and lower caudal clip at Mirabel) to evaluate Chinook smolt migration from the downstream migrant trap on Dry Creek to the Mirabel inflatable dam on the mainstem Russian River- a distance of approximately 27 km. We also gathered initial data on the timing of Chinook smolt movement from the Mirabel dam to the upstream extent of the tidal portion of the Russian River estuary in Duncans Mills- a distance of approximately 28 km. We conclude by matching the 2011 fish data to water temperature and dissolved oxygen data collected at fixed sampling sites in the estuary.

Abundance

In general, indications are that in 2011 juvenile steelhead numbers were down while Chinook salmon smolt and coho salmon YOY and smolt numbers were up relative to 2009 and 2010. Capture of steelhead YOY and parr was highest in Dry Creek (2,879) and Austin Creek (1,800) and lowest at Mirabel (528), Dutch Bill Creek (31) and Green Valley Creek (3); a total of 445 smolts were captured at all five downstream migrant traps, combined, in 2011. The total number of coho salmon smolts captured at the downstream migrant traps was 4,553 as compared to 487 in 2010. Much of the increase came at the Dutch Bill Creek trap (2010 catch =185 vs. 2011 catch=2,904) that resulted from hatchery smolts acclimated in tanks on Dutch Bill Creek (upstream of our trap site) before release during the trapping season; however, there were also significant increases in the number of coho smolts captured at Mirabel (2010 catch=181 vs. 2011 catch=887), Dry Creek (2010 catch=20 vs. 2011 catch=196) and Austin Creek (2010 catch=103 vs. 2011 catch=335). The larger catch in 2011 was comprised of a proportionately higher number of wild smolts as compared to 2010 (2010=0.6% vs. 2011=2.2%). This increasing trend matches recent increasing trends in adult returns (Figure 10.21). When compared to 2010, Chinook salmon smolt capture was 5.9 times higher at Mirabel (2010 catch=2,292 vs. 2011 catch=13,581) and 4.1 times higher at Dry Creek (2010 catch =4,966 vs. 2011 catch=20,389).

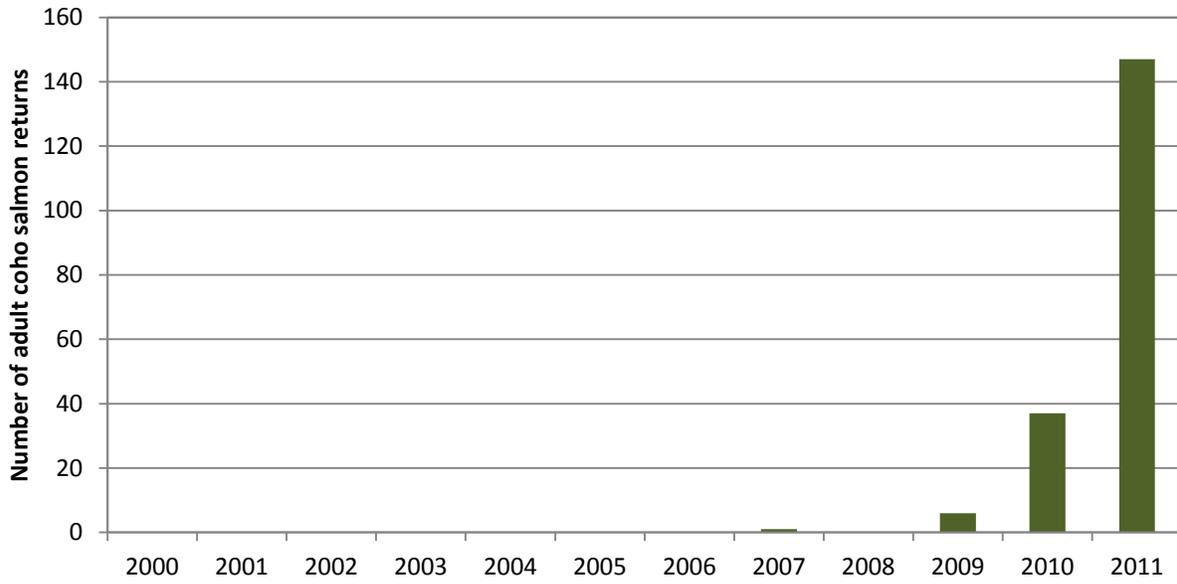


Figure 10.21. Number of adult coho salmon passing the underwater video monitoring station at Mirabel on the mainstem Russian River by return year.

In 2011, estimates of juvenile steelhead abundance were possible for lower Austin Creek (based on downstream migrant trapping combined with a PIT antenna array) and five sites in Dry Creek (based on backpack electrofishing) while indices to juvenile steelhead abundance were possible at 10 sites in the tidal portion of the estuary (based on beach seining). These data show a clear decrease in juvenile steelhead abundance ranging from 46% in Dry Creek to 66% in Austin Creek (Figure 10.22). This is consistent with the fact that in recent years the numbers of adult steelhead returning to Russian River hatcheries have also been down (Figure 10.23).

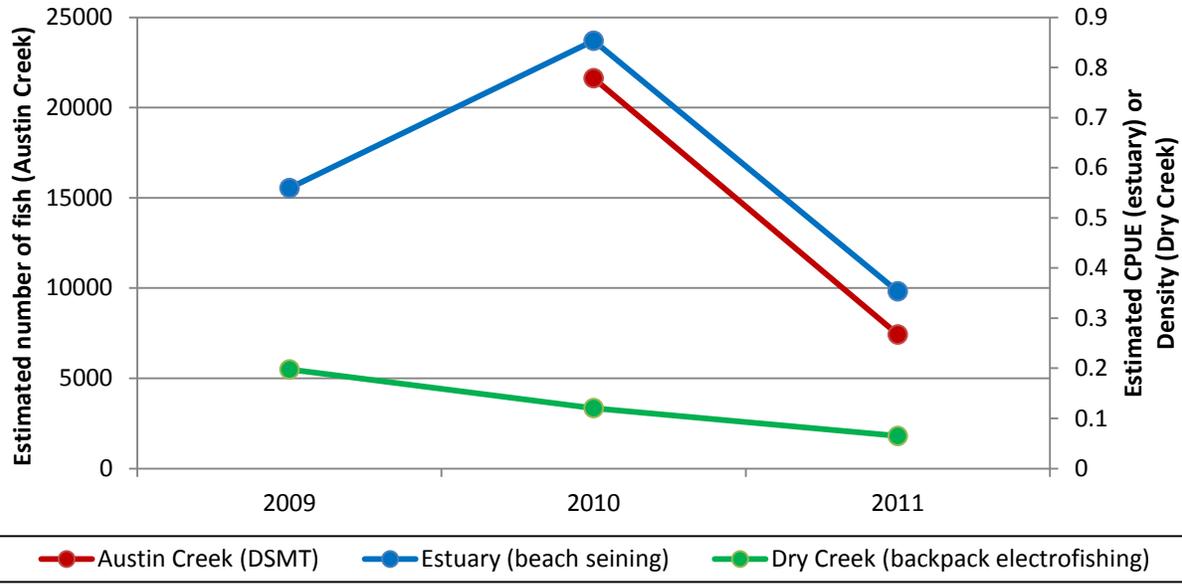


Figure 10.22. Indicators of juvenile steelhead trends in Austin Creek, the estuary and Dry Creek, 2009-2011.

