Russian River Biological Opinion Status and Data Report

Year 2014-2015

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SONOMA COUNTY WATER AGENCY

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CHAPTER 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 Wildlife (CDFW) 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 CDFW.

Project implementation timelines in the Biological Opinion, and Consistency Determination, specify Water Agency reporting requirements to NMFS and CDFW and encourage frequent communication among the agencies. The Water Agency has engaged both NMFS and CDFW 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 sixth report for year 2014-2015. 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 salmon, coho salmon, 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.

References

National Marine Fisheries Service (NMFS). 2008. Biological Opinion for Water Supply, Flood Control Operations, and Channel Maintenance conducted by the U.S. Army Corps of Engineers, the Sonoma County Water Agency, and the Mendocino County Russian River Flood Control and Water Conservation District in the Russian River Watershed. September 24, 2008.

CHAPTER 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[1] 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 – 2014

Meetings

Public Policy Facilitating Committee (PPFC) meeting - The PPFC met in January 2015 for an update of the 2014 activities. Notices for the meeting were sent out to approximately 800 individuals and agencies and a press release was issued. Approximately 80 people attended the meeting and heard presentations from Josh Fuller, NMFS, Mike Dillabough, USACE and, from the Water Agency, Jessica Martini Lamb, Aaron Johnson, Gregg Horton, Dave Manning, Dave Cuneo, Steve Koldis, Ann DuBay, Justin Smith and Pam Jeane.

Community Meetings, Events & Tours – The sixth Russian River Estuary Lagoon Management Community Meeting was held in June 2014 at the Monte Rio Community Center. The meeting included discussions of this summer's Lagoon Management plans, results from 2013 water quality monitoring, what is being learned about harbor seals and other pinnipeds, an update on studies of the historic jetty at Goat Rock Beach State Park and a report on beach access and educational signs. Speakers included Matt Robart, Bodega Marine Lab, Brenda Adelman, Russian River Watershed Protection Committee, Michele Luna, Stewards of the Coast and Redwoods, and Gary Shannon, California State Parks. Speakers from the Water Agency were

[1] DFG (Department of Fish and Game) is now known as the California Department of Fish and Wildlife.

Jessica Martini Lamb, Jeff Church, Chris Delaney and Andrea Pecharich. There were no meetings held regarding the Fish Flow Project, as Water Agency staff worked internally on modeling and analysis.

A community meeting on Dry Creek habitat enhancement was held in May 2014 at the Lake Sonoma Visitors Center. The meeting was co-hosted by the Dry Creek Valley Association, the Winegrape Growers of Dry Creek, the USACE and the Water Agency. Informational mailers were sent to more than 700 people and about 75 people attended the meeting to hear about construction plans for summer 2014 and the conceptual plans for Miles 2 and 3.

Additional outreach included the Salmon Stewards of Dry Creek marketing program, which started in 2014, with the design of a logo and draft marketing materials. Water Agency staff met with winery/vineyard owners who participated in the Demonstration Project to collect their "stories" and to gage interest in the program. Large signs were posted at three prominent Dry Creek Valley locations informing cyclists and drivers of the Demonstration Project construction and possible traffic impacts. Ads were run in the Healdsburg Tribune about construction, and a press release was issued.

Tours held for public officials and others (coordinated with NMFS, DFG, Corps and Water Agency staff) included Congressman Jared Huffman; California's Undersecretary of the EPA, Gordon Burns; California's Office of Planning and Research director Debbie Davis; Nature Conservancy staff; California Governor's Office staff Mike McCoy; State Water Resources Control Board member Dee Dee D'Adamo; National Weather Service and California-Nevada River Forecasting staff; Water Education Foundation; International Water Association; and Dry Creek Valley Association members.

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 CDFW. From 2009 through 2011, the Advisory Group met regularly to review draft documents and discuss potential project plans. As project activities began to shift toward construction and implementation, Advisory Group meetings shifted focus to touring completed projects and receiving updates regarding future habitat enhancement activities.

Other Outreach

Free Media – Several articles about Biological Opinion projects appeared in 2014 in The Press Democrat, the Russian River Times, the West County News and Review, and North Bay Bohemian, and the Russian River Gazette. In 2014, press releases were issued on Mirabel fishway construction, Dry Creek habitat construction, community meetings regarding the estuary and Dry Creek, Chinook returns, coho releases and the Public Policy Facilitating Committee meeting.

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 Dry Creek habitat construction, which can be accessed via the agency's website. Email alerts regarding activities in the estuary were issued about a dozen times in 2014.

Materials – In 2014, the flyer regarding the Dry Creek Demonstration Project was updated several times to reflect different stages of construction and a flyer was mailed to neighbors on the Mirabel fish screen/fish ladder project. Other materials were updated and distributed at meetings, conferences, statewide forums, outreach events and through the Water Agency website.

CHAPTER 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 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 permits[2] issued by the State Water Resources Control Board (SWRCB) that authorize the Water Agency to divert[3] Russian River and Dry Creek flows and to re-divert[4] 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 (6

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[2] SWRCB water-right permits 12947A, 12949, 12950 and 16596.

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

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

to 8 years) process of petitioning the SWRCB for changes to minimum instream flow requirements, public notice of the petition, compliance with 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

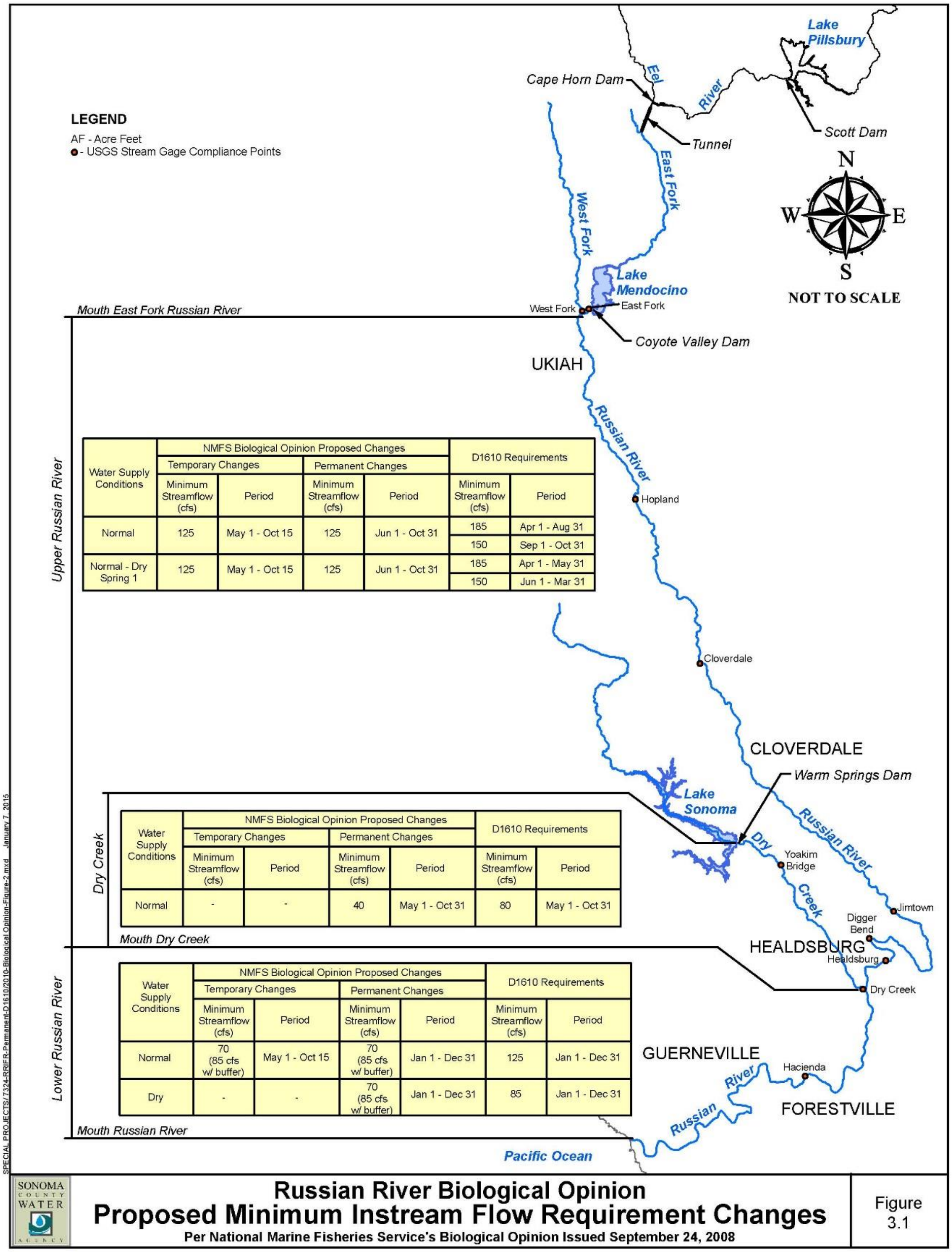
The Russian River Biological Opinion requires the Water Agency to begin the process of changing minimum instream flows by submitting a petition to change Decision 1610 to the SWRCB within one year of the date of issuance of the final Biological Opinion. The Water Agency filed a petition with the SWRCB 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.



Upper Russian River

Water Supply Conditions	NMFS Biological Opinion Proposed Changes: Temporary Changes – Minimum Streamflow (cfs)	Temporary Changes – Period	Permanent Changes – Minimum Streamflow (cfs)	Permanent Changes – Period	D1610 Requirements – Minimum Streamflow (cfs)	D1610 Requirements – Period
Normal	125	May 1 - Oct 15	125	Jun 1 - Oct 31	185	Apr 1 - Aug 31
					150	Sep 1 - Oct 31
Normal - Dry Spring 1	125	May 1 - Oct 15	125	Jun 1 - Oct 31	185	Apr 1 - May 31
					150	Jun 1 - Mar 31

Dry Creek

Water Supply Conditions	NMFS Biological Opinion Proposed Changes: Temporary Changes – Minimum Streamflow (cfs)	Temporary Changes – Period	Permanent Changes – Minimum Streamflow (cfs)	Permanent Changes – Period	D1610 Requirements – Minimum Streamflow (cfs)	D1610 Requirements – Period
Normal	-	-	40	May 1 - Oct 31	80	May 1 - Oct 31

Lower Russian River

Water Supply Conditions	NMFS Biological Opinion Proposed Changes: Temporary Changes – Minimum Streamflow (cfs)	Temporary Changes – Period	Permanent Changes – Minimum Streamflow (cfs)	Permanent Changes – Period	D1610 Requirements – Minimum Streamflow (cfs)	D1610 Requirements – Period
Normal	70 (85 cfs w/ buffer)	May 1 - Oct 15	70 (85 cfs w/ buffer)	Jan 1 - Dec 31	125	Jan 1 - Dec 31
Dry	-	-	70 (85 cfs w/ buffer)	Jan 1 - Dec 31	85	Jan 1 - Dec 31

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 submitted a Temporary Urgency Change Petition to the SWRCB on December 19, 2013, due to severely low storage levels in Lake Mendocino. The SWRCB issued an Order approving the Water Agency's TUCP on December 31, 2013. This Order was amended on March 7, 2014, due to the ongoing drought conditions and in accordance with the Governor's Drought State of Emergency declaration (Appendix A-1).

The Water Agency then petitioned the SWRCB for temporary changes to Decision 1610 on August 13, 2014 (Appendix A-2). 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 order to preserve storage in Lake Mendocino, which was extremely low due to persistent drought conditions in the Russian River watershed since January 2013.

The Water Agency requested that the SWRCB make the following changes to the Water Agency's permits for a period of 180 days from August 15, 2014, until February 10, 2015: (1) reduce the required minimum instream flow in the Russian River from the confluence of the East and West Forks to the river's confluence with Dry Creek from 75 cfs to 50 cfs; and (2) reduce required minimum instream flow in the Russian River from its confluence with Dry Creek to the Pacific Ocean from 85 cfs to 60 cfs. To allow the Water Agency to optimally manage flows in the Upper Russian River and Lower Russian River, the Water Agency requested that the TUCP minimum instream flow requirements be specified as 5-day running averages of the specified minimum average daily stream flows, with the conditions that instantaneous flows in the Upper Russian River were never less than 40 cfs and instantaneous flows in the Lower Russian River were never less than 50 cfs. These 5-day running average provisions allowed the Water Agency to reduce the operational buffers needed to manage these stream flows, thereby allowing the Water Agency to conserve more water in Lake Mendocino. Higher Lake Mendocino storage levels in the fall benefited migrating Chinook salmon and improved carryover storage volumes to meet Upper Russian River demands into 2015. The SWRCB issued an Order approving the Water Agency's TUCP on August 25, 2014 (Appendix A-3). Due to the urgency of storage levels in Lake Mendocino, the SWRCB issued a public notice of the Water Agency's petition on August 26, 2014 (Appendix A-4). The order included several terms and conditions, including requirements for fisheries habitat monitoring and regular consultation with National Marine Fisheries Service and California Department of Fish and Game regarding fisheries conditions (Terms 2 to 6), preparation of a water quality monitoring plan and summary data report (Terms 7 and 10), reporting on hydrologic conditions of the Russian River system (Terms 11, 14 and 15), reporting of activities and programs implemented by the Water Agency and its contractors to assess and reduce water loss and promote increasing water use efficiency (Term 16), and operations in accordance with a Water Demand Reduction Plan (Term 17).

Reports to fulfill the terms of the order were prepared and submitted to the SWRCB and are provided in Appendix A-5. The reports included: Term 16 -Water Loss and Water Use Efficiency; and Provision 17 -Water Demand Reduction Plan.

Provisions 2 through 6 of the State Water Board Order required the Water Agency to conduct and report on fisheries conditions. Updates of fisheries monitoring and consultation status were sent to NMFS and CDFW staff every two weeks per the State Water Board Order.

The Water Agency conducted weekly bacteriological, nutrient and algal mainstem sampling at five sites in the Russian River Estuary. All samples were analyzed for nutrients, chlorophyll *a*, standard bacterial indicators (total coliforms, *E. coli* and enterococci), total and dissolved organic carbon, turbidity, and total dissolved solids. Bacteria analysis for the Water Agency was conducted by the Sonoma County DHS Public Health Division Lab in Santa Rosa. *E. coli* and total coliform were analyzed using the Colilert method and enterococcus was analyzed using the Enterolert method. In addition, data sonds monitoring temperature, dissolved oxygen, pH, and specific conductance were operated at multiple stations from Ukiah to Jenner.

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.

CHAPTER 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 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). When a barrier beach forms and closes the river mouth, a lagoon forms behind the beach and reaches up to Vacation Beach.

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.

The National Marine Fisheries Service's (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 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 2013. These actions are also required by other regulatory permits issued for the Estuary Management Project, including the California Coastal Commission's Coastal Development Permit (CDP). References to the Biological Opinion's RPA are used to maintain consistency with previous annual reports.

Barrier Beach Management

RPA 2 requires the Water Agency, in coordination with NMFS, California Department of Fish and Wildlife (CDFW), and the U.S. Army Corps of Engineers (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, CDFW, 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 Environmental Science 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, CDFW, and California State Parks (State Parks). The annual meeting with regulatory agency staff to discuss the prior year's beach management activities and preparation of the updated 2014 annual Outlet Channel Adaptive Management Plan was held on March 11, 2014. In attendance were staff from the Water Agency, ESA PWA, University of California, Davis's Bodega Marine Laboratory (Bodega Marine Lab), NMFS, CDFW, North Coast Regional Water Quality Control Board (NCRWQCB), and the USACE. Only minor updates to the prior year's plan were made in the 2014 plan, which includes a summary of physical processes during 2011, 2012, and 2013 as Appendices F, G, and H, respectively. The revised plan was in effect for 2014, but no opportunities for management action occurred during the management period. Outlet channel implementation has occurred only in 2010 and is summarized in Appendix F of the 2014 Outlet Channel Adaptive Management Plan (Appendix B-1).

A monthly topographic survey of the beach at the mouth of the Russian River is also required under RPA 2. Topographic data was collected monthly in 2014 and provided to NMFS and CDFW. The December 2014 topographic survey was not performed due to hazardous beach conditions and storm events that month. The beach topographic maps are provided in Appendix B-2.

ESA prepared the 2015 Russian River Estuary Outlet Channel Adaptive Management Plan (Appendix B-3). The approach of the plan was to meet the objective of RPA 2 as described previously. The annual meeting with regulatory agency staff to discuss the prior year's beach management activities and preparation of the updated 2015 annual Outlet Channel Adapative Management Plan was held on April 9, 2015. In attendance were staff from the Water Agency, ESA PWA, Bodega Marine Lab, NMFS, CDFW, NCRWQCB, and the Lawrence Berkeley National Laboratory. Only minor updates to the prior year's plan were made in the 2015 plan, which includes a summary of physical processes during 2011, 2012, 2013, and 2014 as Appendices F, G, H, and I, respectively.

As described in Appendix I of the 2015 Outlet Channel Adaptative Management Plan, during the 2014 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. Although several short-lived closure events occurred throughout late April and early May, the first four months of the management period experienced only tidal conditions. An extended closure event began on September 17, 2014. Because of reduced inflows, the lagoon's stage rose slowly and did not reach an appropriate level for enacting the outlet channel unitl the end of the management period. Except for a few days immediately after artificial breaches, the lagoon remained closed from late September throught late November (ESA PWA 2015).

Lagoon Management Season Closures and Self-Breaches

Time series of Estuary water levels, as well as the key forcing factors (waves, tides, and riverine discharge), are shown in Figure 4.1 for the entire management period (ESA PWA 2015). The lagoon water level time series (Figure 4.1a) summarizes the closure events at the beginning of the management period, as well as the subsequent tidal conditions and later closure events in fall. As shown in Figure 4.1d, discharge was low for most of the management period, dropping from 7,000 ft^3/s on April 2, 2014, to below 100 ft^3/s on May 21. In mid-July, flows briefly reached 200 ft^3/s and remained above 100 ft^3/s for about a week. Afterwards, flows slowly declined until they reached a minimum of 55 ft^3/s on October 7th. As in prior years, wave energy in the subsequent months of July-September was minimal (Figure 4.1b). A late season swell event (H_s > 8 ft, T_p > 14s) occurred in late June, and may have led to the subsequent week of muted tides in the lagoon, but did not lead to full inlet closure. A gap in Pt. Reyes wave buoy data for the dominant period (T_p) for parts of September and October prevented nearshore transformation of waves during this time. At the end of the management season, high wave events overtopped the beach berm, delivering enough water to the lagoon to increase the daily

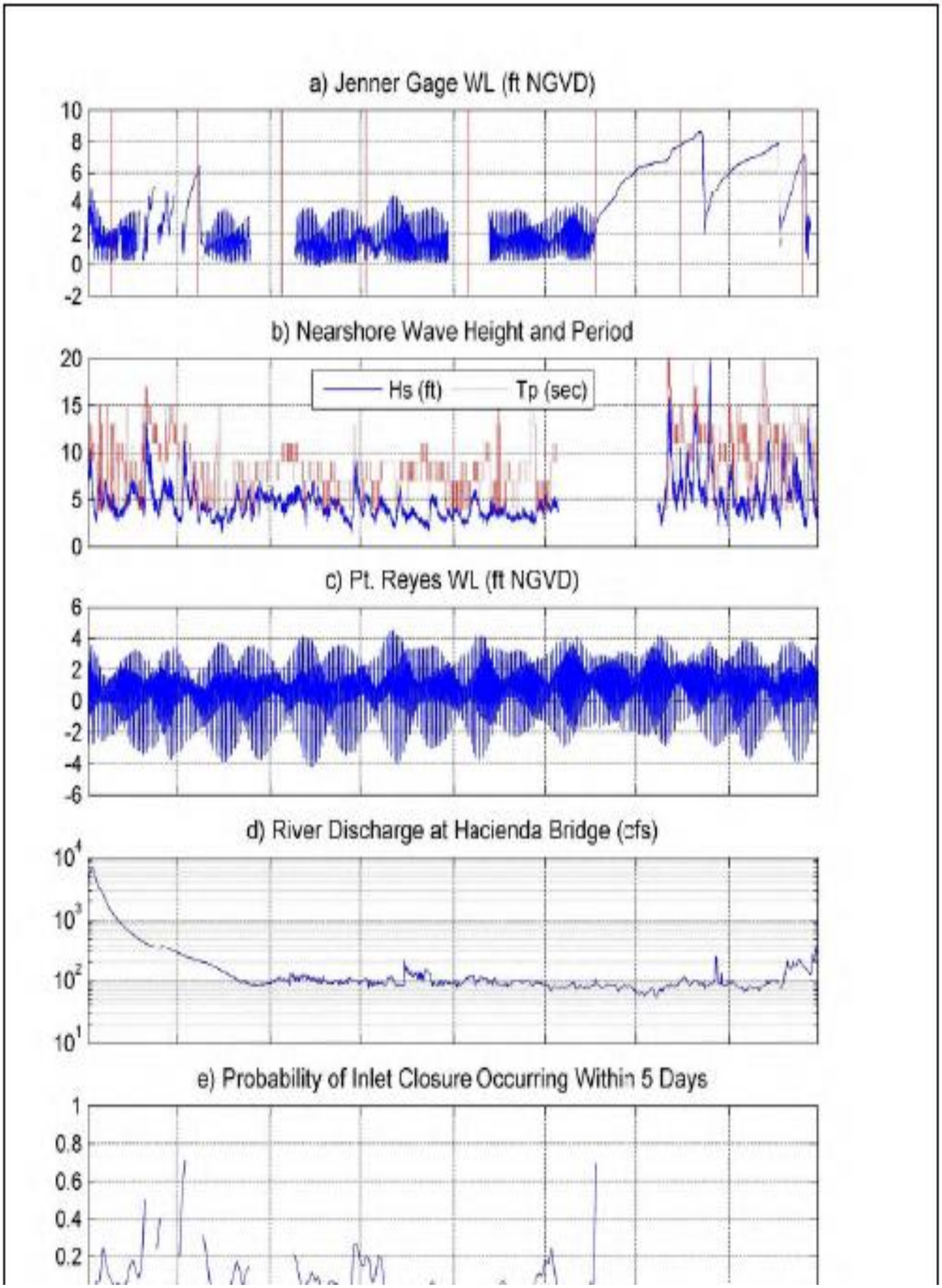


Figure 4.1. Estuary, Ocean, and River Conditions Compared with Closure Probability: April – November 2014.

rises in lagoon stage to 0.4-0.8 ft during the late-season closure event. Overtopping is visible in photographs taken by the river mouth overlook camera. These large waves also prevented breaching equipment from accessing the beach.

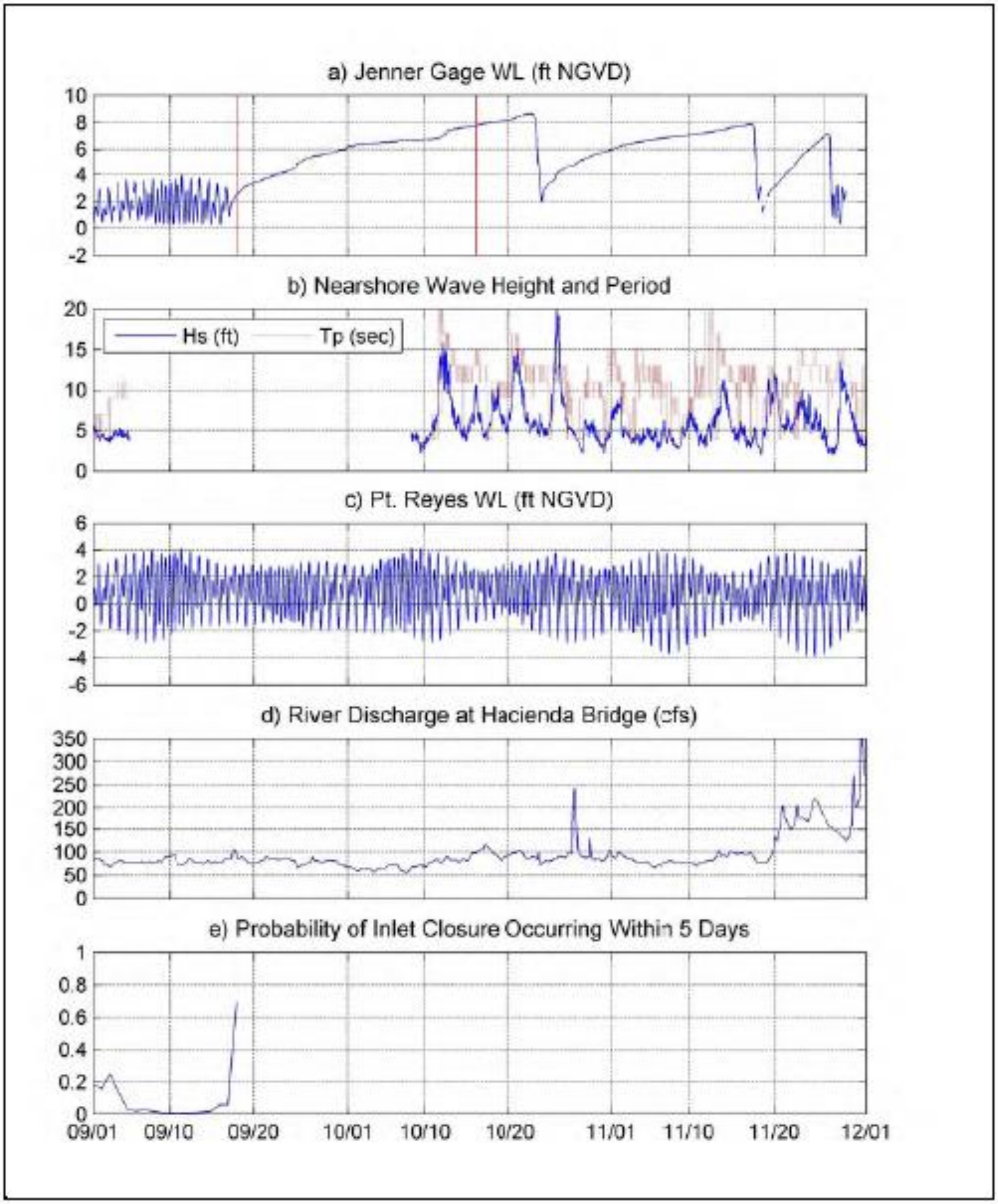
The conditions leading to inlet closure were consistent with the existing conceptual model described in Section 4 of the Management Plan. All closure events coincided with either moderately high waves ($H_s > 6$ ft) having periods greater than 10 s, or with neap oceanic tide ranges of less than approximately 5 ft, with the exception of the September closure event, when nearshore waves could not be estimated. Moderately high waves coincided with the closure events in April and May. The September closure event occurred during a neap tide. The artificial breach events that occurred on October 22 and November 17 were coincident with neap tides and large to moderate waves, and were followed by closure within less than one day. The artificial breach event on November 26 happened during a spring tide, and was not followed by closure. The persistent closure conditions from September through November are examined in more detail in Figure 4.2.

As in 2012 and 2013, all closure events occurred when the inlet was adjacent to the jetty. In former years, this positioning may have prevented perched conditions from arising by shielding this area of the beach from the wave-driven sediment deposition that caused closure, preventing the beach from accreting to a sufficient height to allow the desired outlet channel elevations from being attained. This may have been the case for the September closure event in 2014 as well. Wave overwash in mid-October did appear to provide enough volume to raise the lagoon stage to a level requiring artificial breaching, but the same wave overwash also made work on the beach impossible, and occurred too late in the management season for a channel to be created.

Late-Season Closure Event

The only event that would have provided an opportunity for implementing the outlet channel occurred on September 17th. Inflows generally were below 100 ft^3/s throughout the event, allowing the stage to remain lower than 7 ft NGVD for almost a month of closure. The largest increases in stage happened on September 25th and October 12th due to wave overwash. The overwash raised the stage by about three quarters of a foot. Otherwise the weak inflows allowed the stage to rise at a very slow pace; the stage increased from roughly 5.0 ft NGVD on September 26th to approximately 6.8 ft NGVD on October 11th, and average increase of about 0.1 feet per day. Flows during this time were less than 85 ft^3/s and dipped to as low as 55 ft^3/s.

To better illustrate both the lagoon stage and beach morphology during this time, Figure 4.3 shows a sequence of photos of the inlet before and during this closure event. As was the case for all of the management period, the inlet was located next to the jetty. Figure 4.3a depicts the inlet when it was located next to the jetty several days before closure, indicating a width of less than roughly 40 ft. Nearshore waves could not be estimated for the week of closure, but are likely to have played a role, since waves generally begin to increase in energy in September. Neap tide conditions were present during the week of closure, with the oceanic tide range measured at approximately 4 feet (Figure 4.2c). Figure 4.3d shows extensive wave overwash surging over the beach berm and into the lagoon.

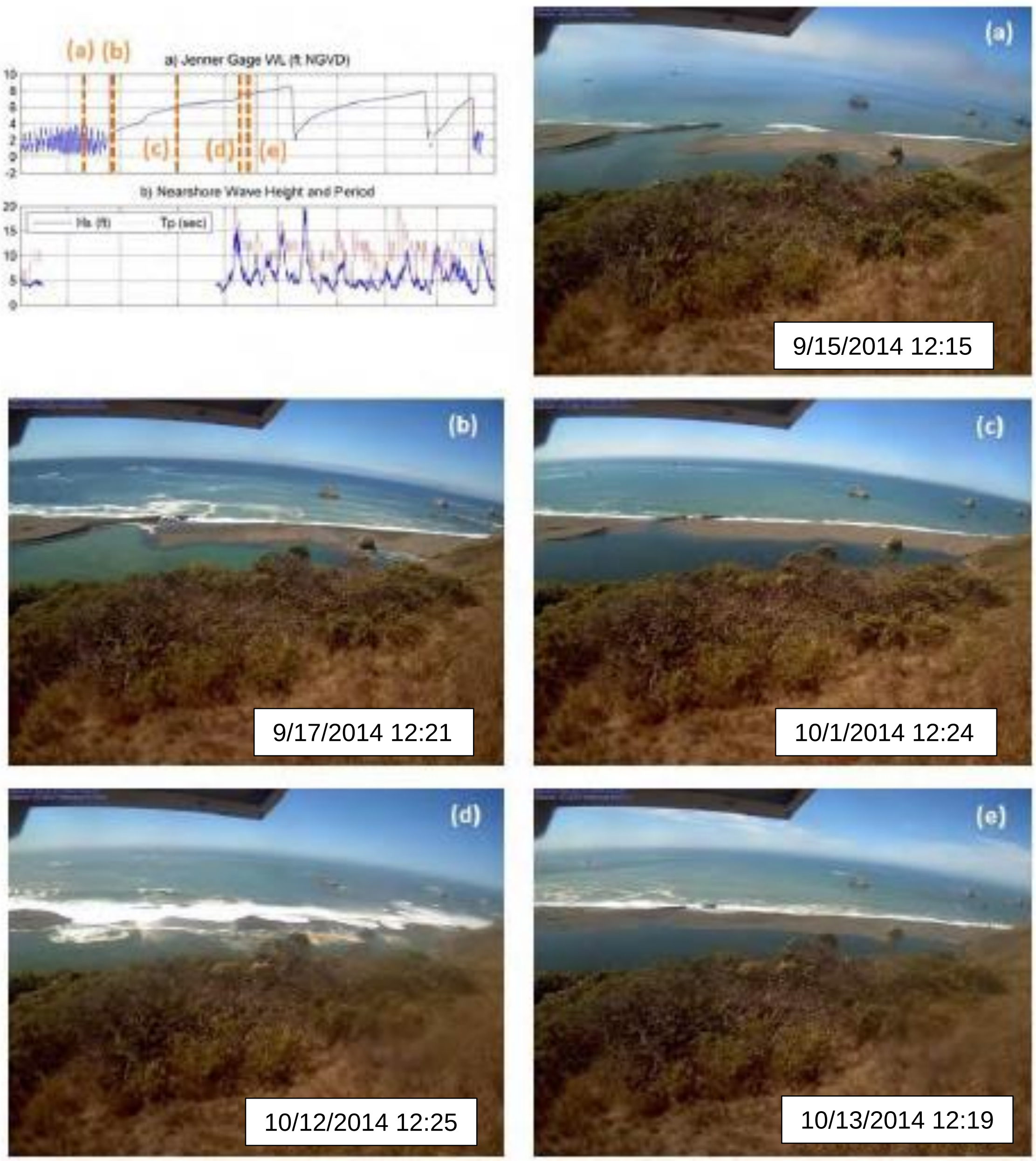


Russian River Estuary Outlet Channel Management Plan . DW01958

SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; Tp=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

Figure 4.2. Estuary, Ocean, and River Conditions Compared with Closure Probability: September – November 2014.



Russian River Estuary Outlet Channel Management Plan . DW01958

SOURCE: SCWA camera

Figure 4.3. Russian River camera photographs showing some of the key morphologic influences during the September-October 2014 closure event.

Unlike the 2012 management period, no natural outlet channels were formed near the jetty in 2014. However, as with 2012 and other previous years, the lowest portion of the beach was consistently located at the jetty. This persistent low portion is probably caused by wave sheltering by the jetty, which may have reduced berm build-up at the inlet's location, leaving a low point in the beach berm that was the site for subsequent overtopping and natural breaching.

Appendix I of the 2015 Russian River Estuary Outlet Channel Adaptive Management Plan offers lessons learned based on 2014 observations of the Estuary, associated physical processes, and the Water Agency's planning for outlet channel management. These are summarized here and may be found in Appendix B-3 of this report for fuller context:

- The beach north of the inlet saw little change from the 16-18 ft NGVD elevations established in 2013. Near the jetty, the berm was lowered by inlet migration while undergoing beach building.
- Similar to the winters of 2011-12 and 2012-2013, the inlet never migrated north of Haystack Rock during winter 2013-14, and returned to the jetty in early spring, much earlier than in most years. This inlet alignment is not common, but has been observed in past years (Behrens et al., 2009).
- Peak annual river discharge has remained below 40,000 ft3/s for 9 consecutive years, a streak unmatched in the 70-year flow record. This may have a connection to the recent lack of inlet migration to the north.
- The beach width in 2014 at Transect 3 (near Haystack Rock) was larger than in 2013. This may suggest that beach width is closely tied to inlet migration – the lack of migration north of Haystack Rock for several years has allowed the beach to grow at this end of the littoral cell.

Artificial Breaching

The Water Agency artificially breached (breaching) the barrier beach at the Russian River mouth outside the lagoon management period in 2014. The breachings were necessary to minimize flood risk to low-lying structures, which occurs at or above an elevation of approximately 9 feet NGVD at the Jenner gage located at State Parks' Jenner visitor center. No beach management activities occurred during the lagoon management period (May 15 – October 15).

The methods to artificially breach the barrier beach followed all state and federal permit requirements. These requirements included notification to State Parks' District headquarters, Sonoma Coast lifeguards, Monte Rio Fire Department, postings at Goat Rock State Beach and the State Parks' visitors center in Jenner (the Water Agency also placed public notifications at seven additional locations in the Estuary area); restricting equipment and activities to the breaching area; removal of equipment daily; and pinniped monitoring before, during, and after breaching.

Dune habitat and pinniped monitoring followed permit requirements from the California State Lands Commission, California Coastal Commission, CDFW, State Parks, NCRWQCB, USACE, and NMFS. No vegetation was disturbed and no animals were injured or killed. Pinniped monitoring followed procedures required by the Marine Mammal Protection Act Incidental Harassment Authorization issued by the NMFS for the Estuary Management Project.

The Water Agency conducted six breachings during winter, spring, and fall 2014 (Table 4.1; Figure 4.4). Time series photographs of each breaching event are shown in Figures 4.5 – 4.10. Three of these mouth closures occurred during December-January and March. These unusual winter to early-spring closures were influenced by very low river flows caused by severe drought. The dry winter conditions coincided with typical winter energetic swell waves that deposited sand on the barrier beach and closed the river mouth. In consultation with the resource agencies, the Water Agency conducted its winter breachings in January and March near the jetty to encourage the inlet to stay open longer for migrating salmonids and to ensure that the breaching stayed within the Water Agency's permitted excavation limits of 2,000 cubic yards (CY). During fall closures in September through Novembe,r artificial breaches were conducted near Haystack Rock, located at the north end of Goat Rock Beach. The intent of this alignment was to discourage the inlet from re-establishing next to the jetty and to build the height and width of the beach north of the jetty. This alignment would facilitate a mouth opening toward the north end of the beach during the lagoon management period.

A pre-construction field meeting to discuss pinniped haulouts, permit conditions, and safety issues was held at the Highway 1 overlook in the morning with Water Agency staff prior to staff entering the beach (Figure 4.4) for each breaching event. Project activities were monitored by the project manager, breaching crew lead staff, and biological monitor at the Highway 1 overlook and were in radio contact with the breaching crew on the beach.

The Water Agency breaching crew was comprised of the equipment operator, two staff on foot monitoring safety conditions, and an additional staff member near the jetty and work area boundary to talk with any beach visitors. The excavator was escorted from the Goat Rock State Beach parking lot across the unvegetated sandbar to the river mouth. Excavation of a pilot channel across the sandbar took about 1 to 4 hours to complete, depending on the size of the barrier beach and water surface elevations. The excavator and field crew departed the beach once the barrier beach was breached. The dimensions of the excavated pilot channel were approximately 50-150 feet long by 15 feet wide with an average depth of 6 feet. The volume of sand excavated was less than the permitted 2,000 CY (Table 4.1). Water surface elevations within the Estuary receded over the next several hours. River flows scoured the pilot channel and side casted sand to a width of approximately 100 feet and depth of 6-8 feet within one day.

Staff and equipment cautiously and slowly approached the breaching site and harbor seal haulout. The locations of harbor seal haulouts and numbers of seals are shown on Figures 4.5 through 4.10. Following a breaching event harbor seals returned to a haulout (usually at the location of the constructed pilot channel) within a day after a breach. Harbor seal numbers the day after breaching were similar, or higher, than observed prior to breaching. No seal pups were observed on the beach during any breaching event. Refer to the “Pinniped Annual Monitoring” section in this report for further details.

Table 4.1. Summary of Russian River barrier beach artificial breachings conducted in 2014. Location of activities are shown on Figure 4.4.

River Closure Date	Breaching Date	Number Days Closed	Start and End Time[1]	Jenner Gage Elevation (feet)	Excavation (CY)[2]	Pilot Channel Location
12/24/2013	01/02/2014	10	1011-1152	7.37	700	Near Jetty
01/11/2014	01/30/2014	19	1143-1514	8.03	450	Near Jetty
03/21/2014	03/24/2014	4	0834-0914	9.42	140	Near Jetty
09/17/2014	10/22/2014	35	1111-1456	8.68	652	Near Haystack Rock
10/24/2014	11/17/2014	24	0930-1330	7.92	1,284	Haystack Rock
11/19/2014	11/26/2014	7	0924-1234	7.16	1,293	Haystack Rock

[1] Estimated period that excavator/bulldozer equipment was on the beach.
[2] Estimated volume of sand excavated with heavy equipment during artificial breaching or lagoon management activity.

Figure 4.4. Russian River at Goat Rock State Beach. General location of artificial breaching pilot channel excavations in 2014.

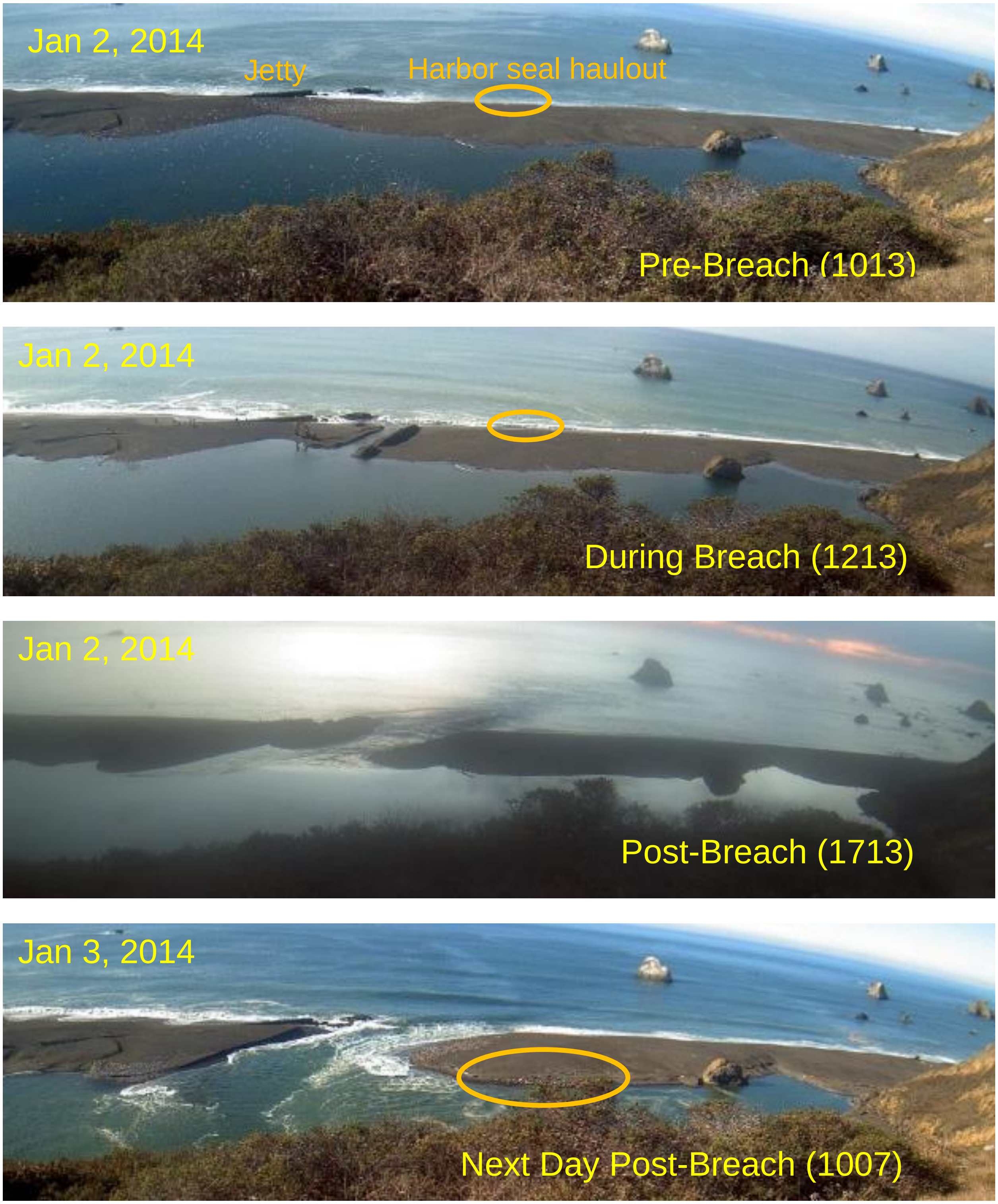


Figure 4.5. Artificial breaching at the mouth of the Russian River Estuary, January 2, 2014. Photographs show pre- through post-breaching conditions.

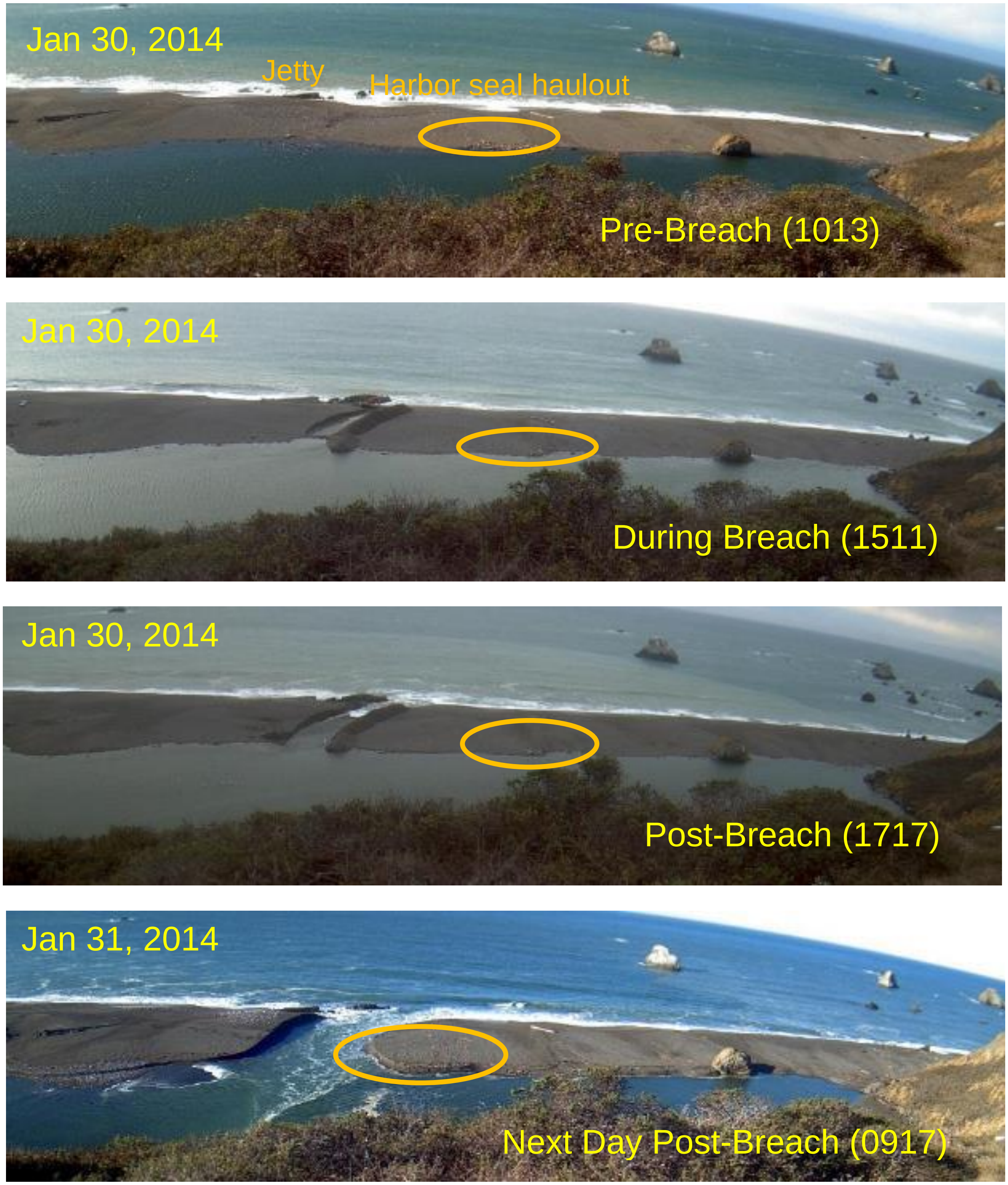


Figure 4.6. Artificial breaching at the mouth of the Russian River Estuary, January 30, 2014. Photographs show pre- through post- breaching conditions.

Figure 4.7. Artificial breaching at the mouth of the Russian River Estuary, March 24, 2014. Photographs show pre- through post-breaching conditions. Early morning photos on March 24 prior to breaching were obscured by fog.

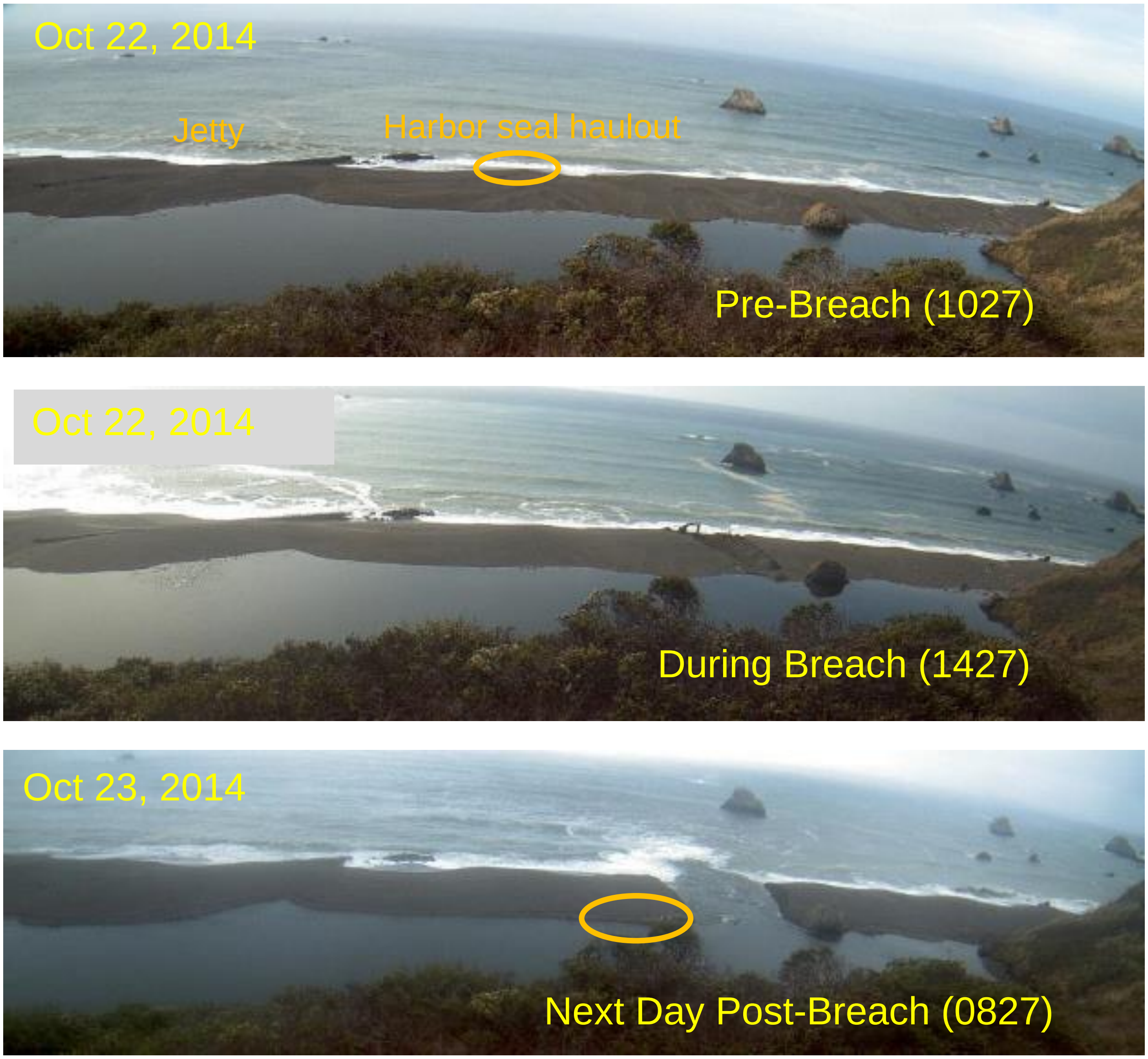


Figure 4.8. Artificial breaching at the mouth of the Russian River Estuary, October 22, 2014. Photographs show pre- through post-breaching conditions.

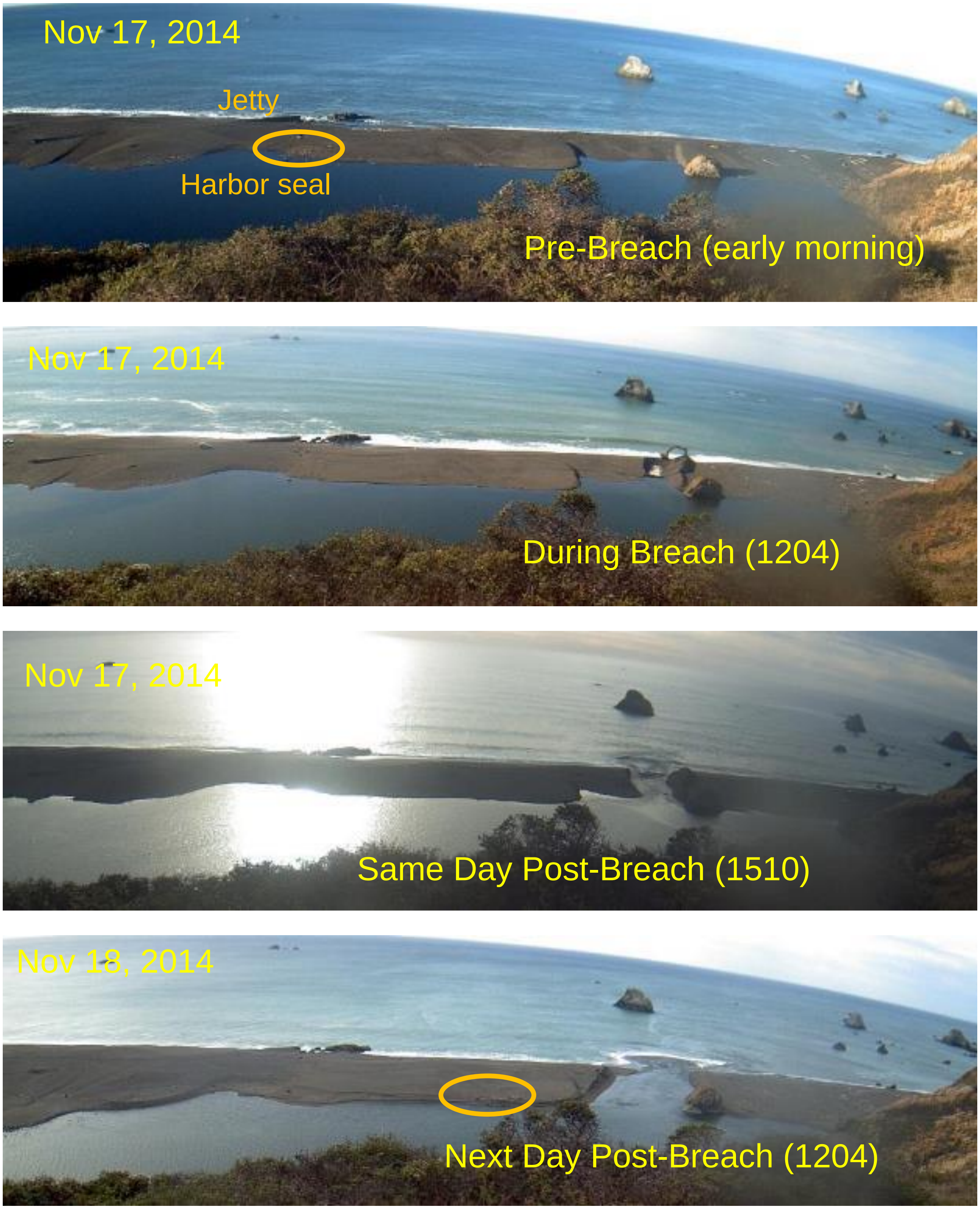


Figure 4.9. Artificial breaching at the mouth of the Russian River Estuary, November 17, 2014. Photographs show pre- through post-breaching conditions.

Figure 4.10. Artificial breaching at the mouth of the Russian River Estuary, November 26, 2014. Photographs show pre- through post-breaching conditions.

Pinniped Annual Monitoring

An Incidental Harassment Authorization (IHA) was issued by the NMFS pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act (16 U.S.C 1361 et seq.) to take small numbers of marine mammals, by Level B harassment, incidental to the Water Agency's Estuary Management Project (issued April 20, 2014, original authorization dated March 30, 2010, NMFS IHA). An annual report of results of monitoring activities was submitted to NMFS and is provided in Appendix B-4. A summary of the results of 2014 pinniped monitoring as reported in the *Russian River Estuary Management Project, Marine Mammal Protection Act Incidental Harassment Authorization, Report of Activities and Monitoring Results – January 1 to December 31, 2014* (SCWA 2015) are provided below.

Harbor seals (*Phoca vitulina richardsi*) regularly haul out at the mouth of the Russian River (Jenner haul-out). California sea lions (*Zalophus californianus*) and northern elephant seals (*Mirounga angustirostris*) are occasionally observed at the haul-out. There are also several known river haul-outs at logs and rock piles in the Russian River Estuary. The Water Agency applied for an IHA under the MMPA for activities associated with Russian River Estuary management activities, which occur in the vicinity of these haul-outs, including:

- excavation and maintenance of a lagoon outlet channel that would facilitate management of a barrier beach (closed sandbar) at the mouth of the Russian River and creation of a summer lagoon to improve rearing habitat for listed steelhead as required by the Russian River Biological Opinion (NMFS 2008);
- artificially breaching the barrier beach to minimize the potential for flooding of low-lying properties along the Estuary;
- biological and geophysical monitoring activities associated with the management actions described above;
- construction and maintenance of monitoring wells on the barrier beach south of the jetty; and
- geophysical surveys conducted at the barrier beach.

Pinniped monitoring was performed in accordance with the requirements of NMFS IHA issued April 20, 2014, and the Russian River Estuary Management Activities Pinniped Monitoring Plan (Sonoma County Water Agency and Stewards of the Coast and Redwoods 2011).

In an attempt to understand possible relationships between use of the Jenner haul-out and nearby coastal and river (peripheral) haul-outs, several other haul-outs on the coast and in the Russian River Estuary were monitored. These haul-outs include North Jenner and Odin Cove to the north, Pocked Rock, Kabemali, and Rock Point to the south, and Penny Logs, Paddy's Rock, and Chalanchawi in the Russian River Estuary.

Two types of monitoring were performed: baseline and water level management activities. Baseline monitoring was performed to gather additional information about the population of harbor seals utilizing the Jenner haul-out including population trends, patterns in seasonal abundance and the influence of barrier beach condition on harbor seal abundance. Pinniped monitoring was also conducted in relation to Water Agency water level management events (lagoon outlet channel implementation and artificial breaching). Each of the peripheral haul-outs was monitored concurrent with Jenner baseline monitoring and monitoring of water level management activities.

A barrier beach was formed eleven times during 2014, but only during six of these closure events did the Water Agency artificially breach the sand bar. The Russian River mouth was closed to the ocean for a total of 110 days (or 30%) in 2014, mostly during the fall months. The Water Agency artificially breached the sand bar five times in 2013 (SCWA 2014). In January 2012 the barrier beach was artificially breached after two days of breaching activity. There were also several periods over the course of the year where the barrier beach closed or became naturally perched and then subsequently breached naturally (SCWA 2013). In 2011 no water level management activities occurred (SCWA 2012). In 2010 one lagoon management event and two artificial breaching events occurred (SCWA 2011). Pinniped monitoring occurred no more than 3 days before, the day of, and the day after each water level management activity.

The Water Agency's Estuary biological and physical monitoring activities are included in the NMFS IHA. The Water Agency surveys the sandbar (or barrier beach) monthly to collect a topographic map of the beach, as required by the Russian River Biological Opinion. A monitor is present during these surveys to record any disturbances of the Jenner haul-out during the survey. In 2014 the Water Agency implemented the Jetty Study Plan (ESA PWA 2011) and a pinniped monitor was present to record any disturbances of the Jenner haul-out, similar to the monthly topographic surveys. Additionally, Water Agency field staff conducting biological and physical monitoring in the Estuary recorded any pinnipeds they encountered hauled out and any disturbance to pinnipeds associated with their activities. The Russian River Estuary Management and Monitoring Activities in 2014 resulted in incidental harassment (Level B harassment) of 2,121 harbor seals and two northern elephant seals, well under the total allowed by NMFS IHA. The Russian River Estuary Management activities in 2013, 2012, 2011 and 2010 resulted in incidental harassment (Level B harassment) of 1,351, 208, 42 and 290 harbor seals, respectively.

The purpose of the Russian River Estuary Management Project Pinniped Monitoring Plan (Sonoma County Water Agency and Stewards of the Coast and Redwoods 2011) is to detect the response of pinnipeds to Estuary management activities at the Russian River Estuary. Specifically, the following questions are of interest:

1. Under what conditions do pinnipeds haul out at the Russian River Estuary mouth at Jenner?
2. How do seals at the Jenner haul-out respond to activities associated with the construction and maintenance of the lagoon outlet channel and artificial breaching activities?
3. Does the number of seals at the Jenner haul-out significantly differ from historic averages with formation of a summer (May 15th to October 15th) lagoon in the Russian River Estuary?

4. Are seals at the Jenner haul-out displaced to nearby river and coastal haul-outs when the mouth remains closed in the summer?

Harbor seals are found at the mouth of the Russian River (Jenner haul-out) throughout the year. They are observed on the beach throughout the tidal cycle and at any time of day. Our baseline pinniped monitoring concluded that tidal state and time of day influenced harbor seal abundance at the Jenner haul-out, with seals less abundant in the early morning and at high tide (SCWA 2012). Harbor seals were most abundant on the Jenner haul-out in July during their annual molt (SCWA 2012), with these same trends being observed in subsequent years (SCWA 2013, 2014). Seasonal variation in the abundance of harbor seals at their haul-out locations is commonly observed throughout their range (Allen et al. 1989, Stewart and Yochem 1994, Gemmer 2002). The variation in their abundance can mostly be explained by changes in their biological and physiological requirements throughout the year. Peak seal abundance occurring in July during their molting season is likely a result of seals spending more time on land in order to help facilitate the molting process. This annual peak is typically followed by a decline in seal abundance which is likely a result of individual seals decreasing the amount of time on the haul-out post-molt to spend more time foraging and also coincides with the time that young seals may temporarily disperse from their natal haul-out (Stewart and Yochem, 1994, Thompson et al. 1994, Small et al. 2005). Most notable for 2014 was the increase in the number of seals observed during February, March and December. While it is difficult to speculate the reasons for these increases after just one year, it could be that it is a result of an overall increase in the number of harbor seals utilizing the Jenner haul-out as a resting area. We do not have the ability to determine if these increases are due to an increase in immigration to or a decrease in emigration from the haul-out. The Jenner haul-out is a harbor seal rookery and we have attempted to standardize a measure of pup counts so that comparisons can be made across years. However, our ability to accurately measure natality (i.e., proportion of births to the number of mature females) is limited by the fact that harbor seals are not sexually dimorphic so the number of adult females on the beach cannot be easily determined. Harbor seal pups are very precocial and are able to swim just after birth, so counts of pups on the beach does not accurately reflect the total number of births. 20 Harbor seals will use the beach when there is an open channel or when a barrier beach has formed, however, the number of seals at Jenner was influenced by river mouth condition. Daily average seal abundance was lower during closed conditions compared to open conditions. This effect is also closely related to time of year, since most closures occur during the fall and winter, when seal abundance is low. While earlier results suggested there may have been a relationship between the level of disturbance and river mouth condition (SCWA 2013, 2014), we did not find evidence that there was a significant increase in the number of people near the haul-out or the number of disturbance events during mouth closed conditions. The response of harbor seals at the Jenner haul-out to water level management activities in 2014 (Question 2 above) was similar to the responses observed in previous years of monitoring (Merritt Smith Consulting 1997, 1998, 1999, 2000; Sonoma County Water Agency and Merritt Smith Consulting 2001; SCWA 2011, 2012, 2013 and 2014). Harbor seals alerted to the sound of equipment on the beach and left the haul-out as the crew and equipment approached closer on the beach. When breaching activities were conducted south of the haul-out location seals often remained on the beach during all or some of the breaching activity. This indicates that seals are less disturbed by activities when equipment and crew do not pass directly past their haul-out. Since the beginning of the modified estuary water level management procedures as a result of the NMFS 2008 Biological Opinion a lagoon outlet channel has only been implemented once (July 2010). While the Water Agency has not had further opportunity to implement and sustain an outlet channel, observations when a barrier beach has formed during the lagoon management period provide information as to how harbor seals respond when aquatic access between the estuary and the ocean is limited (Question 3 above). A barrier beach has formed during the lagoon management period thirteen times, the longest incidence lasting 29 days, with an average duration of ten days. While seal abundance was lower during closed conditions, overall there continues to be a slight increasing trend in seal abundance. These results indicate that while seal abundance may exhibit a short term decline during closed conditions it has not inhibited seals from using the Jenner haul-out during any period of the year. We conclude that the effect of barrier beach condition on seal abundance represents only a short term response, and is not an indication that seals are less likely to choose Jenner as a haul-out overall. We do not yet know how seals would respond to a maintained lagoon outlet channel. As stated above we are unable to draw conclusions about the response of harbor seals to the implementation and maintenance of summer lagoon as outlined in the NMFS 2008 Biological Opinion. Results to date indicate that the peripheral haul-outs located in the Estuary are little used by seals, and even though access is limited by rising water level in the Estuary there is no effect of mouth condition on seal abundance at these sites. The coastal sites are regularly used by harbor seals, albeit in low numbers. Again, we found no effect of mouth condition in the abundance of seals at these peripheral haul-outs. Harbor seals are generalists in many ways: including diet, resting locations and activity patterns. They are able to find refuge on sandy beaches, tidal mud flats and rocky shores (Allen et al. 1989, Gemmer 2002, Small et el. 2005). Seals exploit a wide range of locally abundant prey (Gemmer 2002, Hanson 1993, Tollit et al. 1997): they may forage during the day and come ashore at night, or forage at night and come ashore during the day, or even spend multiple days at sea (Small et al. 2005, Suryan and Harvey 1998, Yochem et al. 1987). Given that harbor seals exhibit this range of behaviors our ability to understand temporal changes in seal behavior and population abundance is limited by the use of periodic count data.

Jetty Study

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 in 2011 (ESA PWA 2011). 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 Biological Opinion. 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. A draft existing conditions report was provided to NMFS and CDFW with analysis including historic information on the jetty's construction, ocean waves, inlet and beach morphology conditions.

Geophysical field studies were completed in 2014. The final report is currently being prepared and the report will be included in the next annual report.

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 RPA 2 in the Russian River Biological Opinion, 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. This preliminary list was updated for the California Coastal Commission Coastal Development Permit application process. 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 97 properties.

The Water Agency is continuing to consult and coordinate with NMFS and the County of Sonoma's Local Coastal Plan update. The County's Permit Resources and Management Department is currently updatings its Local Coastal Plan, including consideration of sea level rise impacts to the lower Russian River and community of Jenner. Updates to the Coastal Plan policies may results in additional evaluaton of feasible engineering solutions to flood risk to low-lying properties along the Estuary. The Water Agency is participating, along with PRMD, in NOAA's Habitat Blueprint, which includes a multiagency effort to develop and expand the United

States Geological Survey (USGS) sea level rise model (the Coast Storm Modeling System or CoSMoS) to inform adaptation planning and Estuary management efforts.

References

Allen, S. G., H. R. Huber, C. A. Ribic and D. G. Ainley. 1989. Population dynamics of harbor seals in the Gulf of the Farallones, California. California Fish and Game 75(4): 224-232.

ESA PWA (Philip Williams and Associates, Ltd.) 2011. Feasibility of alternatives to the Goat Rock State Beach Jetty for managing lagoon water surface elevations - a study plan. Prepared for the Sonoma County Water Agency June 30, 2011.

ESA PWA. 2015. Russian River estuary outlet channel adaptive management plan 2015. Prepared with Bodega Marine Laboratory, University of California at Davis. May 15, 2015.

Gemmer, A. 2002. Ecology of harbor seals, Phoca vitulina, in northern California. M.A. Thesis, Humboldt State University: 128pp.

Hanson, Linda. 1993 The foraging ecology of harbor seals, Phoca vitulina, at the mouth of the Russian River, California. M. A. thesis, Sonoma State University, Rohnert Park, CA 94928.

Heckel 1994. Russian River Estuary Study, 1992-1993. Prepared for Sonoma County Department of Planning and California State Coastal Conservancy. 1994.

Merritt Smith Consulting. 1997. Biological and Water Quality Monitoring in the Russian River Estuary, 1996, Annual Report. February 21, 1997.

Merritt Smith Consulting. 1998. Biological and Water Quality Monitoring in the Russian River Estuary, 1997, Second Annual Report. February 5, 1998.

Merritt Smith Consulting. 1999. Biological and Water Quality Monitoring in the Russian River Estuary, 1998, Third Annual Report. March 15, 1999.

Merritt Smith Consulting. 2000. Biological and Water Quality Monitoring in the Russian River Estuary, 1999, Fourth Annual Report.March 24, 2000.

National Marine Fisheries Service (NMFS). 2008. Biological Opinion for Water Supply, Flood Control Operations, and Channel Maintenance conducted by the U.S. Army Corps of Engineers, the Sonoma County Water Agency, and the Mendocino County Russian River Flood Control and Water Conservation District in the Russian River Watershed. September 24, 2008.

Small, R. J., L. F. Lowry, J. M. Ver Hoef, K. J. Frost, R. A. DeLong and M. J. Rehberg. 2005. Differential movements by harbor seal pups in contrasting Alaska environments. Marine Mammal Science 21(4):671-694

Sonoma County Water Agency. 2011. Russian River Estuary Management Project, Marine Mammal Protection Act Incidental Harassment Authorization (No. 14426), Report of Activities and Monitoring Results - April 1 to December 2010. Prepared for Office of Protected Resources and Southwest Regional Administrator, National Marine Fisheries Service, February 2011.

Sonoma County Water Agency. 2012. Russian River Estuary Management Project, Marine Mammal Protection Act Incidental Harassment Authorization, Report of Activities and Monitoring Results - April 2009 to December 31, 2011. Prepared for Office of Protected Resources and Southwest Regional Administrator, National Marine Fisheries Service, January 2012.

Sonoma County Water Agency. 2013. Russian River Estuary Management Project, Marine Mammal Protection Act Incidental Harassment Authorization, Report of Activities and Monitoring Results – January 1 to December 31, 2012. Prepared for Office of Protected Resources and Southwest Regional Administrator, National Marine Fisheries Service, January 2013.

Sonoma County Water Agency. 2014. Russian River Estuary Management Project, Marine Mammal Protection Act Incidental Harassment Authorization, Report of Activities and Monitoring Results – January 1 to December 31, 2013. Prepared for Office of Protected Resources and Southwest Regional Administrator, National Marine Fisheries Service, January 2014.

Sonoma County Water Agency (SCWA) and Merritt Smith Consulting. 2001. Biological and Water Quality Monitoring in the Russian River Estuary, 2000, Fifth Annual Report. June 12, 2001.

Sonoma County Water Agency and Stewards of the Coast and Redwoods. 2011. Russian River Estuary Management Activities Pinniped Monitoring Plan. February 2011.

Stewart, B. S. and P. K. Yochem. 1994. Ecology of harbor seals in the southern California bight. pp. 123-134 in The fourth California islands symposium: update on the status of resources, W. L. Halvorson and G. J. Maender (eds.), Santa Barbara Museum of Natural History, Santa Barbara, California.

Suryan, R. M. and J. T. Harvey. 1998. Tracking harbor seals (Phoca vitulina richardsi) to determine dive behavior, foraging activity and haul-out site use. Marine Mammal Science 15(2):446-461.

Thompson, P. M., K. M. Kovacs and B. J. McConnell. 1994. Natal dispersal of harbor seals (Phoca vitulina) from breeding sites in Orkney, Scotland. Journal of Zoology, London 234:668-673.

Tollit, D. J., S. P. R. Greenstreet and P. M. Thompson. 1997. Prey selection by harbour seals, Phoca vitulina, in relation to variations in prey abundance. Canadian Journal of Zoology 75:1508-1518.

Yochem, P. K., B. S. Stewart, R. L. DeLong and D. P. DeMaster. 1987. Diel haul-out patterns and site fidelity of harbor seals (Phoca vitulina richardsi) on San Miguel Island, California, in autumn. Marine Mammal Science 3(4): 323-332.

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 Vacation Beach near Guerneville. 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 sandbar breach.

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 (MBA) encompasses the area of the river between Duncans Mills and Vacation Beach 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.

The Estuary experienced several closures during the 2014 monitoring season including one prolonged closure during the management period, which runs from 15 May to 15 October. This closure occurred for a period of 36 days between 17 September and 22 October 2014 before Agency staff artificially breached the barrier beach to prevent flooding of low-lying properties. The barrier beach closed two days later on 24 October and remained closed for another 24 days until Water Agency staff breached the barrier beach on 17 November. The barrier beach began to close the following night on 18 November and remained closed for another 9 days until 26 November when Water Agency staff breached the barrier beach again.

In addition, there were eight Estuary closures in 2014 that occurred before the lagoon management period. Three closures occurred during the winter, beginning with a closure on 23 December 2013 that lasted for 11 days until Water Agency staff breached the barrier beach on 2 January. Another closure occurred for 20 days between 11 January and 30 January before Water Agency staff breached the barrier beach. Finally, a closure occurred for 6 days between 3 February and 8 February before opening naturally. Five closures occurred during the spring, beginning with a closure that lasted for a period of 5 days between 20 March and 24 March until Water Agency staff breached the barrier beach. The river began to close on 21 April and remained closed for 3 days until opening naturally on 23 April. The barrier beach then closed for 2 days from 26 April to 27 April, 3 days between 29 April and 1 May, and 5 days between 4 May and 8 May, before opening naturally each time.

The main body of this report will address monitoring results collected between April and December 2014 as they relate to the lagoon management period. A sub-section at the end of the report will address the monitoring that occurred in the winter and early spring of 2014 during extended drought conditions.

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.

Nine stations were established for continuous water quality monitoring, including five stations in the mainstem Estuary, two tributary stations, and two stations in the MBA near Monte Rio (Figure 4.1.1). One mainstem Estuary station was located in the lower reach at the mouth of the Russian River at Goat Rock State Beach (Mouth Station). Two mainstem Estuary 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). Two mainstem Estuary stations were located in the upper reach; 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 Russian River above Brown's Pool Station. Finally, two mainstem stations were located in the MBA; in a pool across from Patterson Point in Villa Grande (Patterson Point station) and downstream of Monte Rio Beach (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 Patterson Point and Monte Rio stations were established to monitor potential changes to water quality conditions (including potential salinity migration) in the MBA while inundated during lagoon formation (Figure 4.1.1).

Mainstem Estuary and MBA monitoring stations up to Patterson Point were comprised of a concrete anchor attached to a steel cable suspended from the surface by a large buoy (Figure 4.1.2).

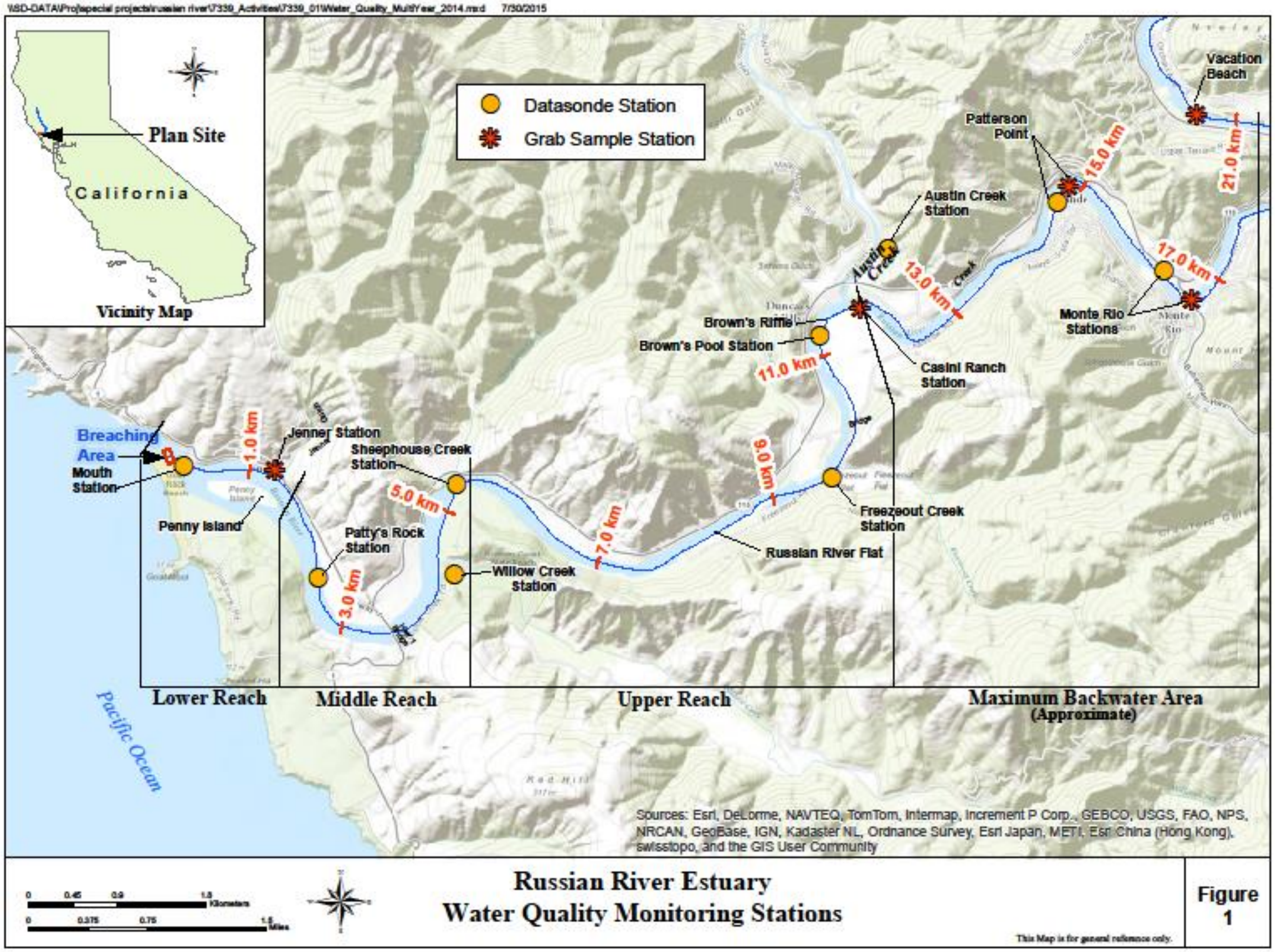


Figure 4.1.1. 2014 Russian River Estuary Water Quality Monitoring Stations

The Mouth, Patty's Rock, and Freezeout Creek stations had a vertical array of two datasondes to collect water quality profiles, whereas the Sheephouse Creek, Brown's Pool, and Patterson Point stations had one datasonde each. Stations in the lower and middle reaches of the Estuary that are predominantly saline had sondes placed at the surface, at approximately 1 meter depth (~1m), and/or at the mid-depth (~3m) portions of the water column. Stations in the upper reaches of the Estuary, where the halocline is deeper and the water is predominantly fresh to brackish, had sondes placed at the bottom (~6-8m) and/or mid-depth (~3-4m) portions of the water column. The Patterson Point monitoring station, located in the MBA, also had one datasonde placed at the bottom (~9-11m) of the pool (Figure 4.1.2). 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.

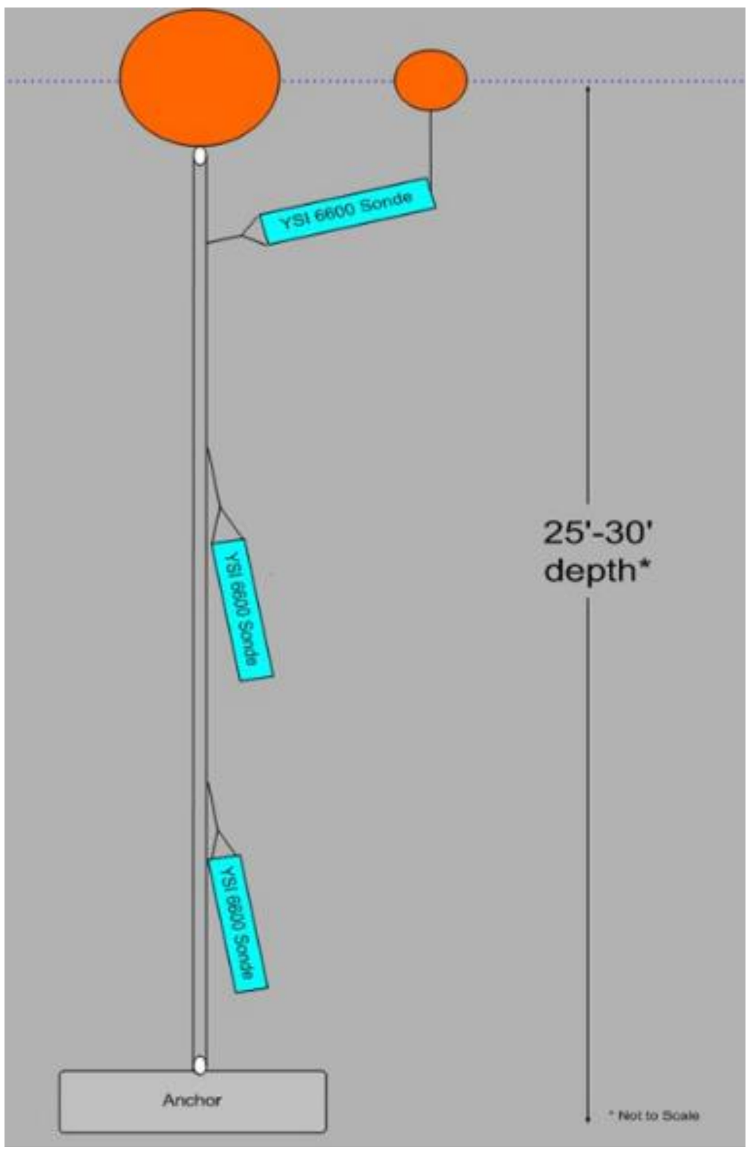


Figure 4.1.2. Typical Russian River Estuary monitoring station datasonde array.

The monitoring stations in Austin Creek, Willow Creek, and at Monte Rio consisted of one datasonde suspended at approximately mid-depth (~1m during open conditions) in the thalweg at each respective site.

The Willow Creek station was deployed from early March until the end of the December. The Austin Creek station was deployed from mid-April until mid-November. The Mouth, Patty's Rock, Sheephouse Creek, Freezeout Creek, and Brown's Pool stations were deployed from early May until mid-November. The Patterson Point and Monte Rio stations were deployed from mid-May until Mid-November. As mentioned above, drought conditions in early 2014 allowed winter monitoring to be conducted at monitoring stations in January and portions of February.

Grab Sample Collection

In 2014, Water Agency staff continued to conduct nutrient and indicator bacteria grab sampling at five stations in the Russian River Estuary and MBA, including three stations established in 2010: the Jenner Boat Ramp (Jenner Station); Casini Ranch across from the mouth of Austin Creek (Casini Ranch Station); and just downstream of the Monte Rio Bridge (Monte Rio Station). The Bridgehaven Station, located at the mouth of Willow Creek, and the Duncans Mills Station, located at Moscow Road Bridge, were relocated in 2014 to Patterson Point in Villa Grande (Patterson Point Station); and just downstream of the Vacation Beach summer dam (Vacation Beach station) to monitor conditions at the two publicly accessible beaches. Refer to Figure 4.1.1 for grab sampling locations.

Water Agency staff collected grab samples weekly from 15 May to 21 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, lagoon outlet channel implementation, sandbar breach, or removal of summer recreational dams. Additional bacterial sampling was also conducted when *Escherichia coli* (E. coli) conditions exceeded recommended criteria at a given station. Nutrient, chlorophyll a, and organic carbon grab samples were analyzed at Alpha Analytical Labs in Ukiah, and bacterial grab samples were analyzed at the Sonoma County Department of Health Services (DHS) lab in Santa Rosa.

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 the presence of indicator bacteria including total coliforms, 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 Appendix B-5; however, an analysis and discussion of these constituents is not included in this report. Temperature, dissolved oxygen, pH, salinity, specific conductance, and turbidity values were recorded during grab sampling events and are included in the Appendix B-5.

Results

Water quality conditions in 2014 were similar to trends observed in sampling from 2004 to 2013, even with drought conditions and lower flows. 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 Brown's Pool 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 MBA 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 has been removed from the data sets, resulting in the data gaps observed in the graphs presented as Figures 4.1.3 through 4.1.38. These data gaps may affect minimum, mean, and maximum values of the various constituents monitored in 2014, including temperature, dissolved oxygen, pH, and salinity at the Patty's Rock surface sonde in September and early October, the Sheephouse Creek mid-depth sonde in late June and early July, and the Patterson Point bottom sonde in June.

Although gaps exist in the 2014 data that affect sample statistics, Agency staff has collected long time-series data on an hourly frequency for several years at most of these stations, and it is unlikely that the missing data appreciably affected the broader understanding of water quality conditions within the estuary. The following sections provide a brief discussion of the results observed for each parameter monitored.

Salinity

Full strength seawater has a salinity of approximately 35 parts per thousand (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.

Table 4.1.1. Russian River Estuary 2014 Water Quality Monitoring Results. Minimum, mean, and maximum values for temperature (degrees Celsius), depth (meters), dissolved oxygen (percent) saturation, dissolved oxygen concentration (milligrams per Liter), hydrogen ion (pH units), and salinity (parts per thousand).

Monitoring Station	Temperature	Depth	Dissolved Oxygen	Dissolved Oxygen	Hydrogen Ion	Salinity
Sonde	(°C)	(m)	(%) saturation	(mg/L)	(pH)	(ppt)
Mouth						
Surface						
May 8, 2014 - November 26, 2014						
Min	9.5	0.8	5.0	55.6	7.6	1.3
Mean	15.7	1.0	9.3	104.7	8.3	19.2
Max	**21.6**	**1.8**	**18.1**	**212.0**	**9.1**	**34.3**
Mid-Depth						
May 8, 2014 - November 26, 2014						
Min	9.5	3.0	1.9	23.5	7.4	8.5
Mean	15.5	3.4	8.8	104.0	8.0	27.8
Max	**22.7**	**3.6**	**33.0**	**386.2**	**9.6**	**34.3**
Patty's Rock						
Surface						
May 8, 2014 - November 26, 2014						
Min	11.1	0.9	1.6	19.9	7.4	1.0
Mean	16.6	1.0	9.1	104.4	8.2	18.7
Max	**22.7**	**2.3**	**16.6**	**199.7**	**9.1**	**33.7**
Mid-Depth						
May 8, 2014 - November 26, 2014						
Min	10.3	3.2	0.0	0.0	7.2	7.4
Mean	15.6	3.6	8.1	95.3	8.1	27.5
Max	**22.8**	**4.3**	**20.8**	**238.4**	**8.8**	**34.0**
Willow Creek						
Mid-Depth						
April 15, 2014 - December 31, 2014						
Min	5.2	0.3	0.1	0.7	6.0	0.0
Mean	18.1	1.0	5.6	63.8	7.4	16.3
Max	**26.2**	**3.5**	**14.3**	**183.5**	**8.8**	**30.7**
Sheephouse Creek						
Mid-Depth						
May 7, 2014 - November 26, 2014						
Min	13.0	3.3	0.1	1.0	7.0	11.8
Mean	18.3	3.6	6.9	84.5	7.8	26.1
Max	**25.4**	**3.8**	**16.5**	**195.1**	**8.5**	**32.2**
Freezeout Creek						
Mid-Depth						
May 7, 2014 - November 26, 2014						
Min	12.3	3.0	0.0	0.4	7.0	0.1
Mean	21.5	3.4	7.4	84.7	8.1	2.5
Max	**24.9**	**4.2**	**18.9**	**203.4**	**9.3**	**14.0**
Bottom						
May 7, 2014 - November 26, 2014						
Min	17.8	4.1	0.1	0.6	6.4	0.1
Mean	21.8	5.9	4.1	46.5	7.5	5.1
Max	**24.6**	**6.9**	**13.1**	**154.2**	**8.9**	**14.1**

(continues on next page)

Table 4.1.1 (cont.). Russian River Estuary 2014 Water Quality Monitoring Results. Minimum, mean, and maximum values for temperature (degrees Celsius), depth (meters), dissolved oxygen (percent) saturation, dissolved oxygen concentration (milligrams per Liter), hydrogen ion (pH units), and salinity (parts per thousand).

Monitoring Station	Temperature	Depth	Dissolved Oxygen	Dissolved Oxygen	Hydrogen Ion	Salinity
Sonde	(°C)	(m)	(%) saturation	(mg/L)	(pH)	(ppt)
Brown's Pool						
Bottom						
May 7, 2014 - November 26, 2014						
Min	12.2	5.8	0.0	0.0	6.1	0.1
Mean	17.3	9.2	1.1	11.9	7.0	5.1
Max	**23.5**	**9.8**	**10.5**	**122.8**	**8.1**	**11.3**
Austin Creek						
Mid-Depth						
April 17, 2014 - December 8, 2014						
Min	11.3	0.2	0.1	0.6	7.2	0.1
Mean	16.5	0.7	4.7	47.8	7.6	0.2
Max	**20.7**	**2.6**	**10.6**	**105.6**	**8.5**	**0.2**
Patterson Point						
Bottom						
May 14, 2014 - November 26, 2014						
Min	12.3	9.0	0.0	0.0	6.0	0.1
Mean	17.9	10.3	1.5	14.9	6.9	0.2
Max	**21.5**	**11.1**	**21.0**	**196.1**	**7.8**	**0.7**
Monte Rio						
Mid-Depth						
May 14, 2014 - December 9, 2014						
Min	12.4	1.1	5.7	63.9	7.4	0.1
Mean	21.0	1.3	8.3	92.6	8.0	0.3
Max	**27.3**	**2.8**	**9.9**	**118.1**	**8.5**	**0.5**

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, brackish conditions 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 MBA; however, brackish water was observed to occur at the bottom of the pool throughout the 2014 monitoring season.

The Austin Creek, Patterson Point and Monte Rio stations are located in the MBA in freshwater habitat that can become inundated during high tides, barrier beach closures, perched conditions, and lagoon formation. Elevated salinity levels were not observed at any of the stations in the MBA during either open or closed barrier beach conditions in 2014.

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 closed barrier beach conditions in the spring and fall (Figures 4.1.3 and 4.1.4). Concentrations ranged from 1.3 to 34.3 ppt at the Mouth surface sonde and 1.0 to 33.7 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 19.2 and 18.7 ppt, respectively.

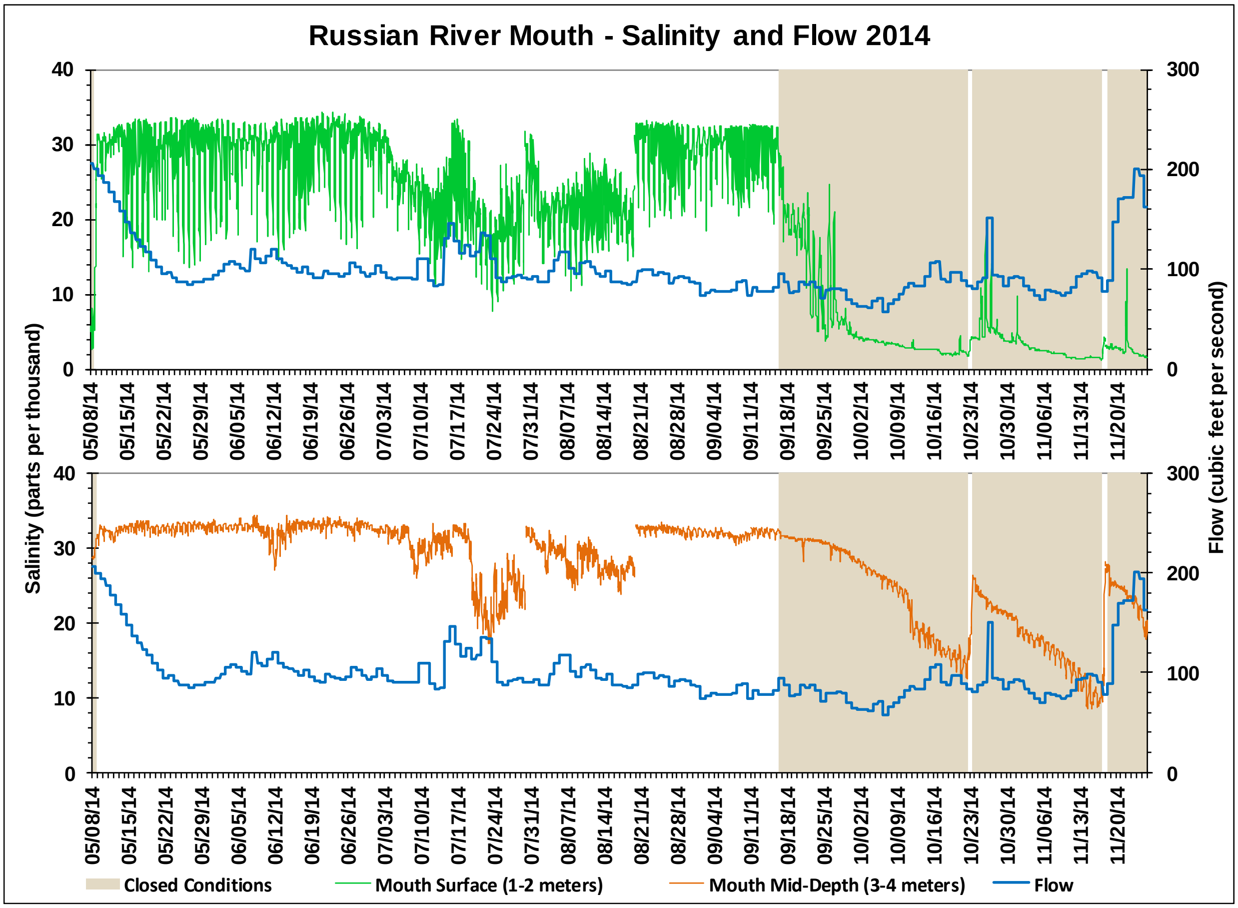


Figure 4.1.3. 2014 Russian River Mouth Salinity and Flow Graph

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 8.5 to 34.3 ppt at the Mouth, 7.4 to 34.0 ppt at Patty's Rock, and 11.8 to 32.2 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 27.8, 27.5, and 26.1 ppt, respectively. Minimum concentrations were observed to occur during river mouth closures at the Mouth and Patty's Rock mid-depth sondes in October and November (Figures 4.1.3 and 4.1.4). Minimum concentrations at Sheephouse Creek were observed to occur during open conditions in June and barrier beach closure in October (Figure 4.1.5).

Salinity concentrations were observed to initially decrease during closed barrier beach conditions in September and October until the barrier beach was breached by Water Agency staff on 22 October to prevent flooding of low lying property, at which point salinity was observed to increase until the barrier beach began to close again on 24 October (Figures 4.1.3

through 4.1.5). Although the Estuary experienced only one closure during the 2014 management period, it was the longest single closure (36 days) to occur since Water Agency staff began monitoring the estuary for the Biological Opinion in 2009. In addition, when combined with the two subsequent closures, they constituted the longest contiguous period of closure (69 days) observed by Water Agency staff (Photos 4.1.1 and 4.1.2).

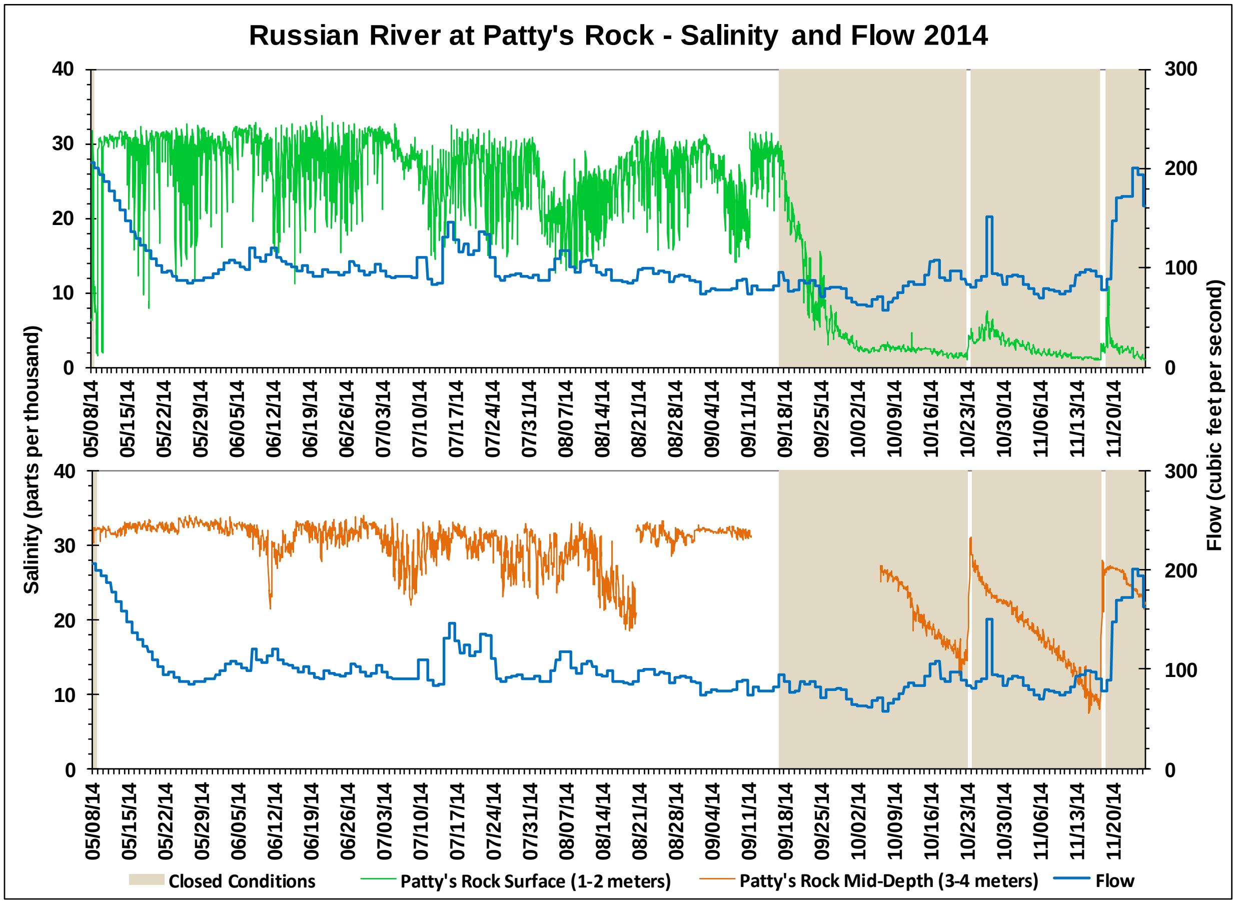


Figure 4.1.4. 2014 Russian River at Patty's Rock Salinity and Flow Graph

Declines in salinity during barrier beach closure and 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 of saline water through the barrier beach. Salinity generally returned t o pre-closure levels after the barrier beach reopened, although the time required to return to pre-closure conditions varied at each site and differed between closure 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.

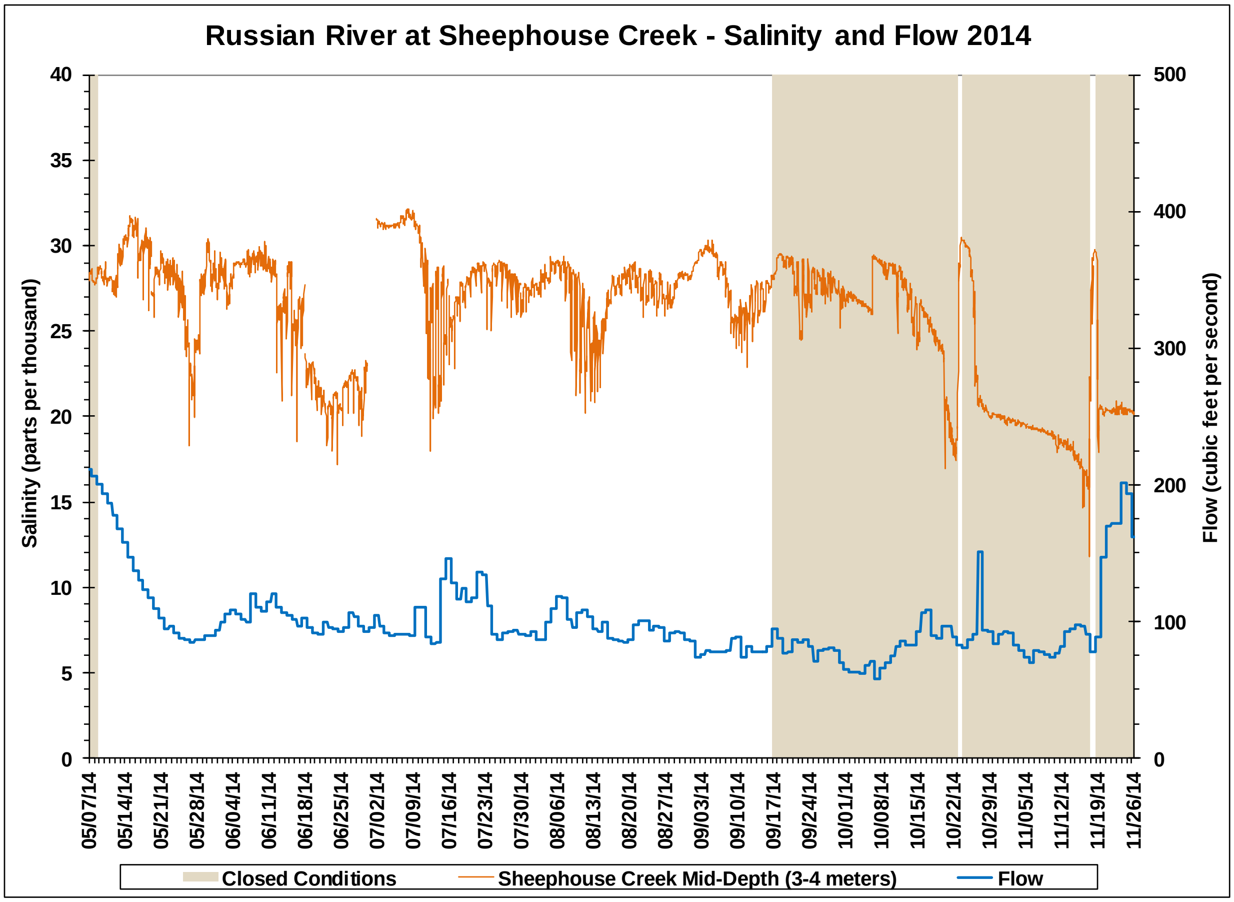


Figure 4.1.5. 2014 Russian River at Sheephouse Creek Salinity and Flow Graph

The Willow Creek station was located in predominantly freshwater habitat through mid-May until spring flows receded below 200 cfs in the mainstem Russian River and increased tidal action allowed saline water to migrate to this station. The station was predominantly brackish to saline through the monitoring sesason until the barrier beach closed on 17 September, at which point the station became brackish and slowly decreased during the extended closures that lasted until 26 November (Figure 4.1.6). Salinity was observed to increase significantly following the opening of the barrier beach on 26 November, however, high stream flows from a storm event in early December flushed out this saline water and the site remained freshwater through the end of the calendar year.

Salinity concentrations fluctuated significantly during open conditions with concentrations that ranged between 8 and 30 ppt from mid-May to mid-September. Salinity concentrations became more stable during the barrier beach closures in September and October and began to slowly decline. Concentrations decreased significantly when the barrier beach was opened by Water Agency staff on 17 November and ranged from about 2-5 ppt during the final closure that lasted until 26 November. Concentrations then briefly increased to 20 ppt under open conditions until rising storm flows pushed out the saline water. The mean salinity of the Willow Creek station throughout the year (including data before and after the lagoon management period) was 16.3 ppt, with a minimum concentration of 0.0 ppt, and a maximum concentration of 30.7 ppt (Table 4.1.1).

Photo 4.1.1. Russian River Mouth and Jetty from Jenner Overlook – September 18, 2014

Photo 4.1.2. Russian River Mouth and Jetty from Jenner Overlook – November 26, 2014

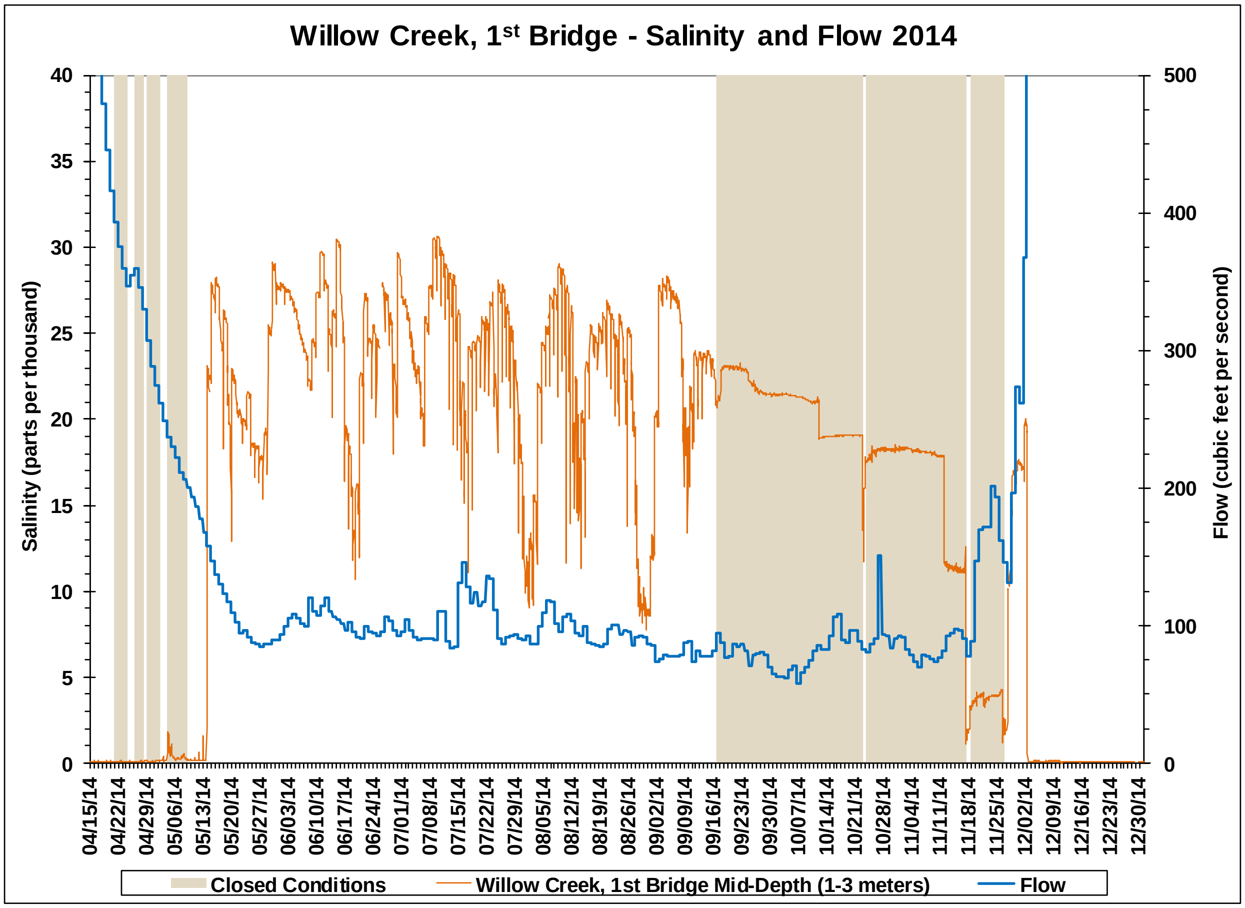


Figure 4.1.6. 2014 Willow Creek Salinity and Russian River Flow Graph

Upper Reach Salinity

Two stations were monitored in the upper reach in 2014; Freezeout Creek and Brown's Pool. Both stations included a bottom sonde and the Freezeout Creek station also had a mid-depth sonde. Sondes were located in this manner to track changes in the presence and concentration of salinity in the water column as well as the presence of thermal refugia for salmonids.