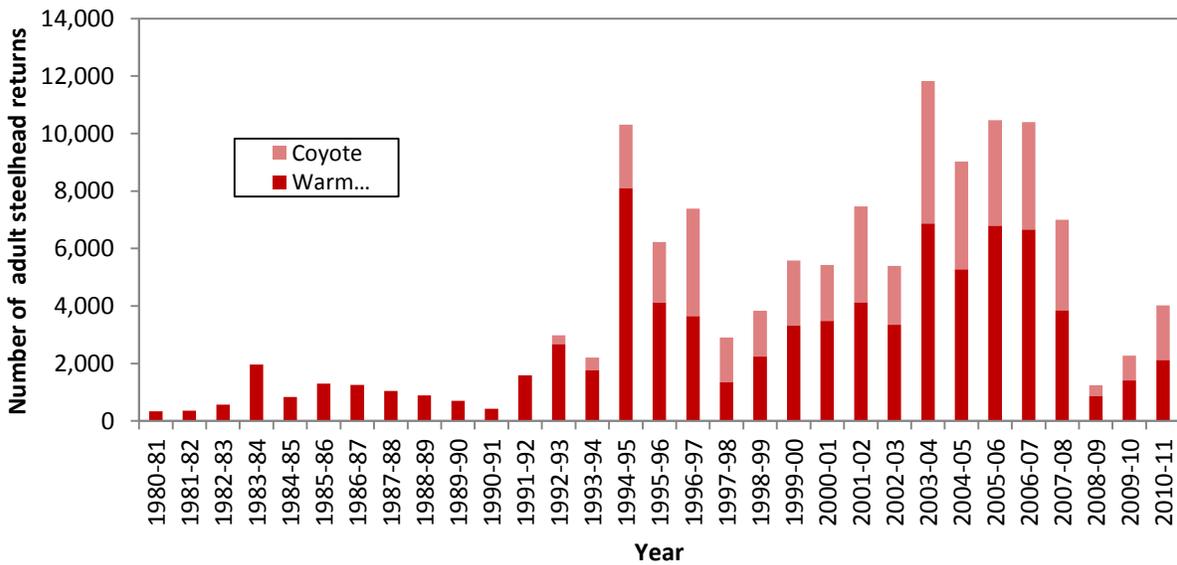


Figure 10.23. Number of adult steelhead returning to Russian River hatcheries by return year (CDFG unpublished data).

After accounting for estimated trap efficiencies (Figure 10.24), the higher captures of Chinook smolts in 2011 resulted in a 3.0-fold increase at Mirabel in estimated Chinook smolt abundance ($305,662 \pm 95\% \text{ CI } 28\%$) as compared to 2010 ($101,975 \pm 95\% \text{ CI } 41\%$) and a 2.7-fold increase in estimated Chinook smolt abundance in Dry Creek (2010= $84,785 \pm 95\% \text{ CI } 19\%$ vs. 2011= $225,392 \pm 95\% \text{ CI } 13\%$). Numbers of Chinook smolts estimated in 2011 at these two sites were the

highest of the three year period 2009-2011 and similar to 2009 on Dry Creek (Figure 10.25). The reasons for this variability are likely related to multiple factors that may include favorable environmental conditions resulting in increased trap efficiency (we suspect this was the case at Mirabel) as well as higher early alevin/fry survival from lower late flows in spring 2009 and 2011 as compared to 2010 (Figure 10.26). As with juvenile steelhead, trends in Chinook smolt abundance were consistent among sites (Figure 10.27) and, as with steelhead, they also reflected recent trends in adult returns (Figure 10.28).

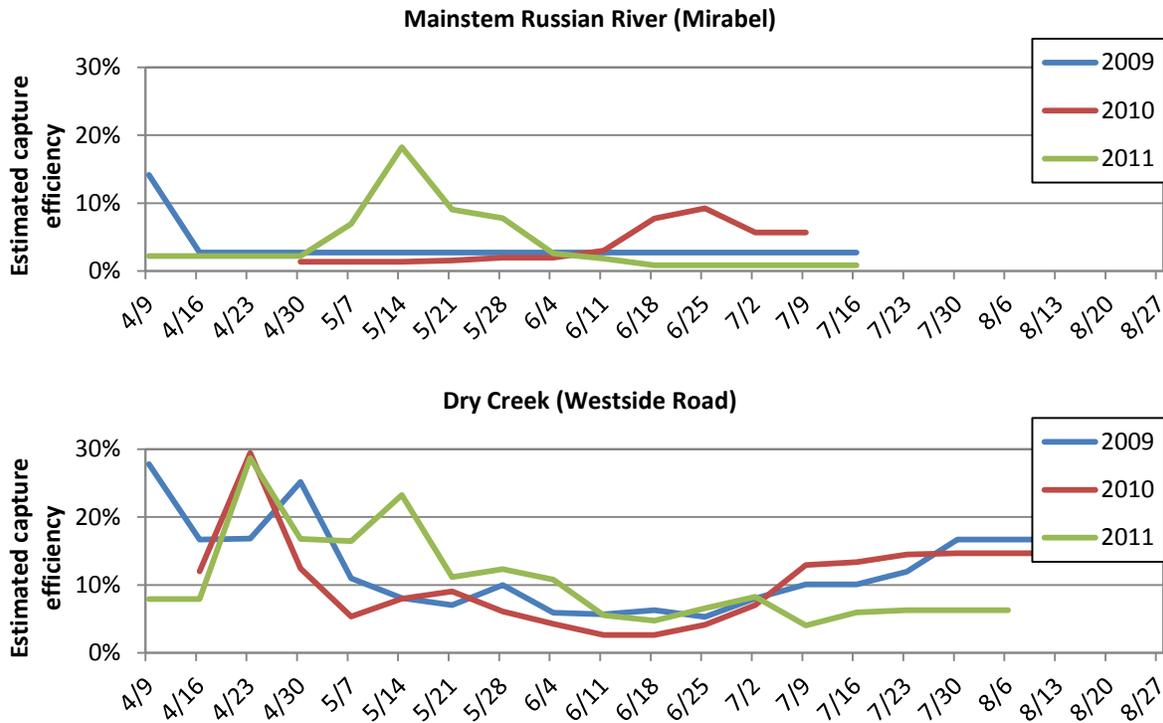


Figure 10.24. Estimated trap capture efficiency for Chinook salmon smolts on the mainstem Russian River (Mirabel) and Dry Creek (Westside Road).

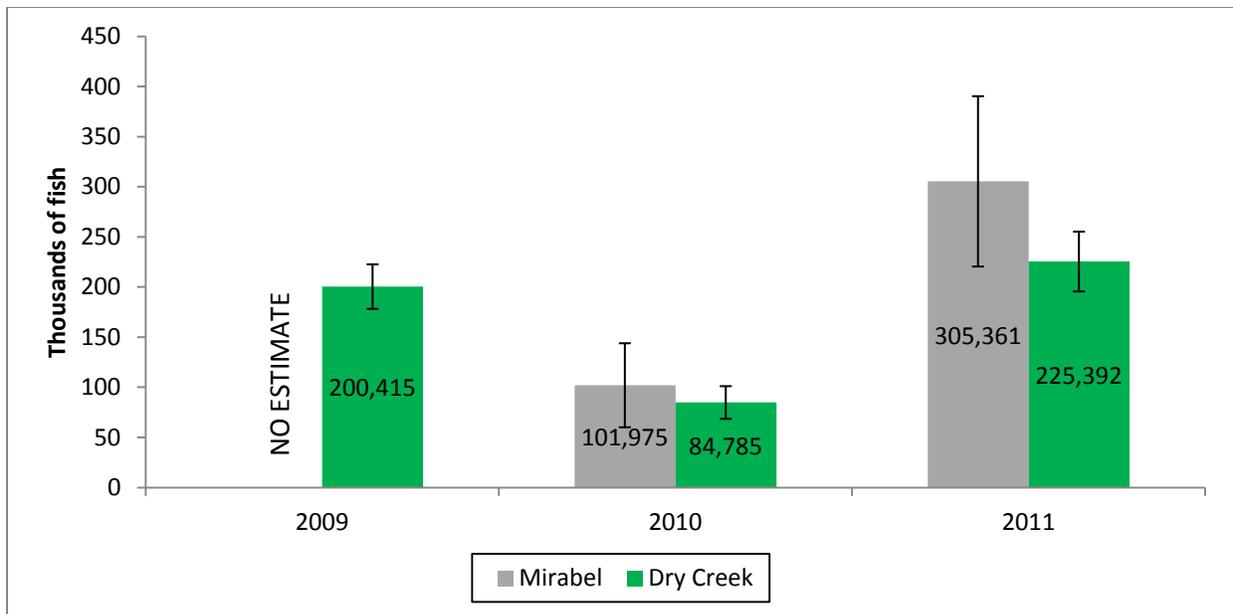


Figure 10.25. Number of Chinook salmon estimated from mark recapture experiments (using program DARR) on the mainstem Russian River (Mirabel) and Dry Creek (Westside Road), 2009-2011.

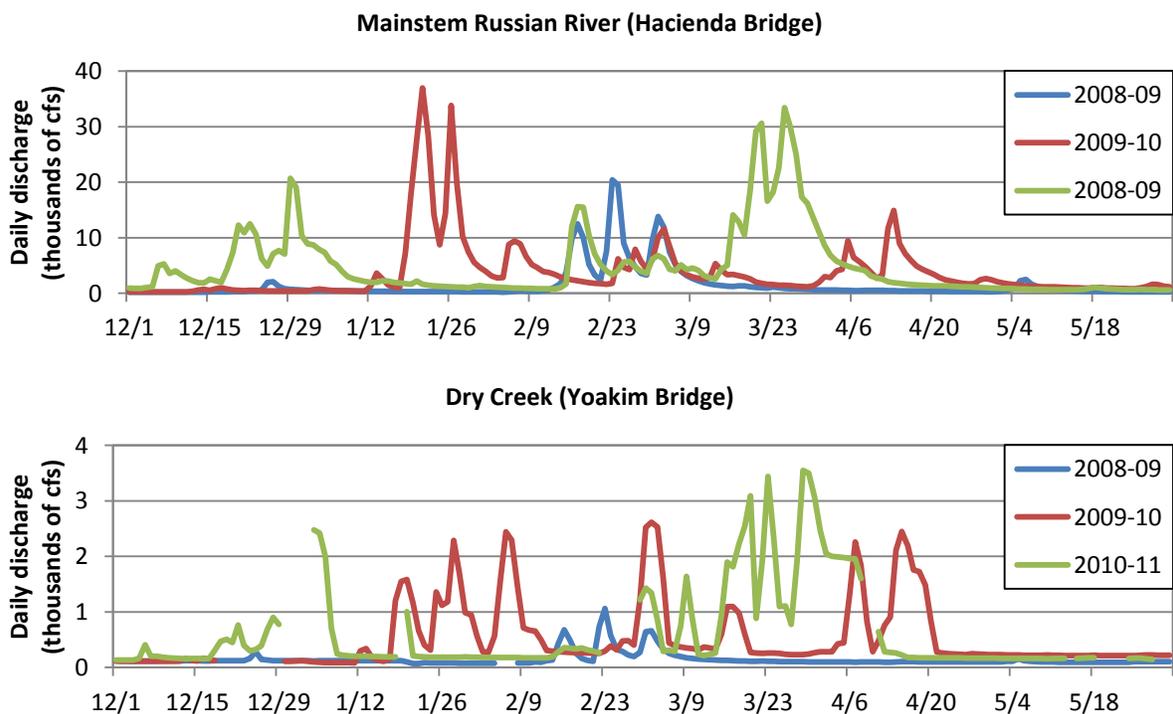


Figure 10.26. Daily discharge on the mainstem Russian River (upper panel) and Dry Creek (lower panel) during December 1-May 31 for water years 2008-2010.

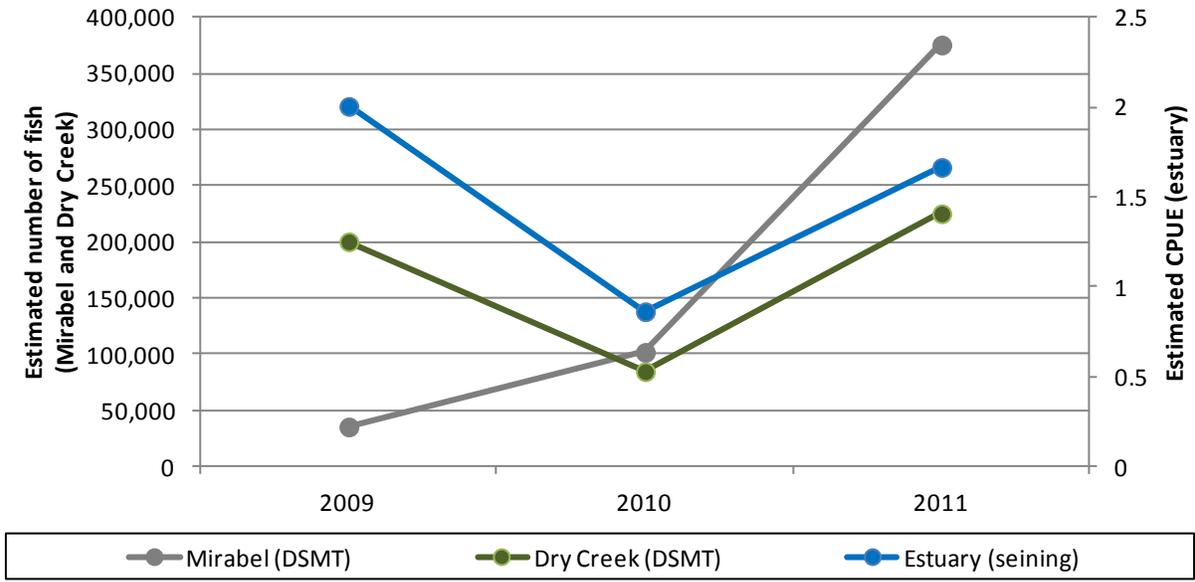


Figure 10.27. Indicators of Chinook salmon trends in the mainstem, Dry Creek and the estuary, 2009-2011.