The Freezeout Creek station is located at River Kilometer 9.5 (RK 9.5), which is 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 subject to elevated salinity levels as the salt wedge migrated up the Estuary during both open and closed conditions (Figure 4.1.7). The elevated salinity levels were predominantly observed at the bottom sonde, though elevated salinity was also seen at the mid-depth sonde during open and closed conditions. The bottom sonde at Freezeout Creek had a mean salinity concentration of 5.1 ppt, and salinity levels that ranged from 0.1 to 14.1 ppt (Table 4.1.1). The mid-depth sonde at Freezeout Creek had a mean salinity concentration of 2.5 ppt, and salinity levels that ranged from 0.1 to 14.0 ppt (Table 4.1.1).

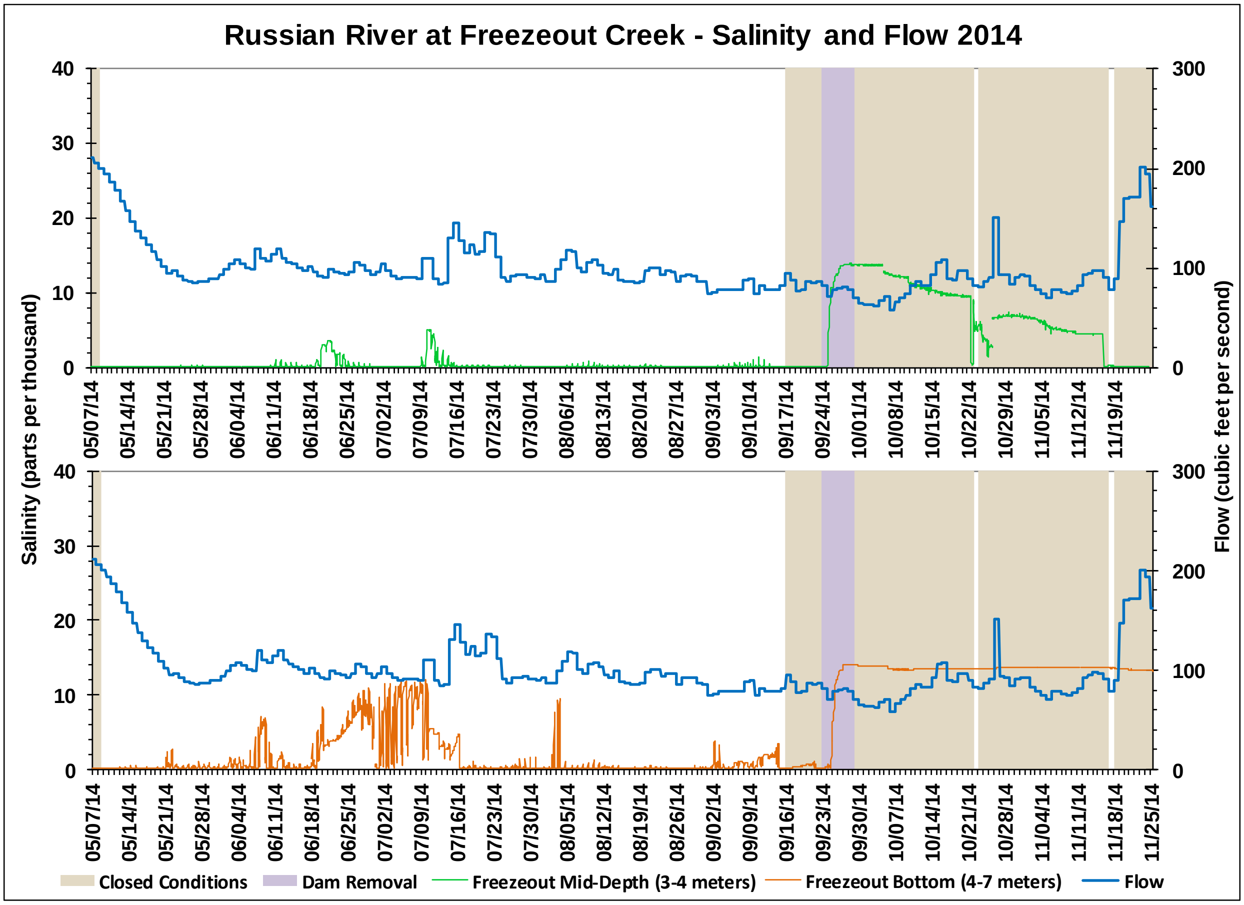


Figure 4.1.7. 2014 Russian River at Freezeout Creek Salinity and Flow Graph

The Brown's Pool station is located at RK 11.3 in a pool that is approximately 10m deep. Brown's Pool is located immediately downstream of Brown's Riffle (RK 11.4) and the confluence of Austin Creek and the mainstem Russian River, which is located at RK 11.65. Brown's Riffle is generally considered the demarcation between the Estuary and the MBA, where salinity levels have not been observed to occur past this point. The sonde at the bottom of Brown's Pool was observed to remain predominantly brackish during the 2014 monitoring season under open and closed conditions, with a few exceptions (Figure 4.1.8).

During the barrier beach closure in September, salinity concentrations at Brown's Pool were observed to initially decrease and then increase to approximately 5 ppt. Salinity concentrations were observed to decrease after the barrier beach was opened on 22 October before returning to brackish conditions during the next closure that began on 24 October. Brackish conditions remained through the November closures until increasing stream flows pushed the brackish water out of the pool (Figure 4.1.8). The mean salinity concentration observed at Brown's Pool was 5.1 ppt, and the minimum salinity concentration was 0.1 ppt (Table 4.1.1). The maximum salinity concentration of 11.3 ppt was observed to occur during open conditions in late May (Figure 4.1.8).

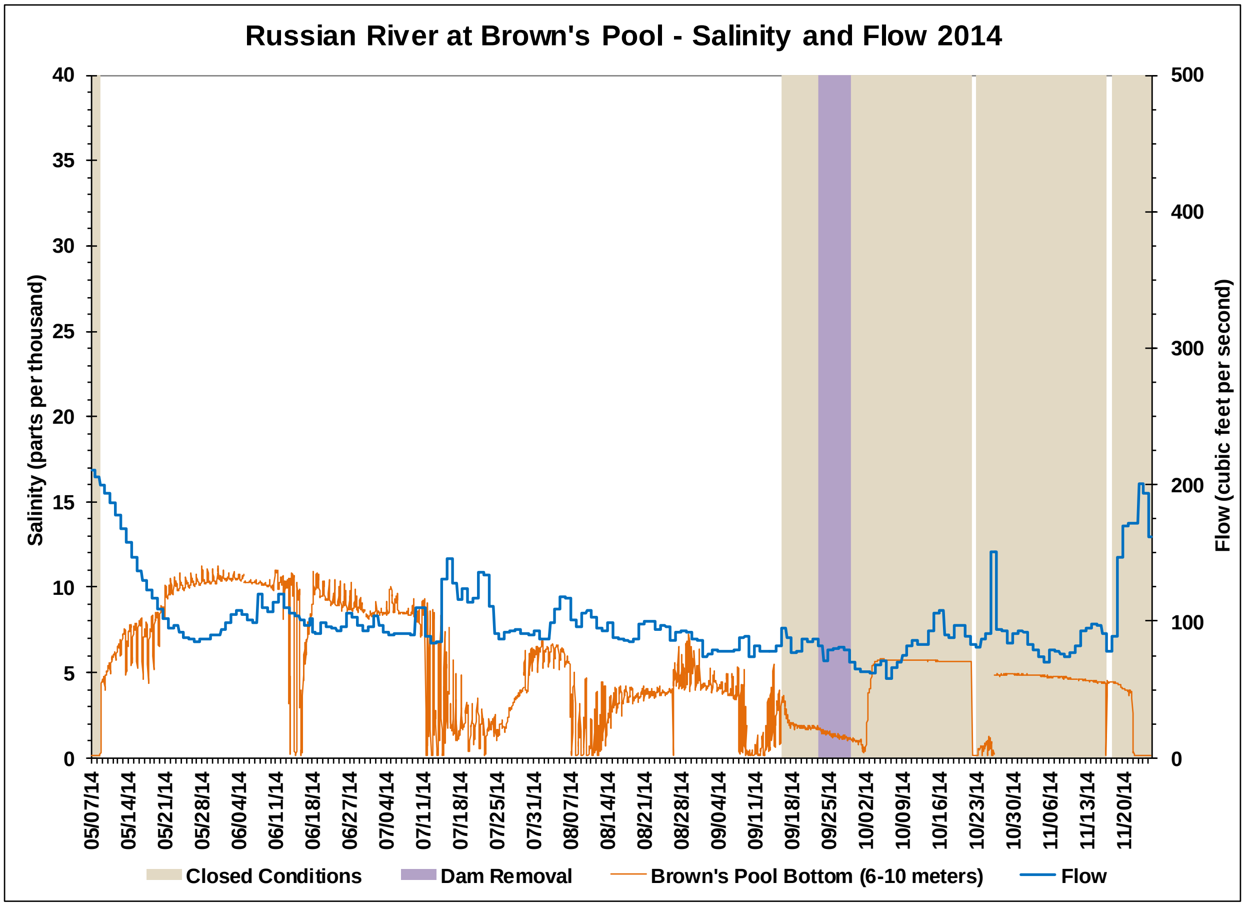


Figure 4.1.8. 2014 Russian River at Brown's Pool Salinity and Flow Graph

Maximum Backwater Area Salinity

Three stations were located in the MBA, including one tributary station in lower Austin Creek and two mainstem Russian River stations located in Patterson Point (RK 14.9) and Monte Rio (RK 16.1) (Figure 4.1.1). None of these three stations were observed to have salinity levels above normal background conditions expected in freshwater habitats, during both open and closed barrier beach conditions (Figures 4.1.9 through 4.1.11).

The Austin Creek station had a mean salinity concentration of 0.2 ppt, with a minimum of 0.1 ppt and a maximum of 0.2 ppt. The Patterson Point station had a mean salinity concentration of 0.2 ppt, a minimum concentration of 0.1 ppt, and a maximum concentration of 0.7 ppt. The Monte Rio station had a mean salinity concentration of 0.3 ppt, a minimum concentration of 0.1 ppt, and a maximum concentration of 0.5 ppt.

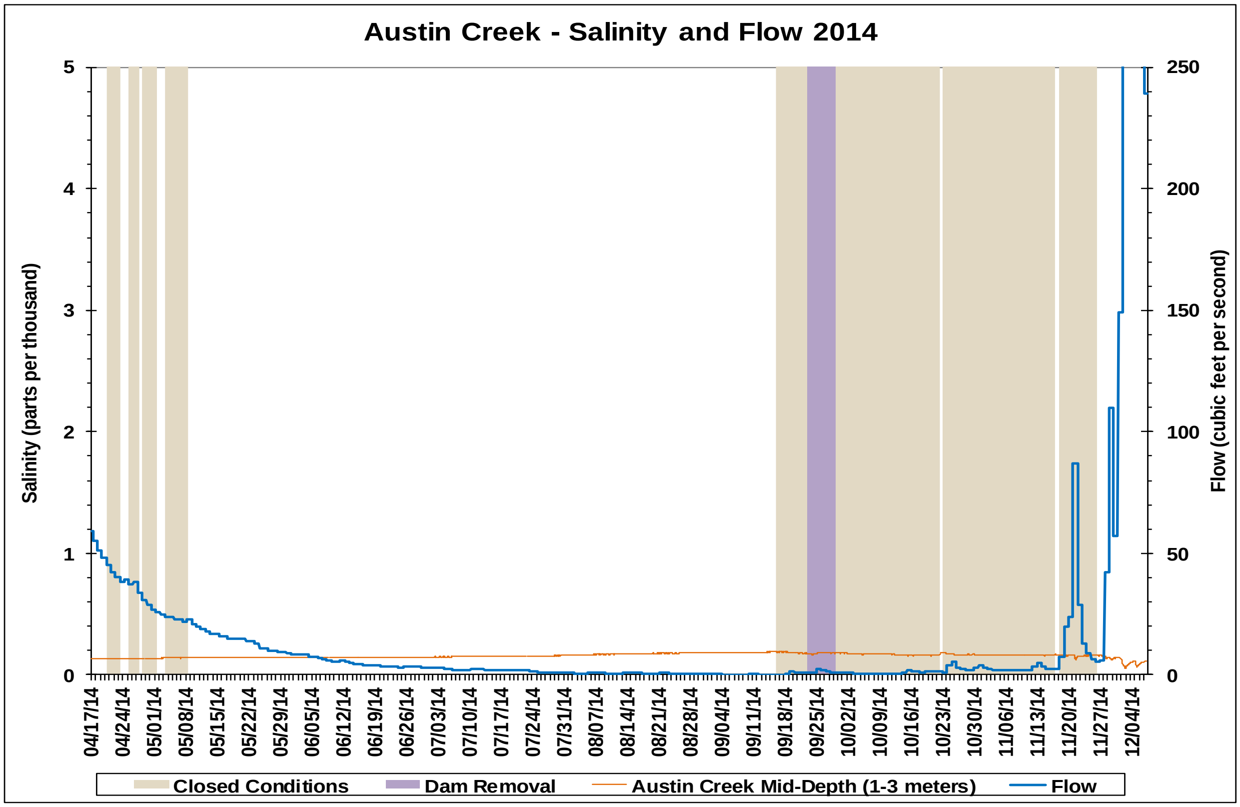


Figure 4.1.9. 2014 Austin Creek Salinity and Flow Graph

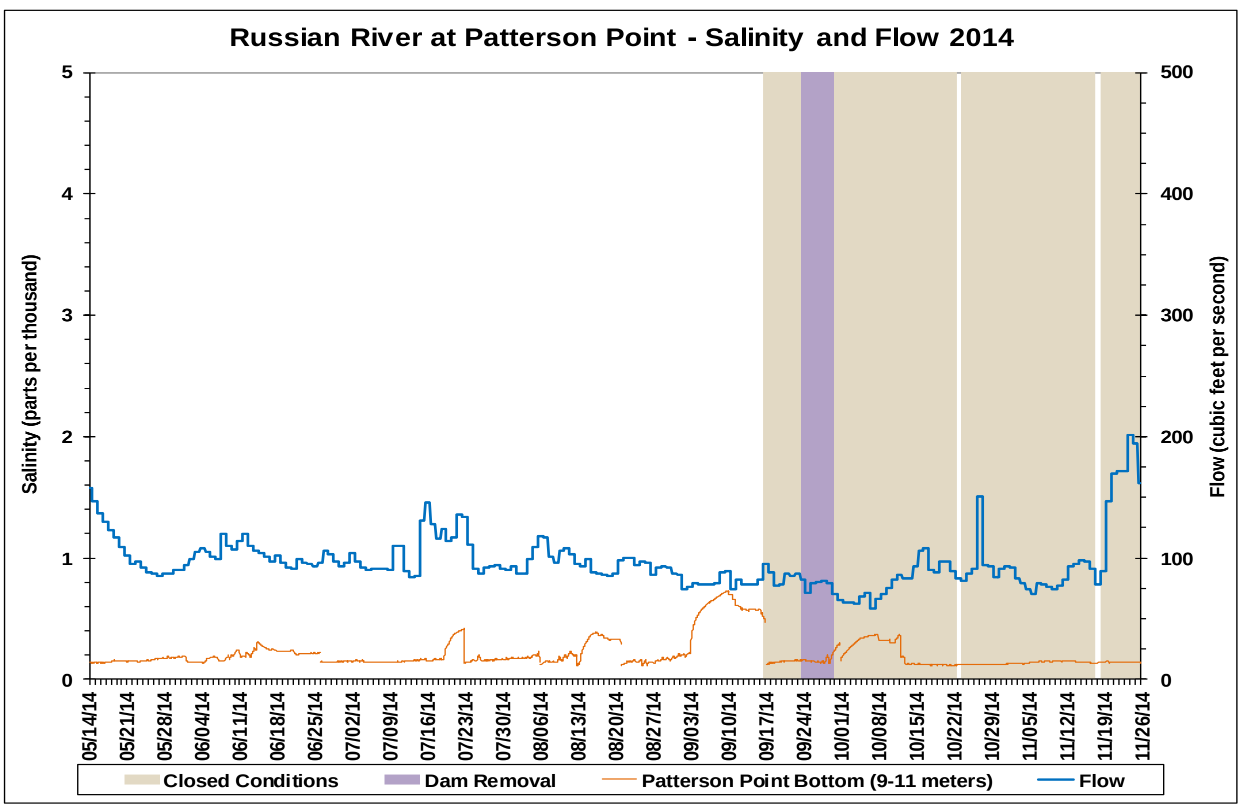


Figure 4.1.10. 2014 Patterson Point Salinity and Flow Graph

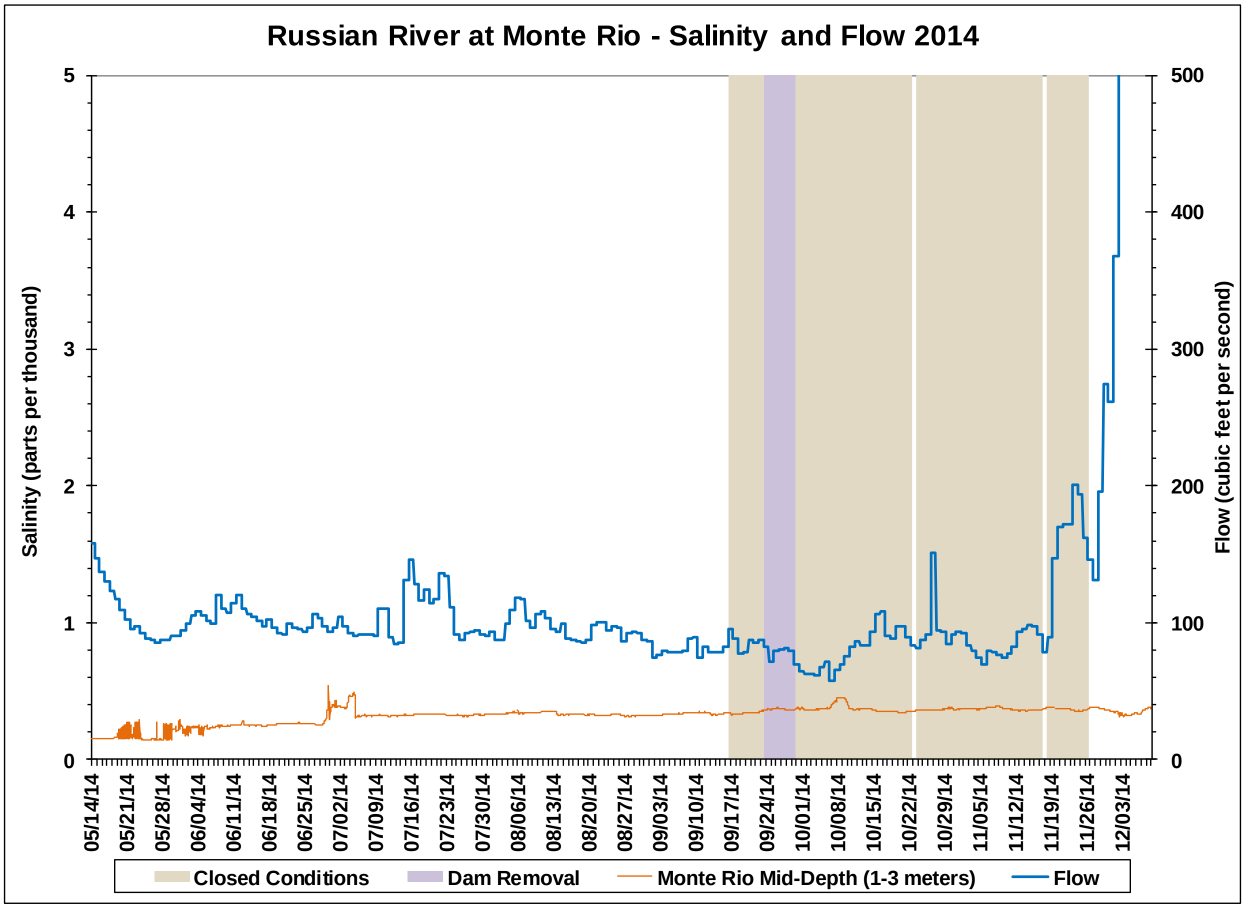


Figure 4.1.11. 2014 Russian River at Monte Rio Salinity and Flow Graph

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 4.1.12 through 4.1.20). 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 Celsius (°C), is the source of saltwater in the Estuary. Whereas, the mainstem Russian River, with water temperatures reaching as high as 27 °C in the interior valleys, is the primary source of freshwater in the Estuary.

During closed Estuary conditions, increasing temperatures associated with fresh/saltwater stratification were observed to occur (Figures 4.1.12 through 4.1.14). 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. Additionally, the overlying freshwater surface 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 (Figures 4.1.12 and 4.1.13). Stratification based heating has also been 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 21.6 and 22.7 °C at the Mouth and Patty's Rock, respectively. Whereas, the mid-depth sondes were located primarily in saltwater and had maximum temperatures of 22.7, 22.8, and 23.2 °C at the Mouth, Patty's Rock, and Sheephouse Creek, respectively (Table 4.1.1). The surface sondes had mean temperatures of 15.7 and 16.6 °C and minimum temperatures of 9.5 and 11.1 °C at the Mouth and Patty's Rock, respectively (Table 4.1.1). The mid-depth sondes had mean temperatures of 15.5, 15.6, and 18.3 °C, and minimum temperatures of 9.5, 10.3, and 13.0 °C at the Mouth, Patty's Rock, and Sheephouse Creek, respectively (Table 4.1.1). The minimum temperature values are higher in the lower estuary than those observed in 2013. This can primarily be attributed to the sondes being retrieved earlier in the season (late November) than in 2013 (late December) and the estuary remaining closed through the end of monitoring in 2014.

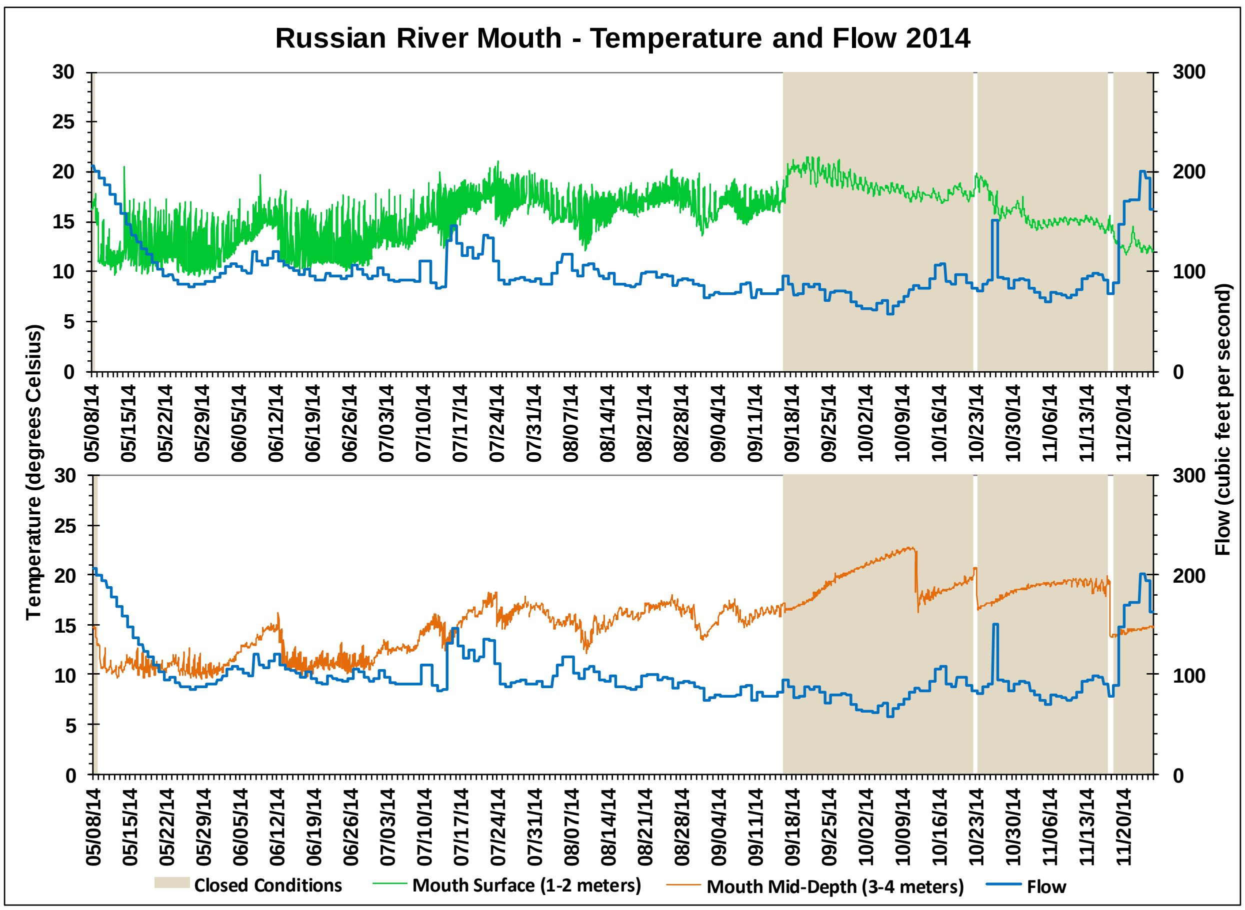


Figure 4.1.12. 2014 Russian River Mouth Temperature and Flow Graph

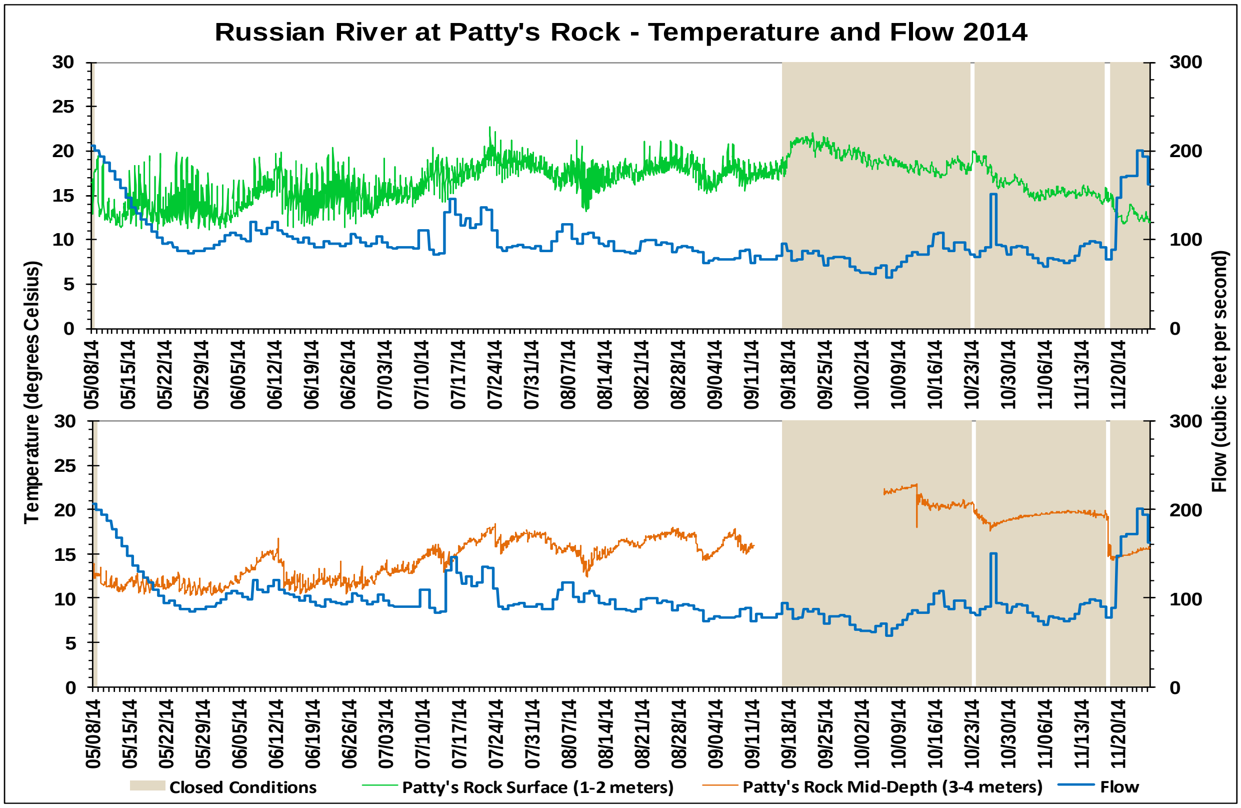


Figure 4.1.13. 2014 Russian River at Patty's Rock Temperature and Flow Graph

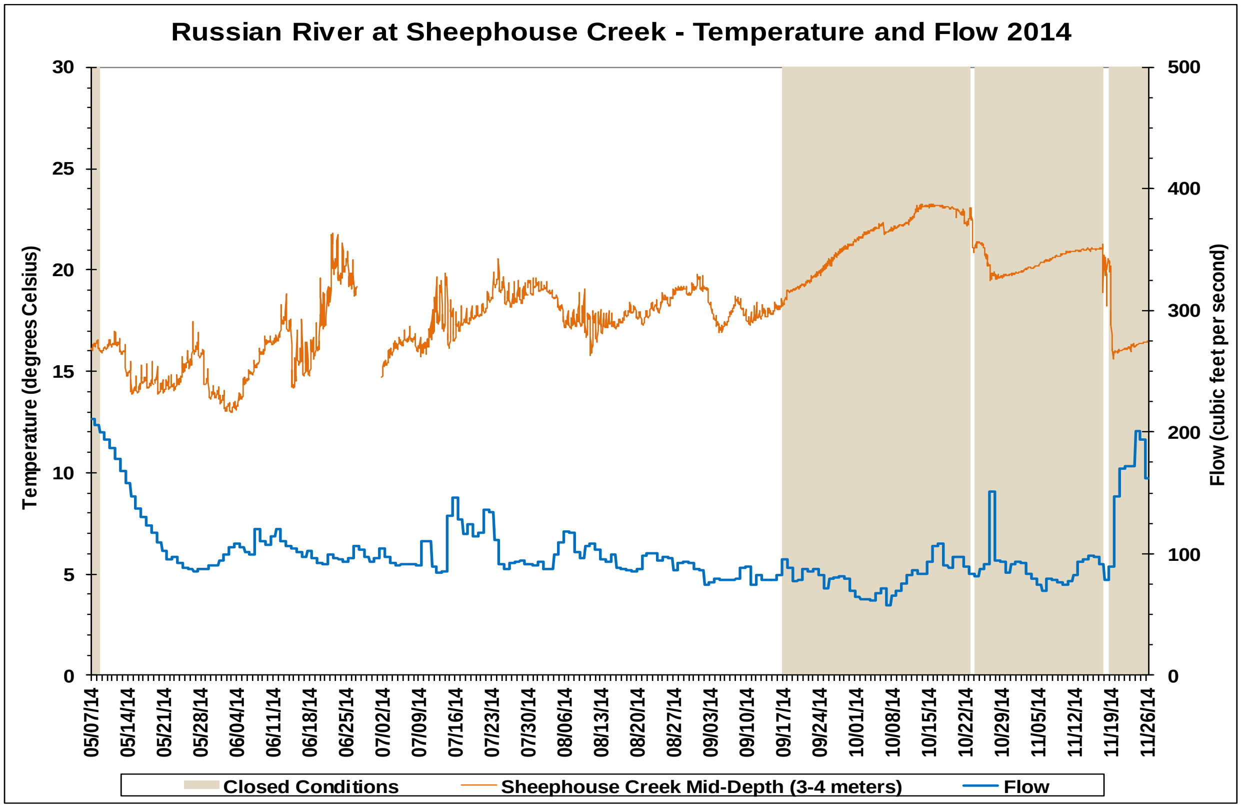


Figure 4.1.14. 2014 Russian River at Sheephouse Creek Temperature and Flow Graph

The Willow Creek station had a maximum temperature of 26.2 °C, which occurred on 25 July in brackish water and open conditions (Figures 4.1.15 and 4.1.6). The mean temperature was 18.1 °C, and the minimum temperature was 5.2 °C. Willow Creek had freshwater conditions prior to the monitoring season that became brackish to saline as flows dropped below 200 cfs in early May (Figure 4.1.6). The station remained brackish through late summer with periodic fluctuations as saline water migrated up and down stream with the tides. Temperatures were observed to fluctuate with the movement of saline water into and out of the station, resulting in both heating and cooling during open and closed Estuary conditions (Figure 4.1.15). This was most apparent following barrier beach closures in October and November when warm brackish water was observed to significantly decrease in temperature after freshwater and/or a fresh source of tidally migrating water migrated to the station during the barrier beach closure (Figure 4.1.15).

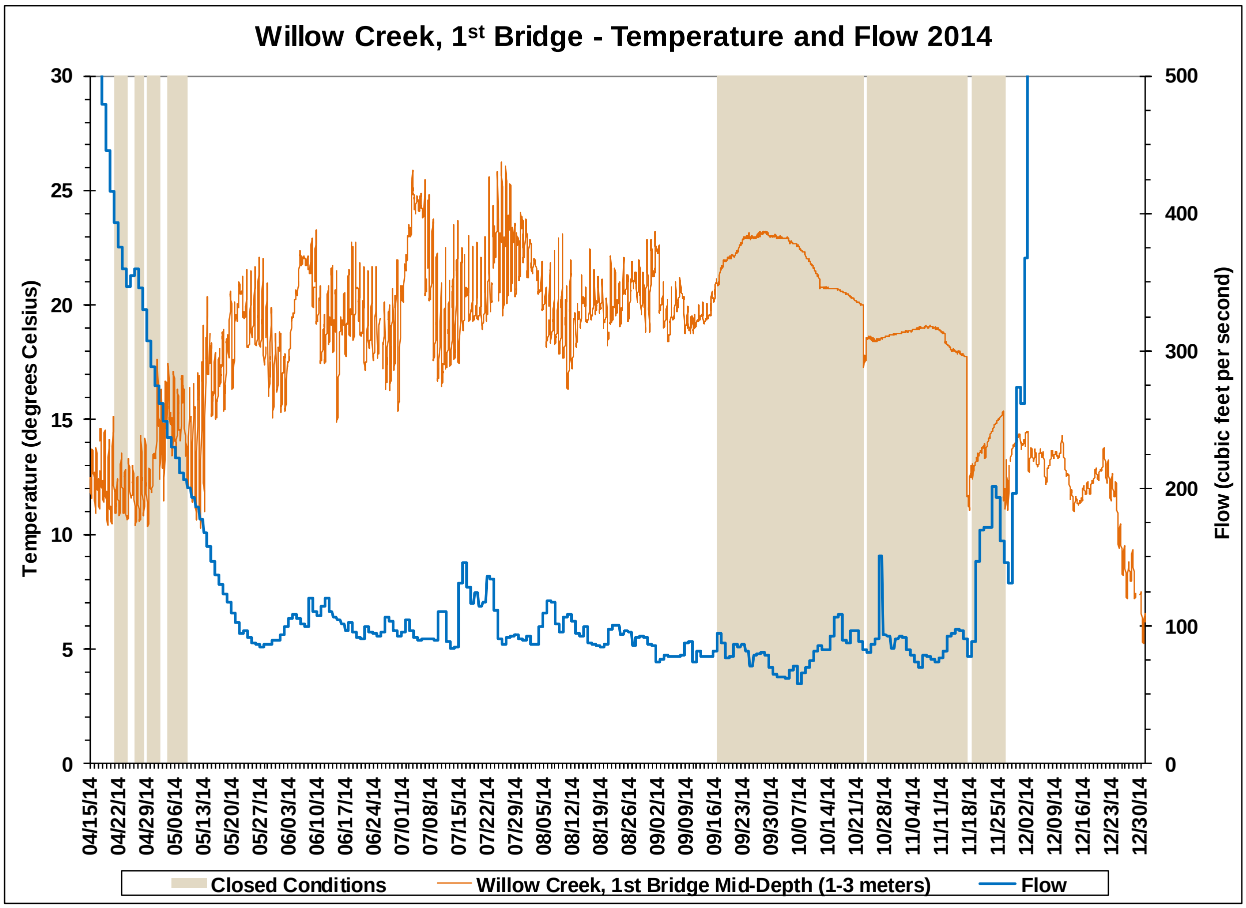


Figure 4.1.15. 2012 Willow Creek Temperature with Russian River Flow

Upper Reach Temperature

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

The bottom sonde at the Freezeout Creek station had a maximum temperature of 24.6 °C, a mean temperature of 21.8 °C, and a minimum temperature of 17.8 °C (Table 4.1.1). The mid-depth sonde had a maximum temperature of 24.9 °C, a mean temperature of 21.5 °C, and a minimum temperature 12.3 °C. Minimum temperatures at the mid-depth sonde occurred in freshwater during closed conditions in November (Figure 4.1.16). Minimum temperatures at the bottom sonde occurred in freshwater during open conditions in May (Figure 4.1.16). The maximum temperatures at the Freezeout Creek sondes were observed to occur in open estuary freshwater conditions in July. However, temperatures were also elevated and near the seasonal maximum value in brackish water during closed conditions in October. (Figure 4.1.16). Temperatures were observed to be fairly stable in the brackish layer during closures later in the season and were observed to decrease at the mid-depth sonde between closures as freshwater briefly replaced and/or mixed with the brackish layer (Figure 4.1.7). After October, temperatures were generally warmer in the saline layer compared to the freshwater layer under both open and closed conditions, which was most apparent during the month of November (Figure 4.1.16).

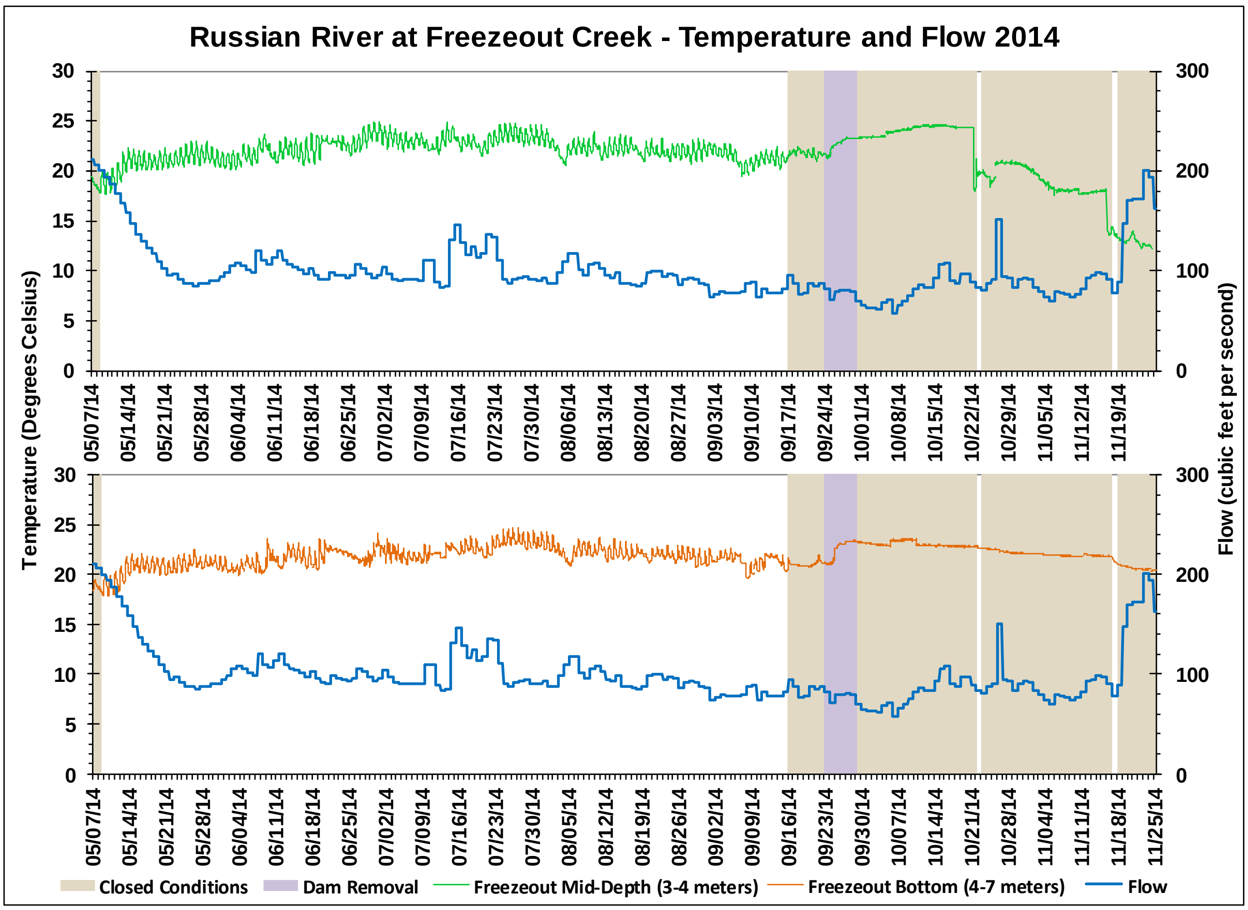


Figure 4.1.16. 2014 Russian River at Freezeout Creek Temperature and Flow Graph

The bottom sonde at the Brown's Pool station had a maximum temperature of 23.5 °C, a mean temperature of 17.3 °C, and a minimum temperature of 12.2 °C (Table 4.1.1). The minimum temperature at the Brown's Pool station was observed during the barrier beach closure in late November when freshwater displaced the brackish water at the bottom of the pool. However, temperatures were observed to be lower when brackish water was present during open conditions (Figure 4.1.17). Under open conditions, warmer freshwater from the MBA would periodically displace the cooler brackish water that was present at the bottom of the pool, resulting in higher temperatures, including the maximum temperature observed on 15 July (Figure 4.1.17). By contrast, temperatures were observed to increase during the closure in early October as warm brackish water migrated to the station and displaced the cooler freshwater (Figure 4.1.8). Temperatures were then observed to decrease between the subsequent closures as the brackish water was displaced by cooler freshwater.

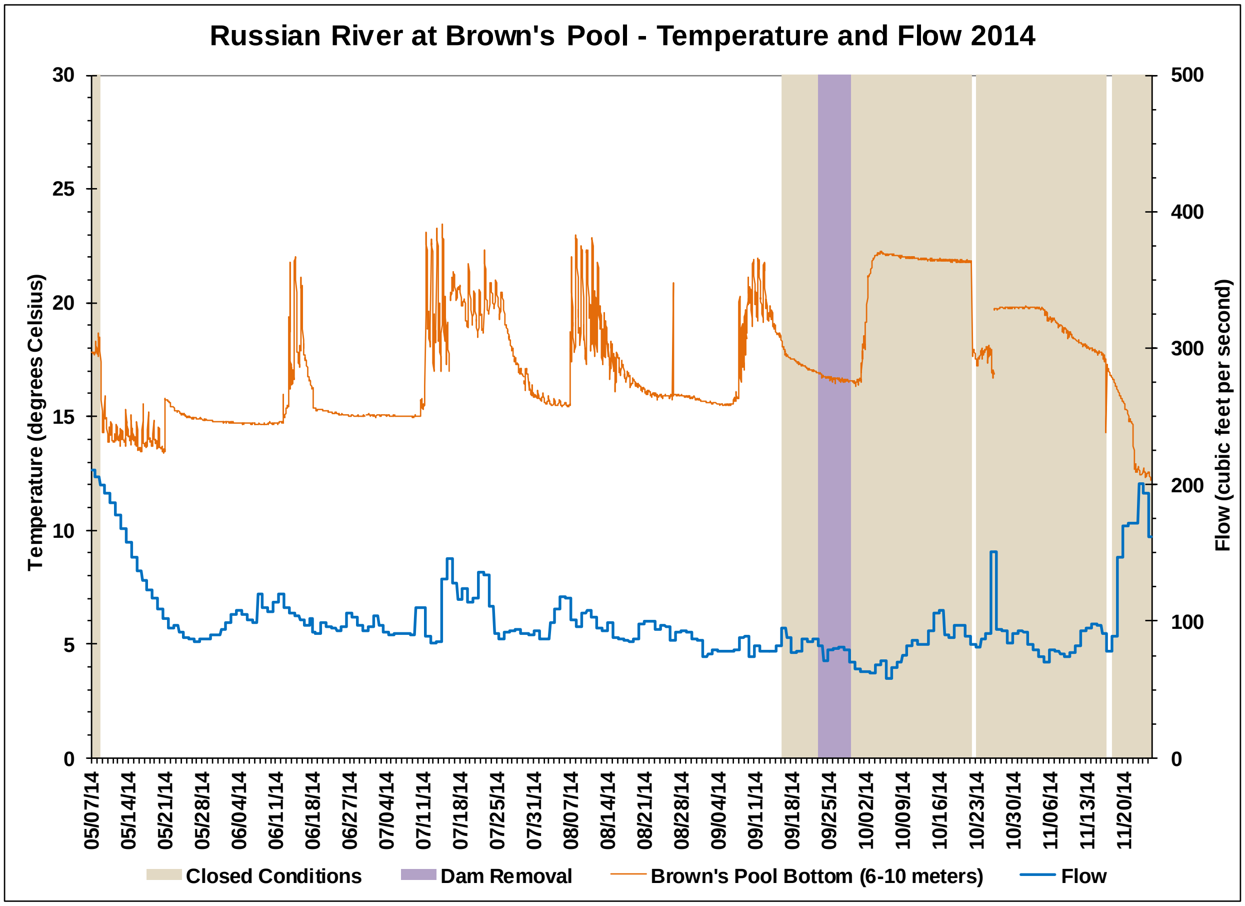


Figure 4.1.17. 2014 Russian River at Brown's Pool Temperature and Flow Graph

Maximum Backwater Area Temperature

Austin Creek had a maximum temperature of 20.7 °C, a mean temperature of 16.5 °C, and a minimum temperature of 11.3 °C (Table 4.1.1). A gradual increase in temperature through the summer months of the Estuary management period coincided with increases in air temperatures (Figure 4.1.18). However, daily fluctuations in temperature dimished significantly once flows dropped below 3 cfs, resulting in lower daily maximums, but higher daily minimums than when higher flows were occurring (Figure 4.1.18). Closed estuary conditions did not appear to have a significant effect on the temperatures at the Austin Creek station. Slight increases and decreases in water temperature during closure events typically coincided with increases and decreases in air temperatures (Figure 4.1.18). However, minor changes to temperatures were observed to occur when the barrier beach was briefly opened between the late season closures. For instance, temperatures slightly increased during the 23 October breaching event, whereas temperatures slightly decreased during the 17 November breaching event. Similarly, increasing flows from late season storm events were also observed to cause minor fluctuations in temperature. For instance, temperatures experienced a brief decrease on 22 November during increased flows with closed conditions, but increased during the 3 December storm event with open conditions Figure 4.1.18). This variability in temperature response can be partially attributed to the variability of inflow water temperature in relation to the receiving water temperature.

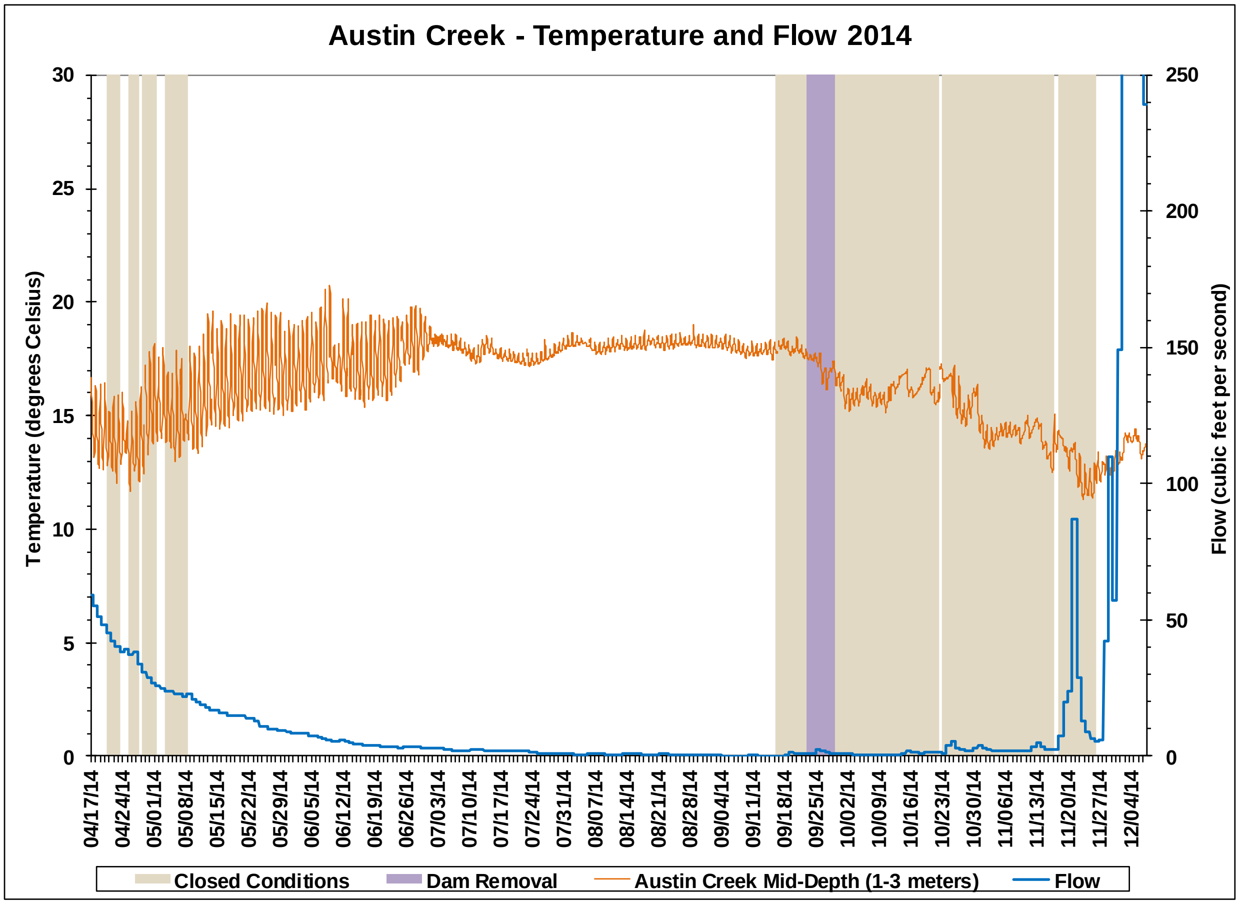


Figure 4.1.18. 2013 Austin Creek Temperature and Flow Graph

Patterson Point had a maximum temperature of 21.5 °C, a mean temperature of 17.9 °C, and a minimum temperature of 12.3 °C (Table 4.1.1). Under open conditions, daily temperatures were lower at Patterson Point than at Brown's Pool in freshwater conditions and at Monte Rio, which suggests that thermal stratification may be occurring at depth (Figure 4.1.19). It is also possible that a groundwater source could be contributing colder water at depth, or it could a combination of both effects occurring in tandem. Daily temperature fluctuations were significantly more stable when compared to Monte Rio (Figure 4.1.20) or Austin Creek before flows became intermittent (Figure 4.1.18), further suggesting some form of thermal stratification or regulation occurring.

During open conditions, periodic spikes in temperature were observed to coincide with brief spikes in dissolved oxygen (DO) concentrations and pH values in an otherwise anoxic environment. A spike in temperature occurred during the September closure, however it did not coincide with a spike in dissolved oxygen or pH, and instead appears to be associated with the removal of the upstream summer dams and subsequent downstream movement of warmer water into the Patterson Point area (Figure 4.1.19). Following this, temperatures continued to decline with atmospheric temperatures through the end of the season and did not appear to be affected by the extended closures.

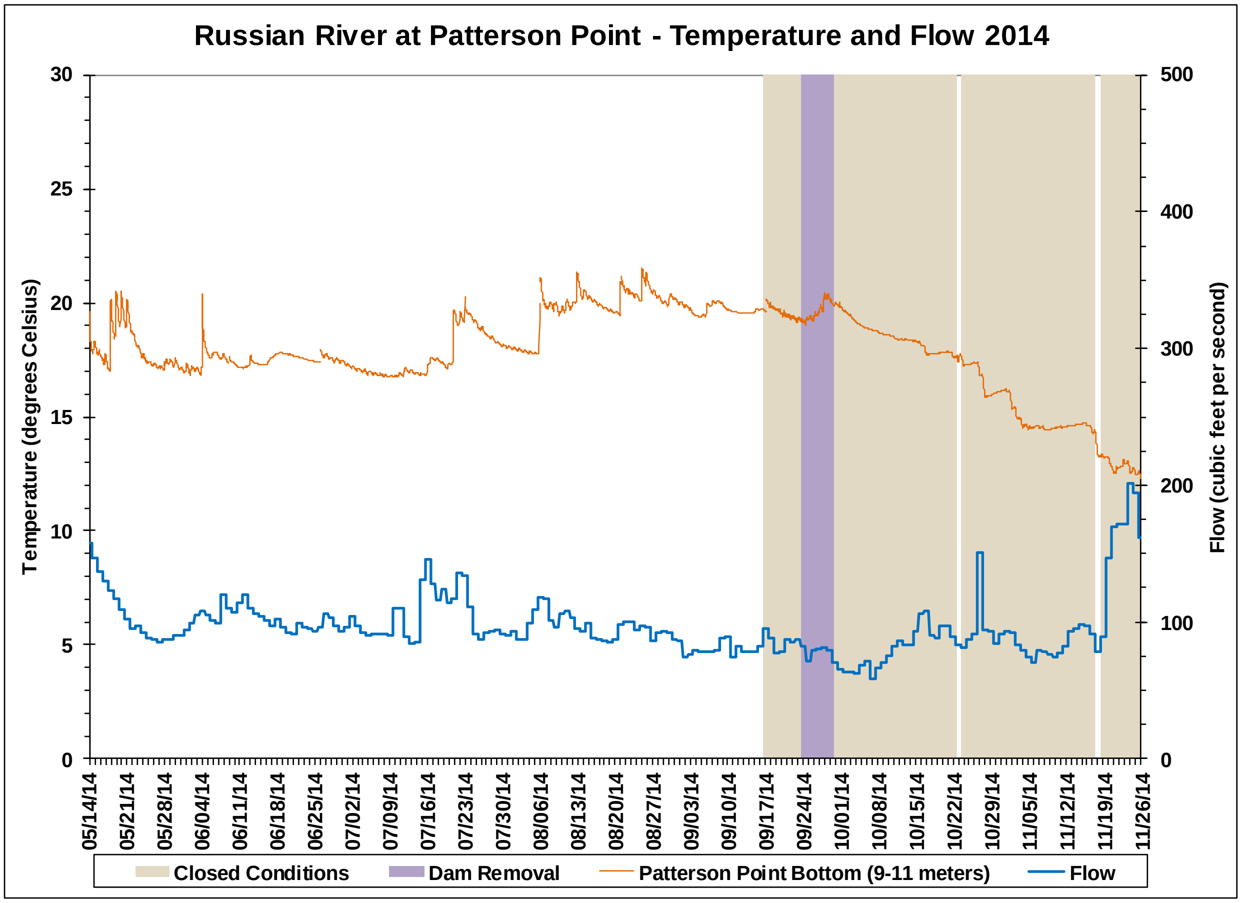


Figure 4.1.19. 2014 Patterson Point Temperature and Flow Graph

The Monte Rio station had a maximum temperature of 27.3 °C, a mean temperature of 21.0 °C, and a minimum temperature of 12.4 °C (Table 4.1.1). Closed Estuary conditions were not observed to have a significant effect on water temperatures at this station, which was consistent with data from previous monitoring efforts at Monte Rio and other monitoring stations within the MBA (Figure 4.1.20). Slight increases and decreases in water temperature during closure events typically coincided with increases and decreases in air temperatures (Figure 4.1.20). However, temperatures can also be affected by increasing flows from storm events and were observed to increase slightly during a storm event in late November after the barrier beach was reopened (Figure 4.1.20). This increase in river temperature can occur when the base temperature of the river is cooler than the temperature of the rain from a given storm.

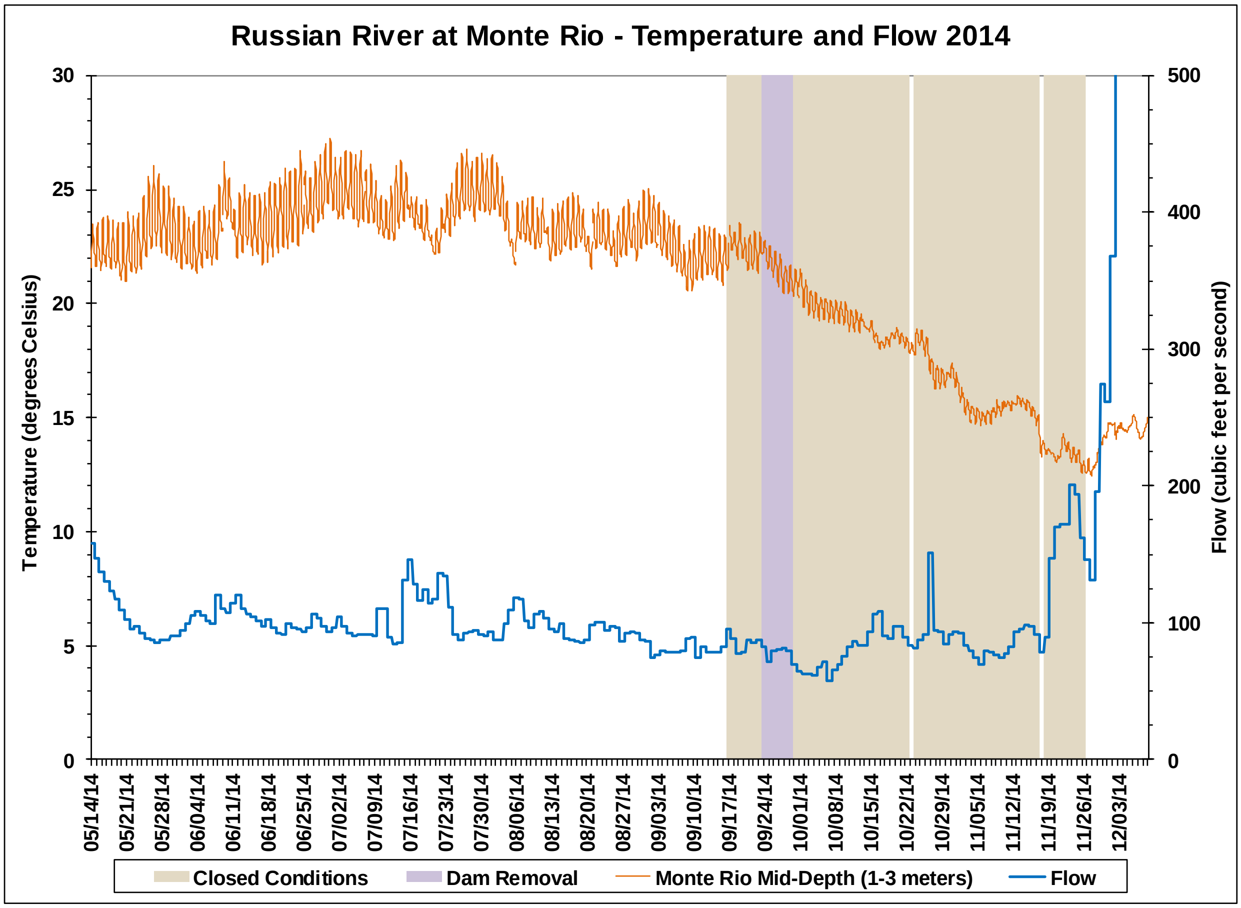


Figure 4.1.20. 2014 Russian River at Monte Rio Temperature and Flow Graph

Dissolved Oxygen

Dissolved oxygen (DO) levels in the Estuary, including the MBA, 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 channel[5]. 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,

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

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.

Mean 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). Although the mid-depth sondes were observed to experience higher supersaturation conditions than the surface sondes, they also experienced more frequent hypoxic and anoxic conditions that served to decrease the mean seasonal value. The Patty's Rock surface sonde was also observed to experience periodic and brief hypoxic conditions during open and closed conditions, whereas the Mouth surface sonde did not. These supersaturation and hypoxic events were observed during open and closed conditions (Figures 4.1.21 through 4.1.23), however supersaturation was more pronounced at the mid-depth sondes during closed conditions and resulted in higher dissolved oxygen concentrations than the corresponding surface sondes (Figures 4.1.21 and 4.1.22). The mid-depth sondes were also observed to experience anoxic conditions that corresponded with brief spikes in salinity during the two barrier beach breachings that occurred between the extended late season closures.

Dissolved oxygen concentrations in Willow Creek were observed to fluctuate in response to a variety of events including tidal water movement, saline intrusion, and open or closed Estuary conditions. Hypoxic events were observed to occur almost daily in the presence of brackish water during open conditions from May through September and were frequently preceded or followed by supersaturation conditions as the day progressed through it's diurnal cycle (Figure 4.1.6). Whereas, dissolved oxygen concentrations were observed to steadily decline over a period of days after the barrier beach closed in mid-September. The Willow Creek station became anoxic and remained that way from late September until the barrier beach reopened in late November and flows were observed to increase (Figure 4.1.24).

Dissolved oxygen concentrations in the upper reach were influenced by the presence or absence of salinity, with lower minimum and mean DO concentrations observed in brackish water and higher minimum and mean concentrations observed in freshwater. The Freezeout Creek station transitioned to a brackish environment at the bottom sonde in June and July, before returning to a primarily freshwater environment until the barrier beach closed in September (Figure 4.1.7). Whereas, the mid-depth sonde at Freezeout Creek remained predominantly freshwater until the September closure. The Brown's Pool station was observed to be predominantly a brackish water environment at the bottom of the pool during the majority of the Estuary management period, with occasional brief periods of freshwater conditions, including between barrier beach closures (Figure 4.1.8). Hypoxic and anoxic conditions at both of these sites were observed to occur in brackish and freshwater conditions, though the anoxia was more persistent in brackish conditions, especially during barrier beach closures (Figures 4.1.25 and 4.1.26).

DO concentrations in the upper reach saline layer were also observed to be lower during open and closed conditions than DO concentrations observed in the saline layer in the lower and 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 closed Estuary conditions, with supersaturation, hypoxic conditions, and to a lesser degree, anoxic conditions being observed (Figures 4.1.21 through 4.1.23).

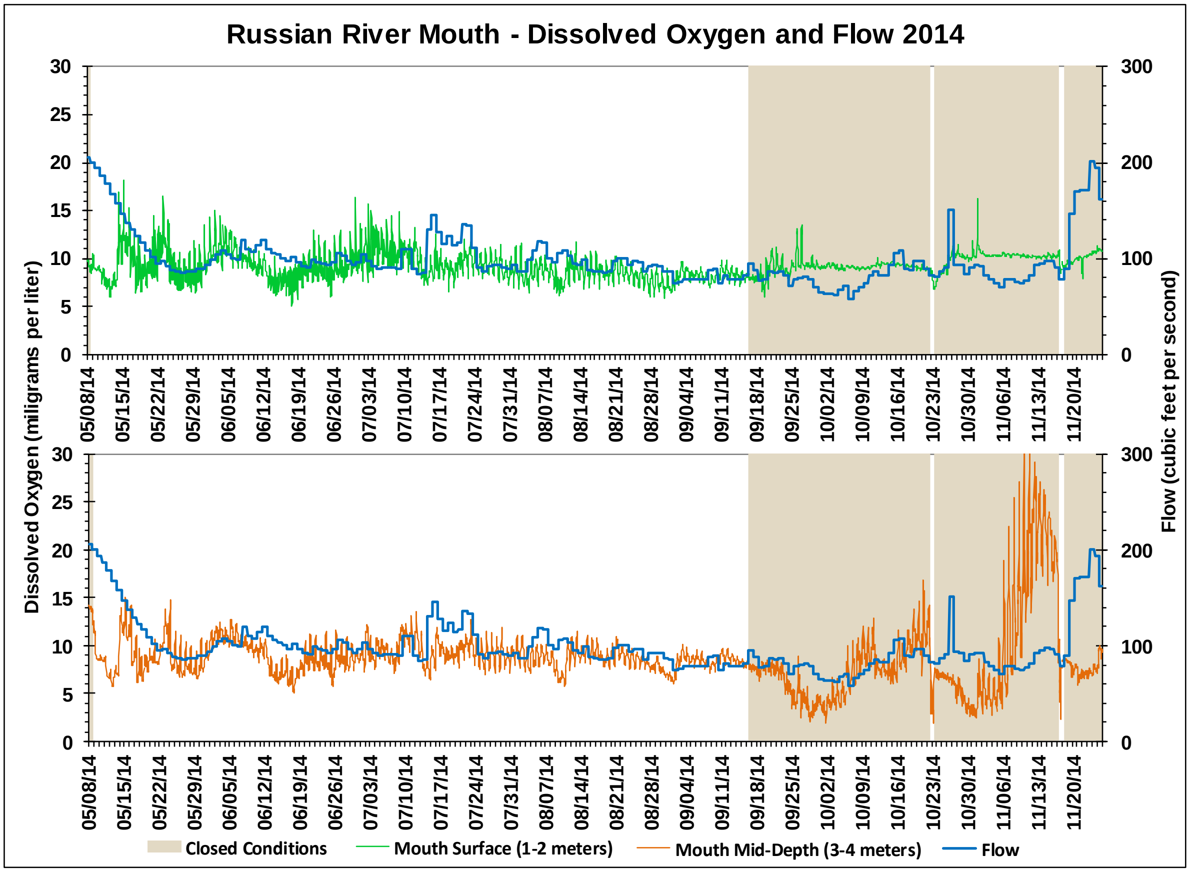


Figure 4.1.21. 2014 Russian River Mouth Dissolved Oxygen and Flow Graph

The surface sondes were observed to have higher mean DO concentrations when compared to the mid-depth sondes (Table 4.1.1). The surface sondes at the Mouth and Patty's Rock had mean DO concentrations of 9.3 and 9.1 mg/L, respectively. Whereas, the mid-depth sondes had mean DO concentrations of 8.8, 8.1, and 6.9 mg/L at the Mouth, Patty's Rock, and Sheephouse Creek stations, respectively (Table 4.1.1).

The effect of closed conditions at the surface sondes was variable as DO concentrations were observed to remain unaffected, slightly decline, or increase in some instances (Figures 4.1.21 and 4.1.22). The Mouth and Patty's Rock surface sondes had minimum DO concentrations of 5.0 and 1.6 mg/L (Table 4.1.1). The minimum concentration was observed at the Mouth surface station during open conditions, whereas the seasonal minimum at the Patty's Rock surface station was observed shortly after the barrier beach closed in September (Figures 4.1.21 and 4.1.22).

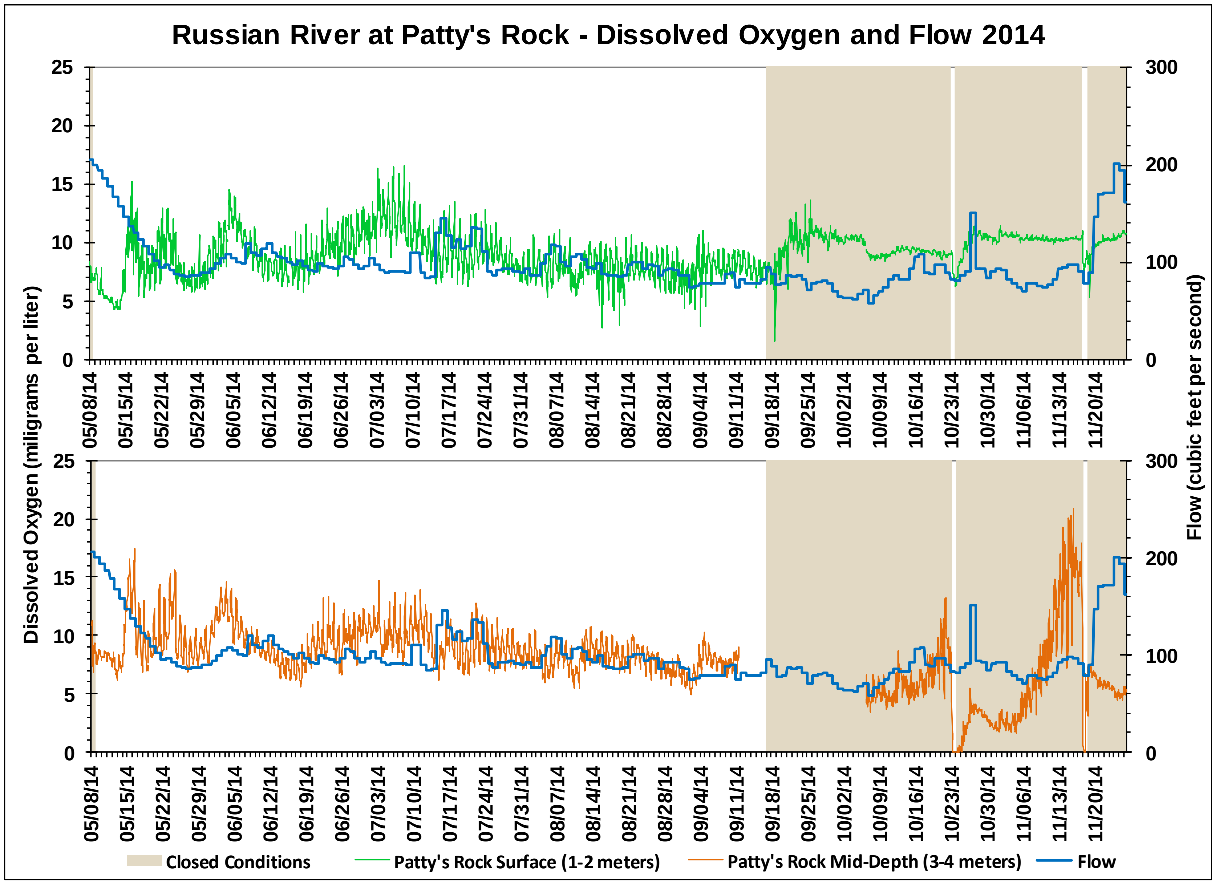


Figure 4.1.22. 2014 Russian River at Patty's Rock Dissolved Oxygen and Flow Graph

Short-term hypoxic and/or anoxic events previously observed during open conditions at mid-depth sondes in 2009 and 2012 were not observed during the 2014 monitoring season (Figure 4.1.21 through 4.1.23). However, DO concentrations were observed to become hypoxic at the mid-depth stations during river closures, and briefly anoxic at the Patty's Rock and Sheephouse Creek mid-depth sondes between the late season closures (Figures 4.1.22 and 4.1.23).

Corresponding minimum concentrations of DO at the mid-depth sondes were 1.9, 0.0, and 0.1 mg/L at the Mouth, Patty's Rock, and Sheephouse Creek stations, respectively (Table 4.1.1). As can be seen from these minimum DO concentrations, lower minimum oxygen levels were observed at the mid-depth sondes than at the surface sondes.

The DO concentrations at the mid-depth sondes were not observed to fluctuate to the same degree as the surface sondes during open conditions (Figures 4.1.21 through 4.1.23). However, they were observed to fluctuate more significantly at mid-depth during closed conditions. During open barrier beach conditions, this increased variability of DO concentrations at the surface sondes corresponded with fluctuations in salinity concentrations, as the surface sondes were placed at the freshwater/saltwater interface. However, during closed conditions, the freshwater layer increases in depth and the surface sondes are located in a primarily freshwater environment where coastal atmospheric conditions tend to temper daily temperature and DO fluctuations. Conversely, DO concentrations were observed to fluctuate more significantly at mid-depth during closed conditions as the saline layer and temperatures fluctuated (Figures 4.1.21 and 4.1.22).

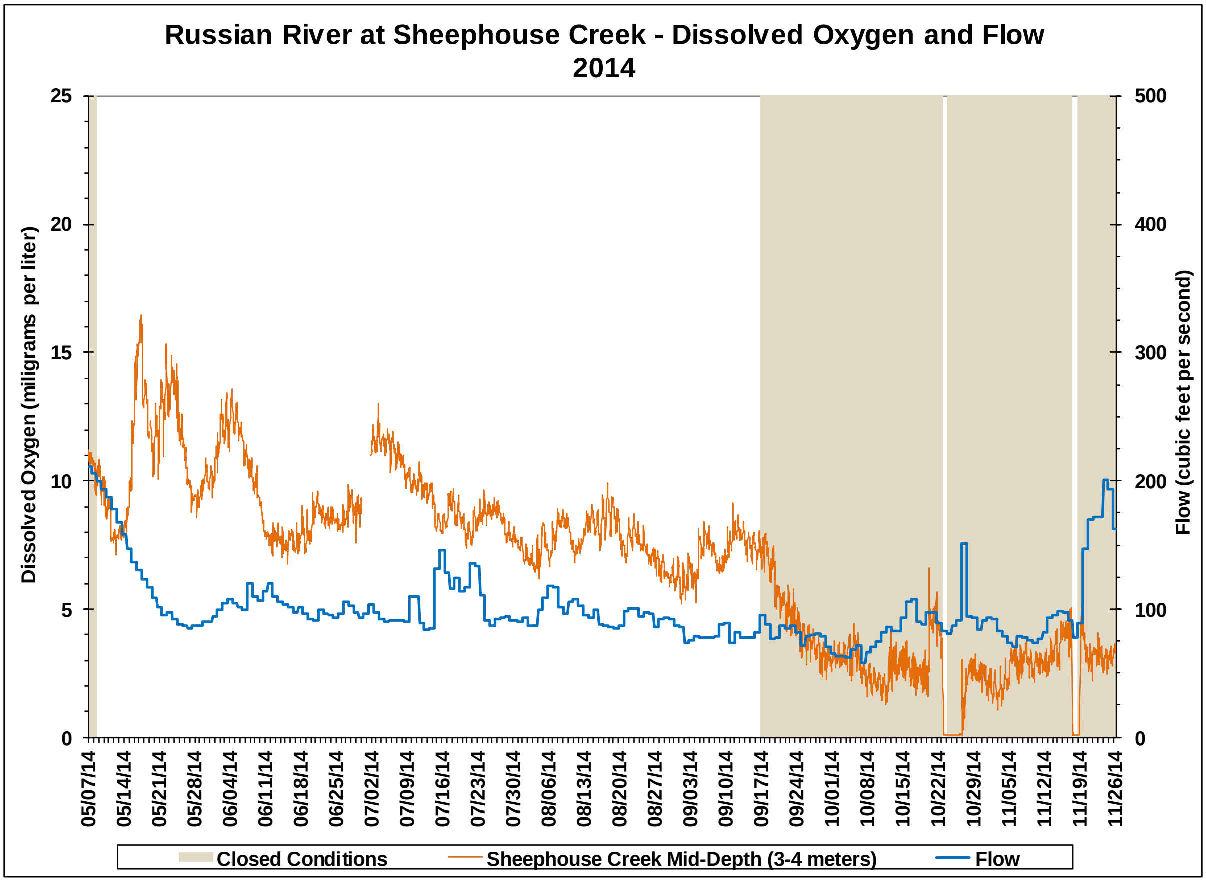


Figure 4.1.23. 2014 Russian River at Sheephouse Creek Dissolved Oxygen and Flow Graph

The lower and middle reach surface sondes, and mid-depth sondes to a lesser degree, 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 °C, but only 8.2 mg/L at 24 °C. Consequently, these two temperature values roughly represent the range of temperatures typically observed in the Estuary.

The most significant supersaturation events at the Mouth and Patty's Rock were generally observed at the surface sondes during open estuary conditions and at the mid-depth sondes during closed estuary conditions, although the surface sondes also experienced brief supersaturation events during the late season closures (Figures 4.1.21 and 4.1.22). Conversely, the Sheephouse Creek mid-depth sonde did not experience any supersaturation events during the closures, but did during open conditions in May, June, and July (Figure 4.1.23).

The Mouth surface sonde had a maximum DO concentration of 18.1 mg/L, which corresponded to 212% saturation. The maximum DO concentration at the Patty's Rock surface sonde was 16.6 mg/L, or 200% saturation (Table 4.1.1). Maximum DO concentrations at the mid-depth sondes were approximately 33.0 mg/L (386%) at the Mouth, 20.8 mg/L (238%) at Patty's Rock, and 16.5 mg/L (195%) at Sheephouse Creek, respectively (Table 4.1.1). The Mouth mid-depth maximum DO occurred on the evening of 10 November during a prolonged Estuary closure (Figure 4.1.21). The Patty's Rock mid-depth maximum DO occurred at mid-night on 15 November under closed Estuary conditions (Figure 4.1.20). The Sheephouse Creek mid-depth maximum DO occurred on 17 May during open conditions (Figure 4.1.23).

The Willow Creek sonde had a minimum DO concentration of 0.1 mg/L, a mean DO concentration of 5.6 mg/L, and a maximum DO concentration of 14.3 mg/L (184%) (Table 4.1.1). Frequent fluctuations between hypoxic and supersaturated DO concentrations were observed during open conditions after brackish water migrated into Willow Creek in early May (Figure 4.1.24). Anoxic conditions were observed to occur in brackish water during the extended Estuary closures in the fall, and DO concentrations did not recover until the mouth was opened and flows increased in late November. (Figure 4.1.24).

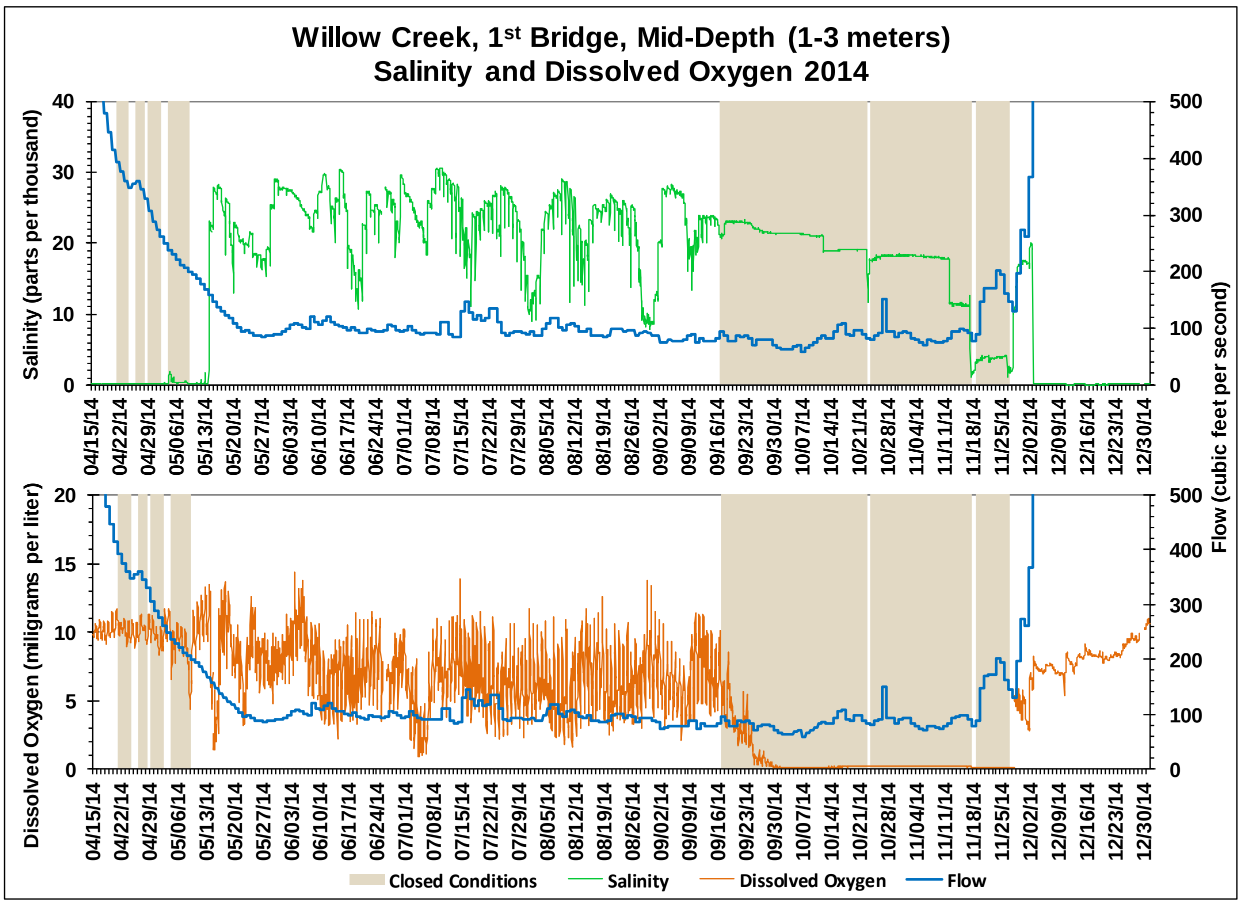


Figure 4.1.24. 2014 Willow Creek Salinity and Dissolved Oxygen Graph

Upper Reach DO

The Freezeout Creek bottom sonde had a minimum concentration of 0.1 mg/L, a mean DO concentrations of 4.1 mg/L, and a maximum concentration of 13.1 mg/L (154%) (Table 4.1.1). The mid-depth sonde at Freezeout Creek had a minimum concentration of 0.0 mg/L, a mean DO concentration of 7.4 mg/L, and a maximum concentration of 18.9 mg/L (203%) (Table 4.1.1).

DO concentrations at the Freezeout Creek bottom sonde fluctuated significantly and became hypoxic and anoxic during open and closed Estuary conditions when saline water was present (Figure 4.1.25). The Freezeout Creek bottom sonde was observed to be primarily brackish from mid-June to mid-July, with concentrations as high as 12 ppt. Otherwise, the bottom was predominantly freshwater during open conditions with frequent minor fluctuations in salinity concentrations of approximately 2 ppt and less frequent episodes with concentrations briefly spiking as high as 10 ppt. These fluctuations in salinity concentration often occurred on a daily and even hourly basis. DO typically fluctuated with changing salinity concentrations, becoming depressed in saline water and recovering in freshwater (Figure 4.1.25). Saline water migrated to the bottom of Freezeout Creek during the estuary closure in late September and remained saline through the subsequent closures. Correspondingly, DO concentrations declined and the bottom of the Freezeout Creek station became anoxic by mid-October and remained anoxic through the subsequent closures (Figure 4.1.25)

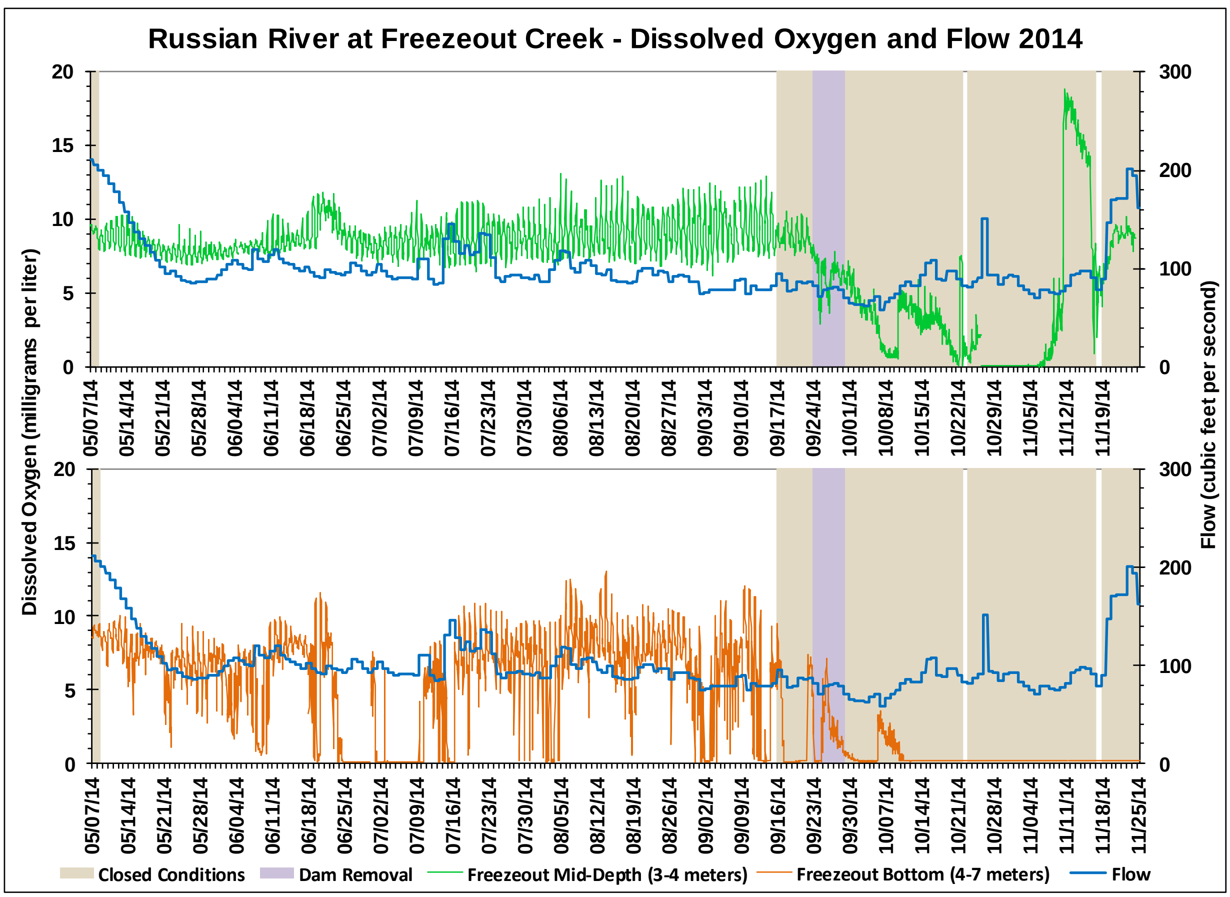


Figure 4.1.25. 2014 Russian River at Freezeout Creek Dissolved Oxygen and Flow Graph

The Freezeout Creek mid-depth sonde was also observed to have brackish conditions during open conditions from mid-June to mid-July, though to a far lesser degree than the bottom sonde (Figure 4.1.7). These brackish conditions were below 5 ppt, which is less than the bottom sonde, and occurred less frequently. DO concentrations were observed to remain stable at the mid-depth sonde in freshwater conditions, but became anoxic and hypoxic in the presence of brackish water during and between Estuary closures from September through early November (Figure 4.1.25). Conversely, DO concentrations became supersaturated at the mid-depth sonde during the early November closure as salinity declined. DO concentrations then returned to pre-closure levels as increasing freshwater flows replaced the mid-depth saline layer during the late November closure (Figure 4.1.25).

The Brown's Pool bottom sonde had a minimum concentration of 0.0 mg/L, a mean DO concentration of 1.1 mg/L, and a maximum concentration of 10.5 mg/L (123%) (Table 4.1.1). The bottom of Brown's Pool was predominantly brackish during the entire monitoring season in open and closed conditions (Figure 4.1.8). As such, DO concentrations at the sonde were observed to be primarily anoxic in the presence of the brackish water during open and closed conditions. However, the bottom of Brown's Pool did experience a brief increase in DO concentrations during the October closure as more oxygenated salt water migrated into the site (Figures 4.1.8 and 4.1.26).

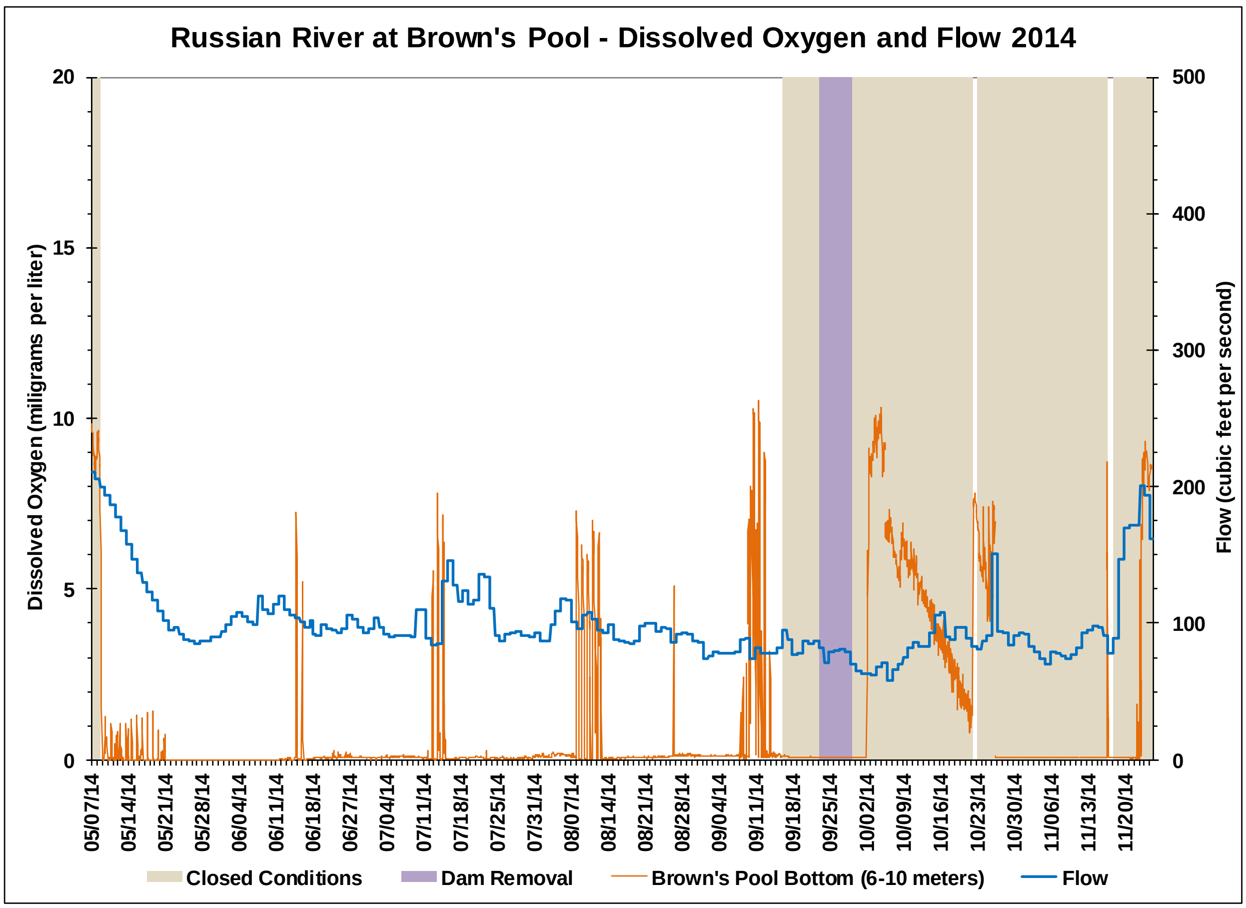


Figure 4.1.26. 2014 Russian River at Brown's Pool Dissolved Oxygen and Flow Graph

Ultimately, concentrations declined over the following three weeks at Brown's Pool to hypoxic conditions before briefly recovering after the barrier beach was breached on 22 October. Conditions then quickly became anoxic during the following closure and were not observed to recover until freshwater flows increase in late November (Figure 4.1.26).

DO response to Estuary closure events was variable in the Upper Reach and dependent on the presence and movement of salinity, the relative strength of stratification, circulation patterns, and flows in the Russian River. The presence of salinity would typically coincide with the presence of depressed DO levels, but not always (i.e. Brown's Pool at the bottom during the October closure), suggesting that variability is dependent on relative DO concentrations in the migrating salt wedge, the length of time of Estuary closures, the timing of subsequent closure events, freshwater inflow rates, the DO concentration of inflowing freshwater, and subsequent tidal inundation and mixing.

Maximum Backwater Area DO

The Austin Creek station had minimum, mean, and maximum DO concentrations of 0.1, 4.7, and 10.6 (106%) mg/L, respectively (Table 4.1.1). Similar to previous monitoring seasons, DO concentrations in 2014 gradually declined through the summer months as flows decreased and mixing was significantly reduced (Figure 4.1.27). As a result of continuing drought conditions, flows became intermittent earlier in 2014 than in 2013 measuring less than 2 cfs at the upstream USGS gauging station by early July. The sonde was now in an isolated pool where DO concentrations became hypoxic. Minimum values at Austin Creek were observed during open conditions in August and during an Estuary closure in September and October (Figure 4.1.27). Interestingly, as the closed estuary filled and began to inundate the Austin Creek station, DO concentrations showed signs of recovery, with daily fluctuations from anoxic to slightly hypoxic conditions increasing over time to a maximum of approximately 7 mg/L by mid-October. However, DO concentrations were again observed to decrease toward the end of the October closure and through the short lived breaching event on 22 October. A brief spike in Austin Creek flows to approximately 5 cfs on 26 October resulted in DO concentrations increasing slightly, but concentrations did not begin to fully recover to springtime levels until storm related flows began to increase in late November (Figure 4.1.27). Summer dam removal did not appear to have a negative effect on DO concentrations. The station was fully anoxic before removal began on 24 October and conditions actually began to improve during and following dam removal.

DO response to estuary closures was variable. Concentrations were observed to initially decline during the closure in September, but were also observed to increase during the same closure and following summer dam removal. Concentrations began to decline again in mid-October and became variable as the barrier beach was breached and then closed again. However concentrations were higher during the closures than during open conditions when flows were intermittent (Figure 4.1.27).

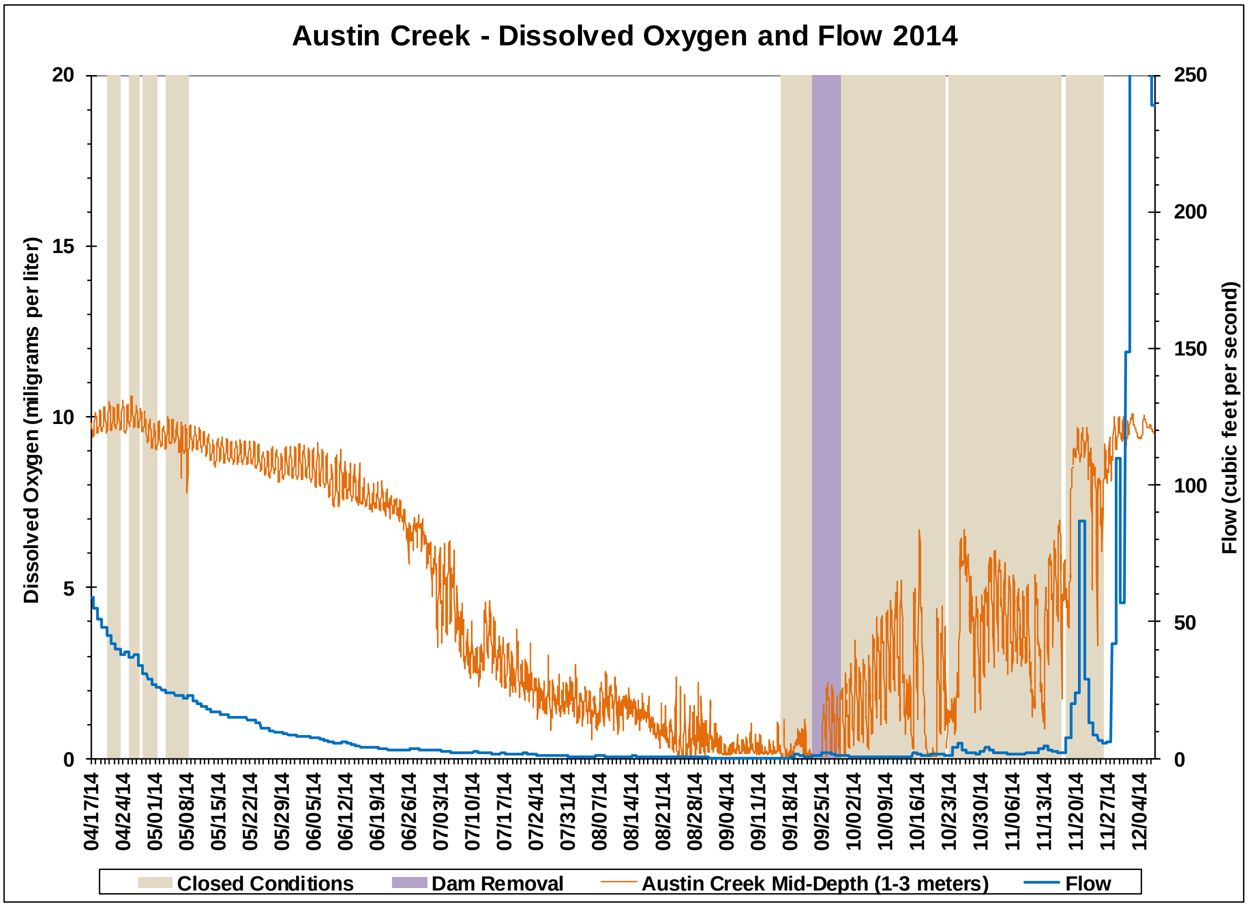


Figure 4.1.27. 2014 Austin Creek Dissolved Oxygen and Flow Graph

Patterson Point had a minimum concentration of 0.0 mg/L, a mean concentration of 1.5 mg/L, and a maximum concentration of 21.0 (196%). The station is located at the bottom of a deep pool and remained predominantly anoxic throughout the monitoring season under both open and closed conditions. Concentrations were observed to recover during closed conditions from mid-October to early November, but then declined to anoxic conditions until concentrations became supersaturated as storm flows increased during the closure in late November (Figure 4.1.28).

The Monte Rio Station had a minimum concentration of 5.7 mg/L, a mean DO concentration of 8.3 mg/L, and a maximum concentration of 9.9 mg/L (118%) (Table 4.1.1). The minimum DO concentration occurred on 13 September during open conditions (Figure 4.1.29). Although there were some temporally localized DO concentrations between 6 and 8 mg/L, DO concentrations did not appear to be significantly affected by summer flows or closed conditions and remained above 8 mg/L, on average, during both open and closed conditions (Figure 4.1.29).

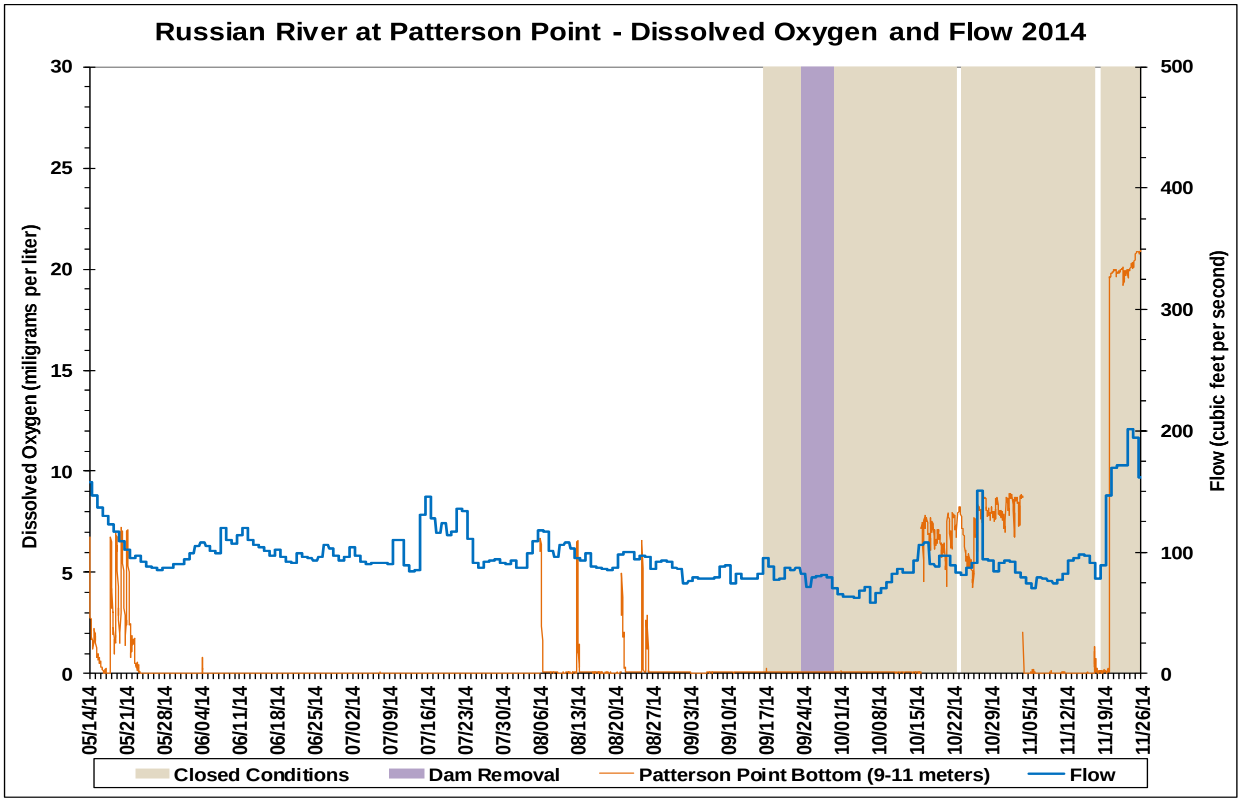


Figure 4.1.28. 2014 Russian River at Patterson Point Dissolved Oxygen and Flow Graph

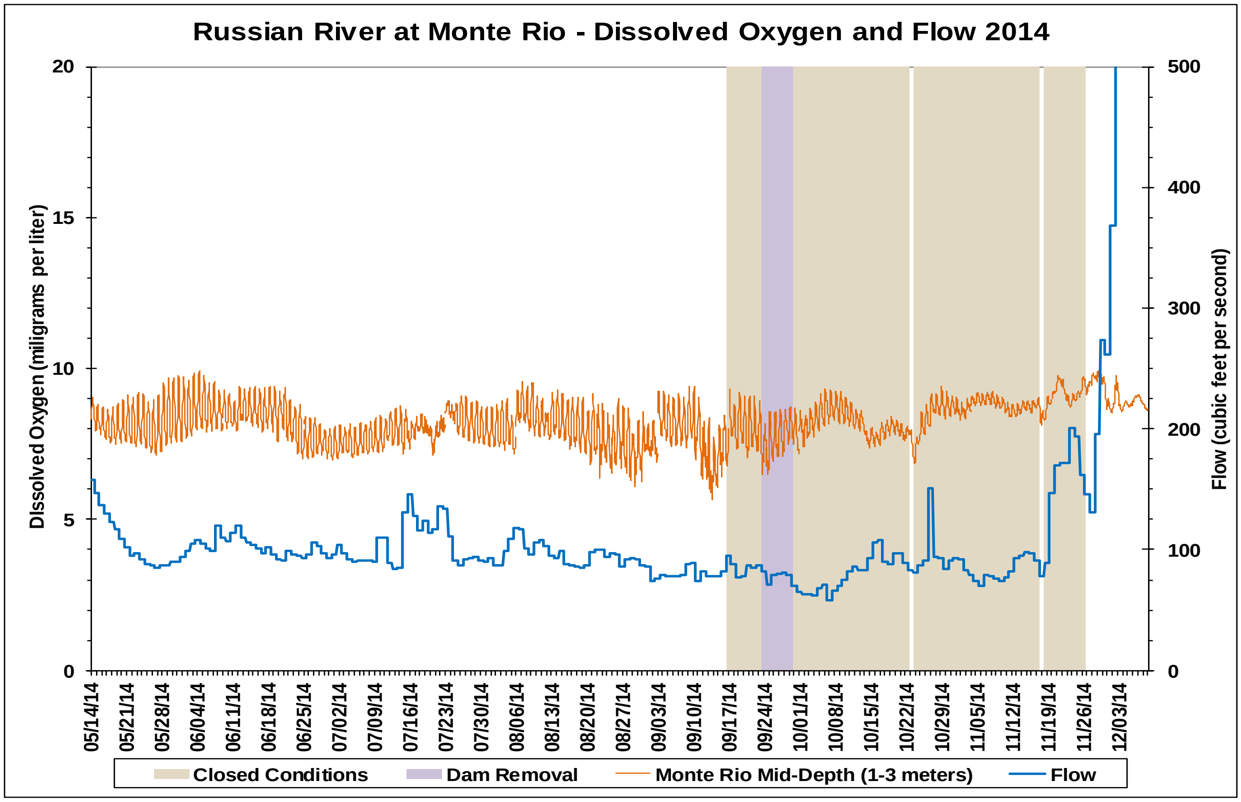


Figure 4.1.29. 2014 Russian River at Monte Rio Dissolved Oxygen and Flow Graph

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

Mean hydrogen ion (pH) values were fairly consistent among all mid-depth stations in the lower and middle reaches, with values of 8.0, 8.1, and 7.8 pH observed at the Mouth, Patty's Rock, and Sheephouse Creek, respectively (Figures 4.1.30 through 4.1.32). The Mouth and Patty's Rock surface sondes were also consistent, with mean pH values of 8.3 and 8.2 pH, respectively (Table 4.1.1).