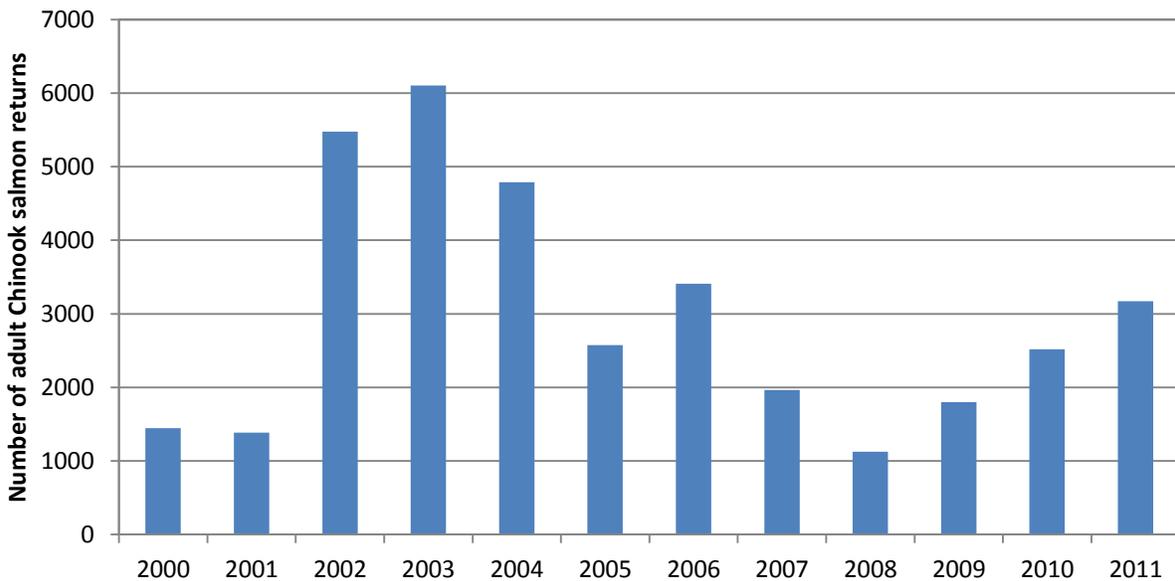


Figure 10.28. Number of adult Chinook salmon passing the video monitoring station at Mirabel on the mainstem Russian River by return year.

Juvenile steelhead movement and growth

In 2011, we PIT-tagged 1,595 individual juvenile steelhead at all sites combined (Table 10.4). We later gathered detection information on a portion of these individuals (Table 10.5) to help inform us about growth (Table 10.6, Figure 10.29) and transit time (Table 10.7) within and among various portions of the estuary, mainstem, lower River tributaries and Dry Creek.

In 2011 we continued to observe high juvenile steelhead growth rates for fish reared in the estuary (Figure 10.29) as well as movement of a significant proportion (77.5%) of steelhead out of lower Austin Creek and into the estuary. Based on detections at the Duncans Mills PIT antenna array, this rate of movement was rapid (<2 days) just as it was in 2010. Other than Austin Creek, we did not detect or capture any of the juvenile steelhead PIT-tagged at an upstream trap site in the estuary during seining or as they transitioned into the estuary at the PIT antenna site in Duncans Mills; however, only 122 juvenile steelhead were PIT tagged at Mirabel, Dutch Bill and Green Valley traps, combined.

Table 10.4. Number of juvenile steelhead PIT-tagged that were PIT-tagged and observed with PIT-tags at capture sites in 2011

Tributary	Survey2	Year	Applied	Observed	TOTAL
DRY CREEK	Downstream migrant trap	2009	0	1	1
		2010	0	2	11
		2011	0	2	2
	Electrofishing	2009	823	104	927
		2010	897	168	1,065
		2011	886	140	1,026
Mainstem	Downstream migrant trap	2009	17	0	17
		2010	96	3	99
		2011	99	1	100
Austin Creek	Downstream migrant trap	2009	0	0	0
		2010	997	113	1,110
		2011	500	30	530
Dutch Bill Creek	Downstream migrant trap	2009	0	0	0
		2010	46	0	46
		2011	23	1	24
Estuary	Downstream migrant trap	2009	4	0	4
		2010	0	0	0
		2011	0	0	0
	Beach seining	2009	0	0	0
		2010	240	41	281
		2011	87	18	105
TOTAL			4,715	624	5,348

Table 10.5. Number of PIT-tagged juvenile steelhead detected at various sites by location of tagging. Shaded numbers on diagonal indicate recapture/detection at the same site. Tributaries and sites are sorted from downstream to upstream (top to bottom and left to right) so numbers below diagonal indicate downstream movement while numbers above diagonal indicate upstream movement.

DETECTION / TAGGING SITE			RECAPTURE SITE														
			Estuary			Austin Creek		Dutch Bill Creek		Green Valley Creek		Mainstem		Dry Creek			
			Lower reach	Middle reach	Upper reach	Steel bridge	Gravel mine	Lower PIT	Smolt trap	Lower PIT	Lower smolt	Mirabel	Lower reach	Middle reach	Upper reach		
			Seining	Seining	PIT antenna	PIT antenna	DSMT	PIT antenna	DSMT	PIT antenna	DSMT	PIT antenna	PIT antenna	Efishing	PIT antenna	Efishing	PIT antenna
Estuary	Lower reach	Seining	11														
	Middle reach	Seining		0	1												
	Upper reach	PIT antenna			na												
		Seining				0											
Austin Creek	Steel bridge	PIT antenna	1	2	24	3	na										
	Gravel mine	DSMT		1	18		245	31	1								
Dutch Bill Creek	Lower PIT	PIT antenna							na								
	Monte Rio Park	DSMT							9	1							
Green Valley Creek	Lower PIT	PIT antenna								na							
	Lower smolt trap	DSMT									na						
Mainstem	Mirabel	PIT antenna									na						
		DSMT							1			na					
Dry Creek	Lower reach	PIT antenna									4		na	1			
		Efishing											53	35			
	Middle reach	PIT antenna											2		na	3	
		Efishing									1		13		18	95	8
	Upper reach	PIT antenna															na
		Efishing															6

Table 10.6. Mean individual growth rates (mm per day) of juvenile steelhead captured and tagged in 2011 and later recaptured in 2011. Numbers in parentheses represent sample sizes. Tributaries and sites are sorted from downstream to upstream (top to bottom and left to right) so numbers below diagonal indicate downstream movement while numbers above diagonal indicate upstream movement.