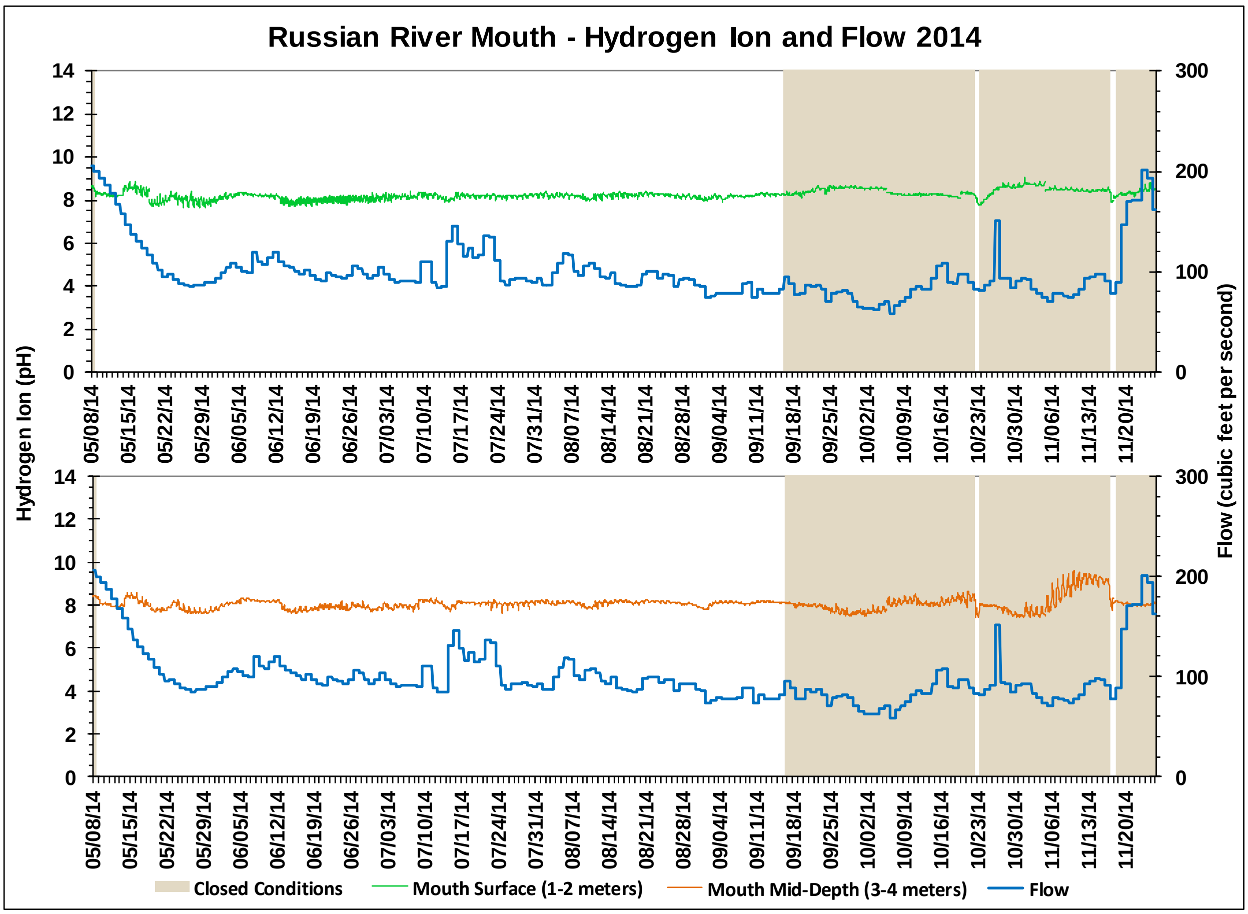


Figure 4.1.30. 2014 Russian River Mouth Hydrogen Ion and Flow Graph

Maximum and minimum pH values were also fairly consistent across stations in the lower and middle reaches at both mid-depth and at the surface, with the exception of the Mouth at mid-depth. Maximum pH values at the Patty' Rock and Sheephouse Creek mid-depth sondes were observed to be 8.8 and 8.5 pH, respectively, while the maximum at the Mouth mid-depth sonde was 9.6 pH. Maximum pH values at the Mouth and Patty's Rock surface sondes were both observed to be 9.1 pH, respectively. Minimum pH values at the mid-depth sondes were 7.4, 7.2, and 7.0 pH at the Mouth, Patty's Rock, and Sheephouse Creek, respectively. Similarly, the minimum pH values at the surface sondes were observed to be 7.6 and 7.4 pH at the Mouth and Patty's Rock, respectively.

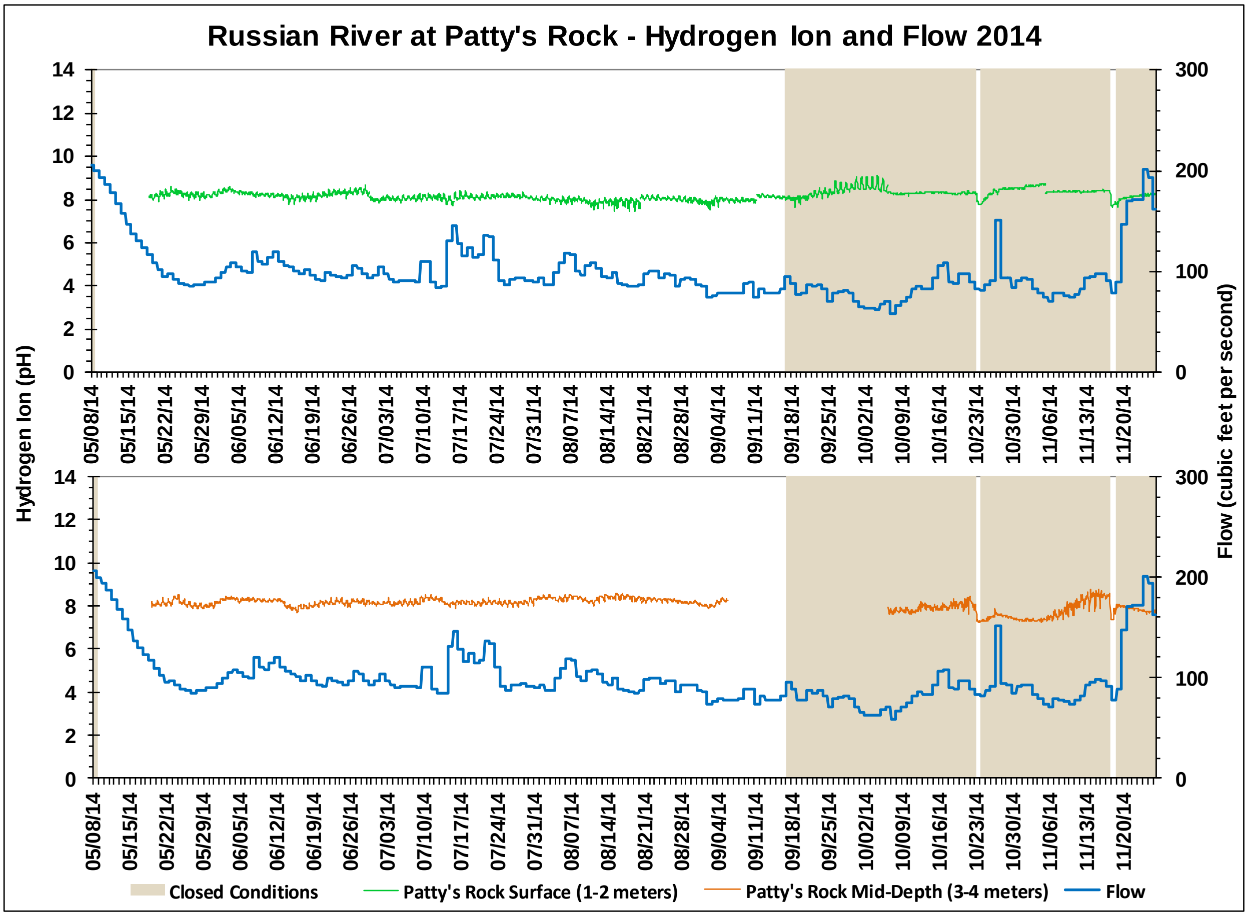


Figure 4.1.31. 2014 Russian River at Patty's Rock Hydrogen Ion and Flow Graph

Although minimum, mean, and maximum pH values were fairly consistent amongst the lower and middle reach stations, pH values were observed to vary with increases and decreases of DO concentrations, with higher values generally observed during supersaturation conditions and lower values during hypoxic conditions (Figures 4.1.30 through 4.1.32). This was especially apparent when pH values were as high as 9.6 at the Mouth mid-depth sonde during a supersaturation event in November when the estuary was closed (Figure 4.30).

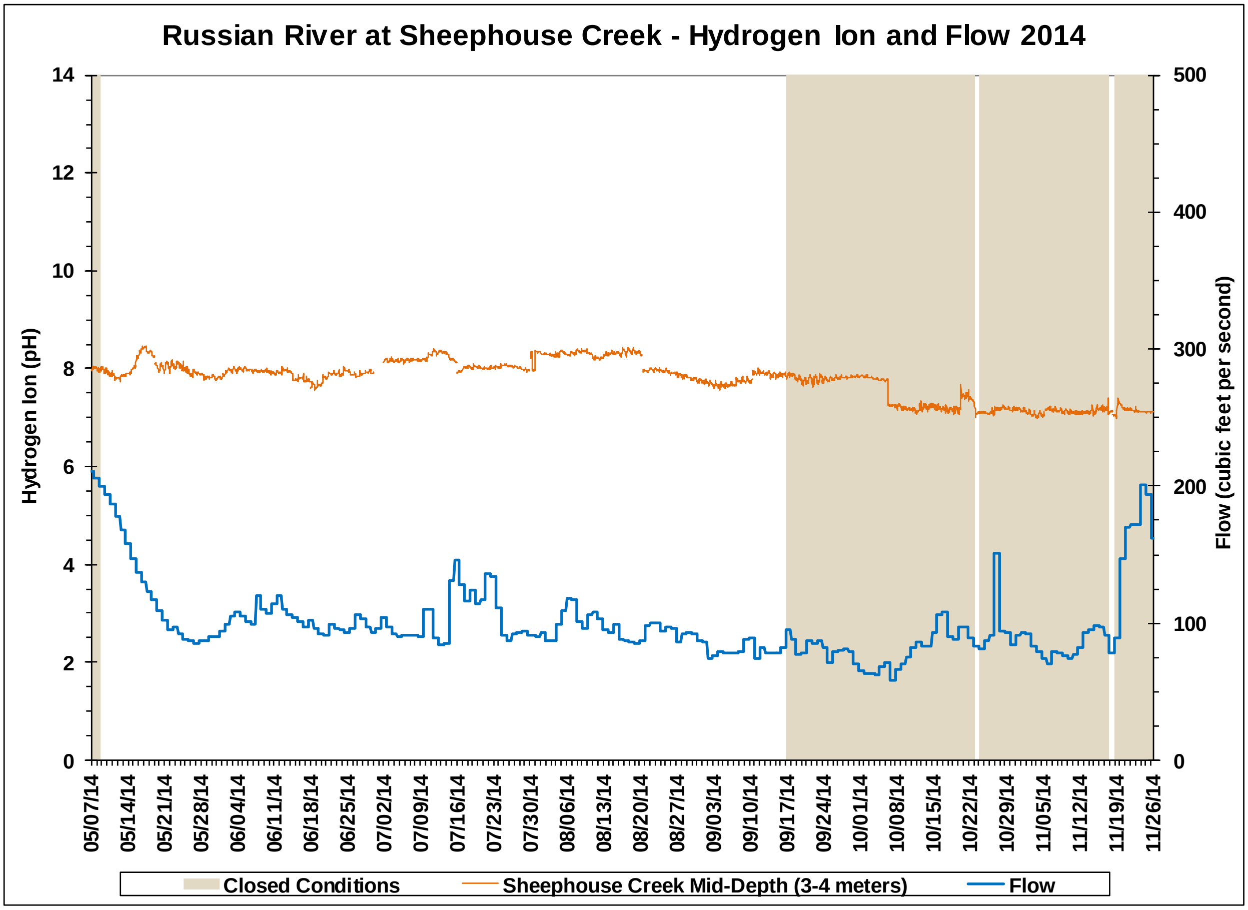


Figure 4.1.32. 2014 Russian River at Sheephouse Creek Hydrogen Ion and Flow Graph

The Willow Creek station had a minimum pH value of 6.0, a mean pH value of 7.4, and a maximum pH value of 8.8 (Table 4.1.1). The Willow Creek station also had pH values that were observed to vary with increases and decreases of DO concentrations, as well as with fluctuations in salinity associated with reduced freshwater flows, tidal influence, and Estuary closures (Figures 4.1.24 and 4.1.33). Minimum pH values were observed during elevated flows in spring and fall in predominantly freshwater conditions, and maximum values were observed in mid-summer during open conditions in brackish water. Values were observed to increase during spring closures when flows and DO concentrations were still elevated. Whereas, pH values were observed to decline during fall closures as the brackish water became anoxic (Figures 4.1.24 and 4.1.33).

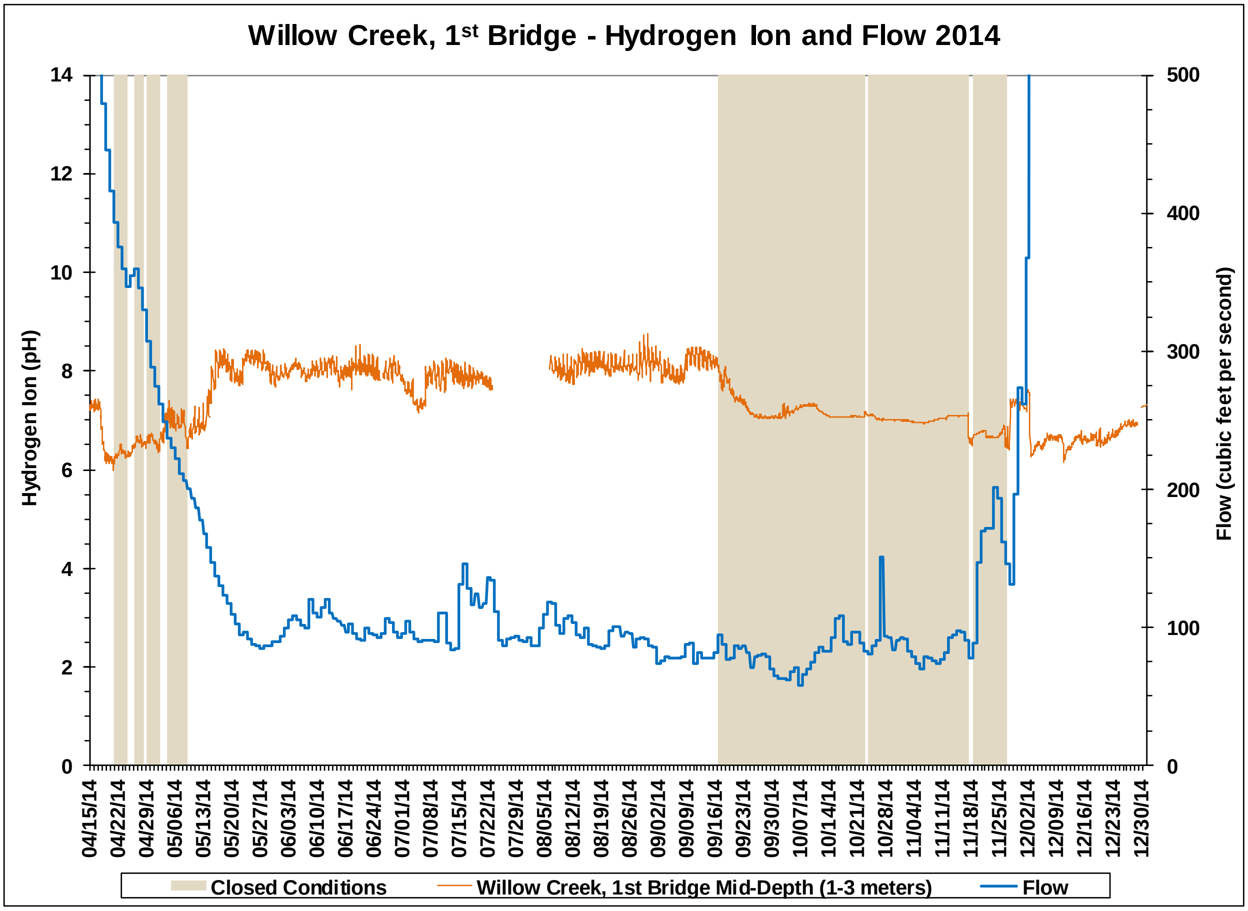


Figure 4.1.33. 2014 Willow Creek Hydrogen Ion and Flow Graph

Upper Reach pH

The Freezeout Creek bottom sonde recorded a minimum pH value of 6.4, a mean pH value of 7.5, and a maximum pH value of 8.9 (Table 4.1.1). The Freezeout Creek mid-depth sonde recorded a minimum pH value of 7.0, a mean pH value of 8.1, and a maximum pH value of 9.3 (Table 4.1.1). The Freezeout Creek station had pH values that were observed to vary with DO concentrations, as has been observed in previous monitoring seasons, and at other monitoring stations. Lower minimum values were generally observed to occur during hypoxic and anoxic conditions, in the presence of both freshwater and saline water. The mid-depth sonde did not experience hypoxic and anoxic conditions with as much frequency as the bottom sonde, resulting in higher minimum pH values at the mid-depth sonde than those observed at the bottom sonde (Figures 4.1.25 and 4.1.34). The mid-depth sonde also experienced a higher maximum pH value during a supersaturation event in November that was not observed to occur at the bottom sonde (Figures 4.1.25 and 4.1.34).

The Brown's Pool bottom sonde had a minimum pH value of 6.1, a mean pH value of 7.0, and a maximum pH value of 8.1 (Table 4.1.1). Minimum pH values were observed during anoxic conditions when the Estuary was open (Figures 4.1.26 and 4.1.35). Maximum pH values were also observed to occur during open Estuary conditions when brief spikes in DO concentrations occurred (Figure 2.1.26).

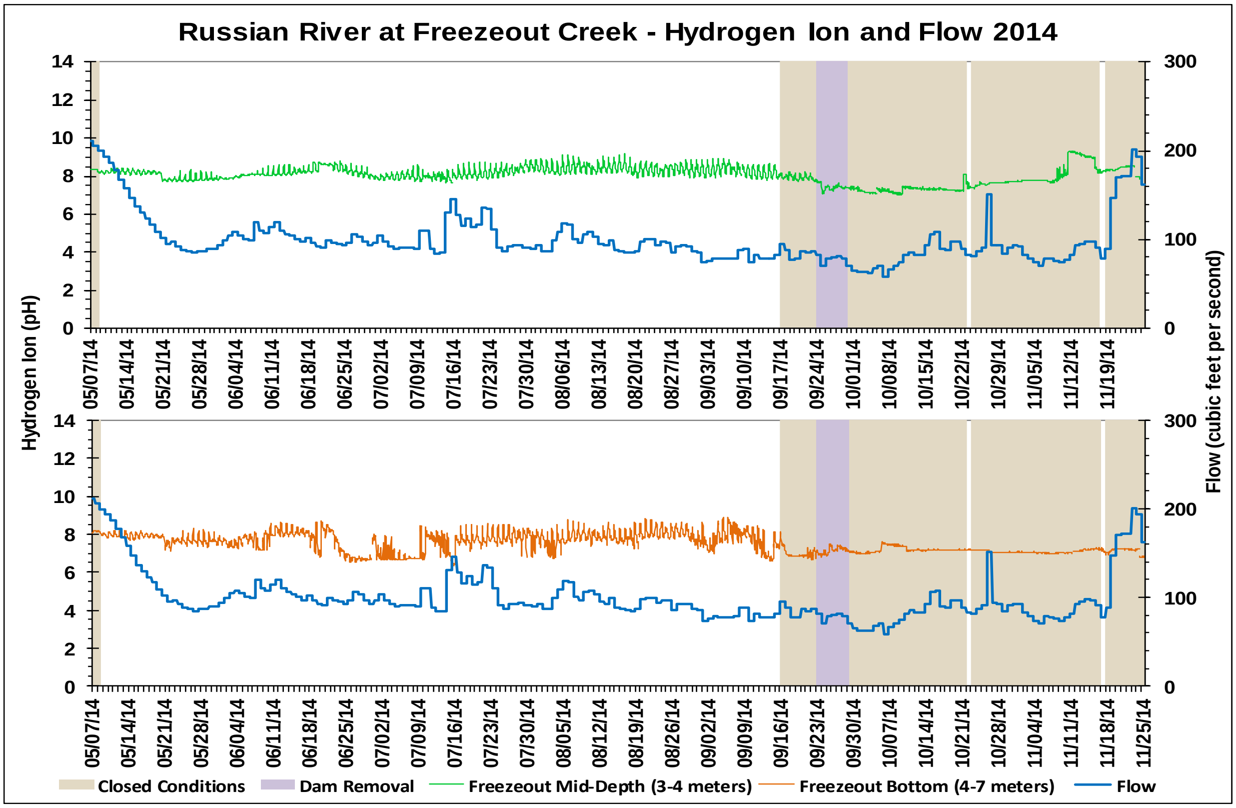


Figure 4.1.34. 2014 Russian River at Freezeout Creek Hydrogen Ion and Flow Graph

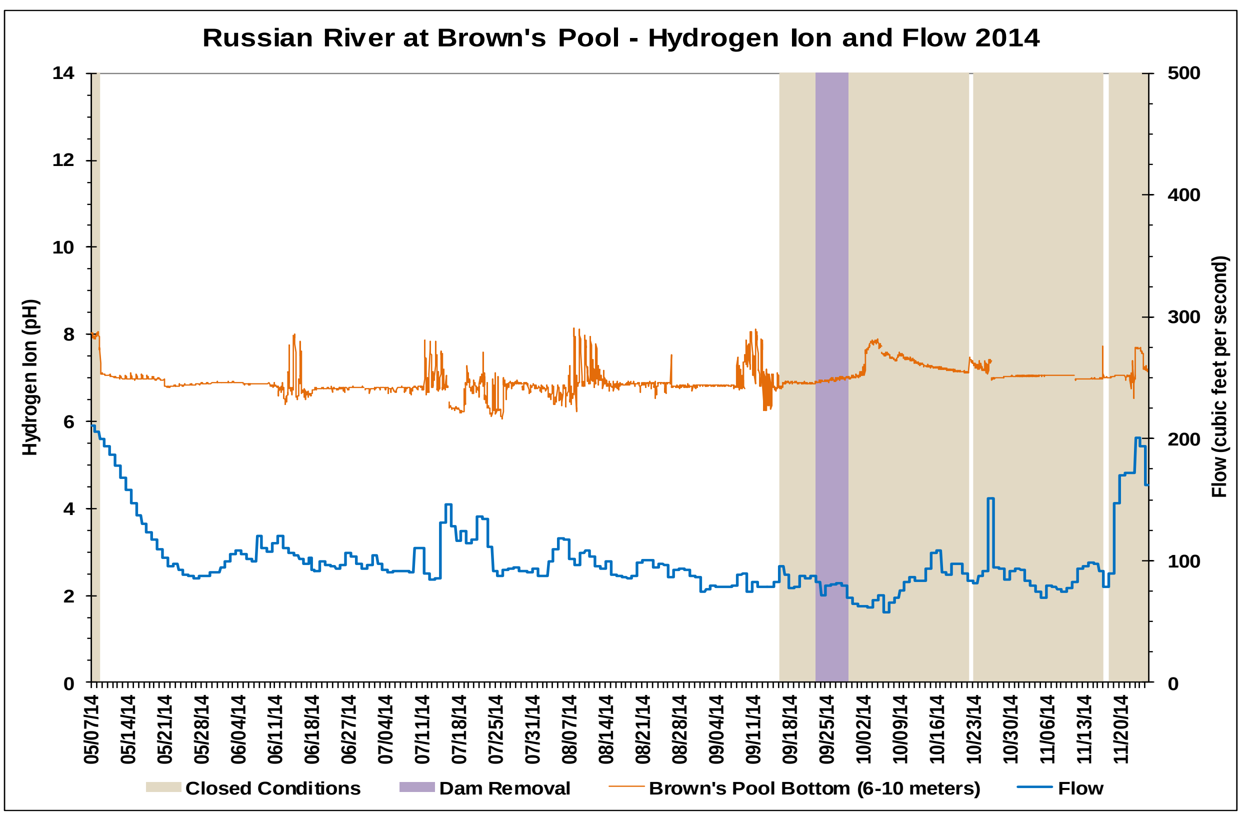


Figure 4.1.35. 2014 Russian River at Brown's Pool Hydrogen Ion and Flow Graph

Maximum Backwater Area pH

The Austin Creek sonde had a minimum pH value of 7.2, a mean pH value of 7.6, and a maximum pH value of 8.0 (Table 4.1.1). The Austin Creek sonde also had pH values that were generally observed to vary with increases and decreases of DO concentrations (Figures 4.1.27 and 4.1.36). Minimum pH values were observed during open and closed Estuary conditions while DO levels were depressed (Figure 4.1.36). Maximum pH values were observed during open and closed Estuary conditions when flows and DO concentrations were higher (Figures 4.1.27 and 4.1.36).

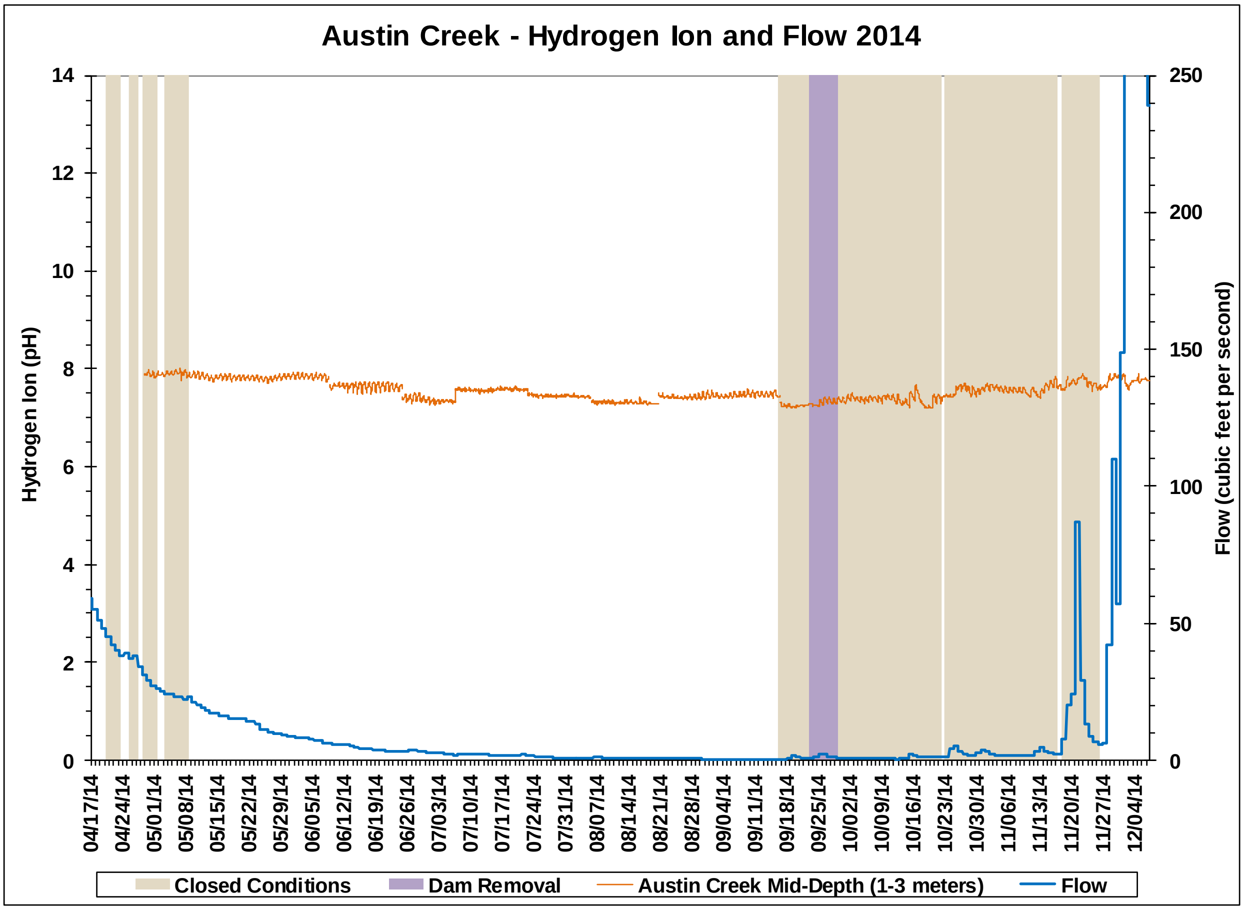


Figure 4.1.36. 2014 Austin Creek Hydrogen Ion and Flow Graph

The Patterson Point sonde had a minimum pH value of 6.0, a mean pH value of 6.9, and a maximum pH value of 7.8 (Table 4.1.1). The Patterson Point sonde also had pH values that were generally observed to vary with increases and decreases of DO concentrations (Figures 4.1.28 and 4.1.37). Minimum concentrations were observed during anoxic conditions when the Estuary was open.

The Monte Rio sonde recorded a minimum pH value of 7.4, a mean pH value of 8.0, and a maximum pH value of 8.5 (Table 4.1.1). Again, the sonde here recorded pH values that were generally observed to vary with increases and decreases of DO concentrations (Figures 4.1.29 and 4.1.38).

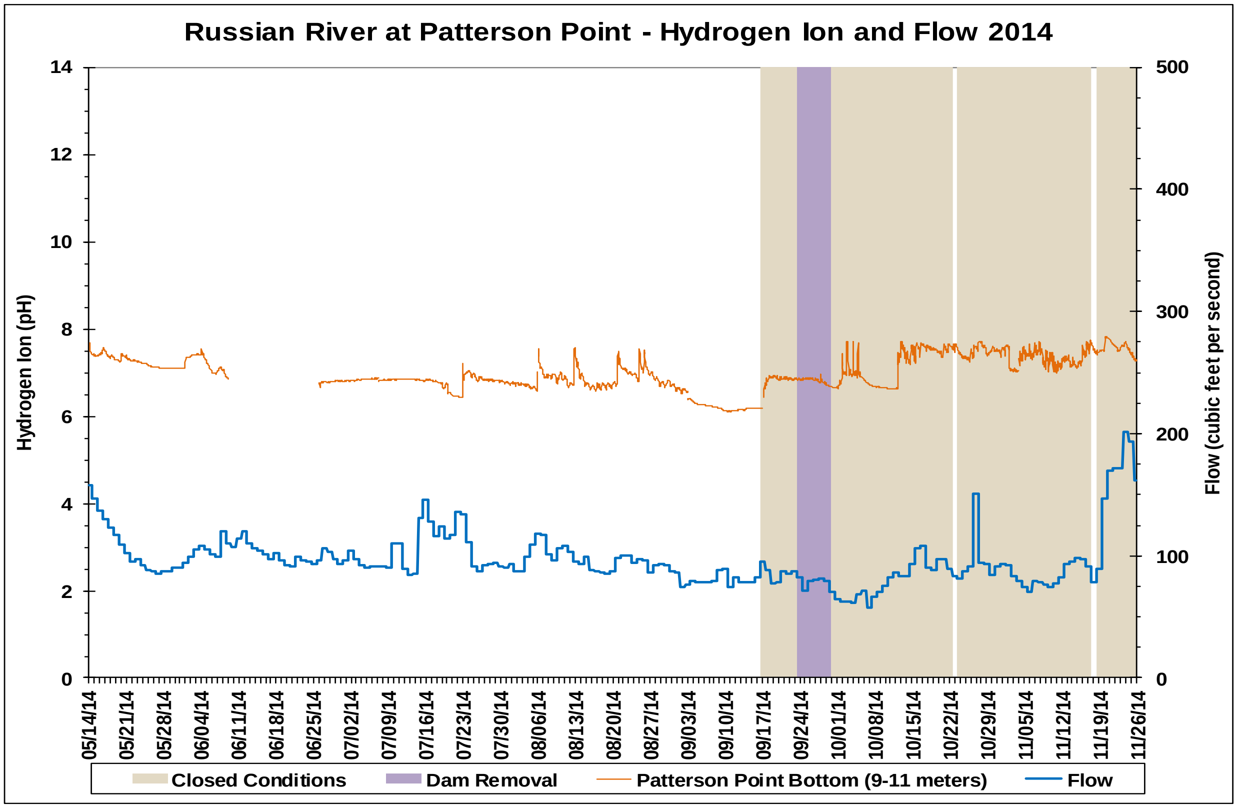


Figure 4.1.37. 2014 Patterson Point Hydrogen Ion and Flow Graph

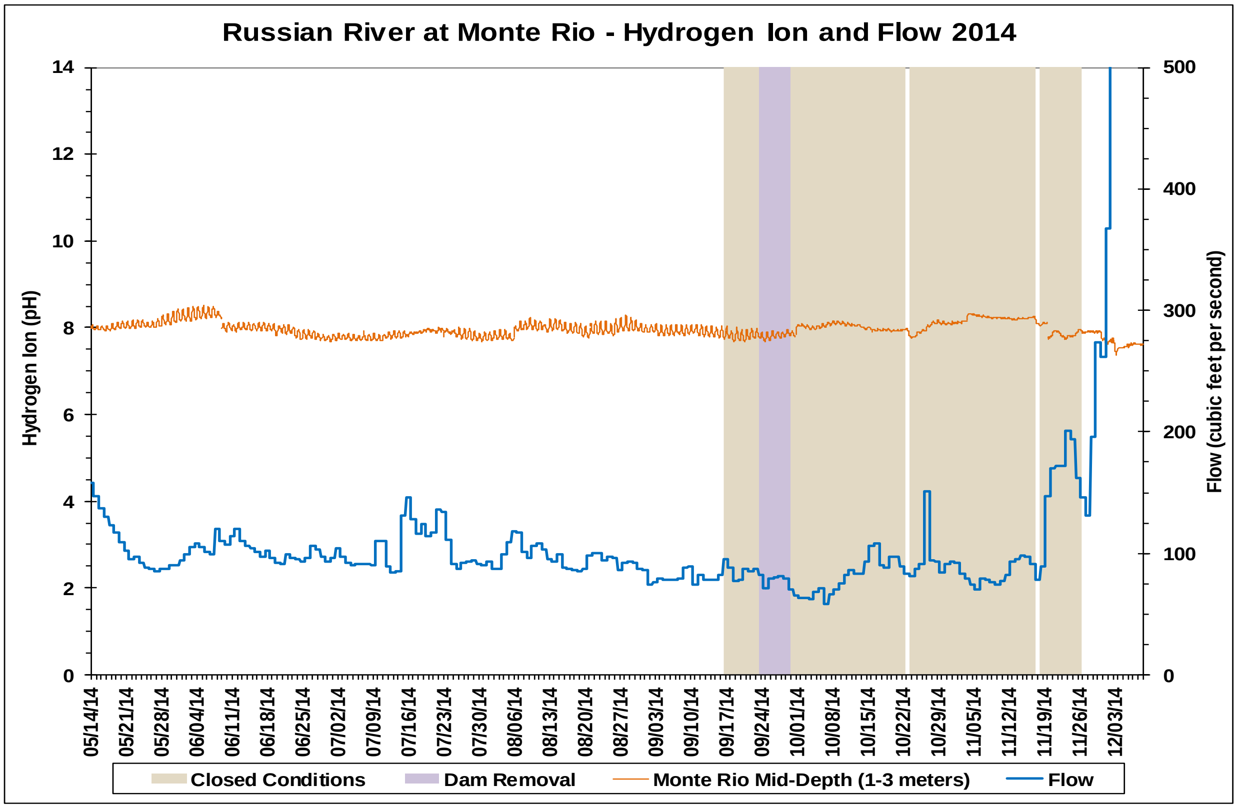


Figure 4.1.38. 2014 Russian River at Monte Rio Hydrogen Ion and Flow Graph

Minimum pH values at Monte Rio were observed to occur as stream flows increased during a storm event in early December (Figure 4.1.38). Maximum pH values at the Monte Rio station were generally observed to occur during supersaturation events. Overall, pH concentrations did not appear to be significantly affected by summer flows or closed conditions and remained fairly stable through the monitoring period (Figure 4.1.38).

Grab Sampling

Grab Sampling was conducted at five mainstem stations from Jenner to Vacation Beach (Figure 4.1.1). Sampling was conducted weekly from 15 May until 21 October when the Estuary was open. Additional focused sampling was conducted during or after Estuary closures, as well as during summer dam removal in late September, where Water Agency staff would collect three samples in ten days (Tables 4.1.2 through 4.1.6). 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 discussed, 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 2013a). USEPA's Section 304(a) criteria are intended to provide for the protection of aquatic life and human health (USEPA 2013b). 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-5).

Total nitrogen concentrations were observed to exceed the recommended USEPA levels periodically at all five monitoring stations (Tables 4.1.2 through 4.1.6). It should be noted that Jenner Boat Ramp is the most downstream station and was typically brackish all season. Exceedances of the total nitrogen criteria were observed to occur during open and closed conditions, throughout the monitoring period and under a variety of flows ranging from 60 cfs to 147 cfs. The number of total nitrogen exceedances varied from station to station, with a low of two exceedances at the Vacation Beach Station (Table 4.1.6) to a high of six exceedances at the Patterson Point Station (Table 4.1.4). Jenner and Monte Rio were each observed to have three exceedances and Casini Ranch had four (Tables 4.1.2, 4.1.3, and 4.1.5). The three exceedances at the Jenner Station occurred during the first half of the monitoring season in open conditions, including a high value of 2.2 mg/L collected on 15 May with mainstem flows of approximately 147 cfs (Table 4.1.2).

The Casini Ranch Station had two exceedances during open conditions and two during closed conditions, including a maximum concentration of 0.45 mg/L collected on 14 October during closed conditions with flows at approximately 86 cfs (Table 4.1.3). The six exceedances at the Patterson Point Station occurred during open conditions, including a high value of 0.44 mg/L collected twice. First on 15 May with flows at approximately 147 cfs, and then on 8 July with flows at approximately 95 cfs (Table 4.1.4). The three exceedances at the Monte Rio Station occurred during the second half of the monitoring season in open and closed conditions, including a high value of 0.53 mg/L collected on 2 September during open conditions with flows at approximately 70 cfs (Table 4.1.5). The two exceedances at the Vacation Beach Station occurred during the first half of the monitoring season in open conditions, including a maximum concentration of 0.48 mg/L collected on 3 June with flows at approximately 105 cfs (Table 4.1.6). Some of the lowest total nitrogen values observed at the five stations occurred during closed conditions in October when flows were as low as 60 to 70 cfs (Figure 4.1.39). Conversely, four of the five stations were observed to exceed the criteria on 8 July during open conditions with flows of approximately 95 cfs (Figure 4.1.39).

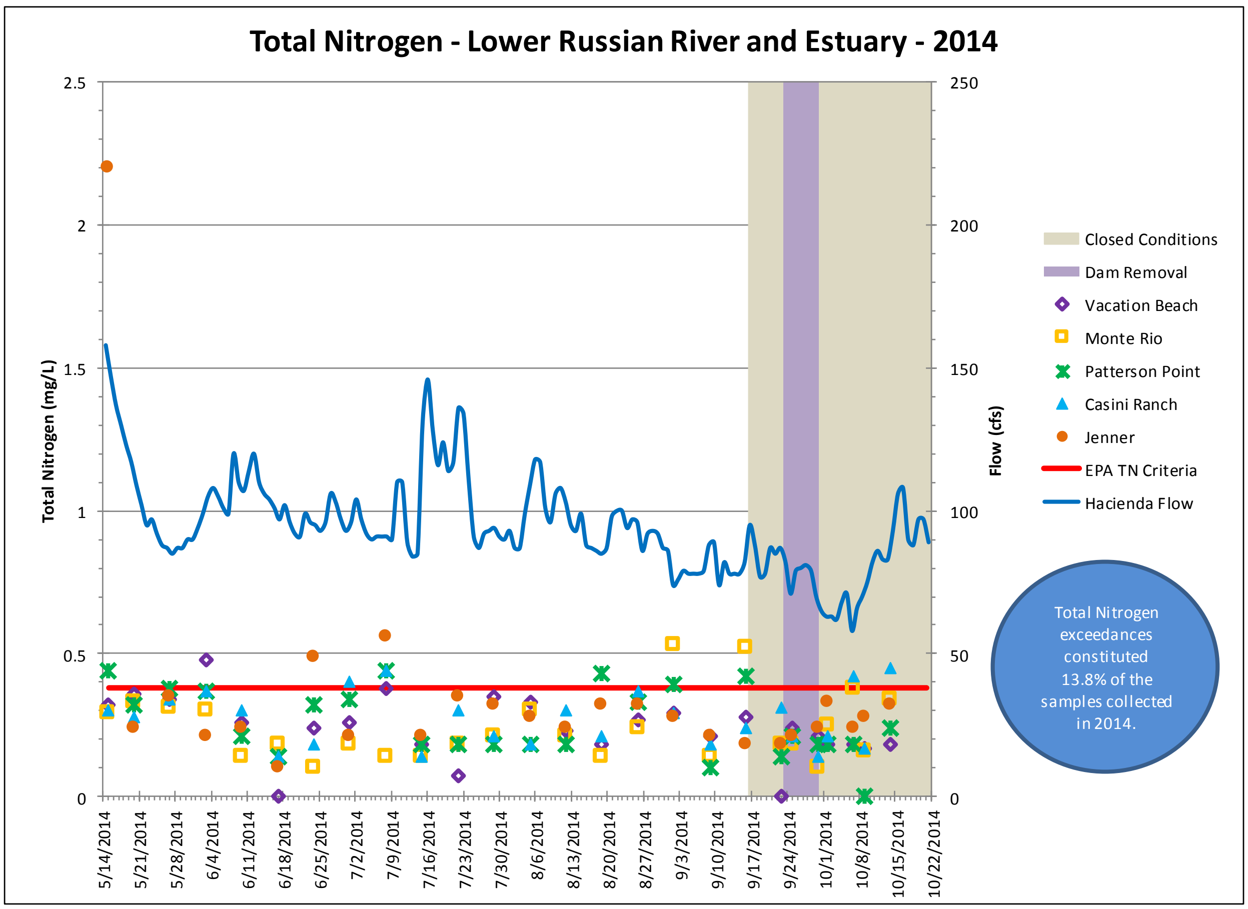


Figure 4.1.39. 2014 Russian River Grab Sampling Results for Total Nitrogen

The USEPA's desired goal for total phosphates as phosphorus in Aggregate Ecoregion III has been established as 21.88 micrograms per liter (µg/L), or approximately 0.022 mg/L, for rivers and streams not discharging into lakes or reservoirs (USEPA 2000). Total phosphorus concentrations at the five Estuary monitoring stations exceeded the U.S. EPA criteria for every sample taken. The maximum total phosphorus values recorded were 0.11 mg/L on 24 June at the Jenner Boat Ramp, 0.088 mg/L on 16 September at Casini Ranch, 0.081 mg/L on 3 June at Patterson Point, 0.099 mg/L on 3 June at Monte Rio, and 0.059 mg/L on 3 June at Vacation Beach (Tables 4.1.2 through 4.1.6). Exceedances occurred in fresh and brackish water, during open and closed Estuary conditions, and in river flows ranging from 60 cfs to 147 cfs. Total phosphorus values were observed to generally be higher in the spring and early summer, trending downward through the rest of the season (Figure 4.1.40).

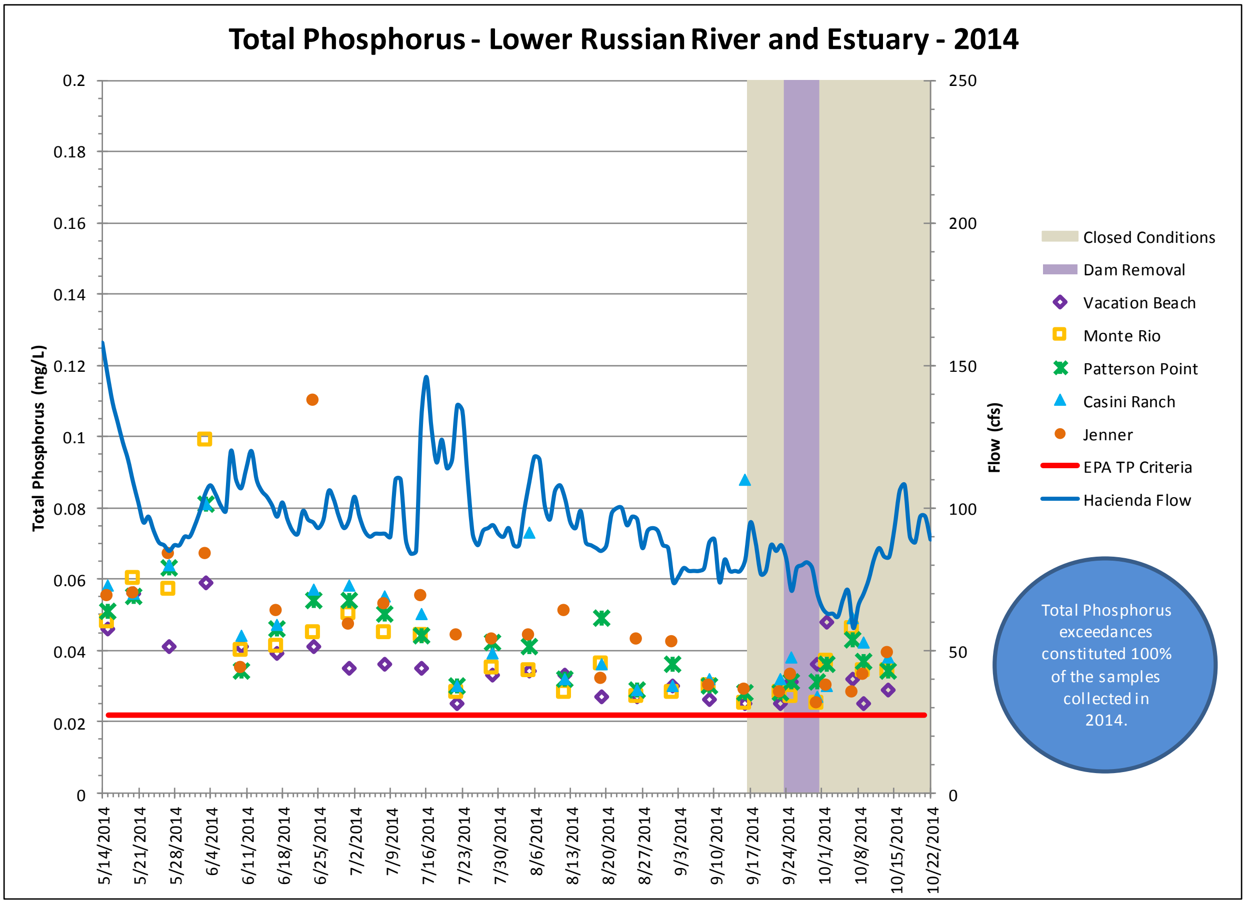


Figure 4.1.40. 2014 Russian River Grab Sampling Results for Total Phosphorus

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.

Chlorophyll a concentrations were less than 0.01 mg/L at all stations during the monitoring period, the level recommended to prevent discoloration of surface waters, with the exception of one sampling event at the Jenner station (Tables 4.1.2 through 4.1.6). This sampling event occurred on 24 June with a Chlorophyll a concentration of 0.019 mg/L (Table 4.1.2).

Table 4.1.2. 2014 Jenner Station Grab Sample Results

Jenner Boat Ramp*	Temperature	Total Nitrogen	Phosphorus, Total	Turbidity	Chlorophyll-a	Total Coliforms (Colilert)	Total Coliforms Diluted 1:10 (Colilert)	E. coli (Colilert)	E. coli Diluted 1:10 (Colilert)	Enterococcus (Enterolert)	Enterococcus Diluted 1:10 (Enterolert)	USGS 11467000 RR near Guerneville (Hacienda)***	
MDL**			0.020	0.020	0.000050	2	20	2	20	2	20	Flow Rate	Estuary
Date	°C	mg/L	mg/L	NTU	mg/L	MPN/100ml	MPN/100ml	MPN/100ml	MPN/100ml	MPN/100ml	MPN/100ml	(cfs)	Condition
5/15/2014	18.4	**2.2**	**0.055**	2.2	0.00068	>2419.6	----	16.8	----	15	----	147	Open
5/20/2014	16.9	0.24	**0.056**	**2.4**	0.0011	>2419.6	----	4.1	----	8.6	----	109	Open
5/27/2014	18.9	0.35	**0.067**	**2.6**	**0.0079**	>2419.6	----	1.0	----	1.0	----	85	Open
6/3/2014	16.2	0.21	**0.067**	**2.7**	**0.0056**	>2419.6	----	3.0	----	3.1	----	105	Open
6/10/2014	19.0	0.24	**0.035**	**2.5**	0.00074	>2419.6	6131	74.9	85	**195.6**	----	106	Open
6/17/2014	15.6	0.10	**0.051**	**2.7**	0.00031	2419.6	7270	5.2	<10	33.7	----	96	Open
6/24/2014	18.2	**0.49**	**0.11**	**20**	**0.019**	>2419.6	**24196**	81.3	<10	**145.5**	----	94	Open
7/1/2014	17.5	0.21	**0.047**	**2.4**	0.0014	>2419.6	4884	222.4	120	**344.1**	----	100	Open
7/8/2014	19.0	**0.56**	**0.053**	**5.9**	**0.0019**	>2419.7	**14136**	22.3	10	22.6	----	95	Open
7/15/2014	18.2	0.21	**0.055**	1.9	0.00093	>2419.6	**10462**	**579.4**	20	**435.2**	----	134	Open
7/22/2014	19.7	0.35	**0.044**	1.7	**0.0051**	>2419.6	**10462**	28.8	10	**613.1**	----	132	Open
7/29/2014	20.4	0.32	**0.043**	2.1	0.0011	>2419.6	**>24196**	15.9	<10	**2419.6**	----	96	Open
8/5/2014	17.8	0.28	**0.044**	1.5	0.0011	>2419.6	**14136**	152.5	41	**103.4**	----	111	Open
8/12/2014	19.0	0.24	**0.051**	**4.8**	**0.0062**	----	**14136**	----	41	**231.0**	----	105	Open
8/19/2014	18.9	0.32	**0.032**	1.9	0.0012	----	7270	----	10	**79.8**	----	87	Open
8/26/2014	19.5	0.32	**0.043**	**3.4**	0.00099	----	3873	----	<10	----	**2046**	93	Open
9/2/2014	19.1	0.28	**0.042**	**2.4**	**0.0034**	----	**10462**	----	<10	----	**289**	70	Open
9/9/2014	18.2	0.21	**0.030**	1.2	0.0012	>2419.6	----	30.2	----	**248.1**	----	81	Open
9/16/2014	18.0	0.18	**0.029**	1.2	0.00062	>2419.6	----	17.3	----	**172.2**	----	84	Open
9/23/2014	19.2	0.18	**0.028**	1.6	**0.0027**	>2419.6	----	59.5	----	**365.4**	----	89	Closed
9/25/2014	19.5	0.21	**0.033**	0.98	**0.0020**	>2419.6	----	87.5	----	18.7	----	73	Closed
9/30/2014	18.2	0.24	**0.025**	1.2	**0.0037**	>2419.6	----	151.5	----	**204.6**	----	73	Closed
10/2/2014	18.3	0.33	**0.030**	1.4	**0.0023**	1732.9	----	16.8	----	45.9	----	64	Closed
10/7/2014	18.1	0.24	**0.028**	----	**0.0019**	2419.6	----	8.5	----	60.2	----	60	Closed
10/9/2014	17.8	0.28	**0.033**	1.1	0.0014	>2419.6	----	23.5	----	32.7	----	75	Closed
10/14/2014	18.0	0.32	**0.039**	1.1	**0.0034**	>2419.6	----	51.9	----	**435.2**	----	86	Closed

* All results are preliminary and subject to final revision
** Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors.
*** United States Geological Survey (USGS) Continuous-Record Gaging Station (Flow rates are preliminary and subject to final revision by USGS).

Recommended EPA Criteria based on Aggregate Ecoregion III
Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L
Total Nitrogen: 0.38 mg/L
Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L
Turbidity: 2.34 FTU/NTU

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
E. coli: 235 per 100 ml
Enterococcus: 61 per 100 ml

The number of exceedances of the U.S. EPA criteria for Chlorophyll a of 0.0018 mg/L varied from station to station, with a low of six exceedances at the Monte Rio and Vacation Beach Stations (Tables 4.1.5 and 4.1.6) to a high of thirteen exceedances at the Jenner Station (Table 4.1.2). Casini Ranch was observed to have eight exceedances (Tables 4.1.3), while Patterson Point had eleven (Table 4.1.4). Exceedances of the Chlorophyll a criteria were observed to occur at all five stations in late May and July during open barrier beach conditions (Figure 4.1.41). Additionally, the Jenner Boat Ramp, Casini Ranch and Patterson Point stations were also observed to have exceedances in October during closed estuary conditions and following summer dam removal (Figure 4.1.41).

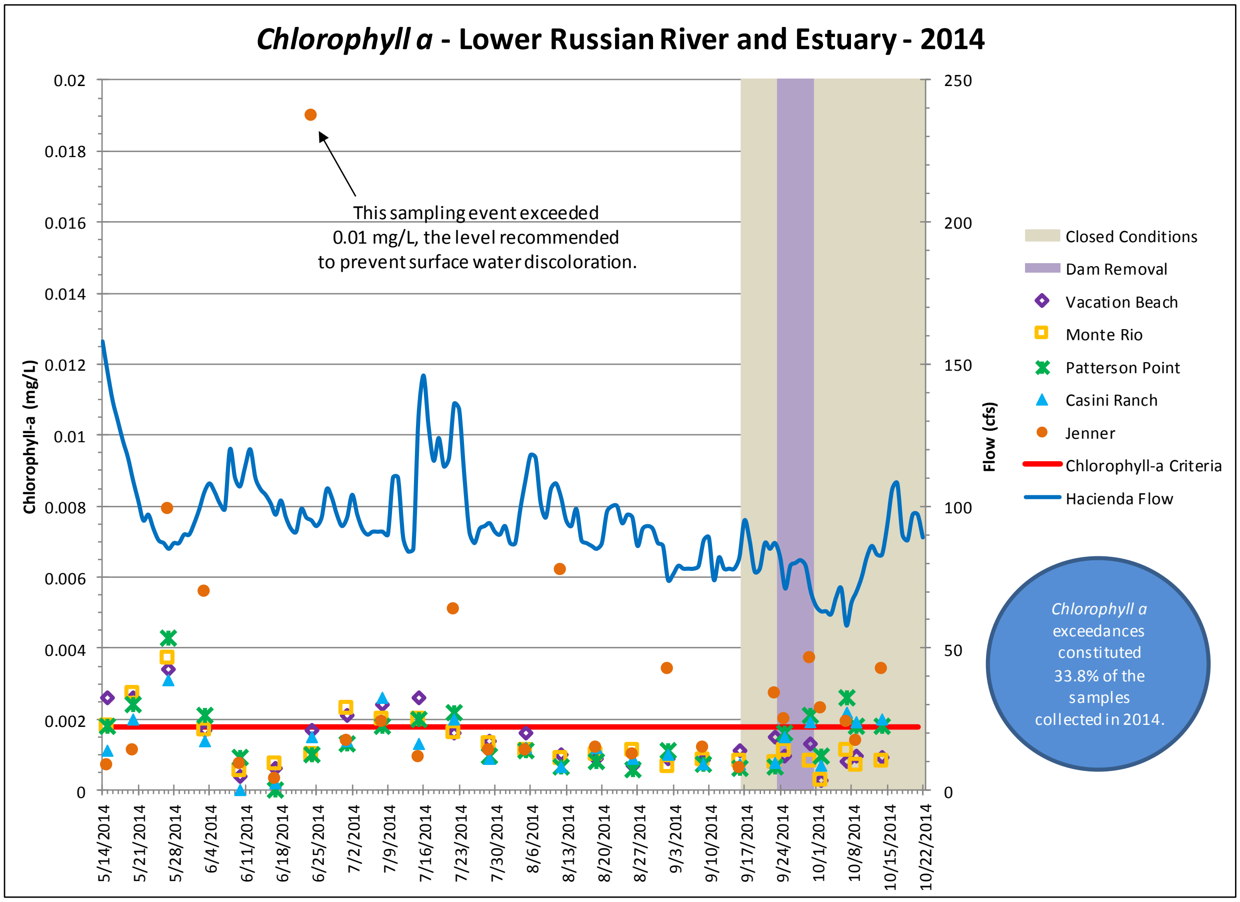


Figure 4.1.41. 2014 Russian River Grab Sampling Results for Chlorophyll-a

The maximum Chlorophyll a concentrations were 0.019 mg/L at the Jenner Boat Ramp on 24 June, 0.0031 mg/L at the Casini Ranch station on 27 May, 0.0043 mg/L at the Patterson Point station on 27 May, 0.0037 mg/L at the Monte Rio station on 27 May, and 0.0034 mg/L at the Vacation Beach station on 27 May (Tables 4.1.2 through 4.1.6). Exceedances were observed in fresh and brackish water, under open and closed Estuary conditions, and during flows ranging from 60 cfs to 147 cfs (Figure 4.1.41).

Table 4.1.3. 2014 Casini Ranch Station Grab Sample Results

Casini Ranch*	Temperature	Total Nitrogen	Phosphorus, Total	Turbidity	Chlorophyll-a	Total Coliforms (Colilert)	Total Coliforms Diluted 1:10 (Colilert)	E. coli (Colilert)	E. coli Diluted 1:10 (Colilert)	Enterococcus (Enterolert)	Enterococcus Diluted 1:10 (Enterolert)	USGS 11467000 RR near Guerneville (Hacienda)***	
MDL**			0.020	0.020	0.000050	2	20	2	20	2	20	Flow Rate	Estuary
Date	°C	mg/L	mg/L	NTU	mg/L	MPN/100ml	MPN/100ml	MPN/100ml	MPN/100ml	MPN/100ml	MPN/100ml	(cfs)	Condition
5/15/2014	22.5	0.30	**0.058**	2.0	0.0011	1553.1	----	21.8	----	13.2	----	147	Open
5/20/2014	22.0	0.28	**0.056**	**2.5**	**0.0020**	1732.9	----	2.0	----	6.3	----	109	Open
5/27/2014	22.3	0.34	**0.064**	2.3	**0.0031**	>2419.6	----	6.3	----	5.2	----	85	Open
6/3/2014	21.1	0.37	**0.081**	2.0	0.0014	1553.1	----	4.1	----	2.0	----	105	Open
6/10/2014	22.6	0.30	**0.044**	1.6	ND	>2419.6	2909	9.8	20	3.0	----	106	Open
6/17/2014	20.6	0.14	**0.047**	1.0	0.00021	>2419.6	2143	5.1	<10	6.2	----	96	Open
6/24/2014	23.4	0.18	**0.057**	**3.6**	0.0015	>2419.6	1918	6.3	10	17.7	----	94	Open
7/1/2014	22.4	**0.40**	**0.058**	1.4	0.0014	>2419.6	2909	<1.0	<10	13.2	----	100	Open
7/8/2014	22.8	**0.44**	**0.055**	1.8	**0.0026**	1732.9	1401	4.1	<10	5.2	----	95	Open
7/15/2014	24.1	0.14	**0.050**	1.1	0.0013	1413.6	1500	5.1	10	11.8	----	134	Open
7/22/2014	23.0	0.30	**0.030**	1.1	**0.0020**	1203.3	1956	3.0	10	4.1	----	132	Open
7/29/2014	24.1	0.21	**0.039**	1.4	0.00087	1203.3	1396	4.1	<10	5.2	----	96	Open
8/5/2014	21.3	0.18	**0.073**	1.3	0.0012	1986.3	1291	3.1	10	3.0	----	111	Open
8/12/2014	21.5	0.30	**0.032**	1.2	0.00067	----	933	----	<10	14.6	----	105	Open
8/19/2014	22.1	0.21	**0.036**	0.81	0.0012	----	959	----	10	2.0	----	87	Open
8/26/2014	21.9	0.37	**0.029**	1.5	0.00089	----	932	----	20	----	41	93	Open
9/2/2014	22.6	0.29	**0.030**	1.5	0.0010	----	1076	----	<10	----	20	70	Open
9/9/2014	20.6	0.18	**0.032**	0.64	0.00074	488.4	----	7.4	----	10.9	----	81	Open
9/16/2014	21.1	0.24	**0.088**	0.82	0.00072	686.7	----	3.1	----	1.0	----	84	Open
9/23/2014	21.5	0.31	**0.032**	1.4	0.00076	2419.6	----	224.7	----	**980.4**	----	89	Closed
9/25/2014	22.9	0.21	**0.038**	0.64	0.0015	2419.6	----	98.7	----	**260.3**	----	73	Closed
9/30/2014	20.3	0.14	**0.027**	0.79	**0.0019**	1732.9	----	142.1	----	**218.7**	----	73	Closed
10/2/2014	20.4	0.21	**0.030**	0.94	0.00068	>2419.6	----	98.8	----	**218.7**	----	64	Closed
10/7/2014	19.4	**0.42**	**0.049**	----	**0.0022**	2419.6	----	108.1	----	**222.4**	----	60	Closed
10/9/2014	18.5	0.17	**0.042**	1.0	**0.0019**	1553.1	----	44.1	----	**66.3**	----	75	Closed
10/14/2014	18.6	**0.45**	**0.038**	0.84	**0.0020**	>2419.6	----	50.4	----	**344.8**	----	86	Closed

* All results are preliminary and subject to final revision
** Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors.
*** United States Geological Survey (USGS) Continuous-Record Gaging Station (Flow rates are preliminary and subject to final revision by USGS).

Recommended EPA Criteria based on Aggregate Ecoregion III
Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L
Total Nitrogen: 0.38 mg/L
Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L
Turbidity: 2.34 FTU/NTU

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
E. coli: 235 per 100 ml
Enterococcus: 61 per 100 ml

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), 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) and are not currently enforceable. 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. The Jenner Boat Ramp grab sample station is located in an area that is predominantly brackish water, whereas the four upstream grab sample stations are located in predominantly freshwater habitat (Casini Ranch, Patterson Point, Monte Rio, and Vacation Beach).

Table 4.1.4. 2014 Patterson Point Station Grab Sample Results

Patterson Point*	Temperature	Total Nitrogen	Phosphorus, Total	Turbidity	Chlorophyll-a	Total Coliforms (Colilert)	Total Coliforms Diluted 1:10 (Colilert)	E. coli (Colilert)	E. coli Diluted 1:10 (Colilert)	Enterococcus (Enterolert)	Enterococcus Diluted 1:10 (Enterolert)	USGS 11467000 RR near Guerneville (Hacienda)***	
MDL**			0.020	0.020	0.000050	2	20	2	20	2	20	Flow Rate	Estuary
Date	°C	mg/L	mg/L	NTU	mg/L	MPN/100ml	MPN/100ml	MPN/100ml	MPN/100ml	MPN/100ml	MPN/100ml	(cfs)	Condition
5/15/2014	21.3	**0.44**	**0.051**	1.9	**0.0018**	1553.1	----	7.5	----	2.0	----	147	Open
5/20/2014	21.6	0.32	**0.055**	**2.8**	**0.0024**	1732.9	----	4.1	----	3.1	----	109	Open
5/27/2014	22.7	**0.38**	**0.063**	**2.4**	**0.0043**	>2419.6	----	4.1	----	6.3	----	85	Open
6/3/2014	21.5	0.37	**0.081**	2.2	**0.0021**	1203.3	----	8.6	----	10.6	----	105	Open
6/10/2014	24.2	0.21	**0.034**	1.9	0.00092	2419.6	1850	39.3	52	22.1	----	106	Open
6/17/2014	21.9	0.14	**0.046**	**3.0**	ND	1732.9	1872	4.1	<10	29.9	----	96	Open
6/24/2014	24.0	0.32	**0.054**	**3.0**	0.0010	>2419.6	1553	16.1	<10	**66.8**	----	94	Open
7/1/2014	24.1	0.34	**0.054**	2.2	0.0013	>2419.6	4611	12.1	<10	55.6	----	100	Open
7/8/2014	23.4	**0.44**	**0.050**	**4.6**	**0.0018**	1986.3	2595	13.4	20	7.2	----	95	Open
7/15/2014	23.6	0.18	**0.044**	**2.7**	**0.0020**	1986.3	2247	8.6	10	19.3	----	134	Open
7/22/2014	22.1	0.18	**0.030**	**2.4**	**0.0022**	1686.3	3255	11.0	31	14.6	----	132	Open
7/29/2014	23.8	0.18	**0.042**	**2.8**	0.00096	2419.6	4352	3.1	10	8.5	----	96	Open
8/5/2014	22.1	0.18	**0.041**	2.0	0.0011	2419.6	3448	11.8	<10	11.0	----	111	Open
8/12/2014	22.2	0.18	**0.032**	**2.7**	0.00067	----	1842	----	10	17.3	----	105	Open
8/19/2014	22.3	**0.43**	**0.049**	2.2	0.00079	----	2909	----	10	5.2	----	87	Open
8/26/2014	21.9	0.33	**0.029**	2.0	0.00059	----	1670	----	31	----	**121**	93	Open
9/2/2014	22.5	**0.39**	**0.036**	**2.4**	0.0011	----	2282	----	10	----	**529**	70	Open
9/9/2014	20.6	0.10	**0.030**	0.9	0.00074	1046.2	----	17.3	----	10.9	----	81	Open
9/16/2014	20.9	**0.42**	**0.028**	1.5	0.00062	1413.6	----	43.5	----	8.5	----	84	Open
9/23/2014	21.9	0.14	**0.028**	1.0	0.00065	1203.3	----	42.8	----	**71.2**	----	89	Closed
9/25/2014	22.0	0.21	**0.031**	1.0	0.0016	>2419.6	----	116.9	----	**62.7**	----	73	Closed
9/30/2014	20.1	0.18	**0.031**	0.86	**0.0021**	1732.9	----	58.3	----	**143.9**	----	73	Closed
10/2/2014	19.8	0.18	**0.036**	1.0	0.00095	1553.1	----	71.4	----	**116.9**	----	64	Closed
10/7/2014	18.7	0.18	**0.043**	----	**0.0026**	1203.3	----	103.9	----	**95.9**	----	60	Closed
10/9/2014	18.6	ND	**0.037**	1.2	**0.0018**	648.8	----	19.9	----	48.7	----	75	Closed
10/14/2014	18.6	0.24	**0.034**	0.68	**0.0018**	>2419.6	----	70.3	----	**114.5**	----	86	Closed
10/21/2014	17.8	----	----	----	----	866.4	----	29.2	----	**86.0**	----	101	Closed

* All results are preliminary and subject to final revision
** Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors.
*** United States Geological Survey (USGS) Continuous-Record Gaging Station (Flow rates are preliminary and subject to final revision by USGS).

Recommended EPA Criteria based on Aggregate Ecoregion III
Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L
Total Nitrogen: 0.38 mg/L
Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L
Turbidity: 2.34 FTU/NTU

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
E. coli: 235 per 100 ml
Enterococcus: 61 per 100 ml

E. coli was analyzed using the Colilert method and Enterococcus was analyzed using the Enterolert method. Samples were not analyzed specifically for total coliforms, but concentrations are determined as part of the analytical process for determining E. coli concentrations and the results are included in the lab report and in the appendices. The decision to focus on E. coli and not total coliform concentrations was done in coordination and consultation with Regional Board staff.

Additionally, NCRWQCB staff has indicated that Enterococcus is not currently being utilized as a fecal indicator bacteria due to uncertainty in the validity of the lab analysis to produce accurate results, as well as evidence that Enterococcus colonies can be persistent in the water column and therefore its presence at a given site may not always be associated with a fecal source. Water Agency staff will continue to collect Enterococcus samples and record and report the data, however, Enterococcus results will not be relied upon when coordinating with the NCRWQCB and Sonoma County DHS about potentially posting warning signs at freshwater beach sites or to discuss potential adaptive management actions including mechanical breaching of the sandbar to address potential threats to public health.

Table 4.1.5. 2014 Monte Rio Station Grab Sample Results

Monte Rio*	Temperature	Total Nitrogen	Phosphorus, Total	Turbidity	Chlorophyll-a	Total Coliforms (Colilert)	Total Coliforms Diluted 1:10 (Colilert)	E. coli (Colilert)	E. coli Diluted 1:10 (Colilert)	Enterococcus (Enterolert)	Enterococcus Diluted 1:10 (Enterolert)	USGS 11467000 RR near Guerneville (Hacienda)***	
MDL**			0.020	0.020	0.000050	2	20	2	20	2	20	Flow Rate	Estuary
Date	°C	mg/L	mg/L	NTU	mg/L	MPN/100ml	MPN/100ml	MPN/100ml	MPN/100ml	MPN/100ml	MPN/100ml	(cfs)	Condition
5/15/2014	21.6	0.29	**0.048**	1.9	**0.0018**	1553.1	----	11.8	----	11.0	----	147	Open
5/20/2014	21.3	0.33	**0.060**	**2.7**	**0.0027**	>2419.6	----	12.2	----	11.0	----	109	Open
5/27/2014	23.2	0.31	**0.057**	**3.1**	**0.0037**	>2419.6	----	7.5	----	2.0	----	85	Open
6/3/2014	21.6	0.30	**0.099**	2.1	0.0017	2419.6	----	7.5	----	6.3	----	105	Open
6/10/2014	24.4	0.14	**0.040**	1.8	0.00055	2419.6	1515	18.7	10	4.1	----	106	Open
6/17/2014	21.9	0.18	**0.041**	1.7	0.00073	1732.9	1985	7.4	10	18.7	----	96	Open
6/24/2014	23.3	0.10	**0.045**	1.8	0.0010	1553.1	1187	14.5	31	44.8	----	94	Open
7/1/2014	24.4	0.18	**0.050**	**3.1**	**0.0023**	>2419.6	1956	21.6	10	24.7	----	100	Open
7/8/2014	24.1	0.14	**0.045**	**2.6**	**0.0020**	2419.6	1935	14.5	10	6.3	----	95	Open
7/15/2014	24.0	0.14	**0.044**	2.2	**0.0020**	2419.6	1989	4.1	<10	7.3	----	134	Open
7/22/2014	22.3	0.18	**0.028**	2.2	0.0016	2419.6	1500	4.1	20	23.8	----	132	Open
7/29/2014	24.0	0.21	**0.035**	1.9	0.0013	1732.9	1376	3.1	20	9.5	----	96	Open
8/5/2014	22.5	0.30	**0.034**	1.6	0.0011	1553.1	1597	12	10	9.3	----	111	Open
8/12/2014	22.6	0.21	**0.028**	1.0	0.00089	----	1076	----	31	6.3	----	105	Open
8/19/2014	22.8	0.14	**0.036**	1.2	0.00099	----	794	----	20	6.2	----	87	Open
8/26/2014	22.1	0.24	**0.027**	1.2	0.0011	----	1334	----	20	----	**105**	93	Open
9/2/2014	23.2	**0.53**	**0.028**	1.4	0.00067	----	1989	----	10	----	**156**	70	Open
9/9/2014	21.0	0.14	**0.030**	0.82	0.00084	1119.9	----	14.8	----	25.9	----	81	Open
9/16/2014	20.9	**0.52**	**0.025**	**2.5**	0.00082	920.8	----	5.1	----	4.1	----	84	Open
9/23/2014	21.5	0.18	**0.028**	0.95	0.00076	648.8	----	29.5	----	5.2	----	89	Closed
9/25/2014	21.7	0.18	**0.027**	1.1	0.0011	2419.6	----	**365.4**	----	**248.9**	----	73	Closed
9/29/2014	----	----	----	----	----	>2419.6	----	162.4	----	**344.8**	----	84	Closed
9/30/2014	20.2	0.10	**0.025**	1.3	0.00081	1732.9	----	187.2	----	**150.0**	----	73	Closed
10/2/2014	19.5	0.25	**0.037**	1.3	0.00027	>2419.6	----	133.4	----	**191.8**	----	64	Closed
10/7/2014	19.0	**0.38**	**0.046**	----	0.0011	1986.3	----	117.8	----	**139.1**	----	60	Closed
10/9/2014	18.9	0.16	**0.034**	1.1	0.00068	>2419.6	----	**410.6**	----	**435.2**	----	75	Closed
10/13/2014	18.8	----	----	----	----	>2419.6	----	**1299.7**	----	**920.8**	----	85	Closed
10/14/2014	18.5	0.34	**0.034**	1.0	0.00082	>2419.6	----	**686.7**	----	**1119.9**	----	86	Closed
10/16/2014	18.0	----	----	----	----	>2419.6	----	**>2419.6**	----	**1986.3**	----	107	Closed
10/17/2014	17.6	----	----	----	----	>2419.6	----	**2419.6**	----	**>2419.6**	----	114	Closed
10/21/2014	18.0	----	----	----	----	1299.7	----	**248.1**	----	**435.2**	----	101	Closed

* All results are preliminary and subject to final revision

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

*** United States Geological Survey (USGS) Continuous-Record Gaging Station (Flow rates are preliminary and subject to final revision by USGS).

Recommended EPA Criteria based on Aggregate Ecoregion III

Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L

Total Nitrogen: 0.38 mg/L

Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L

Turbidity: 2.34 FTU/NTU

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

E. coli: 235 per 100 ml

Enterococcus: 61 per 100 ml

Most recently, Agency staff communicated with staff at the County DHS lab about sample results at the Jenner station that were significantly different between diluted and undiluted results for E. coli (M. Ferris 2015, pers. comm., 20 October). According to County DHS staff, the use of Colilert and Enterolert requires dilution of samples when analyzing brackish water. This was confirmed by a review of the IDEXX Colilert and Enterolert SOPs, which state that samples should be diluted to a 1:10 ratio when specific conductance values are between 3,000 microsiemens (µS) and 10,000 µS, and further states to not utilize either analysis methodology when specific conductance values are above 10,000 µS (add citation). These additional steps and safeguards are taken to avoid false positive values. Samples collected by Agency staff for Total Coliforms and E. coli results were only diluted for part of the season and Enterococcus results were only diluted twice in 2014.

The Jenner station was predominantly brackish in 2014. Specific conductance values were above 10,000 µS during the eighteen sampling events that occurred during open conditions, and specific conductance values were between 3,000 µS and 10,000 µS during the seven sampling events that occurred during closed conditions. Therefore, diluted and undiluted results for Total Coliforms, E. coli, and Enterococcus that were collected during open conditions should not be relied upon for determining compliance with recommended criteria. As well, undiluted Total Coliforms, E. coli, and Enterococcus samples that were collected during closed conditions should also not be relied upon for determining compliance with recommended criteria. Consequently, this leaves all of the data unreliable for comparison to recommended criteria at the Jenner Station. As such, the Jenner data for E. coli and Enterococcus will not be discussed in the findings below and will not be included on the indicator bacteria figures (Figures 4.1.42 and 4.1.43).

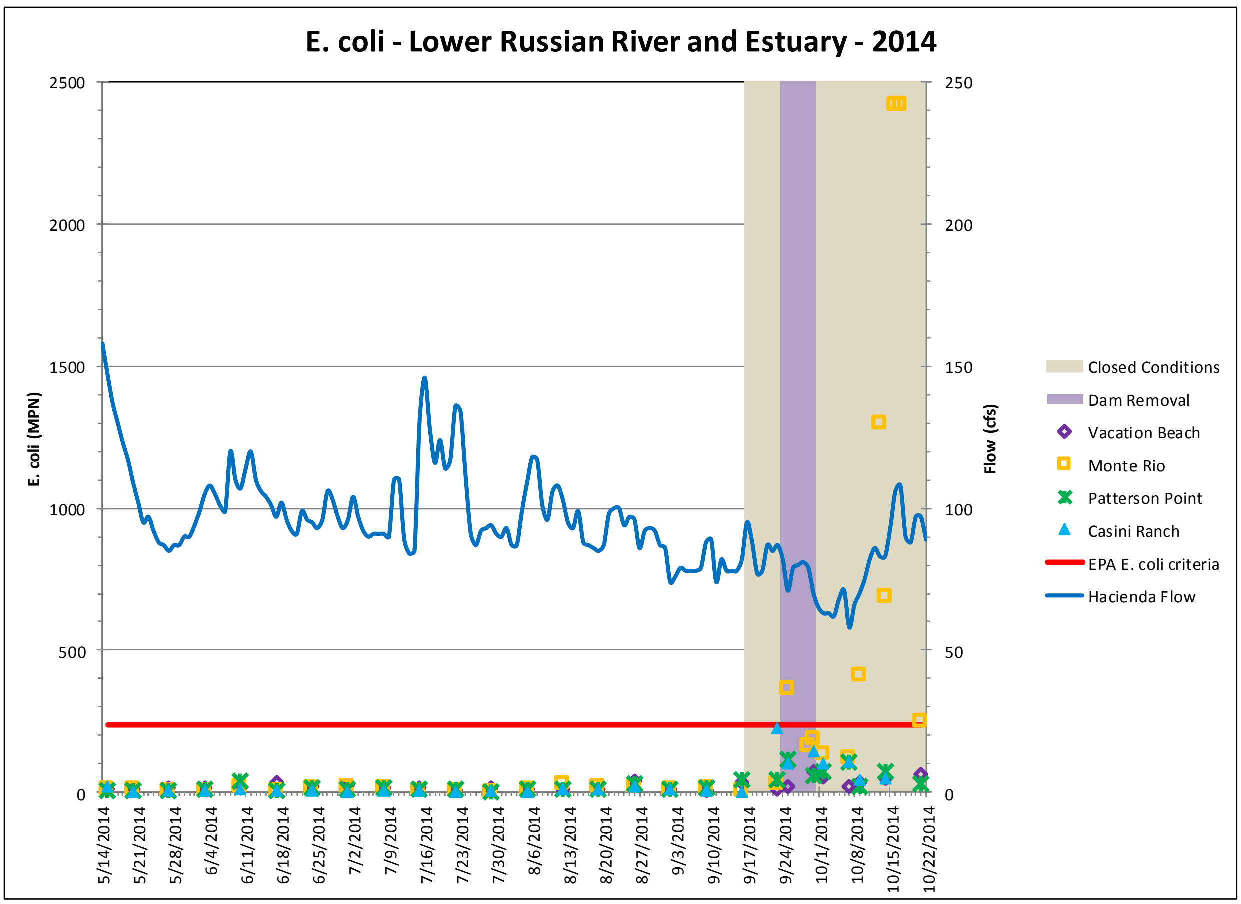


Figure 4.1.42. 2014 Russian River Grab Sampling Results for E. coli

Enterococcus exceedances were observed to occur during both open and closed Estuary conditions in 2014, with all four freshwater stations having exceedances during closed Estuary conditions (Tables 4.1.3 to 4.1.6). However, E. coli exceedances were only noted at the Monte Rio station in 2014, and only during Estuary closures (Figure 4.1.42).

Table 4.1.6. 2014 Vacation Beach Station Grab Sample Results

Vacation Beach*	Temperature	Total Nitrogen**	Phosphorus, Total	Turbidity	Chlorophyll-a	Total Coliforms (Colilert)	Total Coliforms Diluted 1:10 (Colilert)	E. coli (Colilert)	E. coli Diluted 1:10 (Colilert)	Enterococcus (Enterolert)	Enterococcus Diluted 1:10 (Enterolert)	USGS 11467000 RR near Guerneville (Hacienda)***	
MDL**			0.020	0.020	0.000050	2	20	2	20	2	20	Flow Rate	Estuary
Date	°C	mg/L	mg/L	NTU	mg/L	MPN/100ml	MPN/100ml	MPN/100ml	MPN/100ml	MPN/100ml	MPN/100ml	(cfs)	Condition
5/15/2014	21.5	0.32	**0.046**	1.8	**0.0026**	1413.6	----	9.7	----	8.5	----	147	Open
5/20/2014	20.7	0.36	**0.056**	**2.9**	**0.0026**	1986.3	----	8.4	----	9.7	----	109	Open
5/27/2014	22.9	0.34	**0.041**	2.2	**0.0034**	>2419.6	----	17.3	----	5.2	----	85	Open
6/3/2014	21.1	**0.48**	**0.059**	1.8	0.0017	>2419.6	----	16.0	----	26.6	----	105	Open
6/10/2014	23.6	0.26	**0.041**	1.7	0.00037	>2419.6	3143	15.6	20	6.3	----	106	Open
6/17/2014	21.6	ND	**0.039**	**2.4**	0.00063	2419.6	1785	32.7	20	32.7	----	96	Open
6/24/2014	23.9	0.24	**0.041**	2.0	0.0017	>2419.6	2382	19.9	31	47.3	----	94	Open
7/1/2014	24.9	0.26	**0.035**	**2.6**	**0.0021**	1553.1	2187	22.6	<10	49.6	----	100	Open
7/8/2014	24.3	**0.38**	**0.036**	2.3	**0.0024**	2419.6	2613	13.5	<10	28.1	----	95	Open
7/15/2014	24.1	0.18	**0.035**	2.3	**0.0026**	1732.9	2909	14.5	10	28.1	----	134	Open
7/22/2014	22.1	0.07	**0.025**	2.0	0.0016	1413.6	1616	4.1	<10	17.7	----	132	Open
7/29/2014	24.6	0.35	**0.033**	1.6	0.0014	960.6	1872	14.8	41	28.5	----	96	Open
8/5/2014	22.6	0.33	**0.034**	1.5	0.0016	1732.9	1565	12.2	31	12.1	----	111	Open
8/12/2014	22.6	0.23	**0.033**	2.2	0.0010	----	1616	----	<10	7.3	----	105	Open
8/19/2014	23.0	0.18	**0.027**	0.96	0.00089	----	1732	----	<10	9.7	----	87	Open
8/26/2014	22.1	0.27	**0.027**	1.5	0.00069	----	1236	----	41	----	75	93	Open
9/2/2014	22.4	0.29	**0.030**	1.4	0.00089	----	2046	----	10	----	41	70	Open
9/9/2014	21.1	0.21	**0.026**	1.1	0.00084	1553.1	----	5.2	----	3.1	----	81	Open
9/16/2014	21.5	0.28	**0.025**	1.2	0.0011	1986.3	----	33.1	----	4.1	----	84	Open
9/23/2014	21.7	ND	**0.025**	1.7	0.0015	1986.3	----	12.1	----	47.3	----	89	Closed
9/25/2014	21.8	0.24	**0.031**	**2.4**	0.00098	1413.6	----	18.7	----	18.3	----	73	Closed
9/30/2014	19.6	0.21	**0.036**	0.96	0.0013	1299.7	----	70.3	----	**214.3**	----	73	Closed
10/2/2014	19.3	0.18	**0.048**	**3.0**	0.00027	1413.6	----	52.1	----	44.1	----	64	Closed
10/7/2014	19.0	0.18	**0.032**	----	0.00081	601.5	----	18.1	----	**63.1**	----	60	Closed
10/9/2014	18.3	0.17	**0.025**	1.8	0.00095	1119.9	----	32.8	----	46.7	----	75	Closed
10/14/2014	17.9	0.18	**0.029**	2.1	0.00094	472.1	----	50.4	----	**91.1**	----	86	Closed
10/21/2014	17.5	----	----	----	----	770.1	----	63.1	----	**76.7**	----	101	Closed

* All results are preliminary and subject to final revision
** Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors.
*** United States Geological Survey (USGS) Continuous-Record Gaging Station (Flow rates are preliminary and subject to final revision by USGS).

Recommended EPA Criteria based on Aggregate Ecoregion III
Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L
Total Nitrogen: 0.38 mg/L
Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L
Turbidity: 2.34 FTU/NTU

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
E. coli: 235 per 100 ml
Enterococcus: 61 per 100 ml

The recommended E. coli guideline of 235 MPN/100 ml was exceeded seven times at the Monte Rio station (Table 4.1.5). None of the other stations had any exceedances of the recommended guideline. The exceedances at the Monte Rio station all occurred during closed Estuary conditions in September and October. The highest values occurred during the extended closure when elevated water levels (~6.7 feet WSL as measured at the Jenner gauge) had been observed to inundate large amounts of dog feces that were present on the gravel beach prior to inundation (Figure 4.1.42). The maximum value measured >2419.6 MPN on 16 October, during Estuary closure (Table 4.1.5).

All four freshwater stations experienced at least one Enterococcus exceedance during the 2014 monitoring season (Figure 4.1.43). These exceedances were seen during open and closed Estuary conditions, as well as during varying flow regimes. However, the vast majority of exceedances in 2014 were observed to occur during closed Estuary conditions (Figure 4.1.43). There were seven exceedances measured at the Casini Ranch station, with the largest exceedance measuring 980.4 MPN on 23 September with a closed Estuary (Table 4.1.3). There were ten exceedances measured at the Patterson Point station, with the largest exceedance being 529 MPN on 2 September with an open Estuary (Table 4.1.4). There were thirteen exceedances observed at the Monte Rio station, with the largest exceedance being >2419.6 MPN on 17 October during a closed Estuary (Table 4.1.5). Finally, there were four exceedances at the Vacation Beach station, with the largest exceedance measuring 214.3 MPN on 30 September during a closed Estuary (Table 4.1.6).

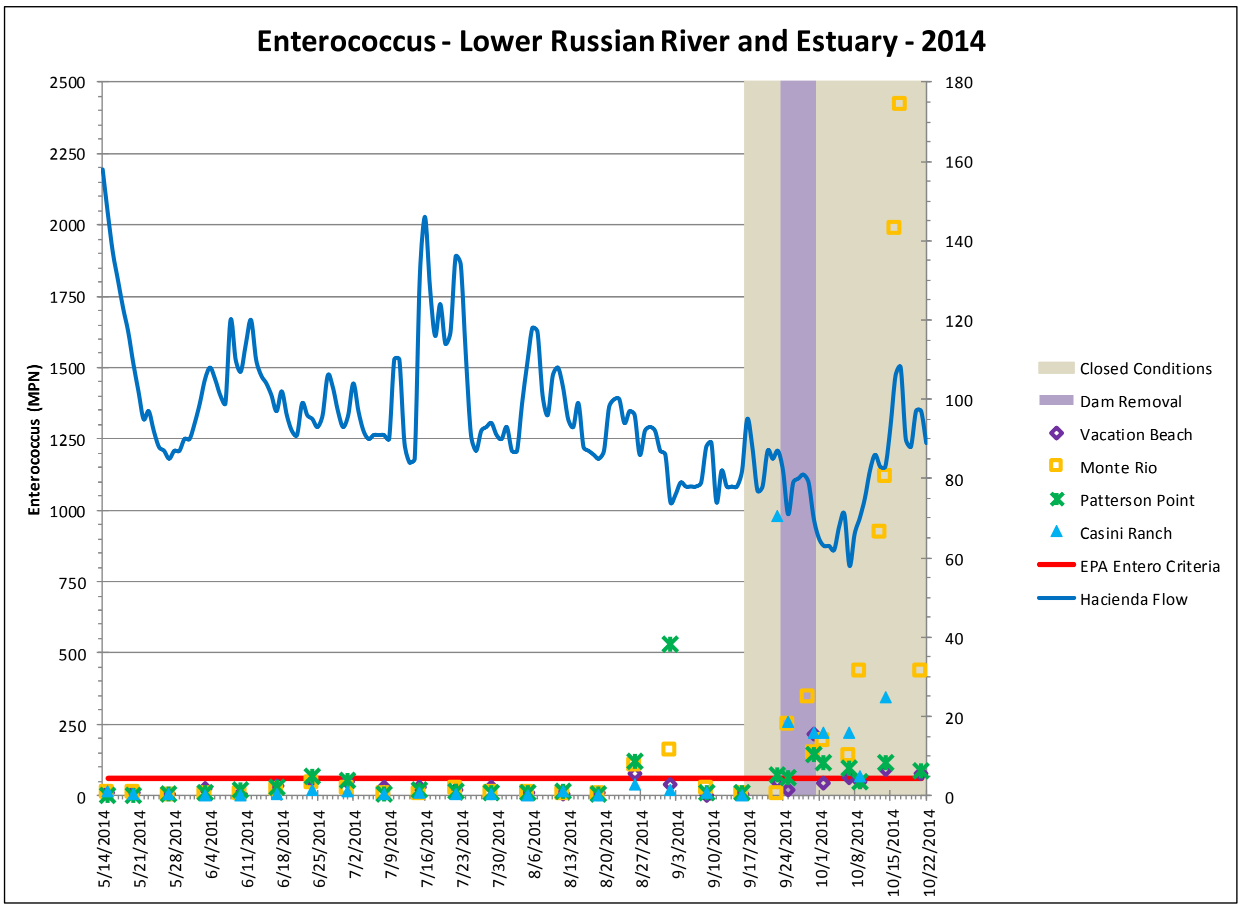


Figure 4.1.43. 2014 Russian River Grab Sampling Results for Enterococcus

Conclusions and Recommendations

Continuous Water Quality Monitoring Conclusions

Water quality conditions observed during the 2014 monitoring season were similar to conditions observed during previous monitoring seasons, and similar to the dynamic conditions associated with an estuarine river system. The differing physical properties associated with freshwater versus those of saltwater play a pivotal role in the stratification that is common in the Russian River Estuary. Since the saltwater is denser than the freshwater inflow, the saltwater layer is observed below the freshwater layer, and the slope of the temperature and density gradients is typically steepest at the halocline. While this relationship is a key player in what shapes the water quality conditions in the estuary, there are other influences at work in the estuary as well, including wind mixing, river inflow, tidal influence, shape and size of the river mouth, air temperatures, and others.

Unfortunately, Water Agency staff were not able to implement the Lagoon Outlet Channel project during Estuary closure. The Estuary remained open through the majority of the monitoring season from May until 16 September, when the first closure of the monitoring season occurred. However, due to the topography of the barrier beach at the Jetty, Water Agency staff were not able to safely access the beach to attempt the creation of an outlet channel. Consequently, there was no opportunity for Agency staff to assess the availability of suitable aquatic habitat for rearing salmonids in comparison to closed and open Estuary conditions. Although Water Agency staff were not able to assess the merits of the Lagoon Outlet Channel project, staff were still able to collect data that provides a fuller understanding of salinity migration in the Upper Reach of the Estuary.

As freshwater flows in the Russian River decrease through spring, the salt layer typically migrates upstream. Due to continued drought conditions in the winter and spring of 2014, mainstem Russian River flows decreased earlier in the season than in 2011 and 2012, but were similar in timing to 2013. Even so, salinity migration patterns were fairly similar to those prior monitoring years, with the exception of Brown’s Pool (RK 11.3). Brackish water had not been observed at Brown’s Pool prior to the 2013 monitoring season, however Water Agency staff had only previously deployed a continuously monitoring sonde at this station in the 2011 season (Manning and Martini-Lamb 2012). Even so, it is not unreasonable to expect salinity migration to periodically occur in this area, given the proximity of the Brown’s Pool station to Moscow Road Bridge (RK 10.15), where brackish water has been observed to occur.

As the 2013 monitoring season was winding down, low winter flows allowed Water Agency staff to continue monitoring the Estuary through early February 2014. During a barrier beach closure in December 2013, brackish water was observed migrating into Brown’s Pool (Martini-Lamb and Manning 2014). On 23 January, 2014, Water Agency staff collected vertical profiles at several pools to determine the upstream extent of brackish conditions. These profiles were conducted downstream from Brown’s Pool and upstream of Brown’s Pool to determine if saline water was migrating from the Upper Reach of the Estuary into the MBA (Figure 4.1.1). While brackish water was observed at Moscow Road Bridge and Brown’s Pool, which are both located downstream of Brown’s Riffle (RK 11.4) and the confluence of Austin Creek with the river, brackish water was not observed in the pools at Laurel Dell (RK 12.5), Villa Grande (RK 14.1), or Patterson Point (RK 14.9), which are all located upstream of Brown's Riffle and the confluence with Austin Creek. It appears that Brown's Riffle and the confluence of Austin Creek may provide a significant hydrologic barrier to salinity migration in the mainstem Russian River.

When 2014 monitoring resumed in May, Brown's Pool was observed to be predominantly brackish during both open and closed conditions. Whereas in 2013, Brown's Pool remained predominantly fresh with brief periods of brackish conditions during estuary closures in October and December (Martini-Lamb and Manning,2014). There are two factors that likely contributed to this difference.

The first involves the timing of two barrier beach closures in 2013 that effectively closed off the river mouth to tidal intrusion from late May through early July (Martini-Lamb and Manning 2014). This time of year is typically when spring freshwater inflows are decreasing and ocean swells are still elevated, creating conditions where salinity migration into the upper reach of the Estuary begins to occur. In 2014, the barrier beach remained open during this time period.

The second involves a difference in the configuration of the river mouth at the barrier beach. If the river mouth is located against the Jetty groin, the northwest orientation of the Jetty on the barrier beach can mute tidal intrusion into the Estuary. By contrast, if the river mouth is deeper or wider, or more exposed to ocean swells, it would be reasonable to expect saline water to migrate further upstream.

Interestingly, brackish water was also observed to be more persistent at Brown's Pool during open conditions compared to the next station downstream at Freezeout Creek (RK 9.5) (Figures 4.1.8 and 4.1.7). Whereas brackish conditions with concentrations as high as 11 ppt were observed in early May at Brown's Pool, similar concentrations were not observed at Freezeout Creek until early July. However by 5 July, concentrations at Freezeout Creek were as high as 12 ppt, compared to maximum values of 10 ppt at Brown's Pool. With the depth of Brown's Pool being approximately 10 meters, compared to a 7 meter depth at the Freezeout Creek station, these observations suggest that the saline layer observed at Brown's Pool was present in the gravel substrate beneath the Freezeout Creek station and migrated up into the site through the gravel alluvium. The fluctuation in concentrations at the bottom sondes during open conditions coupled with a predominantly freshwater condition at the Freezeout Creek mid-depth sonde (4m depth) further suggests that this saline layer was not very thick. Consequently, the bottom of the Freezeout Creek station returned to a predominantly freshwater habitat by mid-July and remained that way until the Estuary closed in mid-September.

Salinity levels increased at Freezeout Creek after the Estuary closed, with concentrations as high as 12 ppt being observed on 25 September at the bottom and mid-depth sondes. While salinity decreased over time at the mid-depth, it remained constant at about 12 ppt at the bottom through the succession of Estuary closures spanning from mid-September through late November.

Salinity concentrations at Brown's Pool initially decreased during the September closure before increasing to approximately 5 ppt on 3 October, where it remained until Water Agency staff breached the barrier beach on 22 October. The mouth closed again on 24 October and concentrations were observed to increase to approximately 4-5 ppt on 28 October where it remained until increased river flows in late November displaced the brackish water (Figure 4.1.8).

By contrast, monitoring conducted at the bottom of the Patterson Point station in Villa Grande did not detect any significant salinity migration into the site during open or closed conditions. Maximum salinity values observed at Patterson Point were approximately 0.7 ppt, and occurred during open conditions from 9 September to 11 September with flows ranging from 74 to 89 cfs. Water is considered fresh at approximately 0.5 ppt. These results correspond with the vertical profiling data collected during January 2014 in the Upper Reach of the Estuary and the MBA.

During prolonged barrier beach closures in 2014, overall water quality conditions were observed to be similar to those of previous years. Typically during a closure or perched event, the mid-depth sondes at the Mouth, and to a lesser extent Patty's Rock and Sheephouse Creek, experience a decrease in salinity and an increase in temperature. Conversely, during prolonged closures or perched events, the upper reach of the Estuary at Freezeout Creek and Brown's Pool typically experience increases in salinity as brackish water migrates into the area, coupled with temperature increases. Conditions observed in the saline layer during the 2014 monitoring season were no exception.

Temperature, pH, and dissolved oxygen patterns during the 2014 monitoring season were also similar to those observed in previous monitoring years. While the Russian River Estuary is a dynamic estuarine system, the seasonal changes during the monitoring seasons have largely followed similar patterns each year since the implementation of the Biological Opinion (BO) in 2009.

To further illustrate the extent of salinity migration, a graphical representation of the maximum salinity levels recorded at various stations in the Russian River Estuary between 2009 and 2014 is being presented (Figure 4.1.44). The sondes chosen for this graph were situated in the lower portion of the water column at each station, where saline water would be expected to occur. This corresponds to approximately three to four meter depths for the Mouth, Patty's Rock, and Sheephouse Creek stations, six to nine meter depths at the Heron Rookery station, six to seven meter depths at the Freezeout Creek station, eight to ten meter depths at the Brown's Pool station, six to eight meter depths at Villa Grande, nine to eleven meters depth at Patterson Point, and one to two meters at the Monte Rio station. In the upper reaches of the Estuary and MBA, the sondes are located on the bottom of the river because the salt layer is typically thin when it occurs at these river locations. Excluding the depth variations, the graph depicts the decrease in salinity the further upstream in the Estuary and MBA the monitoring station is located.

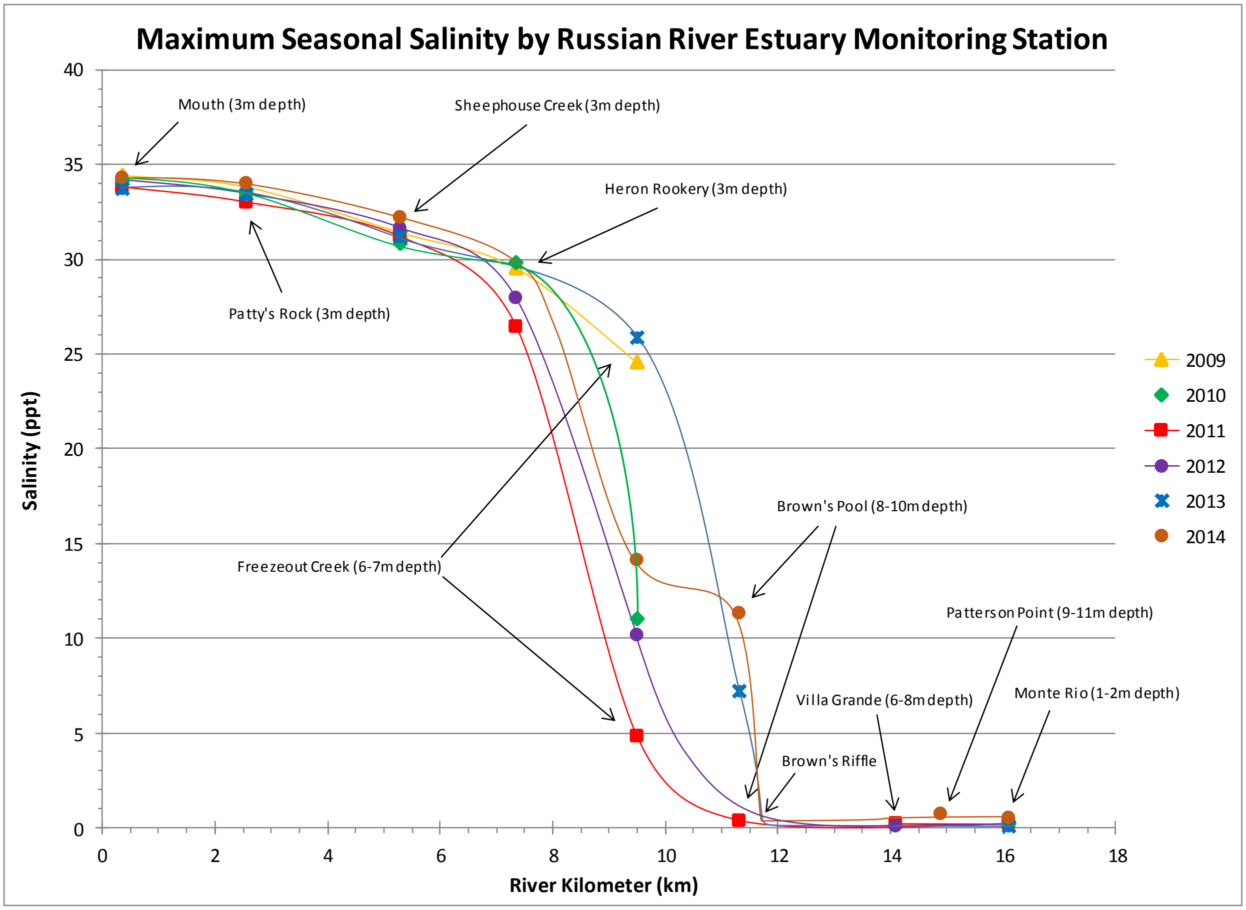


Figure 4.1.44. The maximum salinities at monitoring stations throughout the Russian River Estuary and Maximum Backwater Area between the years of 2009 and 2014.

The graph also illustrates the variable nature of salinity levels in the Upper Estuary, and specifically, one can see that the Brown's Pool maximum concentration was higher in 2014 than had been previously recorded (keep in mind that the values in the graph are maximums and not means; mean values would not as clearly illustrate the degree to which brackish water was observed at Brown's Pool in 2014). Note, however, that a continuously monitoring sonde had only previously been deployed at the Brown's Pool station in the 2011 and 2013 monitoring seasons and further continuous monitoring would be necessary to determine if this degree of brackish water in the Brown's Pool is a common phenomenon.

Also note that there are no elevated salinity levels recorded at Monte Rio for any monitoring seasons. As was mentioned above, it is possible that saline water does not migrate past the riffle between Brown's Pool and the confluence of Austin Creek due to hydrologic and/or geologic conditions that serve to define a transition from the Russian River Estuary and the beginning of the Maximum Backwater Area.

Water Quality Grab Sampling Conclusions

The 2014 grab sampling effort in the Russian River Estuary continued to collect a robust set of data similar in effort to the 2012 and 2013 monitoring seasons. The increased sampling was focused on Estuary closure events and community events where water contact recreation

(REC-1) was likely. Table 4.1.7 shows the total yearly number of sampling trips and the total number of samples collected within the Russian River Estuary and Maximum Backwater Area during each monitoring season since the implementation of the BO in 2009. There was a range of sampling events in 2014, with additional monitoring being conducted at Patterson Point, Monte Rio, and Vacation Beach in response to elevated E. coli levels at Monte Rio.

Table 4.1.7. The total number of grab sampling trips per monitoring season and the total number of samples taken in the Russian River Estuary and Maximum Backwater Area per monitoring season. Note; duplicate and triplicate samples were counted as separate sampling events.

Estuary Monitoring Season	Total Number of Sampling Trips	Total Number of Samples
2009	7	21
2010	14	70
2011	13	78
2012	18	126
2013	33	165
2014	26-31	137

The 2014 grab sampling effort observed Total Phosphorus exceedances for every sample collected. This is not uncommon in the lower Russian River or the Estuary, and similar percentages of the samples analyzed for Total Phosphorus were in exceedance during previous monitoring seasons. Table 4.1.8 shows the percentage of samples that were in exceedance each season since 2009.

The Total Nitrogen and Chlorophyll a exceedances for samples taken during 2014 were also similar to percentages observed in previous monitoring years, with Total Nitrogen exceedances being lower than all previous years (Table 4.1.8). Year to year variability in the percentage of exceedances for these three constituents can be attributed in part to: the frequency and timing of storm events, fluctuating freshwater inflow rates, the frequency and timing of barrier beach closures, the strength of tidal cycles, summer dam removal, topography, relative location within the Estuary, and wind mixing.

Table 4.1.8. The percentages of samples taken that were in exceedance of U.S. EPA water quality criteria for Total Phosphorus, Total Nitrogen, and Chlorophyll a. Note; Chlorophyll a was not quantified below 0.01 mg/L in 2009, and as such, cannot be verified against the U.S. EPA criteria of 0.00178 mg/L. Also, the Total Nitrogen values in 2009 were not quantified sufficiently against the criteria to make comparisons. The U.S. EPA criteria for Total Nitrogen is 0.38 mg/L, and the criteria for Total Phosphorus is 0.02188 mg/L.

Estuary Monitoring Season	Percentage of Total Phosphorus Samples in Exceedance	Percentage of Total Nitrogen Samples in Exceedance	Percentage of Total *Chlorophyll a* Samples in Exceedance
2009	91	N/A	N/A
2010	88	23	22
2011	94	45	35
2012	73	20	16
2013	99	23	59
2014	100	14	34

The E. coli exceedances since the implementation of the BO in 2009 until 2014 can be seen in Table 4.1.9. Although the Jenner results are not being compared for 2014, the percentages of exceeded samples are still similar among sampling seasons. As was mentioned in the results section above, the Jenner results are not reliable due to lab analysis limitations associated with sampling marine waters. Samples collected in 2009 and 2010 were analyzed using the multiple tube fermentation technique, whereas samples collected from 2011 through 2014 were analyzed using the Colilert Quanti-Tray method. Percentages for total coliform samples are not shown here since values were not quantified above 1600 MPN for 2010 and a portion of 2011, or above >2419.6 MPN for 2012, 2013 and a portion of the 2014 season. Both levels are below CDPH Guidelines, therefore it is impossible to establish percent criteria exceedances in this case.

Data collected through the grab sampling effort in 2014 appear similar to data collected between 2009 and 2013. Further analysis could elucidate any trends that may exist temporally or longitudinally through the Russian River Estuary and guide water quality monitoring efforts in the future.

Time series trend analyses of the grab sampling data collected under the Biological Opinion could prove useful in the future. Trend analyses could determine if there have been changes over time for any of the constituents collected under this project. Certain trend tests are used for non-parametric data analysis such as water quality data, including the Sen Slope test, the Kendall-Theil test, the Seasonal Kendall test, or a variety of other suitable statistical tests. Analyses of this nature require both time and expert knowledge of environmental statistical analysis. As such, they are difficult to run and outside the scope of this project at this time. In the future, allocating resources to analyses of this nature, on these data, would likely give a better understanding of the existence, or absence, of trends in the data.

Table 4.1.9. The percentages of samples taken that were in exceedance of CDPH Guidelines for E. coli for the sampling years 2009 through 2014. Note that for 2009-2010, the analyzing method was multiple tube fermentation, and for 2011-2014 the method was Colilert Quanti-Tray.