DETECTION / TAGGING SITE			RECAPTURE SITE						
			Estuary			Austin Creek	Dry Creek		
			Lower reach	Middle reach	Upper reach	Gravel mine	Lower reach	Middle reach	Upper reach
			Seining	Seining	Seining	DSMT	Electrofishing	Electrofishing	Electrofishing
Estuary	Lower reach	Seining	1.01 (11)						
	Middle reach	Seining		No recaptures					
	Upper reach	Seining			No recaptures				
Austin	Gravel mine	DSMT	1.3 (1)	0.89 (2)	1.7 (3)	na			
Dry Creek	Lower reach	Electrofishing					0.61 (15)		
	Middle reach	Electrofishing					0.25 (1)	0.48 (43)	
	Upper reach	Electrofishing							0.34 (3)

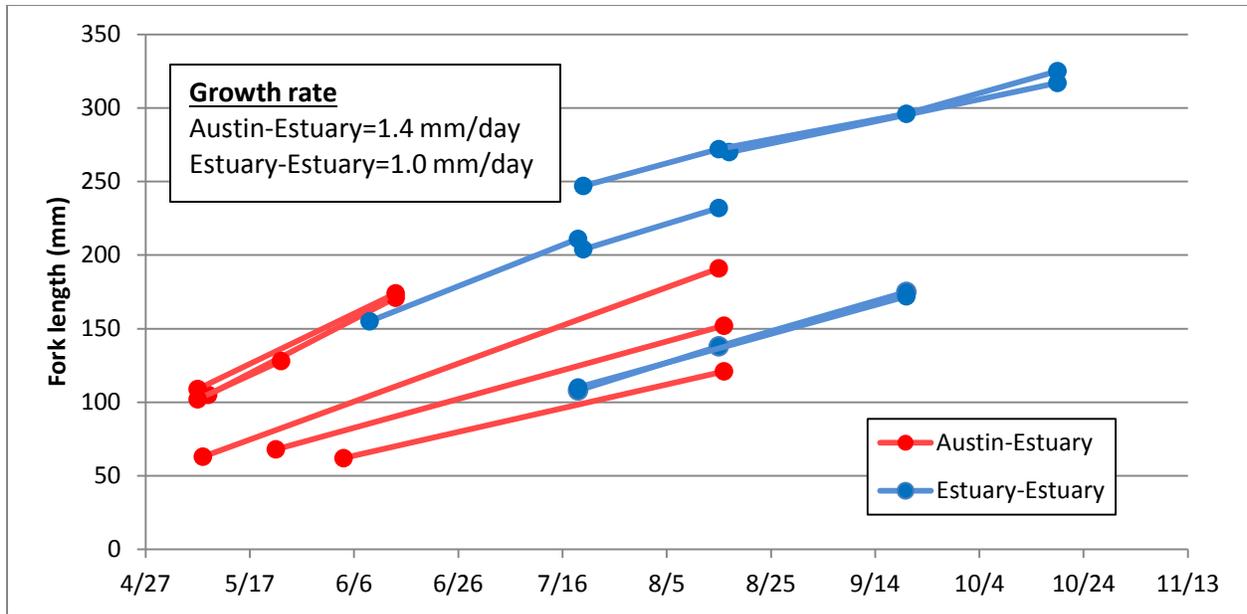


Figure 10.29. Fork lengths of individual PIT-tagged juvenile steelhead that were initially caught at the Austin Creek downstream migrant trap then later recaptured while beach seining in the estuary or initially captured while beach seining in the estuary then recaptured later while beach seining in the estuary.

Table 10.7. Median transit time (days) of juvenile steelhead between locations, 2011. Numbers in parentheses represent sample sizes. Tributaries and sites are sorted from downstream to upstream (top to bottom and left to right) so numbers below diagonal indicate downstream movement while numbers above diagonal indicate upstream movement.

DETECTION / TAGGING SITE			RECAPTURE SITE											
			Estuary				Austin Creek		Dutch Bill Creek		Green Valley Creek		Mainstem	
			Lower reach	Middle reach	Upper reach		Steel bridge	Gravel mine	Lower PIT	Smolt trap	Lower PIT	Lower smolt	Mirabel	
			Seining	Seining	PIT antenna	Seining	PIT antenna	DSMT	PIT antenna	DSMT	PIT antenna	DSMT	PIT antenna	DSMT
Estuary	Lower reach	Seining	29 (11)											
	Middle reach	Seining		nr	48 (1)									
	Upper reach	PIT antenna			na									
		Seining			nr									
Austin Creek	Steel bridge	PIT antenna	99 (1)	79 (2)	0 (24)	36 (3)	na							
	Gravel mine	DSMT		1	5 (18)		245	1 (31)	5 (1)					
Dutch Bill Creek	Lower PIT	PIT antenna							na					
	Monte Rio Park	DSMT							2 (9)	1				
Green Valley Creek	Lower PIT	PIT antenna									na			
	Lower smolt trap	DSMT										na		
Mainstem	Mirabel	PIT antenna										na		
		DSMT								2 (1)		na		

Chinook smolt migration

The addition of a downstream migrant trap on Dry Creek in 2009 has resulted in an ability to focus on an important smolt habitat transition area from two of the most highly flow-regulated portions of the watershed: Dry Creek and the mainstem Russian River. Significant changes to the flow regime in both Dry Creek and the mainstem are being contemplated thereby elevating the urgency for understanding the interactions between flow (and related factors) on salmonid growth and survival. Further, Dry Creek and its tributaries are of central importance for Chinook and steelhead populations in the basin and those streams are a focus of coho salmon recovery both in terms of ongoing efforts by the Russian River Coho Salmon Captive Broodstock Program as well as the extensive habitat enhancement projects outlined in the RPA and now being implemented in mainstem Dry Creek. In the following, we evaluate data from an increased effort in 2011 to understand how current conditions in this particular habitat transition area may affect Chinook smolt survival with the idea that these data can and should be extended to consider their affects on coho salmon smolts as well.

During the period April 18 through June 20 two groups of Chinook salmon smolts were captured, marked and captured again: a Mirabel-marked group and a Dry Creek-marked group. The Mirabel group was made up of 2,604 fish initially captured at the Mirabel trap, lower-caudal-clipped and released in Wohler pool approximately 1 km upstream of the trap between April 18 and June 19. A total of 167 of these fish (6.4%) were recaptured at the Mirabel trap between April 19 and June 20. The Dry Creek group was made up of 2,979 fish initially captured at the Dry Creek trap, upper-caudal-clipped and released back into Dry Creek between April 18 and June 18. A total of 108 of these fish (3.6%) were subsequently captured at the Mirabel trap between April 19 and June 20. That means that under a scenario of similar migration mortality for the two groups (Wohler to Mirabel vs. Dry Creek to Mirabel) we would expect to capture 6.4% of the entire population emigrating from Dry Creek at Mirabel yet we only captured 3.6%. Put another way, for every 1,000 fish leaving Dry Creek we should expect to have captured 64 at Mirabel yet we only captured 36 (a 44% reduction).

This lower capture rate of Dry Creek-marked fish at Mirabel could reflect higher migration mortality between the Dry Creek and Mirabel trap sites (approximately 27 km) as compared to Mirabel (approximately 1 km). If so, we can extend this result to estimate that approximately 2.1% per km of the Dry Creek population is perishing between the Dry Creek and Mirabel traps to result in 44% mortality. If we extend this 2.1% per km mortality rate another 40 km from Mirabel to the ocean, then 23% of the Chinook smolt population leaving Dry Creek between mid-April and mid-June survived to the ocean in 2011 (77% mortality). By comparison, we estimate that 43% of the fish making it to Mirabel survived to ocean entry (57% mortality).

Though significant, this level of mortality is not unrealistic in light of the annual number of adult Chinook returning to points upstream of the Mirabel dam. The range in annual smolt abundance estimated at Mirabel is 19,473 ($\pm 26\%$) to 375,662 ($\pm 28\%$). Assuming 43% of these fish survive to ocean entry, we estimate that that the number of smolts produced from points upstream of Mirabel that actually make it to the ocean has ranged from 8,373 to 131,305.