Estuary Monitoring Season	Percentage of Total E. coli Samples in Exceedance
2009	5
2010	14
2011	4
2012	1
2013	3
2014	6

References

California Department of Public Health (CDPH), Draft Guidance for Freshwater Beaches. Division of Drinking Water and Environmental Management. http://www.cdph.ca.gov/HealthInfo/environhealth/water/Documents/Beaches/DraftGuidanceforFreshWaterBeaches.pdf. Last update: January 2011.

Deas, M. and G. Orlob., University of California Davis, Report No. 99-04. Klamath River Modeling Project, Sponsored by the U.S. Fish and Wildlife Service Klamath Basin Fisheries Task Force. Project #96-HP-01, Assessment of Alternatives for Flow and Water Quality Control in the Klamath River below Iron Gate Dam, 1999.

Entrix. 2004. Russian River Biological Assessment. Prepared for: U.S. Army Corps of Engineers, San Francisco District, San Francisco, California, and Sonoma County Water Agency Santa Rosa, California. Entrix, September 29, 2004.

Horne, Alexander J. and Charles R. Goldman. 1994. Limnology. Second Edition. McGraw-Hill, Inc.

Manning, D.J., and J. Martini-Lamb, editors. 2012. Russian River Biological Opinion Status and Data Report Year 2011 – 2012. Sonoma County Water Agency, Santa Rosa, CA. p. 245

J. Martini-Lamb and Manning, D.J., editors. 2014. Russian River Biological Opinion Status and Data Report Year 2013 – 2014. Sonoma County Water Agency, Santa Rosa, CA. p. 293

North Coast Regional Water Quality Control Board (NCRWQCB), 2013. TMDL – Impaired Waterbodies. TMDL Projects. Russian River. Pathogen/Indicator Bacteria TMDL.

http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/russian_river/ November 27, 2013.

Smith, J.J. 1990. The Effects of Sandbar Formation and Inflows on Aquatic Habitat and Fish Utilization in Pescadero, San Gregorio, Wadell, and Pomponio Creek Estuary/Lagoon Systems, 1985-1989. Department of Biological Sciences, San Jose State University, San Jose, California. December 21, 1990.

United States Environmental Protection Agency (USEPA), 2000. Ambient Water Quality Criteria Recommendations. Information Supporting the Development of State and Tribal Nutrient Criteria for Rivers and Streams in Nutrient Ecoregion III. Office of Water. 4304. EPA-B-00-016. December 2000. http://water.epa.gov/scitech/swguidance/standards/upload/2007_09_27_criteria_nutrient_ecoregions_rivers_rivers_3.pdf

United States Environmental Protection Agency (USEPA), 2013a. Nutrient Policy Data. Ecoregional Criteria Documents. http://www2.epa.gov/nutrient-policy-data/ecoregional-criteria-documents. Last Updated April 10, 2013.

United States Environmental Protection Agency (USEPA), 2013b. Water. Water Quality Criteria. http://water.epa.gov/scitech/swguidance/standards/criteria/index.cfm. Last Updated January 30, 2013.

4.2 Algae Sampling

Introduction

Algae sampling was conducted in the Russian River Estuary, between Patterson Point and Vacation Beach. Water Agency staff implemented the field based rapid periphyton sampling procedure described below. Baseline conditions were sampled on 12 September 2014 and follow up sampling was conducted at every 2 foot rise in water surface elevation following closure of the estuary (sample dates of 9/24, 10/3, and 10/23).

Methods

Periphytic Algae and Cyanobacteria

Monitoring for presence of periphytic algae in newly flooded shoreline areas was conducted during river mouth closures from 15 May to 15 October. Transects to monitor periphytic algal growth, including the potential presence of cyanobacteria, were established at the 3 surface water sites located in the maximum backwater area (Figure 4.2.1). Sampling was conducted along shallow over-bank habitat that becomes inundated during river mouth closure and may provide additional habitat substrate for algal mats to grow.

Transects were located on gravel bars that become inundated during estuary closure on the downstream side of Patterson Point beach, in the vicinity of the island downstream of Monte Rio, and on the gravel bar downstream from the Vacation Beach summer dam. Sampling methodology was developed based on modification of *Standard Operation Procedures for Collecting Stream Algae Samples and Associated Physical Habitat and Chemical Data for Ambient Assessments in California* (Fetscher, et al. 2009) to address monitoring periphytic algae growth in newly flooded shoreline areas.

Two transects were established at each monitoring site. Transect endpoint 0 was established at a 1 m depth in the main stem Russian River and extended 12.5 m landward or to a 9 foot elevation as diagramed in Figure 4.2.2. Transect locations avoided locations such as tributaries, outfalls, and man-made structures to minimize influence of algal growth from contributions in nutrients, temperature, or canopy cover from such sources.

Percent algal cover was calculated as an algal indicator of productivity measured as algal abundance using a point-intercept collection methodology. Algal cover is the amount of microalgae coating and macroalgae taken at 5 equidistant points along each transect. The percentage of the points across the transects at each monitoring site then provide an estimate of percent algal cover.

The presence of algae was recorded for each point along the transect and identified as microalgae or macroalgae. Microalgae is defined as a “film-like coating” of algae. Measurement of microalgae thickness followed the method identified in Fetscher, et al. 2009 and an estimate of film-like coating followed descriptions in Table 4.2.1. Thicker microalgae layers were

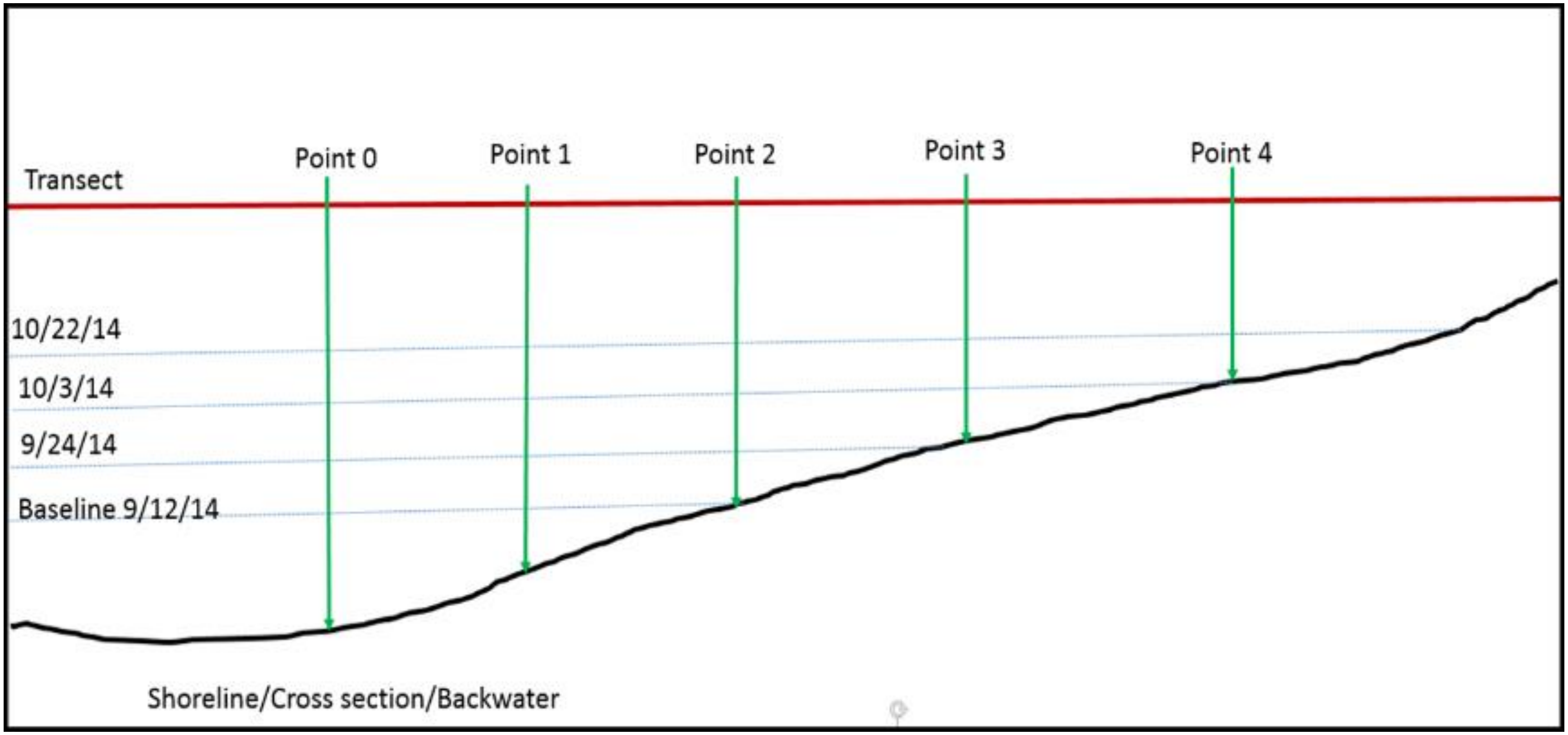


Figure 4.2.2. Transect schematic indicating transect sampling points and a representation of water levels following closure of the mouth of the Russian River.

Table 4.2.1. Microalgal thickness codes and descriptions (from Fetscher, et al. 2009 and adapted from Stevenson and Rollins 2006).

Code	Thickness	Diagnostics
0	No microalgae present	The surface of the substrate feels rough, not slimy.
1	Present, but not visible	The surface of the substrate feels slimy, but the microalgal layers is too thin to be visible.
2	<1mm	Rubbing fingers on the substrate surface produces a brownish tint on them, and scraping the substrate leaves a visible trail, but the microalgal layers is too thin to measure.
3	1-5mm	
4	5-20mm	
5	>20mm	
UD	Cannot determine if a microalgal layer is present	

measured using a ruler or rod with demarcations at 1, 5, and 20 mm. The presence or absence of attached macroalgae or unattached, floating macroalgae was recorded at each point.

Prior to collection of percent algae cover, algae samples were collected 1 m downstream and adjacent to each point (to avoid trampling on samples during collection of percent algal cover data), beginning at the downstream transect. A single sample (10 cm diameter) was collected at each of the 5 equidistant points along the transect. Each sample was collected from the substrate that was uppermost within the stream and had highest possibility of sun exposure (i.e. if a thick layer of macroalgae covers the substrate, collection will include the layer). Samples were be placed in a cooler to protect the algae from heat and desiccation and to preserve specimen integrity. Algal species present were identified to the lowest taxa, preferably species but at least genera (Dillard 1999, Prescott 1978). In addition, an evaluation for the presence of cyanobacteria within the algal samples was conducted, and if target species were identified (including species of Anabaena, Microcystis, Planktothrix, and Oscillatoria), the potential for the production of cyanotoxins was also evaluated by the species observed during sampling (Lee 1989). Keenan Foster, a taxonomic botanist and Principal Environmental Specialist with the Water Agency, conducted the algae identification and evaluation for the presence of cyanobacteria.

Water chemistry measurements were recorded near the substrate at each transect point using a YSI 6600 datasonde and YSI 650MDS datalogger. Conditions measured included water temperature, dissolved oxygen, specific conductance, pH, and turbidity. Water depth was measured.

Monitoring and sample collection occurred under certain conditions and following specific river management and operational events, noted below, at the sites described above.

- Transects were established during open river mouth conditions in September 2014. Monitoring of percent algae cover and collection of samples were completed with establishment of the transects.
- The next monitoring and sampling event occurred when the river mouth was closed, in an extended perched condition. Monitoring and sample events were then repeated with each 2 foot stage change (e.g. 6.5 feet and 8.5 feet) until the river mouth returns to an open condition or at the end of the monitoring period (15 October) (Table 4.2.2).

Results

Monitoring locations were established at three sites that supported backwater habitats targeted for sampling. These locations are indicated in Figure 4.2.1 and include Vacation Beach, Monte Rio, and Patterson Point. Transects were established perpendicular to the shoreline in locations that were expected to be submerged during mouth closure. Transect endpoints were installed and initial data was collected while the river mouth was open on 12 September 2014. Following closure of the Estuary on 17 September follow-up sampling was conducted on 24 September, 3 October, and 22 October, which corresponded to an approximate water surface elevation gain of 2 feet additively for each sampling event.

Table 4.2.2 summarizes mico versus macro algal cover data. Table 4.2.3 indicates the genera encountered during sampling and notes the relative abundance during surveys. Blue green algae cover was sampled as a total estimate along with other forms of microalgae including microscopic Green Algae (Chlorophyta) and Golden Brown Algae (Chrysophyta - diatoms). Figures 4.2.3 - 4.2.7 illustrate the relationship and shift in relative cover by micro and macroalgae following estuary closure. Figure 4.2.3 illustrates this relationship graphically, first all sites represented in one graph together, then individually by sampling location (Figures 4.2.4 - 4.2.6), and finally represented as average change in cover by micro and macroalgae for all sites (Figure 4.2.7). Figures 4.2.8 through 4.2.13 illustrate the variety of growing conditions for algae on the Russian River. Figures 4.2.14 and 4.2.15 illustrate benthic drift conditions typical of back water and shoreline areas. Figures 4.2.16 through 4.2.18 provide the macroscopic view of cyanobacterial colonies typically seen in the Russian River associated with fall benthic blooms. Figures 4.2.19 and 4.2.20 show the new waterline and freshly captured littoral zone following estuary closure. Figure 4.2.21 illustrates cyanobacterial colonies separated by genera in the lab. Figure 4.2.22 shows typical drift that accumulates on the shoreline following estuary closure. Figures 4.2.23 through 4.2.40 display representative genera observed during sampling.

Table 4.2.2. Change in relative cover over time between micro- and macro- algae between 9/12/14 and 10/22/14.

Date	Sampling Location	Microalgae Cover	Macroalgae Cover	Estuary Condition
09/12/2014	Vacation Beach	69%	31%	Open (baseline)
09/24/2014	Vacation Beach	69%	31%	Closed
10/3/2014	Vacation Beach	52%	48%	Closed
10/22/2014	Vacation Beach	28%	72%	Closed
09/12/2014	Monte Rio	60%	40%	Open (baseline)
09/24/2014	Monte Rio	73%	27%	Closed
10/3/2014	Monte Rio	29%	71%	Closed
10/22/2014	Monte Rio	67%	33%	Closed
09/12/2014	Patterson Point	36%	64%	Open (baseline)
09/24/2014	Patterson Point	58%	42%	Closed
10/3/2014	Patterson Point	24%	76%	Closed
10/22/2014	Patterson Point	30%	70%	Closed

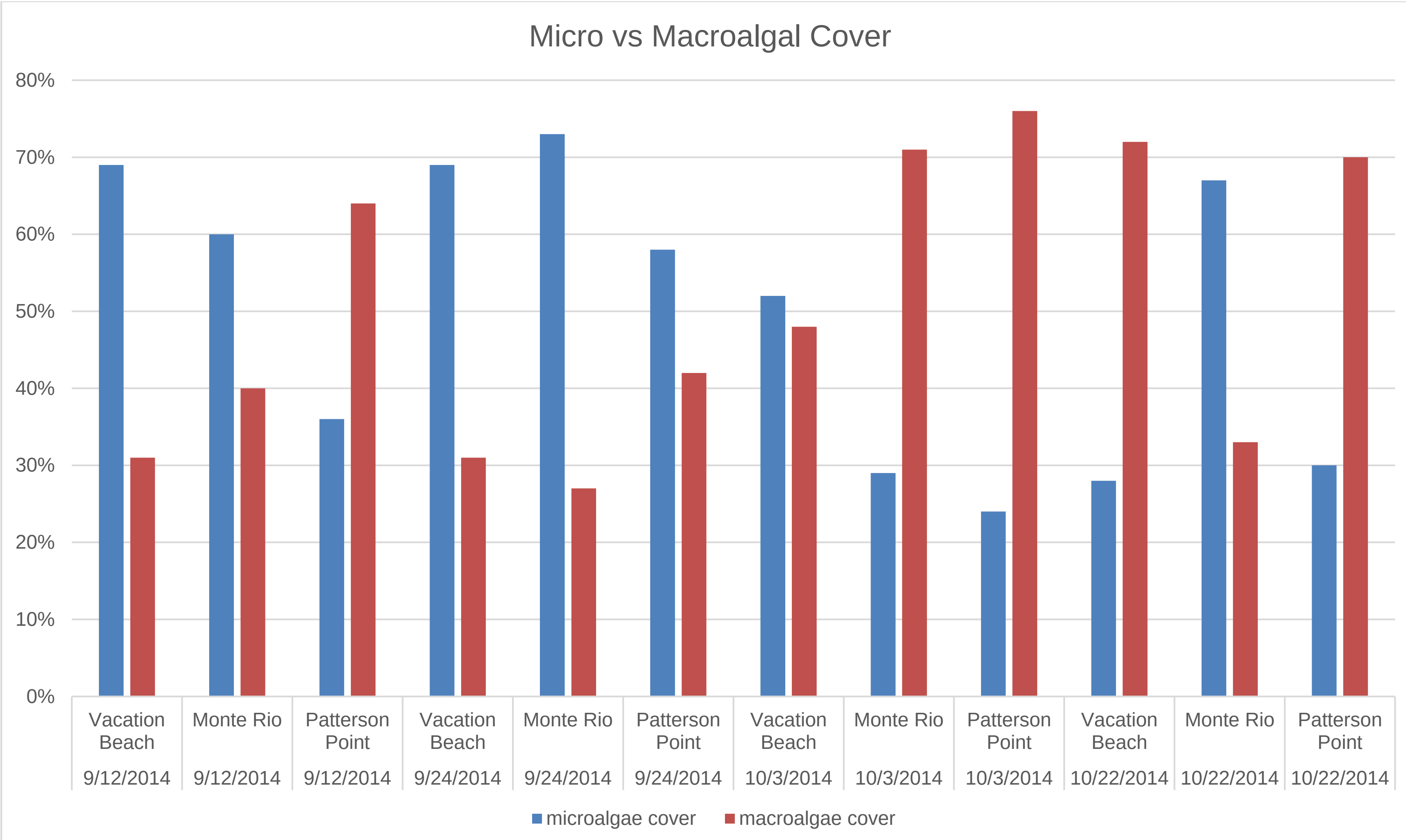


Figure 4.2.3. Change in microalgae versus macroalgae cover at all sampling sites during Russian River Estuary mouth closure.

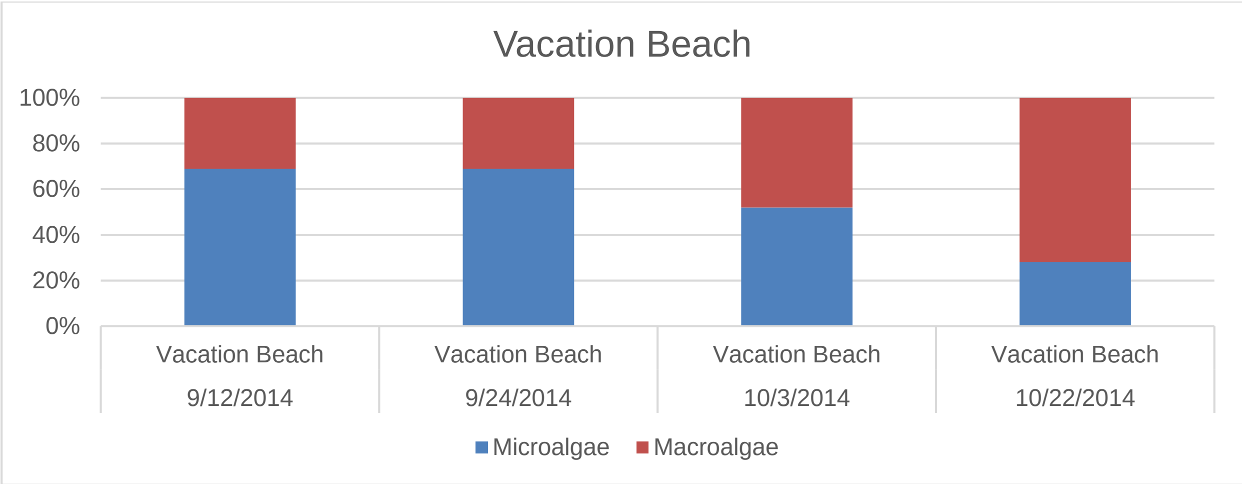


Figure 4.2.4. Change in microalgae versus macroalgae cover at Vacation Beach during Russian River Estuary mouth closure.

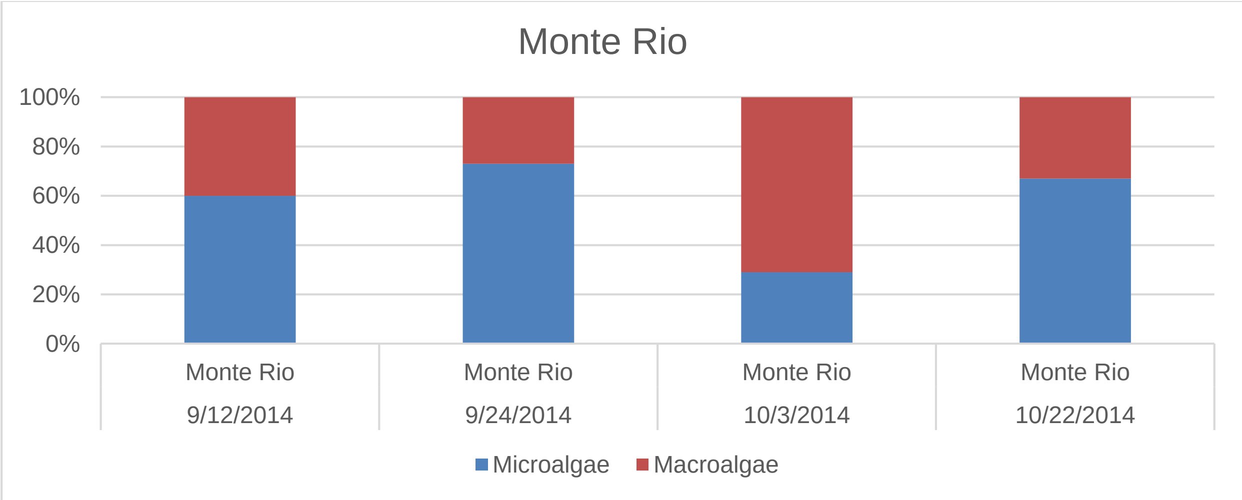


Figure 4.2.5. Change in microalgae versus macroalgae cover at Monte Rio during Russian River Estuary mouth closure.

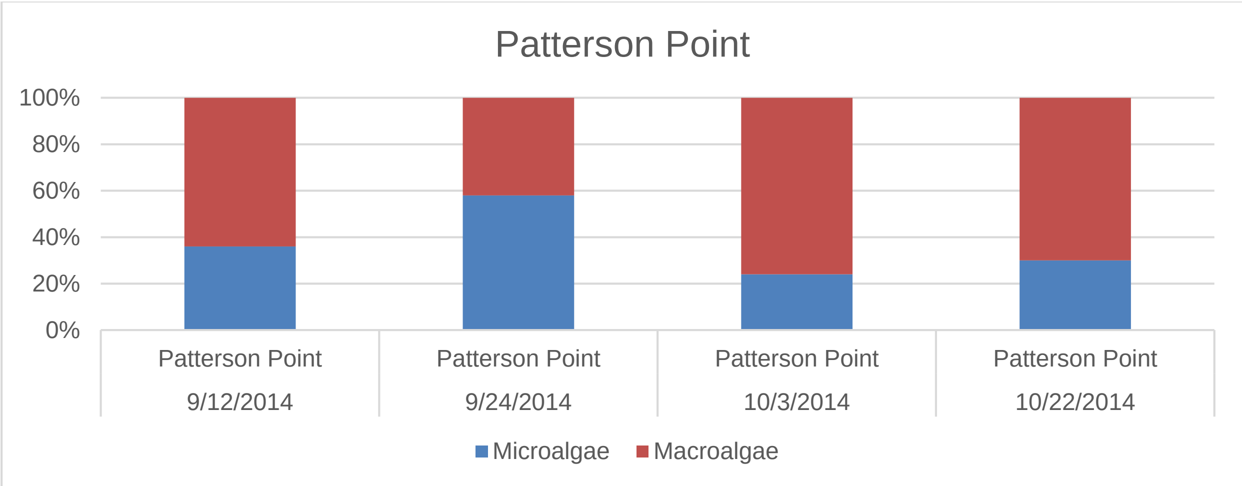


Figure 4.2.6. Change in microalgae versus macroalgae cover at Patterson Point during Russian River Estuary mouth closure.

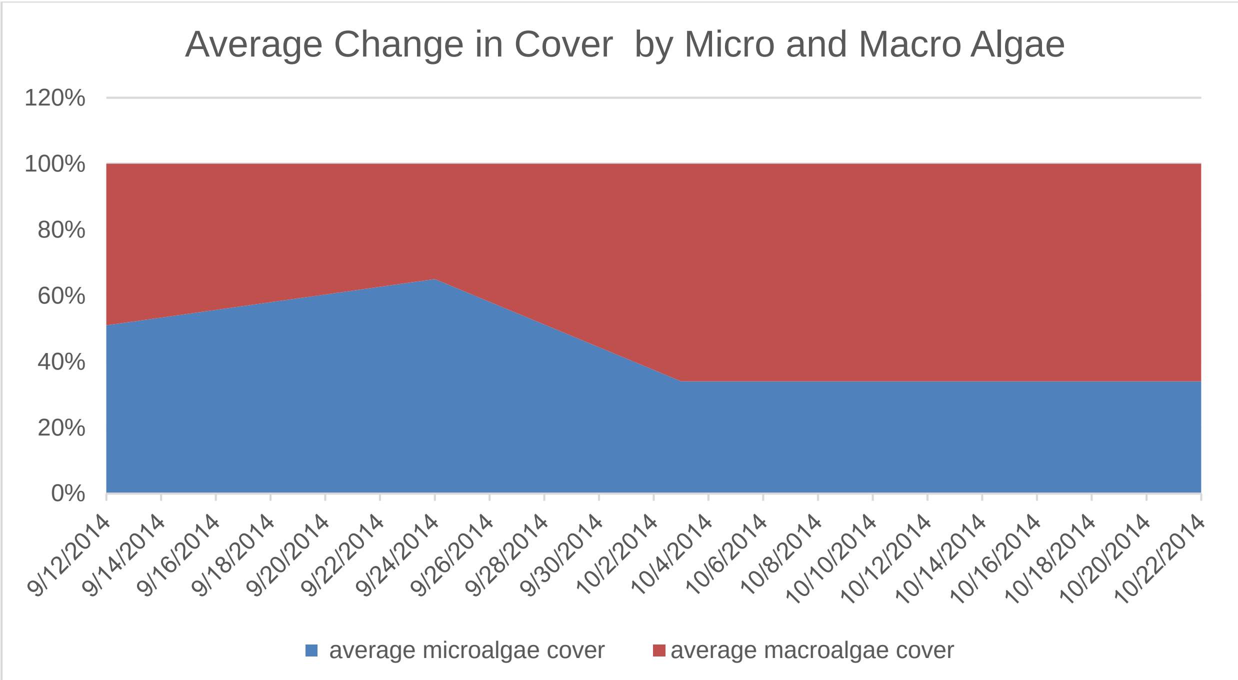


Figure 4.2.7. Average change (at all sites) in microalgae versus macroalgae cover during Russian River Estuary mouth closure.

Figures 4.2.8 and 4.2.9. Typical aquatic habitat in the Russian River. Note the filamentous green algae attached to rocks and/or free floating.


Figures 4.2.10 and 4.2.11. Typical shallow water periphyton habitat in the Russian River. Complex mixture of filamentous green algae (Cladophora, Zygnema, Spirogyra) (mostly lighter green), mixed diatoms (golden brown color), and mixed cyanobacterial benthic colonies (Anabaena, Cylindrospermum, Gleotricha) (pine to blue green).

Figure 4.2.12. Backwater at Monte Rio, inset close up of observed bacterial colonies and the blue green alga (Ocillatoria sp.), mixed with iron and sulfur reducing bacterial taxa.

Figure 4.2.13. Typical summer algal conditions in shallow backwater areas. Note feathery accumulation of mixed blue-green colonies.

Figures 4.2.14 and 4.2.15. Accumulations of algal drift along the shoreline in a backwater at Patterson Point, the Russian River. Samples examined were composed of decaying and deteriorated filamentous greens (Zygnema, Spirogyra) mixed with the the cyanobacteria-Anabaena.

Figure 4.2.16. Typical close up of benthic algae along the shore line. The light filamentous material is mainly diatoms, the darker areas are mixed colonies of cyanobacteria including Anabaena, Cylindospermum, and Ocillatoria.

Figure 4.2.17. Benthic cyanobacteria along the shore line at Patterson Point. The light green alga forming bubble towers is Anabaena sp.


Figure 4.2.18. Filamentous green alga drift with lighter specks composed of gas bubbles and small cyanobacteria colonies.


Figure 4.2.19. Sampling the backwater at Monte Rio on 10/3/2014.

Figure 4.2.20. Conditions at Monte Rio following Russian River Estuary mouth closure (10/3/14). Note the increase in wetted width which is followed by colonization of benthic algae especially along the shoreline.

Figure 4.2.21. Mixed blue green genera in petri dish. Macroscopic characteristics.

Figure 4.2.22. Typical drift accumulating along shoreline following Russian River Estuary mouth closure. Composed largely of mixed cyanobacterial colonies.

Figure 4.2.23. Green Alga -Cladophora sp.

Figure 4.2.24. Green Alga - Spirogyra sp.

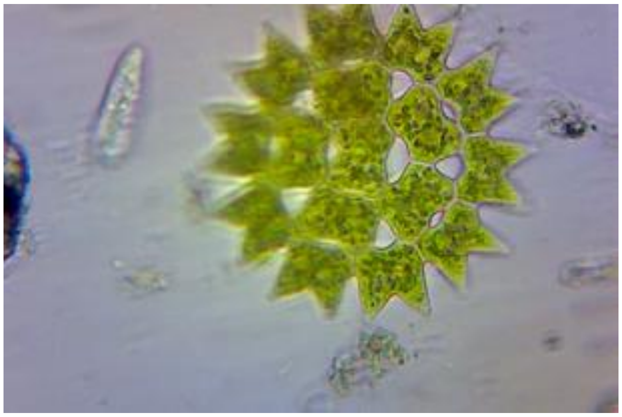


Figure 4.2.25. Green Alga –Desmid-Pediastrum sp.

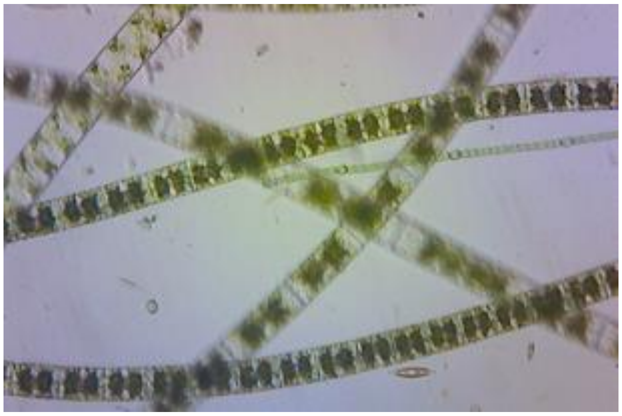


Figure 4.2.26. Green Alga -Zygnema sp with Spirogyra sp, and Anabaena trichome.

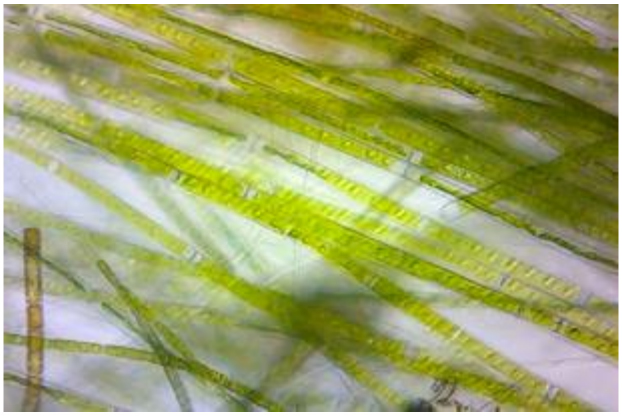


Figure 4.2.27. Green Alga -Mougotia sp.

Figure 4.2.28. Green Alga -Cladophora sp. with epiphytic diatoms

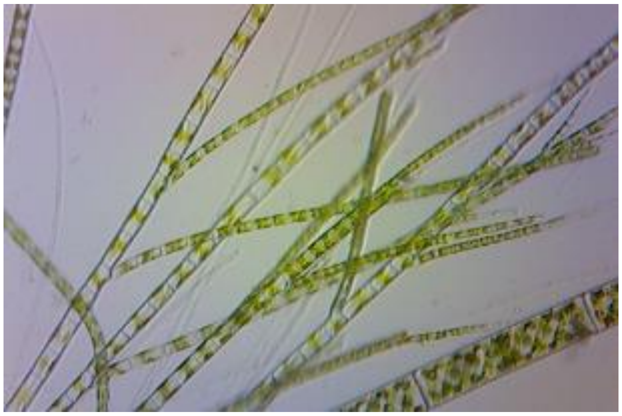


Figure 4.2.29. Green Alga-Stigeclonium sp.

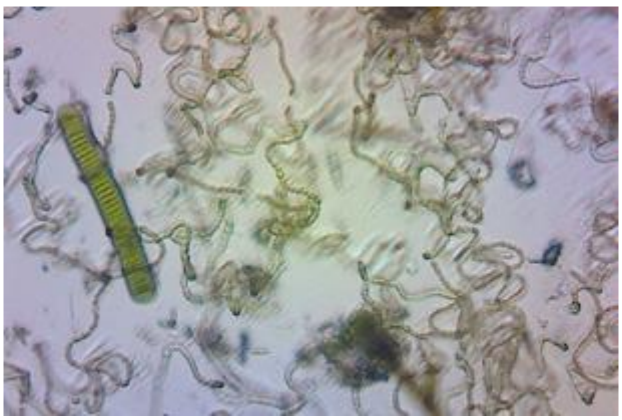


Figure 4.2.30. Cyanobacteria-Nostoc sp. encased in gelatinous sheath. Note Ocillatoria trichome.

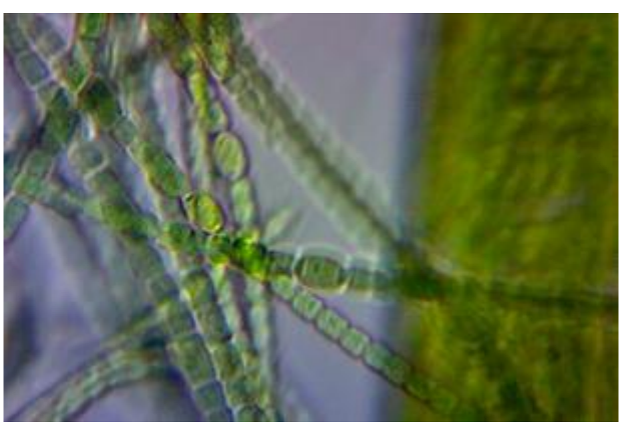


Figure 4.2.31. Cyanobacteria-Anabaena sp.

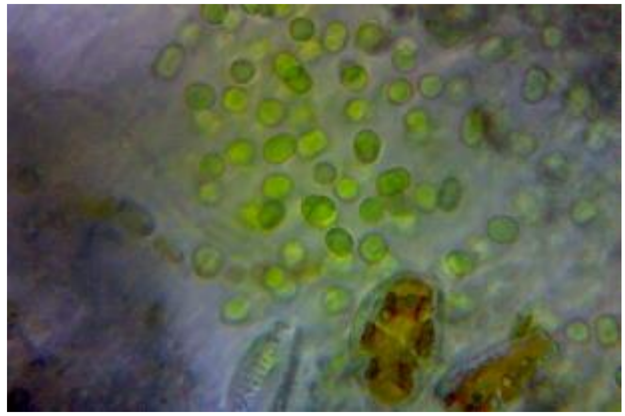


Figure 4.2.32. Cyanobacteria-Ahanocapsa sp.

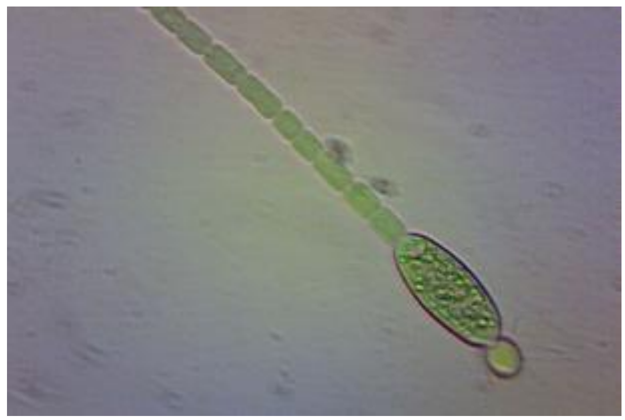


Figure 4.2.33. Cyanobacteria-Cylindrospermum sp. Note akinete and heterospore.

Figure 4.2.34. Cyanobacteria-mass of Cylindrospermum sp.

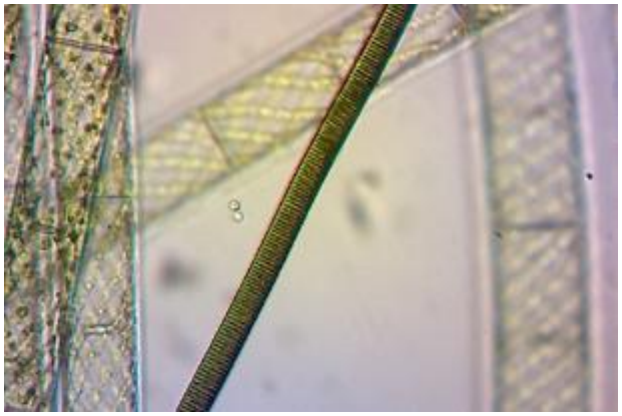


Figure 4.2.35. Cyanobacteria-Ocillatoria sp. (darker trichome)

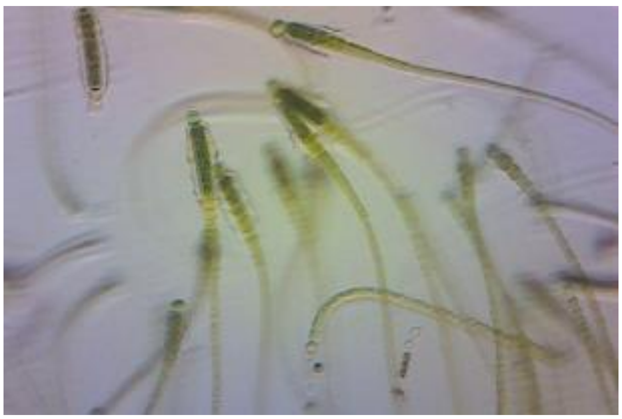


Figure 4.2.36. Cyanobacteria- Gleotrichia sp.

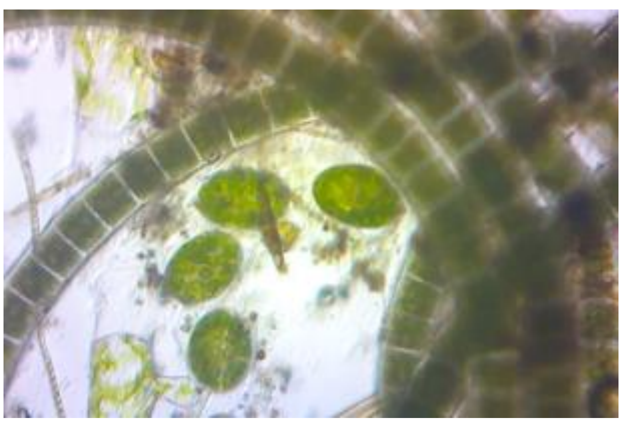


Figure 4.2.37. Green Alga-Zygnema filaments with Spirogyra resting spores.

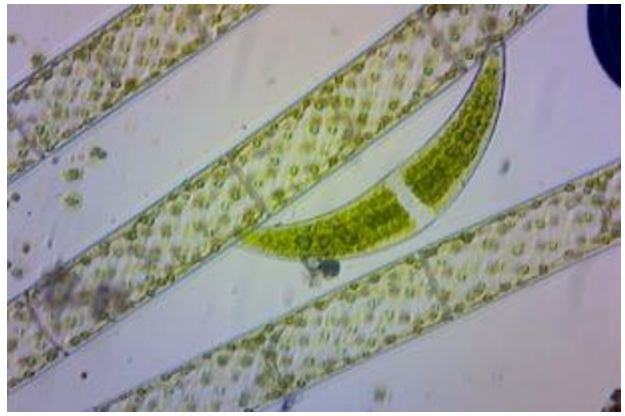


Figure 4.2.38. Green alga- Spirogyra with a fresh water desmid Closterium sp.

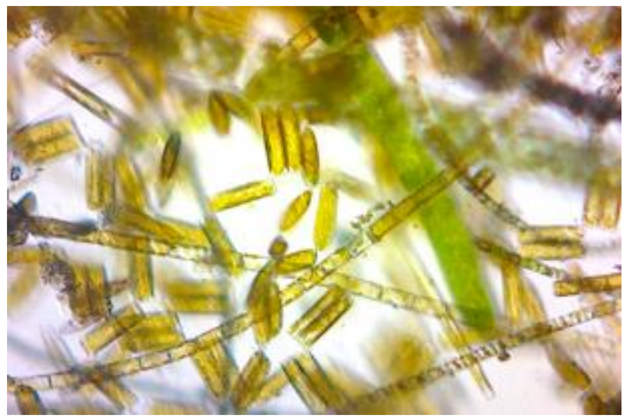


Figure 4.2.39. Golden Brown Alga-Mixed diatoms.

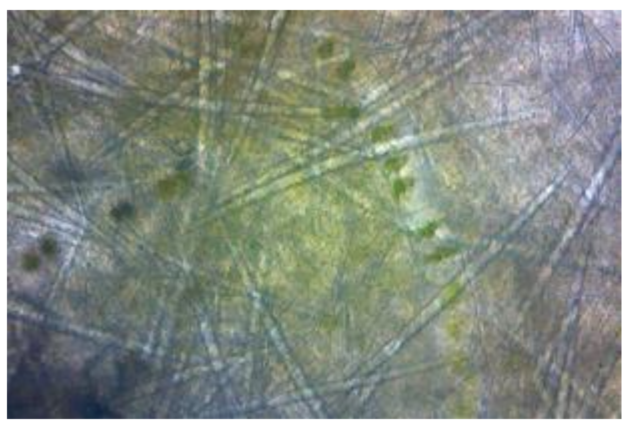
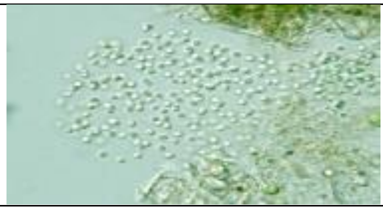
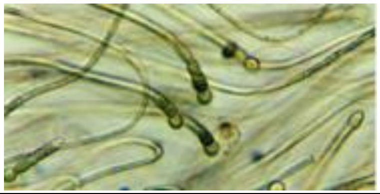


Figure 4.2.40. Fresh water sponge. (Novel to find)

Table 4.2.3. Genera Observed during Algal Monitoring September - October 2014

Algal Class	Genus	Notes on Occurrence/Ecology[6]	Known Toxins	Photograph
Cyanophyta	Anabaena	Common: individual or in colonies masses of individual filiments no sheath, common, easy to confuse with Nostoc sp. if gelatinous sheath indiscernible. Saxicolous, goes planktonic later in season, possibly stimulated by Russian River Estuary mouth closure, or shortening day, accumulates on shoreline in backwater areas.	Microcystins, Anatoxin, Saxitoxins	
Cyanophyta	Ahanocapsa sp.	Occasional: colonies embedded in detritus on fine substrate.		
Cyanophyta	Cylindrospermum sp.	Common: saxicolous, goes planktonic later in season, possibly stimulated by estuary closure, or shortening day, accumulates on shoreline in backwater areas	Anatoxin	
Cyanophyta	Gloeotricha sp.	Occasional: forms brownish hollow, gelatinous thallus. Saxicolous then planktonic, accumulates on shoreline in backwater areas (see Figure 13 for macroscopic appearance).		
Cyanophyta	Nostoc sp.	Occasional: forms small gelatinous hollow balls (see Figure 13 for macroscopic appearance).	Microcystins	

[6] Note- Common- Observed in 90% of samples, Occasional –Observed in about 50% of samples, Rare-Observed in only one sample.

Table 4.2.3 (cont.). Genera Observed during Algal Monitoring September - October 2014

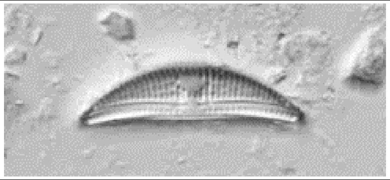
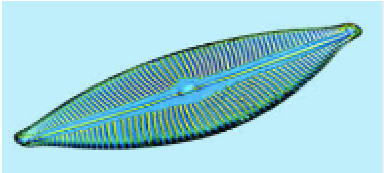
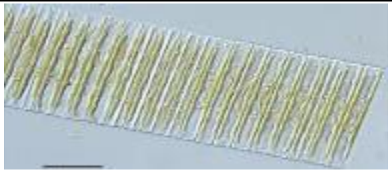
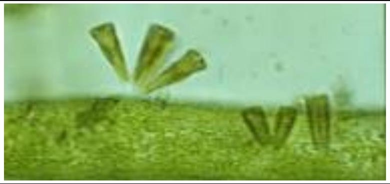
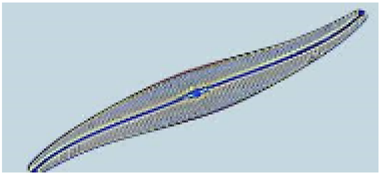
Algal Class	Genus	Notes on Occurrence/Ecology	Known Toxins	Photograph
Cyanophyta	Oscillatoria sp.	Common: forms flat threadlike colonies , very dark blue green in color, or occurs individually. (see Figure 13 for macroscopic appearance).	Microcystins	
Bacillariophyta	*Amphora* sp.	Common in diatomaceous layer on substrate		
Bacillariophyta	*Cymbella* sp.	Common in diatomaceous layer on substrate		
Bacillariophyta	*Fragilaria* sp.	Common in diatomaceous layer on substrate		
Bacillariophyta	*Gomphonema* sp.	Common in diatomaceous layer on substrate and debris. Most abundant species observed. Golden brownish in color, epiphyte on macroalgae		
Bacillariophyta	*Gyrosigma* sp.	Common in diatomaceous layer on substrate		

Table 4.2.3 (cont.). Genera Observed during Algal Monitoring September - October 2014

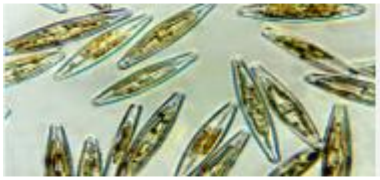
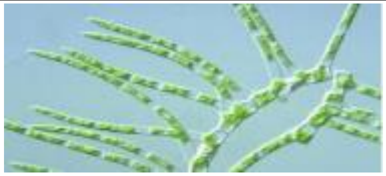
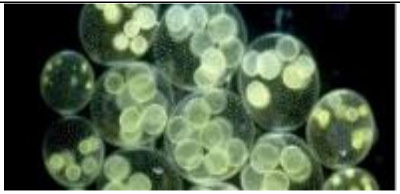
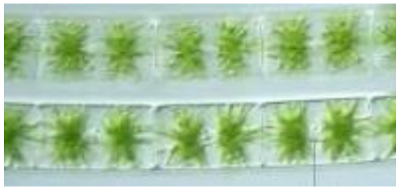
Algal Class	Genus	Notes on Occurrence/Ecology	Known Toxins	Photograph
Bacillariophyta	*Melosira* sp.	Generally marine species, likely carried in with the tide.		
Bacillariophyta	*Navicula* sp.	Common in diatomaceous layer on substrate.		
Bacillariophyta	*Surirella* sp.	Common in diatomaceous layer on substrate.		
Bacillariophyta	*Synedra* sp.	Common in diatomaceous layer on substrate.		
Bacillariophyta	Tabellaria sp.	Common in diatomaceous layer on substrate.		

Table 4.2.3 (cont.). Genera Observed during Algal Monitoring September - October 2014

Algal Class	Genus	Notes on Occurrence/Ecology	Known Toxins	Photograph
Chlorophyta	Cladophora sp. (few species)	Very Common: dark pine green, saxicolus, branching filament, reticulate chloroplast multiple pyrendoids. Goes planktonic when reproductive.		
Chlorophyta	Mougeotia sp.	Occasional: Vacation Beach		
Chlorophyta	Spirogyra sp. (at least 3 diff species)	Very Common: light green, saxicolous, unbranched filament, helical chloroplast with multiple pyrenoids. Goes planktonic when reproductive. Slippery cell walls, feels slimy.		
Chlorophyta	Stigeclonium sp.	Occasional: saxicolous (Vacation Beach) branched bright green.		
Chlorophyta	Volvox sp.	Rare: in one sample (Patterson Point)		
Chlorophyta	Zygnema sp.	Very Common: light green, saxicolous, unbranched filament, platelike chloroplast. Goes planktonic when reproductive. Two star shaped cholorplasts per cell		

Discussion/Observations

Algae occurs in the Russian River under a variety of conditions and species commonly found worldwide are present in the system. Conditions supporting algal abundance in the Russian River are largely driven by light, temperature, and nutrient availability. Generally the most visible type of algae in the Russian River are filamentous Green Algae (Family Chlorophyta) initially growing on rocks and substrate (generally cobble, gravels, and occasionally finer grained sands and silts) (saxicolous) and then becoming planktonic during their reproductive phase which is driven by largely by season, unless another environmental parameter changes and triggers the life cycle switch (light, temperature, nutrient availability, and changes in water depth). Figure 4.2.41 illustrates a representative cross section of a water body, showing the littoral, limnetic, and profundal zones. The profundal zone being below the area of active photosynthesis. Depending on the annual conformation of the substrate following high flow events, the littoral zone may be larger or smaller depending on where the river moved the substrate during functional flows. Cover data on macro versus microalgae indicate that following Estuary mouth closure and the following slow increase in depth (with the corresponding reduction in what used to be photosynthetically active littoral zone) there is a shift in algal dominance (cover) from micro-algae dominated to macro-algae dominated. This shift is associated with all forms of algae and is triggered by environmental change. In this case the environmental change is the increasing water depth and the corresponding shift in the base elevation of the column of water that can be penetrated by sunlight.

Green Algae

Common green algae Genera in the Russian River include Chladophora sp, Spirogyra sp, and Zygnema sp. (Figures 4.2.8 through 4.2.11, 4.2.18, 4.2.23, 4.2.26, and 4.2.27). Besides diatoms (described below), Green Algae is one of the most prevalent types of algae recognizably visible at the macro-scale. Chladophora is a common branching green alga (often slightly darker green) that grows on rocks and is observed in almost every habitat niche available (cobble, gravel, shallow, fast, deep, slow, shaded, direct sun, etc.) in the littoral zone. The greens provide the base for the periphyton (complex mixture of algae, detritus, and microbes). Early in the season the filaments are lightly colonized by diatoms and cyanobacterial colonies. Flow also affects what can be retained in the periphyton. Fast water can preclude accumulations but if enough large substrate (submerged wood, cobble, large gravels, aquatic plants) is present filamentous greens can reach their maximum sizes. In backwater areas, or locations with sluggish flow at the water edge, the chladophora generally gets completely encrusted in diatoms and cyanobacteria colonies. These green algae start their growth attached to the substrate but if physically disturbed or when forming reproductive propagules (generally in the Fall) (Figure 4.2.37) the filaments detach and form large floating and visible rafts (these can negatively affect dissolved oxygen while they are decomposing). Often the green algae or emergent plants provides a substrate for other forms of algae, including diatoms (Figure 4.2.28), unicellular greens, and cyanobacteria. Floating mats were observed to include in varying proportions a wide variety of other algal genera including diatoms, cyanobacteria, and other greens.

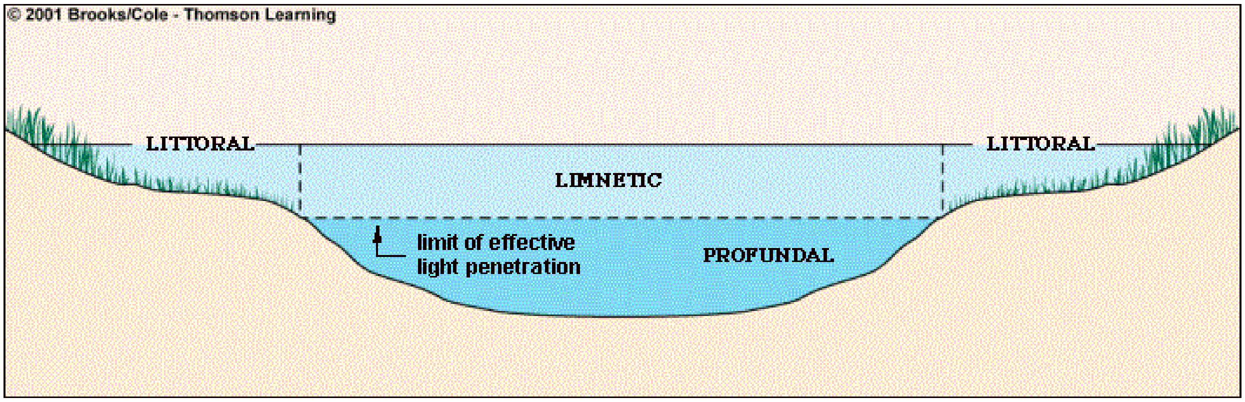


Figure 4.2.41. Diagram indicating littoral vs limnetic and profundal zones. Following estuary closure, the profundal zone moves into the littoral zone and existing benthic algae either detach or if they have the means, move and re-colonize the newly wetted littoral zone.

Golden Brown Algae

The most numerous and abundant type of algae found in most freshwater systems and true for the Russian River as well, are diatoms, members of the Golden Brown Algae (Family Chrysophyta). These algae develop siliceous (glass) cell walls called "frustules," and display a wide range of shapes and sizes (Figures 4.2.28 and 4.2.39). Diatoms comprise the majority of the micro-aglal crusts and fluffy brown growths found on submerged substrate (Figures 4.2.10, 4.2.11, and 4.2.17) in the photic zone (littoral) (Figure 4.2.41). Diatoms have a variety of life styles and can be found as free-swimming (gliding) individuals, colonies of hundreds to thousands cells that form and live togther in gelatinous tubes, and in long filaments (Figure 4.2.39). They make up a large part of the periphyton and were commonly observed mixed in the "planktonic drift" following Estuary mouth closure.

Cyanobacteria

Cyanobacteria or "blue green algae" are bacteria that, like plants, use solar energy and carbon dioxide to grow. As bacteria (procaryotes) they lack the complex cellular organization found in eucaryotic cells (nucleus, mitochondria, chloroplasts, endoplasmic reticulum, etc.). Cyanobacteria occur naturally in both freshwater and marine (salt) water bodies. Cyanobacteria are extremely common in the shallow water habitats along the Russian River. Dominant cyanobacterial genera sampled include *Anabaena*, *Gleotrichia*, *Cylindrospermum*, and *Ocillatoria*. Cyanobacteria colonies and their macroscopic appearance is shown in Figures 4.2.10 through 4.2.18, 4.2.19, and 4.2.20. Figures 4.2.30 through 4.2.36 identify individual cyanobacterial genera.

Toxic cyanobacteria are found worldwide in inland and coastal water environments. At least 46 species have been shown to cause toxic effects in vertebrates (WHO 2003). The most common toxic cyanobacteria in fresh water are *Microcystis* spp., *Cylindrospermopsis raciborskii*, *Planktothrix* (syn. *Oscillatoria*) *rubescens*, *Synechococcus* spp., *Planktothrix* (syn. *Oscillatoria*) *agardhii*, *Gloeotrichia* spp., *Anabaena* spp., *Lyngbya* spp., *Aphanizomenon* spp., *Nostoc* spp., some *Oscillatoria* spp., *Schizothrix* spp. and *Synechocystis* spp. Toxicity cannot be excluded for further species and genera (WHO 2003).

Blooms

Algae are photosynthetic microorganisms that are found in most habitats. Algae vary from small, single-celled forms to complex multi-cellular forms. An algal bloom is a rapid increase in the density of algae in an aquatic system. Algal blooms sometimes are natural phenomena, but their frequency, duration and intensity are increased by nutrient pollution. Algae can multiply quickly in waterways with an overabundance of nitrogen and phosphorus, particularly when the water is warm and the weather is calm. This proliferation causes blooms of algae that turn the water noticeably green, although other colors can occur. Some species of algae grow in clumps covered in a gelatinous coating and have the capability to float, allowing cells to stick together into large surface scums in calm weather. Other algae form thick mats that float on or just below the surface along the shoreline. In the Russian River, accumulations of algae floating at the surface have been observed to be composed of green algae, cyanobacteria, and diatoms. In the Russian River these “blooms” have been sampled and are composed of discrete aggregates of what used to be attached to to the substrate as part of the periphyton (clumps of detritus mixed with whole colonies of different genera of cyanobacteria, green algal reproductive spores, partially decayed filamentous green algal genera, tube dwelling diatoms, individual trichomes of *Occilatoria*, etc).

Most algae species go planktonic when reproductive and can form large floating mats in backwater areas that locally affect dissolved oxygen as the thallus (algal body) disintegrates into propagules (resting spores, aplanospores, akinetes) (Figures 4.2.33 through 4.2.37). Stimulus to convert algal metabolism from vegetative to reproductive is tied to light and substrate availability in conjunction with water quality, nutrient availability, and the average life cycle of the species in question. Spring through early fall are the times of year that water bodies typically exhibit the most visible response to water quality problems. Algal blooms can be dramatic and can be a result of excess nutrients from fertilizer, wastewater and storm water runoff, coinciding with lots of sunlight, warm temperatures and shallow, slow-flowing water. The challenge is separating a bloom caused through natural stimuli (reduced insolation from shorter days, increased shading due to inclination of the sun, leading to cooler water temperatures and slower metabolism) from the bloom caused from man-induced stimuli (un-natural fertilizer inputs, stirring up substrate, artificially modifying depth of littoral zone, etc.).

Rivers are not known for having cyanobacterial blooms that are composed of individual cells in the water column. Generally rivers are similar to oligotrophic lakes with low nutrient content in the water. Algal blooms in rivers are generally a result of the benthic genera (periphyton) going planktonic because of an environmental change or the end of the life cycle of a clone. These benthic mats can only grow in clear water where sunlight penetrates to the bottom, and reach their greatest development in locations with high light intensities. During sunny days, especially in the Fall, photosynthesis drives oxygen production which forms bubbles in the colony mats (making up the periphyton) that loosen parts of the mats and drives dicrete clumps of them to the surface (Figures 4.2.17 and 4.2.18). Mats and broken bits of benthic cyanobacteria colonies wash up on the shore line and can be a hazard if ingested (Figures 4.2.13 through 4.2.15). These mats are potentially lethal to animals when ingested depending on the species and if toxins are released. The human impact of benthic cyanobacterial mats is less than from planktonic blooms in the water column, but is worth noting as these kinds of waters, or algae in this form is not generally recognized as producing cyanotoxins (WHO 2003).

Cover Shifts

Cover data displayed in Table 4.2.2 and represented in Figures 4.2.3 through 4.2.7, are indicative of the shift in cover triggered by water level increase. Water level rise causes the benthic mats of microalgae to detach from their locations in the littoral zone and through shoreline accumulation of floating colonies (and motile cells) begin to re-colonize the freshly wetted gravel bars, and other newly inundated low-lying areas. Figure 4.2.42 diagrammatically illustrates conditions before closure. Bethic algae is found in the photosynthetically active littoral zone but drops off in abundance quickly below the littoral zone. Figure 4.2.43 illustrates conditions following closure. In most cases, the area of habitat in the littoral zone increases as the water surface elevation increases. The benthic algae and periphyton break away from the substrate and drift onto the shoreline. Motile genera including diatoms strat colonizing the new areas but where not observed re-developing into the thick crust present before estuary closure.

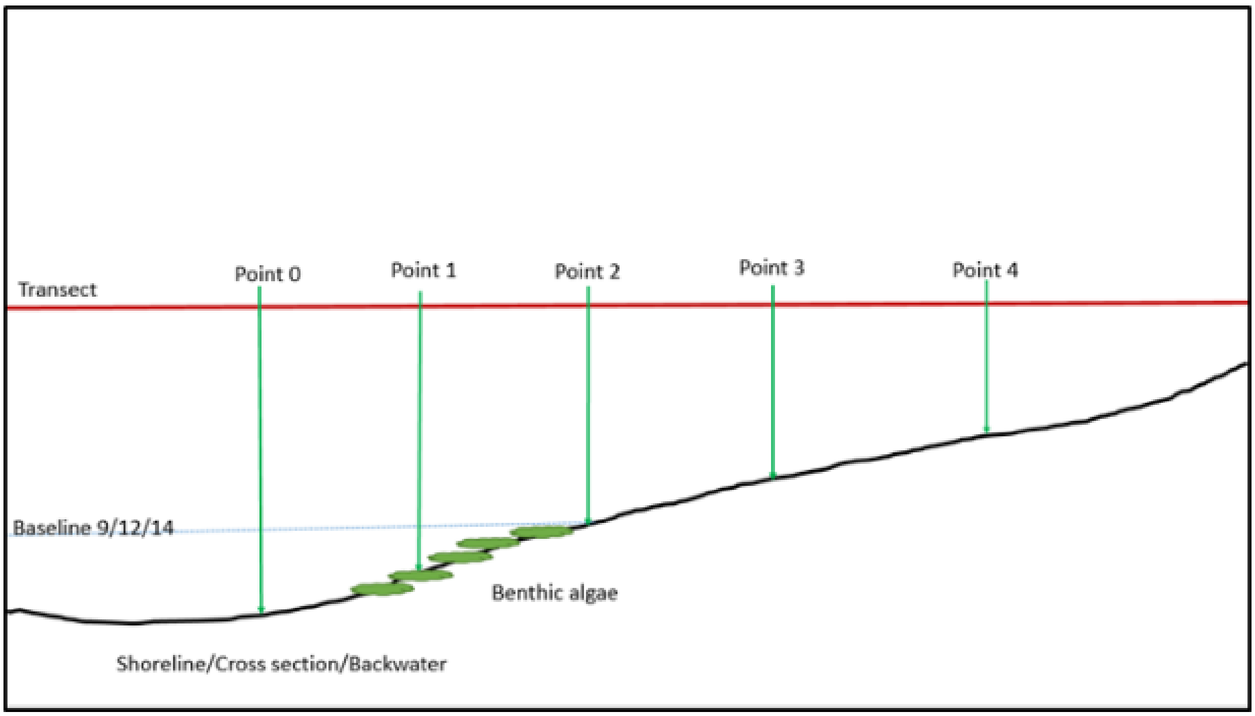


Figure 4.2.42. Before the Russian River Estuary mouth closes algae is spread relatively evenly across the littoral zone.

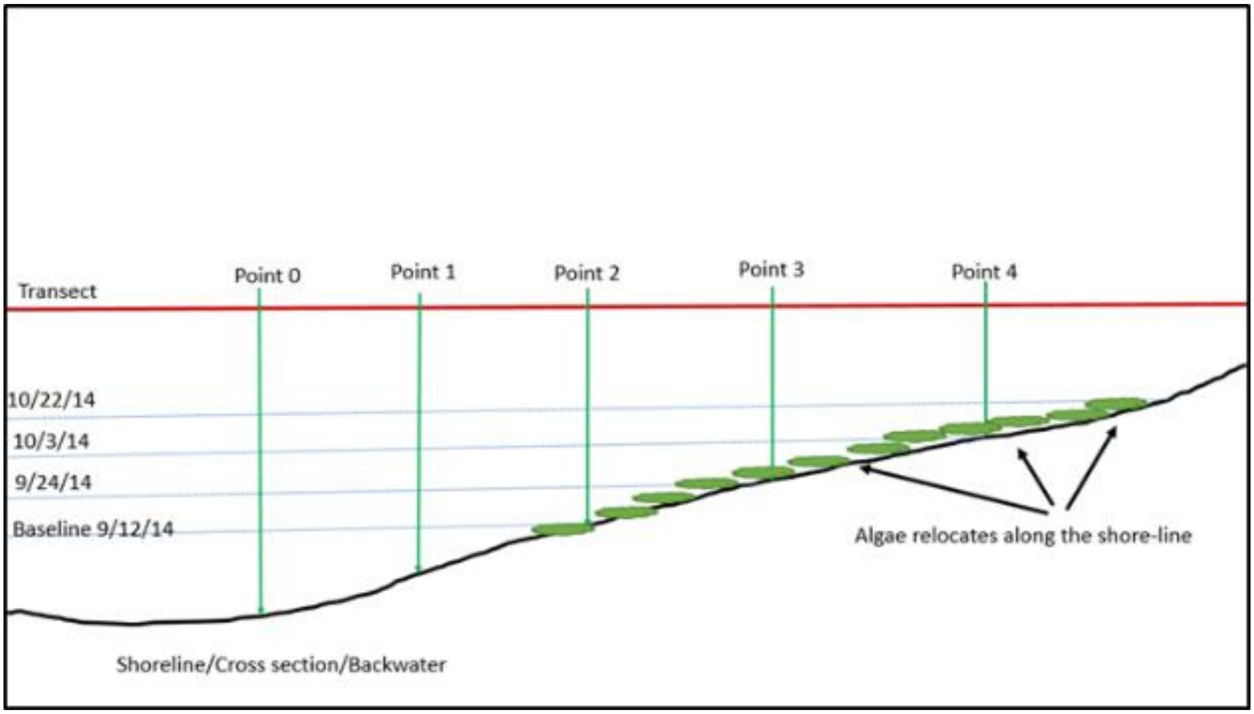


Figure 4.2.43. After the Russian River Estuary mouth closes algae moves upslope either by drift or active motility and colonizes the newly wetted littoral zone.

Recommendations

There was a clear response to Estuary mouth closure observed and measured during algae sampling/monitoring. Water level rise causes the benthic mats of microalgae to detach from their locations in the littoral zone and through shoreline accumulation of floating colonies (and motile cells) begin to re-colonize the freshly wetted gravel bars, and other newly inundated low-lying areas.The current methods of sampling cover does not provide data on what genera are comprising the cover. Further analysis would be helpful to understand the shifts in algal cover by genera over the growth season. Studying initial recolonization following spring scour through to Fall reproductive blooms would be helpful to better understand both the genera and successional processes involved.

Further taxonomic work should be done to identify the cyanobacteria in the Russian River to the species level as species toxicity can vary widely across individual genera. Studies should be designed to determine under what conditions or if these colonies release or retain their cyanotoxins during planktonic periods in their life cycles. Determining what factors lead benthic cyanobacterial colonies and or “benthic blooms” to release their toxins would assist in determining hazard associated with these floating colonies. Benthic sampling should be expanded to evaluate the planktonic algae occurring in the water column so they can be evaluated specifically for their taxonomy and abundance as well.

References

Dillard, G.E. 1999. Common Freshwater Algae of the United States. J. Cramer, Berlin, Germany. 173 pp.

Fetscher, et al. 2009. Standard Operation Procedures for Collecting Stream Algae Samples and Associated Physical Habitat and Chemical Data for Ambient Assessments in California.

Prescott, G.W. 1978. How to Know the Freshwater Algae. W.C. Brown Co., Dubuque, Iowa. 293 pp.

Lee, R.E. 1989. Phycology 2nd. Ed. Cambridge University Press, Cambridge, New York. 645 pp.

World Health Organization. 2003. Guidelines for safe recreational water environments. Chapter 8.

4.3 Invertebrate Prey Monitoring, Salmonid Diet Analysis and Juvenile Steelhead Behavior

The Biological Opinion requires the Water Agency to “monitor the effects of alternative water level management scenarios and resulting changes in depths and water quality (primarily salinity, dissolved oxygen concentration, temperature, and pH) on the productivity of invertebrates that would likely serve as the principal forage base of juvenile salmonids in the Russian River estuary. Specifically, SCWA is determining the temporal and spatial distribution, composition (species richness and diversity), and relative abundance of potential prey items for juvenile salmonids in the Russian River estuary, and evaluating invertebrate community response to changes in sandbar management strategies, inflow, estuarine water circulation patterns (stratification), and water quality. The monitoring of invertebrate productivity in the estuary focuses primarily on epibenthic and benthic marine and aquatic arthropods within the classes Crustacea and Insecta, the primary invertebrate taxa that serve as prey for juvenile salmonids, especially steelhead (*Oncorhynhus mykiss*) that may be particularly characteristic of conditions unique to estuarine lagoons for which steelhead may be adapted in intermittent estuaries near the southern region of their distribution (Hayes and Kocik 2014). The monitoring effort will involve systematic sampling and analysis of zooplankton, epibenthic, and benthic invertebrate species” (NMFS 2008, page 254).

Commensurate with assessment of potential responses to Estuary conditions by the macroinvertebrate prey of juvenile salmonids, the Water Agency is also monitoring juvenile salmonid diet composition and behavior. Based on the hypothesis that both diet and behavior of juvenile salmonids will vary as a function of increased water level and rearing space when the mouth of the estuary is closed, the potentially differential effects of density-dependent interactions on diet composition and consumption rate are being compared between open and closed estuary conditions. To facilitate the synthesis of this information with more precise information on juvenile salmonid exposure to variability in estuary salinity and thermal regime, the Water Agency is supporting hydroacoustic telemetry of their position, behavior and residence as a function of Estuary conditions. The purpose of this effort is to determine for juvenile steelhead in the Estuary between June and September the variation under different Estuary conditions in: (1) the Estuary’s water quality environment and the specific water quality conditions experienced by the juvenile steelhead; (2) their behavior in terms of estuarine habitat, reach occupancy and intra-estuarine movement patterns; (3) diet composition; and (4) potential (modeled) and empirical growth. These are used to refine parameters used in the Seghesio (2011) bioenergetics model to generate more empirically-based potential growth estimates during juvenile steelhead response to changing conditions in this intermittent estuary.

The Water Agency entered into an agreement with the University of Washington, School of Aquatic and Fishery Sciences’ Wetland Ecosystem Team (UW-WET) to conduct studies of the ecological response of the Russian River estuary to natural and alternative management actions associated with the opening and closure of the estuary mouth. This component of the Biological

Opinion study is designed to evaluate how different natural and managed barrier beach conditions in the Russian River estuary affect juvenile salmon foraging and their potential prey resources over different temporal and spatial scales. 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 changes in water level, salinity, temperature and dissolved oxygen conditions. A second approach, event sampling, was originally proposed in 2009 to contrast juvenile salmonid foraging and prey availability changes over estuary closure and re-opening events. The hydroacoustic telemetry component was particularly adaptable and targeted for the event sampling.

Methods

Sampling Sites

Sampling for fish diet and prey availability is designed to coincide with established Water Agency and other related sampling sites distributed in the lower, middle, and upper reaches of the Estuary during the Lagoon Management Period (May 15 to October 15; Figure 4.3.1). During 2014, sampling for the salmonid diet study were coincident with beach seining at nine sites (three in each reach) sampled for juvenile salmon by the Water Agency – (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. These locations also overlap with sites established by water quality measurements—dissolved oxygen, temperature and salinity (Figure 1.2.1; modified from Largier and Behrens [2010]). When possible, samples are selected for diet analysis from the overall beach seine collections from Jenner Gulch to represent the lower Estuary reach, Bridgehaven to represent the middle reach and Casini Ranch, Freezeout Bar and Sheephouse Creek to represent the upper reach. Incidental steelhead diet samples also originate from Penny Point (lower), Willow Creek (middle), and Sheephouse Creek, Freezeout Bar, and Casini Ranch (upper) sites when there are not sufficient samples from the primary reach sites.

Prey resource availability sampling occurred at four sites in the lower, middle, and upper reaches of the Russian River estuary – River Mouth, Penny Point, Willow Creek, and Freezeout Bar (Figure 4.3.2). Each of the sites includes three, lateral transects across the estuary (Figures 4.3.3a-d).

Juvenile Salmon Diet Composition

Systematic sampling of the diets of five or more ($n \geq 5$) juvenile steelhead ≥55 mm FL are derived, when available, from the beach seine samples during the lagoon management period between May 15 and October 15. If resources are available and sample sizes are less than 5 individual fish (n=<5) during systematic sampling, event sampling around scheduled beach management at the barrier beach are coordinated with Water Agency fisheries monitoring and physical measurements of estuarine response. During 2014, samples for diet analyses were specifically drawn from periods that reflected maximal overlap with fish sampled by hydroacoustic telemetry.

To the degree possible, all fish designated for diet analysis were gastric lavaged and released according to the University of Washington animal care protocols. Stomach lavage follows

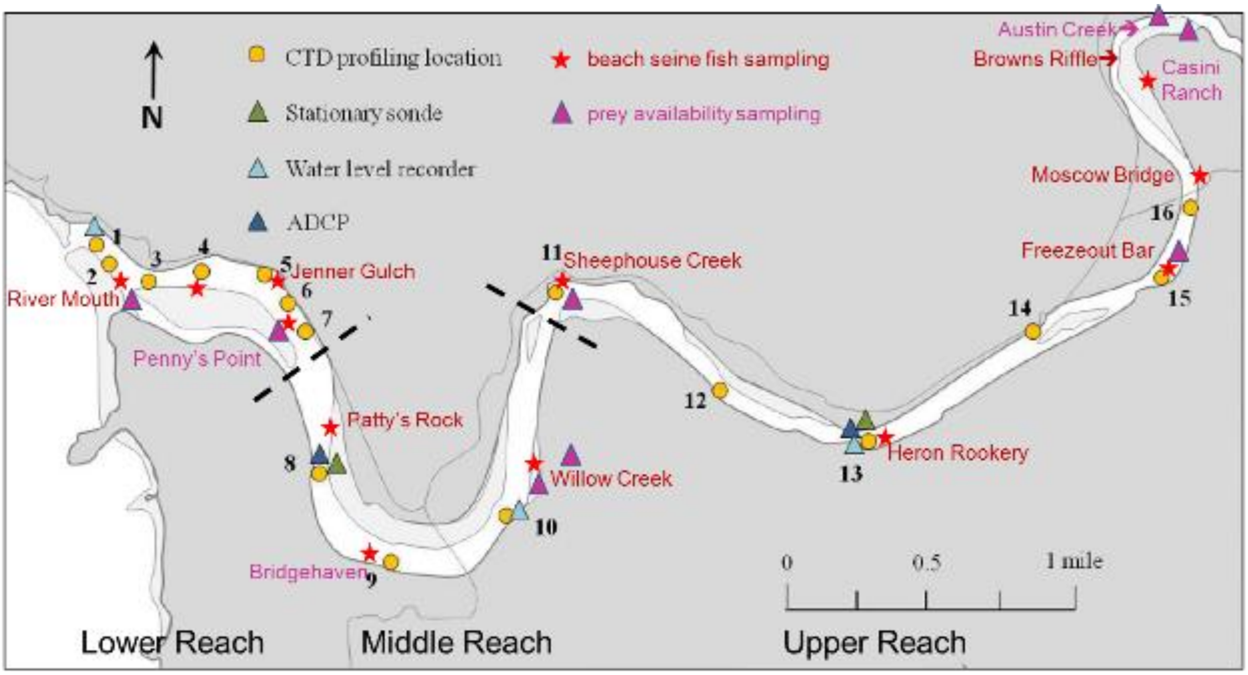


Figure 4.3.1. Locations of sampling stations for juvenile salmon diet (seining location) and prey resource availability (benthic infauna, epibenthos, zooplankton) in three reaches of the Russian River Estuary.

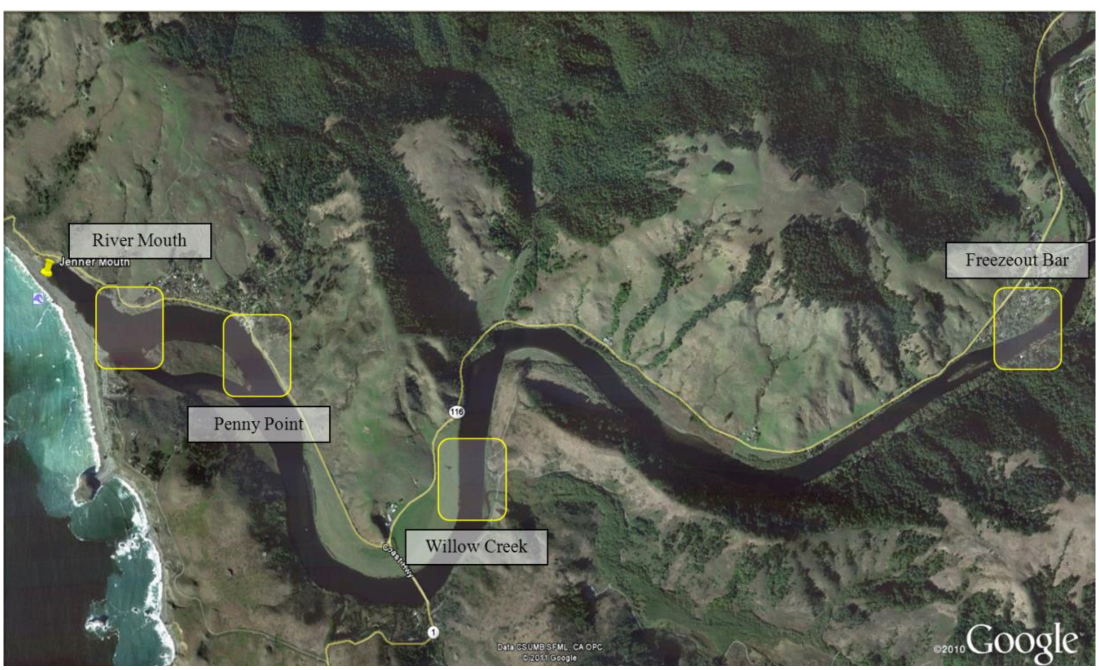


Figure 4.3.2. Distribution of juvenile salmonid prey resource availability sampling sites in the Russian River estuary.

(a) Distribution of juvenile salmonid prey availability sampling transects and techniques at the River Mouth site in the Russian River estuary.

(b). Distribution of juvenile salmonid prey availability sampling transects and techniques at the Penny Point site in the Russian River estuary.

Figure 4.3.3 a-b. Distribution of juvenile salmonid prey availability sampling transects and techniques in the Russian River estuary: (a) River Mouth; (b) Penny Point; (c) Willow Creek; and (d) Freezeout Bar.

(c). Distribution of juvenile salmonid prey availability sampling transects and techniques at the Willow Creek site in the Russian River estuary.

(d). Distribution of juvenile salmonid prey availability sampling transects and techniques at the Freezeout Bar site in the Russian River estuary.

Figure 4.3.3 c-d. Distribution of juvenile salmonid prey availability sampling transects and techniques in the Russian River estuary: (a) River Mouth; (b) Penny Point; (c) Willow Creek; and (d) Freezeout Bar.

Foster (1977) and Light et al (1983). Diet contents were preserved in 10% formalin for later laboratory processing. As per Water Agency fisheries protocols (see 4.4 Beach Seining section below), fork lengths and weights were taken from each fish. Each fish are scanned for a passive integrated transponder (PIT) tag and tagged if no previous PIT tag was detected.

In the analysis of 2014 fish diet collections, priority of sample processing was based on juvenile steelhead samples that were most coincident with the hydroacoustic telemetry monitoring of tagged steelhead. Focusing on diet composition and consumption rate of these selected fish provided the maximum overlap for bioenergetic model estimation of potential growth using the combination of the empirical diet data for fish at the same time and in the same reaches as the thermal regime of the tagged fish.

Prey Resource Availability

Benthic infauna and epibenthos prey resource sampling were conducted once per month in the Lagoon Management Period during open, tidal (baseline) conditions. If barrier beach closure or outlet channel implementation resulted in a closure, epibenthos and benthic infauna were sampled at 7 and 14 days after closure. Following an extended closure of 14 days or more, prey resource availability sampling was to continue beginning at day 14 and every three weeks after and include benthic infauna, epibenthos, and zooplankton resource availability sampling as described below. In 2014, 696 individual samples were collected (Table 4.3.1).

Benthic Infauna—Replicate core samples (0.0024-m^2 PVC core inserted 10 cm into the sediment) are 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). Additional samples would be added along the transect with increasing water level (inundation of the shoreline) during closure or outlet channel implementation. The sediment cores are preserved in 10% buffered formalin for laboratory analysis.

Epibenthos—Epibenthic organisms at the sediment-water interface are 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 from shore and then pulled along the bottom perpendicular 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-m^2 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). Additional samples would be added along the transect with increasing water level (inundation of the shoreline) during closure or outlet channel implementation. Captured organisms are preserved in 10% buffered formalin for laboratory analysis.

Table 4.3.1. Prey resource availability samples collected in 2014. Samples were collected at four locations under varied river mouth conditions.

Date	Mouth Condition	Water Level at Jenner Gage (ft) (10am-2pm)	Benthic Core	Sled Channel	Epi-Benthic Net to Shore	Zooplankton Haul
River Mouth						
6/3/2014	OPEN	Gauge Down	12	9	5	3
7/1/2014	OPEN	1.1-1.5	12	9	5	3
7/29/2014	OPEN	0.2-2.1	12	9	5	3
8/26/2014	OPEN	0.6-2.4	12	9	5	3
9/23/2014	CLOSED (6th day of closure	4.2	12	9	5	3
10/9/2014	CLOSED (22nd day of closure)	6.7	12	9	5	3
Penny Point						
6/3/2014	OPEN	Gauge Down	12	9	5	3
7/1/2014	OPEN	1.1-1.5	12	9	5	3
7/29/2014	OPEN	0.2-2.1	12	9	5	3
8/26/2014	OPEN	0.6-2.4	12	9	5	3
9/23/2014	CLOSED (6th day of closure	4.2	12	9	5	3
10/9/2014	CLOSED (22nd day of closure)	6.7	12	9	5	3
Willow Creek						
6/3/2014	OPEN	Gauge Down	12	9	5	3
7/1/2014	OPEN	1.1-1.5	12	9	5	3
7/29/2014	OPEN	0.2-2.1	12	9	5	3
8/26/2014	OPEN	0.6-2.4	12	9	5	3
9/23/2014	CLOSED (6th day of closure	4.2	12	9	5	3
10/9/2014	CLOSED (22nd day of closure)	6.7	12	9	5	3
Freezeout						
6/3/2014	OPEN	Gauge Down	12	9	5	3
7/1/2014	OPEN	1.1-1.5	12	9	5	3
7/29/2014	OPEN	0.2-2.1	12	9	5	3
8/26/2014	OPEN	0.6-2.4	12	9	5	3
9/23/2014	CLOSED (6th day of closure	4.2	12	9	5	3
10/9/2014	CLOSED (22nd day of closure)	6.7	12	9	5	3
Subtotal by sample type			**288**	**216**	**120**	**72**
Total Number of Samples						**696**

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-µm Nitex mesh and cod end cup. Replicated (n=3) vertical water column hauls are made by lowering the zooplankton net 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. Captured organisms are preserved in 10% buffered Formalin for laboratory analysis.

Prey Availability Sampling Completed—Monthly sampling was completed from June through October 2014 (Table 4.3.1). Invertebrate sampling was completed under a range of open and closed river mouth conditions and water surface elevations only between August 26 and October 9.

Hydroacoustic Telemetry

Juvenile steelhead for hydroacoustic tagging are captured during the periodic Water Agency beach seining and from the downstream migrant trap at Austin Creek. After capture, all steelhead were anesthetized with buffered MS-222 at a dose of 40mg/l prior to being processed. After adequate anesthesia is ensured, all fish were measured for length (mm FL), weight (g, wet), and a life stage assigned. If the size (weight of 10.0g) requirement was satisfied, a transmitter was surgically implanted into the body cavity. To prevent spread of disease or pathogens, all transmitters and surgical equipment were soaked in a 10% povidone-iodine (Bentadine) for 24 hours followed by a rinse in a sterile saline solution prior to the surgery. In order to ensure maximum control and minimal impact to the fish, the fish were placed ventral side up on a V-shaped foam lined surgical table with an anesthetic bath flowing over the gills. After wiping the incision site on the abdomen region with a sterile saline solution, a short incision was made to allow the transmitter to be inserted into the body cavity. The incision was then sutured with size 5-0 absorbable sutures. After surgery, the fish were held in natal water until fully recovered from the anesthetic (approximately 10 minutes) and then released into the wild to minimize stressful conditions.

Spatial and temporal occupation of different estuarine reaches and habitats were assessed by fixed and mobile tracking of steelhead implanted with acoustic tags. A total of 50 acoustic tags were allocated for the 2014 field study, to be distributed in relatively equal batches (e.g., ~10 fish) throughout contrasting mouth conditions, reaches and habitats (Appendix B-6). Due to the uncertainty in catches, movements and mouth conditions, we emphasized increased seining effort, tagging and surveys around closure events to ensure adequate numbers of steelhead are sampled during closures. Due to the heterogeneous distribution of fish catches and the lack of closed estuary conditions when tagged fish were deployed, the actual distribution of deployed tags by reach and estuary condition differed from the ideal tag allocation (Table 4.3.2).

Table 4.3.2. Tag allocation for juvenile steelhead releases into the Russian River Estuary in 2014; deployed tags in parentheses. See Figure 4.3.1 for locations of reaches.

Reach	Lower	Middle	Upper
Open Conditions	8 (17)	8 (12)	8 (16)
Closed Conditions	8 (0)	8 (0)	8 (0)

The Lotek MM-421T hydroacoustic transmitters (Table 4.3.3) are equipped with a temperature sensor that with simultaneous tracking will be able to give information about the thermal regime that the fish occupy with precision to the nearest 0.8˚ Celsius. The Water Agency provided four MAP 600 RT 200 khz receivers with submersible hydrophones for this study. They operate on a frequency of 200khz and can be detected with the supplied MAP 600 RT receivers. Each receiver has two cables and two hydrophones (Figure 4.3.4). The accuracy of each tags temperature sensor is measured and documented at multiple temperatures prior to implementation to minimize any error in readings. The detection range and detection efficiency are calculated prior to tagging and tracking fish (the equipment has had a detection range of 100 meters during a previous study; Josh Fuller, personal communication, March 25, 2014).

Table 4.3.3. Transmitter specifications of Lotek Wireless MM-412T hydroaoustic tags.

Weight in Air	0.58 g
Physical Dimensions (LxWxH)	11.0 X 6.6 X 6.1mm
Battery life	10 days
Burst Interval	10 sec
Frequency	200 khz

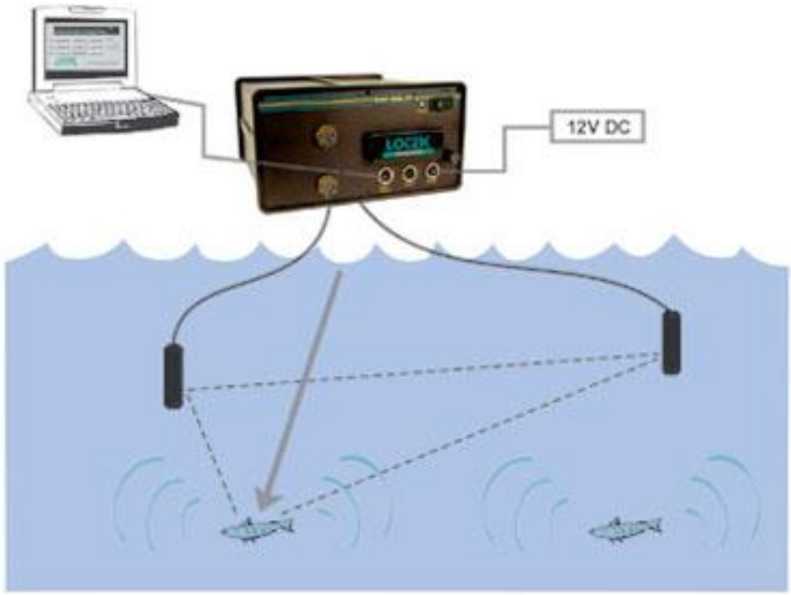


Figure 4.3.4. Example of how location of fish is calculated with using the MAP 600 RT 200 khz receiver with submersible hydrophones (Lotek).

The general location and temperature of tagged fish were recorded during mobile tracking surveys. The duration, timing, and effort allocated during mobile tracking events depends on the number of tags deployed and the location of the last detection of each tag. Mobile tracking to record location of fish and water temperature was designed to include all times of day, tidal cycles, and mouth conditions. The location of the mobile tracking boat was determined with using a Garmin eTrex 30 GPS. The maximum distance of the fish from the boat was determined by relating the signal strength to the maximum distance observed during field testing (Figure 4.3.4). The water quality parameters inhabited by the tagged fish was be determined by conducting a water quality profile of the water column and correlating that with the reading from the temperature sensor of the tag (Figure 4.3.4). Precision of this measurement was reduced if there was no distinct stratification of the water column. The profile of the water column was taken with a YSI Model 85 water quality instrument to record temperature, salinity, and dissolved oxygen at 0.5 meter depth intervals.

In addition to mobile tracking, three receivers were used in stationary arrays. The location and timing of stationary array installation was correlated with high densities and/or high site fidelity of tagged fish. The location of each hydrophone was documented with GPS and all distances between each hydrophone measured. The water quality parameters inhabited by the tagged fish was calculated in the same way as mobile tracking. A general location of the tagged fish in the water column was estimated by correlating the temperature reading from transmitter’s sensor with a water quality profile.

Sample Processing and Analyses

Stomach contents from juvenile salmon were identified to the species level if possible under a dissecting microscope. Invertebrates found in the diets of steelhead and collected in the prey resource samples were identified to species level, except for insects which were identified to family level. Any invertebrate collected during prey sampling and not found to be part of the steelhead diet was identified to order or family level. Each of the identified prey taxa were counted (for numerical composition) and weighed (for gravimetric [biomass] composition) and the frequency of occurrence. The state of total stomach content biomass was normalized by individual fish weight to provide an additional index of relative consumption rate ("instantaneous" ration).

In addition to individual metrics of diet composition, the Index of Relative Importance (IRI; Pinkas *et al.* 1971) was also calculated, wherein %Total IRI for each discrete prey taxa takes into account the proportion that prey taxa constitutes of the total number and biomass of prey and the frequency of occurrence of that taxa among in the total number of fish stomach samples:

$$IRI_i = FO_i*[NC_i + GC_i]$$

where NC is the percent numerical composition, GC is the percent gravimetric (biomass) contribution, FO is the percent frequency of occurrence for each of the prey taxa, and *i* is the prey taxa; results are expressed as a percentage of the total IRI for all prey items. We also interpret diet composition using just GC_i in order to better represent the bioenergetic contribution of prominent (from a FO_i standpoint) prey.

In accordance with a recent revision of the IRI index, we calculated the Prey-Specific Index of Relative Importance (PSIRI) which substitutes NC and GC with their corresponding prey-specific abundances, %PNC and %PGC:

$$PSIRI_i = FO_i*[\%PNC_i + \%PGC_i]$$

PSIRI sums to 200% and therefore diving by 2 results in a version of the standardized %IRI (Amundsen et al. 1996; Cortẽs 1997), with an important distinction: the PSIRI is additive with respect to taxonomic levels, such that the sum of PSIRI for species would be equal to the PSIRI of the family containing those species.

An index of food consumption is also derived from the diet data as the "instantaneous ration," which is the total biomass of prey found in individual fish stomach contents relative to the biomass of the fish expressed as $g\ g^{-1}$. It is recognized that this is only a short-term index of consumption, and will vary by fish size, time of day and other factors influencing foraging behavior. If fish are captured under the same general conditions, this index can provide an indication of differences in feeding performance. Under some conditions, the instantaneous ration can be used to develop an estimate of daily ration that can be used in bioenergetic modeling of potential growth.

Multivariate analyses are also utilized to organize fish diet sample compositions and prey availability samples into statistically distinct groupings. All statistical analyses are performed using the PRIMER v6.0 multivariate statistics analysis package (Clarke and Gorley 2006). We calculated similarity indices for samples using the Bray-Curtis similarity coefficient. The primary analyses included non-metric multidimensional scaling (NMDS) and associated analyses of similarities (ANOSIM) and similarity percentages (SIMPER) of factors (in this case, organism taxa) that account for the similarity. The primary ANOSIM statistic for differences between groups is the Global R, which varies between 0 (no significant difference) to 1 (maximum difference). 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

Samples collected during the 2014 Lagoon Management Period analyzed by University of Washington were prioritized for contrast in estuary status/water level. Benthic samples from 2012 included those from 29 May (muted tides, leading to closure; 1.1-0.6 ft) and 25 June (muted tides, after opening; 2.5-2.4 ft); channel epibenthic sled and epibenthic net samples included the May-June contrast and the 10 September (open; 1.2-0.6 ft) and 8 October (closed, first day of closure; 2.1 ft) contrast. Zooplankton samples from 2012 included the September and October contrast. Benthic samples from 2013 included a somewhat stronger contrast in Estuary state, between 21 May (muted tides, leading to closure; 1.9 ft), 26 June (closed, 19th day of closure; 6.5 ft), as well as the open period between 23 July (open; 0.5-1.7 ft) and 20 August (open, 1.6-2.0 ft), and a subsequent strong contrast between 23 September (open, day before closure; 2.0 ft) and 7 October (closed, 14th day of closure; 7.1 ft). Zooplankton samples from 2013 included May-July.

In all cases except for zooplankton (which were grouped into only planktonic taxa), the resulting benthos and epibenthos results displayed here are only for the most common prey taxa identified from the juvenile steelhead and Chinook diet composition from 2009 to 2013(Seghesio 2011, Manning and Martini-Lamb 2012, Martini-Lamb and Manning 2014).

Juvenile Steelhead Diet Composition

A total of 35 juvenile steelhead were sampled for diet composition and consumption rate on six occasions from the beach seine sites (Table 4.3.4). Overall, composition of juvenile steelhead diets in 2014 was very consistent with previous years' findings, wherein epibenthic crustaceans—the gammarid amphipods *Eogammarus confervicolus* and *Americorophium* spp., and the isopod *Gnorimosphaeroma insulare*—dominated the numberical and gravimetric composition and occurred in greater than 60% of the samples (Figure 4.3.5). Corixid beetles (water boatman), the estuarine mysid *Neomysis mercedis* and insects also appeared as supplementary prey.

Table 4.3.4. Sample sources of juvenile steelhead sample for diet composition and consumption rate; size range (FL mm) in parentheses.

Date	Jenner Gulch	Bridgehaven	Willow Creek	Sheephouse Creek
2-Jun-14		10 (64-179)		
25-Jun-14		3 (74-82)		
26-Jun-14				1 (93)
8-Jul-14	10 (73-193)	4 (87-113)		
9-Jul-14	1 (152)			
7-Oct-14			4 (117-261)	2 (172-157)
TOTAL	11	17	4	3

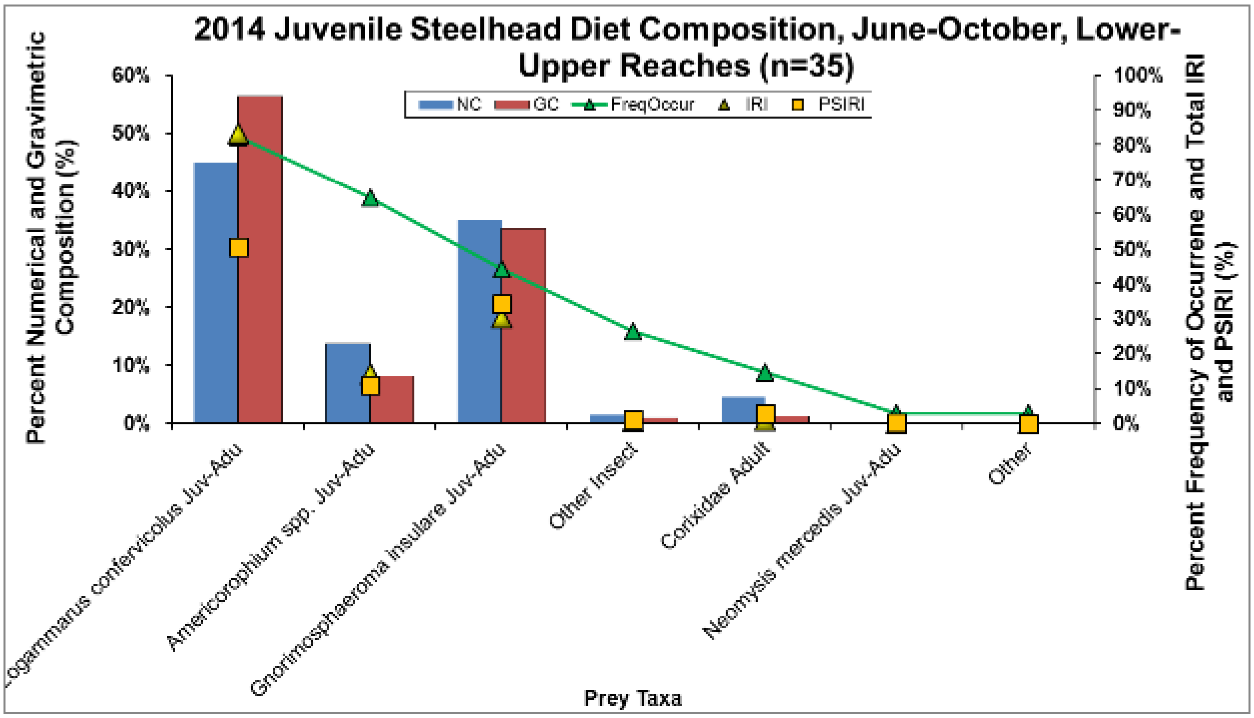


Figure 4.3.5. Percent numerical (NC) and gravimetric (GC) composition, frequency of occurrence and total Percent Relative Importance (IRI) and Prey-Specific Index of Relative Importance (PSIRI).

The dominance of *E. confervicolus* and *G. insulare* in the diets was pervasive across all reaches during June, July and October except for the middle reach in July, when *Americorophium* spp. equaled *E. confervicolus* in percent gravimetric composition (Figure 4.3.6). Corixids and mysids were slight contributors to the prey biomass only in the middle reach in June.

Variations of instantaneous ration indices for fish of the same relative size caught in different sites suggest some differences in feeding performance (Figure 4.3.7). The most apparent comparison evidenced by sufficient sample sizes was the apparently higher consumption by fish from Bridgehaven (middle reach) in June as compared to Bridgehaven in July and Jenner Gulch (lower reach) in July.

Prey Resource Availability

Benthic Infauna—Benthic macroinvertebrates documented as occurring in the diets of juvenile steelhead salmon occurred most commonly and abundantly at Penny Point in June when the estuary was open (Figure 4.3.8; samples not available from Willow Creek). The tubicolous amphipods *Americorophium spinicorne* and *A. stimpsoni* and the epibenthic isopod *Gnorimosphaeroma insulare* were the most abundant, averaging between ~17,000 and ~27,000 organisms m^{-2}. *A. spinicorne* was one of the few taxa occurring in the upper reach, at Freezeout Bar, in comparable abundance (~11,000 m^{-2}) and capitellid polychaetes were the only prey of significance (~~9,000 m^{-2}) at the River Mouth site.

The Estuary did not close for any significant period until late September, when the barrier beach developed on September 17; by the time of prey availability sampling on September 23, it had been closed six days and the water level had risen to 4.2 ft (Table 4.3.1). At this time, the dominant juvenile steelhead prey were more uniformly distributed among all reaches of the Estuary (Figure 4.3.9). *Americorophium* spp. amphipods and *G. insulare* isopods were most abundant, averaging between ~2,000 and ~15,000 organisms m^{-2}, in the lower and middle reaches but less so in the upper reach, at Freezeout Bar. The epibenthic amphipod *Eogammarus confervicolus* had also appeared in average densities of up to ~6,000 m^{-2}, also predominantly in the lower and middle reaches. By October 10, 22 days into the closure and the estuary's water elevation having risen to 6.7 ft, prey availability had diminished at all sites except for Penny Point, were densities of *Americorophium* spp. were still comparable to September 23 but *G. insulare* and *E. confervicolus* had declined (Figure 4.3.10).

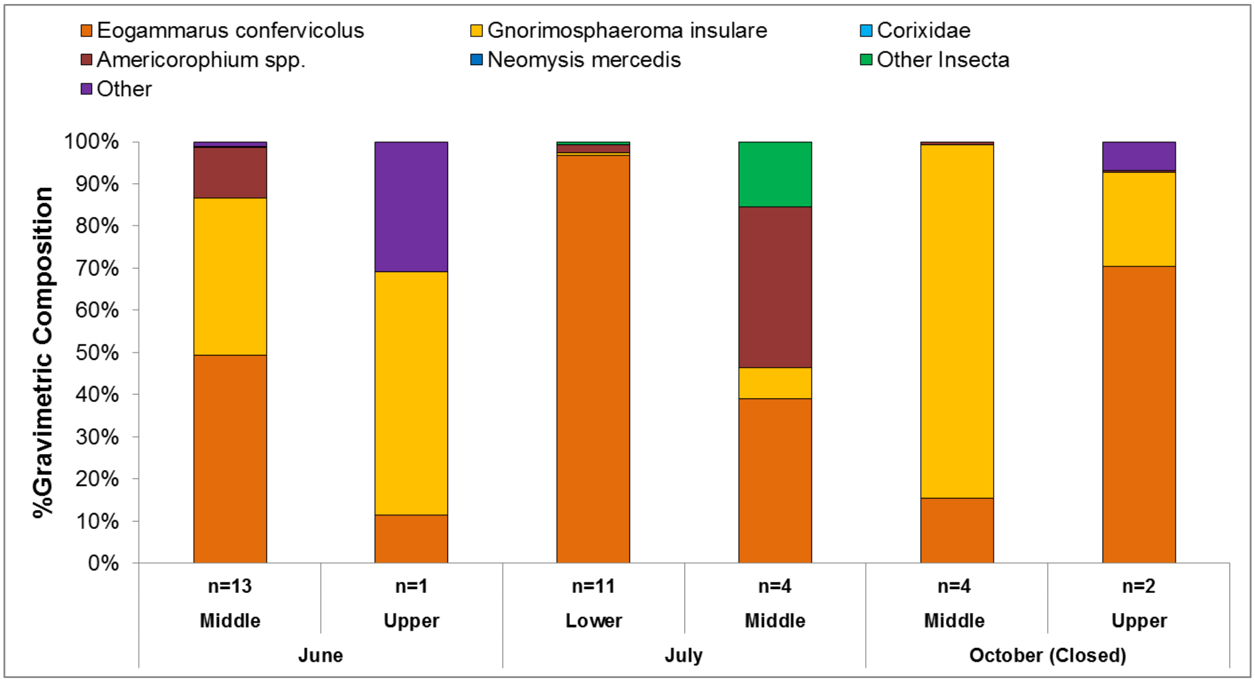


Figure 4.3.6. Percent gravimetric composition of juvenile steelhead in lower, middle and upper reaches of the Russian River Estuary, June-October 2014.

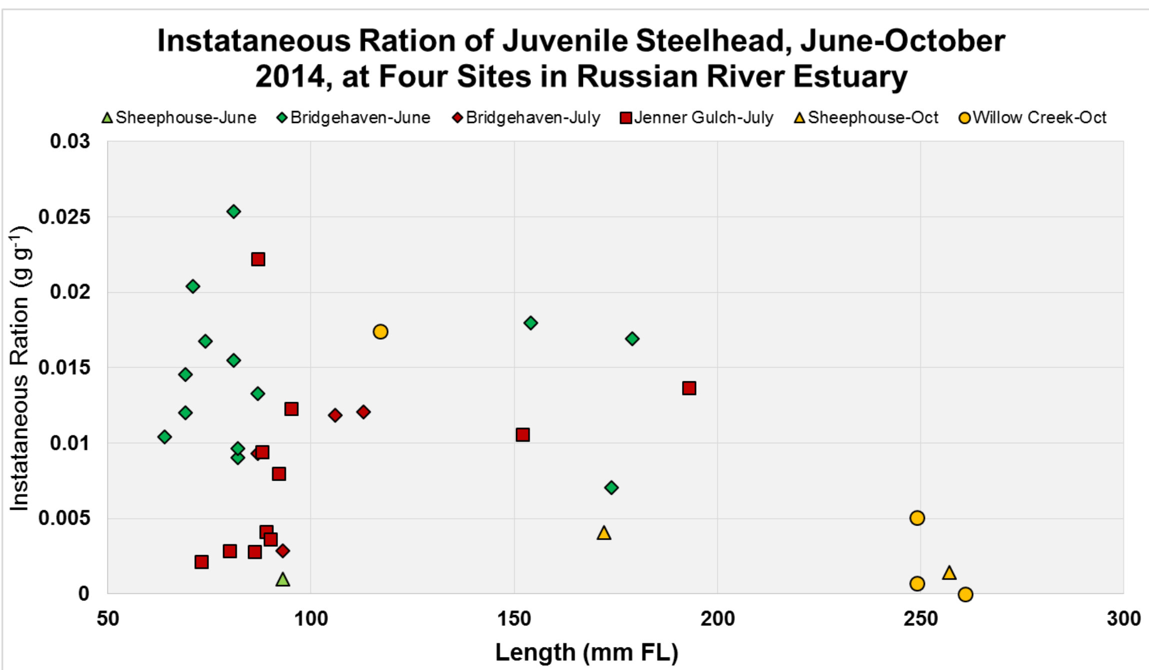


Figure 4.3.7. Instantaneous ration of juvenile steelhead at four sites, June-October 2014, in Russian River Estuary.