Based on the number of adult Chinook returning upstream of Mirabel (1,125 to 6,103), this suggests marine survival in the range of 1.5 to 4.6%, values that are consistent with the range of marine survival estimates reported in the literature.

The data outlined above forms the basis for a preliminary Russian River Chinook salmon population model that we constructed for the Russian River. Although several of the model parameters are as yet imprecisely estimated, this model could eventually be useful in evaluating the possible consequences of flow management changes in the mainstem Russian River and Dry Creek in relation to their impacts on smolt migration survival. For example, if marine survival was held constant, the current model suggests that a 10% increase in smolt migration mortality from Mirabel to the ocean would result in 25% fewer adult returns for a given cohort.

This preliminary Russian River Chinook salmon population model can be refined by more closely evaluating existing data as well as by collecting new data. An important area to explore is the effect of observed differences in body size between fish captured at the Dry Creek trap vs. fish captured at the Mirabel trap. Assuming Chinook fry emergence timing in Dry Creek is similar to fry emergence timing in the mainstem Russian River, size data collected since 2009 suggest that juvenile Chinook salmon grow slower in Dry Creek when compared to the mainstem and that mean differences in size are greatest during the early portion of the season (Figure 10.30). In order for individuals produced in Dry Creek to reach the size of individuals observed at Mirabel, growth rates would need to average 3.6 mm/day over the course of the sampling period and as high as 6.5 mm/day in mid-May. Based on travel time (median=2 days) and mean individual growth in fork length (0.43 mm/day) of 44 smolts that were PIT-tagged at the Dry Creek downstream migrant trap and subsequently captured at Mirabel (Figure 10.31), it is unlikely that Dry Creek fish grew quickly enough to catch up in size by the time they reached Mirabel. Instead, we hypothesize that observed size differences in the earlier part of the season were more a reflection of an increasing proportion of the Mirabel catch being comprised of Dry Creek fish as the season progressed; this is consistent with the later run timing observed in Dry Creek as well (Figure 10.32). Consequences of timing differences are that later migrating individuals are most likely facing less hospitable conditions (e.g., higher mainstem and estuary water temperatures) as compared to earlier migrating individuals. We expect that water temperature could affect survival either directly if fish become physiological compromised or indirectly through higher feeding activity by warm-water predators. By better understanding relationships between body size, timing and migration mortality, we could improve the model by adding components to the model that account for this sort of spatial and temporal variability.

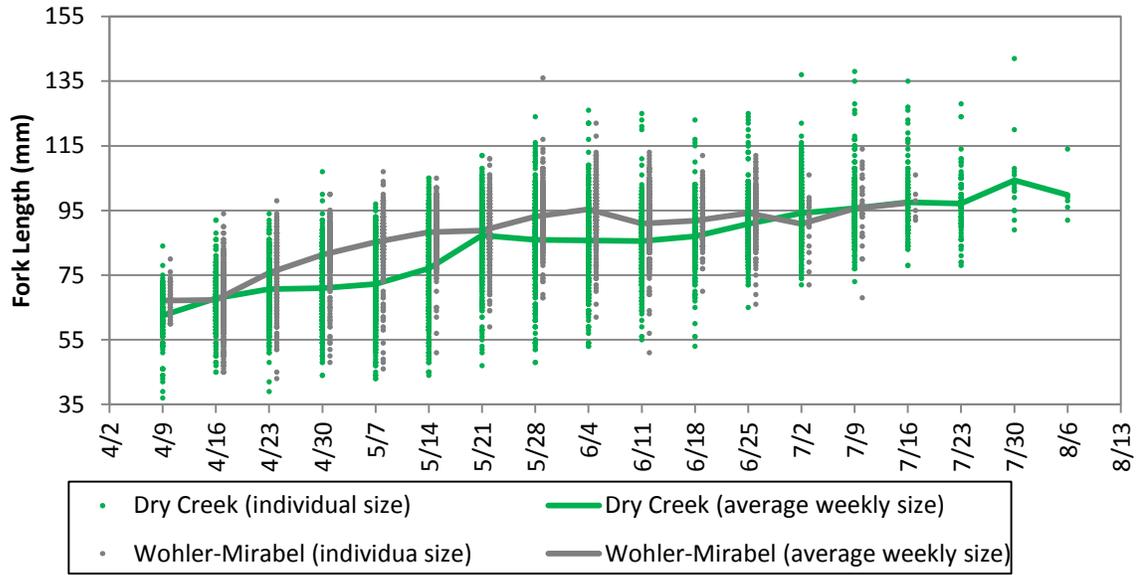


Figure 10.30. Individual and average weekly Chinook salmon smolt sizes at Dry Creek and Mirabel, 2011.

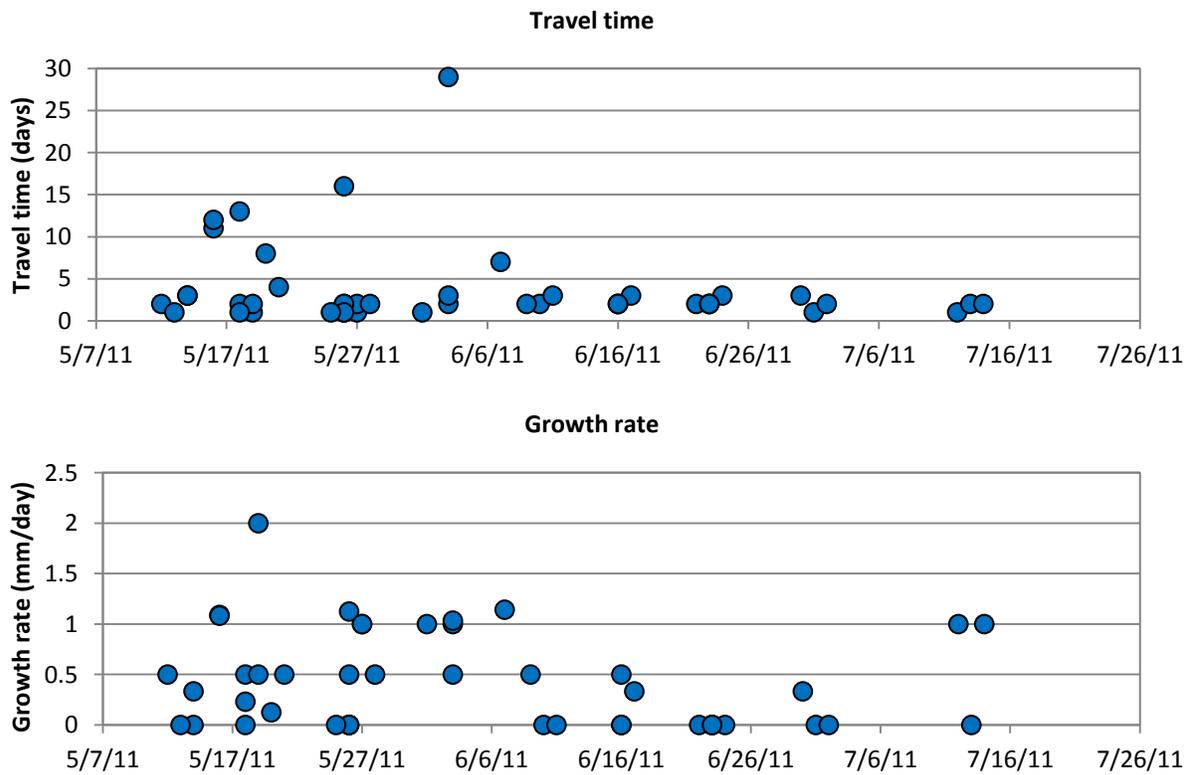


Figure 10.31. Travel time and growth rates of individual Chinook smolts PIT-tagged at the Dry Creek downstream migrant trap and subsequently recaptured at the Mirabel downstream migrant trap.