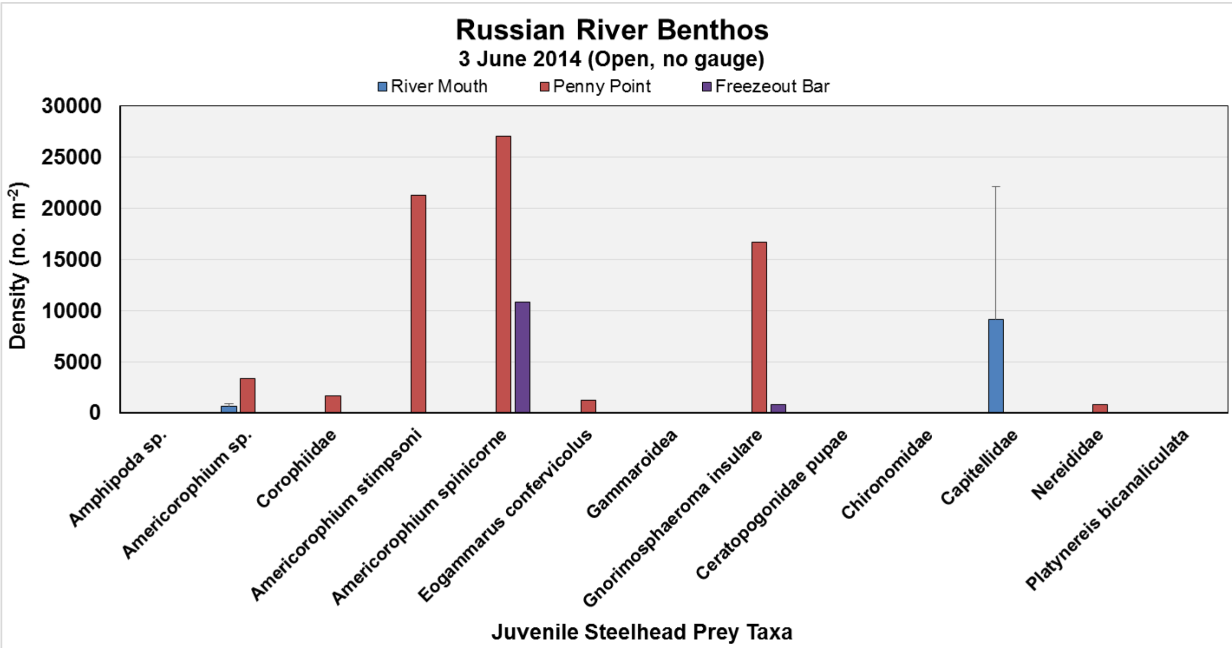


Figure 4.3.8. Density of benthic macroinvertebrates documented as juvenile steelhead prey, three sites in the Russian River Estuary, 3 June 2014.

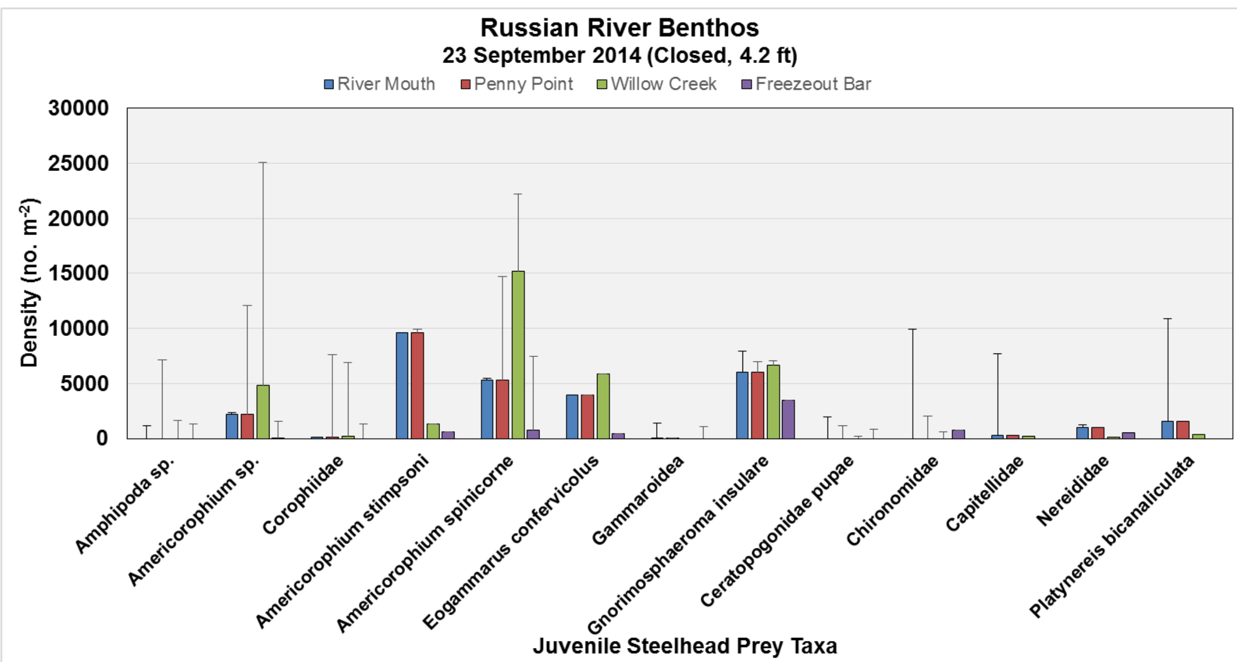


Figure 4.3.9. Density of benthic macroinvertebrates documented as juvenile steelhead prey, four sites in the Russian River Estuary, 23 September 2014.

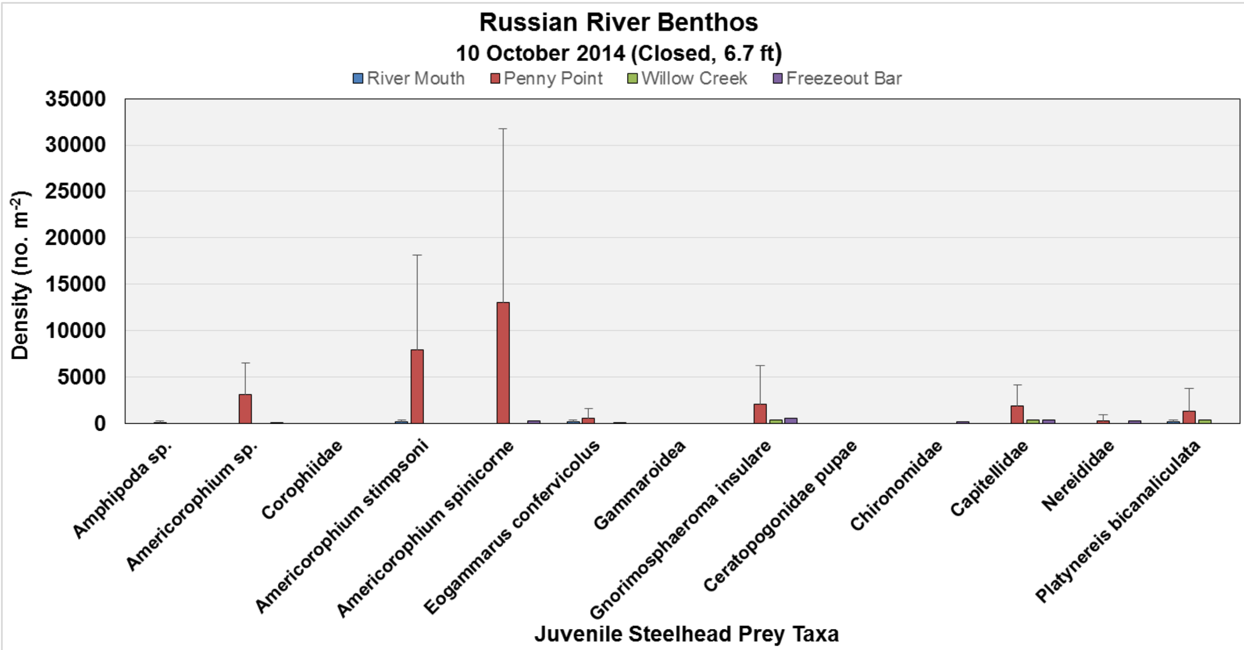


Figure 4.3.10. Density of benthic macroinvertebrates documented as juvenile steelhead prey, four sites in the Russian River Estuary, 10 October 2014.

Multivariate analysis of benthic macorinvertebrate prey composition (density) indicated that the assemblages were not significantly different among the sites compared to the differences within sites (Figure 4.3.11; Global R = 0.21). This is evident in viewing the NMDS plot, wherein 80% of the samples were concentrated in a very tight multidimenstional space that was expanded to illustrate overlapping assemblage structure. Although there was not a significant difference across all sites, SIMPER pairwise comparisons indicated that the benthic macroinvertebrate prey assemblages were most dissimilar between Freezeout Bar and River Mouth (Average dissimilarity = 94.21%) and least dissimilar between Penny Point and Willow Creek (59.65%). Benthic macroinvertebrate prey assemblages were not statistically different when compared among dates (Global R = 0.152). All pair-wise comparisons indicated high similarity in assemblage (density) composition between dates, even between the two periods of estuary closure.

Epibenthic Net to Shore—As described in Methods, sampling by the epibenthic net samples within 10 m of the high water level was the most indicative of a shift in prey organism distribution as a function of estuary water level and volume. Under open estuary, tidally-fluctuating, low water elevation conditions in early June, juvenile Chinook salmon prey were concentrated in the lower two stations, where *Americorophium* spp. and *E. confervicolus* amphipods and *G. insulare* isopods reached average densities as high as ~1,000 m^{-2} at River Mouth (Figure 4.3.12). By late September, early into estuary closure with the water elevation at 4.2 ft, prey taxa had diversified and expanded through the middle and upper estuary reaches although at lower densities (Figure 4.3.13). Average densities of amphipods and isopods were ≤ 50 m^{-2} in the lower three sites but corixid beetles and dipterans—chironomid and ceratopogonid—larvae and pupae now approached up to ~100 m^{-2} in the upper reach, at Freezeout Bar.

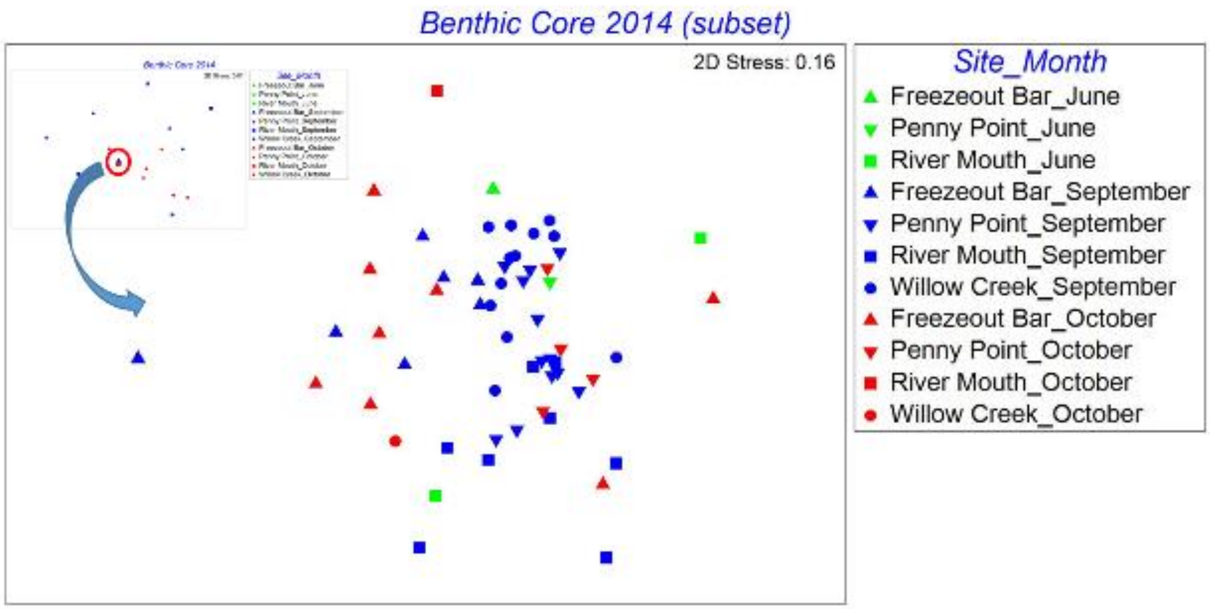


Figure 4.3.11. Non-metric multidimensional scaling diagram of benthic macroinvertebrate (juvenile steelhead prey) assemblages at four sites on three dates in the Russian River Estuary, 2014. The insert illustrates the tightly associated samples that are expanded in the full-size image.

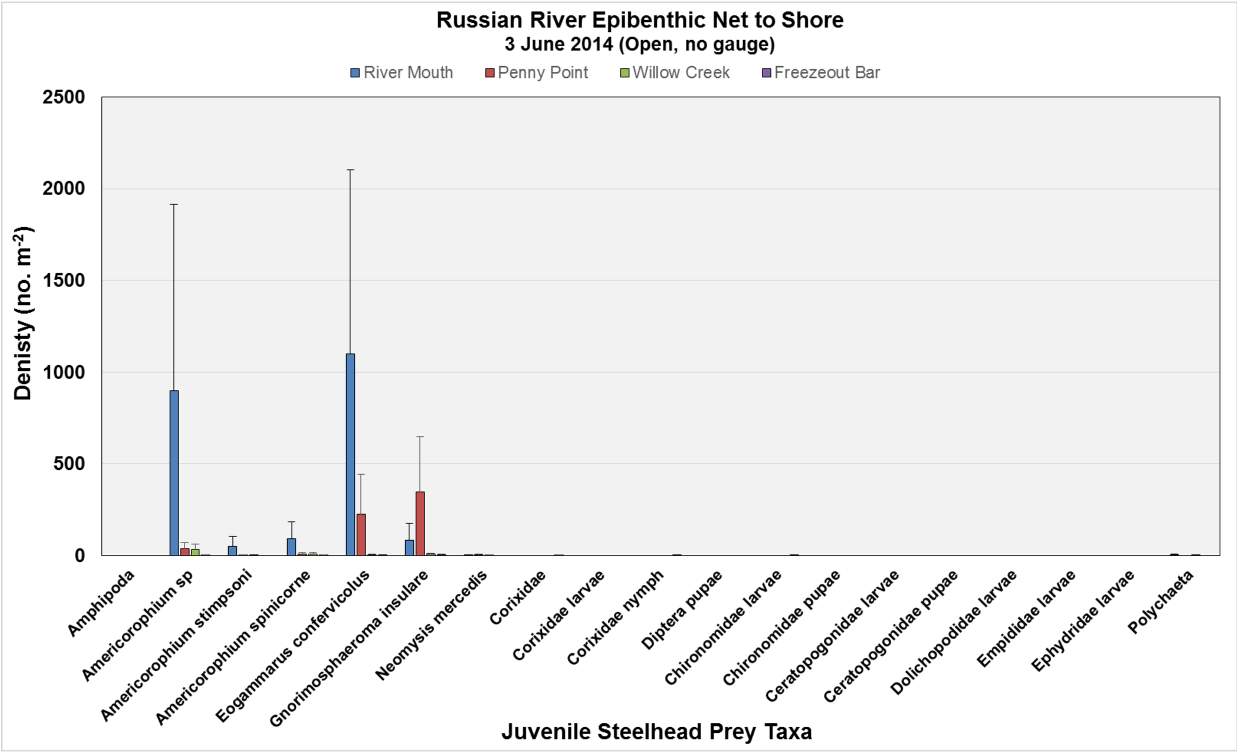


Figure 4.3.12. Density of epibenthic macroinvertebrates documented as juvenile steelhead prey, epibenthic net to shore at four sites, Russian River Estuary, 3 June 2014.

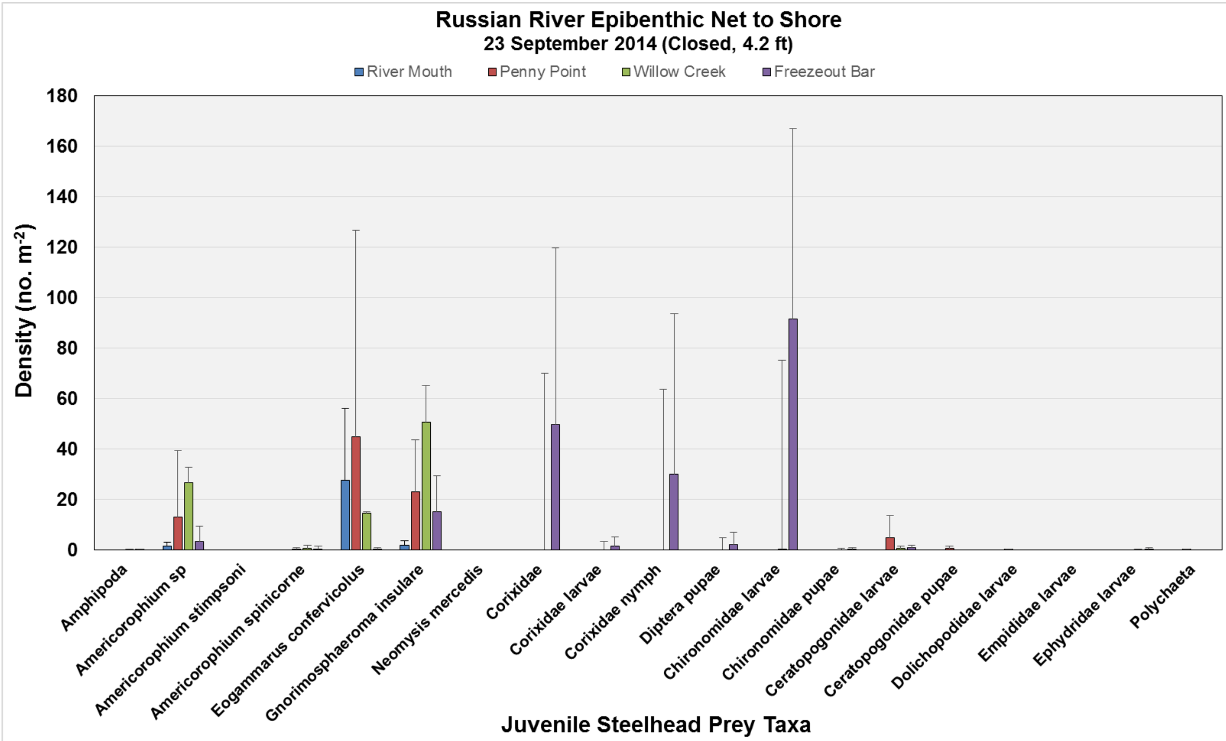


Figure 4.3.13. Density of epibenthic macroinvertebrates documented as juvenile steelhead prey, epibenthic net to shore at four sites, Russian River Estuary, 23 September 2014.

After 22 days of estuary closure, with the water level at 6.7 ft at the Jenner gage, composition and densities of the same prey had expanded further into their recently inundated intertidal habitat and the aquatic insects (corixids and chironomids) averaged 114-144 m^{-2} at Freezeout Bar (Figure 4.3.14). In part, this likely represents the mobility of the epibenthic crustaceans and aquatic insects, as well as perhaps the effect of expanded, productive intertidal habitat, as compared to the benthic macroinvertebrates, which may be delayed or otherwise constrained in recruiting to the expanded habitat.

The NMDS plot indicated the epibenthic net to shore invertebrate density composition was distinct between the lower and middle reach sites and the upper reach site at Freezeout Bar, however, there was little distinction among the three dates despite the persistent estuary closure (Figure 4.3.15). The ANOSIM-based difference among the site groups was moderate (Global R = 0.54) comared to a minor difference (Gobal R = 0.36) for the date effect on juvenile salmon prey density composition. Pairwise dissimilarity was highest between Freezeout Bar and both River Mouth (Average dissimilarity = 89.9%) and Penny Point (81.3%), and in both cases differences in densities of *E. confervicolus* and chironomid larvae accounted for much of the separation in the epibenthic invertebrate assemblages between the lower and upper sites. As expected and illustrated by the lack of distinct monthly sample groups in the NMDS plot (Figure 4.3.15), the epibenthic assemblages from the epibenthic net to shore sampling were more dissimilar (63.9% - 69.0%) for the June versus September or October samples, but was somewhat less dissimilar (51.6%) between the September and October samples despite the difference in water level over 16 additional days of estuary closure. Consistent contributions of

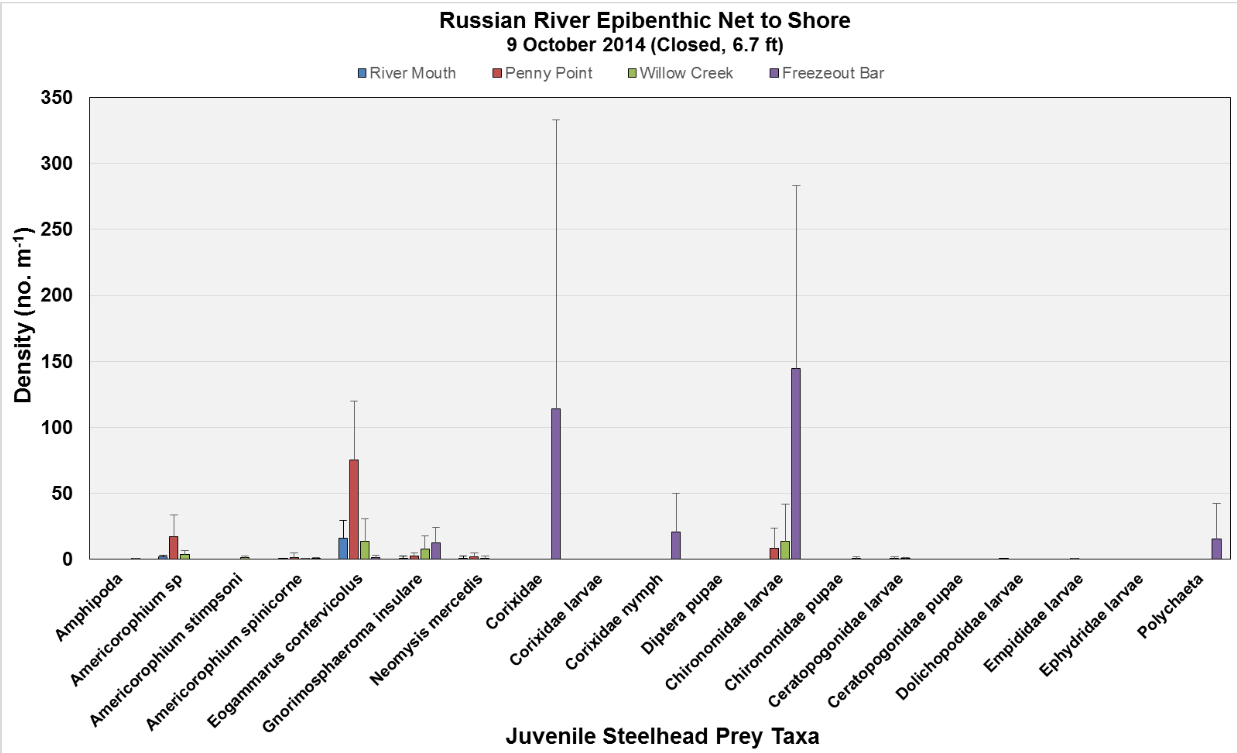


Figure 4.3.14. Density of epibenthic macroinvertebrates documented as juvenile steelhead prey, epibenthic net to shore at four sites, Russian River Estuary, 9 October 2014.

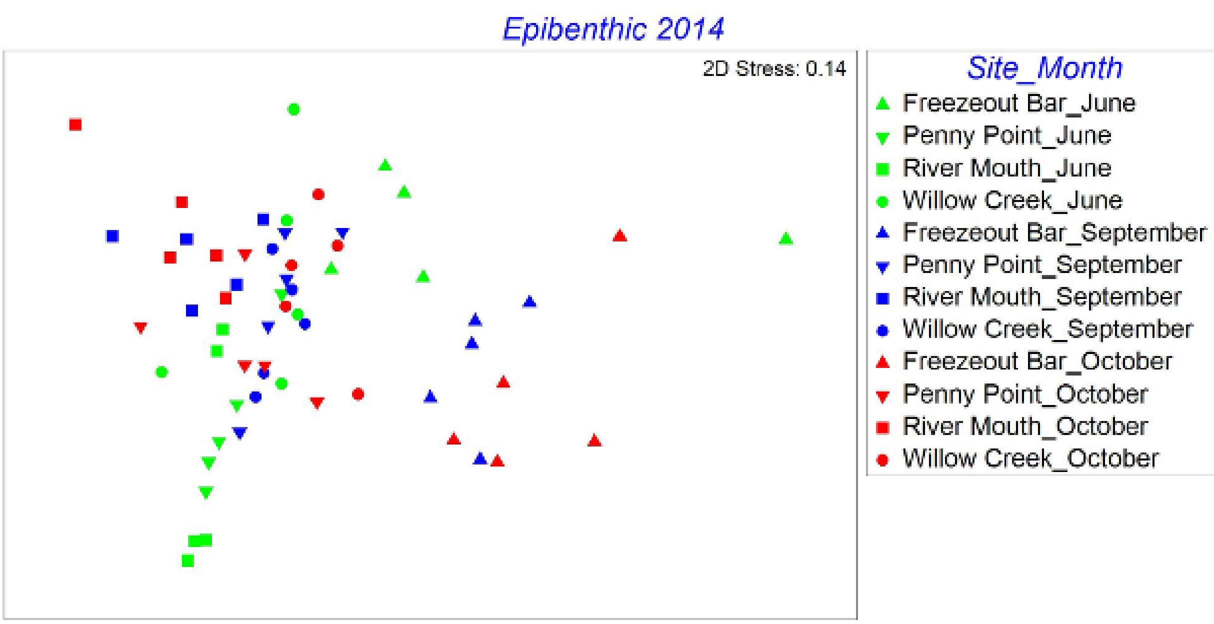


Figure 4.3.15. Non-metric multidimensional scaling diagram of epibenthic macroinvertebrate (juvenile steelhead prey) assemblages in epibenthic net to shore samples at four sites on three dates in the Russian River Estuary, 2014.

just *G. insulare*, *E. confervicolus*, *Americorophium* spp. and chironomid larvae densities (accounting for ~70% of the dissimilarity in all cases) to the date dissimilarity, and only modest similarity within dates, likely reflects the relatively low diversity of the estuary's macroinvertebrate fauna and its within-reach benthic-epibenthic complexity across the potential extent of inundation.

Epibenthic Sled—Epibenthic sled samples mirrored the epibenthic net to shore findings to some degree with the exception of increased capture of the estuarine mysid *Neomysis mercedis* and the reduced abundance of corixid beetles. As with the epibenthic net samples in June, there were few available prey in the upper reach at Freezeout Bar except for higher average density (>300 m^{-2}) of mysids than in any other reach (Figure 4.3.16). Densities of *E. confervicolus* averaged ~414-515 m^{-2} at River Mouth and Penny Point, and *G. insuare* ~110 m^{-2} at Willow Creek; *Americorophium* spp. were not dense (<50 m^{-2}) in any reach. By September in the early stages of estuary closure, the epibenthic amphipods, isopods and mysids and were distributed more uniformy across the estuary but only *G. insulare* approached ~50 m^{-2} at Willow Creek and Feezeout Bar (Figure 4.3.17). As in the epibenthic net to shore results, early life history stages of aquatic insects were abundant at this time, especially chironomid larvae averaging over 150 m^{-2}. In October, after 22 days of estuary closure, densities of most epibenthic prey had diminished to <10 m^{-2} except for *Amercorophium* sp. and *A. spinicorne*, which had increased to 37 m^{-2} to 25 m^{-2}, respectively just at Penny Point (Figure 4.3.18). As the sampling by the epibenthic sled had shifted shoreward (i.e., two shoreward transects, relative to the middle channel, 'thalweig' transect, which remained in the same location) with the increased water elevation during the closure, the this increase suggests that the distribution of some of these prey taxa represented colonization of newly inundated intertidal habitat.

Multivariate analysis of epibenthic macroinvertebrates from the sled samples were moderately different among the sites (Global R = 0.53) (Figure 4.3.19). Pairwise tests indicated the greatest differences between River Mouth and Freezeout Bar (R = 0.62) and River Mouth and Willow Creek (R = 0.61). Freezeout Bar was also moderately distinct from Penny Point (R = 0.59) and Willow Creek (R = 0.58). Average similarity within sites was modest, ranging from 32.4% (River Mouth) to 59.4% (Willow Creek). Epibenthic prey composition was also moderately different between dates across all sites (Global R = 0.61). Within-date similarity was moderate (32.0% to 61.9%). The occurrence and high density of the mysid *N. mercedis* in the June samples accounted for significant dissimilarity (73.0% to 87.5%) with both the September and October samples. However, the late September and early October sled samples, six and 22 days into estuary closure respectively, were equally dissimilar (77.0%).

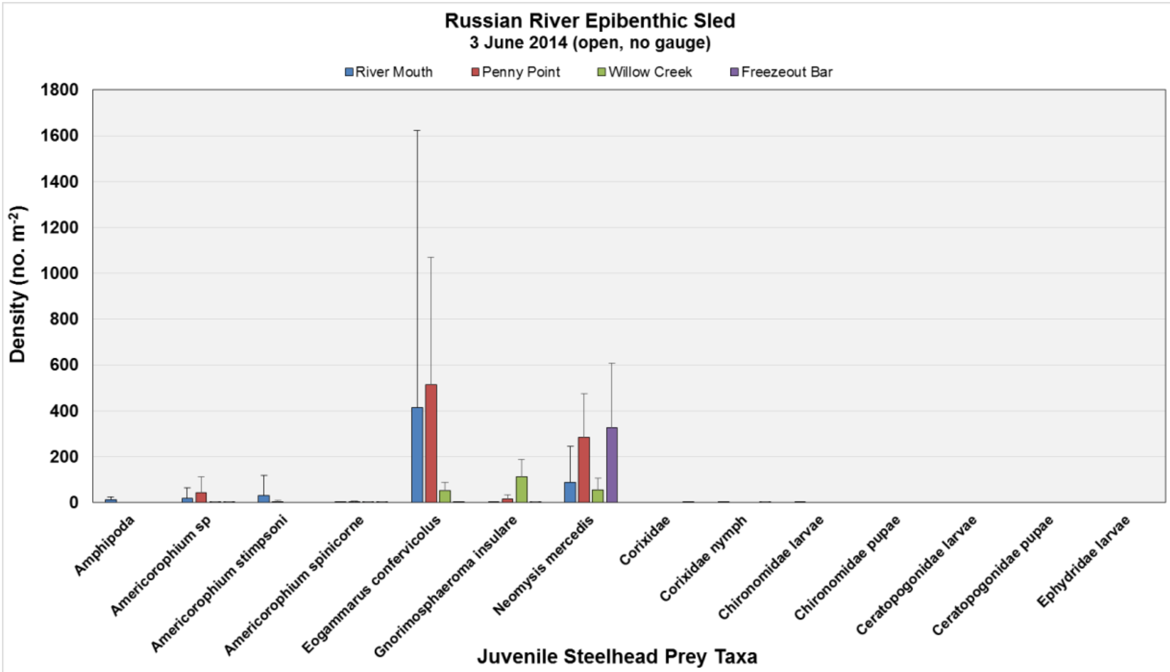


Figure 4.3.16. Density of epibenthic macroinvertebrate document to be prey of juvenile steelhead, epibenthic epibenthic channel sled at four sites of the Russian River Estuary, 3 June 2014.

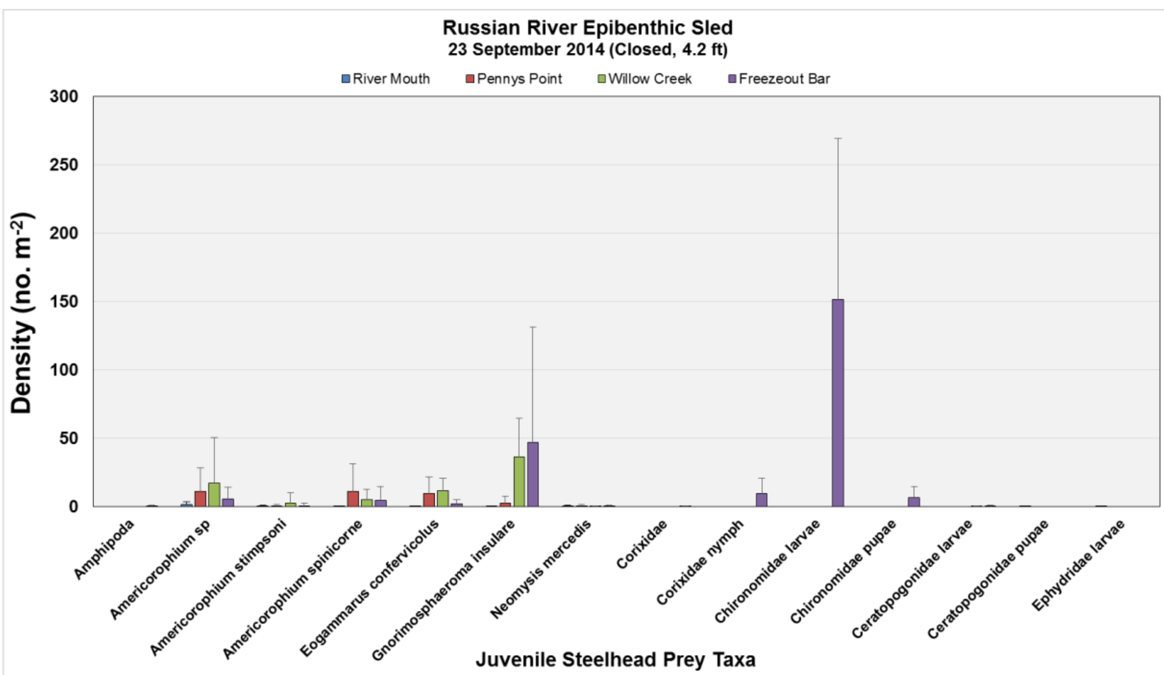


Figure 4.3.17. Density of epibenthic macroinvertebrate document to be prey of juvenile steelhead, epibenthic epibenthic channel sled at four sites of the Russian River Estuary, 23 September 2014.

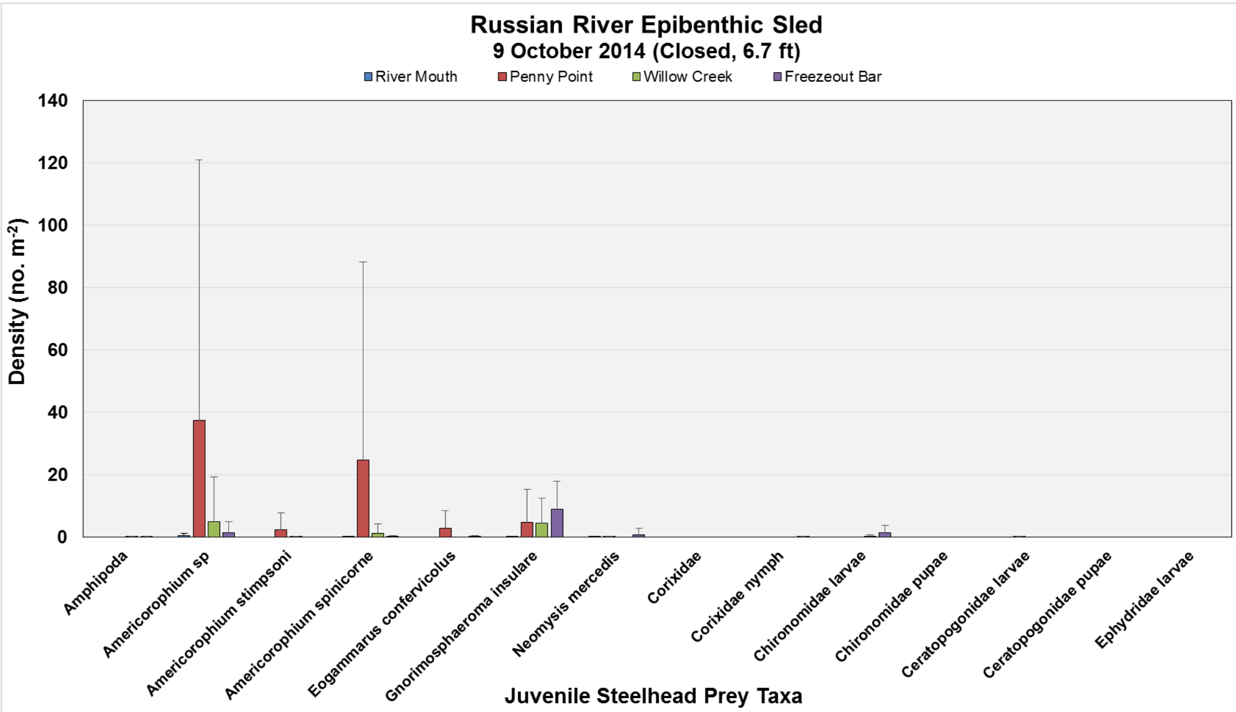


Figure 4.3.18. Density of epibenthic macroinvertebrate document to be prey of juvenile steelhead, epibenthic epibenthic channel sled at four sites of the Russian River Estuary, 9 October 2014.

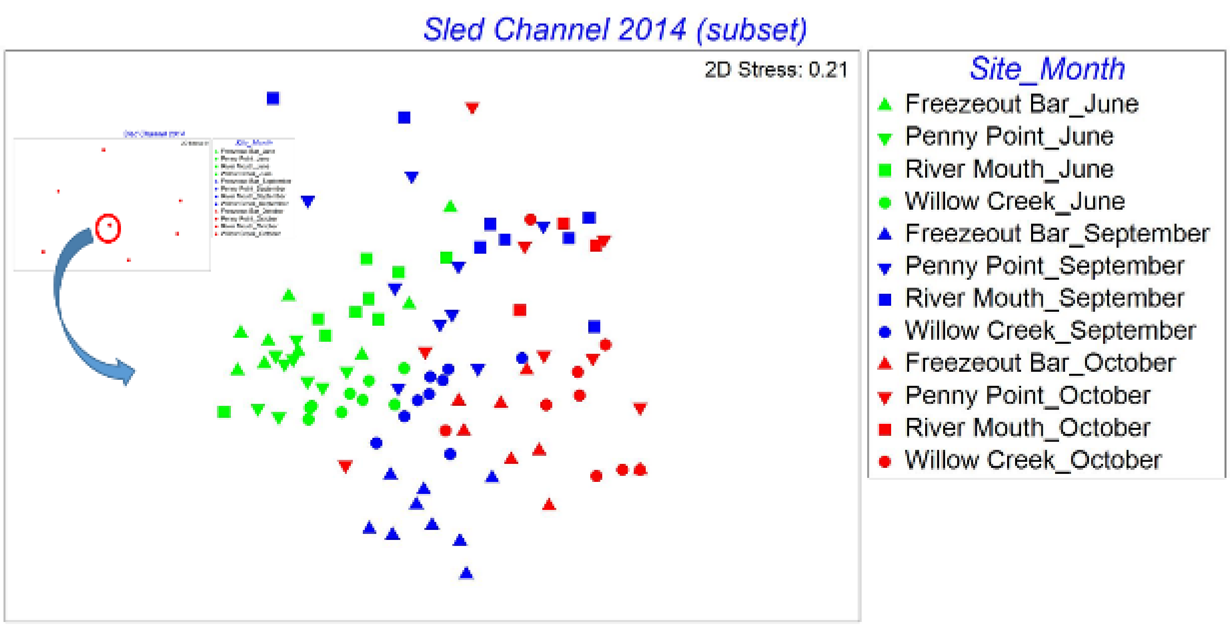


Figure 4.3.19. Non-metric multidimensional scaling diagram of epibenthic macroinvertebrates (juvenile steelhead prey) assemblages from epibenthic sled samples at four sites on three dates in the Russian River Estuary, 2014. The insert illustrates the tightly associated samples that are expanded in the full-size image.

Further partitioning of the epibenthic sled data into the positions of the three transects along the estuary axis at each of the four sites indicated some consistency in epibenthic prey distribution by depth/habitat (Figures 4.3.20 – 4.3.23). Epibenthic prey at the outside, shallower transect samples at River Mouth were generally more dense that in mid-channel, but densities were ~two orders of magnitude lower in late September and early October, during estuary closure, than in June (Figure 4.3.20). At Penny Point, densities tended to be somewhat higher on the margins of the central channel in June (Figure 4.3.21) but an increase in the *Americorophium* spp. appeared in both late September and October, during the estuary closure (Figure 4.3.21). Because the positions of the two outside transects (sled samples 6, 15, 24, and 8, 17, 26) were shifted landward during the estuary closure to compensate for the rising water elevation, the higher densities in October might suggest that the *Americorophium* spp. amphipods are moving or even increasing with shallow water inundation.

A similar pattern of higher prey densities along the outside, shallower transects also held at Willow Creek although, compared to the tubiculous *Americorophium* spp. amphipods, *E. confervicolus* and *G. insulare* appeared in higher densities along the mid-channel transect in late September (Figure 4.3.22). Epibenthic prey in the upper reach, at Freezeout Bar, were relatively indistinct in their density distribution among the three transects (Figure 4.3.23). All three transects often displayed somewhat similar densities even during estuary closure, although densities had declined by an order of magnitude between six days and 22 days after closure. Although there are indications that epibenthic prey may recruit to newly inundated shallow water during an estuarine closure, without more samples across the channel x-section, we cannot determine whether prey are functionally shifting their distribution or just expanding numerically.

Zooplankton—Density and numerical composition of zooplankton (data filtered to remove benthic or other non-pelagic organisms) indicated higher diversity of taxa and greater abundance in September-October, during estuary closure, than in June (Figures 4.3.24 and 4.3.25). Among the sites, Freezeout Bar consistently had the lowest zooplankton densities and was unique in the significant contribution of freshwater taxa, such as cladoceran and cyclopoid copepods, particularly on 23 September.

Marine and estuarine plankton taxa dominated the lower and middle reach sites, most notably *Acartia tonsa*, *Eurytemora affinis* and other calanoid copepods or cladocerans, as well as the neritic harpacticoid copepod *Euterpina acutifrons*. These marine/estuarine plankters did appear, albeit in low densities, at Freezeout Bar in June and October, suggesting salinity intrusion into the estuary's upper reach. The copepod *E. affinis* appears to be a definite indicator of oligohaline/brackish water bodies because it does not occur at River Mouth at any time but is particularly prominent at Penny Point and Willow Creek in June, and a prominent component of the plankton assemblage in October.

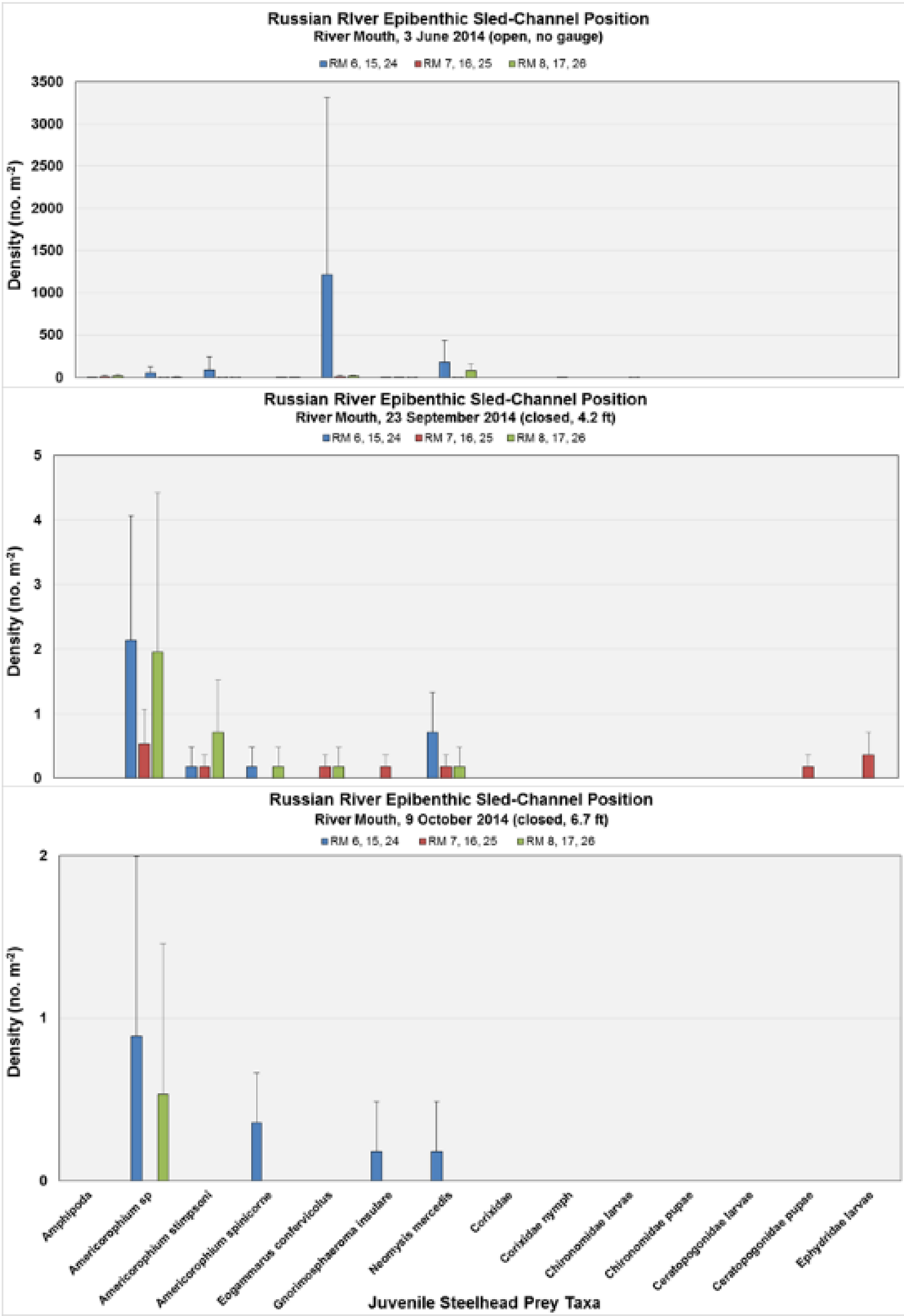


Figure 4.3.20. Density distribution of juvenile steelhead prey taxa in epibenthic sled samples along three channel positions at the Russian River Mouth site during three dates, 2014. Transects RM 7, 16 25 are in center of Estuary channel and transects RM 6, 15, 24 and RM 8, 17, 26 are positioned to the right and left (facing up estuary) of the center transects, respectively (Figure 4.3.4).

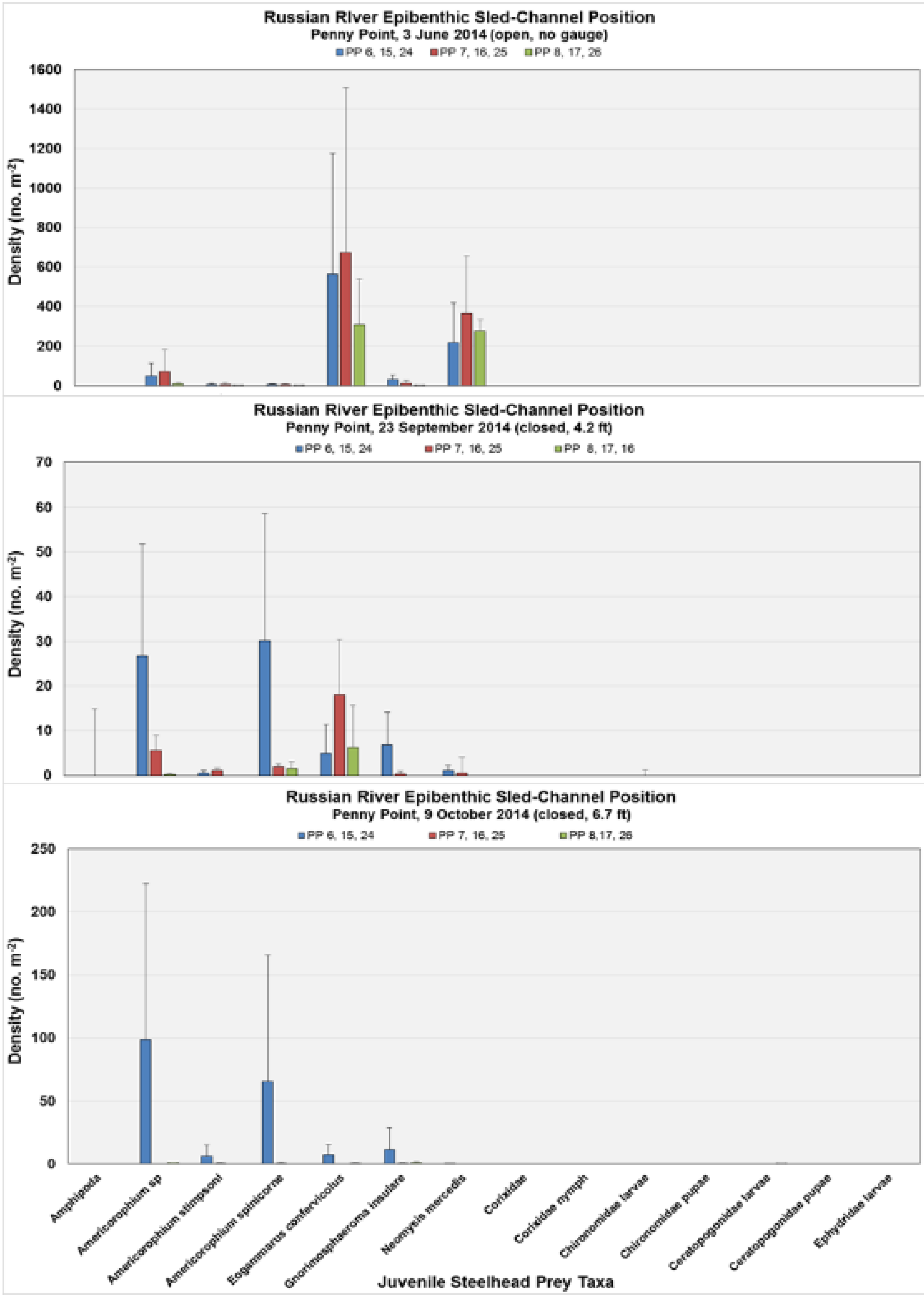


Figure 4.3.21. Density distribution of juvenile steelhead prey taxa in epibenthic sled samples along three channel positions at the Penny Point site during three dates, Russian River estuary, 2014. Transects RM 7, 16 25 are in center of estuary channel and transects RM 6, 15, 24 and RM 8, 17, 26 are positioned to the right and left (facing up estuary) of the center transects, respectively (Figure 4.3.4).

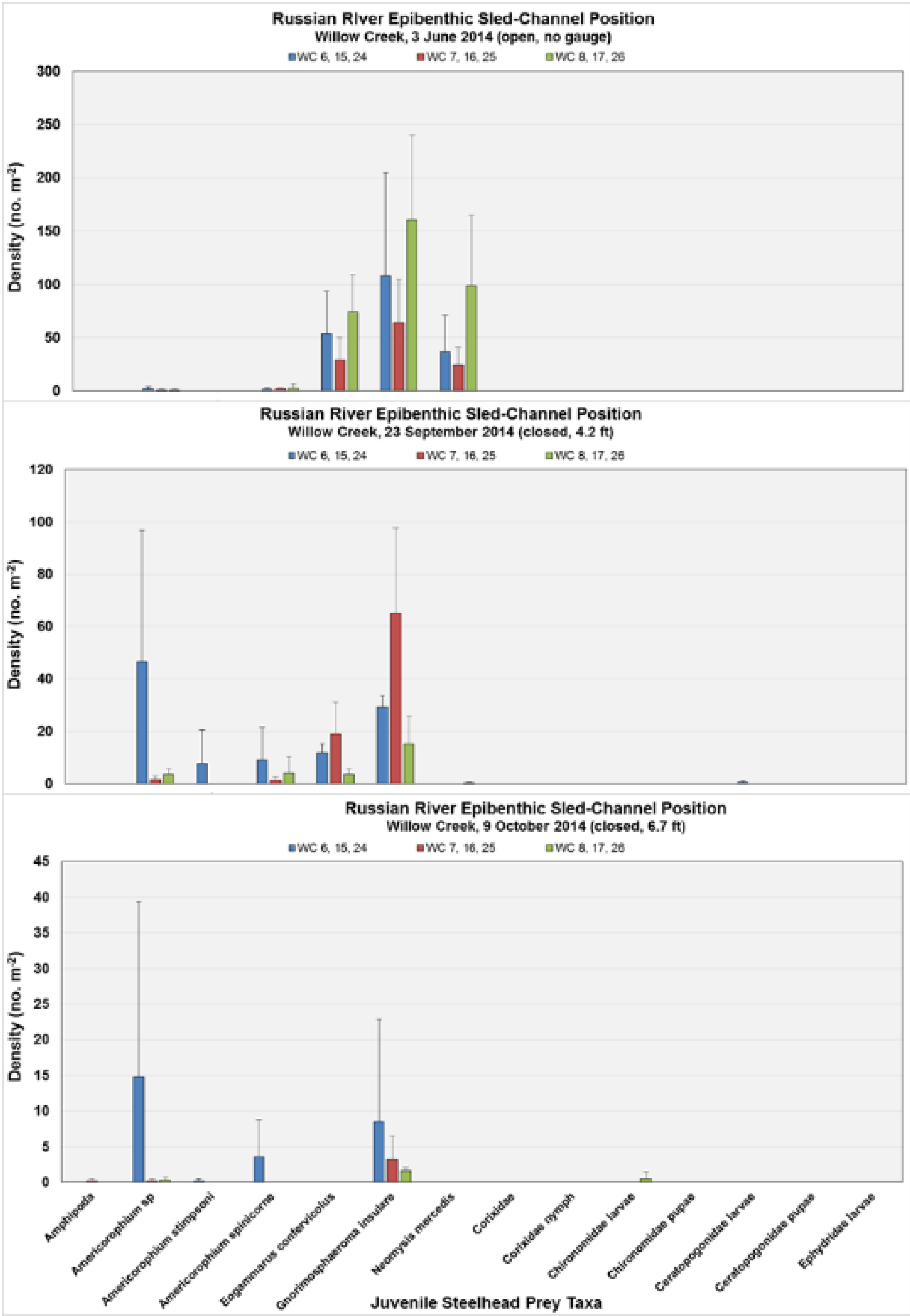


Figure 4.3. 22. Density distribution of juvenile steelhead prey taxa in epibenthic sled samples along three channel positions at the Willow Creek site during three dates, Russian River estuary, 2014. Transects RM 7, 16 25 are in center of estuary channel and transects RM 6, 15, 24 and RM 8, 17, 26 are positioned to the right and left (facing up estuary) of the center transects, respectively (Figure 4.3.4).

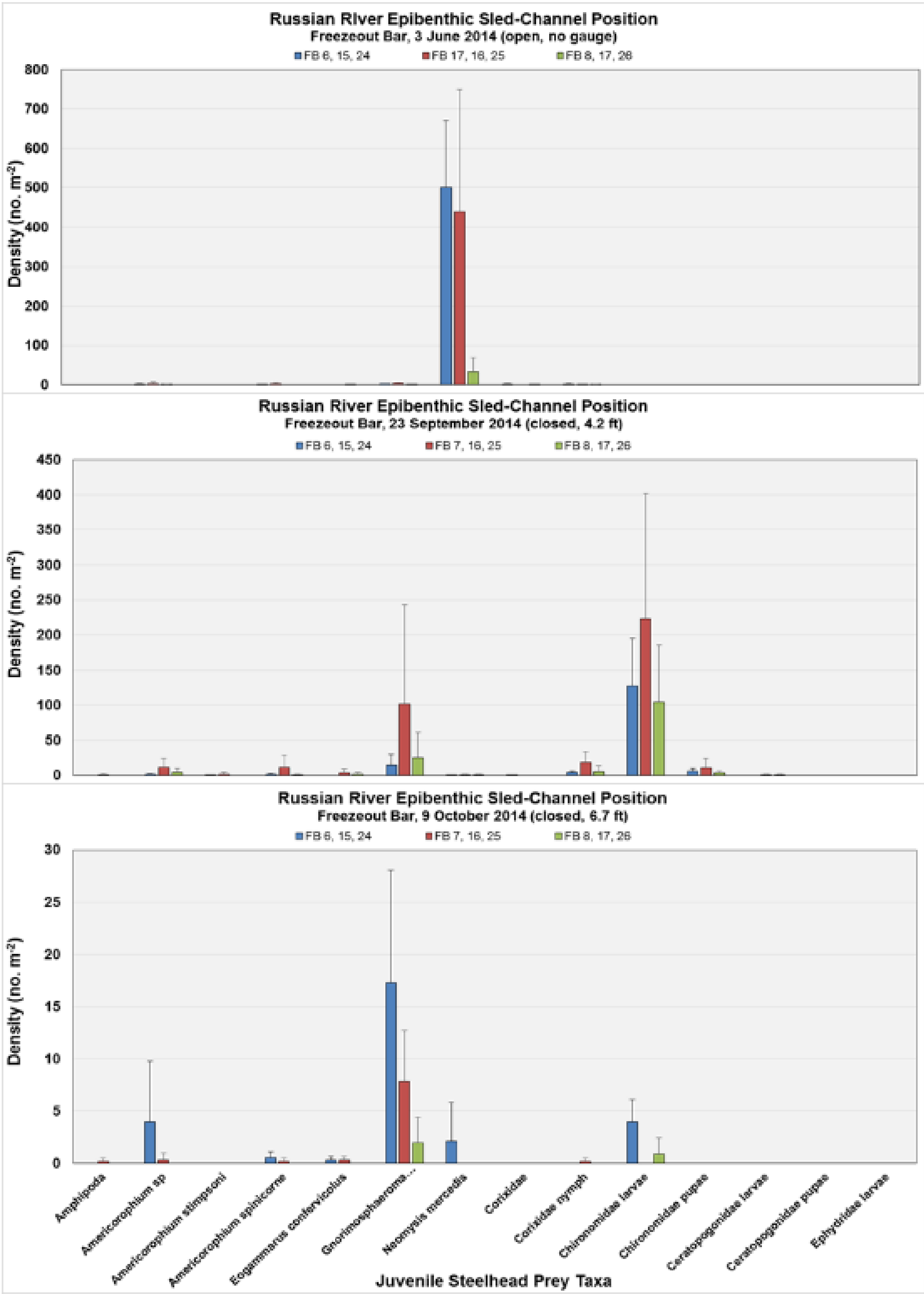


Figure 4.3.23. Density distribution of juvenile steelhead prey taxa in epibenthic sled samples along three channel positions at the Freezeout Bar site during three dates, Russian River estuary, 2014. Transects RM 7, 16 25 are in center of estuary channel and transects RM 6, 15, 24 and RM 8, 17, 26 are positioned to the right and left (facing up estuary) of the center transects, respectively (Figure 4.3.4).

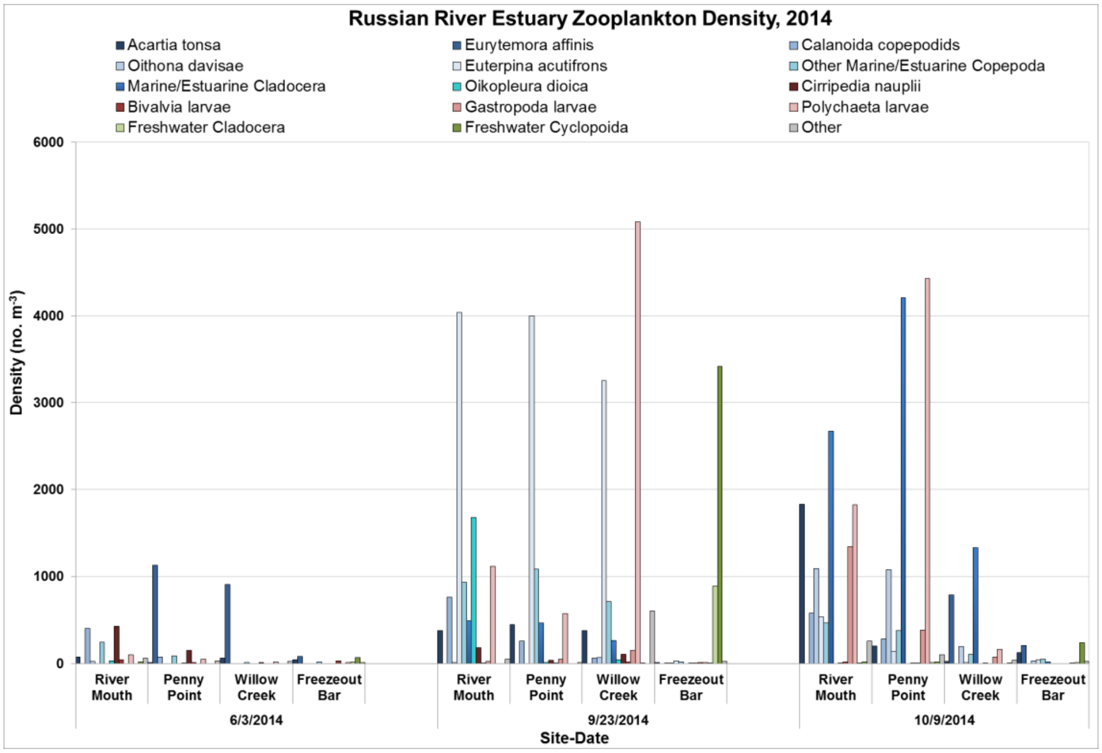


Figure 4.3.24. Density of selected planktonic zooplankton at four sites over three dates in the Russian River Estuary, 2014. In this and the next figure, blue patterns represent estuarine and marine plankton taxa, red patterns represent larval invertebrates, and green patterns represent freshwater taxa.

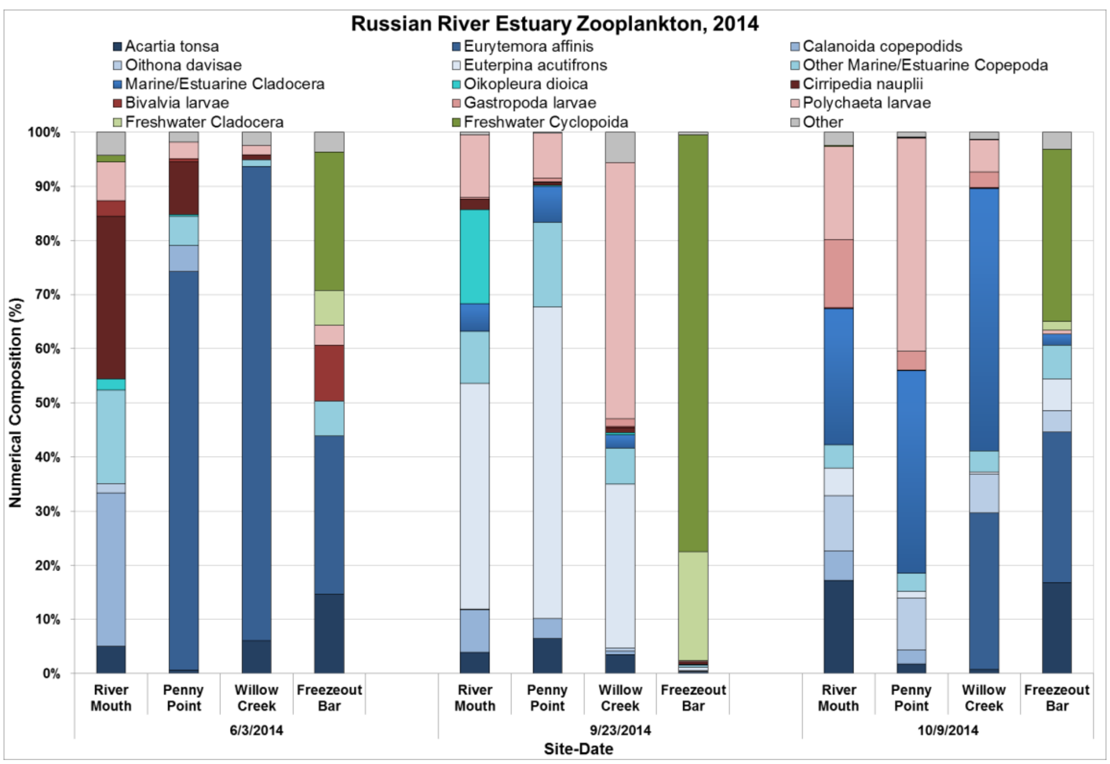


Figure 4.3.25. Numerical composition of selected planktonic zooplankton at four sites over three dates in the Russian River Estuary, 2014.

This difference in assemblage structure and abundance is readily evident from the multivariate analysis (Figure 4.3.26). While the density composition appears to be most similar among River Mouth and Penny Point, and to a lesser extent Willow Creek, plankton is always comparatively distinct due to the more distinct Freezeout Bar assemblages; Global R is high for differences among site groups (Global R = 0.87) and date groups (Global R = 0.96). As described above, *E. affinis* was the dominant contributor to the similarly in plankton assemblage structure at Willow Creek (75.5%) and Penny Point (0.52%) in June and Freezeout Bar in October (26.7%).

It should be noted in this and earlier reports that none of the pelagic zooplankton taxa appeared in the prey composition of juvenile steelhead in the estuary.

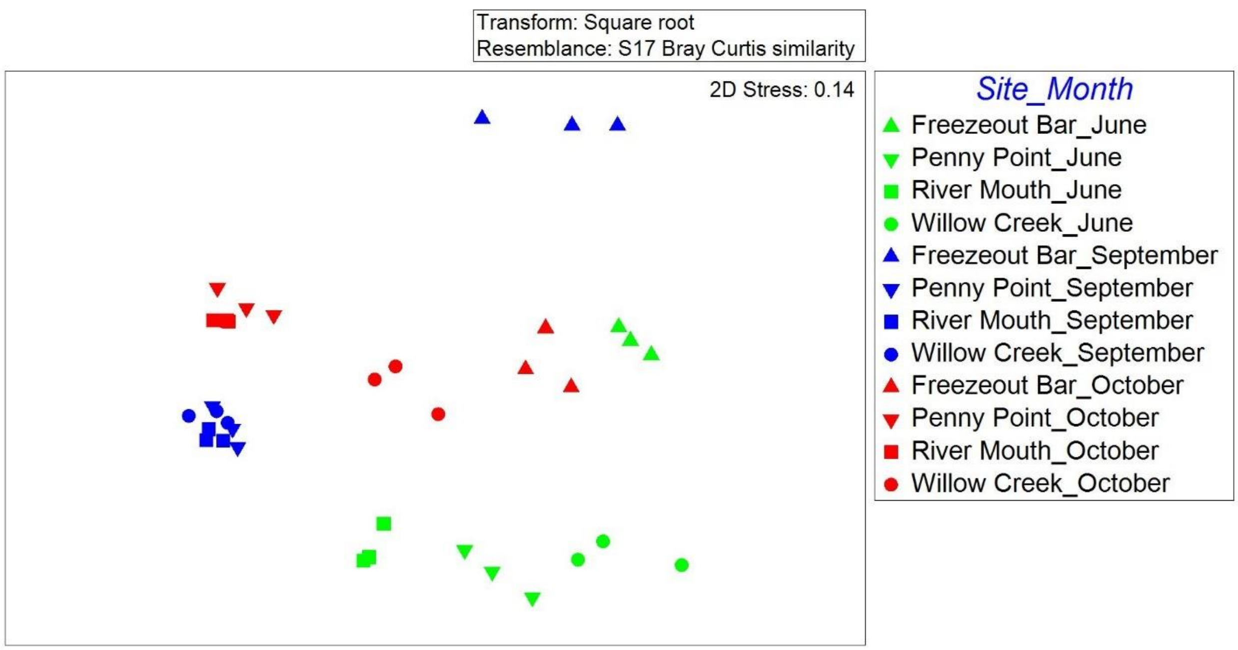


Figure 4.3.26. Non-metric multidimensional scaling diagram of selected zooplankton assemblages at four sites on three dates in the Russian River Estuary, 2014.

Hydroacoustic Telemetry

Juvenile Steelhead Behavior—Hydroacoustic telemetry was deployed extensively as a pilot study in 2014, with the primary goal of documenting "baseline conditions" of juvenile steelhead habitat, thermal regime and behavior when the estuary was open. Operational tasks involved perfecting the tag insertion surgery protocol, understanding the range and limitations of the permanent receiver arrays, developing the real-time tracking methodology, and refining the data acquisition/management system. All tags had been deployed and reached the end of their battery life before the late-September, early-October estuary closure occurred. Based on this pilot phase, the following should be considered preliminary findings, which we have focused on thermal regime exposure, life history (fish length) variation, and residency in different estuary reaches and sites that we interpreted from stationary receiver arrays and mobile tracking data.

Temperatures detected of tagged fish varied and encompassed the range of water temperatures documented in the Estuary during the duration of tagged fish being present (Figure 4.3.27). The thermal regime of fish in the lower and middle reaches of the Estuary overlapped extensively, while the majority of detections in the upper reach were in much higher temperatures. Temperature detections of tagged fish supported evidence of two thermal regimes: (1) 10°C-20°C in the Estuary's lower 4 km, below Willow Creek; and, (2) 18°C-25°C in the upper reach to approximately Austin Creek (Figure 4.3.28).

There is an initial indication that larger (>125 mm FL) steelhead may have the capability to occupy colder water where the Estuary is strongly stratified, such as in the middle reach (Figure 4.3.29). This phenomenon is also evident in the correlation of fish length with the likelihood that detections were within or below the halocline, where one was distinguished and could be related to hourly-averaged data sondes (Figure 4.3.30).

Residence (total number of hours a fish was detected at the release site relative to the maximum number of hours the tag was possibly detected; Vianna et al. 2013) also varied by fish length and reach (Figure 4.3.31). Note that the number of samples in each reach/site are not equal, which constrains the interpretability of any evident patterns.

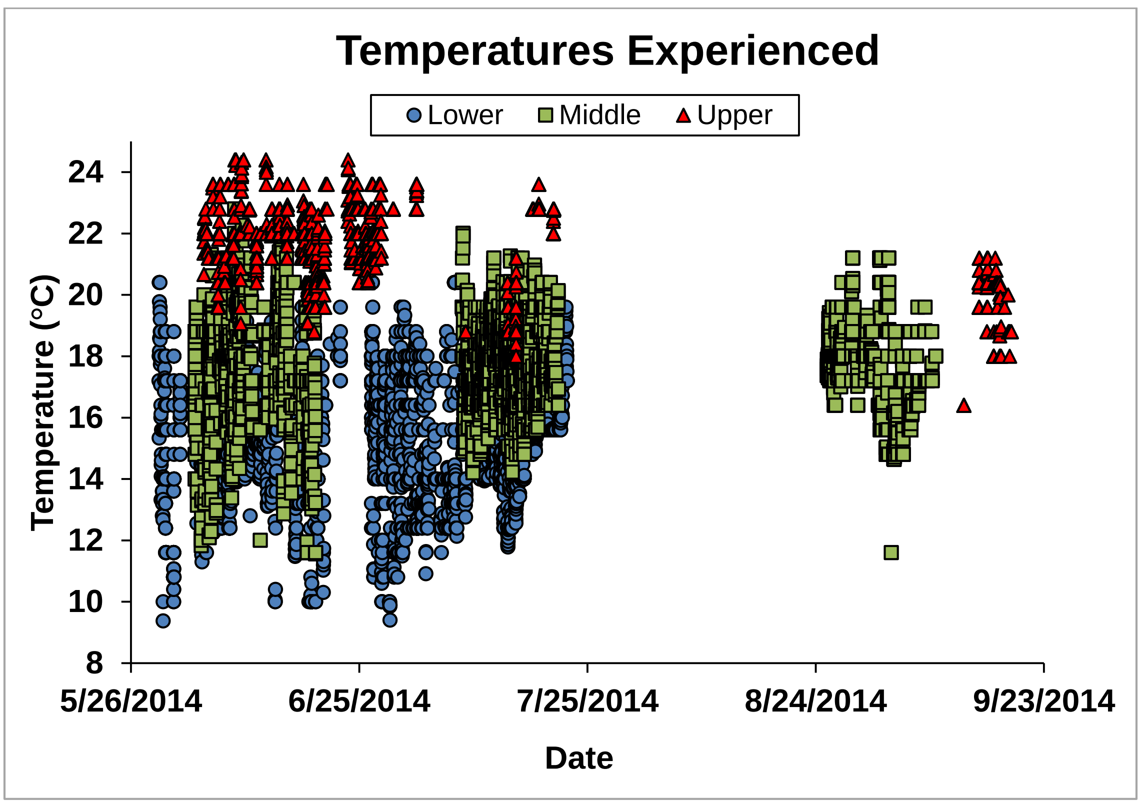


Figure 4.3.27. Temperature of individually tagged juvenile steelhead recorded in the Russian River Estuary, 2014.

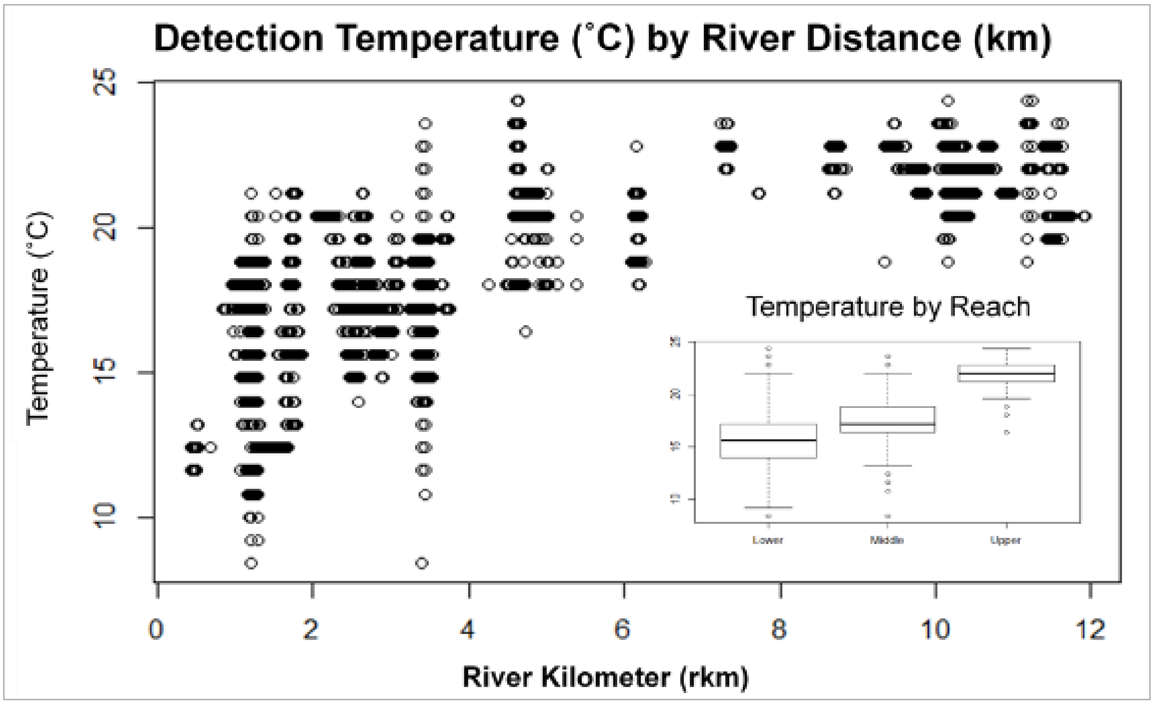


Figure 4.3.28. Temperature detections of juvenile steelhead as a function of distance from the mouth of the Russian River Estuary, 2014.

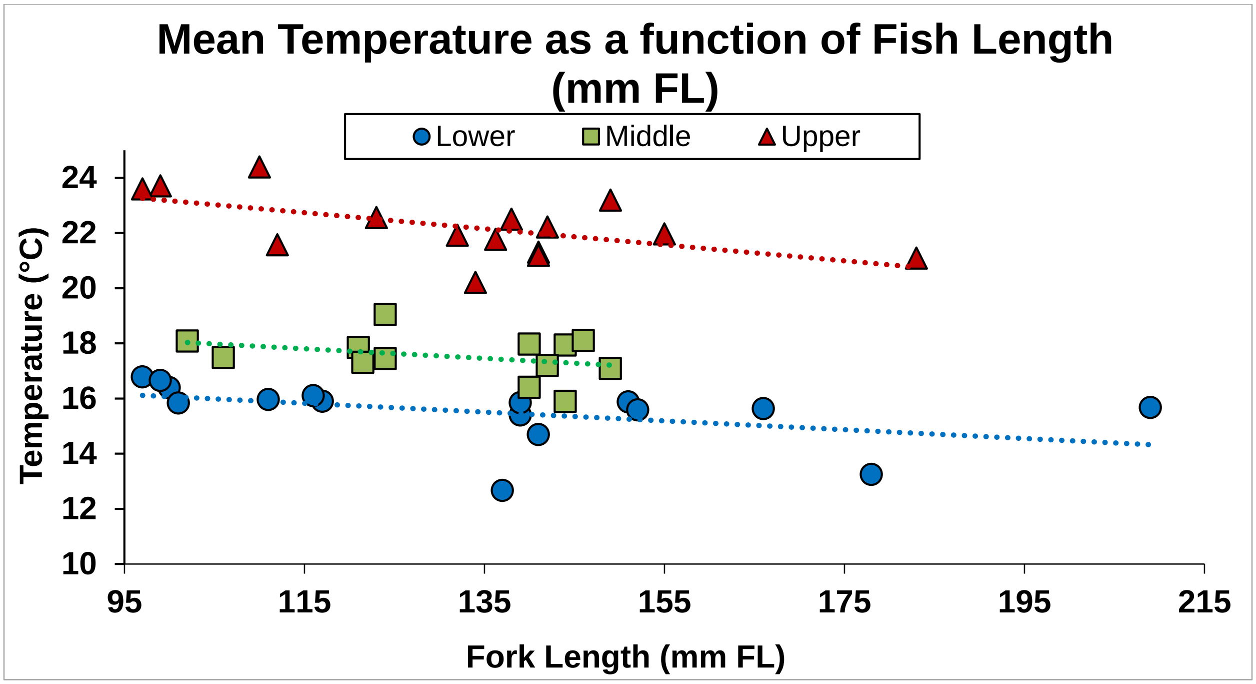


Figure 4.3.29 The mean temperature and fork length of each tagged fish separated by release reach in the Russian River Estuary, 2014.

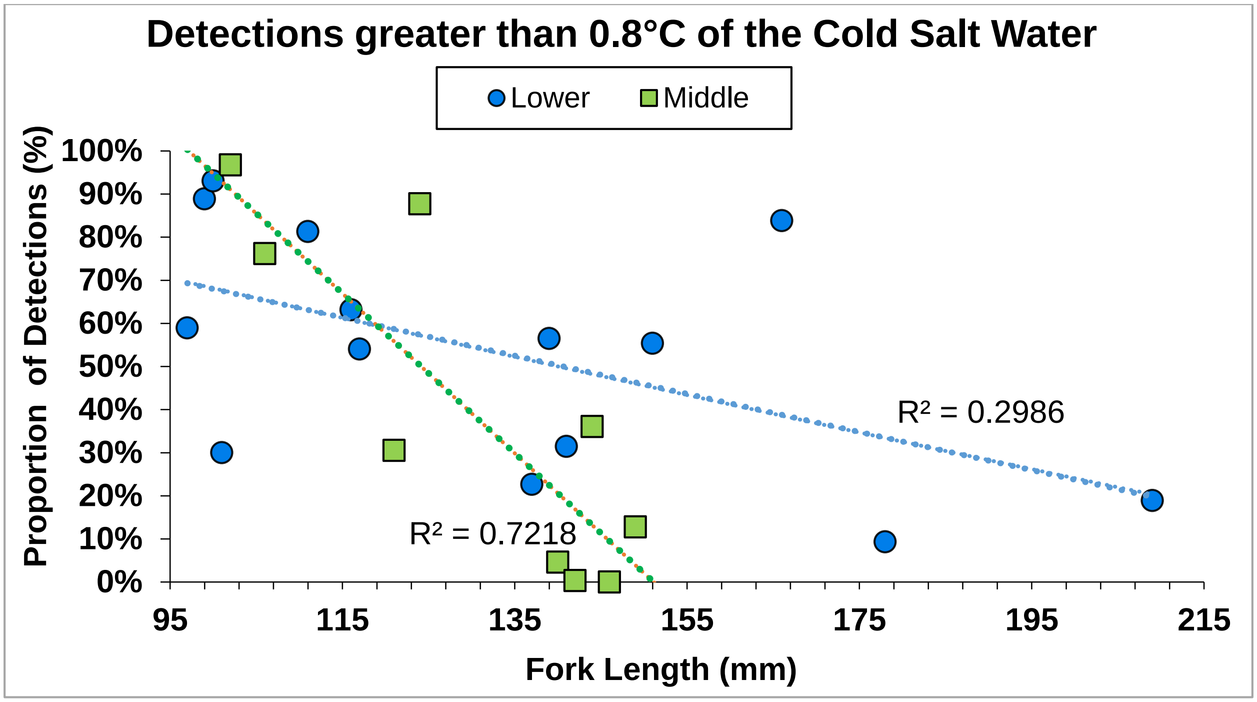


Figure 4.3.30. Proportion (%) of temperature detections greater than 0.8°C of water below halocline (were established) at two sites in the Russian River Estuary, 2014.

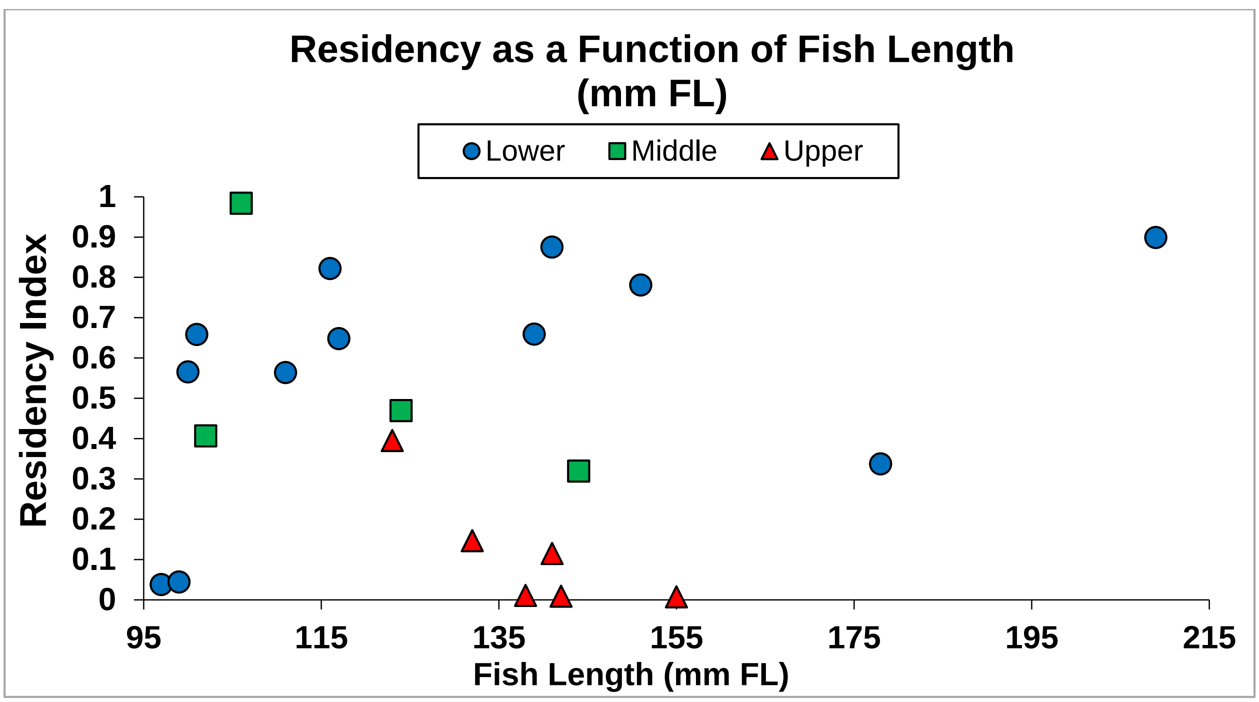


Figure 4.3.31. Residency (Vianna residency index) as a function of fish length at three sites/reaches in the Russian River Estuary, 2014. Fish were only used if released in close proximity to stationary receivers and were potentially detected for more than 100 hours.

Conclusions and Recommendations

Findings

Juvenile steelhead in the Russian River estuary are adapted to feed relatively specifically on a limited suite of epibenthic crustaceans and aquatic insects, as demonstrated in diet composition documented through this study since 2009. These prey, dominated by two genera of gammarid amphipods, tube-dwelling *Ameriocorophium* spp. and epibenthic *Eogammarus confervicolus*, the epibenthic isopod *Gnorimosphaeroma insulare*, mysid *Neomysis mercedis,* and aquatic insects of the Hemipteran family Corixidae (water boatmen) are broadly representative of the diet of juvenile steelhead documented for other estuaries along the northeastern Pacific, including other intermittent systems (Needham 1940; Shapovalov Taft 1954; Meyer et al. 1981; Martin 1995; Salamunovich and Ridenhour 1990; Daly et al*.* 2014). Only in a few cases, of small, persistent estuarine lagoons such a Waddell Creek, have other prey such as aquatic insects become more prominent (Needham 1940). This dominantly epibenthic feeding strategy indicates that juvenile steelhead in this, and seemingly most estuaries, are foraging along the bottom, whether in deeper channel or shallower, marginal habitats.

Prey availability varies naturally over time and space under open estuary conditions. In general, densities of prey organism are higher early in the sampling period and diminish by roughly an order of magnitude by late summer. Some of the major prey taxa also occur in the highest densities in the lower reach early but their distribution expands into the middle and upper reach, potentially related to the expansion of oligohaline conditions and stratification. In 2014, with closure from late September to early October, most of the epibenthic amphipods and isopods were equally or more dense in the middle and upper reaches than the lower reach, and aquatic insects (larvae and pupae, as well as adult corixids) dominated the prey assemblage in the upper reach, at Freezeout Bar. The mysid *Neomysis mercedis* was the only potential prey that appeared somewhat uniquely, being present in relatively high abundance at all sites only early in the study season.

Prey densities were relatively comparable between the epibenthic net to shore and channel sled samples, suggesting that there was equal or a relatively minor gradient of prey density distribution from their deeper channel to shallower marginal habitats, even under a prolonged closed estuary condition. The prominent exception are corixids, which in 2014 occurred in any density almost exclusively in the epibenthic net to shore samples in the upper reach, suggesting that they were available only in shallow water within 10 m of the shoreline. Coincidentally, it should be noted that, unlike other years of this study, in 2014 corixids did not appear significantly in steelhead diet. Density distribution of prey in the epibenthic sled channel samples did not display any distinct skewness among the channel transects, although the right bank samples (transects 6, 15 and 24) typically had the greatest density or even only occurrence of epibenthic crustaceans early in the sampling period or in early October, 22 days into Estuary closure.

Benthic macroinvertebrates appeared in somewhat consistent densities through the three sampling periods, although six days into estuary closure in late September the diversity and density distribution was much more uniform among the four study sites; the Freezeout Bar site was the only site that appear to have minimal taxa diversity and density. However, for an unknown reason, benthic macroinvertebrates at Penny Point almost dominated the assemblages across the entire estuary in early June and October.

Results of the initial hydroacoustic telemetry study, albeit preliminary, indicate that under ”baseline,” open estuary conditions, juvenile steelhead were detected across the scale of ambient temperatures and salinities in the estuary. However, patterns and variation in behavior relative to thermal regime were evident. Specifically, smaller juvenile steelhead spend less time in cold saline water, perhaps indicative of being less physiologically adapted for salt water and potentially limited to low salinity conditions in open conditions. We also found that smaller juvenile steelhead tend to have less site fidelity and travel greater distances, especially when released in the upper study reach. Although these increased movements in the upper reach are likely attributed to stressful temperatures, there was no evidence that less stressful temperatures were found in the upper reach.

Recommendations

Strategic modification of the protocols for laboratory processing of prey availability samples should be considered to improve relevance and completeness of that task. Given the extremely consistent prey selection by juvenile salmon, which has been established in these studies since 2010 (Seghesio 2011; Water Agency Manning and Martini-Lamb 2012, Martini-Lamb and Manning 2014), the project could appreciably increase the efficacy of the documentation of prey availability by selectively processing the epibenthic net to shore and channel sled samples to the ~14-20 taxa that reflect known or likely prey, rather than the entire spectrum of macroinvertebrate taxa. Presently, considerable laboratory processing time and expertise is allocated to enumerating taxa (e.g., ostracods, nematodes, oligochates, foraminiferans, turbellarians) that occur rarely, if at all, in juvenile steelhead diets. While the total biotic community dataset is unusually complete and valuable in its own right, it is now sufficiently documented to consider such a strategic change, which would guarantee that all samples in any field season can be processed for the target juvenile steelhead prey availability. An alternative would be to process all taxa during estuary closure periods; benthic samples might also be considered a separate case, in terms of the multiple uses that dataset provides.

At the time of this report, revisions to the initial, pilot hydroacoustic telemetry study were already being implemented in the 2015 study period. The highest priority will be to intensify the tagging and other data acquisition on the behavior and thermal regime of juvenile steelhead during a prolonged estuary closure, the “treatment” effect relative to the “baseline” conditions documented in 2014. Other refinements to the sampling design will involve targeted mobile tracking that will provide more precise association of juvenile steelhead positions and movement relative to more certain depth, salinity, and dissolved oxygen regimes that can be interpreted from water quality monitoring and circulation modeling. Tagging requirements will change by adhering to a minimum of five individuals tagged per event. Another recommendation includes the transport of tagged fish to a different reach to evaluate the response of fish to a change in habitat and water quality conditions. As time and other resources permit, mobile tracking may also be deployed to assess behavioral patterns of individual fish, such as movement rates, feeding and crepuscular activity, and response to tidal variation (water direction, velocity and mixing). Supplementary to these mobile tracking modifications, data from circulation modeling can better inform interpretation about the influence of velocity and water direction on juvenile steelhead movements and behavioral patterns.

Differences in potential consumption rate, indicated by patterns in the size-specific instantaneous ration in prior years and in 2014 (Figure 4.3.32), imply reach differences in potential availability among the suite of preferred prey taxa. While the instantaneous ration is a viable index of consumption rate, consideration should be given to conducting periodic diet sampling of juvenile steelhead over a 24-hr or 30-hr period in order to obtain a more precise estimate of daily ration, which is a fundamental measurement for bioenergetic modeling of potential growth. It should be recognized that this involves periodic sampling during nocturnal hours, which may be unfeasible given Water Agency policies or resources.

References

Amundsen, P. A., H. M. Gabler, and F. J. Staldvik. 1996. A new approach to graphical analysis of feeding strategy from stomach contents data—Modification of the Costello (1990) method. J. Fish. Biol. 48:607-614.

Bottom, D. L., and K. K. Jones. 1990. Species composition, distribution, and invertebrate prey of fish assemblages in the Columbia River estuary. Prog. Oceanog. 25: 243-270.

Cortés, E. 1997. A critical review of methods of studying fish feeding based on analysis of stomach contents: Application to elasmobranch fishes. Can. J. Fish. Aquat. Sci. 54:726-738.

Daly, E. A., J. A. Sheurer, R. D. Brodeur, L. A. Weitkamp, B. R. Beckman and J. A. Miller. 2014. Juvenile steelhead distribution, migration, feeding, and growth in the Columbia River estuary, plume, and coastal waters. Mar. Coast. Fisheries: Dyn. Mgmt. Ecosyst. Sci. 6:62-80

Foster, J. R. 1077. Pulsed gastric lavage: an efficient method of removing the stomach contents of liver fish. The Prog. Fish. Cult. 39:166-169.

Hayes, S. A., and J. F. Kocik. 2014. Comparative estuarine and marine migration ecology of Atlantic salmon and steelhead: blue highways and open plains. Rev. Fish. Biol. Fish. 24:757–780

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 Marine Laboratory, University of California, Davis. 72 pp.

Light, R. W., P. H. Alder and D. E. Arnold. 1983. Evaluation of gastric lavage for stomach analyses. N. Am. J. Fish Mgmt. 3:81-85.

Martin, J. A. 1995. Food habits of some estuarine fishes in a small, Central California lagoon. M.A. thesis, San Jose State Univ., CA.

Meyer, J. H., T. A. Pearce and S. B. Patlan. 1981. Distribution and food habits of juvenile salmonids in the Duwamish estuary, Washington, 1980. U.S. Dept. Interior, U.S. Fish Wildl. Serv., Olympia, WA. 42 pp.

Needham, P. R. 1940. Quantitative and qualitative observations on fish foods in Waddell Creek Lagoon. Trans. Am. Fish. Soc. 69:178-186.

Seghesio, E. E. 2011. The influence of an intermittently closed, morthern California estuary on the feeding ecology of juvenile steelhead (Oncorhynchus mykiss) and Chinook salmon (Oncorhynchus tshawytscha). M.S. thesis, School Aquat. Fish. Sci., Univ. Washington, Seattle, WA. 106 pp.

Salamunovich, T. J., and R. L. Ridenhour. 1990. Food habits of fishes in the Redwood Creek estuary. U.S. Natl. Park Trans. Proc., Ser. 8 :111-123.

Shapovalov, L., and A.C. Taft. 1954. The life histories of the steelhead rainbow trout (Salmo gairdneri gairdneri) and silver salmon (Oncorhynchus kisutch) with special reference to Waddell Creek, California and recommendations regarding their management. State California Dept. Fish Game, Fish Bull. 98. 375 pp.

Vianna, G. M. S., M. G. Meekan, J. J. Meeuwig, and C. W. Speed. 2013. Environmental influences on patterns of vertical movement and site fidelity of grey reef sharks (Carcharhinus amblyrhynchos) at aggregation sites. PLOSone 8 e60331. DOI: 10.1371/journal.pone.0060331

4.4 Fish Sampling – Beach Seining

The Water Agency has been fish 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 2014, 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 (¼ 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. From 2004 to 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.

Salmonids were anesthetized with Alka-seltzer tablets or MS-222 and then measured, weighed, and examined for general condition, including life stage (i.e., parr, smolt). All salmonids were scanned for passive integrated transponder (PIT) tags or other marks. Steelhead and coho salmon were identified as wild or hatchery stock by a clipped adipose fin. Hatchery coho salmon were no longer clipped after spring 2013 and were either marked with a coded wire tag or PIT tag. Tissue and scale samples were collected from some steelhead. Unmarked juvenile steelhead caught in the Estuary greater than 60 mm fork length were surgically implanted with a PIT tag. Fish were allowed to recover in aerated buckets prior to release.

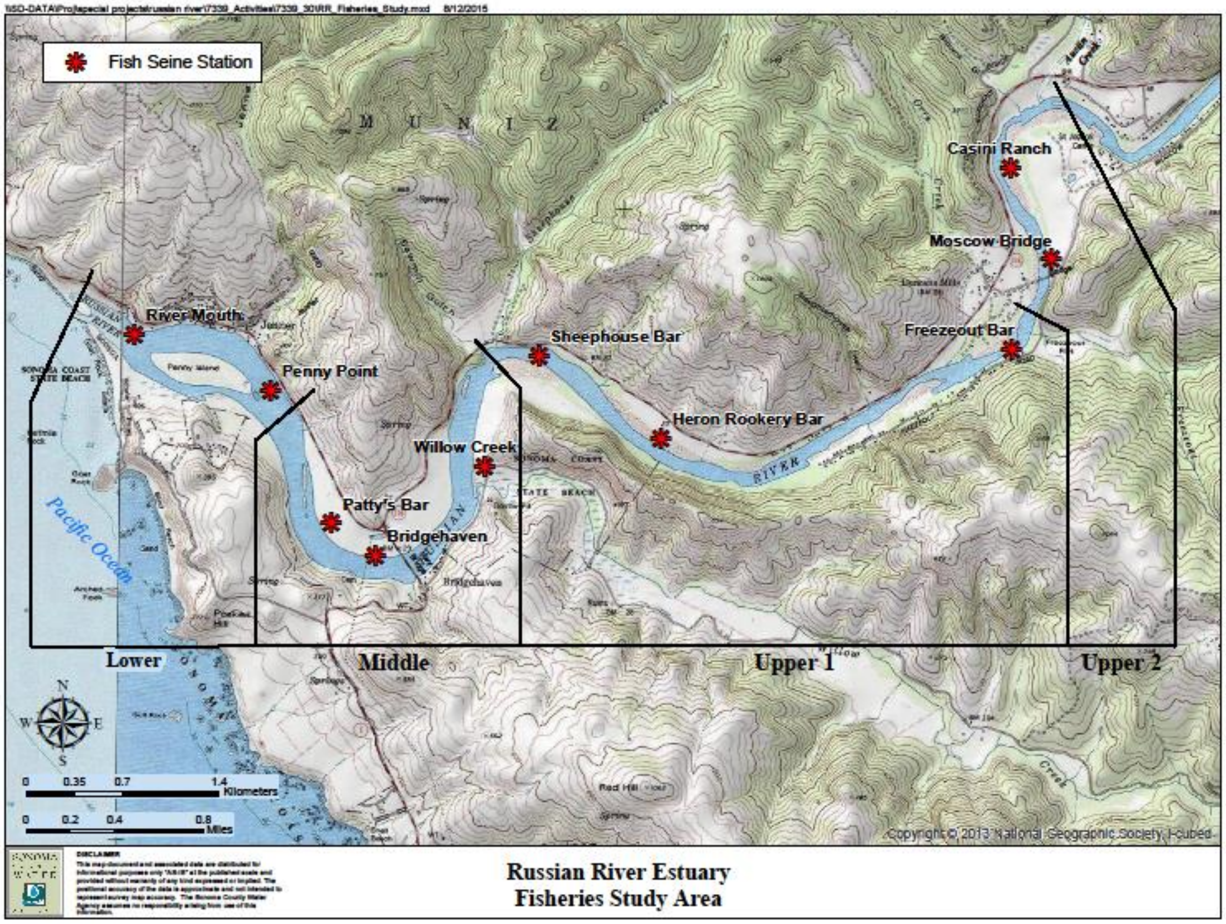


Figure 4.4.1. Russian River Estuary fisheries seining study reaches and sample sites, 2014.

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 where 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. In 2014 the seining sampling effort was conducted in May, June, September, and October to characterize the Estuary under tidal conditions during the beginning and end of the lagoon management period. Seining in July and August were not completed because a lagoon outlet channel could not be installed to form a freshwater lagoon.

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 4.1.1). 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 were located 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. Catch 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 2014 are summarized in Table 4.4.1. During the 11 years of study, over 190,000 fish comprised of 50 species were caught in the Estuary. In 2014, seine captures consisted of 11,351 fish comprised of 24 species. No new fish species were detected in the Estuary during 2014 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). Fish commonly found in the Lower Reach were marine and estuarine species including surf smelt (*Hypomesus pretiosus*), English sole (*Parophrys vetulus*), and staghorn sculpin (*Leptocottus armatus*). 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*) and bay pipefish (*Syngnathus leptorhynchus*). Freshwater dependent species, such as the Sacramento sucker (*Catostomus occidentalis*), Sacramento pikeminnow (*Ptychocheilus grandis*), and Russian River tule perch (*Hysterocarpus traskii pomo*), were predominantly distributed in the Upper Reach. Anadromous fish, such as steelhead (*Oncorhynchus mykiss*) and American shad (*Alosa sapidissima*), which can tolerate a 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 2014, a total of 56 steelhead were captured (Table 4.4.1) in 200 seine sets. The resulting CPUE was 0.28 fish/set (Figure 4.4.4). In comparison, during 2013, a total of 67 steelhead were captured in 150 seine sets for a CPUE of 0.45 fish/set. The highest CPUE for all study years was 1.66 fish/set in 2008. All steelhead captured in 2014 were wild, except one hatchery fish. The seasonal abundance of steelhead captured varied annually in the Estuary (Figure 4.4.5). Juvenile steelhead were captured during all four survey events in 2014. The highest steelhead abundances are typically in June and August. During 2014, steelhead captures were highest during June at 0.58 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). 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 2014 steelhead were captured in all study reaches, except the Lower Reach, in relatively low numbers. Captures were highest in the Middle Reach at 0.58 fish/set.

Table 4.4.1. Total fish caught by beach seine in the Russian River Estuary, 2014. Each station was sampled monthly during May, June, September, and October for a total of 200 seine sets for all sites. Monthly seine sets per station are shown in parentheses.

		Seining Station										
Life History	**Species**	**River Mouth (7)**	**Penny Point (3)**	**Patty's Bar (3)**	**Bridge-haven (7)**	**Willow Creek (5)**	**Sheep-house Bar (5)**	**Heron Rookery Bar (6)**	**Freeze-out Bar (4)**	**Moscow Bridge (5)**	**Casini Ranch (5)**	**Total**
Anadromous	American shad					9		7	4	85	126	231
	Chinook salmon	68	1		65	20	47				6	206
	coho salmon	2			13	3	1					19
	steelhead				25	4	6		9	1	11	56
Estuarine	bay pipefish	1	2	2	12	3	3					23
	shiner surfperch		1	18	147	110	76					352
	staghorn sculpin	24	46	18	24	1		13				126
	starry flounder	29	1	11	63	42	2	14	8	43	46	259
	topsmelt	930	554	417	1729	605	167					4402
Freshwater	black crappie											
	bluegill											
	California roach								12	99		111
	common carp									2		2
	cyprinid sp							3	1		18	22
	fathead minnow											
	green sunfish											
	hardhead											
	hitch									40		40
	largemouth bass											
	mosquitofish											
	Russian River tule perch				1	12				178		191
	Sacramento blackfish											
	Sacramento pikeminnow				2		3	7	75	431	91	609
	Sacramento sucker							21	19	99	22	161
	white catfish											

		Seining Station										
Life History	**Species**	**River Mouth (7)**	**Penny Point (3)**	**Patty's Bar (3)**	**Bridge-haven (7)**	**Willow Creek (5)**	**Sheep-house Bar (5)**	**Heron Rookery Bar (6)**	**Freeze-out Bar (4)**	**Moscow Bridge (5)**	**Casini Ranch (5)**	**Total**
Marine	buffalo sculpin											
	cabazon	11										11
	English sole											
	northern anchovy											
	Pacific herring											
	Pacific sanddab	2										2
	poacher sp.											
	saddleback gunnel											
	sebastes sp.	30	2		1							33
	sharpnose sculpin		1									1
	shortnosed sculpin											
	silver spotted sculpin											
	surf smelt	364	34		35							433
	jacksmelt											
	kelp greenling											
	lingcod											
	Pacific sand sole	1										1
	Pacific sardine											
	penpoint gunnel											
	smelt sp											
	smoothead sculpin											
	snailfish sp											
	striped kelpfish											
	tidepool sculpin											
Generalist	prickly sculpin	4	14	74	143	80	18	37	27	20	10	427
	threespine stickleback	4	304	485	849	299	583	351	218	426	113	3632
Grand Total		**1470**	**960**	**1025**	**3109**	**1188**	**906**	**453**	**373**	**1424**	**443**	**11351**

*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.

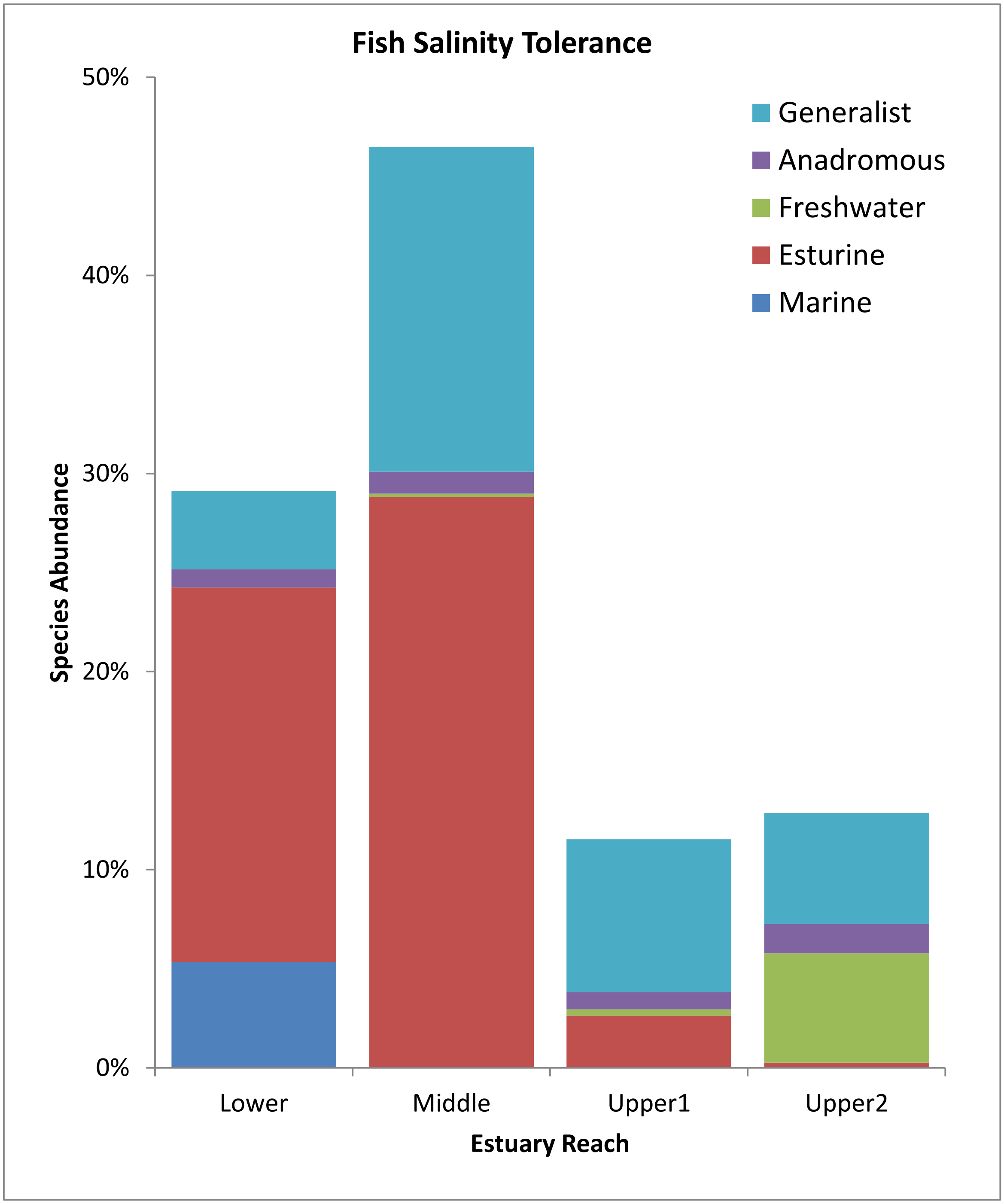


Figure 4.4.2. Distribution of fish in the Russian River Estuary based on salinity tolerance and life history, 2014. Data is from monthly seining during May, June, September, and October. **Groups include: generalist species that occur in a broad range of habitats; species that are primarily anadromous; 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.**

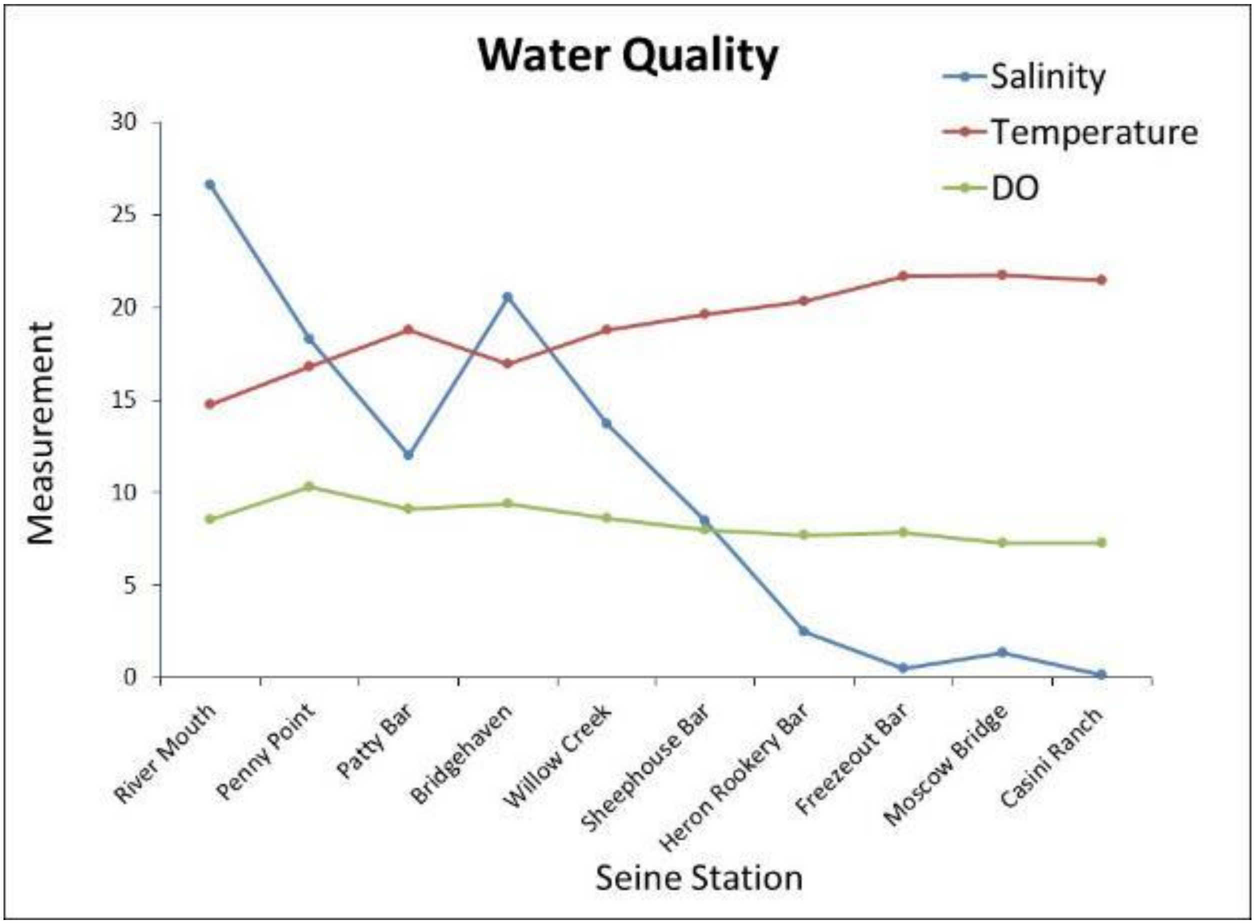


Figure 4.4.3. Generalized water quality conditions at fish seining stations in the Russian River Estuary, 2014. Values are averages collected at 0.5 m intervals in the water column during beach seining events from May, June, September, and October. Salinity values are in parts per thousand (ppt), dissolved oxygen (DO) milligrams per liter (mg/L), and water temperature Celsius (C).

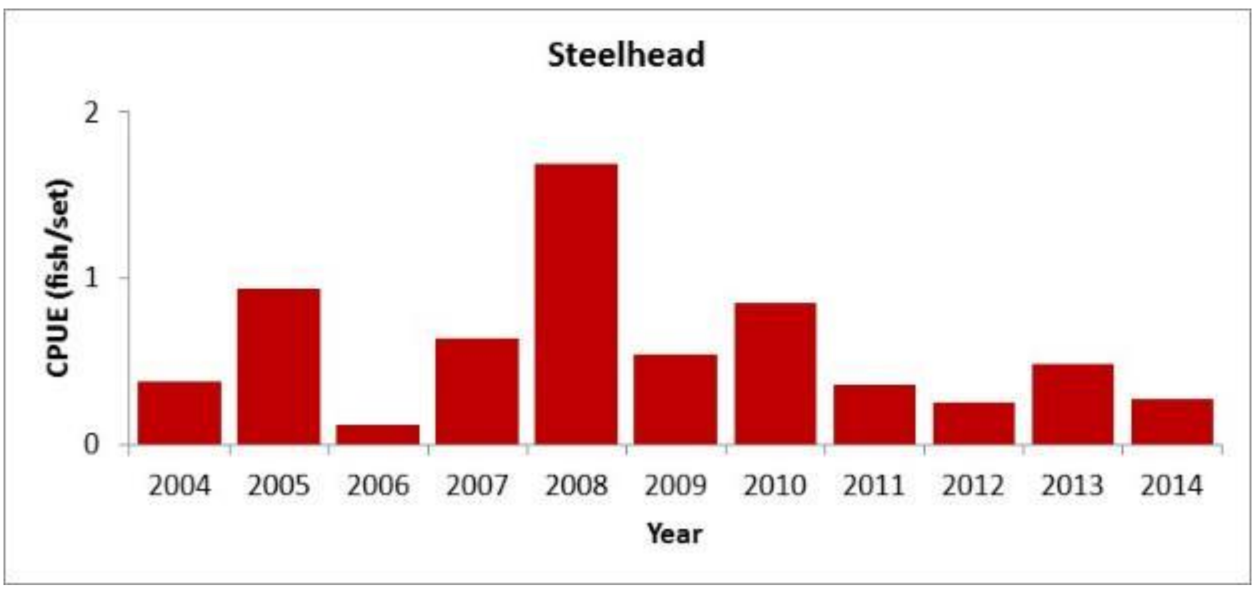


Figure 4.4.4. Annual abundance of juvenile steelhead captured by beach seine in the Russian River Estuary, 2004 to 2014. Samples are from 96 to 300 seine sets conducted yearly between May and October.

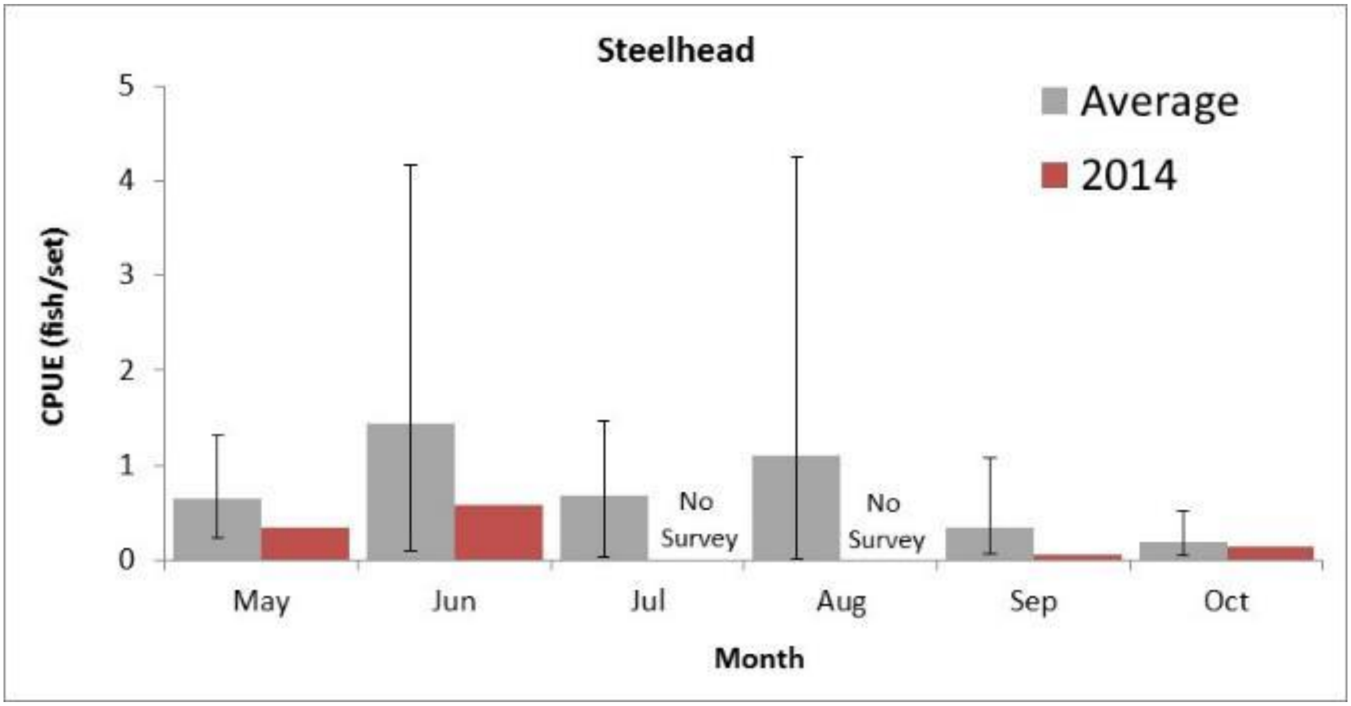


Figure 4.4.5. Seasonal abundance of juvenile steelhead captured by beach seine in the Russian River Estuary, 2004-2014. Seining events consisted of 21 to 50 seine sets approximately monthly. October surveys began in 2010. Data from 2004 to 2014 were averaged and whiskers indicate minimum and maximum values.

Figure 4.4.6. Distribution of juvenile steelhead captured by beach seine in the Russian River Estuary, 2004-2014. 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. Data from 2004 to 2014 were averaged and whiskers indicate minimum and maximum values.

The temporal and spatial distribution of juvenile steelhead in the Estuary in 2014 was strongly influenced by relatively large captures in the Upper1, Upper2, and Middle Reaches in May and June (Figure 4.4.7). A few late season steelhead were caught in these same reaches. No steelhead were captured in the Lower Reach. However, many steelhead were seined-captured at Jenner Gulch (Lower Estuary) for a telemetry study.

Most captured juvenile steelhead were age 0+ parr or age 1+ smolts and ranged in size from 52 mm to 340 mm fork length (Figure 4.4.8). Estuary steelhead in May and June appeared to consist of age 0+ parr less than 100 mm fork length and age 1+ smolts up to 179 mm fork length. A few large parr and smolts with sizes up to 340 mm fork length were captured in September and October.

In 2014, 36 juvenile steelhead captured during Estuary seining surveys and an additional 138 juveniles captured during a telemetry study conducted by the University of Washington were implanted with PIT tags. Also, 590 juvenile steelhead where PIT-tagged in Austin Creek during downstream migrant trapping studies and another 1,493 juveniles in the upper Russian River watershed. No steelhead tagged in the upper Russian River watershed were recaptured in the Estuary. A single steelhead parr tagged in lower Austin Creek (located near the Upper2 Estuary) was recaptured at the Casini Ranch seining station.

Of the 174 steelhead tagged in the Estuary in 2014, 28 were later recaptured in the Estuary. The number of days between captures ranged from 10 to 88 days. Recapture sites consisted of 25 steelhead at Jenner Gulch, 2 at Casini Ranch, 1 at Bridgehaven. All of these fish were recaptured at the same location suggesting a strong fidelity to local rearing sites.

The growth rate patterns of juvenile steelhead in the Estuary are shown in Figure 4.4.9. The growth rate of steelhead marked and recaptured in the Estuary in 2014 ranged from 0.2 mm/day at Casini Ranch (Upper2 Estuary) to 1.3 mm/day at Jenner Gulch in the Lower Estuary. The average growth rate of the 25 Jenner Gulch steelhead was 0.8 mm/d. Based on previous growth patterns steelhead typically grow 1 mm/d or more while rearing the in Estuary.

Chinook Salmon

A total of 206 Chinook salmon smolts were captured by beach seine in the Estuary during 2014 (Table 4.4.1). The abundance of smolts in the Estuary has varied since studies began in 2004 (Figure 4.4.10). Chinook salmon abundance was lowest in 2005, 2012, and 2013 at 0.7 fish/set. The highest peak for Chinook salmon smolts was in 2008 at 4.6 fish/set. The CPUE in 2014 was moderately-low at 1.1 fish/set. Chinook salmon smolts were usually most abundant during May and June (Figure 4.4.11) and rarely encountered after July. Monthly smolt captures in 2014 were highest during May and June at 2.1 fish/set. One smolt was captured late in the survey season in September. Chinook salmon smolts were distributed throughout the Estuary with captures at most sample stations and reaches annually (Figure 4.4.12).

There were 7 Chinook smolts PIT-tagged in Dry Creek and the mainstem Russian River at the Wohler trap station that were recaptured in the Estuary at Sheephouse Bar, Bridgehaven, and Jenner Gulch sites. Transit times ranged from 7 days from Wohler to Sheephouse Bar to 41 days from Dry Creek at Westside Road Bridge to Jenner Gulch. These smolts ranged in size from 80 to 96 mm fork length and had an average growth rate of 0.5 mm/d.

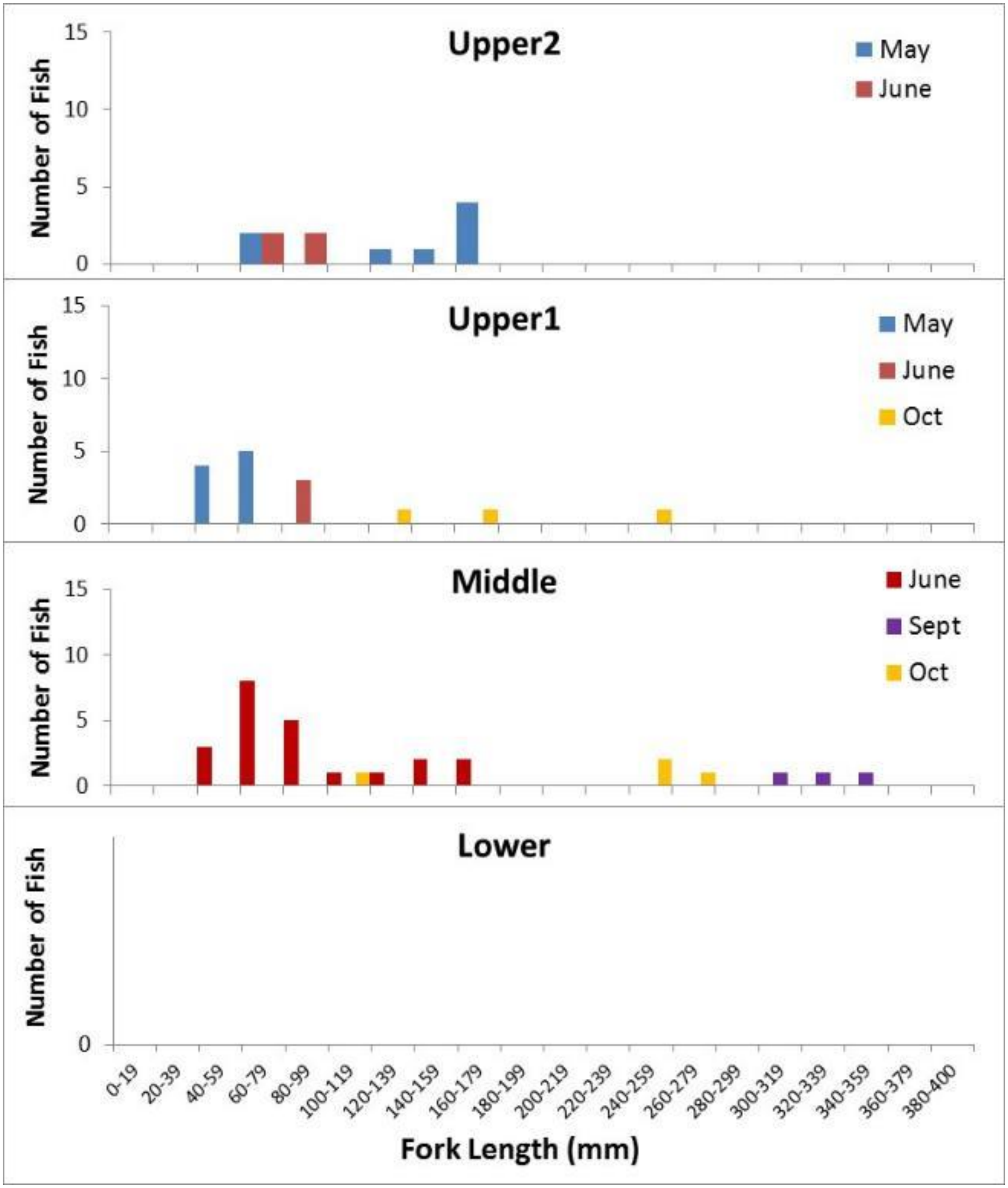


Figure 4.4.7. Length frequency of juvenile steelhead captured by beach seine in the Russian River Estuary, 2014. Fish captures are grouped by Estuary reach and month.

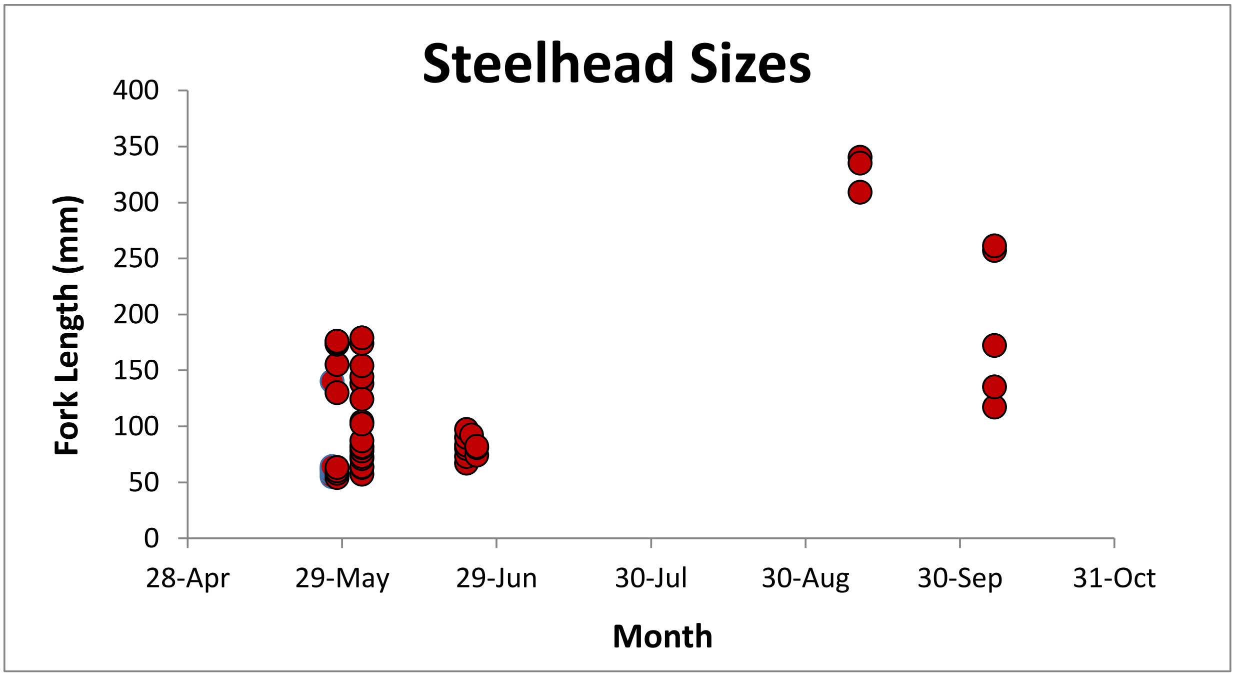


Figure 4.4.8. Juvenile steelhead sizes captured by beach seine in the Russian River Estuary, 2014.

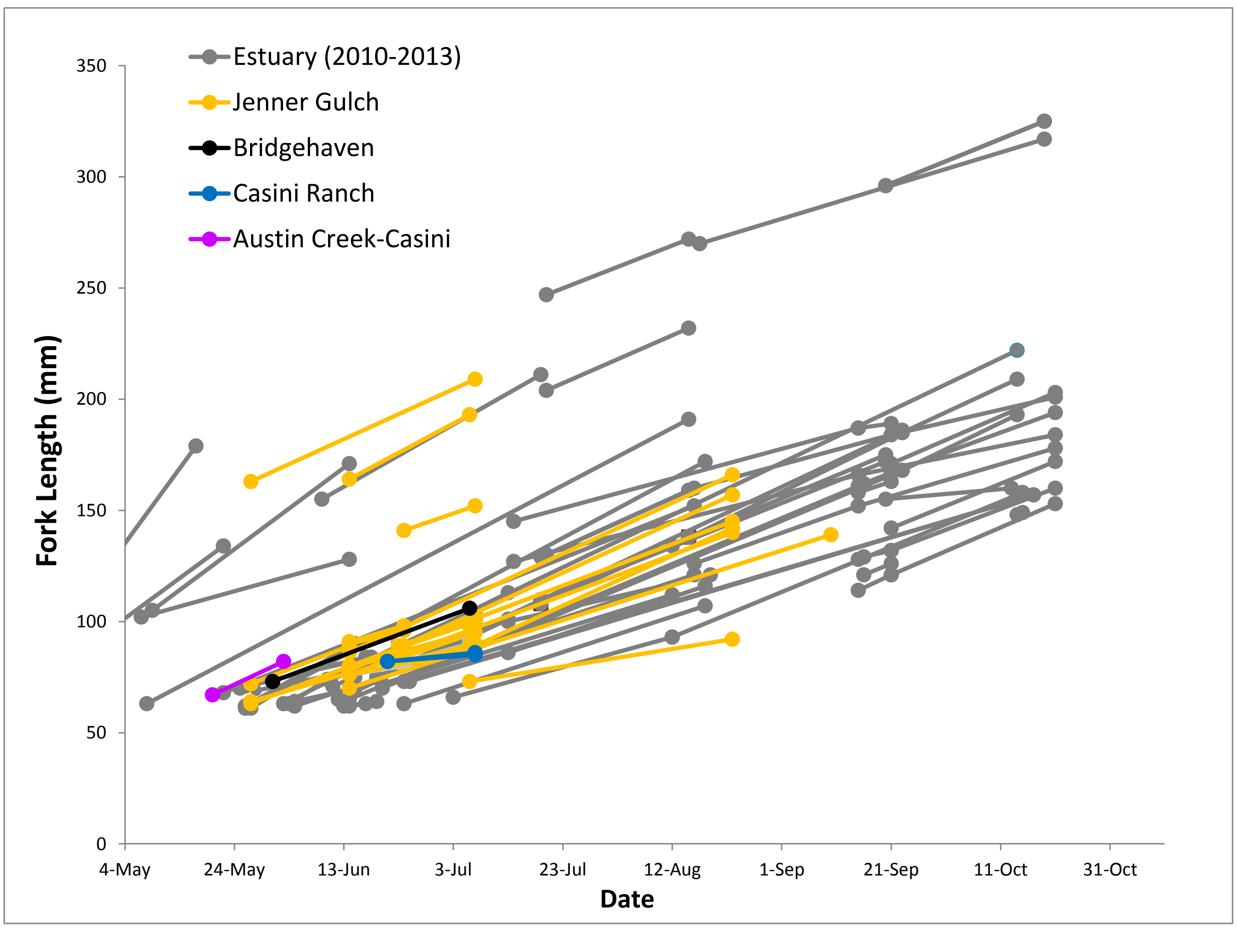


Figure 4.4.9. Growth rates of juvenile steelhead in the Estuary, 2010-2014. Fish were either PIT tagged in the Estuary or upstream and then recaptured in the Estuary. Fish from 2010-2013 are shown in gray. All other colors are steelhead from 2014.

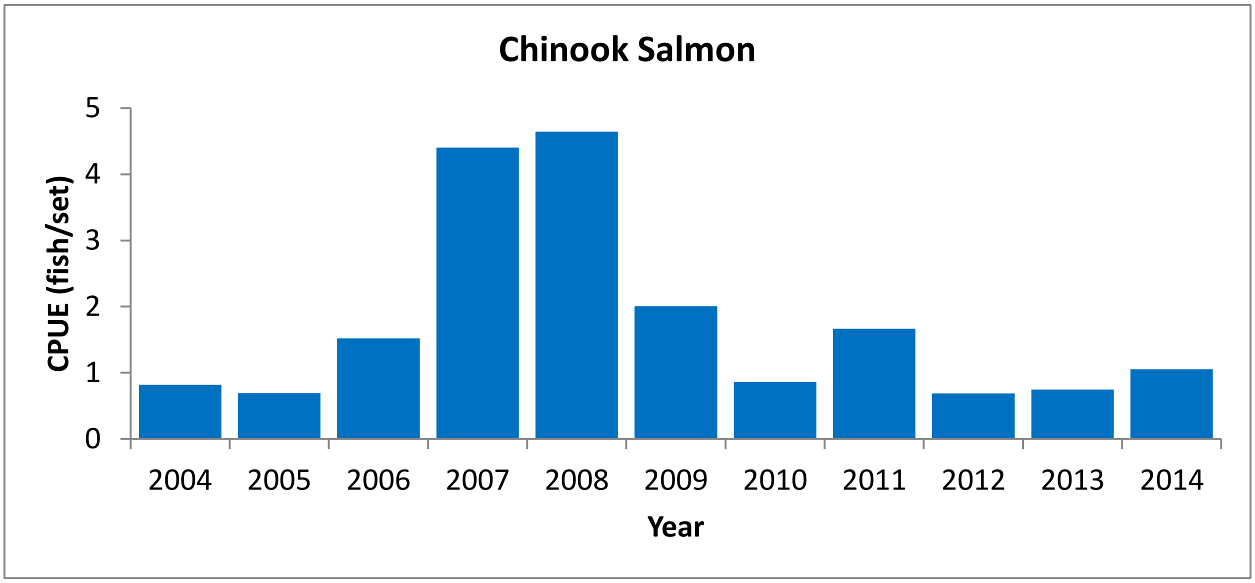


Figure 4.4.10. Annual abundance of Chinook salmon smolts captured by beach seine in the Russian River Estuary, 2004-2014. Samples are from 96 to 300 seine sets yearly between May and October.

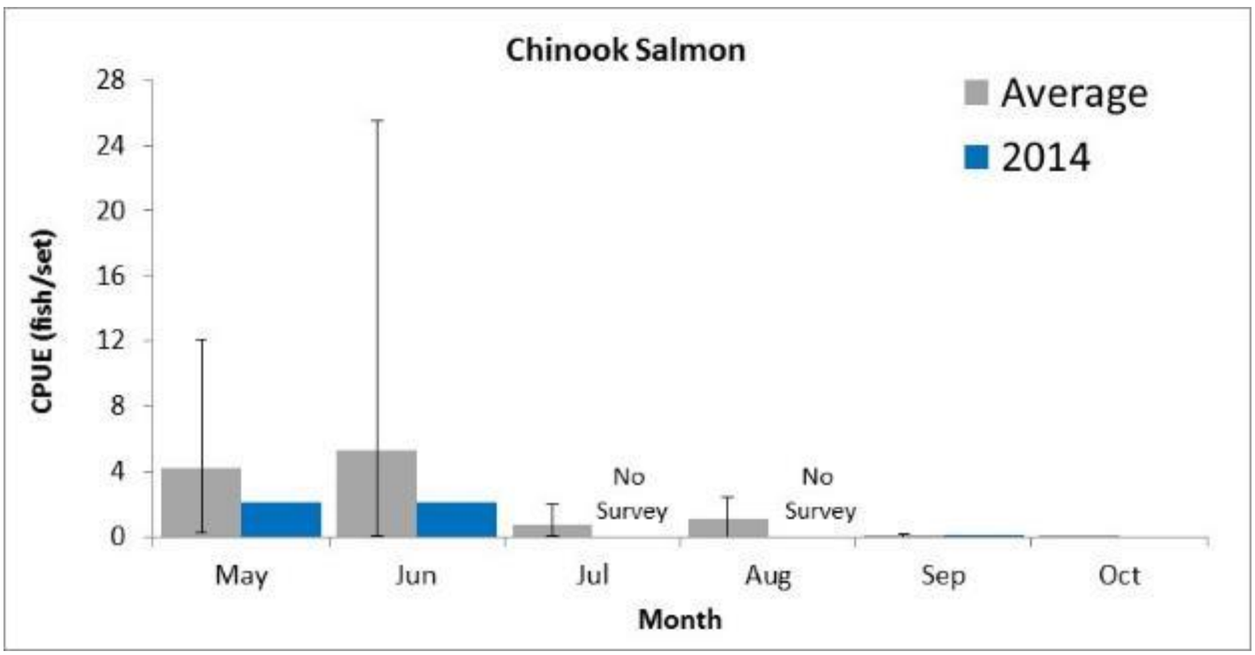


Figure 4.4.11. Seasonal abundance of Chinook salmon smolts captured by beach seine in the Russian River Estuary, 2004-2014. Seining events consisted of 21 to 50 seine sets approximately monthly. October surveys began in 2010. Data from 2004 to 2014 were averaged. Whiskers indicate minimum and maximum values.

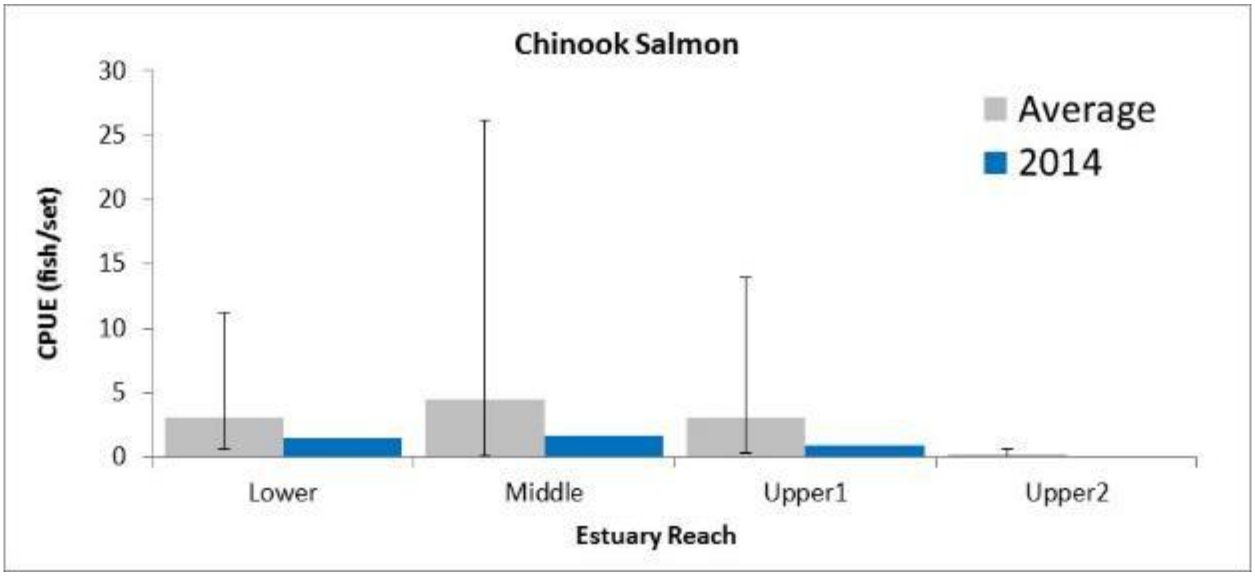


Figure 4.4.12. Spatial distribution of Chinook salmon smolts in the Russian River Estuary, 2004-2014. Fish were sampled by beach seine consisting of 96 to 300 sets annually. Data from 2004 to 2014 were averaged. Whiskers indicate minimum and maximum values. No surveys were conducted in the Upper2 Sub-Reach (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 (Figure 4.4.13). The first coho salmon smolt captured in the Estuary was a single fish in 2006. In 2011 there was a marked increase in captures of 263 coho smolts with a CPUE of 0.9 fish/set. However, 187 of these smolts were captured during a single seine set on May 17 at Patty's Bar station in the Middle Reach. During 2014 the total captures of coho smolts was 19 for a CPUE of 0.10 fish/set. Eight of these smolts were tagged with a coded wire and 2 with a PIT, indicating a hatchery origin from the Coho Salmon Captive Broodstock Hatchery Program. The remaining fish were presumably wild. The relatively low coho salmon captures in the Estuary are related to their scarcity 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 coho salmon smolts were captured during June (Figure 4.4.14). The spatial distribution of coho smolts has varied annually (Figure 4.4.15). In general, most smolts are captured in the Lower and Middle Estuary reaches.

Two of the Estuary-captured coho salmon were PIT-tagged hatchery fish (Mariska Obedzinski, UC extension, unpublished data). Below is a sequence of detections from release to final capture in the Estuary.

> Coho #384.1B796E73EA was released at Purrington Creek on November 13, 2013, passed Green Valley Creek antenna station on May 23, 2014, passed the Northwood antenna station in the lower Russian River on May 26, then was recorded at the Duncans Mills antenna station in the upper Estuary one day later on May 27. The smolt was captured at the River Mouth seining station in the Lower Estuary on June 26 with a fork length of 142 mm and weight of 35.6 g. Apparently, this fish transited from its release creek to the upper Estuary in 4 days and reared in the Estuary for at least 31 days before migrating to the ocean.

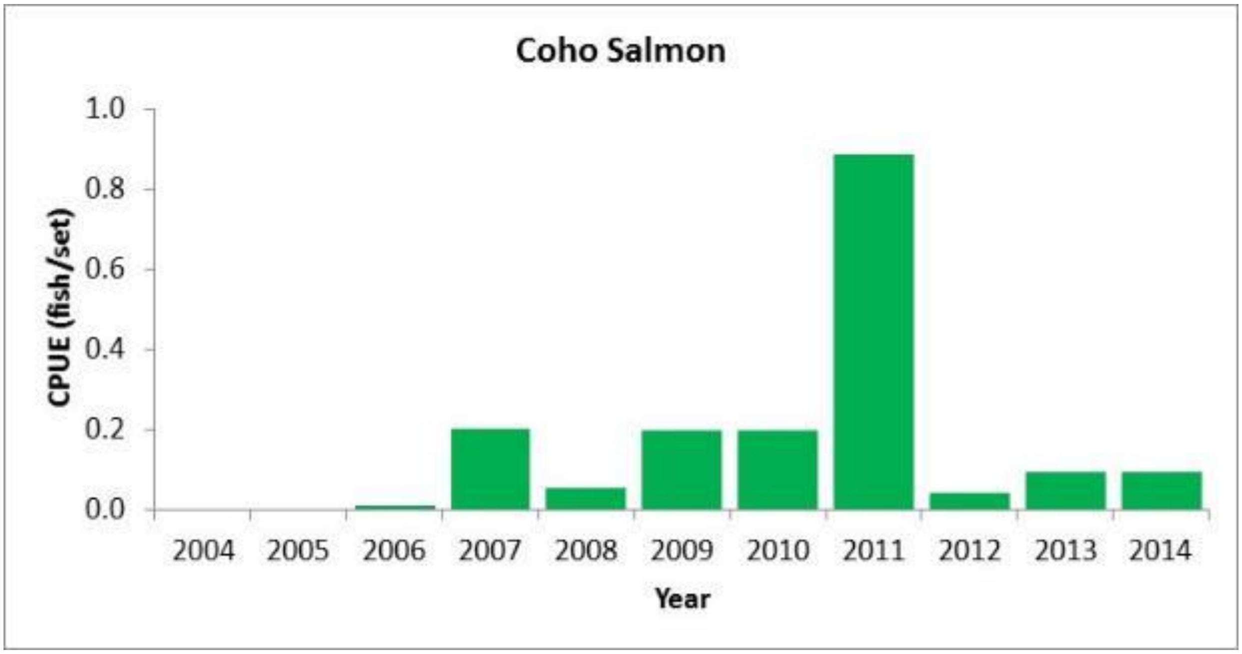


Figure 4.4.13. Annual abundance of coho salmon smolts captured by beach seine in the Russian River Estuary, 2004 to 2014. Samples are from 96 to 300 seine sets yearly from May to October.

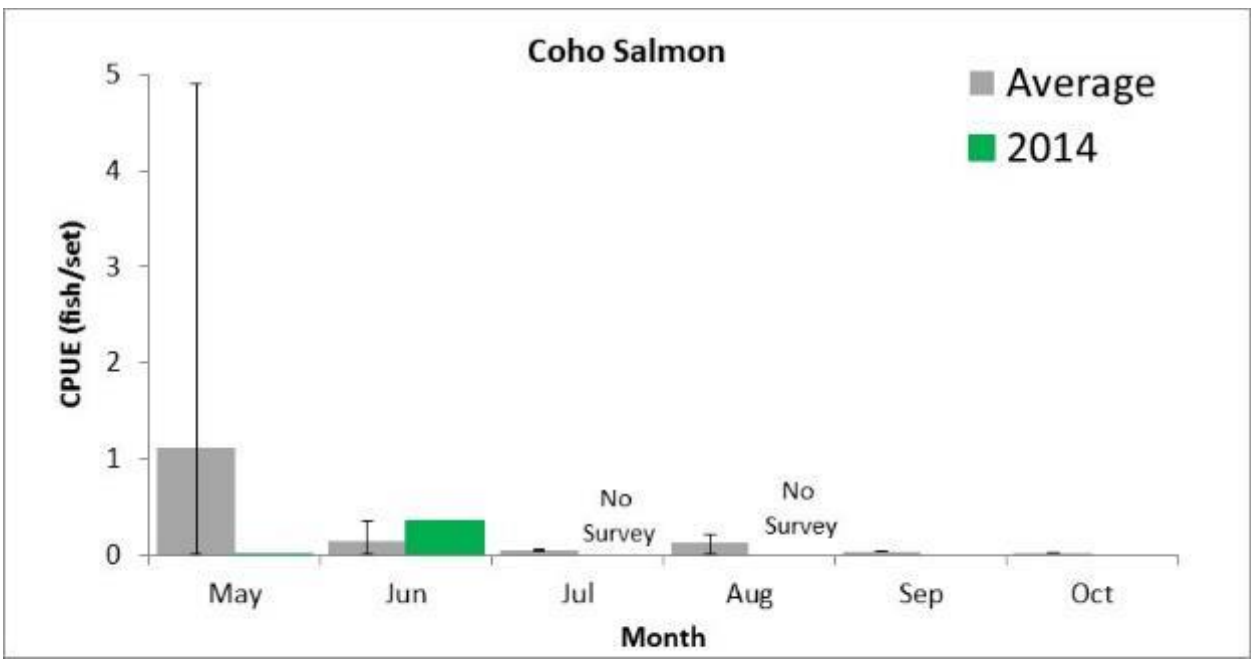


Figure 4.4.14. Seasonal abundance of coho salmon smolts captured by beach seine in the Russian River Estuary, 2004-2014. Seining events consisted of 21 to 50 seine sets approximately monthly. October surveys began in 2010. Data from 2004 to 2012 were averaged. Whiskers indicate minimum and maximum values.

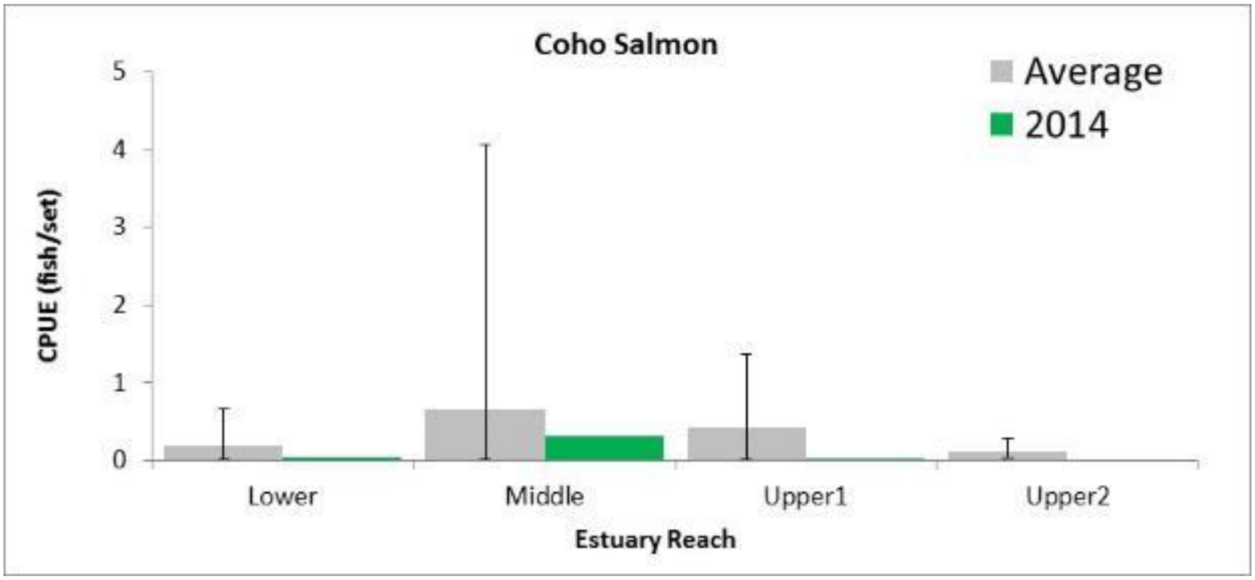


Figure 4.4.15. Spatial distribution of coho salmon smolts in the Russian River Estuary, 2004-2014. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the Upper2 Sub-Reach (Casini Ranch and Moscow Bridge stations) from 2004 to 2009. Data from 2004 to 2014 were averaged. Whiskers indicate minimum and maximum values.

Coho #384.1B796FB9C1 was released in Dutch Bill Creek on June 13, 2013, passed the Dutch Bill lower antenna station on May 9, 2014, and was captured 24 days later on June 2, 2014 at the Bridgehaven seining station in the Middle Estuary. The smolt had a fork length of 134 mm and weight of 30.5 g.

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 during 2014 was 1.2 fish/set (Figure 4.4.16). This low abundance may have been influenced by the reduced seining effort in 2014 where no surveys were conducted during July and August. Typically, juvenile American shad first appear in relatively large numbers in July and the catch usually peaks in August. The highest captures were 24.3 fish/set in 2006. Shad are typically distributed throughout the Estuary, although in 2014 they were only found in the Upper1 Reach (Figure 4.4.17).

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.

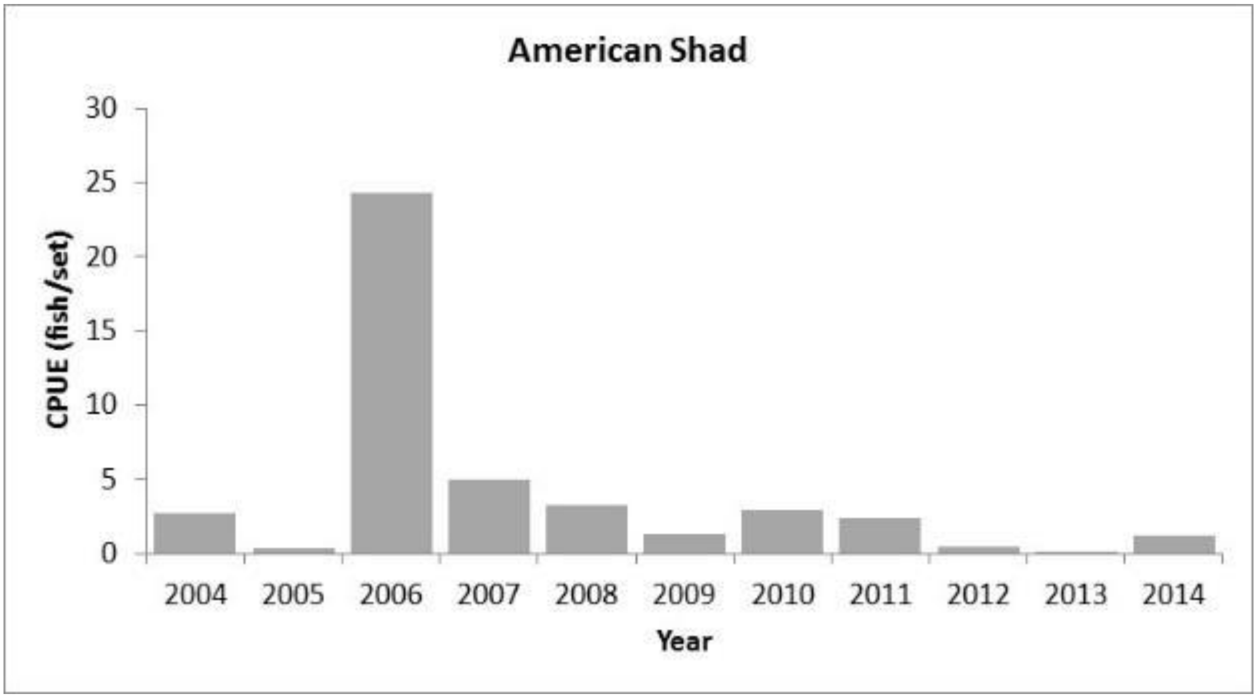


Figure 4.4.16. Annual abundance of juvenile American shad captured by beach seine in the Russian River Estuary, 2004-2014. Samples are from 96 to 300 seine sets yearly from May to October.

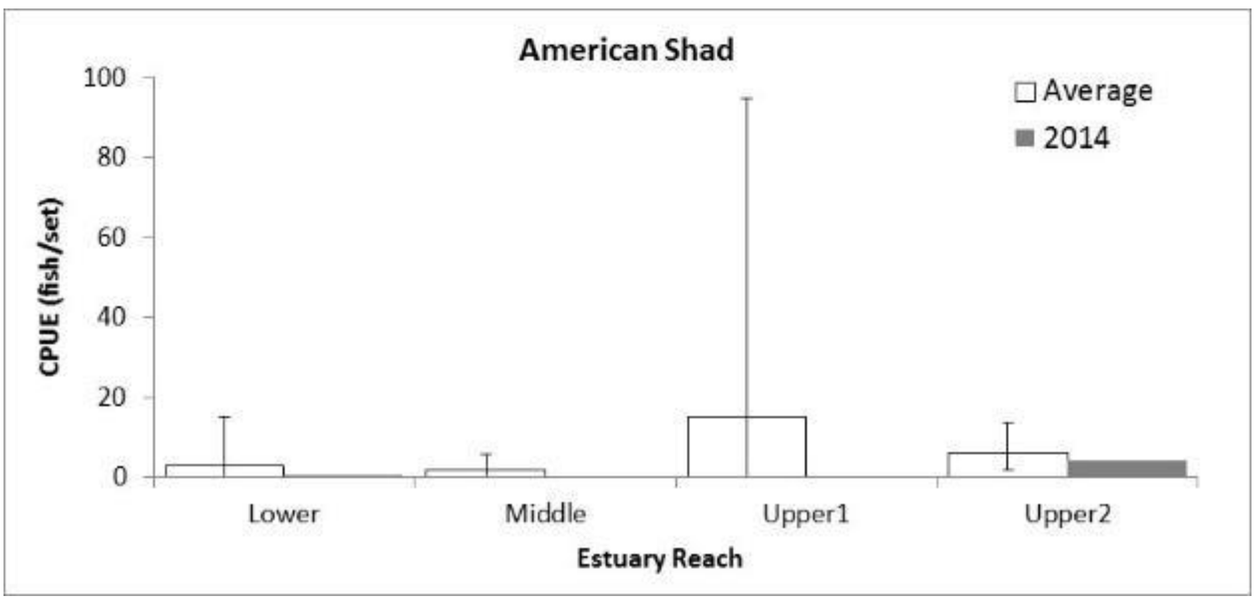


Figure 4.4.17. Spatial distribution of juvenile American shad in the Russian River Estuary, 2004-2014. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the Upper2 Reach during 2004 and 2009. Data from 2004 to 2014 were averaged. Whiskers indicate minimum and maximum values.

Topsmelt is a common fish in the Russian River Estuary. However, the abundance of topsmelt in the Estuary has varied substantially since 2004. After a peak in 2006 with a CPUE of 13.4 fish/set the abundance of topsmelt decreased until 2012 with a CPUE of 0.3 fish/set (Figure 4.4.18). The CPUE in 2014 was the highest on record at 22.2 fish/set. Typically, the catch of topsmelt peaks in July and August. Topsmelt were mainly distributed in the Lower and Middle Reaches, where brackish water conditions are common, and were seldom captured upstream where tidal influences are low (Figure 4.4.19).

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 and 2005 (Figure 4.4.20). Juvenile flounder have been at relatively low abundance since 2006. The CPUE in 2014 1.4 fish/set. 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 4.4.21). Starry flounder have been detected as far as Austin Creek at the upstream end of the Estuary (Cook 2006).

Conclusions and Recommendations

Fish Sampling - Beach Seining

The results of Estuary fish surveys from 2004 to 2014 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 predominantly open river mouth conditions allowing daily tidal circulation in the Estuary. The results of the 2014 fish studies contribute to the 11-year dataset of existing conditions and our knowledge of a tidal brackish system. This baseline data will be used to compare with a closed mouth lagoon system. However, until a prolonged lagoon is formed reducing the seining effort may be acceptable as was the case in 2013 and 2014 when seining surveys were conducted in May, June, and September. Seining surveys are conducted in October 2014 because a mouth closure occurred between September 17 through October 22. However, this late season closure appeared to have little effect on the

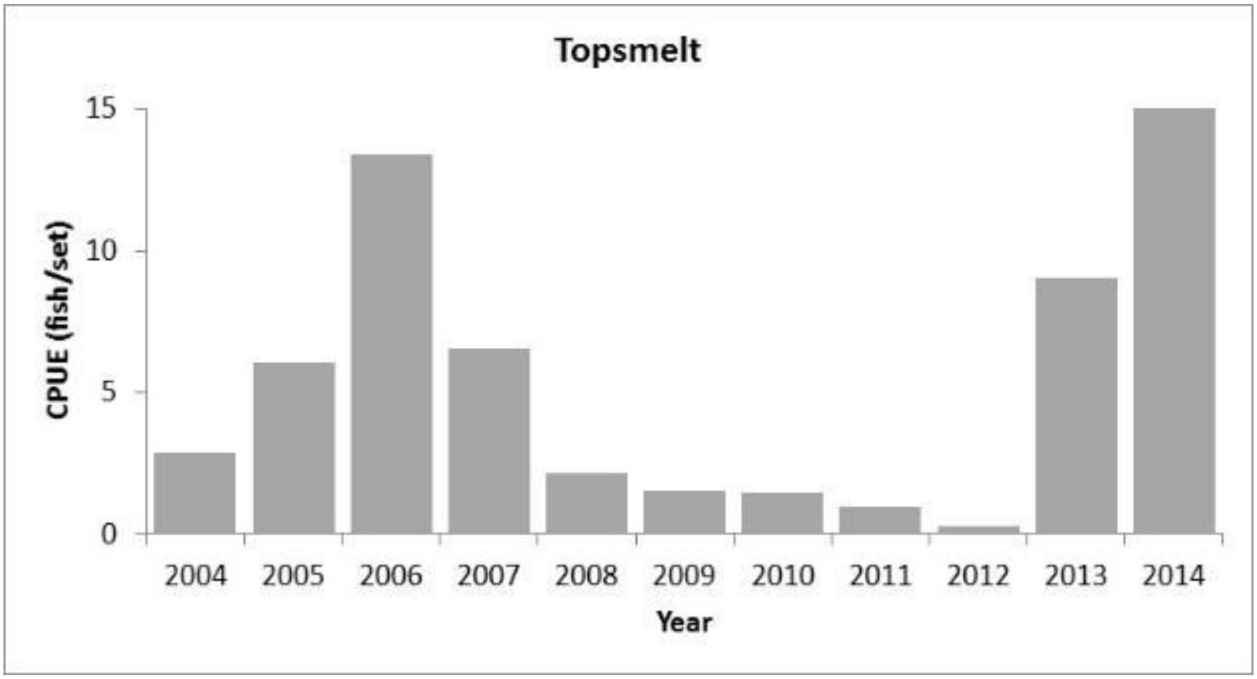


Figure 4.4.18. Annual abundance of topsmelt captured by beach seine in the Russian River Estuary, 2004- 2014. Samples are from 96 to 300 seine sets yearly from May to October.

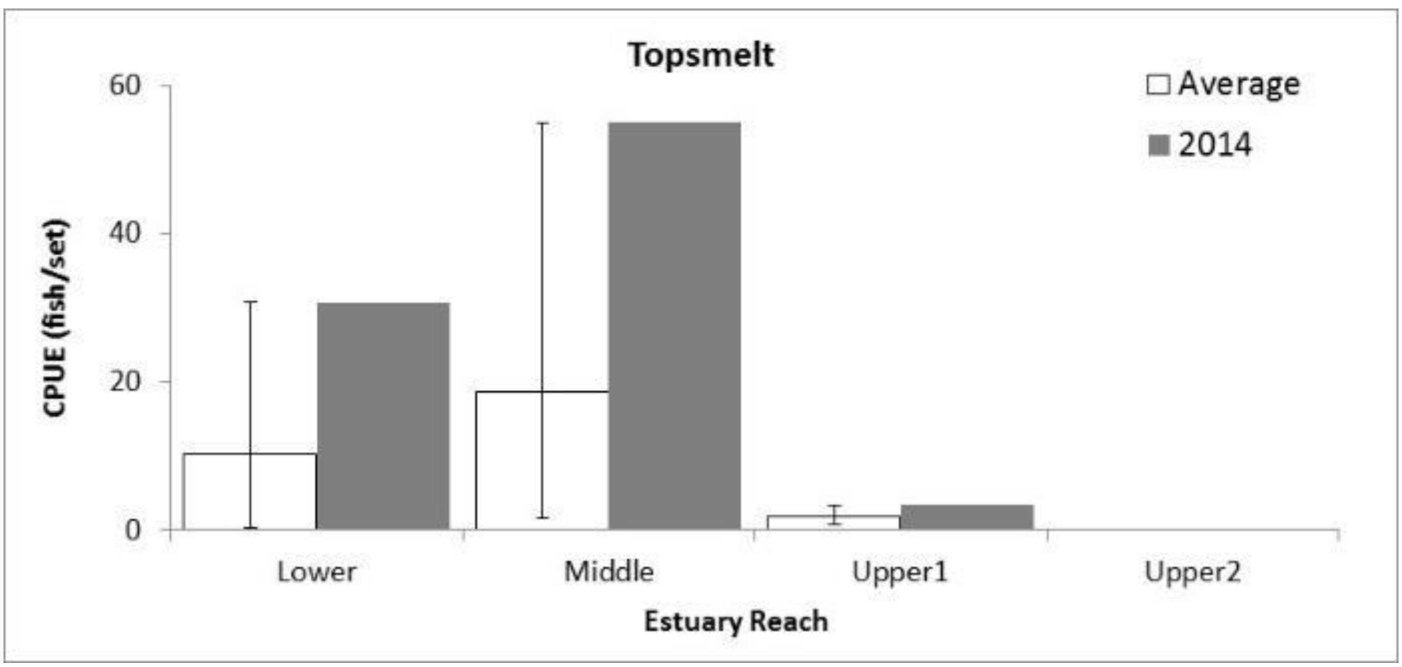


Figure 4.4.19. Spatial distribution of topsmelt in the Russian River Estuary, 2004-2014. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the Upper2 Reach during 2004 and 2009. Data from 2004 to 2014 were averaged. Whiskers indicate minimum and maximum values.

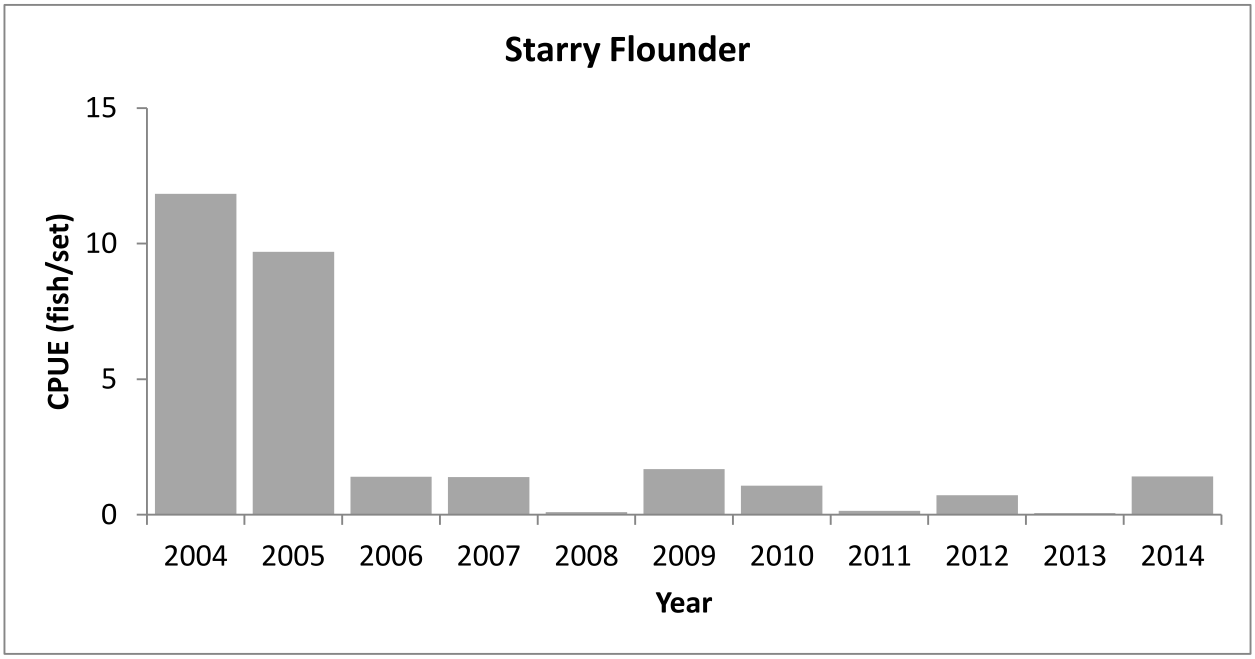


Figure 4.4.20. Annual abundance of juvenile starry flounder captured by beach seine in the Russian River Estuary, 2004-2014. Samples are from 96 to 300 seine sets yearly from May to October.

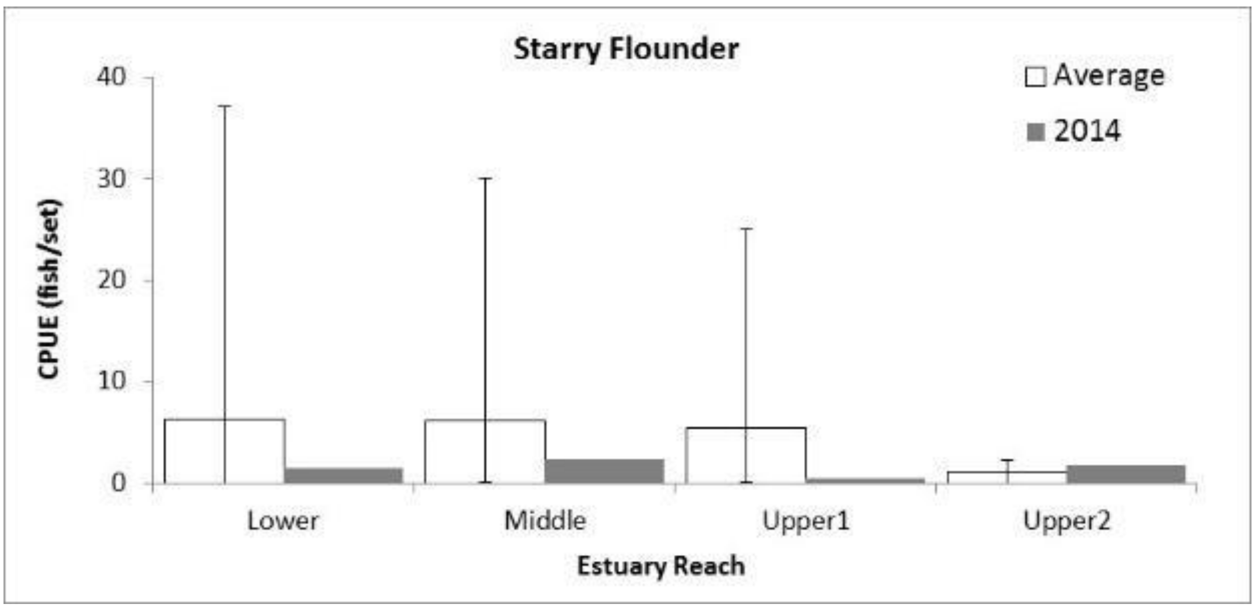


Figure 4.4.21. Spatial distribution of juvenile starry flounder in the Russian River Estuary, 2004-2014. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the upper Estuary during 2004 and 2009. Data from 2004 to 2014 were averaged. Whiskers indicate minimum and maximum values.

steelhead that continued to have low abundance and similar spatial distribution as found before the closure.

The distribution and abundance of salmonids in the Estuary differed spatially, temporally, and by species. Steelhead were usually captured from May to October during each study year. PIT-tagged steelhead showed strong fidelity to specific sites in the Estuary and grew rapidly. This indicates that steelhead rear in the Estuary under current river mouth management conditions.

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.

Although beach seining is widely used in estuarine fish studies, beach seines are only effective 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 quantitative comparisons among reaches and years.

References

Baxter R., K. Hieb, S. DeLeon, K. Fleming, and J. Orsi. 1999. Report on the 1980-1995 fish, shrimp, and crab sampling in the San Francisco Estuary, California. California Department of Fish and Game. Technical Report 63.

Cook, D. G. 2004. Russian River estuary flow-related habitat project, survey methods report 2003. Santa Rosa, (CA): Sonoma County Water Agency. 15 p.

Cook, D. G. 2006. Russian River estuary fish and macro-invertebrate studies, 2005. Sonoma County Water Agency.

Moyle, P. B. 2002. Inland fishes of California. University of California Press. Pp. 502.

Steele, M. A., S. C. Schroeter, and H. M. Page. 2006. Experimental evaluation of biases associated with sampling estuarine fishes and seines. Estuaries and Coasts 29:1172-1184.

4.5 Downstream Migrant Trapping

The Reasonable and Prudent Alternative (RPA) in the Russian River Biological Opinion compels the Water Agency to provide information about the timing of downstream movements of juvenile steelhead, their relative abundance and the size/age structure of the population as related to the implementation of an adaptive management approach to promote formation of a perched freshwater lagoon. 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 (≥age-1) (collectively referred to as juveniles) as well as smolts. In order to help accomplish the objectives listed above, the Water Agency undertook fish capture and PIT-tagging activities at selected trapping sites upstream of the estuary (Figure 4.5.1): Dry Creek; Mainstem Russian River at Mirabel; Mark West Creek; Dutch Bill Creek; and Austin Creek.

Stationary PIT antenna arrays were operated in the following locations:near the mouth of Dry Creek (riverkm 0.36); mainstem Russian River at Nothwood (riverkm 19.16); upstream end of the Russian River Estuary in Duncans Mills (riverkm 10.46); and near the mouth of Austin Creek (riverkm 0.5).

Implementation of the monitoring activities described here are the result of a continually-evolving process of evaluating and improving on past monitoring approaches. 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 and the Mirabel downstream migrant traps on the mainstem Russian are presented elsewhere in this report.

Methods

In 2014 we again relied on downstream migrant traps and stationary PIT antenna arrays at lower-basin trap sites to address the objectives in the RPA. Similar to 2010 through 2013, fish were physically captured at downstream migrant traps (rotary screw trap, funnel trap or pipe trap depending on the site), sampled for biological data and released. PIT tags were applied to a subset of age-0 steelhead captured at trap sites and fish were subject to detection at downstream PIT antenna arrays if they moved downstream into the estuary. In the sections that follow, we describe the sampling methods and analyses conducted for data collected at each site.

Estuary/Lagoon PIT antenna systems

Two antenna arrays with multiple flat plate antennas (antennas designed to lay flat on the stream bottom) were installed in the upper Russian River Estuary near the town of Duncans Mills (riverkm 10.44, 10.46) to detect PIT-tagged fish entering the Estuary (Figure 4.5.2). Generally, 12 antennas were operated continuously from January 1 until July 17 (the period during which Austin Creek remained connected to the mainstem Russian river by surface flow), except for brief periods when we were attempting to run both arrays simultaneously. Unfortunately, we never solved issues related to interference between the arrays and were therefore unable to estimate antenna detection efficiency of the Duncans Mills PIT antenna site.

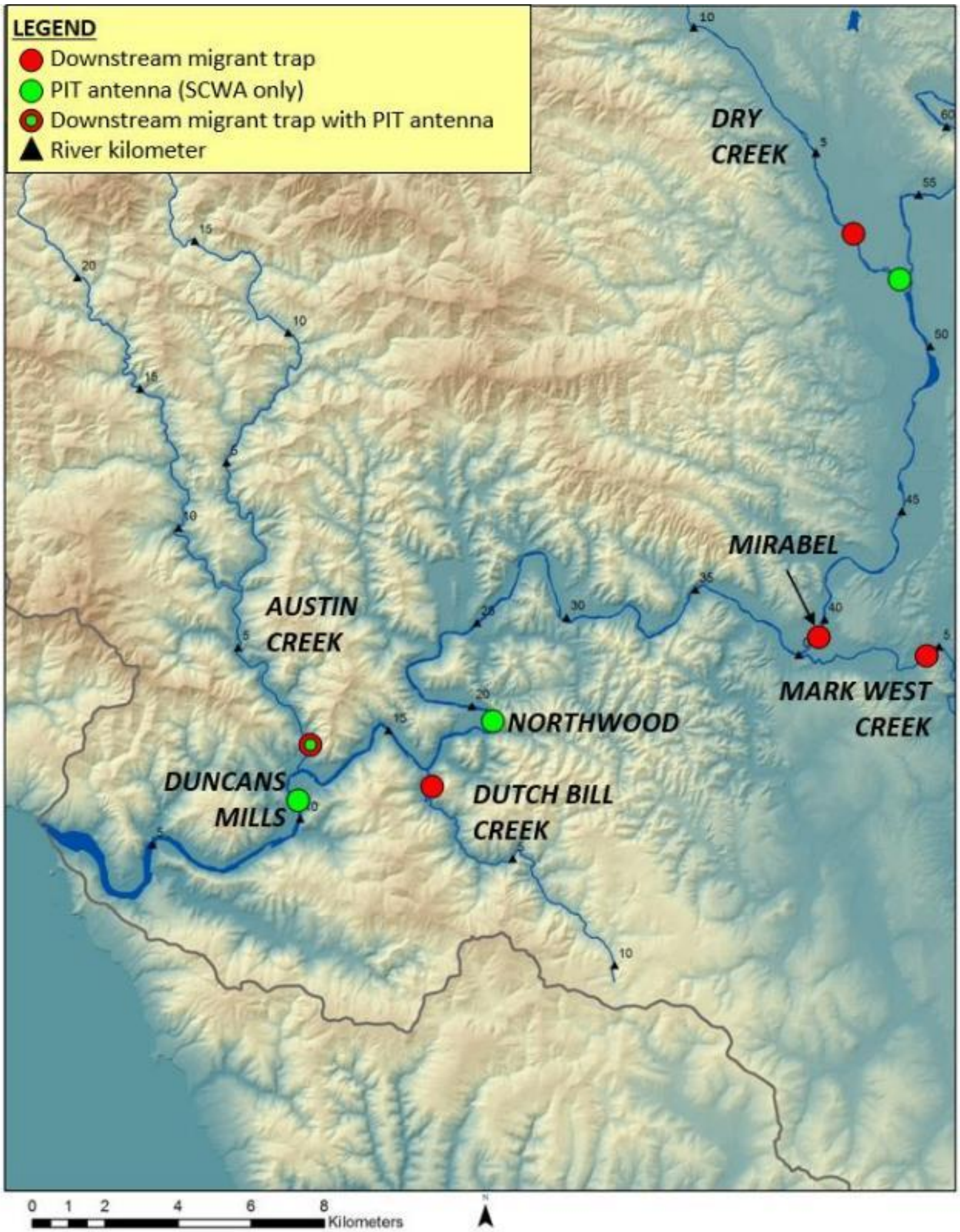


Figure 4.5.1. Map of downstream migrant detection sites in the lower Russian River, 2014. Numbered symbols along stream courses represent distance (km) from the mouth of each stream.

Figure 4.5.2. Flat plate antenna arrays at Duncans Mills (riverkm 10.44 and 10.46). Rectangles represent individual flat plate antennas.

As in 2013, a dual flat plate PIT antenna array was operated in the mainstem Russian River in the vicinity of the golf course near the community of Northwood. The objective of this effort was to provide a means of detecting movements of juvenile steelhead that were PIT-tagged at upstream trap sites that may move into that portion of the mainstem of the Russian River that is non-tidal but can be inundated under perched lagoon or closed river mouth conditions. The antenna array consisted of two PIT antennas oriented so that they spanned approximately 75% of the wetted width including the entire thalweg during open-mouth/non-perched conditions.

Lower River Fish Trapping and PIT tagging

Following consultation with NMFS and CDFW, the Water Agency identified three lower River tributaries (Mark West Creek, Dutch Bill Creek and Austin Creek, Figure 4.5.1) in which to operate fish traps as a way to supplement data collected from the Duncans Mills PIT antenna array and during sampling by beach seining throughout the estuary. In addition to PIT-tagging juvenile steelhead at these sites, juvenile steelhead were also captured and PIT-tagged at the Water Agency’s downstream migrant trapping site on the mainstem Russian River at Mirabel and mainstem Dry Creek near Healdsburg; this resulted in a total of five possible sources of PIT-tagged fish that we could monitor if and when they entered the estuary (Figure 4.5.1). The Water Agency operated three types of downstream migrant traps in 2014: rotary screw trap, funnel trap and pipe trap depending on the stream, water depth, and velocity (Figure 4.5.3). Two rotary screw traps were operated at the Mirabel dam site. 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. All PIT-tagged fish were measured for fork length (±1 mm) and weighed (±0.1 g). Additionally, a subset of all non-PIT-tagged individuals were measured and weighed each day. PIT tags were implanted in a portion of the total number of steelhead YOY and parr captured that were ≥60 mm in fork length. Growth data collected from fish originally PIT-tagged in lower river traps and later recaptured during beach seining surveys is covered in the Synthesis chapter of this report.

Mark West Creek: Rotary screw trap (fished 4/25-5/13) switched to pipe trap (fished 5/14-6/26).

Dutch Bill Creek: Pipe trap (4/19-5/29).

Austin Creek: funnel trap (fished 4/15-6/19).

Figure 4.5.3. Photographs of downstream migrant traps operated by the Water Agency (Mark West, Dutch Bill and Austin Creeks). See other sections of this report for details regarding operation of the Mirabel and Dry Creek traps.

Mainstem Russian River at Mirabel and Dry Creek at Westside Road

Two rotary screw traps (one, 5 foot and one, 8 foot in diameter) adjacent to one another were operated on the mainstem Russian River immediately downstream of the Water Agency's inflatable dam site at Mirabel (approximately 38.7 km upstream of the river mouth in Jenner) from April 23 to July 17 (Table 4.5.1). The purpose of these trapping efforts 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 Mirabel and Dry Creek downstream migrant trapping sites in the Results section.

Table 4.5.1. Installation and removal dates, and total number of days fished for lower river monitoring sites operated by the Water Agency.

Monitoring site (gear type)	Installation date	Removal date	Number of days fished
Dry Creek (DSMT)	3/19	8/14	142
Mirabel (DSMT)	4/23	7/17	70
Mark West Creek (DSMT)	4/25	6/26	61
Northwood (PIT antenna array)	5/5	8/19	106
Dutch Bill Creek (DSMT)	4/19	5/29	37
Austin Creek (DSMT)	4/15	6/19	65
Duncans Mills (PIT antenna array)[1]	continuous (not removed)	continuous (not removed)	entire downstream migration season

[1]See text for details on changes to PIT antenna array throughout the season.

Mark West Creek

A five-foot-diameter rotary screw trap was installed on Mark West Creek approximately 4.8 km upstream of the mouth on April 25. On May 13 the rotary screw trap was removed and replaced with a pipe trap because of low water velocities. The pipe trap was removed and all trapping operations were suspended on June 26 when fish captures dropped off rapidly (Table 4.5.1).

Dutch Bill Creek

A pipe 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 19. The trap was fished until the completion of trapping operations on May 29 when stream flow in lower Dutch Bill Creek became disconnected (Table 4.5.1).

Austin Creek

A rotary screw trap was installed on Austin Creek on April 15. To increase trap efficiency, wood-frame/plastic-mesh weir panels were installed to direct fish and flow into the screw trap.

By early May, the rotary screw trap was not fishing effectively due to low stream velocities; therefore, on May 19 we replaced the rotary screw trap with a funnel net trap that fished through the end of the trapping season on June 19. The funnel trap consisted of wood-frame/plastic-mesh weir panels, a funnel net and a wooden live box. Trapping continued until surface flow in lower Austin Creek was no longer contiguous and daily catches of steelhead dropped to zero (Table 4.5.1).

Steelhead parr were marked with PIT tags and released upstream of the trap in order to measure trap efficiency and estimate population size of fish passing the trap site. We operated a dual PIT antenna array approximately 0.2 km downstream of the rotary screw trap and approximately 0.5 km upstream from the mouth of Austin Creek in order to detect PIT-tagged steelhead moving out of Austin Creek (Figure 4.5.4). The PIT antenna array was located at the upstream extent 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. A second PIT tag antenna array located in the Russian River estuary at Duncans Mills (approximately 1.5 km downstream) was used to calculate antenna efficiency for the PIT antenna array located in Austin Creek.

Results

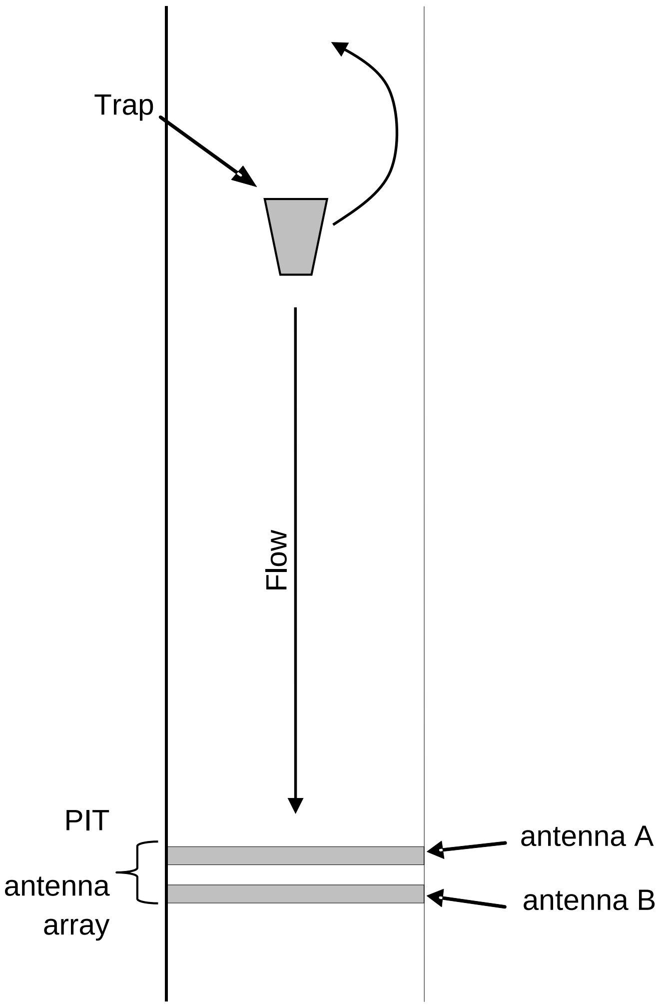
Stream flow largely dictates when downstream migrant traps can be installed (Figure 4.5.5). Our sampling period most likely encompassed a high portion of the juvenile steelhead movement period but we probably missed a substantial portion of the steelhead smolt migration period.

Estuary/Lagoon PIT antenna systems

Steelhead

Steelhead were most frequently encountered in Dry and Austin Creeks while only 60 steelhead were captured in Mark West Creek (Figure 4.5.6). Of the 2,078 juvenile steelhead that were PIT-tagged in downstream migrant traps in 2014, 165 (7.9%) were detected on the PIT antenna array at Duncans Mills (Table 4.5.2). Reasons for non-detection include an unknown number of fish that simply did not move into the estuary as well fish that moved into the tidal portion of the estuary but were not detected due to imperfect PIT antenna array detection efficiency at Duncans Mills.

Trapping operations in Dry Creek allowed us to PIT tag significantly more steelhead in 2014 than would have been possible without operating this trap site. Nearly two-thirds of the fish tagged in 2014 were tagged at Dry Creek (Table 4.5.3).



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 either antenna in 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 4.5.4. Diagram illustrating the relative location of the downstream migrant trap and PIT antenna array operated on Austin Creek and outline of how antenna efficiency was estimated.

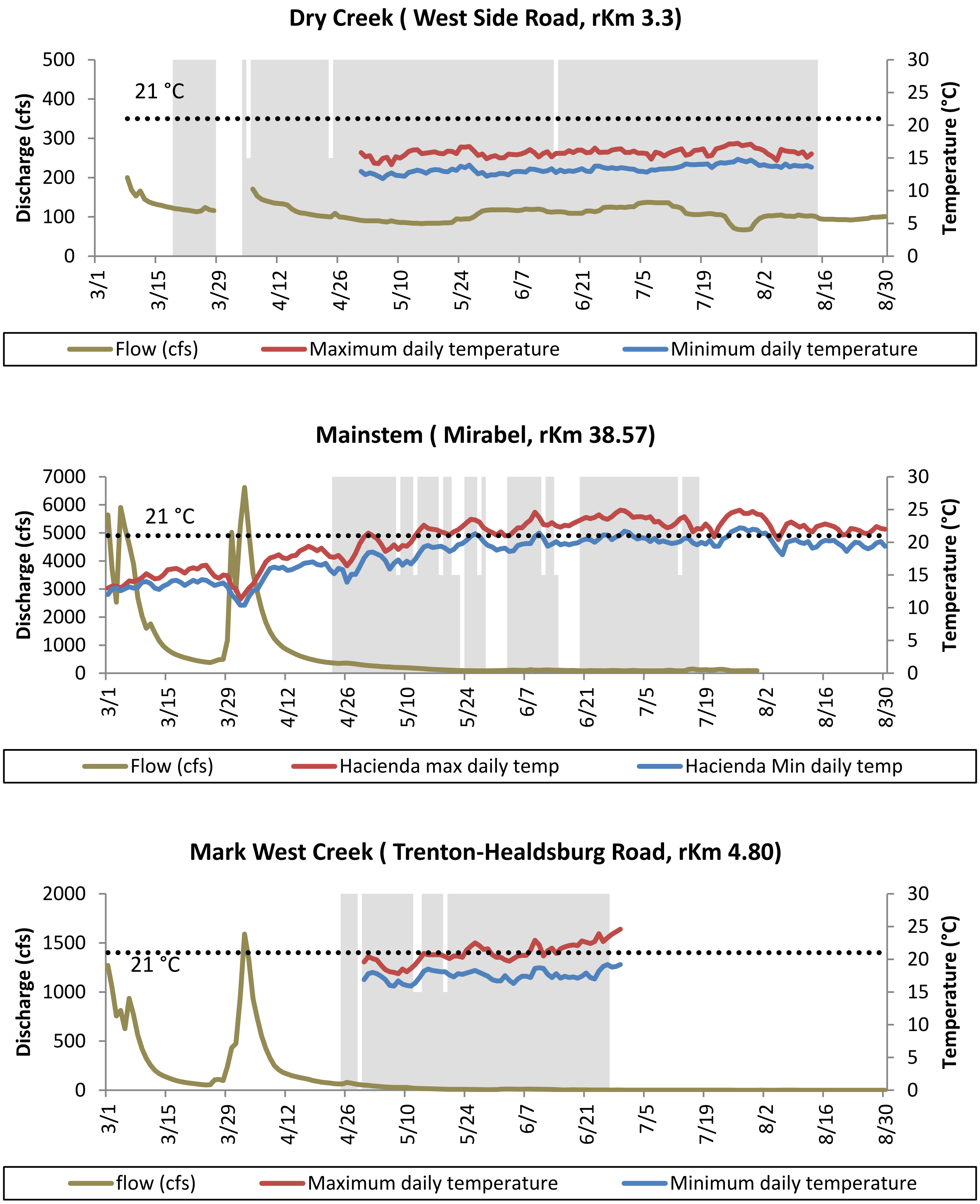
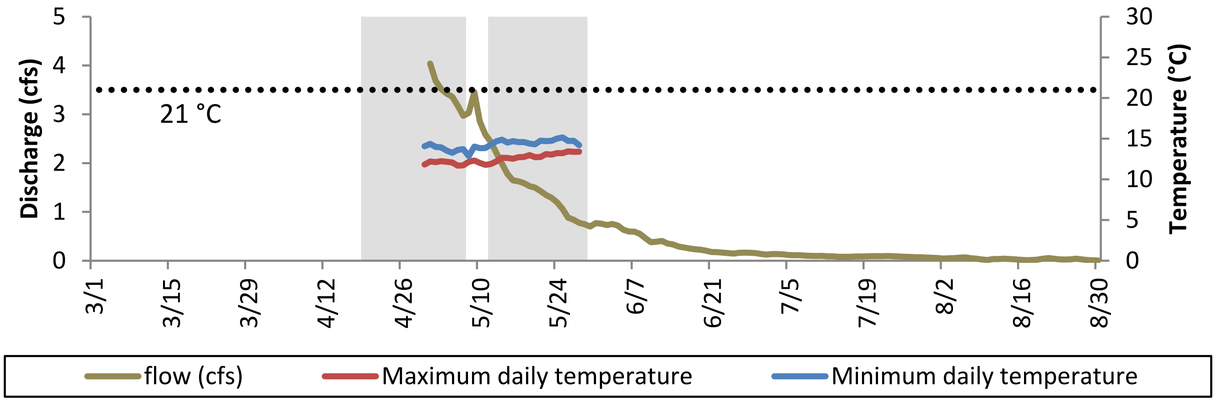
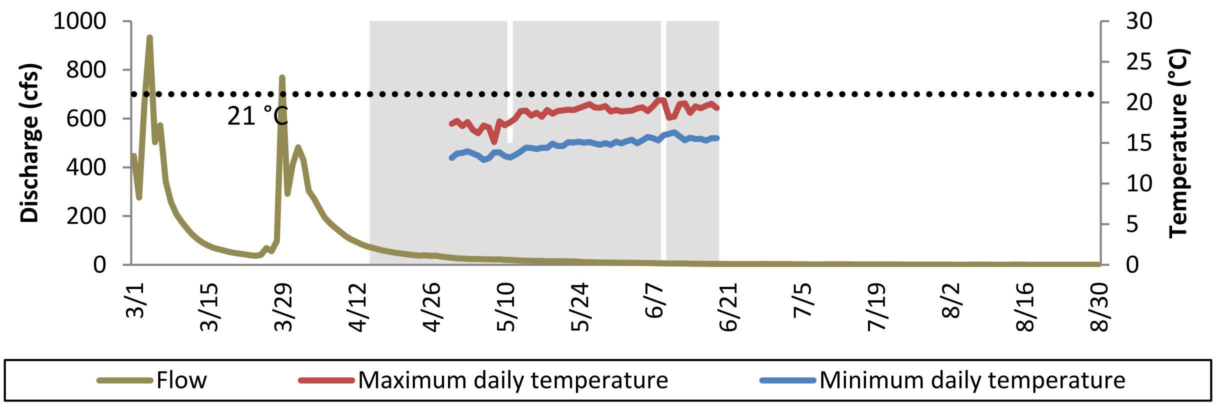


Figure 4.5.5. Environmental conditions at downstream migrant detection sites from March 1 to August 31, 2014. Gray shading indicates the proportion of each day that each facility was operated and discharge data are from the USGS gage at Hacienda (mainstem Russian, 11467000), the USGS gage at Trenton-Healdsburg Road (Mark West Creek, 11466800), a gage operated by CEMAR on Dutch Bill Creek and the USGS gauge at Cazadero (Austin Creek, 11467200). Stage data for the estuary are from the Jenner gage. Temperature data are from the data loggers operated by the Water Agency at each monitoring site. The 21°C line represents the temperature limit above which the Water Agency is only permitted to identify and count captured fish (i.e., fish cannot be measured, weighed or PIT tagged).

Dutch Bill Creek (Monte Rio Park, rKm 0.28)



Austin Creek (Gravel Mine, rKm 1.10)



Estuary (Duncans Mills, rKm 10.46)

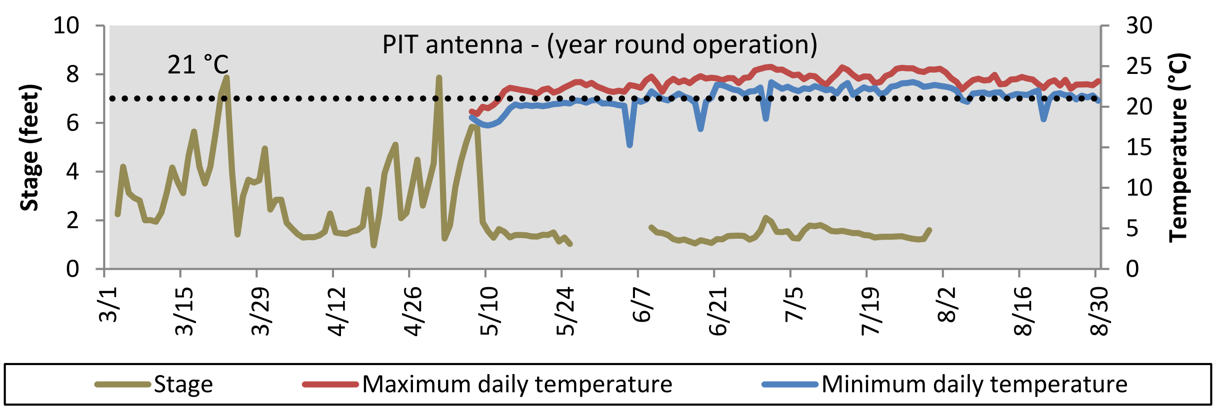


Figure 4.5.5. (cont.)

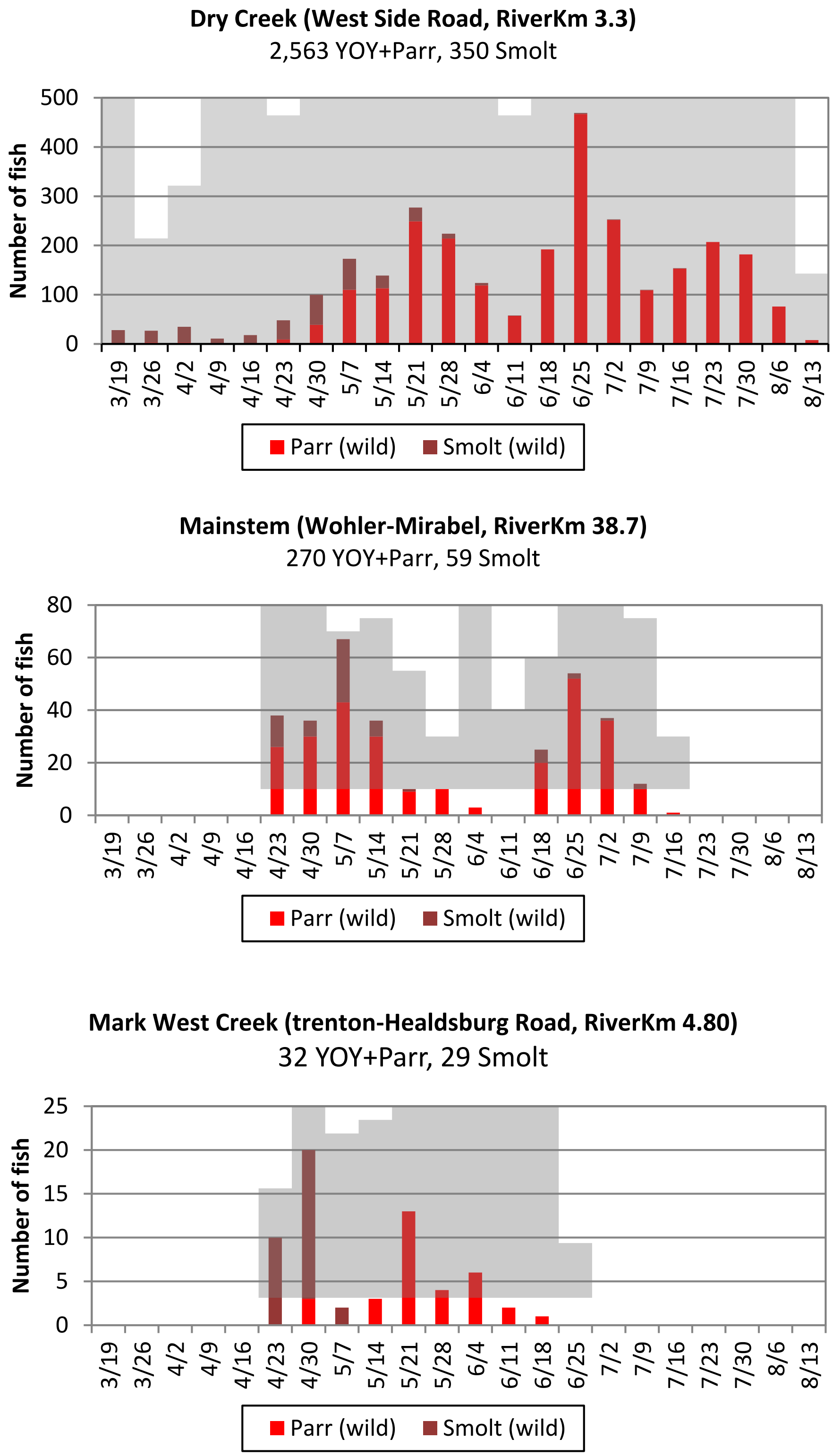
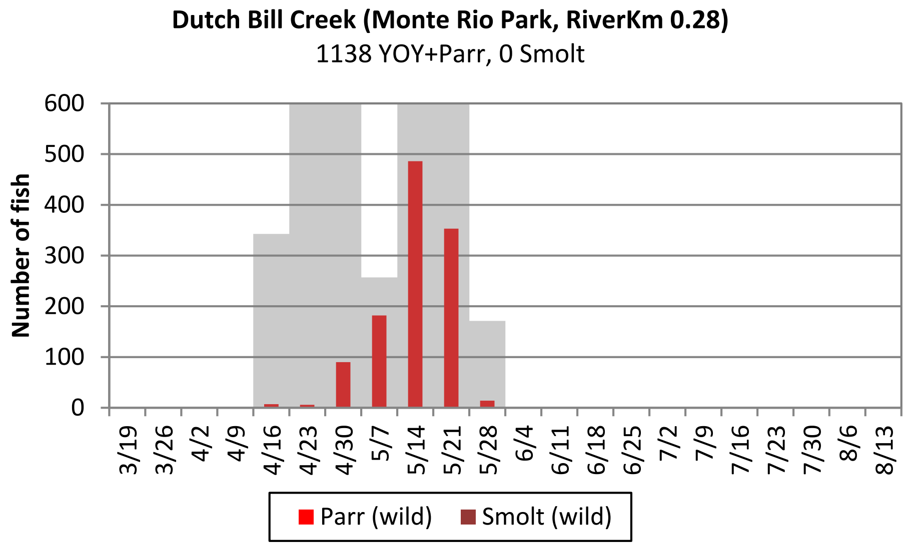


Figure 4.5.6. Weekly capture of steelhead by life stage at lower river downstream migrant trapping sites, 2014. Gray shading indicates portion of each week trap was fishing. Note the different vertical scale among plots for each site.



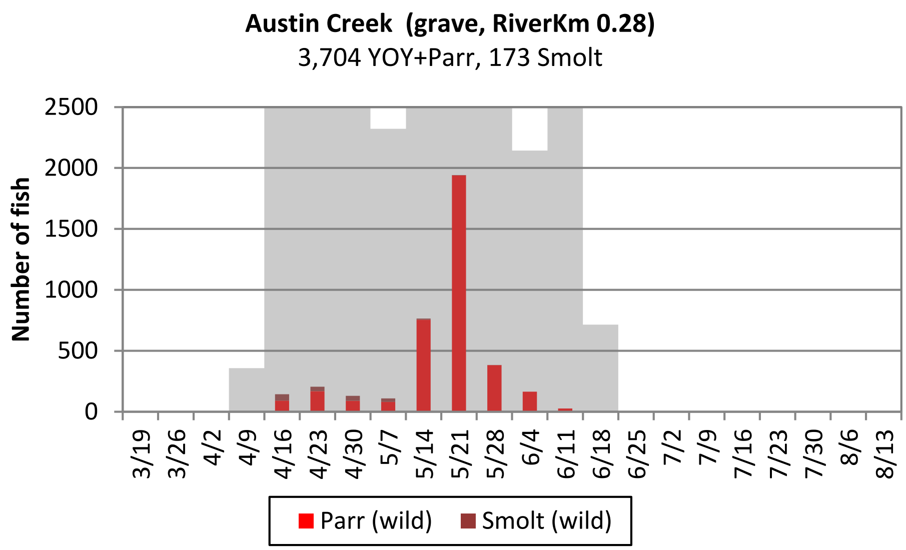


Figure 4.5.6 (cont.)

Table 4.5.2. The number of steelhead captured at downstream migrant traps, the number PIT tagged and the number detected on the Duncans Mills PIT tag detection systems, 2014.

Site	Number Captured	Number PIT-Tagged	Number (proportion) Detected at Duncans Mills
Dry Creek	2,913	1,348	1 (0.07%)
Mainstem	329	101	0 (0.0%)
Mark West Creek	61	18	0 (0.0%)
Dutch Bill Creek	1,183	21	2 (9.3%)
Austin Creek	3,877	590	162 (27.5%)
Total	**8,363**	**2,078**	**165 (7.9%)**

Table 4.5.3. Number of steelhead juveniles PIT-tagged at downstream migrant traps, 2009-2014.

Site	2009	2010	2011	2012	2013	2014
Dry Creek	no tagging	no tagging	no tagging	no tagging	2,703	1,348
Mainstem	5	96	99	315	100	101
Mark West Creek	not fished	not fished	not fished	43	135	18
Dutch Bill Creek	not fished	46	22	6	12	21
Austin Creek	not fished	996	500	1636	1749	590
Total	**5**	**1,138**	**621**	**2,000**	**4,699**	**2,078**

With the exception of 2011, fewer steelhead were captured and available for tagging at Austin Creek than in all previous years. Over the course of the season, 3,877 steelhead were captured of which 1,137 were YOY (541 of the 1,137 YOY were ≥60 mm, Figure 4.5.11). Although we applied PIT tags to 590 total individuals (YOY+parr), we estimate that, based on their size, 483 were YOY. In total, 214 PIT-tagged steelhead were released upstream of the trap and 269 were released downstream of the trap (Table 4.5.3). Because 275 of the 483 PIT-tagged YOY were detected on the PIT antenna array downstream of the trap in Austin Creek, we have high certainty that at least 57% (275/483) moved downstream into the estuary/lagoon. Because of imperfect antenna detection efficiency, we expanded those minimum counts that were based only on PIT-tagged YOY to the entire population of YOY in the vicinity of the Austin Creek trap (both tagged and untagged) as follows.

Of the 162 individuals detected on the downstream antenna in the array, 129 were also detected on the upstream antenna in the array resulting in an estimated antenna efficiency of 79.6 % (129/162). In order to estimate the number of YOY out of the original 483 that actually moved downstream of the Austin antenna array, we used this proportion to expand the 275 detections to 345 (275/79.6%).

Of the 57 YOY detected on the downstream PIT antenna array that were released upstream of the trap, two were first recaptured in the trap resulting in an estimated trap efficiency of 3.5% (2/57). Because recapture numbers were so low, we did not attempt to estimate the population size of steelhead YOY moving past the trap site which meant we also could not estimate the number of YOY that emigrated to the Estuary.

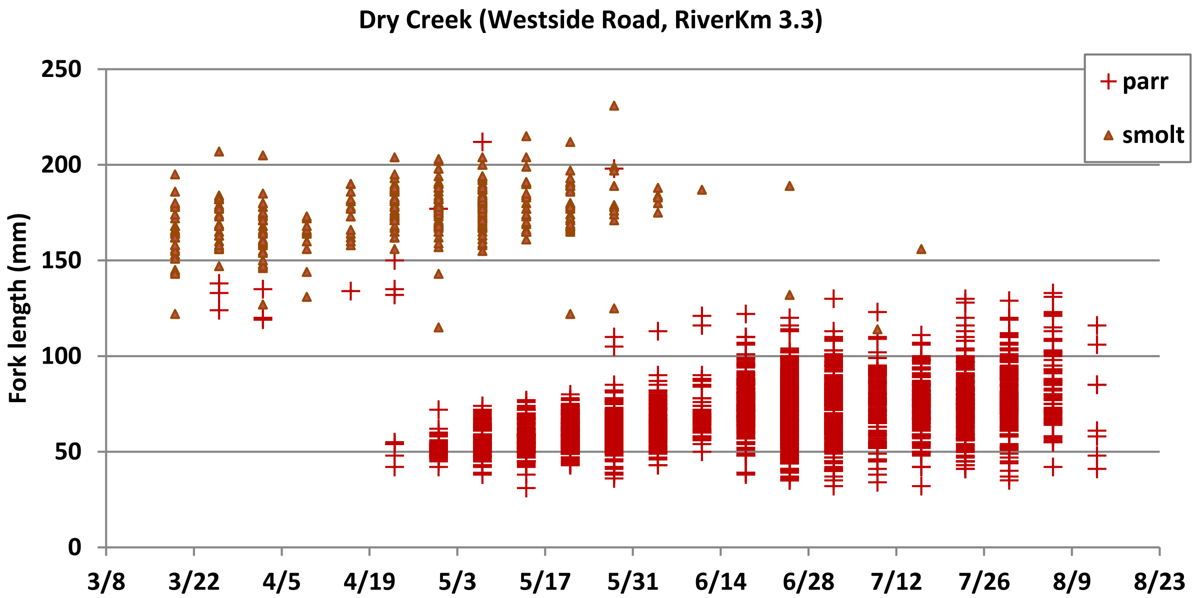
When compared to Dry and Austin creeks fewer numbers of juvenile steelhead were captured at Mirabel, Mark West and Dutch Bill Creeks (Figure 4.5.6) meaning that fewer numbers of juvenile steelhead were PIT-tagged at these locations (Table 4.5.3). Fork lengths of fish caught at these traps show at least 3 year classes with steelhead YOY present at each of the trapping locations (Figure 4.5.7). As in other years, we assume that the few steelhead smolts captured at any of the trap sites 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 have been variable (Figure 4.5.9 through Figure 4.5.12).

Only one of the 1,354 juvenile steelhead PIT-tagged on Dry Creek was detected at the Northwood antenna. This same individual was also detected at the Duncans Mills antenna array and it represented the only individual tagged at Dry Creek and detected at Duncans Mills. In 2013, 45% (1,212) of the 2,702 fish that were PIT-tagged on Dry Creek were detected leaving Dry Creek (detected at PIT antenna at river km 0.36, Martini-Lamb 2014). However in 2014 only 12% (162) of the 1,354 steelhead PIT tagged at Dry Creek were detected leaving Dry Creek. Without being able to estimate antenna efficiency at Northwood and Duncans Mills for steelhead, we were unable to conclude the fate of steelhead leaving Dry Creek.

Table 4.5.4. PIT tag and trap capture metrics and values for YOY steelhead in Austin Creek. Note that 2010 numbers differ from Martini-Lamb and Manning (2011) because they have been adjusted to only include YOY.

Metric	2010	2011	2012	2013	2014
Number PIT-tagged YOY released upstream of trap	765	324	1,356	0	214
Number PIT-tagged YOY released downstream of trap	195	2	162	1,746	269
Number PIT-tagged YOY detected on antenna array that were tagged in Austin Creek	547	131	574	1,335	275
Number PIT-tagged YOY released upstream & detected on antenna array	389	131	486	0	57
Number released upstream & recaptured in trap & detected on antenna	47	8	196	0	2
ESTIMATED TRAP EFFICIENCY	**12.1%**	**6.1%**	**40.3%**	**N/A**	**N/A**
Number YOY+parr detected on both antennas in array	241	93	85	399	129
Number YOY+parr detected on downstream antenna only	288	178	129	463	162
ESTIMATED ANTENNA EFFICIENCY	**83.6%**	**52.2%**	**65.9%**[1]	**86.2%**[1]	**79.6%**[1]
Number YOY captured and PIT-tagged	960	324	1,518	1,746	483
Total number of YOY captured (≥60 mm only)	2,617	453	2,341	4,216	541
ESTIMATED NUMBER OF PIT-TAGGED YOY EMIGRANTS (≥60 mm only)	**632**	**251**	**759**	**1,549**	**325**
ESTIMATED PROPORTION OF PIT-TAGGED YOY THAT EMIGRATED (≥60 mm only)	**65.8%**	**77.5%**	**50%**	**88.5%**	**67.3%**
ESTIMATED POPULATION SIZE OF YOY AT TRAP	**21,628**	**7,426**	**5,804**	**N/A**	**N/A**
ESTIMATED NUMBER OF YOY IN POPULATION THAT EMIGRATED	**14,231**	**5,755**	**2,901**	**N/A**	**N/A**

[1]Efficiency is based on detections of PIT-tagged fish at Duncans Mills.



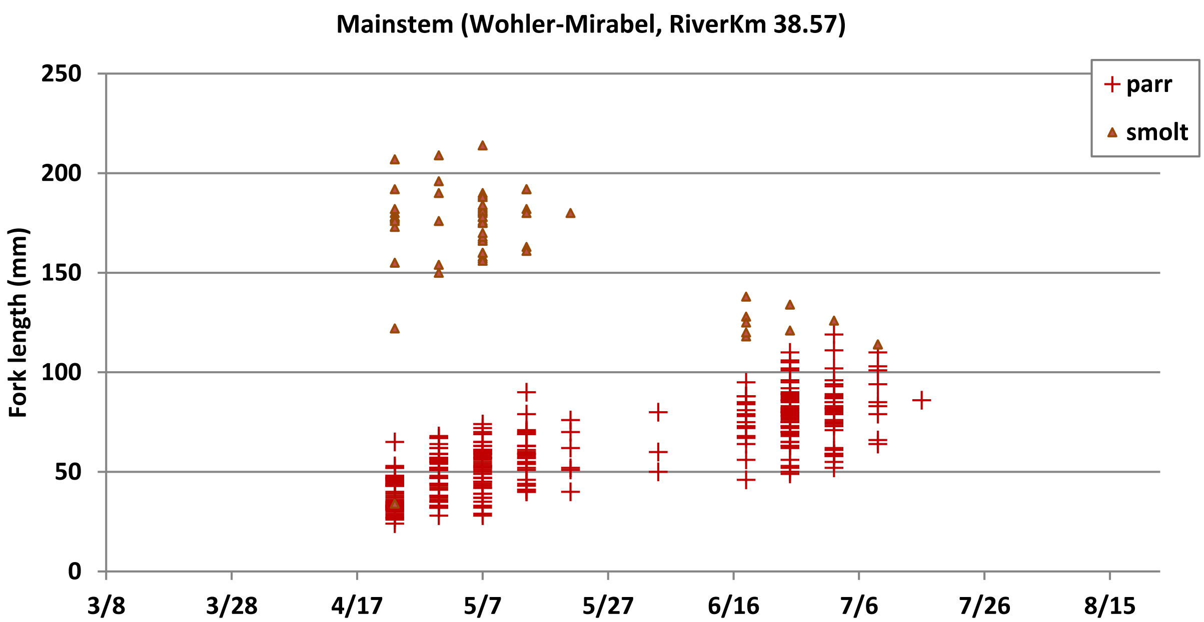
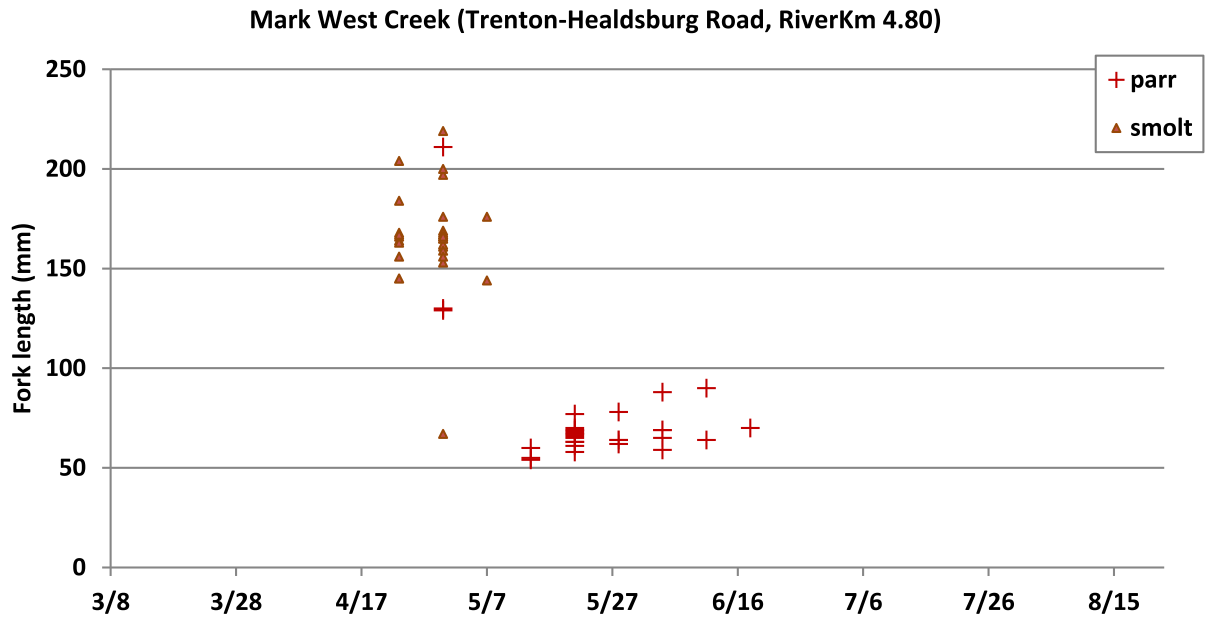


Figure 4.5.7. Weekly fork lengths of steelhead captured at lower river downstream migrant trap sites, 2014.