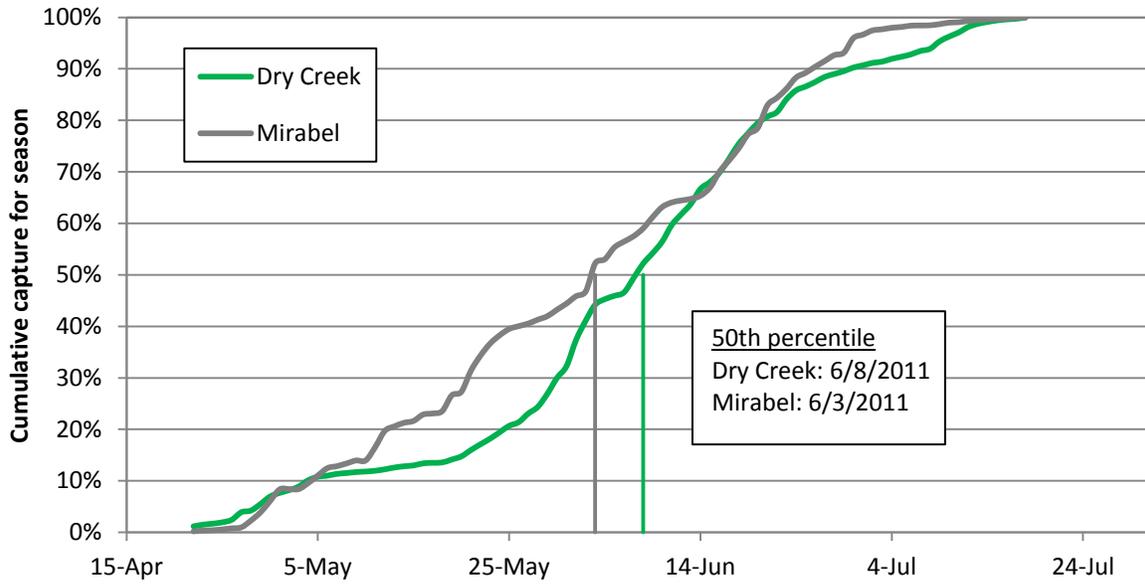


Figure 10.32. Cumulative daily population estimate of Chinook salmon smolts, 2011. Vertical lines represent date when 50th percentile was estimated at each trap location.

Salmonid movement and estuarine conditions

Water quality conditions in the tidal portion of the Russian River estuary vary along the approximately six mile length with generally warmer, less saline conditions in the upper reach and cooler more saline conditions in the lower reach (Manning and Martini-Lamb 2011; Martini-Lamb and Manning 2011). However, river inflow, water depth, barrier beach formation and wind patterns can strongly influence conditions at smaller spatial scales leading to a complex and dynamic system that varies greatly over space and time. Without high resolution data to match fish location (e.g., from acoustic telemetry studies) to water quality data specific to those locations, it will remain difficult to measure how fish respond to conditions in the estuary. In a general sense, however, we can begin to understand the range in water quality conditions that fish may be encountering as they move into and through the estuary by overlaying data on timing of fish movements with water quality data from upper and lower reaches of the estuary. These data sets can be augmented by considering information on fish travel time to the estuary from various upstream locations, residence time in the estuary and spatiotemporal patterns in food availability in the estuary.

We selected hourly records of water quality (temperature and dissolved oxygen) collected in Freezeout Pool (upper estuary) and Patty’s Rock (lower estuary) to represent water quality conditions in the tidal portion of the estuary in relation to water temperature and dissolved oxygen criteria from the literature (Table 10.8). We then show these data in relation to timing of fish capture at upstream trapping sites (Austin Creek, Mirabel, Dry Creek) as a way to illustrate conditions that were likely encountered by juvenile steelhead, coho smolts and Chinook smolts as they moved into and through the estuary in 2011.

Table 10.8. Temperature and dissolved oxygen thresholds used for ranking observed estuarine water quality for rearing salmonids in 2010. Temperature thresholds are based on Sullivan et al. (2000) and NCRWQCB (2000).

Quality	Maximum weekly average temperature (°C)	Dissolved oxygen (mg/l)
Excellent	13-17	7-12
Good	17-19	5-8
Poor	19-24	3-5
Very poor	>24	<3

Based on the seven day running average water temperature in the upper estuary (Freezeout Pool, RiverKm=9.6) and the lower estuary (Patty’s Rock, RiverKm=2.5) and the 50th percentile of the cumulative catch curves from upstream capture sites, fish emigrating during the first half of the outmigration period (May 1 to June 1) likely encountered predominantly good temperature and excellent dissolved oxygen conditions in the upper estuary and predominantly excellent temperature and dissolved oxygen conditions in the lower estuary (Patty’s Rock) (Figure 10.33). However, in the upper estuary during the later portion of the emigration period (after June 1) potentially stressful water temperature conditions (>21°C) prevailed. Water temperatures remained favorable (<19°C) later into the year in 2011 (June 8) than in 2010 (May 31) but high water temperatures (<24°C) were more common in 2011 than in either 2009 or 2010 (Figure 10.34).