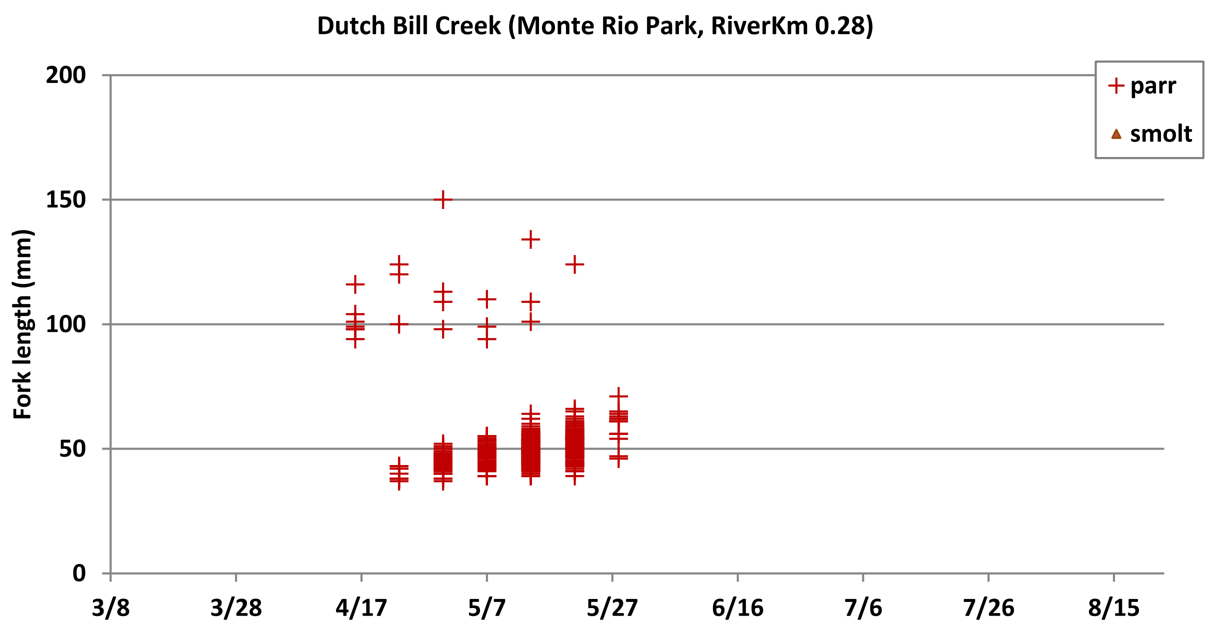
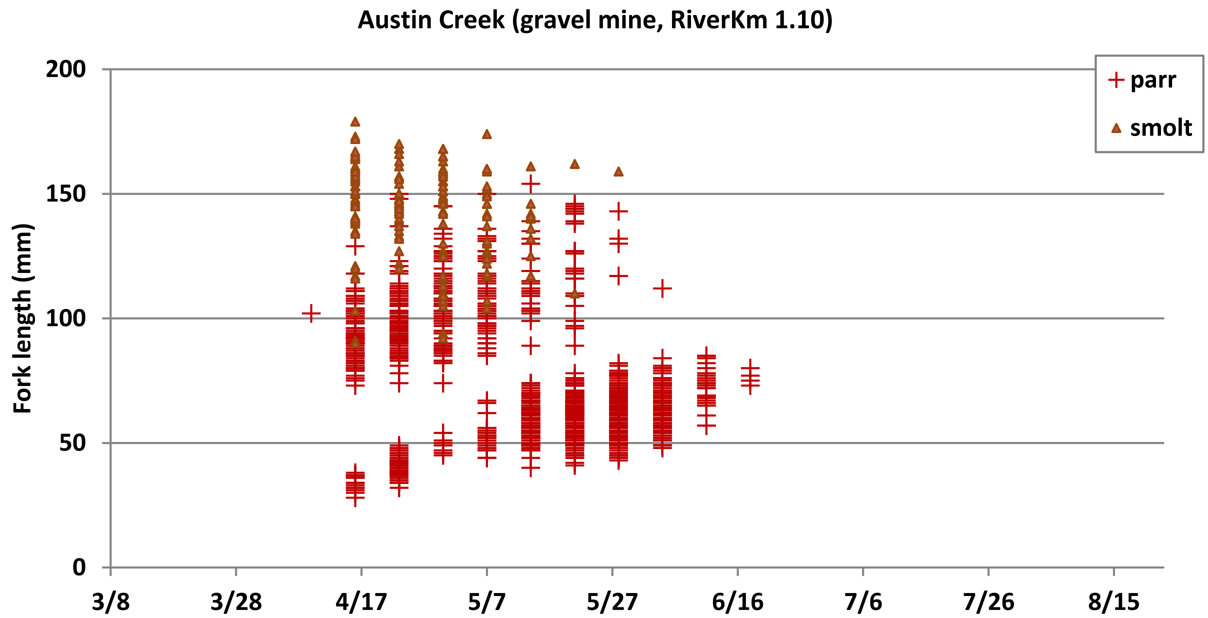


Figure 4.5.7 (cont).



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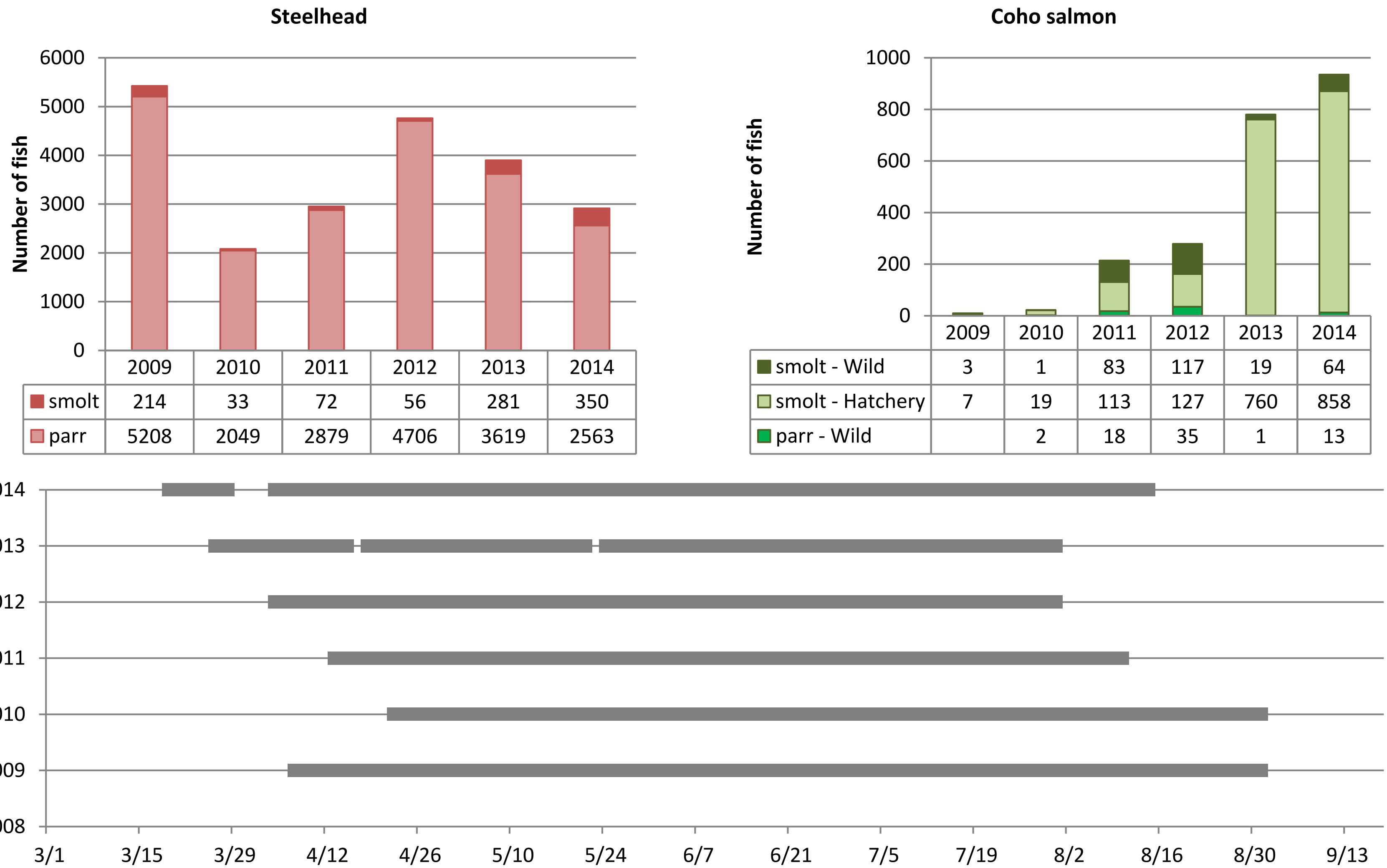


Figure 4.5.8. Number of steelhead and coho salmon captured by life stage and origin at the Dry Creek downstream migrant trap (upper panels) and duration and timing of trap operation (lower panel), 2009-2014.

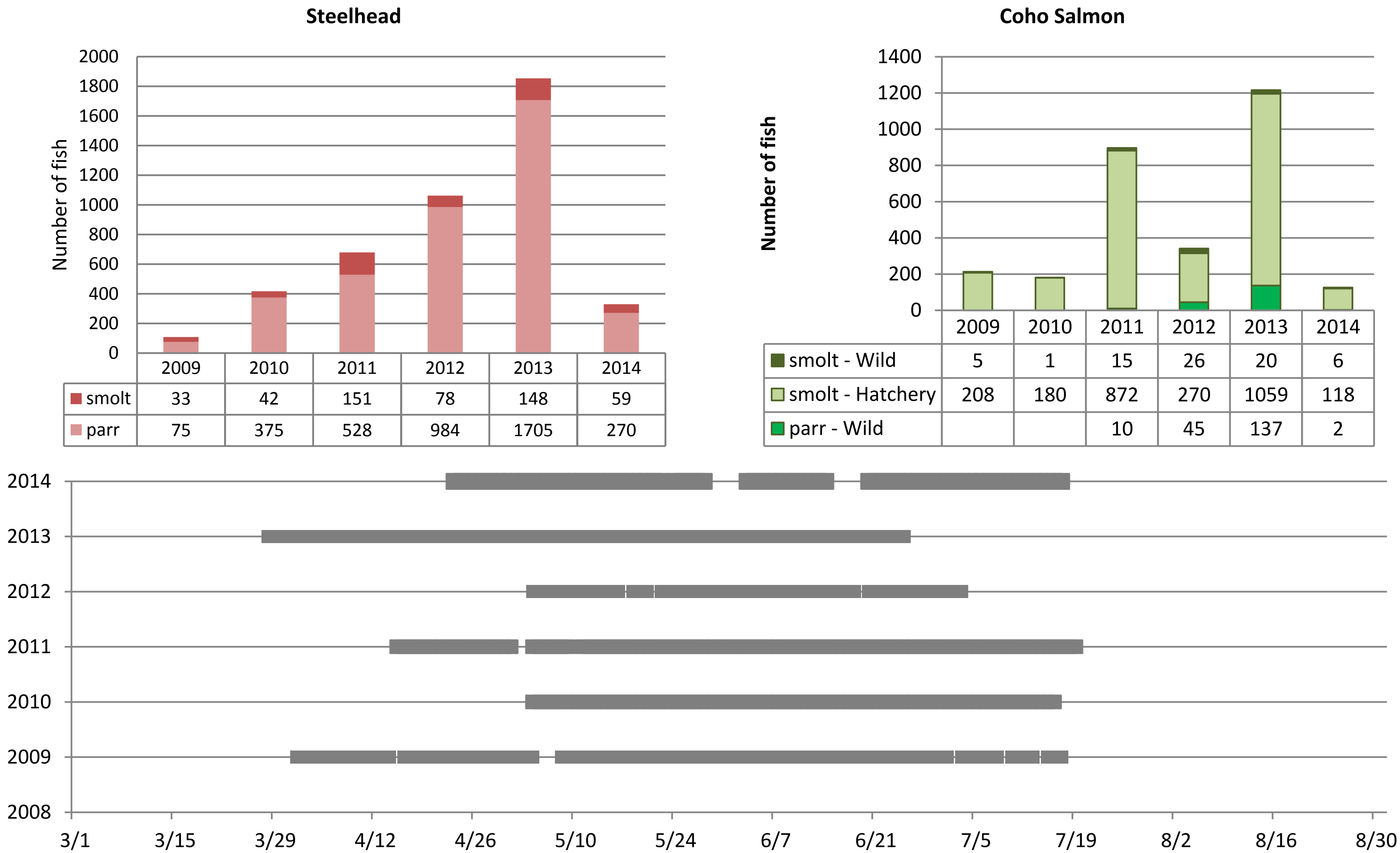


Figure 4.5.9. Number of steelhead and coho salmon captured by life stage and origin at the Mainstem downstream migrant trap, (upper panels) and duration and timing of trap operation (lower panel), 2009-2014.

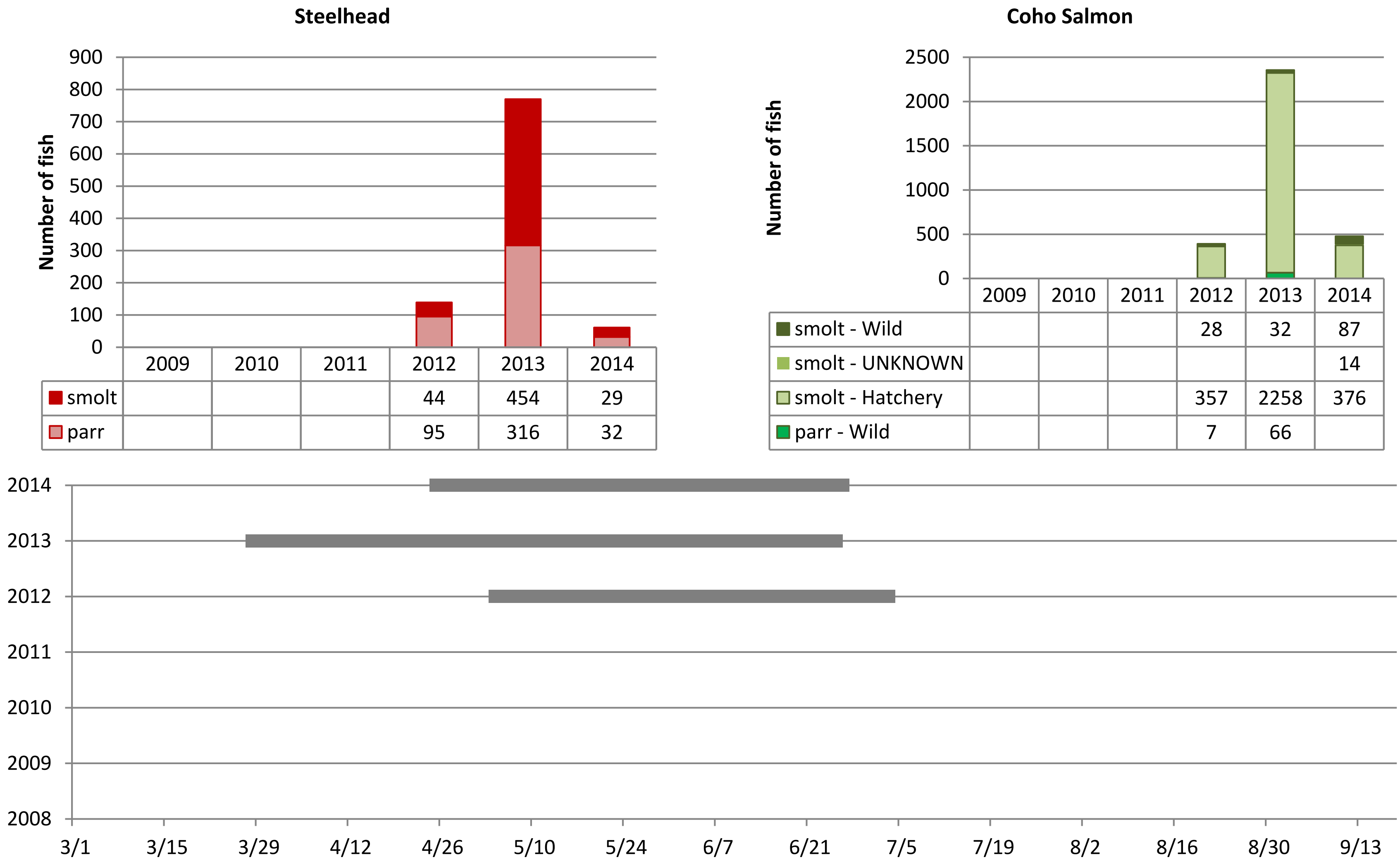
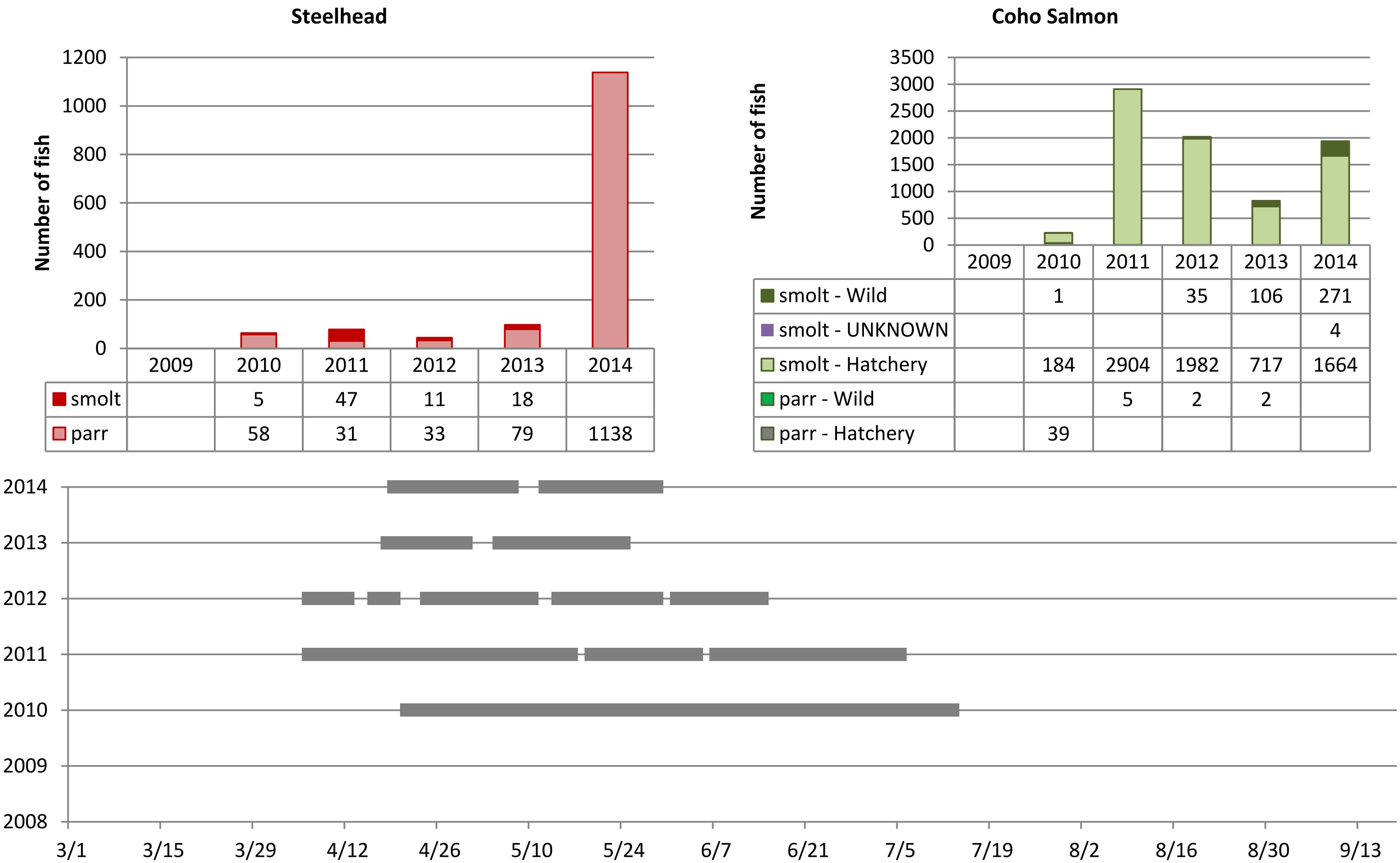


Figure 4.5.10. Number of steelhead and coho salmon captured by life stage and origin at the Mark West Creek downstream migrant trap, (upper panels) and duration and timing of trap operation (lower panel), 2009-2014.



Steelhead

	2009	2010	2011	2012	2013	2014
smolt		5	47	11	18	
parr		58	31	33	79	1138

Coho Salmon

	2009	2010	2011	2012	2013	2014
smolt - Wild		1		35	106	271
smolt - UNKNOWN						4
smolt - Hatchery		184	2904	1982	717	1664
parr - Wild			5	2	2	
parr - Hatchery		39				

Figure 4.5.11. 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), 2009-2014.

Steelhead	2009	2010	2011	2012	2013	2014
smolt		213	175	164	14	173
parr		4682	1829	3672	7397	3704

Coho Salmon	2009	2010	2011	2012	2013	2014
smolt - Wild				37	12	399
smolt - Hatchery		103	335	507	74	899
parr - Wild			14	372	38	4
parr - Hatchery		1906	45	584	24	

Figure 4.5.12. 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), 2009-2014.

Coho

At Mirabel, 118 hatchery smolts, 6 wild smolts, and 2 wild parr were captured (Figure 4.5.9 and Figure 4.5.13). At Mark West Creek, 376 hatchery smolts, 87 wild smolts, and 14 smolts of unknown origin were detected at the trap (Figure 4.5.10 and Figure 4.5.13). A total of 1,664 hatchery and 271 wild coho smolts were captured at the Dutch Bill Creek trap which was the highest total of any of the trap sites operated in 2014 (Figure 4.5.11 and Figure 14.5.13). At Austin Creek, 899 hatchery smolts, 399 wild smolts, and 4 wild parr were captured (Figure 4.5.12 and Figure 4.5.13). Based on length data collected at the lower river traps, there were at least two age groups (YOY: age-0 and parr: ≥age-1) of coho captured (Figure 4.5.13). For a more detailed analysis of downstream migrant trapping catches of coho from other Russian River streams see UCCE Coho Salmon Monitoring Program results for 2014.

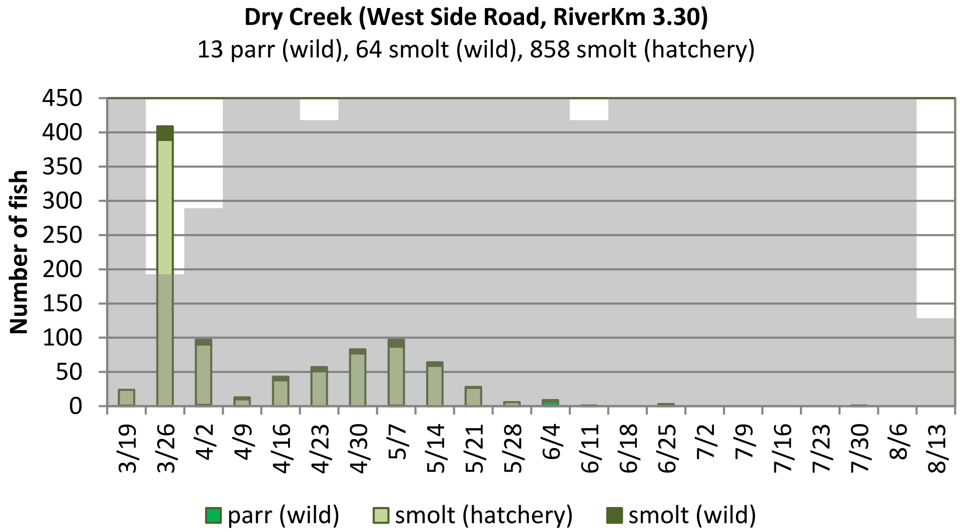
Chinook

In 2014 relatively few Chinook smolts were captured in Austin Creek, Dutch Bill Creek, and Mark West Creek (68, 10 and 65 respectively). For more details on characteristics of Chinook smolts captured at Mirabel and Dry Creek see other chapters of this report.

Conclusions and Recommendations

Russian River Biological Opinion objectives regarding the timing of estuary entry are partially met by using PIT tag detections from the paired antenna array in lower Austin Creek where antenna efficiency estimates are possible and where fish moving past that array have effectively entered the estuary. Steelhead YOY originating in Austin that enter the Estuary is significant (Table 4.5.4), but it is only one of the many possible tributaries that could be contributing steelhead to the Estuary. Approximately 27.5% of the steelhead YOY that were PIT-tagged at Austin Creek were later detected on the antenna array at Duncans Mills. It is reasonable to expect that a similar proportion of YOY tagged at upstream sites other than Austin Creek should be detected at a similar rate (the expectation would be 27.5% of 1,488 = 411 individuals) provided their travel path, movement mortality and propensity to move is similar to steelhead YOY tagged in Austin Creek. However, from 2010-2012 there were no detections of steelhead PIT-tagged at Dutch Bill Creek, Mark West Creek, or Mirabel, in 2013 only 4 steelhead parr tagged at these sites were detected on the Duncans Mills antenna, and in 2014 only 3 steelhead parr (one from Dry Creek and two from Dutch Bill Creek) were detected at Duncans Mills from the upsteam trap sites.

While the PIT tag antenna at Duncans Mills spanned the Russian River for the 2014 outmigration season, detections of PIT-tagged fish were not guaranteed because there are sections between antennas where fish could pass undetected. Fish orientation, and multiple PIT-tagged fish in the detection field of the same antenna at the same time can also effect detection probability. Brackish water occasionally occurs at the antenna site which cause decreases in antenna read range and water depths may exceed the detection field of some antennas. Collectively, these limitations all result in decreases in overall antenna efficiency; however, they are non-issues as long as detection efficiency can be estimated for use in expanding the number of fish detected. Unfortunately, efficiency estimates at Duncans Mills have not been possible because of the lack of a second antenna array in close proximity to the first (e.g., as is the case in Austin Creek, Figure 4.5.4). Regardless of these issues, PIT-tagging



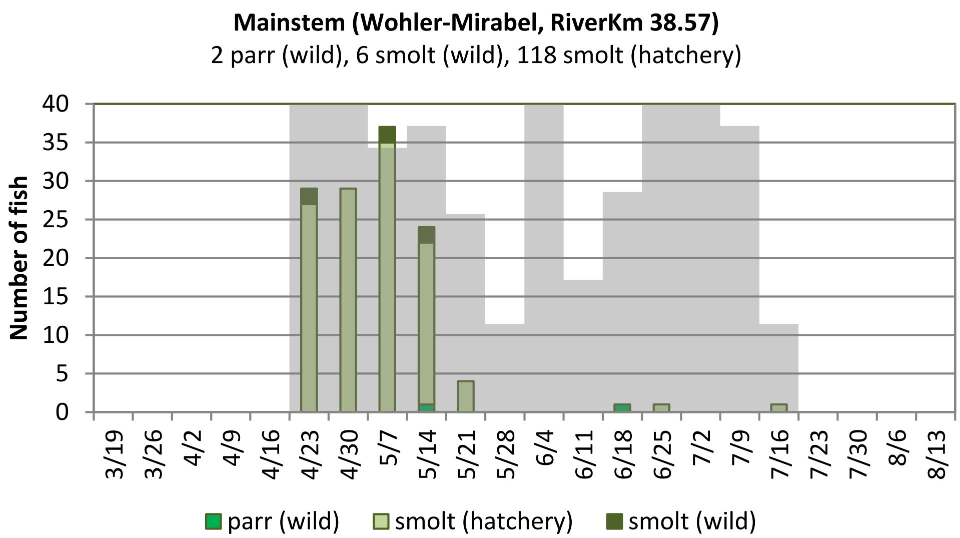
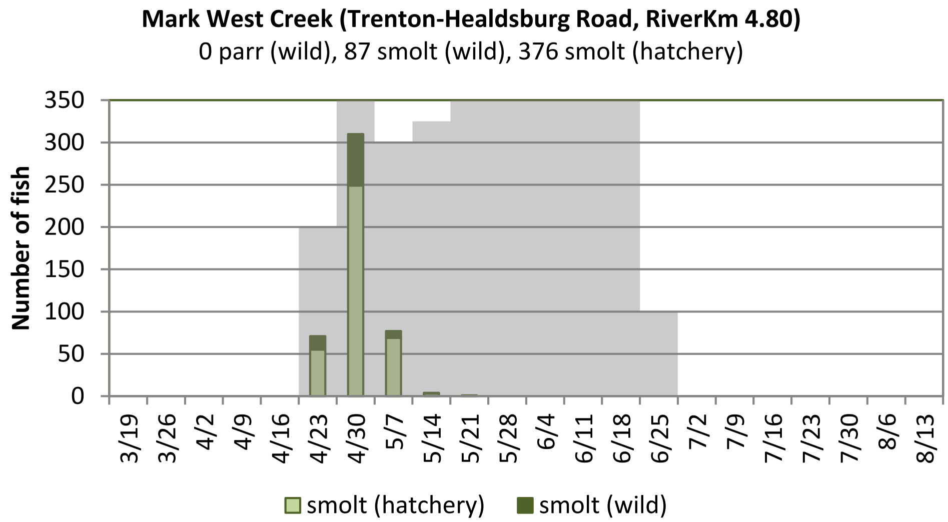
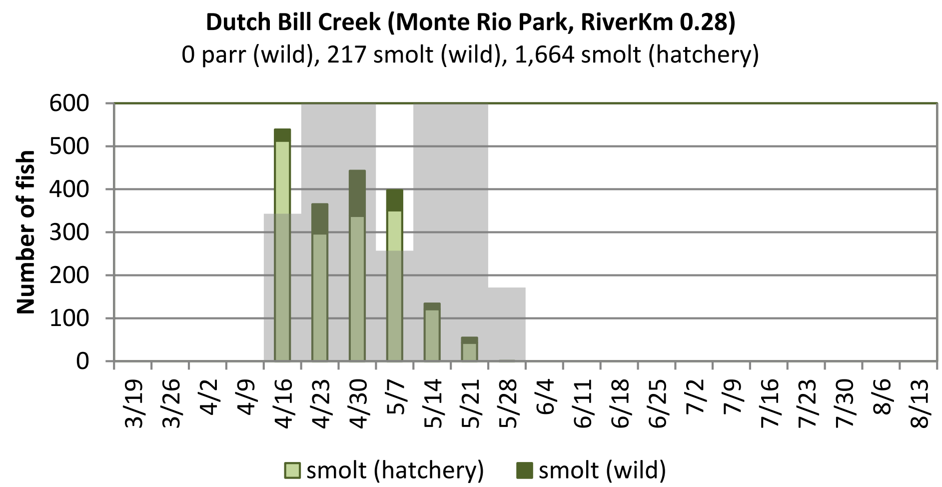
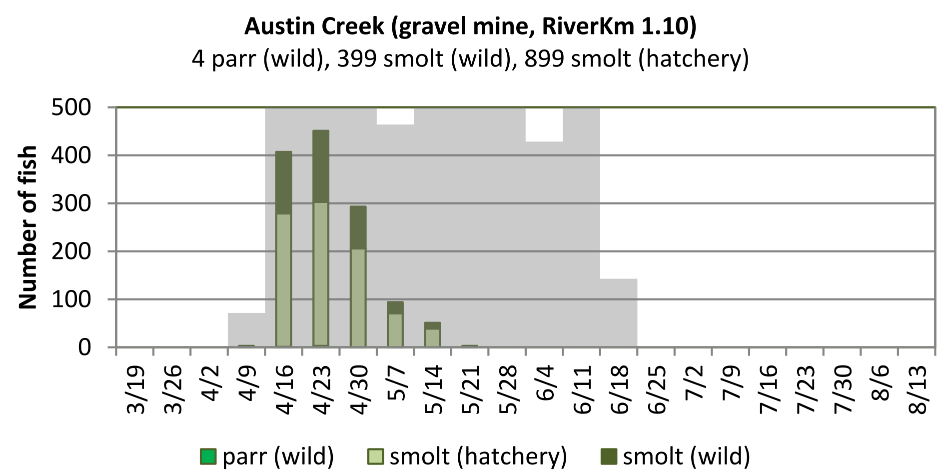


Figure 4.5.13. Weekly capture of coho salmon by life stage at lower river downstream migrant trapping sites, 2014. Gray shading indicates portion of each week trap was fishing. Note the different vertical scale among plots for each site.







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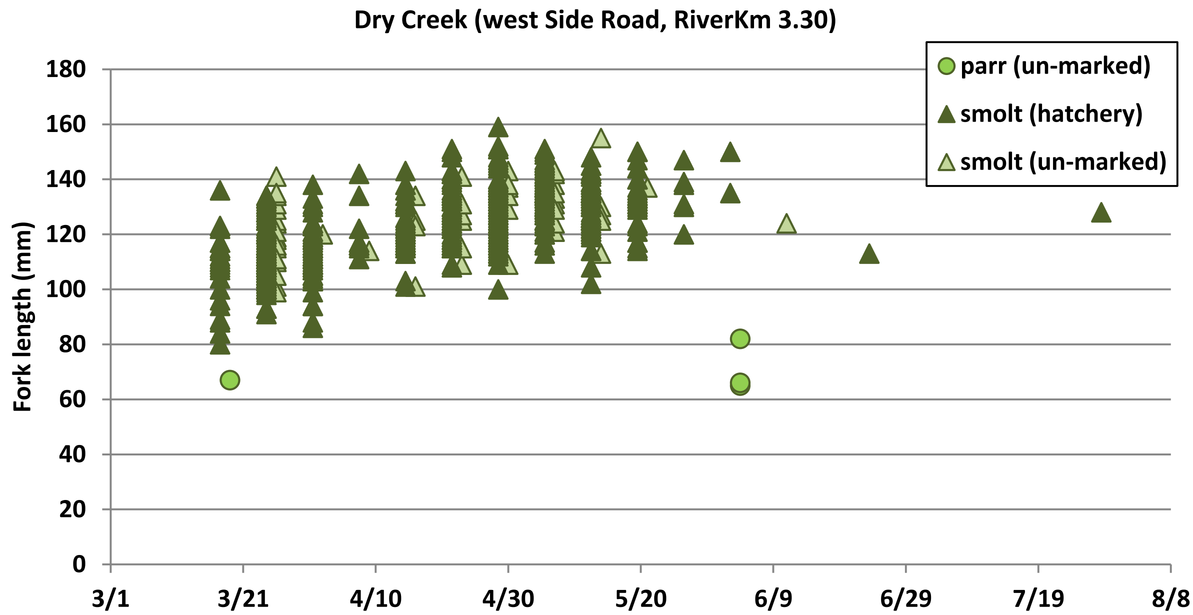


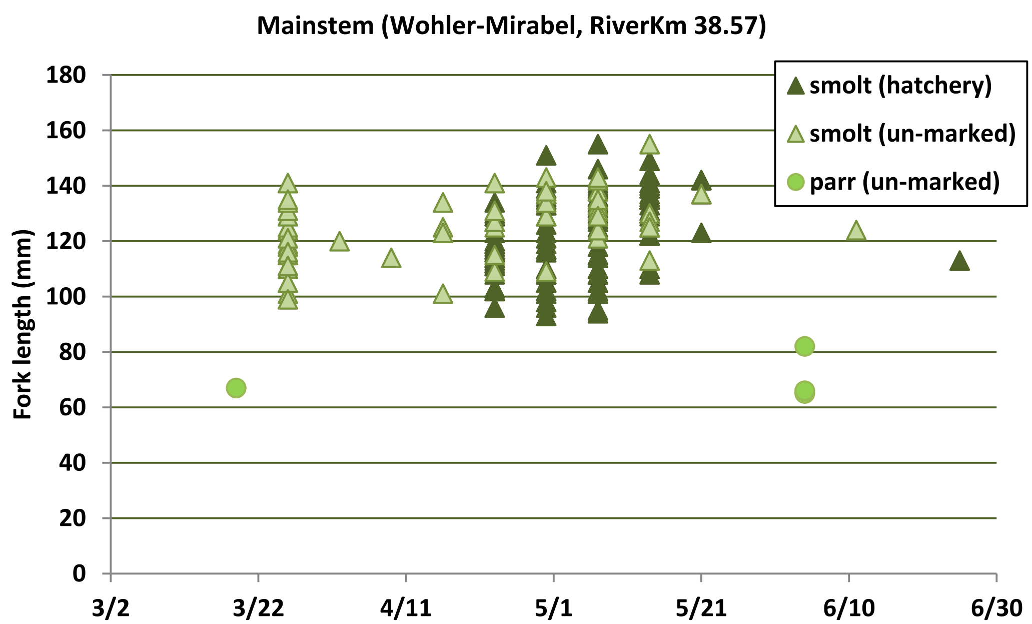
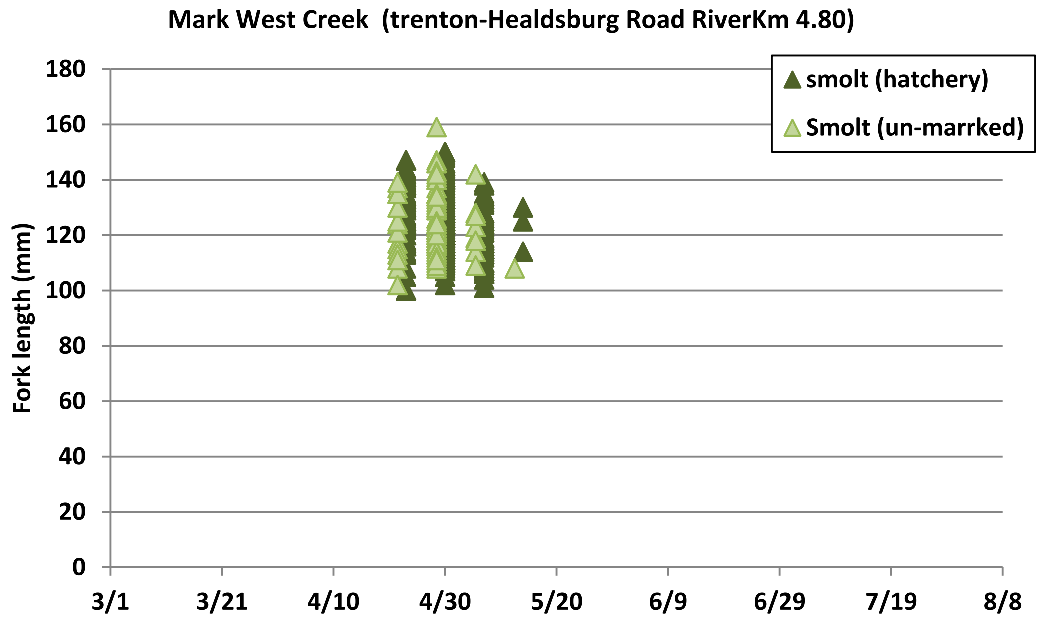


Figure 4.5.14. Weekly fork lengths of coho salmon captured at lower river downstream migrant trap sites, 2014



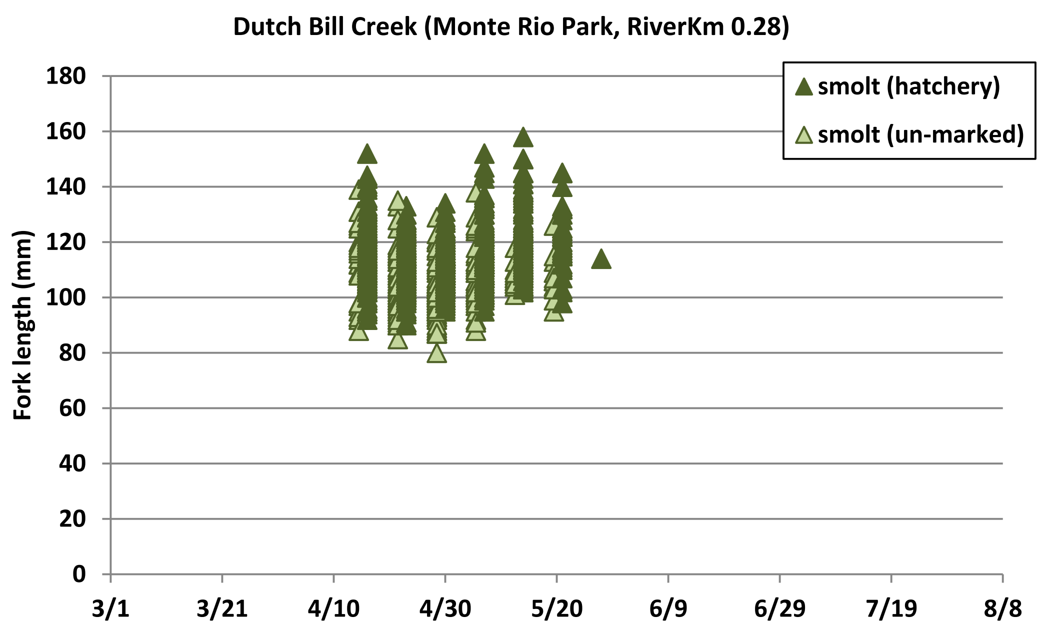


Figure 4.5.15 (cont.)

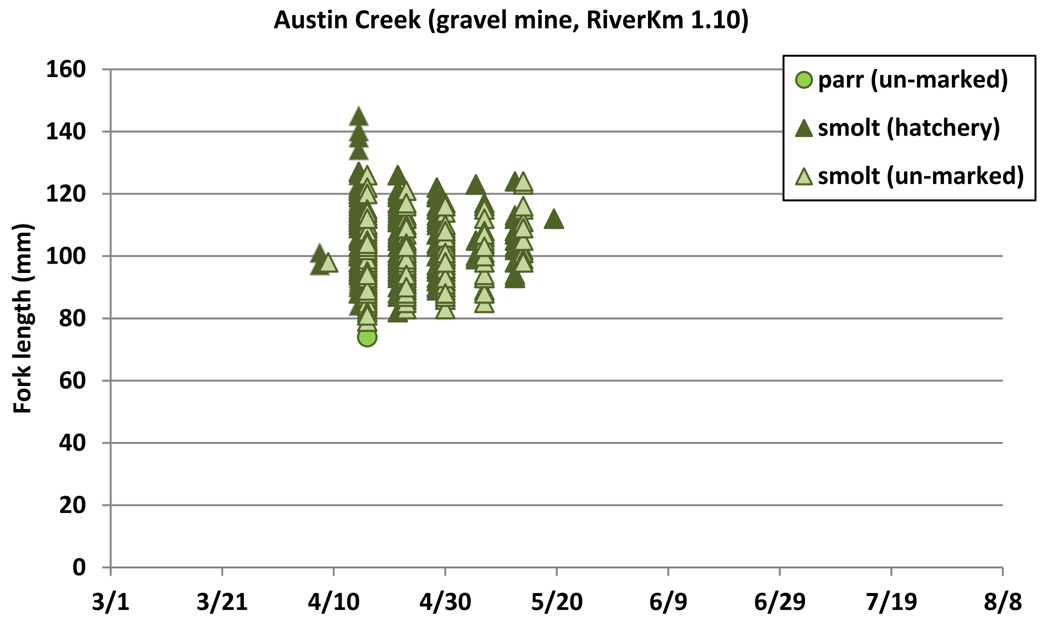


Figure 4.5.16 (cont.)

steelhead YOY at upstream locations and detecting those individuals if and when they move into the Estuary (along with beach seining in the Estuary itself) remain as the only viable method we know of for addressing the fish monitoring objectives in the Russian River Biological Opinion. Attempts continue to measure antenna efficiency so that expanded counts of PIT tagged individuals passing the antenna array can be constructed in future years.

References

Manning, D.J., and J. Martini-Lamb, editors. 2011. Russian River Biological Opinion status and data report year 2009-10. Sonoma County Water Agency, Santa Rosa, CA. 200 pp.

Martini-Lamb J., and D.J. Manning, editors. 2014. Russian River Biological Opinion status and data report year 2013-14. Sonoma County Water Agency, Santa Rosa, CA. 208 pp.

CHAPTER 5: Dry Creek Habitat Enhancement, Planning, and Monitoring

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 was 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.

In 2012, the Water Agency began construction of the first phase of the Dry Creek Habitat Enhancement Demonstration Project. A second phase of the Dry Creek Habitat Enhancement Demonstration Project was constructed in 2013 with a third and final phase scheduled for construction in 2014. The Dry Creek Habitat Enhancement Demonstration Project consists of a variety of habitat enhancement projects along a section of Dry Creek a little over one mile in length in the area centered around Lambert Bridge. Concurrently, the U.S. Army Corps of Engineers completed construction in 2013 of a habitat enhancement project on U.S. Army Corps of Engineers owned property just below Warm Springs Dam (Reach 15 area).

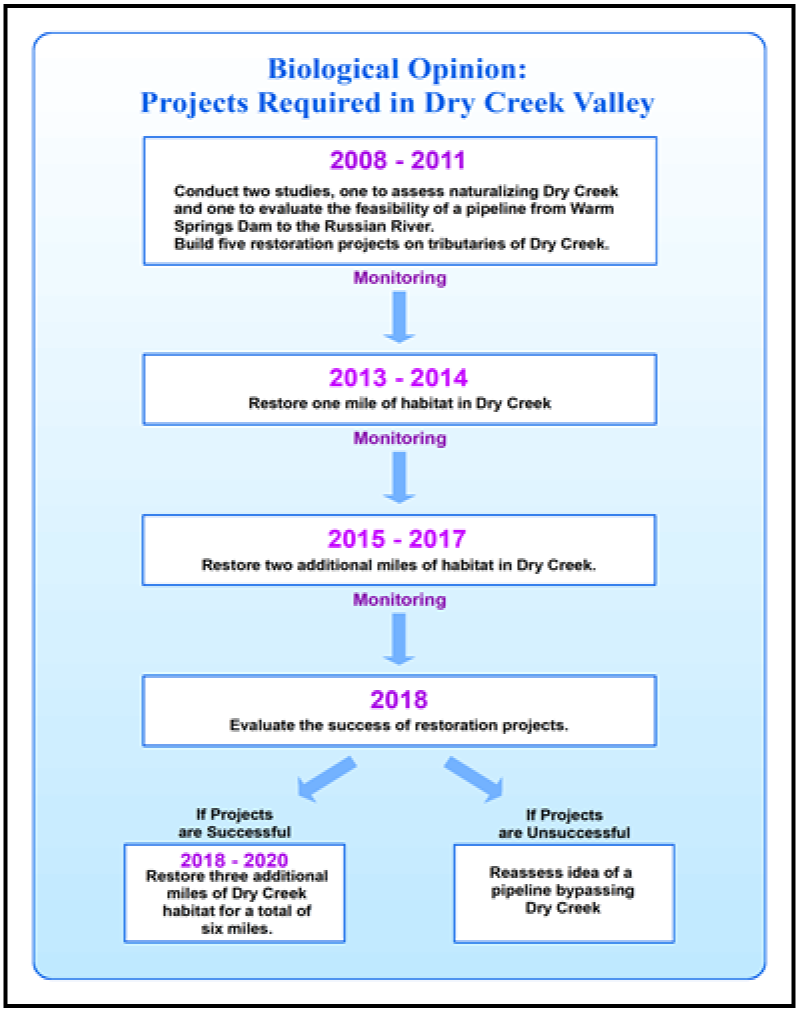


Figure 5.1.1. Timeline for implementation of Biological Opinion projects on Dry Creek.

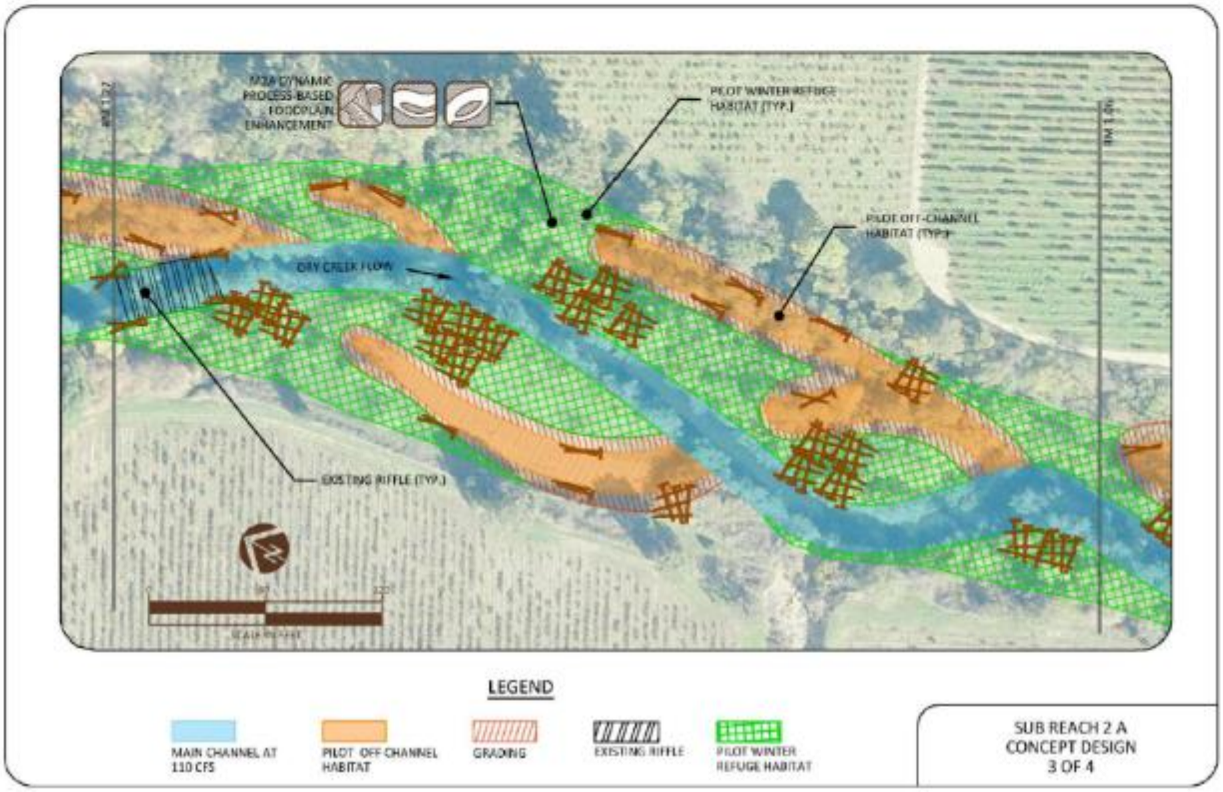
Habitat Enhancement Feasibility Study

The Water Agency regulates summer releases from Warms 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.


PILOT WINTER REFUGE HABITAT (TYP.)
PILOT OFF-CHANNEL HABITAT (TYP.)
DRY CREEK FLOW
EXISTING RIFFLE (TYP.)
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


BACKWATER CHANNEL
RIFFLE CONSTRUCTION/ POOL ENHANCEMENT
M31 RIFFLE CONSTRUCTION/ POOL ENHANCEMENT
LOGJAM, TYP.
WOOD PLACEMENT, TYP
BACKWATER CHANNEL
DRY CREEK FLOW
LEGEND
MAIN CHANNEL AT 110 CFS
OFF CHANNEL HABITAT
GRADING LIMIT
RIFFLE CONSTRUCTION/ ENHANCEMENT
SUB REACH 10 A CONCEPT DESIGN 1 OF 2

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.

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
		4c	Medium	Low	Low	High
	Tier II	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

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

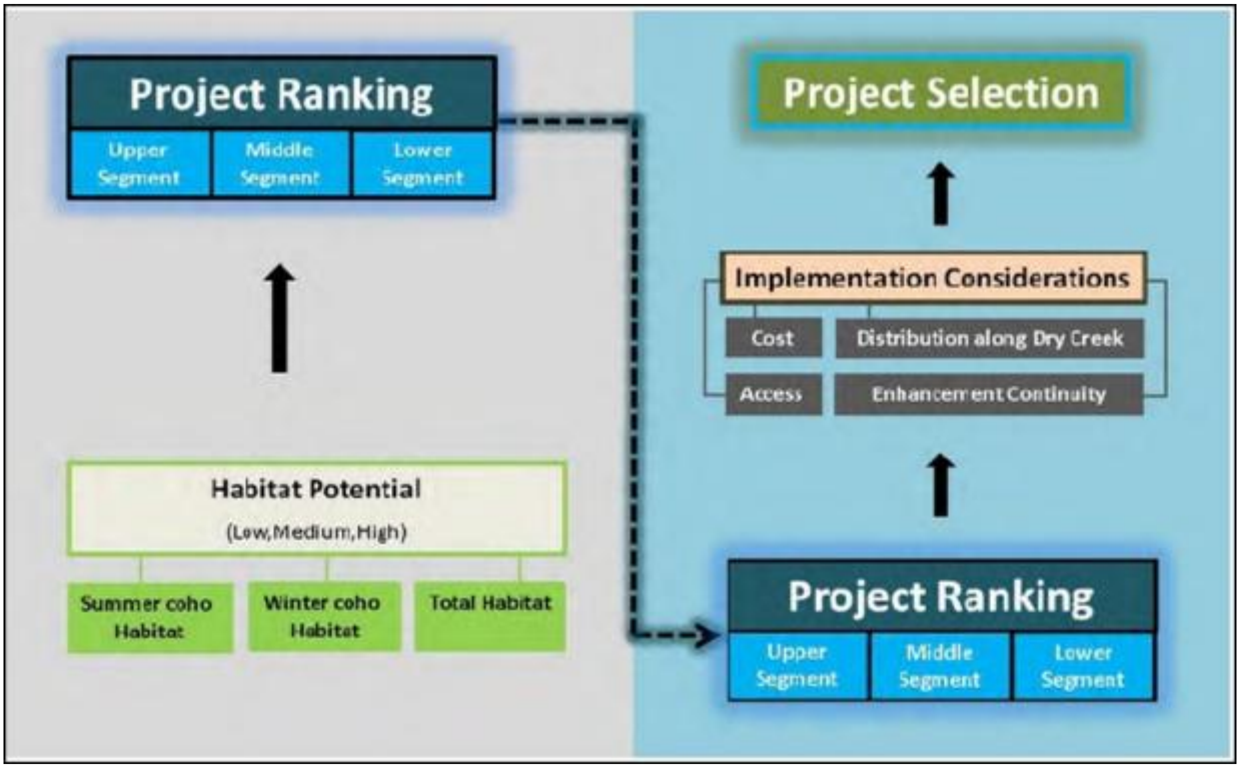


Figure 5.1.3. Conceptual depiction of habitat project prioritization approach. The left side of the figure represents the first phase of the prioritization process which includes ranking of the enhancement subreaches based solely on their inherent potential for habitat enhancement. The second phase, 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 has worked to implement the Dry Creek Habitat Enhancement Demonstration Project. The U.S. Army Corps of Engineers has implemented a similar habitat enhancement (Reach 15 Project) 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 DFW, 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 September 2012, the first phase of the Demonstration Project was constructed by BioEngineering Associates at the Quivira Winery site just downstream of the confluence of Grape Creek and Dry Creek. This project included the construction of a backwater channel for winter refuge habitat, placement of large wood structures, and removal of invasive plant species.

In 2013, work on the Demonstration Project continued downstream of Lambert Bridge at the Dry Creek Vineyard and Amista Winery sites. The Water Agency's contractor, Hanford ARC, constructed a large backwater pond for summer and winter habitat, installed boulder clusters and log jams, and implemented a bank stabilization treatment to prevent erosion and enhance habitat.

In 2014, Hanford ARC continued with the third and final phase of construction of the Demonstration Project. In 2014, Hanford ARC worked both upstream and downstream of Lambert Bridge on additional backwater ponds and channels, log jams, riffles, and bank stabilization treatments. Hanford ARC completed construction of the Demonstration Project components in November of 2014.

Together, the Water Agency's Demonstration Project and the Corps of Engineer's Reach 15 project provide slightly more than one mile of improved habitat at a total cost of $9 million to $10 million. Pre and Post project data are being gathered and the results of these projects and will be reported in future annual reports.

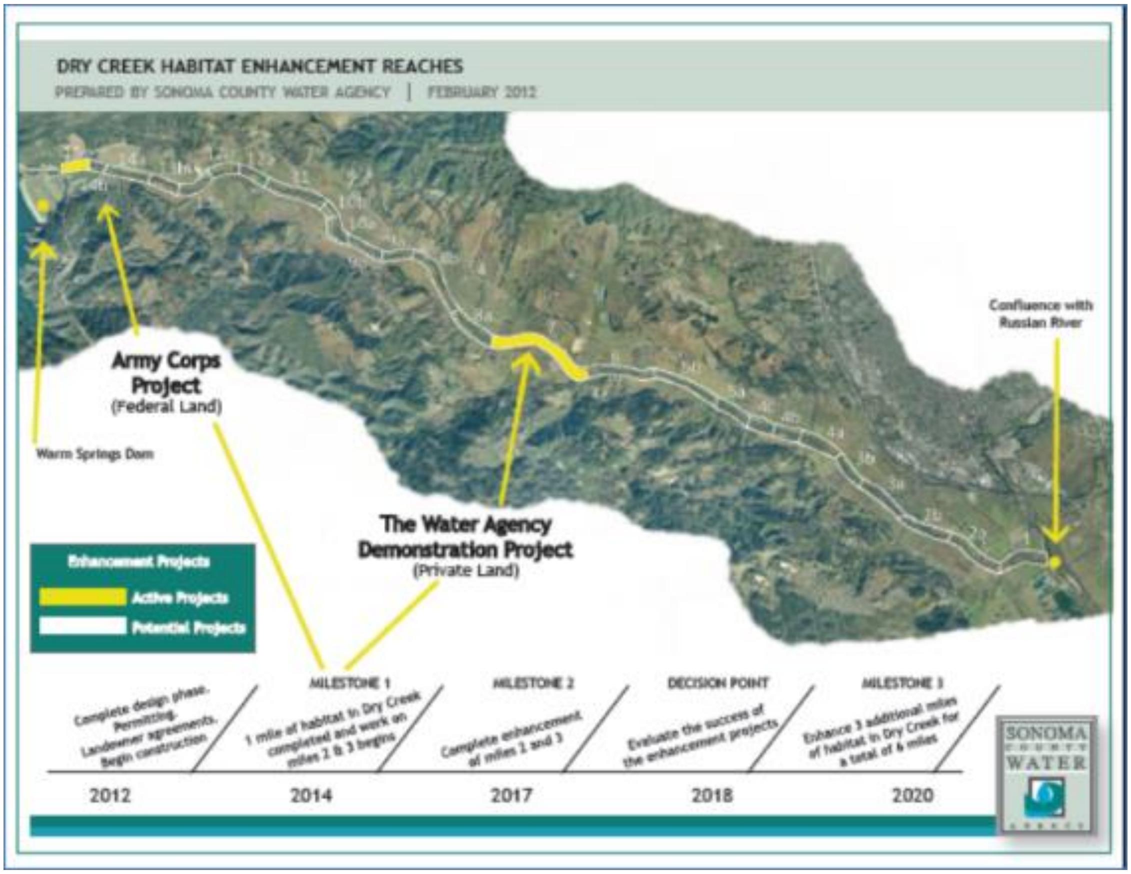


Figure 5.1.4. The location of Water Agency and Army Corps of Engineers Dry Creek habitat enhancement projects to meet Biological opinion milestones.

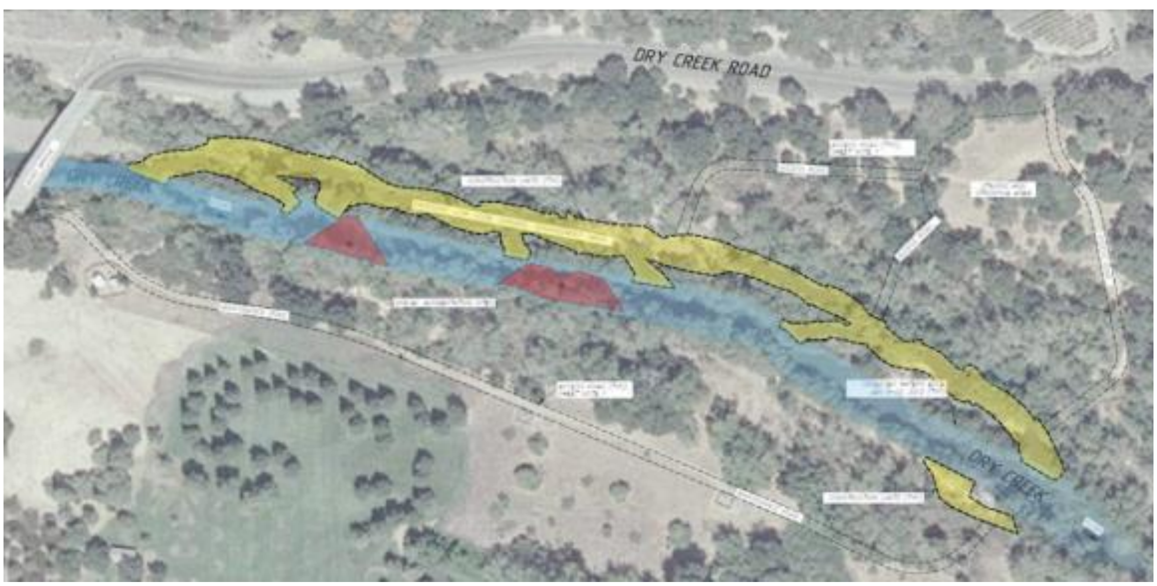


Figure 5.1.5. The Army Corps of Engineers Dry Creek Reach 15 habitat enhancement project. The blue shows the existing flow of Dry Creek. The yellow area shows the side channel area constructed in 2013. The red area shows instream gravel augmentation areas constructed implemented as part of the Reach 15 construction in 2013.

Photo 5.1.1. The Army Corps of Engineers Dry Creek Reach 15 habitat enhancement project.

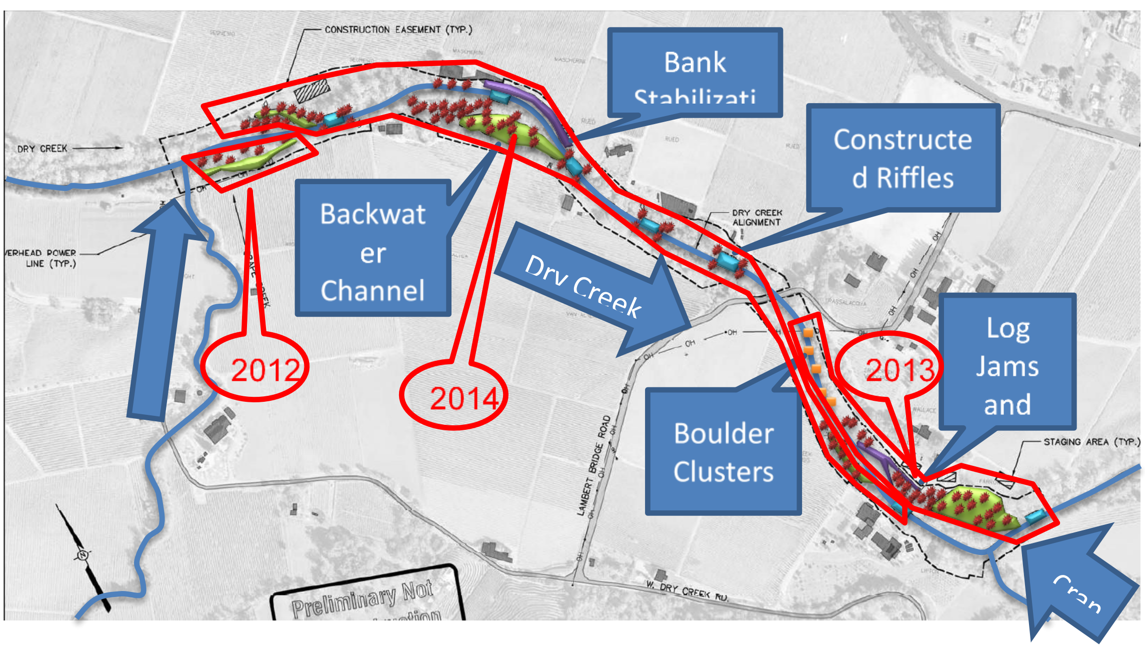


Figure 5.1.6. The Water Agency's Demonstration Project. The blue shows the existing flow of Dry Creek. The red outlines indicate the areas constructed in 2012 and 2013 and the areas scheduled for construction in 2014.

Photo 5.1.2. The Quivira Winery site backwater winter refuge channel constructed in 2012.

Photo 5.1.3. The Quivira Winery site backwater winter refuge channel December 19, 2014.

Photo 5.1.4. In stream riffle construction in Dry Creek upstream of Lambert Bridge (Rued/Van Alyea properties) October 2, 2014.

Photo 5.1.5. In stream riffle construction in Dry Creek upstream of Lambert Bridge (Rued/Van Alyea properties) October 13, 2014.

Photo 5.1.6. Backwater pond area at Amista Winery site downstream of Lambert Bridge. Constructed in 2013.

Photo 5.1.7. Backwater pond area at Amista Winery site downstream of Lambert Bridge. November 13, 2014.

Photo 5.1.8. Backwater pond area at Amista Winery site downstream of Lambert Bridge. High flow event on December 11, 2014.

Photo 5.1.9. Backwater pond area at Amista Winery site downstream of Lambert Bridge. Same view as Photo 5.1.8. December 15, 2014.

Photo 5.1.10. Bank stabilization and log jams at Wallace site downstream of Lambert Bridge. Constructed in 2013.

Photo 5.1.11 Dry Creek Vineyards/Lipton Backwater under construction. July 16, 2014.

Photo 5.1.12 Dry Creek Vineyards/Lipton Backwater construction complete. September 11, 2014.

Photo 5.1.13 Mascherini Bank repair under Construction. September 22, 2014.

Photo 5.1.14 Van Alyea Backwater and Mascherini Bank Repair. November 17, 2014.

Photo 5.1.15 Mascherini Bank Repair complete. November 17, 2014.

Photo 5.1.16 Rued/Van Alyea boulder field in Dry Creek. October 13, 2014.

Adaptive Management Plan and Monitoring

A question raised by the Biological Opinion is whether Dry Creek habitat enhancements will have the desired benefits. This question is important both for receiving credit toward the total amount of habitat enhancements set forth in the Biological Opinion (six miles) and for assessing the relative effectiveness of various habitat enhancements options. For the latter reason, the Biological Opinion states that “an adaptive management, monitoring and evaluation plan” will be developed that identifies “project goals, objectives and success criteria”. ESSA Technologies Ltd. (an independent consulting firm from Vancouver Canada) facilitated the collaborative development of an adaptive management plan (AMP) for Dry Creek in an iterative process of meetings, discussions and document revision.

The goal of the Dry Creek AMP is to serve as a guide for monitoring juvenile coho salmon and steelhead populations and the habitats they live in over multiple years to detect change resulting from habitat enhancement. A series of multi-agency workshops were convened to address the following objectives:

1. Identify performance measures;
2. Develop success criteria for each performance measure;
3. Select approaches for evaluating performance measures relative to success criteria;

4. Agree on a set of decision rules for determining credit toward the total amount of habitat enhancement.

Evaluation of performance measures will be based on the results of **implementation** monitoring, **effectiveness** (habitat) monitoring, and **validation** (fish) monitoring.

For each type of monitoring, quantitative data for performance measures will be gathered using specific data collection protocols. These quantitative data will then be used to qualitatively rate whether the habitat enhancement was implemented correctly, whether it is having the desired effect on physical habitat conditions and whether juvenile coho and steelhead are benefiting from the work.

Implementation monitoring is “monitoring to determine if the habitat enhancement was done according to the approved design” (NMFS Russian River Biological Opinion 2008, pg. 266). In other words, did the contractor/builder do what they said they were going to do? Implementation monitoring will occur immediately post-construction and will serve as a check-in point to determine if all the essential elements were placed according to the design as approved by NMFS/CDFW. Based on the results of post-construction implementation monitoring, the Water Agency’s, USACE’s or other engineering techniques and approaches will be re-visited as deemed necessary.

Effectiveness monitoring is “monitoring to determine whether habitat enhancement is having the intended effect on physical habitat quality” (NMFS Russian River Biological Opinion 2008, pg. 266). This definition implies that protocols should facilitate a detailed comparison between baseline habitat quantity and quality data collected prior to any enhancement actions (pre-enhancement monitoring) and the habitat amounts/condition as measured over time after each implementation phase (post-enhancement monitoring). For example, pre-enhancement monitoring will occur prior to each enhancement phase, and post-enhancement monitoring will occur after the first geomorphically-effective flow (i.e., flow that deposits substantial sediment on the flood plain), or within 3 years following each enhancement phase, and then at minimum every 3 years until 2023, to assess the long term sustainability of all implemented habitat enhancement actions

Validation monitoring is “monitoring to determine whether habitat enhancement work is achieving the intended objective (i.e., creating habitat that is inhabited by listed salmonids and appreciably improves the production and survival of rearing steelhead and coho salmon in Dry Creek”; NMFS Russian River Biological Opinion 2008, pg. 266). Establishing the temporal component for validation monitoring (i.e., when should validation monitoring start and for how long) is challenging because of the inherent time lag between the physical habitat response and the expected biological response.

In addition to monitoring the habitat efforts over time (temporal scale), there is also a spatial scale at which data to evaluate habitat efforts are collected at the implementation, effectiveness, and validation monitoring stages. This spatial scale includes four progressively broader scales: feature, site, enhancement reach, project reach.

- Features: Individually engineered elements (e.g., large woody debris accumulation, riffle, pool, side channel, alcove, boulder cluster, etc.) that will individually or in composite make up a habitat enhancement site (see definition for Site below). Features can in some cases represent complete habitat units (see definition for Habitat Unit below), while in other cases they represent only structural components within a habitat unit (e.g., large wood placement).
- Site: One or more engineered habitat features (see definition for Features above) that have been designed to work in combination to enhance a stream reach.
- Enhancement reach: A specified collection of enhancement sites (see definition for site below) that are implemented in close proximity to one another.
- Project reach: A specified collection of enhancement reaches (see definition for Enhancement Reach above)

Mile 1 (Demonstration Project and USACE Reach 15 Project) Implementation Monitoring

An important initial step prior to the commencement of post-construction effectiveness monitoring within a given enhancement reach will be an agreed-on definition of what constitutes a feature and a site within that reach. For features that will be enhanced (e.g., existing pools, placement of boulder clusters) this step could occur prior to the commencement of construction so that the degree of improvement in meeting target habitat conditions can be assessed for a given site. However, in cases where no habitat currently exists (e.g., construction of new off-channel habitat) features and sites will be defined immediately following construction (i.e., during implementation monitoring).

The focus of implementation monitoring is simply to determine whether actions have/have not been undertaken as intended/planned. As a matter of course, NMFS/CDFW will approve the construction plans for each phase of project construction. This approval is based on several factors including whether habitat enhancement in selected reaches is being designed in such a way to maximize the benefit to juvenile salmonids given the geomorphic opportunities and other constraints in the immediate vicinity of the enhancement reach.

The implementation monitoring design can be envisioned as a way to ensure that each feature has been constructed when, where and how intended and without any structural changes or omissions that would compromise integrity. Monitoring protocols and associated implementation monitoring checklists identified in the AMP provide a useful, consistent template that will be used for describing/documenting the implementation status of engineered enhancements in Dry Creek reaches. There is a separate checklist with respect to the three relative locations within the stream channel where habitat enhancement is being contemplated: 1) instream, 2) off-channel, 3) channel reconstruction and bank stabilization. Enhanced features will be assessed using one of these implementation checklists. Suites of feature-level assessments will then be rolled-up into a final composite site rating that will be used to determine whether enhancements at a particular site are considered successful or whether further remediation will be necessary. The final overall qualitative site-scale rollup assessments of habitat enhancement implementation (i.e., excellent, good, fair, poor, fail) will be undertaken by a Joint Monitoring

Team consisting of representatives from NMFS, CDFW and either the Water Agency or USACE (or both as appropriate). In the event that implementation was insufficient, remedial action may be recommended by the Joint Monitoring Team.

Summary of implementation monitoring steps:

- Every attempt will be made to implement habitat enhancement measures in a manner that is consistent with designs approved by NMFS and CDFW.
- Upon completion of implementation, a Joint Monitoring Team consisting of representatives from NMFS, CDFW and either the Water Agency or USACE (as appropriate) will conduct a walk-through of newly-implemented enhancement reaches in order to evaluate whether the features were implemented according to the approved designs. The outcome of this step will be a site-scale rollup (see Figure 8a and Table 2).
- Modifications to the approved designs will be documented and determination made as to whether modifications were beneficial to performance or otherwise
- If implementation did not sufficiently follow the approved design, the Joint Monitoring Team will recommend what adjustments (if any) should be made.

The first mile of Dry Creek habitat enhancement projects have been completed over a three-year period and under three separate construction contracts:

- U.S. Army Corps of Engineers' Reach 15 Fish Habitat Enhancement Project. Constructed in 2013 by Contractor Services Group.
- Sonoma County Water Agency's Dry Creek Habitat Enhancement Demonstration Project, Phase 1. Constructed in 2012 by Bioengineering Associates.
- Sonoma County Water Agency's Dry Creek Habitat Enhancement Demonstration Project, Phase 2. Constructed in 2013 and 2014 by Hanford ARC.

An implementation monitoring report prepared for these first mile of Dry Creek habitat enhancement projects is included in Appendix C of this report.

Mile 1 (Demonstration Project and USACE Reach 15 Project) Effectiveness Monitoring

As noted above under implementation monitoring, the first mile of habitat enhancement work in Dry Creek was completed in 2014. Soon after completion of the first mile of habitat, the region received significant rainfall events in December of 2014 and February of 2015, which resulted in geomorphically-effective flows in Dry Creek (5,770 cubic feet per second at Yoakim Bridge gage station on 12/11/14 and 2,530 cubic feet per second on 2/7/15).

Once geomorphically-effective flows occurred post-construction of the habitat features, Water Agency staff began collecting physical measurements (e.g. depths, velocities, temperature, dissolved oxygen, cover) to document the habitat characteristics in the project area. Initial field data collection efforts for the effectiveness monitoring was completed in December of 2015.

Water Agency staff is now processing the field data. Initial evaluation of the field data indicates that the habitat features are performing as intended to meet the target depth (0.5-2.0 feet) and velocity (<0.5 feet per second) goals, which are the two primary metrics for the habitat features.

Photo 5.1.17 Dry Creek effectiveness monitoring. 2015.

Photo 5.1.18 Dry Creek effectiveness monitoring. 2015.

Photo 5.1.19 Dry Creek effectiveness monitoring. 2015.

Mile 2-3

Building on the rankings described above that were developed as part of InterFluve's Dry Creek Fish Habitat Enhancement Conceptual Design Report, the Water Agency has begun outreach to landowners in the upper, middle, and lower segments of Dry Creek as potential sites to make up the next 2 miles of habitat work beyond the Water Agency's Demonstration Project and the Corps of Engineer's Reach 15 project. For the next 2 miles of habitat work, the Water Agency is targeting those sites listed as Tier 1 sites for habitat potential in Dry Creek. The Water Agency completed its California Environmental Quality Act documentation in November 2015 and is in the process of developing engineering designs for the Miles 2 and 3 of the Dry Creek habitat enhancement work. Construction on sections of both the Mile 2 and 3 sections is expected to begin in the summer of 2016.

Validation Monitoring

Part of the Adaptive Management Plan (AMP) for validating the effectiveness of habitat enhancement in mainstem Dry Creek calls for a multiscale monitoring approach in both space and time (Porter et al. 2013). The current section of this report focuses on the results of validation monitoring for juvenile and smolt salmonid populations in mainstem Dry Creek in 2014. These data are part of an ongoing pre-construction (baseline) monitoring effort begun in 2008 and outlined in the Reasonable and Prudent Alternative section of NMFS' Russian River Biological Opinion. In addition, validation monitoring data collected in newly-constructed habitats in summer 2014, winter 2013-14 and winter 2014-15 are reported as well as continued efforts to monitor trends in juvenile and smolt abundance at the watershed scale.

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 (Table 1). In 2009-2010, 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 incorporated into the Dry Creek AMP (Porter et al. 2013). The methods currently employed for validation monitoring in Dry Creek are largely based on the outcome of that work (Manning and Martini-Lamb 2011; Martini-Lamb and Manning 2011).

Table 1. 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 tools
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 salmonid density

In 2014, construction of habitat enhancements limited our ability to conduct summer-time juvenile monitoring within the first mile of habitat enhancements in mainstem Dry Creek (the "demonstration project"). However, we were able to conduct sampling in stream reaches outside of the demonstration project. All of those stream sections sampled in 2014 were similar to those sampled in previous years but they also including a few not sampled in previous years (Figure 1).

We sampled by making multiple backpack electrofishing passes through relatively long stream sections in an attempt to estimate juvenile steelhead abundance in mainstem Dry Creek. Unlike 2008-2013, we did not conduct sampling aimed at estimating oversummer growth and survival in these sections (Figure 1). Although our primary target species for the habitat enhancement work is coho salmon, steelhead juveniles are currently the only salmonid species present in the summer that are abundant enough to estimate the aforementioned parameters in a meaningful way.

Sampling involved capturing individual juvenile steelhead with a backpack electrofisher in late September/early October followed 2 days later by a recapture pass through each section. 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 (White et al. 1982).

We adopted the geomorphically-based reach designations identified by Inter-Fluve (2011) for defining reaches for use in summarizing density estimates. Those reaches are: lower reach (Dry Creek mouth to just downstream of the lowest grade control sill; river km 0.00 to 5.27), middle reach (just downstream of the lowest grade control sill to the confluence of Pena Creek; river km 5.27 to 17.71) and upper reach (river km 17.71 to 22.00).

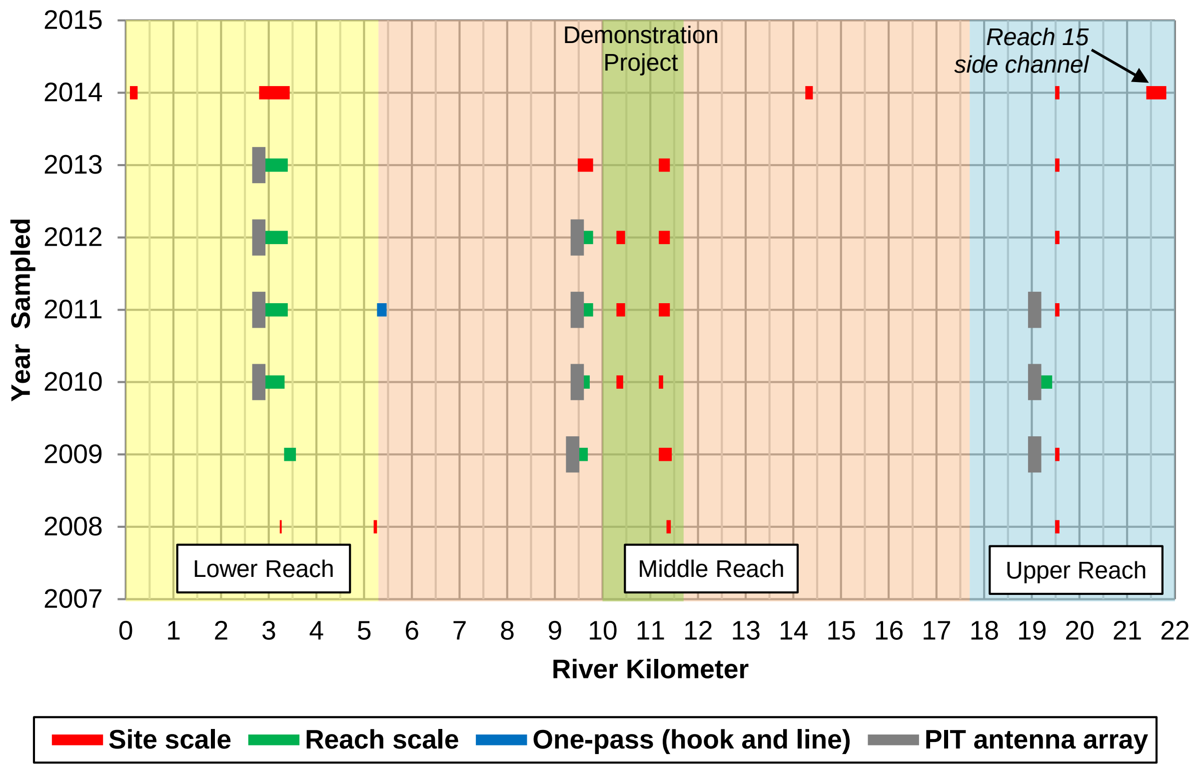


Figure 1. Years sampled and river kilometer (from the mouth) where juvenile steelhead populations were sampled in mainstem Dry Creek, 2008-2014. Line length for each site is scaled to the length of stream sampled. Data collected at the site scale were analyzed using mark-recapture (either a multiple-pass depletion or Petersen model) and reach scale data collected in 2009 were analyzed with the core-sampling approach (see Manning and Martini-Lamb 2011 for details) while reach scale data collected in 2011-14 were analyzed with the multistate model using program MARK (White and Burnham 1999). The green-shaded area indicates the stream section that has been targeted to receive the first mile of habitat enhancements (the "Demonstration Project").

Juvenile salmonid habitat utilization

Summer / Fall

We conducted seven snorkel surveys in the Farrow backwater and four dive surveys from May to October 2014. Surveys were conducted with two snorkelers working in tandem. From May through November we operated a continuously-recording temperature and dissolved oxygen logger near the mouth of the Farrow backwater. On the same day as four of the Farrow snorkel surveys, we measured water temperature and dissolved oxygen at 0.5 m depth increments throughout the water column at the location of the continuous logger. These data allowed us to construct vertical dissolved oxygen profiles.

Winter

In 2013, we installed a PIT antenna at the mouth of the Farrow backwater in the fall immediately after construction was completed and operated it into spring 2014. In fall 2014, we again installed the Farrow antenna and also installed an antenna midway upstream of the mouth of the Wallace backwater and an antenna near the mouth of the Van Alyea backwater (both completed in fall 2014). Although antennas did not span the width of the backwaters, they did cover the majority of the wetted width.

The source of PIT-tagged fish included: PIT-tagged juvenile coho from Warm Springs hatchery that were released directly into the backwater in the fall as age-0+ (Table 2); (2) PIT-tagged juvenile coho from Warm Springs hatchery that were released at other locations throughout the Dry Creek system; (3) wild (natural-origin) juvenile steelhead that were PIT-tagged during spring and summer surveys. The residence time of PIT-tagged juvenile coho released into the backwater was calculated as the number of days betwen release date and their final detection date on the PIT antenna. We also detected some of these fish at downstream locations.

Table 2. Number of coho young-of-the-year released from Warm Springs Hatchery in or near the off-channel habitats constructed on Dry Creek, 2013 and 2014.

Mainstem or Off-channel	Release Site	Release River Km	2013	2014
Mainstem	Adjacent to Farrow backwater	9.90		200
Off-channel	Farrow backwater	10.00	759	632
Off-channel	Wallace backwater	10.34		277
Mainstem	Adjacent to Wallace backwater	10.70		200
Mainstem	Adjacent to Quivira backwater	11.62		825
Off-channel	Reach 15 side channel	21.45	250	635

Smolt abundance

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. Wood-frame mesh 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 for the purpose of identifying these fish as coming from Dry Creek when and if recaptured during sampling at downstream locations (e.g., estuary seining). Between Monday and Thursday each week, up to an additional 50 Chinook smolts were PIT-tagged and released upstream of the trap to augment the sample size of recaptures for population estimation. When combined with yet a second group of up to 50 PIT-tagged that were released downstream, PIT-tagged fish provided the potential to evaluate migration mortality and migration time as fish were detected at downstream monitoring sites (i.e., Northwood and Duncans Mills PIT antenna arrays). Finclipped and PIT-tagged 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). The population estimate of Chinook salmon smolts produced in the Dry Creek watershed upstream of the trap were based on the PIT-tagged portion of the population only. For this reason, the abundance estimate of Chinook smolts reported in 2014 applies to the March 20-July 8 time period (the PIT-tagging period) even though additional Chinook smolts were captured in the trap after this time period.

Results

Juvenile salmonid density

We captured a total of five wild coho YOY (four in the middle reach and one in the upper reach) during electrofishing sampling. Although the total number was low, fish were found from river km 10.3 to river km 19.5 indicating that they were relatively spread out and probably not from redd(s) in a single location.

Densities of juvenile steelhead in 2013 ranged from less than 0.08 fish/m^2 to 0.54 fish/m^2 (Figure 2). When averaged for all sites within a year, densities in 2013 were 0.07 fish/ m^2 higher than the six year average from 2008-2013 (Figure 3).

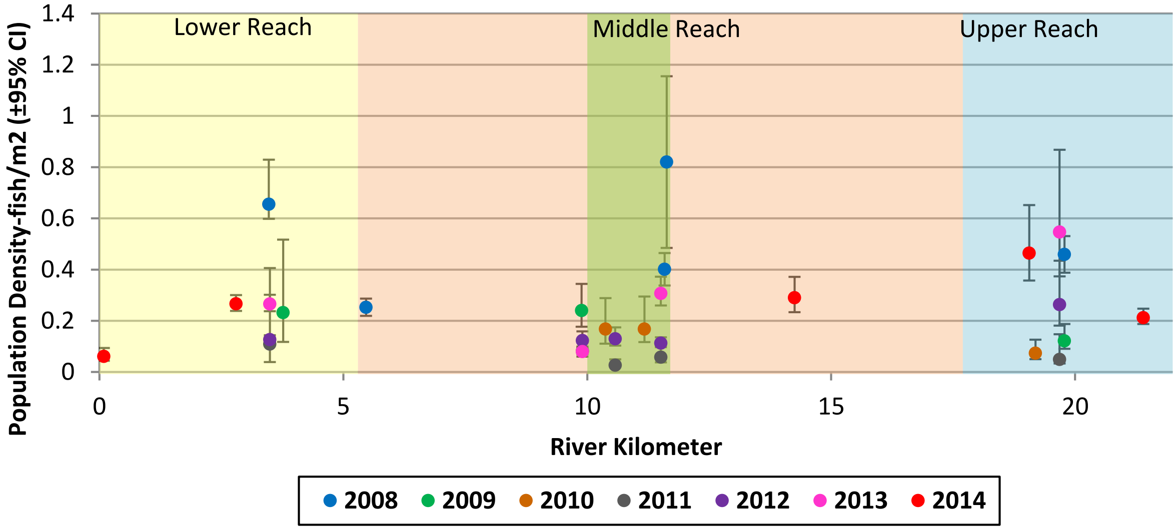


Figure 2. Estimated density of juvenile steelhead in mainstem Dry Creek, 2008-2013. Estimates are from a variety of approaches all based on mark-recapture models (see text of this and previous Russian River Biological Opinion status and data reports for details).

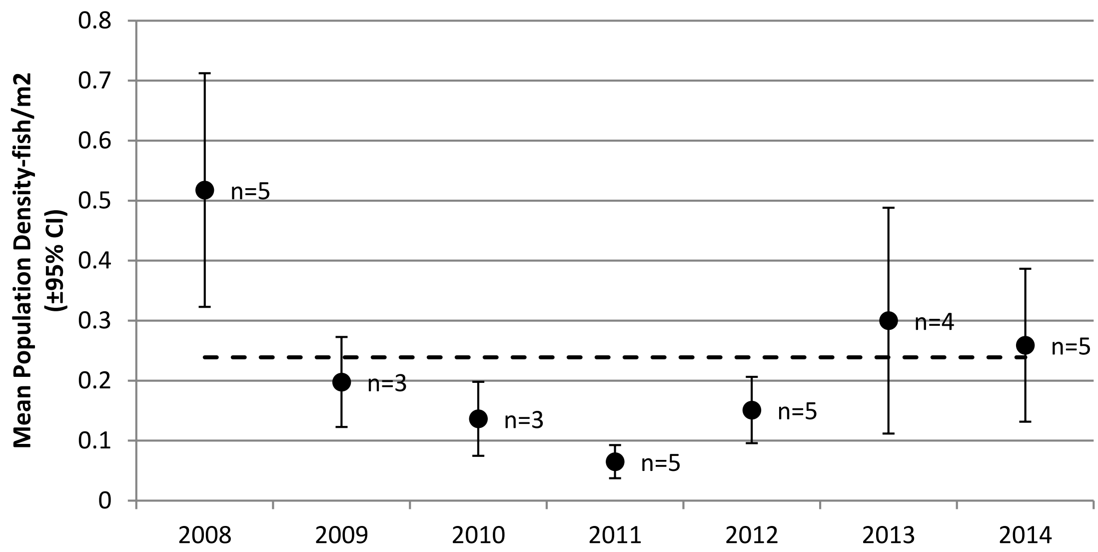
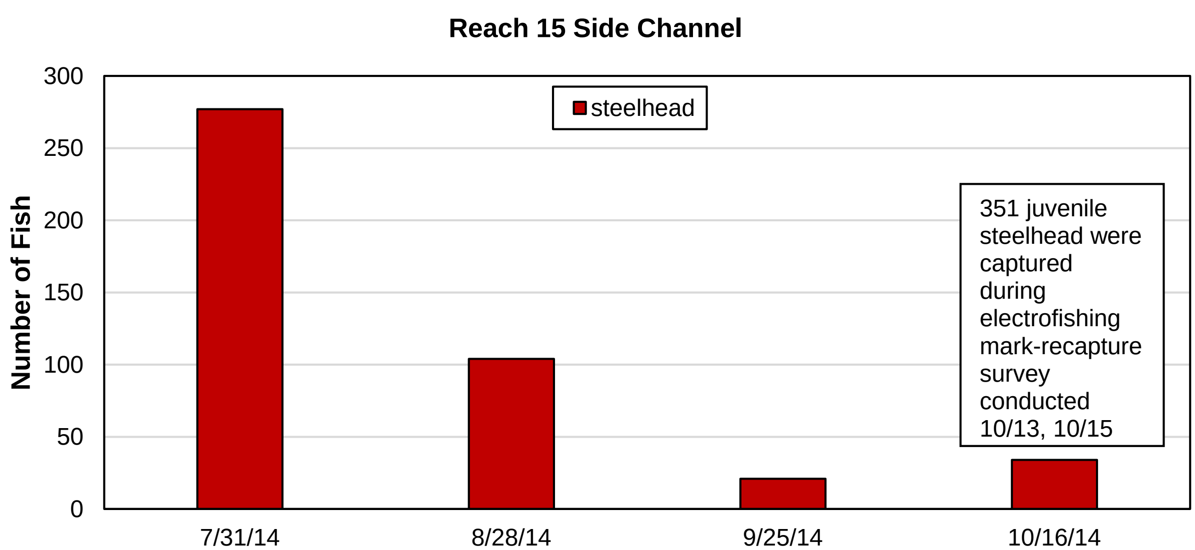


Figure 3. Mean juvenile steelhead density among all sites sampled within a year in mainstem Dry Creek, 2008-2014. "n" refers to the number of sites sampled. Dashed line is the seven year average density for all sites combined.

Juvenile salmonid habitat utilization

Summer / Fall

Counts of juvenile salmonids in the reach 15 side channel and the Farrow backwater were much higher during May surveys as compared to later surveys (Figure 4). In both sites, however, rooted aquatic vegetation (reach 15) and algae growth (Farrow) adversely affected our ability to observed juvenile salmonids (Figure 5) particularly as vegetation increased throughout the summer. Evidence of vegetation impacts on snorkeling visibility is clear when the number of fish observed in the October snorkel survey in reach 15 (34) is compared to the 351 steelhead captured by electrofishing a few days earlier.



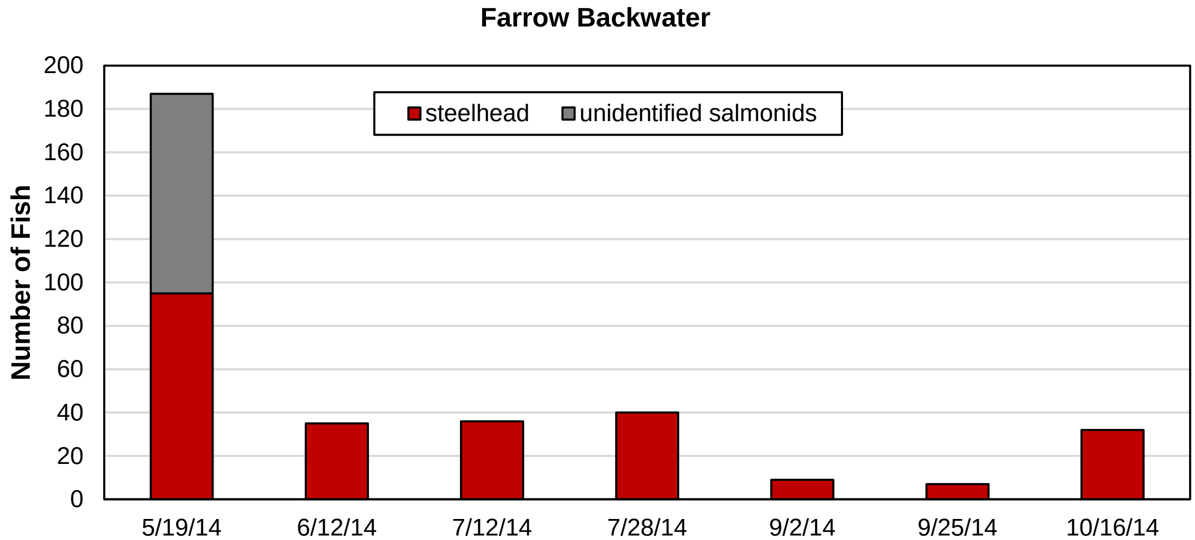


Figure 4. Number of juvenile salmonids observed during snorkel surveys conducted in 2014.

Figure 5. Underwater photo in Farrow backwater illustrating dense algae growth.

While it is impossible to quantify the effect on juvenile salmonid counts from deteriorating visibility caused by increasing amounts of algae in the Farrow backwater, we suspect that low dissolved oxygen did impact salmonid use. Mean daily dissolved oxygen and vertical water quality profiles showed deteriorating conditions both seasonally and throughout the water column (Figure 6).

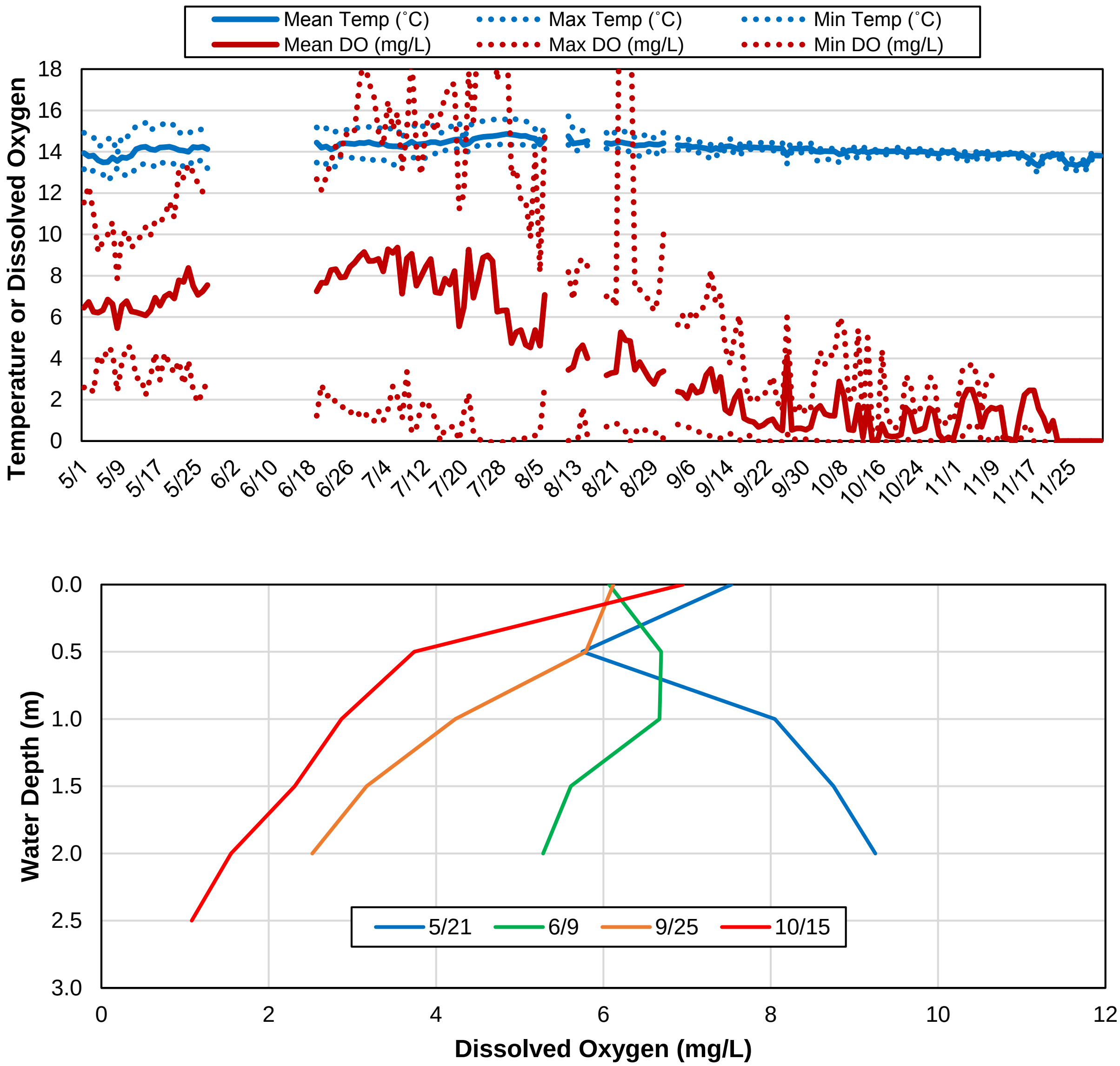


Figure 6. Daily mean, minimum and maximum dissolved oxygen and water temperature collected with a stationary, continuously recording probe (upper panel) and dissolved oxygen from vertical water quality profiles collected with a handheld probe at 0.5 m depth increments (lower panel). Both data sets were collected in the same location near the mouth of the Farrow backwater in 2014.

Winter

Of the 759 PIT-tagged coho YOY stocked in the Farrow backwater in November 2013, 440 were later detected on the PIT antenna situated at the mouth of the backwater (Table 3). Of those 440, 228 (52% of 440 detections and 30% of all PIT-tagged fish released) were detected the day they were released in the backwater and never again detected at Farrow; 7 of those 228 were detected at the PIT antenna array at the mouth of Dry Creek approximately 10 km downstream. Including those 7 individuals, a total of 28 were detected at the mouth of Dry Creek between release and December 28, 2013. One individual was detected 4 days after release at the Duncans Mills PIT antenna array, a distance of approximately 62 km downstream from the backwater. The low residence time of a significant portion of newly-released individuals is consistent with observations of released coho YOY in other locations in the Russian River watershed (University of California Sea Grant / Cooperative Extension and Warm Spring Hatchery staff, personal communication). Of the 250 PIT-tagged coho YOY stocked in the reach 15 side channel in November, 2013, 4 were later detected on the PIT antenna situated at the mouth of the Farrow backwater, a distance of nearly 12 km downstream. Of those, 2 were detected within 2 days of release while the other 2 were detected in February.

Of the 277 PIT-tagged coho YOY stocked in the Wallace backwater in November 2014, 204 were later detected on the PIT antenna situated at the mouth of the backwater (Table 3). Similar to the 2013 release of fall coho YOY in Farrow, there was a high initial flight of fish out of Wallace as indicated by the 159 individuals (48% of 204 detections and 35% of all PIT-tagged fish released in the backwater) that were detected the day they were released in the backwater and never again detected at Wallace.

Due to technical issues, the antenna at the mouth of the Farrow backwater did not function for a significant part of the 2014-15 winter season. Therefore, the number of detections at Farrow in fall 2014 significantly under-represents the number of fish moving out of that backwater. Nevertheless, 204 of the 632 individuals (32%) and 68 of the 200 individuals (34%) stocked in the Farrow backwater and mainstem Dry Creek adjacent to Farrow were detected in the Wallace backwater at some point over the fall/winter and into the following spring. Of the 825 PIT-tagged individuals released into mainstem Dry Creek adjacent to Quivira, 24 and 17 were detected in the Van Alyea and Wallace backwaters, respectively. A total of 28 fish released either within or adjacent to Farrow and Wallace backwaters were detected on the Van Alyea backwater antenna.

Table 3. Number of individual PIT-tagged coho by release group and location of backwater antenna detection, 2013 and 2014 release years.

Released							Antenna Detection					
							Farrow (rkm 10.00)		Wallace (rkm 10.34)		Van Alyea (rkm 11.05)	
Year	Season	Tributary	Site	River Km	Life Stage	Number	Winter[7]	Spring[8]	Winter	Spring	Winter	Spring
2013	Fall[9]	Dry Creek	Farrow backwater	10.00	YOY	759	438	2	not yet constructed			
			Reach 15 side channel	21.45	YOY	250	4					
		Pena Creek	Pena Creek	17.71	YOY	1504	2	8				
2014	Fall[3]	Dry Creek	Mainstem adjacent to Farrrow	9.90	YOY	200			48		3	2
			Farrow backwater	10.00	YOY	632	13		129		12	1
			Wallace backwater	10.34	YOY	277	2		204		13	1
			Mainstem adjacent to Wallace	10.70	YOY	200			12		6	
			Mainstem adjacent to Quivira	11.62	YOY	825	3		17		24	
			Reach 15 side channel	21.45	YOY	635	1		2		1	1
		Mill Creek	Mill Creek	1.11	YOY	3726			1			
		Grape Creek	Grape Creek	11.69	YOY	455	5			1	5	
		Pena Creek	Pena Creek	17.71	YOY	1511	1		1		2	
	Winter[10]	Dry Creek	Farrow backwater	10.00	Smolt	380		69				
			ACOE well-field	21.33	Smolt	4004		42			1	

[7] Winter (antenna detection): November 1 to February 28 following release.
[8] Spring: March 1 to June 30 following release.
[9] Fall: Fall of the release year
[10] Winter (release): March 1 to June 30.

In addition to winter-time use of the Farrow backwater by juvenile coho, we detected 13 steelhead parr that were PIT-tagged during electrofishing and downstream migrant trap surveys in 2013 and 2014. Adult coho, steelhead and Chinook that had been PIT-tagged as juveniles or smolts during earlier surveys conducted by the Water Agency also used the Farrow backwater during their spawning migration. For example, of the 18 adult coho detected at the PIT antenna array at the mouth of Dry Creek, 11 were detected at the Farrow backwater. Adult steelhead that were PIT-tagged as juveniles during electrofishing surveys in Dry Creek in 2011 and 2012 also entered Farrow as well as one adult Chinook that was PIT-tagged at the Dry Creek downstream migrant trap in 2012. We also observed adult steelhead and Chinook residing in the Farrow backwater during multiple site visits during the 2013-14 and 2014-15 adult migration season.

Smolt abundance

We installed the rotary screw trap on March 18 which was the earliest date of operation since we began trap operation in 2009 (Figure 7). Except for brief periods when trapping was suspended because of high debris loading in the trap from high winds, the trap was checked daily during operation from March until it was removed on August 14.

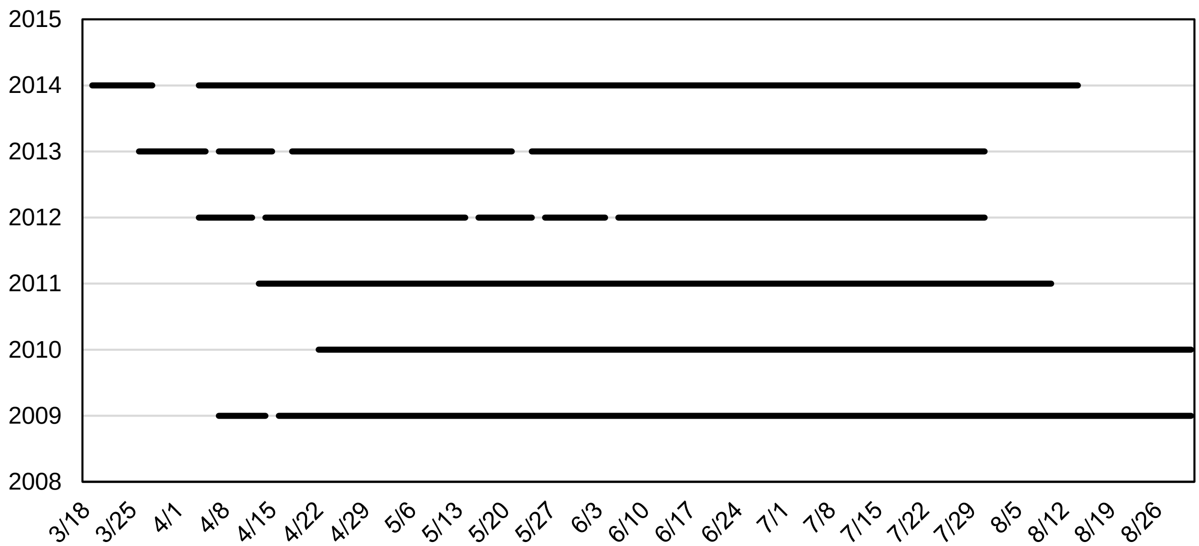


Figure 7. Begin and end dates and data gaps (spaces in lines) for operation of the Dry Creek downstream migrant trap, 2009-2014.