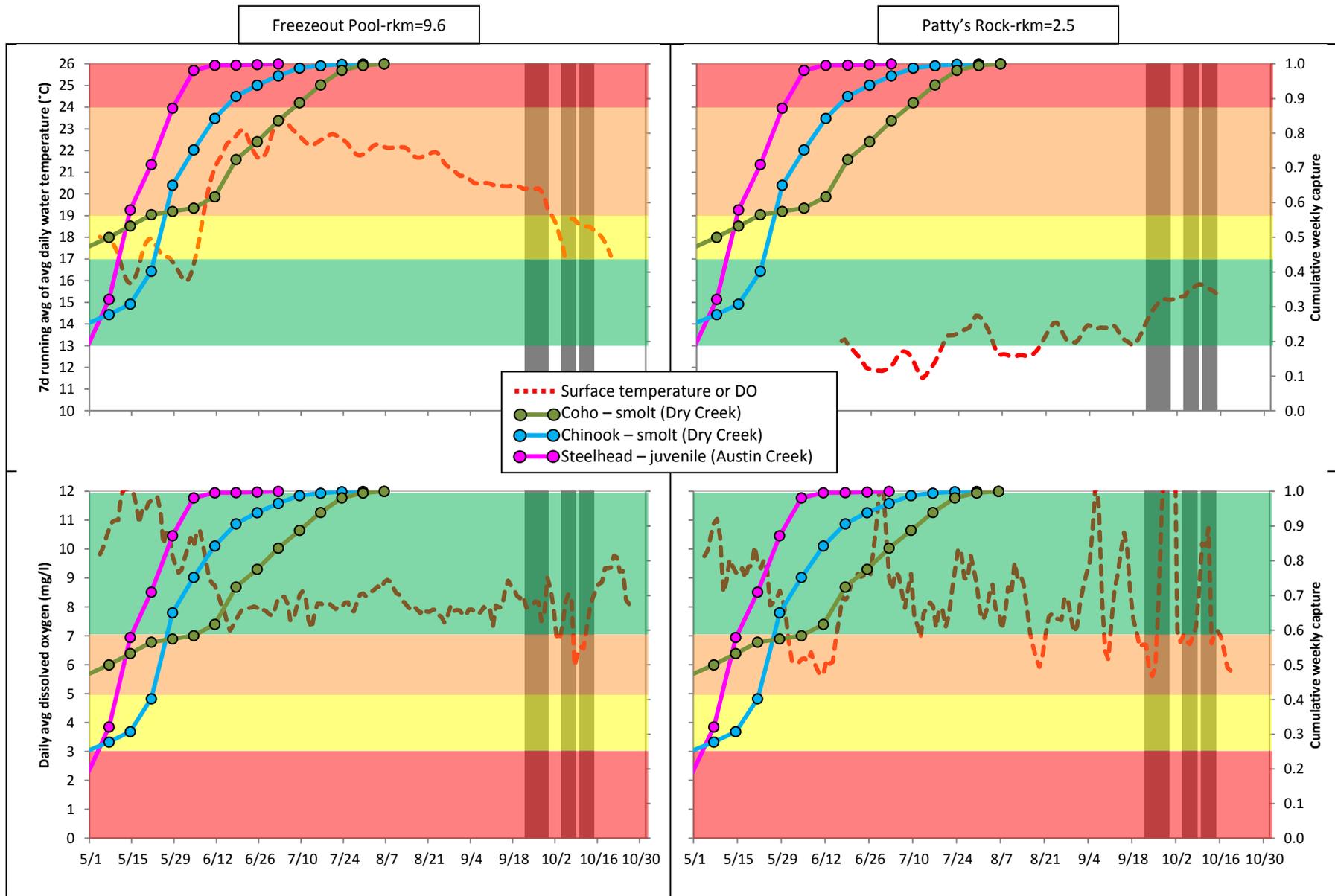


Figure 10.33. Seven day running average of daily average water temperature (upper panels) and average daily dissolved oxygen (lower panels) at Freezeout Pool (upper estuary) and Patty's Rock (lower estuary). Salmonid capture is from representative sites in the basin. Horizontal shaded areas correspond to literature-based criteria (see Table 10.8) and shaded vertical areas depict periods when the estuary was closed.

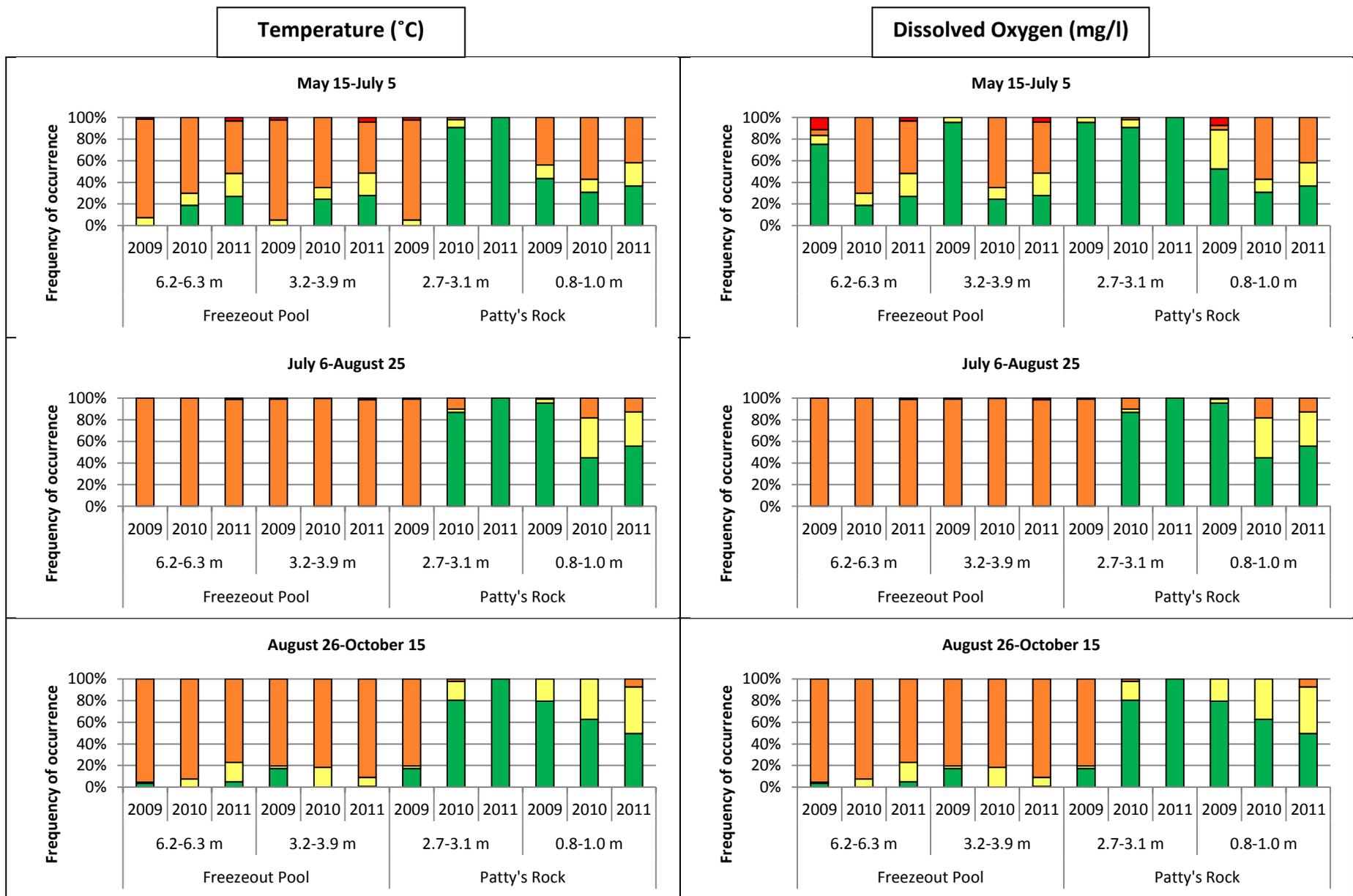


Figure 10.34. Comparison of frequency of occurrence of water temperature and dissolved oxygen bins at water quality monitoring sites in the upper estuary (Freezeout Pool) and lower estuary (Patty's Rock) between May 15 and October 15, 2009-2011.

Conclusions and Recommendations

In 2011, the Water Agency continued to refine methods and approaches for gathering the information necessary to inform the decisions as the RPA is implemented. As the Water Agency continues to implement the Russian River Biological Opinion, information on abundance, movement and growth will be key to our understanding of how various management actions outlined in the RPA translate to population benefits.

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11: Appendices

All Appendices are included in the accompanying electronic media.