As in other years, the peak capture of Chinook smolts (3,266) occurred during the week of 5/14 (Figure 8 upper panel). Based on the estimated average weekly capture efficiency (range: 7% to 42%, Figure 8 middle panel), the resulting population size of Chinook salmon smolts passing the Dry Creek trap between March 20 and July 8 was 172,444 (±95% CI: 17,321236, Figure 8 lower panel). Because the Chinook smolt estimate is based only on PIT-tagged fish, the estimate does not include abundance based on the 901 captures after July 8.

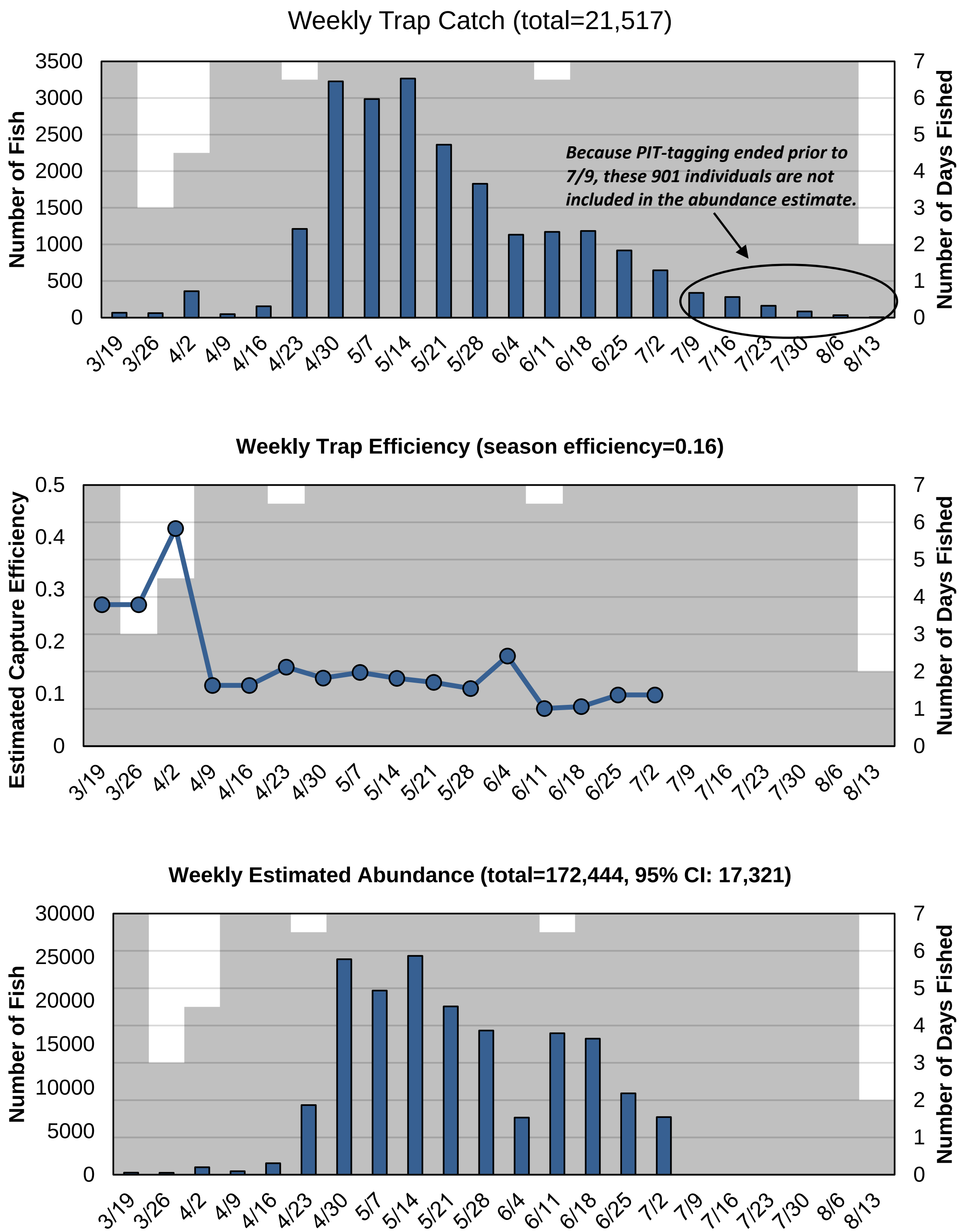


Figure 8. Weekly trap catch (upper panel), estimated average weekly capture efficiency (middle panel) and population estimate of Chinook salmon smolts in the Dry Creek rotary screw trap (lower panel), 2014. Estimates are from DARR (Bjorkstedt 2005). The number of days of each week the trap was fished is represented by the shaded area.

The pattern in estimated weekly capture efficiency of Chinook smolts was higher earlier in the season but quickly dropped off and leveled out as the season progressed (Figure 9, upper panel). This pattern was similar to other years with the exception of 2013. The 2014 abundance estimate was very similar to the average for the six years the trap has been operated (Figure 9, lower panel).

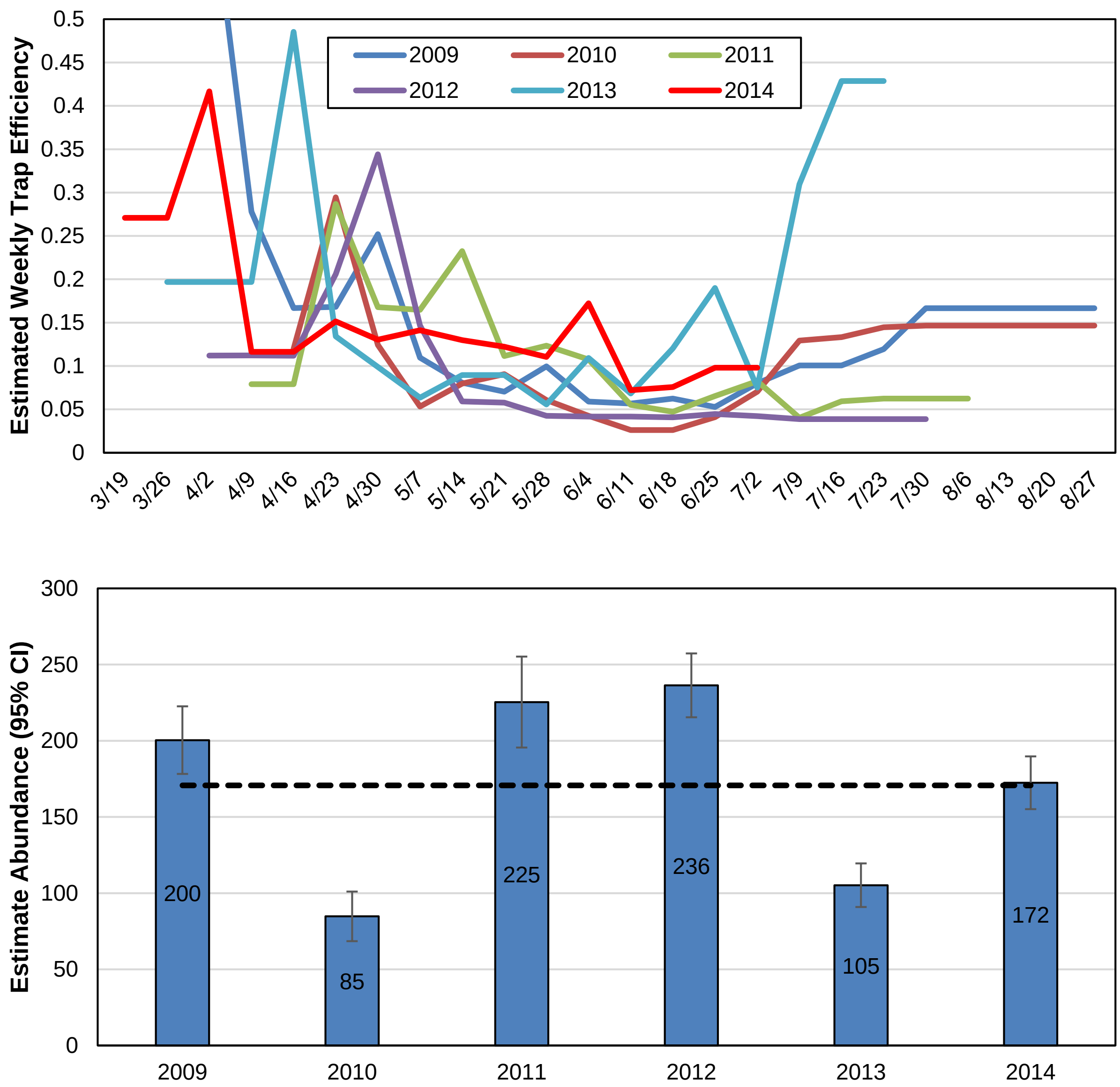


Figure 9. Estimated average weekly capture efficiency (upper panel) and population estimate of Chinook salmon smolts (x1000) produced from the Dry Creek watershed upstream of Westside Road smolt trap site (lower panel), 2009-2014. Dashed line is the six year average abundance for all years combined. Note that the 2014 estimate does not include abundance based on captures after July 8 (see text for explanation).

Coho were the least abundant of the three salmonid species captured. Hatchery smolt numbers were dominated by high capture during the week of March 26 (315 individuals, 36% of the season total). Steelhead parr capture was highest in June before declining in July (Figure 10).

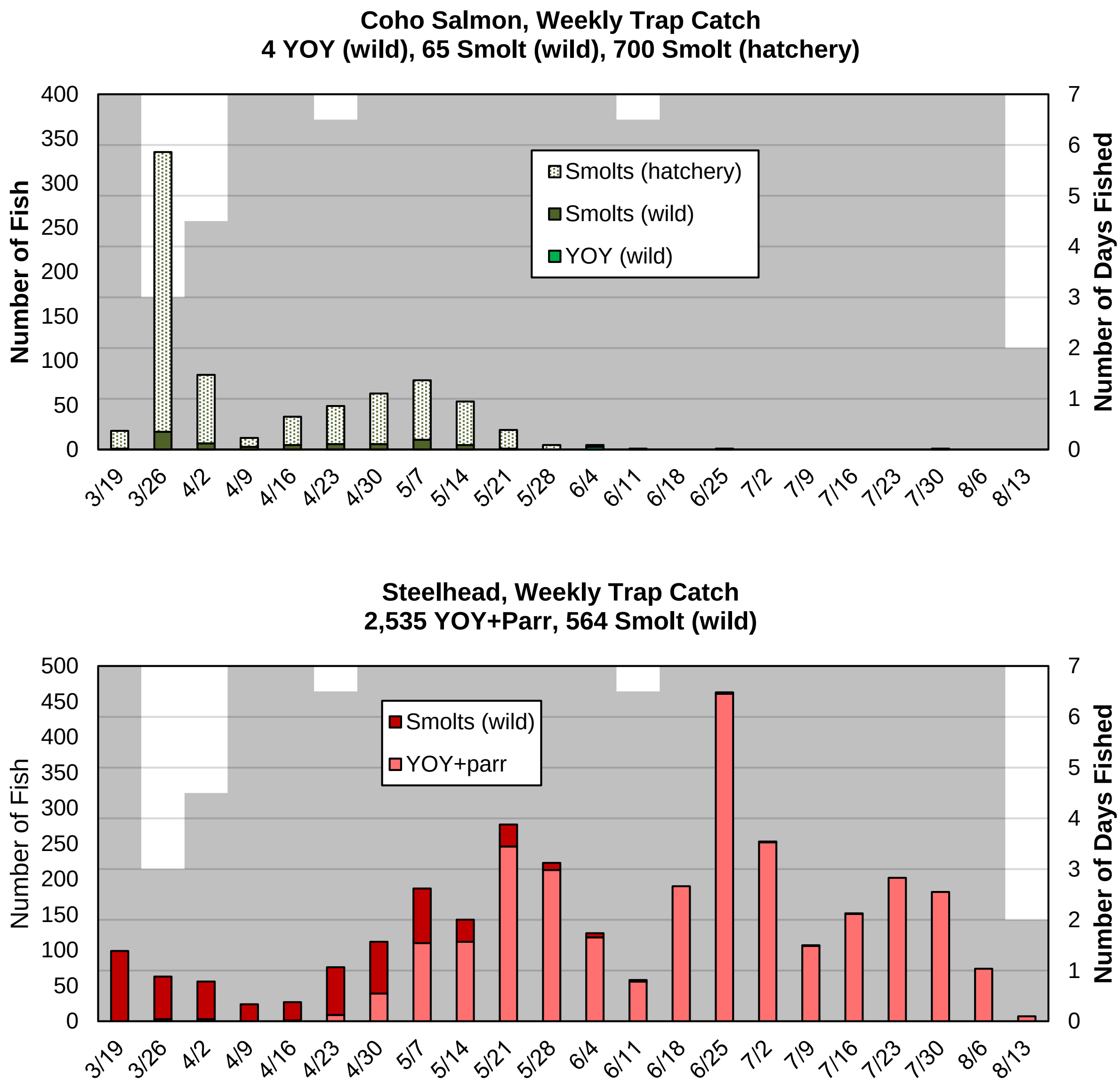
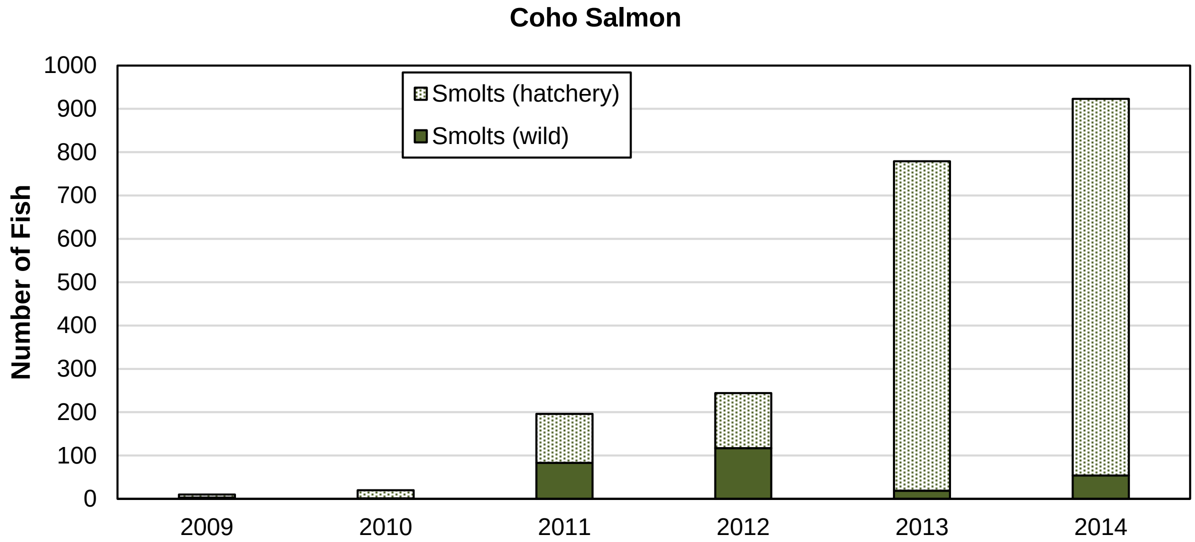


Figure 10. Weekly trap catch of juvenile coho salmon and steelhead in the Dry Creek rotary screw trap, 2014.

Coho smolt trap catch for the season was higher in 2014 than for any of the previous years of trap operation (Figure 11). Although the capture of wild coho was slightly higher in 2014 than 2013, the catch was still quite low (54). The relatively high number of steelhead smolts captured (564) was most likely due in part to the early date that we began operating the trap.



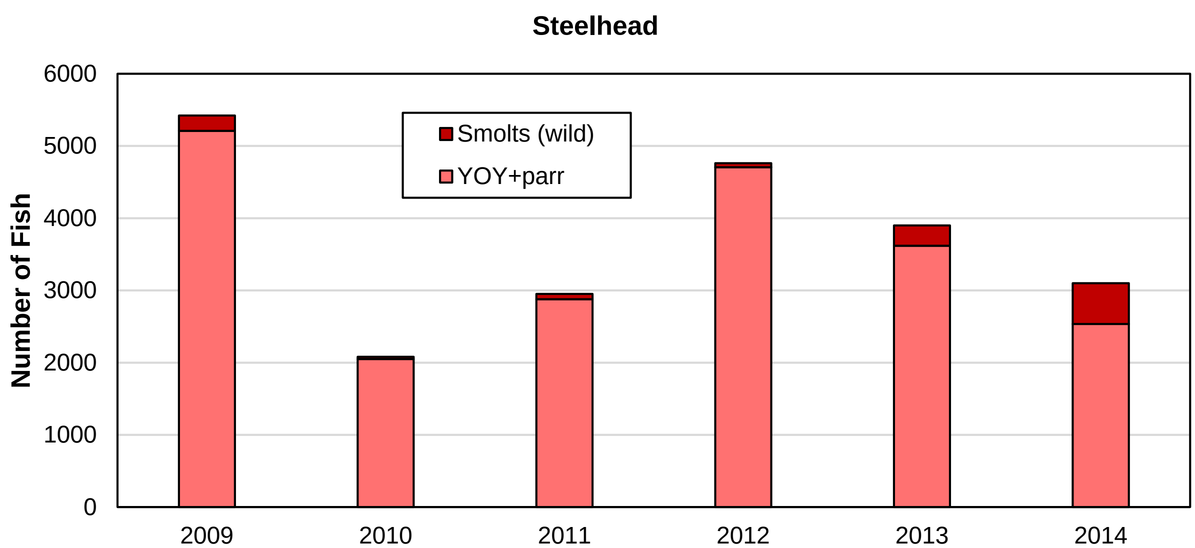


Figure 11. Trends in trap catch for coho smolts and steelhead smolts and juveniles.

Weekly sizes of all salmonids captured at the Dry Creek trap increased in size over the course of the trapping season in 2014 (Figure 12).

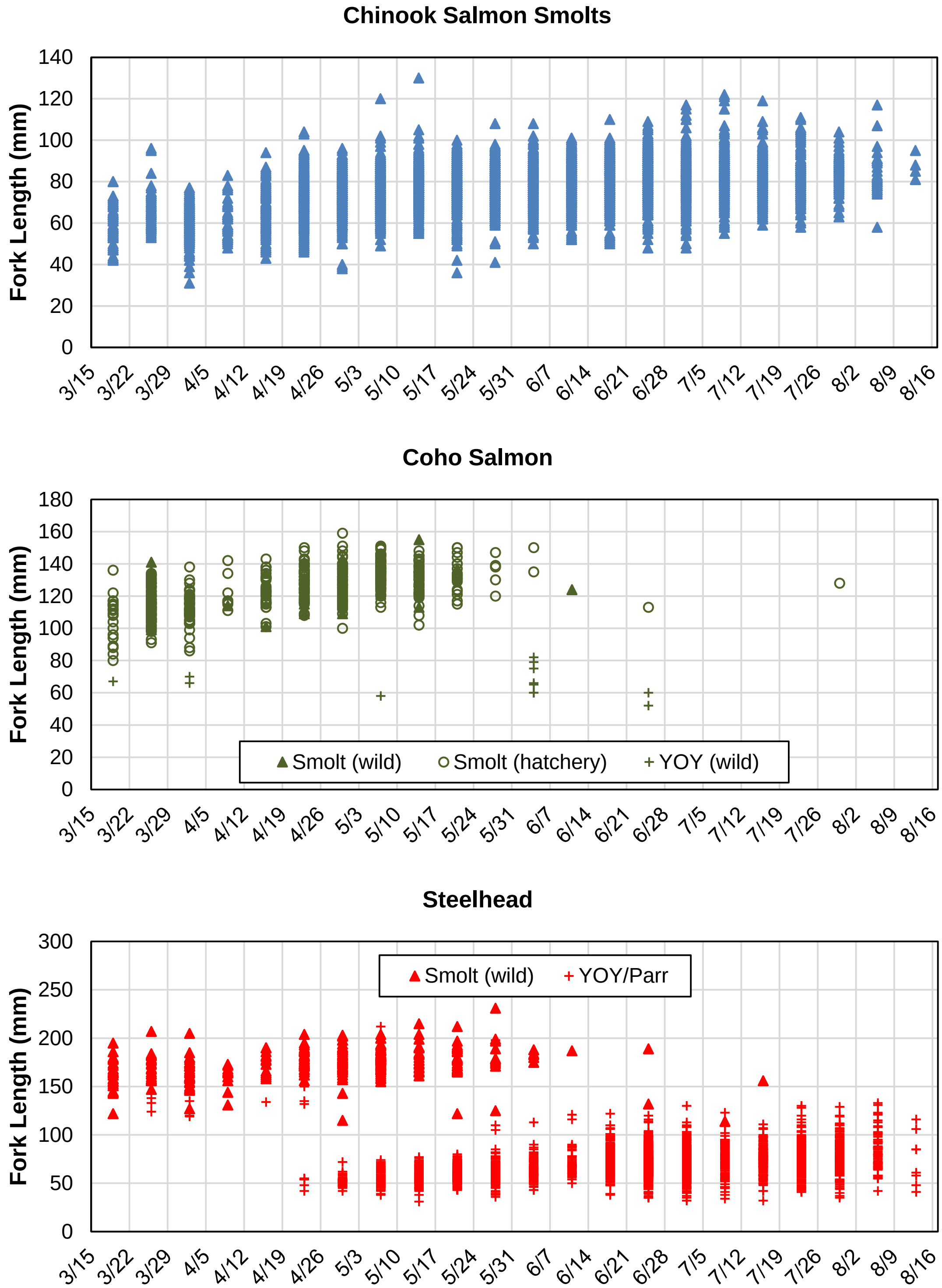


Figure 12. Fork lengths of juvenile salmonids captured in the Dry Creek rotary screw trap by week, 2014.

Conclusions and Recommendations

In 2013, the first of the off-channel habitats constructed in Dry Creek were completed giving us the opportunity to conduct biological monitoring in those features. Our method for validating fish use in the late fall through winter has been through the use of PIT antennas within the backwaters. This approach provided data that various life stages of all three species are indeed using these habitats in the winter and we expect this method will continue to be useful. Unfortunately, marginal visibility due to high turbidity and vegetation growth in these newly-created habitats hampered our ability to effectively observe fish during summer/fall snorkel surveys. In the future, we will consider alternative methods to estimating summer use of these habitats by juvenile salmonids including PIT-tagging/antennas and radio telemetry. Although we continued to estimate baseline late summer/fall juvenile density in mainstem Dry Creek with backpack electrofishing, because of deep water we were only able to estimate density using this tool in the reach 15 side channel. We will continue to estimate density in the reach 15 side channel as well as in other features where such sampling is feasible.

Monitoring trends in smolt abundance at the downstream migrant trap in 2014 illustrated issues with differing dates of trap operation and the weakness in our monitoring approach which, to date, has been solely based on trap catch as opposed to estimated abundance for coho and steelhead smolts. For example, we are very likely only trapping the late-run tail of the steelhead smolt outmigration period. Because environmental conditions favored earlier trap operation in 2014 as compared to other years, we were likely able to capture more of that late-run tail which probably accounted for the relatively higher catch of steelhead smolts as opposed to some biological- or habitat-related reason. Although we could standardize our trap catch to only include those fish captured between dates of trap operation that are common to all or most years, failure to account for within-season differences in trap efficiency would still be problematic. In the future, we plan to explore methods to account for differences in trap efficiency within and among years. Methods could include incorporation of PIT-tagging hatchery coho smolts and/or wild steelhead smolts in order to estimate species-specific efficiency estimates. This would allow a more robust comparison of smolt abundance estimates among years which would, in turn, facilitate detection of trends in abundance over time.

It will be impossible to confidently attribute changes in juvenile salmonid response to habitat enhancements in Dry Creek without some consideration of the broader context in which salmon and steelhead populations exist. Towards that end, 2014 marked the second year of California Coastal Salmonid Monitoring Program (CMP, Adams et al. 2011) implementation in the Russian River. By employing the spatially balanced random sampling afforded by the generalized random tessellation stratified (GRTS) framework outlined in the CMP, we should be able to provide that broader context and therefore accurately validate the effectiveness of habitat enhancement measures in Dry Creek.

References

Adams, P. B., L. B. Boydstun, S. P. Gallagher, M. K. Lacy, T. McDonald, and K. E. Shaffer. 2011. California coastal salmonid population monitoring strategy design and methods. CA Department of Fish and Game, Fish Bulletin 180, Sacramento, CA.

Bjorkstedt, E.P. 2005. DARR 2.0: updated software for estimating abundance from stratified mark-recapture data. NOAA Technical Memorandum NMFS-SWFSC-368. 13 p.

Inter-Fluve. 2011. Fish Habitat Enhancement Feasibility Study Dry Creek Warm Springs Dam to the Russian River, Sonoma County, CA for Sonoma Water County Agency, Santa Rosa CA (Draft prepared: March 11, 2011).

Manning, D.J., and J. Martini-Lamb, editors. 2011. Russian River Biological Opinion status and data report year 2009-10. Sonoma County Water Agency, Santa Rosa, CA. 200 p.

Martini-Lamb, J. and D. J., Manning, editors. 2011. Russian River Biological Opinion status and data report year 20010-11. Sonoma County Water Agency, Santa Rosa, CA. 208 p.

Porter, M. D., D. M. Marmorek, D. Pickard, and K. Wieckowski. 2013. Dry Creek Adaptive Management Plan (AMP), Version 0.93. Draft document prepared by ESSA Technologies Ltd., Vancouver, BC. for Sonoma County Water Agency, Santa Rosa CA. 33 pp. + appendices.

White, G. C., Anderson, D. R., Burnham, K. P., and Otis, D. L. 1982. Capture-recapture and removal methods for sampling closed populations. Los Alamos National Laboratory, LA-8787-NERP, Los Alamos, New Mexico.

White, G. C., and K. P. Burnham. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46:120-13

CHAPTER 6: Tributary Habitat Enhancements

Tributary Habitat Enhancement

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 intended to complete were 1) Grape Creek Habitat Improvement Project; 2) Willow Creek Fish Passage Enhancement Project; 3) Mill Creek Fish Passage Project; 4) Wallace Creek Fish Passage Project; and 5) Grape Creek Fish Passage Project. The Water Agency entered into agreements with the Sotoyome Resource Conservation District, now named Sonoma Resource Conservation District (RCD), to coordinate and implement two of these projects (the Grape Creek Habitat Improvement Project and Mill Creek Fish Passage Project), and with Trout Unlimited to provide funding towards the Willow Creek Fish Passage Enhancement Project. The Water Agency was also coordinating work with the Sonoma County Department of Transportation and Public Works to implement the Wallace Creek and Grape Creek Fish Passage Projects. After efforts to secure landowner access for the Mill Creek Fish Passage Project were unsuccessful, the Water Agency abandoned efforts on the Mill Creek Fish Passage Project and directed the Sotoyome Resource Conservation District to substitute the Crane Creek Fish Passage Project. The Water Agency also amended its agreement with the RCD to allow the RCD to oversee the implementation of the Grape Creek Fish Passage Project. The Wallace Creek Fish Passage Project, again after efforts to secure landowner access were unsuccessful, has been abandoned. The Water Agency is working with the National Marine Fisheries Service on an alternative as a substitute for the Wallace Creek Fish Passage 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 the California Department of Fish and Wildlife, 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 6.3). Riparian plantings were monitoring and maintained in 2012. Follow-up post-construction monitoring efforts were conducted during the summer of 2013. The next post-construction monitoring efforts are scheduled for the summer of 2015.

Figure 6.1. Grape Creek – Phase 1. In-Stream Large Woody Debris Structure Example (2009 post construction)

Figure 6.2. Grape Creek – Phase 1. In-Stream Large Woody Debris Structure Example. December 2014 winter flows.

Figure 6.3. Grape Creek – Phase 1. 2011 Post-Construction Monitoring

Figure 6.4. Grape Creek – Phase 1. February 2012.

Figure 6.5. Grape Creek – Phase 1. December 2014

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 6.6). 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 6.7). Riparian plantings were monitoring and maintained in 2012. Follow-up post-construction monitoring efforts were conducted during the summer of 2013.

Figure 6.6. Grape Creek – Phase 2. Large Woody Debris and Bank Layback Example

Figure 6.7. Grape Creek – Phase 2. 2011 Post-Construction Monitoring.

Figure 6.8. Grape Creek – Phase 2. February 2012.

Figure 6.9. Grape Creek – Phase 2. February 2012.

Figure 6.10. Grape Creek – Phase 2. December 2014.

Figure 6.11. Grape Creek – Phase 2. December 2014.

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 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 6.12 and 6.13).

Figure 6.12. Willow Creek Bridge Installation. September 2011.

Figure 6.13. 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 6.14). 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 6.14. Crane Creek Fish Passage Access Project. Bedrock outcropping.

Figure 6.15. Crane Creek Fish Passage Access Project. Chiseling pools in bedrock outcropping.

Figure 6.16. 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 6.17). 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 and cost, the revised project design was required to be put out to bid as a general construction contract, which required detailed project drawings and construction specifications. The Water Agency worked with a consultant through the Sotoyome Resource Conservation District to prepare the project construction drawings and specifications. Construction of the Grape Creek Fish Passage Project was completed in October of 2012.

Figure 6.17. Grape Creek Fish Passage Project – Flat culvert invert proposed for modification.

Figure 6.18. Grape Creek Fish Passage Project – Newly Constructed October 2012

Figure 6.19. Grape Creek Fish Passage Project – First Flows November-December 2012.

Mill Creek Fish Passage Project

The Water Agency had been working towards the construction of the Wallace Creek Fish Passage Project, which would have consisted of the modification of a concrete box culvert where Wallace Creek flows under Mill Creek Road. Engineering designs were completed and the National Marine Fisheries Service had approved those engineering designs for the project. The County of Sonoma Permit and Resource Management Department had submitted permit applications and coordinated site visits with California Department of Fish and Wildlife, National Marine Fisheries Service, U.S. Army Corps of Engineers, and the North Coast Regional Water Quality Control Board. Unfortunately, the Water Agency was been unable to secure the necessary landowner permissions from two of the three landowners in the project area. Because of the inability to secure the necessary landowner permission for the project, the Water Agency abandoned efforts to construct the Wallace Creek Fish Passage Project and began working with the National Marine Fisheries Service on an alternative as a substitute for the Wallace Creek Fish Passage Project.

In April of 2015, the National Marine Fisheries Service acknowledged that a proposal by the Water Agency to provide $200,000 in funding towards the construction of the Mill Creek Fish Passage Enhancement Project would meet the intent of the Russian River Biological Opinion and would be considered as the completion of the fifth and final tributary enhancement project required under the Russian River Biological Opinion. The Mill Creek Fish Passage Enhancement Project is a high-value project that would restore coho salmon access into 11.2 miles of upper Mill Creek. The initial estimate for the Mill Creek Fish Passage Enhancement Project described in the Russian River biological Opinion estimated the cost of the project at $100,000 to $200,000; however, recent estimates place the costs closer to $1,500,000. The Water Agency will donate $200,000 towards the project costs, which is consistent with the original estimate. The remaining funding for the project will come from NOAA grant funding and California Department of Fish and Wildlife Fisheries Restoration Grant Program funding. The project, which will be constructed in the summer of 2016, will allow for fish passage past an existing rock and mortar sill that is a barrier for fish passage under most flow conditions.

Figure 6.17. Mill Creek Fish Passage Project. Existing passage barrier in Mill Creek. December 2009.

CHAPTER 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 innovate program is a multi-partner effort involving USACE, CDFW, NMFS, University of California Cooperative Extension (UCCE)/California Sea Grant (CSG), and the Sonoma County Water Agency (SCWA). 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 CDFW to produce a minimum of 10,000 coho smolts for release directly into Dry Creek.

The Water Agency purchased 15 tanks for the Coho Program In spring 2010 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 imprinting tanks used on Dutch Bill Creek and Green Valley Creek. The Water Agency also hired a technician in spring 2010 and she has been working full time at the hatchery since the summer of 2010. The technician’s primary duties at the hatchery include assisting the Coho Program Biologists with seasonal inventories of Broodstock. Starting in the summer of 2013 she began managing teams of SCWA program assistants on special projects; such as spawning, rearing, tagging and release of all coho salmon progeny.

The Water Agency’s hatchery support technician continued to work with the biologists from the Coho Program throughout the 2013-14 release year. In addition to providing direct hatchery support, the technician was the lead point of contact for scheduling additional help for the Coho Program from available Water Agency Natural Resource Program Assistants (NRPA’s). The Water Agency technician and the NRPA’s primarily assisted the Coho Program with PIT-tagging efforts, juvenile releases, and the smolt imprinting efforts. The 2013-14 release plan originally included a new strategy of releasing fish as pre-smolts during the winter of 2013-14 into the lower reaches of Green Valley and Willow Creeks. However, Due to the lack of rain and subsequent drought-like stream conditions, fish originally allocated for this effort were released as smolts into Dry Creek and Big Austin Creek instead. Along with these fish, the fish originally allocated for the Grape Creek fall release and the Mill Creek smolt imprinting pond were also released into Dry Creek at the smolt-stage for the same reason (Table 7.1). Since the Coho Program conducts all if its juvenile releases into tributaries of the Russian River, there is always potential that these streams become sub-optimal for juvenile coho rearing during drought years.

Due to this, Dry Creek was used as the primary “back-up” release stream for the Coho Program during the 2013-14 release year. This resulted in approximately 30,000 smolts being released into Dry Creek in the winter/spring of 2014. There were also approximately 3,000 fish released into the new Dry Creek habitat enhancement sites (Farrow Backwater and Reach 15) during the fall of 2013 (Table 7.1).

Beginning in 2014, The Water Agency began providing the hatchery with support on an as need basis as opposed to a full-time hatchery support technician. The primary role of the hatchery support was to assist with the PIT-tagging effort. Approximately 15% of the coho released from the hatchery receive a PIT-tag, and the 2014-15 coho release was largest in the history of the program in which over 240,000 fish were released throughout the Russian River Watershed (Table 7.2). Coordinated through the lead biologist at hatchery, The Water Agency would send up 2 – 4 technicians per day during the tagging season to help complete this effort. This resulted in a substantial amount of hatchery support provided by The Water Agency during 2014-15.

Of the 240,000+ coho released during 2014-15, approximately 5,100 were released into Dry Creek during the fall release. This release group was divided into 4 sub-groups (~1,270 fish each) that were released directly into four of the newly constructed Dry Creek habitat enhancement sites: Farrow, Wallace, Van Alyea, and Reach 15. As in years past, the ~10,000 smolts allocated for Dry Creek were divided into 3 sub-groups and released into the main-stem of Dry Creek approximately one week apart from each other (Table 7.2). Due to the record number of coho produced at the hatchery for the 2014-15 release season, along with the ongoing drought conditions that were experienced throughout the watershed, all excess fish were also released into Dry Creek as smolts. This resulted in an additional 11,672 smolts (divided into two groups) being released into Dry Creek during May, 2015 (Table 7.2).

Table 7.1. Russian River Coho Program 2013-14 juvenile releases (B. White, USACE, personal communication).

Release Date	Release Stream	# Released	Ave FL (mm)	Ave Wt. (g)	Tagging Strategy
6/4/2013	Devil Creek	4,017	65 ± 5	3.2 ± 0.9	Snout + Peduncle CWT + 20% PIT
6/5/2013	Thompson Creek	2,037	67 ± 6	3.9 ± 1.1	CWT + 20% PIT
6/5/2013	Gilliam Creek	4,040	67 ± 7	3.7 ± 1.3	Peduncle CWT + 20% PIT
6/6/2013	Gray Creek	4,033	66 ± 6	3.5 ± 1.1	CWT + 20% PIT
6/12/2013	Grape Creek	410	66 ± 6	3.5 ± 1.1	100% PIT-tag only
6/12/2013	Mill Creek	1,017	65 ± 6	3.4 ± 1.1	100% PIT-tag only
6/13/2013	Dutch Bill Creek	1,019	66 ± 6	3.6 ± 1.1	100% PIT-tag only
6/13/2013	Green Valley Creek	210	68 ± 6	3.7 ± 1.1	100% PIT-tag only
6/17/2013	Black Rock Creek	4,078	67 ± 6	3.5 ± 1.2	CWT + 20% PIT
6/20/2013	Palmer Creek	7,027	71 ± 8	4.4 ± 1.7	CWT + 20% PIT
	2013 Spring Release Total:	***27,888***			
10/25/2013	Walker Creek (Marin)	6,501	87 ± 9	7.9 ± 2.7	CWT only
11/14/2013	Dry Creek-Farrow	1,005	100 ± 8	12.2 ± 3.2	CWT + 50% PIT
11/14/2013	Sheephouse Creek	2,532	98 ± 9	11.5 ± 3.2	CWT + 15% PIT
11/15/2013	Purrington Creek	3,041	96 ± 11	11.0 ± 3.8	CWT + 15% PIT
11/18 & 11/19/2013	Mill Creek	18,151	94 ± 9	9.9 ± 3.0	CWT + 15% PIT
11/20 & 11/21/2013	Mark West Creek	15,143	96 ± 11	11.4 ± 3.9	CWT + 15% PIT
11/22/2013	Dry Creek-Reach 15/Farrow	2,031	99 ± 8	12.7 ± 3.3	CWT + 25% PIT
11/25/2013	Willow Creek	10,092	94 ± 10	10.1 ± 3.3	CWT + 15% PIT
11/26/2013	Freezeout Creek	2,576	101 ± 9	12.6 ± 3.2	CWT + 15% PIT
11/27/2013	Porter Creek	8,045	97 ± 11	10.9 ± 3.7	CWT + 15% PIT
12/10 & 12/13/2013	Pena Creek	10,112	98 ± 12	11.9 ± 4.3	CWT + 15% PIT
12/11 & 12/16/2013	Dutch Bill Creek	12,083	96 ± 8	10.9 ± 3.1	CWT + 15% PIT
12/12/2013	Green Valley Creek	7,146	96 ± 9	11.0 ± 3.5	CWT + 15% PIT

	2013 Fall Release Total:	***98,458***			
3/3/2014	Dry Creek-Farrow [1]	2,584	115 ± 10	18.1 ± 4.7	CWT + 15% PIT
3/3/2014	Dry Creek-WSH [2]	10,116	108 ± 12	15.3 ± 5.4	CWT + 15% PIT
3/7/2014	Big Austin Creek [3]	10,117	106 ± 10	14.3 ± 4.8	CWT + 15% PIT
3/17/2014	Dry Creek Grp. 1	3,495	113 ± 11	17.3 ± 5.1	CWT + 15% PIT
3/25/2014	Dry Creek Grp. 2	3,501	115 ± 13	18.2 ± 5.7	CWT + 15% PIT
3/31/2014	Dry Creek Grp. 3	3,528	115 ± 9	18.3 ± 4.4	CWT + 15% PIT
4/2/2014	Dry Creek-WSH [4]	6,239	117 ± 10	18.3 ± 4.8	CWT + 15% PIT
4/15/2014	Dutch Bill Creek Grp. 1	2,190	116 ± 13	18.5 ± 6.0	CWT + 15% PIT
4/24/2014	Green Valley Creek Grp. 1	2,098	118 ± 13	18.6 ± 5.9	CWT + 15% PIT
5/7/20014	Dutch Bill Creek Grp. 2	2,000	120 ± 12	19.3 ± 5.7	CWT + 15% PIT
5/8/2014	Green Valley Creek Grp. 2	2,096	123 ± 12	20.7 ± 6.2	CWT + 15% PIT
5/22/2014	Green Valley Creek Grp. 3	2,026	124 ± 11	20.9 ± 5.8	CWT + 15% PIT
5/28/2014	Dutch Bill Creek Grp. 3	2,011	126 ± 12	22.6 ± 6.1	CWT + 15% PIT
	2014 Smolt Release Total:	***52,001***			
	2013-14 Release Total:	***178,347***			

[1] This group was originally designated for the Grape Creek fall release.

[2] This group was originally designated for the Green Valley pre-smolt release.

[3] This group was originally designated for the Willow Creek pre-smolt release.

[4] This group was originally designated for the Mill Creek smolt imprinting pond.

Table 7.2. Russian River Coho Program 2014-15 juvenile releases (B. White, USACE, personal communication).

Release Date	Release Stream	# Released	Ave FL (mm)	Ave Wt. (g)	Tagging Strategy
5/29/2014	Palmer Creek	7,204	65 ± 5	3.1 ± 0.8	CWT + 18% PIT
6/11/2014	Willow Creek	15,393	66 ± 5	3.4 ± 0.9	CWT + 15% PIT
6/12/2014	Green Valley Creek	505	65 ± 5	3.6 ± 0.9	100% PIT only
6/12/2014	Dutch Bill Creek	1,009	65 ± 5	3.4 ± 0.8	100% PIT only
6/13/2014	Mill Creek	1,009	65 ± 5	3.5 ± 0.9	100% PIT only
6/17/2014	Gray Creek	6,080	67 ± 6	3.5 ± 1.1	CWT + 15% PIT
6/18/2014	Gilliam Creek	5,148	70 ± 6	4.1 ± 1.2	CWT + 15% PIT
6/19/2014	Devil Creek	4,053	70 ± 7	4.0 ± 1.3	CWT + 15% PIT
6/23/2014	Black Rock Creek	4,102	70 ± 7	4.2 ± 1.4	CWT + 15% PIT
6/24/2014	Thompson Creek	2,102	72 ± 6	4.8 ± 2.6	CWT + 15% PIT
2014 Spring Release Total:		***46,605***			
11/4/2014	Walker Creek	6,894	n/a	n/a	CWT only
11/12/2014	Big Austin Creek	10,102	88 ± 8	8.6 ± 2.4	CWT + 15% PIT
11/13/2014	E. Austin Creek	10,067	88 ± 9	9.1 ± 2.8	CWT + 15% PIT
11/17/2014	Sheephouse Creek	3,066	89 ± 8	8.3 ± 2.2	CWT + 15% PIT
11/19/2014	Dry Creek	5,110	89 ± 10	8.6 ± 3.3	CWT + 60% PIT
11/20/2014	Porter Creek	8,084	96 ± 13	11.0 ± 4.5	CWT + 15% PIT
11/25 & 11/26/2014	Mark West Creek	15,127	90 ± 11	9.0 ± 3.5	CWT + 15% PIT
12/2 & 12/3/2014	Mill Creek	18,173	93 ± 14	10.2 ± 4.1	CWT + 15% PIT
12/4/2014	Dutch Bill Creek	12,164	93 ± 13	9.9 ± 3.5	CWT + 15% PIT
12/8/2014	Freezeout Creek	3,051	98 ± 10	11.5 ± 3.4	CWT + 15% PIT
12/9/2014	Purrington Creek	5,012	87 ± 14	8.7 ± 4.4	CWT + 15% PIT
12/9/2014	Green Valley Creek	10,088	88 ± 12	8.6 ± 3.3	CWT + 15% PIT
12/10/2014	Pena Creek	10,095	89 ± 12	9.1 ± 3.8	CWT + 15% PIT
12/10/2014	Grape Creek	3,012	95 ± 10	10.2 ± 3.3	CWT + 15% PIT
2014 Fall Release Total:		***120,045***			
2/17/2015	Green Valley Creek	15,248	106 ± 9	14.3 ± 3.9	CWT + 15% PIT

2/27/2015	Willow Creek Grp. 1	7,610	107 ± 10	14.5 ± 4.1	CWT + 15% PIT
3/4/2015	Willow Creek Grp. 2	7,690	107 ± 9	14.5 ± 4.0	CWT + 15% PIT
2015 Pre-smolt Release Total:		***30,548***			
3/30/2015	Green Valley Creek Grp. 1	3,104	113 ± 11	17.0 ± 4.8	CWT + 15 % PIT
3/31/2015	Mill Creek Grp. 1	5,266	118 ± 11	19.3 ± 5.4	CWT + 15 % PIT
4/20/2015	Green Valley Creek Grp. 2	3,050	113 ± 10	17.2 ± 4.5	CWT + 15 % PIT
4/20/2015	Mill Creek Grp. 2	5,246	122 ± 12	20.7 ± 6.1	CWT + 15 % PIT
4/30/2015	Dutch Bill Creek Grp. 1 [1]	2,053	112 ± 9	16.3 ± 3.9	CWT + 15 % PIT
4/30/2015	Dry Creek Grp. 1	3,500	124 ± 11	21.9 ± 6.1	CWT + 15 % PIT
5/6/2015	Dry Creek - Excess Grp. 1	6,019	120 ± 9	19.2 ± 4.5	CWT + 15 % PIT
5/7/2015	Dry Creek Grp. 2	3,526	124 ± 10	21.6 ± 5.9	CWT + 15 % PIT
5/14/2015	Dry Creek - Excess Grp. 2	5,653	126 ± 10	21.4 ± 5.3	CWT + 15 % PIT
5/14/2015	Dry Creek Grp. 3	3,507	124 ± 10	20.7 ± 4.7	CWT + 15 % PIT
5/15/2015	Dutch Bill Creek Grp. 2 [2]	2,050	115 ± 10	17.0 ± 4.3	CWT + 15 % PIT
5/29/2015	Dutch Bill Creek Grp. 3 [3]	2,049	120 ± 11	19.4 ± 4.6	CWT + 15 % PIT
2015 Smolt Release Total:		***45,023***			
2014-15 Release Total:		***242,221***			

[1] Imprinted for 16 days prior to release; trucked to the Monte Rio boat ramp for release.

[2] Imprinted for 14 days prior to release; trucked to the confluence of the RR and Willow Creek for release.

[3] Imprinted for 11 days prior to release; trucked to the confluence of the RR and Willow Creek for release.

CHAPTER 8:Wohler-Mirabel Diversion Facility

Introduction

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 collectors 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.

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 CDFW 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 CDFW 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. In February of 2013, CDFW approved $1,184,049.00 in FRGP funds towards the construction of the new fishway at Mirabel to improve fish passage at the facility.

In January 2013, the Water Agency's Board of Directors approved and adopted an Initial Study and Mitigated Negative Declaration in accordance with the California Environmental Quality Act (CEQA).

The CEQA document for the project provided 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 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 will 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 shows a plan view of the project design. Figure 8.2 shows a conceptual design drawing of the project components.

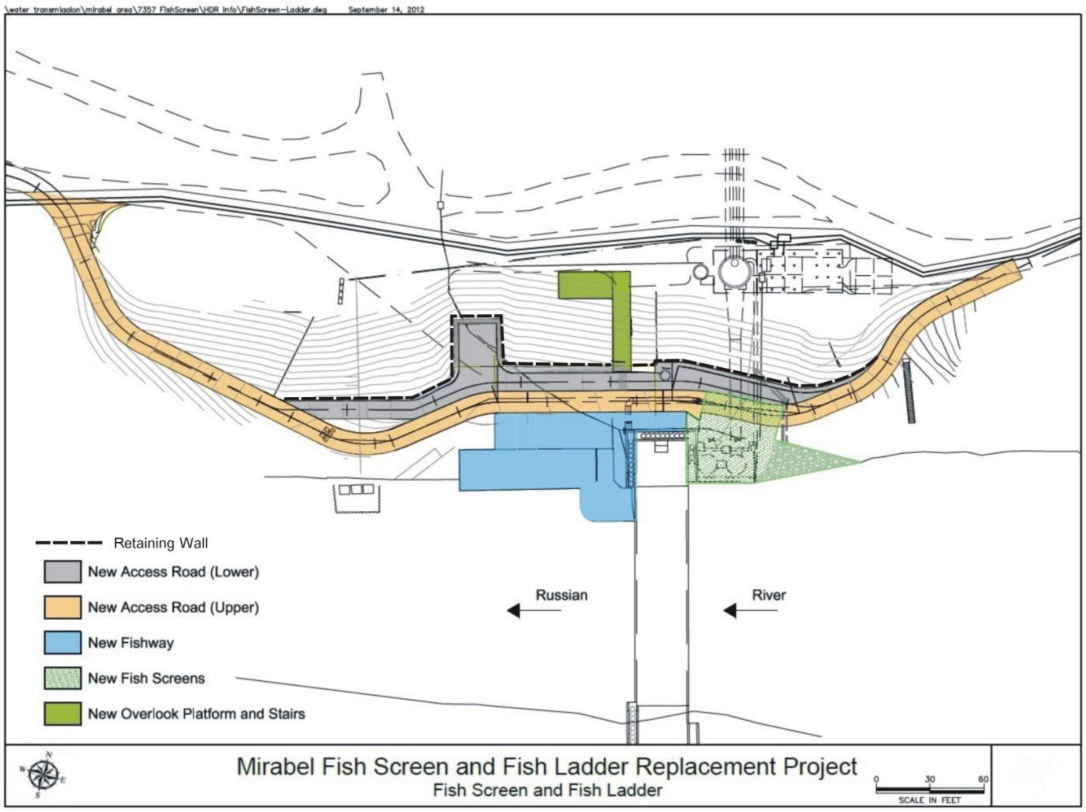


Figure 8.1. Conceptual plan view drawing of new fish screen and fishway structure at Mirabel.

Figure 8.2. Artist rendering of new fish screen and fishway structure at Mirabel.

Fish Screen

The proposed intake screen will consist of six 12-foot tall by 6-foot wide panels, with a total area of 432 square feet. The new fish screen will 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 will 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 will 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 will also be accommodated, but is not the primary focus of design. The fish ladder will 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 will 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 project includes a viewing area, separate from the video monitoring viewing window, which will allow visitors to see into the side of the fish ladder. The educational experience for schoolchildren will be improved by having the opportunity to actually see fish travelling up or down the fish ladder.

Supporting Components

The project design includes a variety of other components that support the primary fish screen and fish ladder aspects of the project. These other components consist of items such as seismic stabilization of the soils around the Mirabel dam, 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 turn around or back 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. A stairway from the top of bank down to the Mirabel Dam will allow visitor access from the upper levee road area down to the Mirabel Dam.

Construction Status

In March 2014, Hayward Baker began construction on the first phase of site improvements at the Mirabel Dam. This work consisted of the seismic stabilization of the soil area around the area of the Mirabel intake screens and fish ladder on the west bank of the Russian River. Seismic stabilization consisted of the installation of approximately 300 compacted stone columns along the levee berm at the Mirabel facility. The Mirabel seismic improvement work was completed in July of 2014 by Hayward Baker, which then allowed the second phase of construction activities to begin. Once Hayward Baker had demobilized their equipment from the work area, a second contractor (F&H) mobilized to the site in July of 2014 to begin the construction of the fish screen, fish ladder, and viewing chamber project.

Photo 1. Seismic Stabilization work at Mirabel, March 2014. Photo shows two cranes that were used by Hayward Baker to construct the rock columns. The crane on the left would drill a pilot hole while the crane on the right would complete the process by placing and vibrating into place rock to form the compacted stone columns. The Water Agency's River Diversion building at Mirabel can also been seen in this photo.

Because construction of the fish screen, fish ladder, and viewing chamber project requires the temporary inability of the Water Agency to utilize its inflatable dam which is necessary to maintain water supply production capacity, installation of a temporary cofferdam just upstream of the Wohler Bridge was the first step in the fish screen, fish ladder, and viewing chamber project. Construction of this cofferdam was started on August 4th 2014. The cofferdam remained in place until October 30, 2014. Installation of this temporary cofferdam was necessary again during the summer of 2015 between June and October. Construction activities are continuing through the winter 2015/2016 and will likely be completed during the spring of 2016.

Photo 2. Temporary Cofferdam Upstream of Wohler Bridge. August 2014.

Once the upstream cofferdam was in place, work proceeded downstream at the Mirabel dam site. The first stage of construction was to isolate the work area from the active flow of the Russian River. The construction contractor is utilizing a sheet pile cofferdam to isolate the river from the construction area.

Photo 3. Mirabel Dam work area isolated from Russian River using sheet piles. November 2014.

Photo 4. Structure that housed old intake screens. The new screen system will not be in place until 2016, but the goal of no longer using the old screens by September 2014 as required under the Russian River Biological Opinion was met. October 2014.

Photo 5. Outlet structure of new vertical slot fishway. December 2015.

Photo 6. New vertical slot fishway. Photo showing fishway channel with the rebar framework of the vertical slot baffles. Photo also shows the openings for the viewing windows into the side of the fishway. December 2015.

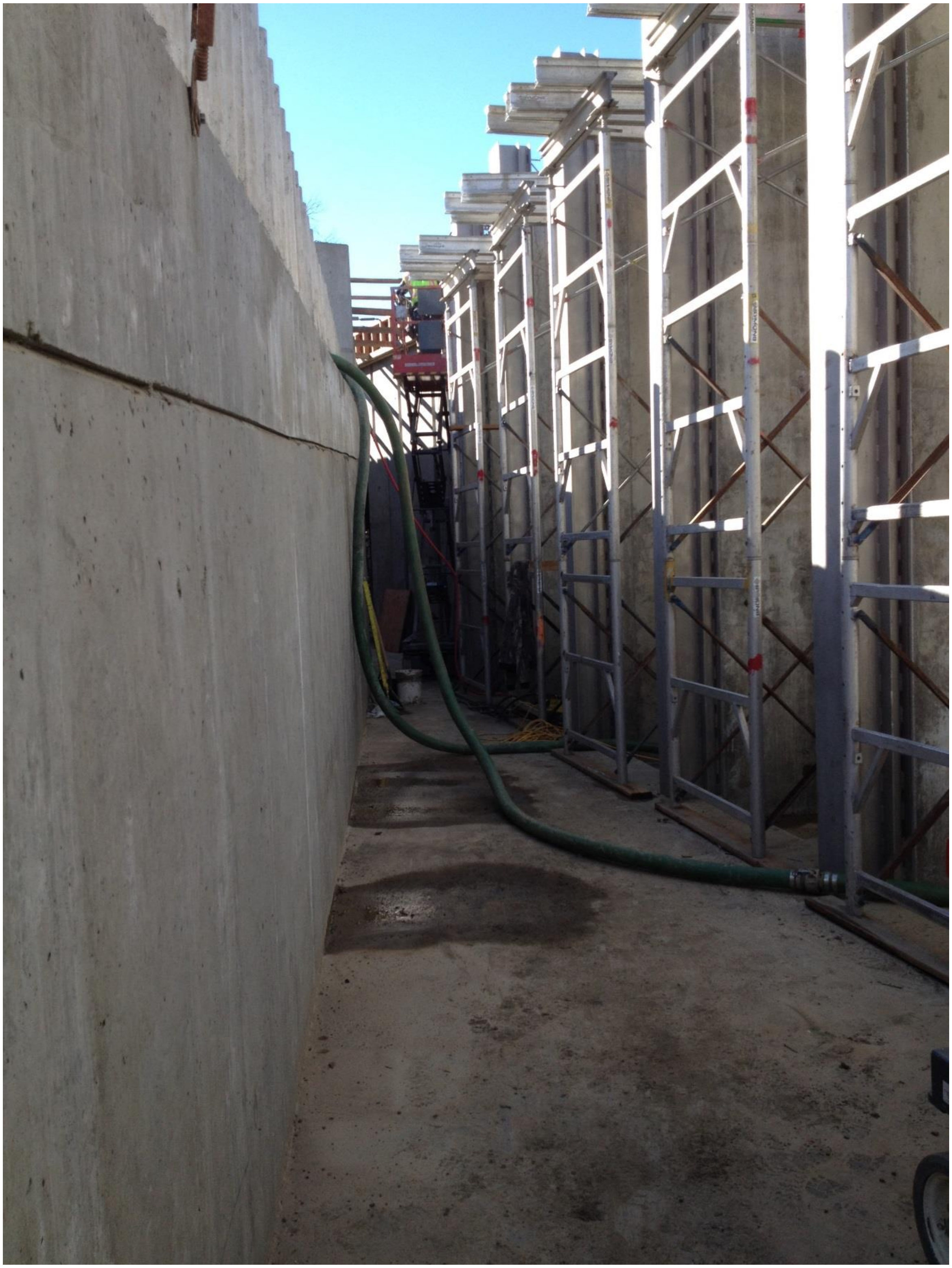


Photo 7. Upstream entrance of new vertical slot fishway. Scaffolding visible on the right side of photo is the location of where the new vertical panel fish screens will be located. December 2015

Mirabel Fisheries Monitoring

2014 marked the 15th year that fishery studies have been conducted at the Wohler-Mirabel site. Fisheries monitoring at the Mirabel site was constrained by the ongoing construction of the new fish screen and fish ladder project required by the Russian River Biological Opinion. In addition, the prolonged drought affecting the Russian River watershed led to low flow conditions which may have affected fish and fish sampling.

Although this report details the findings of the 2014 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 Wildlife 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 species migrating past the Mirabel 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 2014, two rotary screw traps (one 1.5-m diameter and one 2.5-m diameter) were operated. Trapping is initiated during the spring when streamflow decrease to levels suitable to safely and efficiently operate the traps. In 2014, the traps were deployed on April 23 at a flow of 360 cfs, and fished through the morning of July 17 at a flow of 128 cfs (flows recorded at the Hacienda Gauge) when construction began on the new Mirabel fish screen/ ladder project necessitated the removal of the downstream migrant traps.

Fish captured 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 maintain DO level near saturation. Once the fish regained equilibrium, they 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 2014, a mark-recapture study was initiated on April 23 (first day of trapping) and conducted through July 17 in an attempt to estimate the number of juvenile Chinook salmon emigrating past the dam. This study has been initiated each year since 2001 once the majority of juvenile Chinook salmon 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 500 meters upstream of 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 2005).

Beginning in 2009, PIT tags were applied to young-of-the-year steelhead once they reached a length of ≥60 mm FL in length. Lengths (nearest mm/FL) and weights (nearest 0.1 gram) were recorded for all PIT tagged fish. PIT tagged steelhead were handled in a manner similar to marked Chinook salmon with the exception that the steelhead were released downstream (PIT tag monitoring is discussed in detail in the Synthesis chapter of this report).

Results

The mainstem downstream migrant traps were operated for 75 days from April 23 through July 17 (Table 8.3.1). A total of 25 species including 8,165 individual fish were captured (excluding young-of-the-year suckers and cyprinids, Table 8.3.2). The catch included 15 species native to the Russian River. Three species, Chinook salmon, steelhead (wild), and coho salmon (hatchery and wild) accounted for 87.7 percent of the total catch.

Chinook salmon

A total of 5,700 juvenile Chinook salmon were captured in 2014. Chinook smolts were captured from the first day of sampling through the last day (April 23 – July 17) (Table 8.3.2). Excluding 2005[11], 2006[1], 2009[2] and 2010[12], overall trapping efficiency has ranged from 6.2 to 11.4 percent. In 2014, operational challenges associated with low flows and construction activities suspended normal fishing activities at the Mirabel site. The periodic loss of sampling days, combined with the start of the season being delayed by high flows, precluded the development of a robust population estimate.

[11] high streamflows curtailed downstream migrant trapping
[12] The traps performed poorly due to changes in river morphology and the operation of the dam

Table 8.3.1. Summary of Mirabel Dam rotary screw operations from 2000 to 2014.

Year	Deployment date	End date	Dam inflated	Dates of non-operation	Number of days operated
2000	April 8	June 29	May 2	April 18, 19	80
2001	April 20	June 7	April 21	April 22; May 28, 29	47
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	67
2006	May 4	May 24	May 11	May 12-15	17
2007	March 21	June 28	March 28	March 30; May 30	98
2008	March 20	June 26	April 11	Apil 11-13; May 17-18; June 10, 16, 24	91
2009	April 1	July 17	July 8	April 15; May 5-7; July 2, 9, 14	101
2010	May 4	July 16	June 11	--	74
2011	April 15	July 19	May 9	May 2, 3, 10	93
2012	April 25	July 3	May 31	May 31; June 2, 18	67
2013	March 26	July 27	May 2	July 7; July 8	124
2014	April 22	July 17	May 23	May 23 May 29–June 2 June 15–June 19	75

Table 8.3.2. Overall results at the Mirabel Dam rotary screw trap. 2014.

2014	Catch	Percent of catch
American shad	14	0.2
black crappie	3	0.0
Bluegill	51	0.7
California roach	72	1.0
Chinook salmon	5,700	78.5
coho salmon	126	1.7
common carp	3	0.0
golden shiner	1	0.0
green sunfish	27	0.4
hardhead	40	0.6
hitch	6	0.1
lamprey sp.	18	0.2
mosquitofish	1	0.0
Pacific lamprey	90	1.2
redear sunfish	1	0.0
Russian River tule perch	32	0.4
Sacramento blackfish	3	0.0
Sacramento pikeminnow	35	0.5
Sacramento sucker	459	6.3
sculpin sp.	22	0.3
Smallmouth bass	195	2.7
steelhead	329	4.5
threespine stickleback	29	0.4
western brook lamprey	1	0.0
white catfish	4	0.1
TOTAL	7,262	100.0

Average fork lengths for Chinook salmon ranged from 69 mm in late April to 84 mm by late June (Figure 8.3.1). Weekly average fork lengths in 2014 were below the 15 year average.

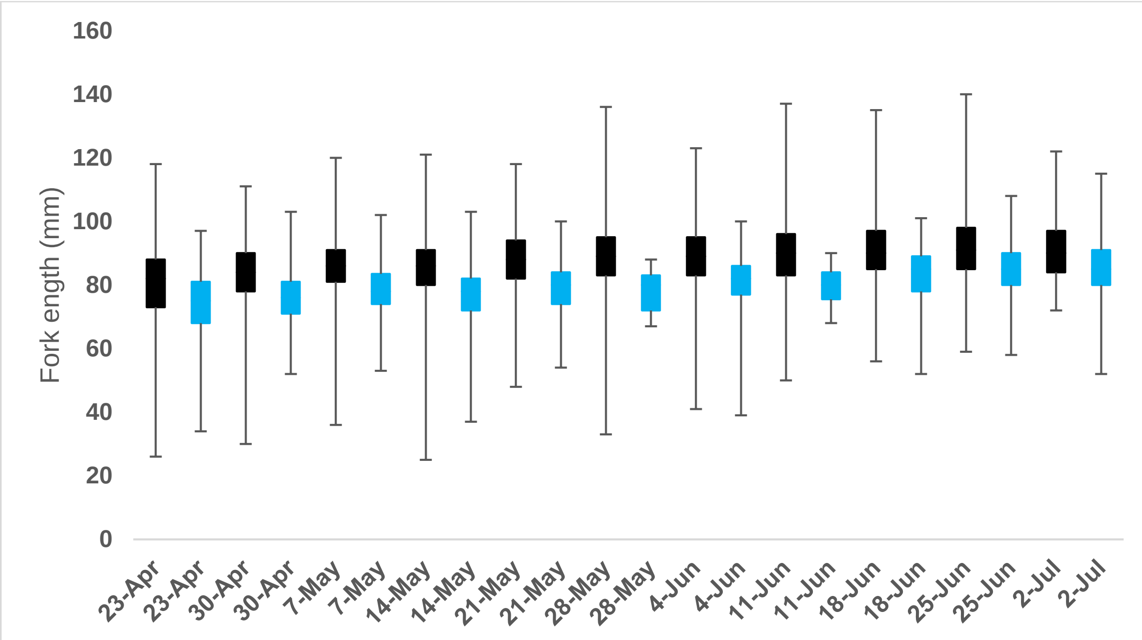


Figure 8.3.1. Weekly average fork lengths of Chinook salmon smolts measured at the Mirabel Dam trap site in 2014 vs the weekly average fork lengths, 2000-2013. Blue squares represent Chinooks salmon lengths measured in 2014. Black squares represent average lengths from 2000-2013, combined.

Steelhead

For the season, 270 wild (natural origin) steelhead parr were captured, most of which were likely YOY based on length-frequency data (Table 8.3.3, Figure 8.3.2). In addition, 59 wild origin steelhead smolts were captured between April 26 and June 27 (Table 8.3.4). In 2014, 102 PIT tags were applied to steelhead captured at Mirabel. In addition, 4 Dry Creek tagged steelhead were observed at Wohler (PIT tag monitoring is discussed in detail in the Synthesis chapter of this report).

Steelhead smolts ranged in length from 150 to 214 mm FL, averaging 177 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 23 (first day of sampling) and July 17 (May 5 for wild coho smolts). For the season, 22 wild smolts and 89 hatchery smolts were captured (Table 8.3.5). Wild coho smolts ranged in length from 96 to 142 mm FL, averaging 120 mm. Hatchery coho smolts ranged from 86 to 163 mm FL, averaging 121 mm FL (Figure 8.3.3).

Table 8.3.3. Weekly catch of steelhead young-of the year (age 0+) and parr (age 1+) at the Mirabel Dam trapping site, 2000 – 2013.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
26-Feb	--[1]	--	0	1	--	--	--	--	--	--	--	--	--		
5-Mar	--	--	0	5	--	--	--	--	--	--	--	--	--		
12-Mar	--	--	1	3	--	--	--	--	--	--	--	--	--		
19-Mar	--	--	8	13	--	--	--	1	1	--	--	--	--		
26-Mar	--	--	3	67	--	--	--	27	7	--	--	--	--	4	
2-Apr	--	--	56	170	3	--	--	8	14	4	--	--	--	41	
9-Apr	3	--	51	132	14	86	--	12	35	4	--	--	--	80	
16-Apr	20	1	447	4	12	100	--	39	34	4	--	2	--	78	
23-Apr	33	17	81	20	16	97	--	136	74	8	--	3	1	55	26
30-Apr	224	4	658	0	10	523	14	58	118	11	33	13	40	380	30
7-May	30	13	756	22	3	354	12	164	133	7	36	168	140	450	43
14-May	49	23	976	74	1	75	182	157	52	3	39	55	399	78	30
21-May	80	34	1315	246	1	25	26	185	101	8	81	62	114	64	9
28-May	74	32	806	223	2	110	--	173	59	6	60	58	67	124	10
4-Jun	102	26	467	55	2	136	--	684	76	2	26	119	91	134	3
11-Jun	40	--	164	29	1	40	--	176	50	8	41	11	53	34	20
18-Jun	58	--	60	28	10	29	--	5	26	4	22	25	35	53	52
25-Jun	50	--	1	2	7	9	--	22	10	4	25	6	36	60	36
2-Jul	--	--	--	1	--	--	--	--	--	1	8	5	7	15	10
9-Jul	--	--	--	--	--	--	--	--	--	0	2	1	--	29	1
16-Jul	--	--	--	--	--	--	--	--	--	0	--	--	--	12	
23-Jul	--	--	--	--	--	--	--	--	--	0	--	--	--	6	
30-Jul														1	
Total	763	150	5,850	1,095	82	1,584	234	1,847	790	74	373	528	983	1,698	270

[1] -- Indicates that traps were not operated during that week

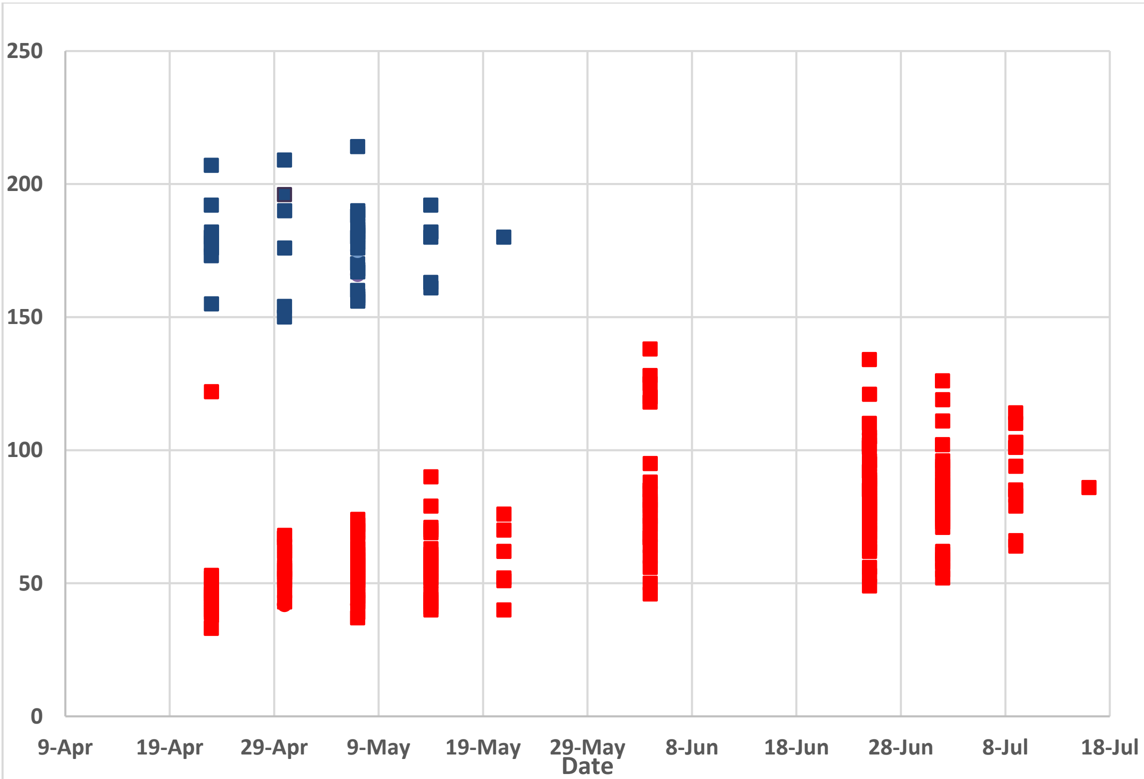


Figure 8.3.2. Length of steelhead captured in 2014, grouped by week of capture. Red squares represent young-of-the-year (age 0+) and parr (age 1+), and blue squares represent smolts (primarily age 2+).

Table 8.3.4. Weekly catch of wild steelhead smolts at the Mirabel trapping site, 2000 – 2013 averaged, and 2014.

Date	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
26-Feb	--1	--	1	4	--	--	--	--	--	--	--	--	--		
5-Mar	--	--	1	3	--	--	--	--	--	--	--	--	--		
12-Mar	--	--	38	5	--	--	--	--	--	--	--	--	--		
19-Mar	--	--	15	3	--	--	--	24	0	--	--	--	--		
26-Mar	--	--	24	39	--	--	--	99	1	--	--	--	--	17	
2-Apr	--	--	31	39	3	--	--	24	3	12	--	--	--	22	
9-Apr	19	--	33	18	14	0	--	25	0	5	--	1	--	19	
16-Apr	24	7	30	--	11	18	--	43	4	5	--	16	--	18	
23-Apr	24	16	23	--	14	9	--	61	8	2	--	6	11	13	12
30-Apr	21	16	23	--	10	7	9	14	12	1	4	6	11	11	6
7-May	8	9	7	--	3	3	10	17	4	1	8	27	15	13	24
14-May	14	4	9	26	1	1	5	11	0	2	14	54	18	5	6
21-May	9	0	9	16	1	3	6	3	1	2	9	17	9	5	1
28-May	6	0	3	6	1	0	--	2	0	0	4	13	2	5	0
4-Jun	1	1	0	2	2	3	--	1	0	0	1	9	8	7	0
11-Jun	4	--	1	1	1	2	--	0	0	0	4	2	3	2	0
18-Jun	2	--	0	0	2	1	--	0	0	2	--	--	0	5	5
25-Jun	2	--	0	0	0	1	--	0	0	0	--	--	2	5	2
2-Jul	--	--	--	--	--	--	--	--	--	1	--	--	0	2	1
9-Jul	--	--	--	--	--	--	--	--	--	0	--	--	--	2	2
16-Jul	--	--	--	--	--	--	--	--	--	0	--	--	--	1	
23-Jul	--	--	--	--	--	--	--	--	--	0	--	--	--	1	
30-Jul														2	
Total	134	53	248	162	63	48	30	324	33	33	44	151	79	155	59

[1] -- Indicates that traps were not operated during that week

Table 8.3.5. Weekly catch of coho salmon smolts at the Mirabel Dam trapping site, 2006 – 2013. Most fish were marked from the Russian River Coho Salmon Hatchery Broodstock Program. (Coho salmon were not captured prior to 2006).

	2006	2007	2008	2009	2010	2011	2012	2013	2014
26-Feb	--	--	--	--	--	--	--	--	--
5-Mar	--	--	--	--	--	--	--	--	--
12-Mar	--	--	--	--	--	--	--	--	--
19-Mar	--	3	1	--	--	--	--	--	--
26-Mar	--	1	6	4	--	--	--	90	--
2-Apr	--	0	6	23	--	--	--	494	--
9-Apr	--	2	2	35	--	16	--	75	--
16-Apr	--	9	10	38	--	362	--	55	--
23-Apr	--	8	16	33	--	111	78	67	29
30-Apr	1	15	17	3	38	45	52	80	29
7-May	1	38	23	26	53	51	83	64	37
14-May	1	24	9	23	30	138	48	53	23
21-May	0	7	1	9	15	83	15	46	4
28-May	--	1	0	7	21	31	9	45	0
4-Jun	--	0	0	1	19	32	7	5	0
11-Jun	--	0	0	4	0	11	3	1	0
18-Jun	--	0	0	0	3	2	0	1	0
25-Jun	--	0	0	0	1	0	0	3	1
2-Jul	--	--	--	0	0	0	1	--	0
9-Jul	--	--	--	0	1	1	--	--	0
16-Jul	--	--	--	0	--	--	--	--	1
Total	**3**	**108**	**91**	**206**	**181**	**891**	**296**	**780**	**124**

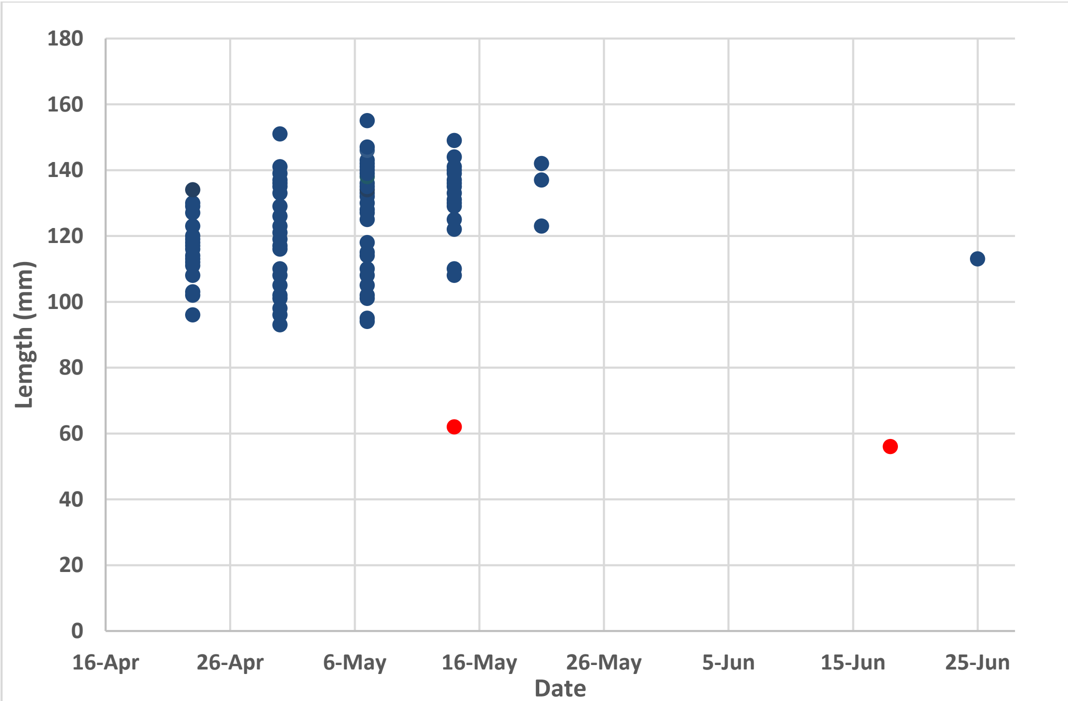


Figure 8.3.3. Lengths of wild coho salmon captured in 2014 grouped by week of capture. Red circles represent young-of-the-year (age 0+), and blue circles represent smolts (primarily age 1+).

Conclusions and Recommendations

This project is an essential component of the overall Russian River fisheries monitoring program and provides valuable information that informs the management of all three federally-listed species. Data 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 14 years of sampling, juvenile Chinook salmon begin hatching by at least late-February, with peak captures of out-migrants at Mirabel typically occurring between mid-March and mid-May. However, significant numbers of Chinook smolts have been captured through June and into July in some years.

Factors stimulating downstream movement of Chinook smolts are not well understood; however, time of year, fish size, discharge, and social interactions are suspected (Healy 1991). In the mainstem Russian River, spring conditions are generally a period of decreasing flows and increasing water temperatures, particularly beginning in May into July. Conversely, for Chinook smolts inhabiting Dry Creek, discharge and temperature remain fairly stable during this timeframe.

Because water temperatures in the mainstem Russian during the late spring can reach levels that are stressful to juvenile salmonids, the timing of smolt emigration through the lower river is potentially detrimental to late-season emigrants. Water temperatures recorded at the Diggers Bend and at the Hacienda gauges generally exceed 20°C by mid-to-late-May in most years. Increasing water temperatures combined with decreasing streamflows in the upper river likely stimulate mainstem rearing fish to emigrate prior to temperatures becoming overly stressful. However, streamflow and water temperature in Dry Creek are controlled by releases from Warm Springs Dam, and flow remains steady while water temperatures remain cold throughout the spring and early summer. This modified streamflow and temperature regimes likely dampens natural cues motivating juvenile salmonids to emigrate. In 2014, average daily water temperature at Diggers Bend first exceeded 21.1°C on May 13. The rise in water temperature at Diggers Bend would likely stimulate salmonids rearing in the upper river to begin migrating downstream. Conversely, in Dry Creek the average water temperature was <14.0°C in late May. The delayed smolt emigration from Dry Creek may result in these fish encountering marginal water temperatures during their migration through the lower Russian River. We hypothesize that the effect is disproportionately higher mortality for Dry Creek-produced fish as compared to mainstem-produced fish.

Juvenile steelhead (mainly young-of-the-year) captures at the Wohler-Mirabel traps peak in May, with low numbers being caught through 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 in some years), and few steelhead have been observed rearing in this reach of the river.

Although data are limited, hatchery coho salmon appear to migrate past the Inflatable Dam primarily in April and May, with a few fish being detected in June. The time of year and the numbers of hatchery smolts captured at the trap may be influenced by the stocking practices of the captive coho broodstock program, and may not be reflect the true abundance or run timing of these fish. Numbers of wild coho smolts have ranged from 1 in 2010, to 26 in 2012. In 2013, 20 wild coho smolts were captured at the Wohler trap.

Mirabel Fish Ladder Video Monitoring

In 2014, ongoing construction of the new fish screen and fish ladder complex prevented the normal operation of the Inflatable Dam at Mirabel. Instead, the Agency constructed a temporary coffer dam upstream of the Inflatable Dam site. The coffer dam had a functional fish passage facility; however, because of the temporary nature of the coffer dam, the Agency was unable to operate a fish counting station at this site. The Agency install a video fish counting station at the Healdsburg fish ladder and a DIDSON counting station in Dry Creek near the confluence with the Russian River (USGS site). These stations were partially successful in estimating the 2014 Chinook salmon run on the Russian River. Challenges included technical issues with setting up stations in new environs, as well as physical constraints including exceptionally low flows and a closed estuary at the start of the run, followed almost immediately by high flows which precluded video monitoring just as the run started. As a result of these challenges, the data do not represent the true run size for 2014.

Methods

The passage of adult salmonids through the Healdsburg fish ladder was assessed using digital underwater video cameras from September 1 until December 3, 2014, when high stream flows forced the removal of the camera. Underwater cameras and lighting systems were located in a fishway pool ("camera pool") near the upstream end of the ladder, and were operated 24 hours a day, 7 days a week. The camera was angled to capture fish as they passed over the weir leading into the camera pool. Video data are stored on a hard drive located in a nearby building. Each morning, video data stored on the hard drive are downloaded for review. Once reviewed, the video footage containing fish is copied to DVDs for archival purposes.

Fish were counted as moving upstream once they exited the upstream end of the camera pool. For each adult salmonid observed, the reviewer recorded the species (when possible), date, and time of upstream passage. 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. Fish that could not be identified beyond salmonid were lumped into a general category called "unknown salmonid." Unknown salmonids were then partitioned into individual species by taking the proportion of each species positively identified in the ladder on a given day, and multiplying the number of unknown salmonids on that same day by these proportions. On days when no salmonids could be identified to species, an average ratio from adjacent days was used to assign species for the unidentified salmonids.

In most years, high turbidity events associated with rainstorms reduces visibility to the point where the cameras are ineffective. The Water Agency deployed a DIDSON systems (on loan from the Department of Fish and Game) at the downstream end of the 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.

Technical and Environmental Challenges

A primary technical challenge encountered in 2014 was locating the camera in a manner that allowed for the complete census of fish migrating through the camera pool. Unlike the Wohler fish ladders where a specially built camera box forces the fish to swim in front of the camera, at the Healdsburg fish ladder it was possible for a Chinook to jump over the cameras field of view and avoid detection.

A more significant challenge was the low flow conditions that led to a closed estuary conditions for most of the sampling period. Upstream migrating salmonids had few opportunities to enter the Russian River, and those entering the river faced exceptionally low streamflows. The mouth of the estuary closed around September 18 (based on water surface elevations) and remained closed until it was artificially breached on October 23. Chinook salmon would not have had access to the Russian River during this time. The estuary remained opened for approximately 3 days after the October 23rd breaching event. The estuary again closed until a second artificial breaching event on November 17th opened the mouth for approximately 4 days. The estuary breached a final time on November 26 and remained open for the final week of the video monitoring season (December 3).

Results

In 2014, the Healdsburg fish ladder camera was in operation continuously from September 1 to December 3 (Table 8.3.6). During the majority of the season, the image quality of the videos was sufficient to identify and count fish passing through the fish ladders. Species observed in the last 14 years include, but are not limited to Chinook and coho salmon, steelhead, Pacific lamprey, Sacramento pikeminnow, hardhead, Sacramento sucker, common carp, and channel catfish.

Unknown Salmonids

In 2014, 17 (3.5%) fish were categorized as an “unknown salmonid” (i.e., they possessed the general body shape of an adult salmonid, but could not be identified to species). These 17 unknown salmonids were partitioned into 16 Chinook salmon, and 1 steelhead.

Chinook

For the 2014 video monitoring season, 461 adult Chinook salmon were observed passing the Healdsburg by December 3rd (including “unknown salmonids”). In addition, we observed 443 Chinook salmon on a video camera operated near the mouth of Dry Creek. We also attempted to count fish using Dry Creek with the aid of a DIDSON. In addition, we detected 486 large fish migrating upstream through Dry Creek between September 1 and December 31. Based on the time of year, the majority of these fish were assumed to be Chinook salmon. The overall estimate for Chinook salmon passing the counting station at Healdsburg and Dry Creek in 2014 was 1,432. Several caveats need to be placed on this estimate. Low streamflows and the extended closure of estuary likely delayed the Chinook salmon run. The peak of the run typically occurs between mid-October and mid-November (2000-2013 data, Table 8.3.7). Based on DIDSON and video counts, the Chinook run in 2014 began to ramp up in mid-November, and likely would have peaked in December. In addition, the video camera at Healdsburg was removed on December 3 in anticipation of high flows. The removal of the Camera prior to the truncated our sampling effort prior to the end of the run. Although the total of 1,432 is the third lowest record since 2000, we believe that this number would have been higher had we been able to census the entire run.

Table 8.3.6. Deployment and removal dates for the Mirabel underwater video system, 2000 – 2013.

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[1]
2011	September 1	January 17 (2012)
2012	September 1	November 21,
2013	September 1	February 8 (2014)
2014	September 1	December 3

Table 8.3.7. Weekly count of adult Chinook salmon at the Mirabel Dam fish ladders, 2000 – 2013. Dashes indicate that no sampling occurred during that week.

Week	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	20143
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	4	0	0	1	0	0	0	0	1	0
5-Sep	9	1	18	7	1	4	0	0	0	0	0	0	1	1	1
12-Sep	38	7	19	20	3	14	2	0	2	0	0	0	1	2	1
19-Sep	23	12	65	23	8	14	3	1	18	0	3	1	0	1	0
26-Sep	50	17	1,223	181	16	31	7	0	84	0	1	158	74	17	0
3-Oct	31	240	113	146	42	27	120	10	126	21	680	540	49	44	0
10-Oct	115	51	628	515	51	112	255	39	82	394	914	388	888	4	1
17-Oct	81	10	272	232	585	556	531	26	13	362	349	1063	1834	8	0
24-Oct	466	300	153	532	2284	309	83	103	21	305	54	275	768	27	53
31-Oct	63	661	505	2969	183	613	1169	249	503	75	144	217	1647	315	32
7-Nov	24	81	2,337	1289	1164	699	696	429	173	217	140	92	604	739	127
14-Nov	182	--	20	47	217	127	472	152	14	229	33	123	832	1063	174
21 Nov	200	--	37	95	57	63	53	96	24	63	108	264		179	300
28 Nov	111	--	14	45	59	33	18	375	19	84	76	6	--	100	280
5-Dec	19	--	54	--	15	0	--	486	17	20	3	1	--	172	--
12-Dec	14	--	--	--	--	--	--	4	3	31	--	2	--	125	--
19-Dec	17	--	--	--	--	--	--	0	13	0	--	10	--	73	--
26-Dec	1	--	--	--	--	--	--	--	--	0	--	15	--	32	31
2-Jan	0	--	--	--	--	--	--	--	--	--	--	2	--	53	--
9-Jan	--	--	--	--	--	--	--	--	--	--	--	12	--	50	--
16-Jan	--	--	--	--	--	--	--	--	--	--	--	0	--	28	--
23-Jan	--	--	--	--	--	--	--	--	--	--	--	--	--	73	--
30-Jan	--	--	--	--	--	--	--	--	--	--	--	--	--	37	--
6-Feb	--	--	--	--	--	--	--	--	--	--	--	--	--	10	--
Total	1,445	1,383	5,474	6,103	4,788	2,607	3,410	1,970	1,113	1,801	2,502	3,169	6,696	3,154	1,4324

[1]Dam was deflated between October 29 and November 3.

[2]Only one day was sampled during this week

[3]Weekly counts column only includes weeks where both Healdsburg and Dry Creek were in operation simultaneously.

[4]Includes Healdsburg data through 12/3 and DIDSON data through 12/31

Coho

In 2014, 11 coho salmon (jacks and adults) were identified on the video system by December 3. These images were reviewed by multiple fisheries biologist from the Water Agency, NMFS, and University of California Cooperative Extension/California Sea Grant (UC). Coho were observed migrating past the Healdsburg fish ladder beginning from November 23. Although the video system was removed at the beginning of the coho salmon run, the 2014 data suggest that coho utilize portions of the Russian River above Dry Creek, (likely the Maacama Creek system).

Steelhead

Based on hatchery returns, steelhead migrate and spawn in the Russian River primarily between December and March. Therefore, the 2014 data collected at the Healdsburg data are of little value.

Conclusions and Recommendations

Data collected in 2014 cannot be used to assess the run size primarily because of the unusual hydrologic conditions that existed in that year. Upstream migration was limited because the estuary was closed for most of the period sampled. Further, streamflow in the lower river may have limited upstream migration for fish that were able to enter the river during the brief periods after the sand bar was breached. Flows were generally less than 80 cfs until November 20 when it increased to 147 cfs (Hacienda gauge) in response to a brief rainstorm. Shortly after the sand bar was opened for the final time in 2014, a high flow event forced the removal of video counting station. Thus, the counting system was in operation for a very short period of time when fish would have been expected migrating through the river. Under more moderate (i.e., “normal”) flow conditions, data collected at Healdsburg will allow us to estimate the proportion of the total run that utilizes the mainstem and Dry Creek for spawning and rearing habitat.

Refrences

Bjorkstedt, E.P. 2008. DARR 2.0: Updated software for estimating abundance from stratified mark-recapture data. NOAA-TM-NMFS-SWFSC-368.

Chase, S.D., R.C. Benkert, D.J. Manning, and S.K. White. 2005. Results of the Sonoma County Water Agency's Mirabel Rubber Dam/Wohler Pool Fish Sampling Program – Year 5 Results: 2004. Sonoma County Water Agency.

Healy, M.C. Life history of Chinook salmon. 1998. In Pacific Salmon Life Histories, Groot, C. and L. Marcolis, eds. UBC Press, Vancouver, Canada.

Chapter 9: Chinook Salmon 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.

No Chinook salmon spawner surveys were completed in the Russian River during fall 2014. Heavy rainfall and subsequent high river flows occurred in early December 2014 that prevented field studies to be conducted during the peak migration period of salmon. Preliminary spawner surveys were conducted in Dry Creek prior to the December rains. A summary of Dry Creek spawner surveys can be found in *Implementation of California Coastal Salmonid Population Monitoring in the Russian River Watershed Report* (SCWA et al. 2015).

References

Sonoma County Water Agency and University of California Cooperative Extension/California Sea Grant. 2015. Implementation of California Coastal Salmonid Population Monitoring in the Russian River Watershed. Santa Rosa, CA. 39 pp. + appendices.

Chapter 10: Synthesis

Introduction

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.

As in previous years of RPA Russian River Biological Opinion implementation, we collected fish and related environmental data from a broad spatial and temporal extent in the Russian River Basin (Figure 1). We collected juvenile and smolt data from multiple locations in the mainstem Russian River, Dry Creek, Mark West Creek, Dutch Bill Creek, Austin Creek and the Russian River estuary. We counted adult salmonids in mainstem Russian River at Healdsburg dam, mainstem Dry Creek at the mouth and we conducted four repeat Chinook spawner surveys on the on the 22 km of stream length in mainstem Dry Creek downstream of Warm Springs Dam. Sites, gear types, and target life stages monitored included: downstream migrant trapping with rotary screw traps on Dry Creek, mainstem Russian River at Mirabel, Mark West Creek at Trenton-Healdsburg Road and Austin Creek at the Bohan & Canelis gravel mine as well as a funnel net on Dutch Bill Creek in Monte Rio; operation of a PIT antenna 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 main-channel and off-channel sites in Dry Creek. Complementary data on water quality were collected by means of continuously-recording data sondes at 9 sites throughout the estuary/lagoon and from bi-weekly and weekly grab samples at additional sites. Details regarding the specifics of these monitoring activities are covered in individual chapters of this report.

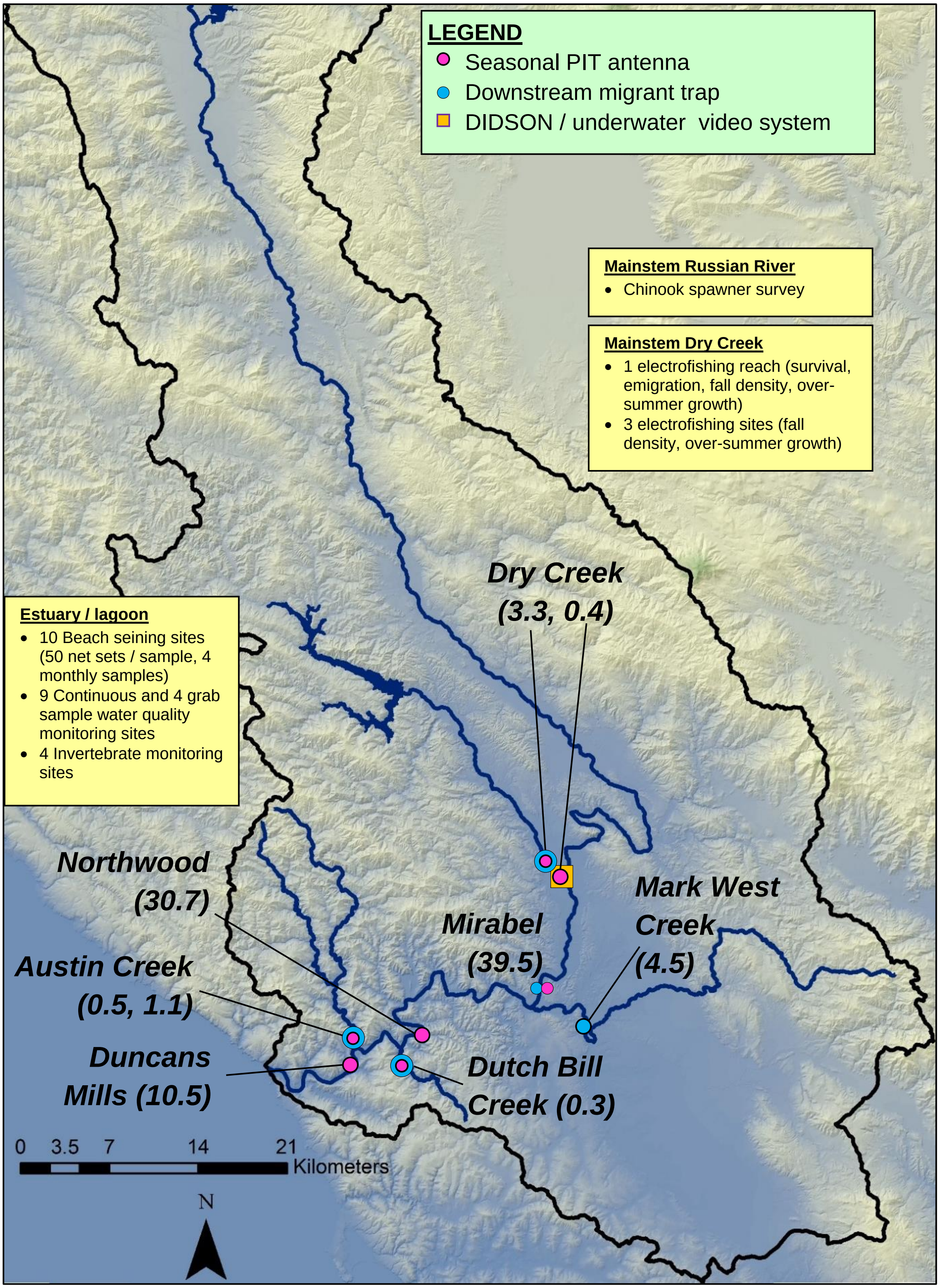


Figure 1. Spatial extent of fisheries and water quality monitoring related to the Russian River Biological Opinion, 2014. Numbers in parentheses are the distances in km (rkm) of the site from the mouth of the stream the site is located in.

In the sections that follow, we summarize population and movement dynamics of juvenile and smolt salmonids based on data from tributary and mainstem sites sampled in 2014. 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 fish were detected during beach seining sampling bouts in the estuary and at downstream migrant traps and stationary PIT-tag antennas located throughout the system (Figure 1). In the first section below, we broadly summarize available abundance information to describe some general temporal trends and variability in abundance. Following that, we focus specifically on movement of juvenile steelhead and Chinook salmon smolts from Dry Creek through the lower mainstem Russian River and estuary. We conclude with a discussion of the importance of consistent, broad-scale approaches to monitoring so that the effects of management on salmonid populations can be decoupled from environmental effects.

Abundance

Combined juvenile steelhead downstream migrant trap (DSMT) catch at Dry Creek, Mirabel, Dutch Bill Creek and Austin Creek was significantly lower in 2014 as compared to 2013 bu approximately equal to the five year average from 2009-2013.. The decrease relative to 2013 was most pronounced for Austin Creek (Figure 2). Indicators of juvenile steelhead density (backpack electrofishing density estimates on Dry Creek and beach-seining CPUE estimates in the estuary) showed slight increases relative to recent years (Figure 3) and Chinook salmon smolt estimates in Dry Creek showed a modest increase relative to 2013 (Figure 3). Due to construction of a new fish ladder and fish screens at Mirabel, the Mirabel smolt trap was only operated for part of the season meaning that no Chinook smolt estimate was possible at that site in 2014. Captures of wild coho smolts increased at Dutch Bill and Austin Creeks (Figure 3). Similar to other years, juvenile trends roughly matched adult trends for all three species (Figure 4).

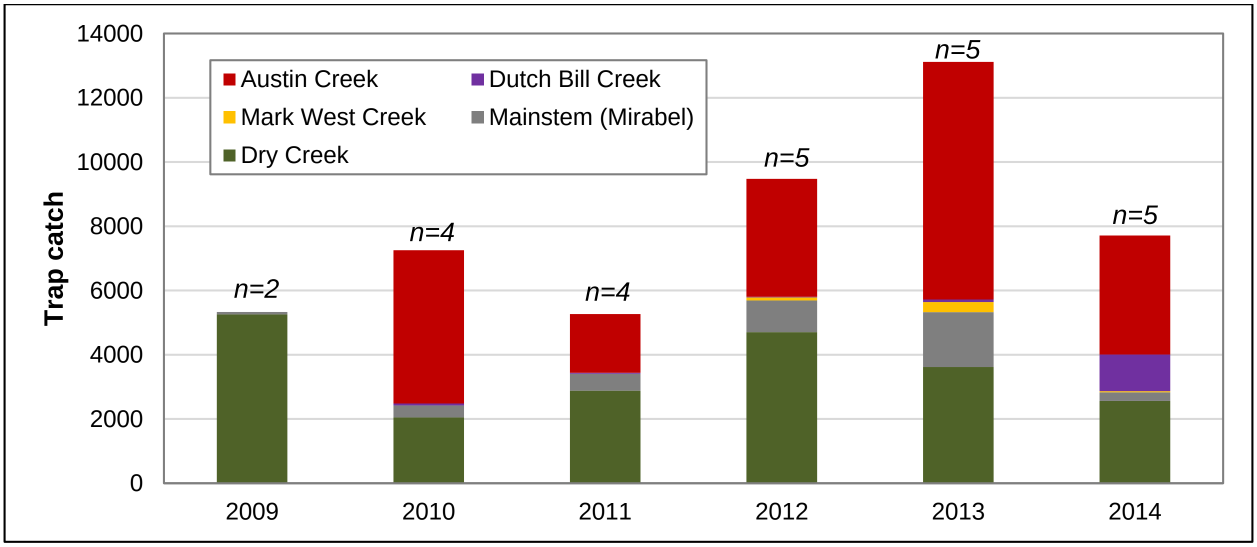


Figure 2. Number of juvenile (YOY + smolt combined) steelhead captured at downstream migrant trap sites operated by the Water Agency, 2009-2014

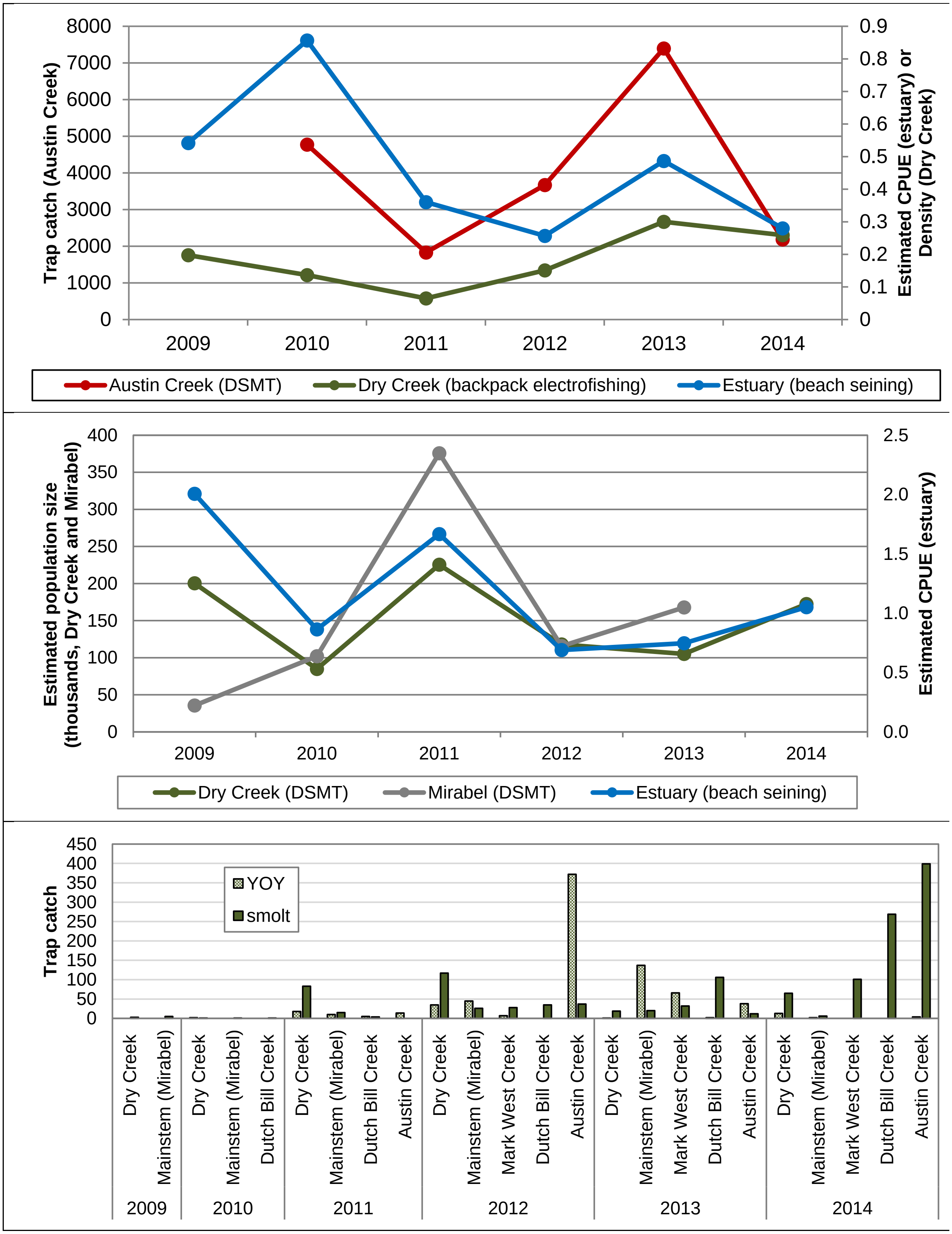


Figure 3. Indicators of juvenile steelhead (top panel), Chinook smolts (middle panel) and wild coho smolt/YOY (lower panel) trends based on monitoring conducted by the Water Agency, 2009-2014.

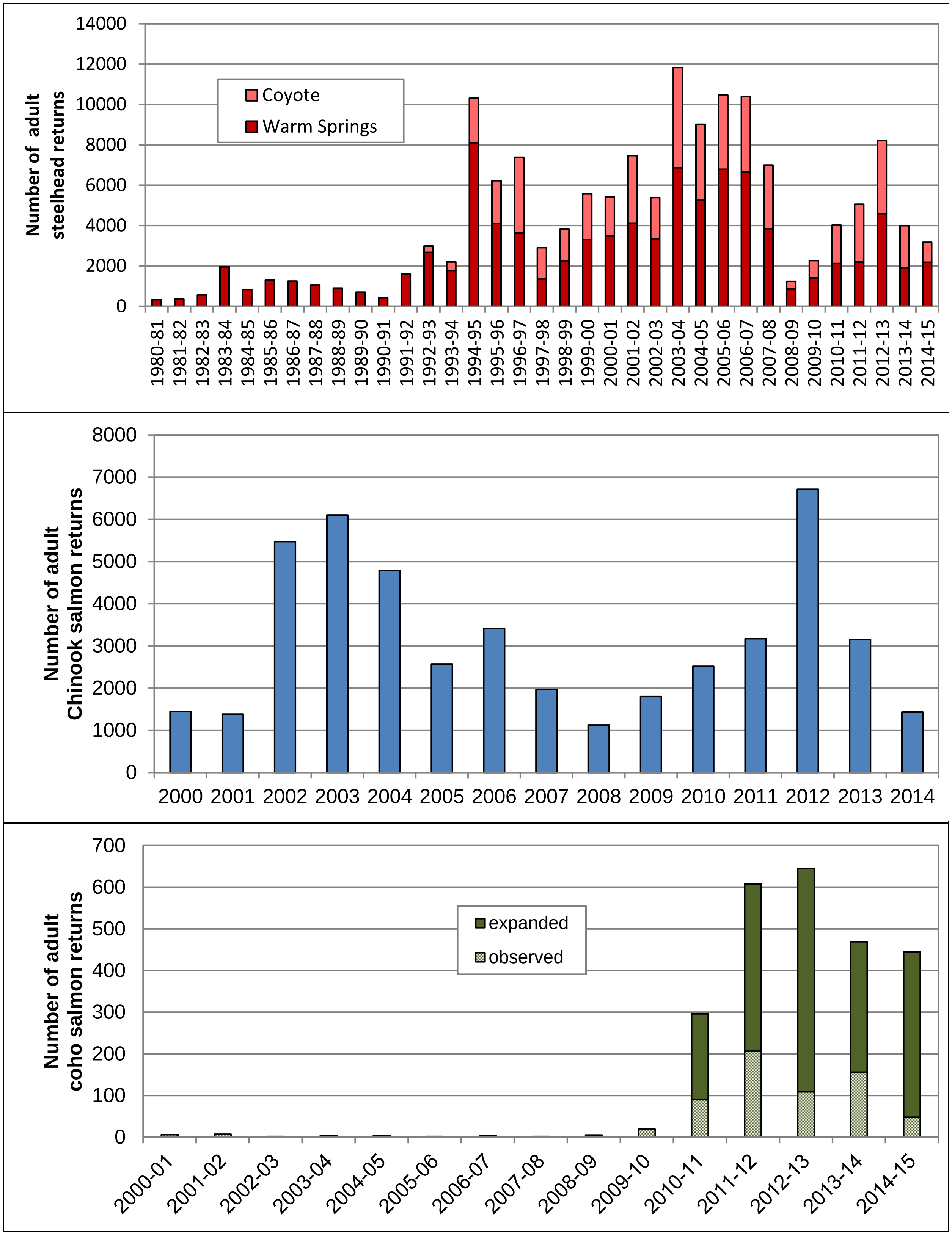


Figure 4. Indicators of adult steelhead (counted at Russian River hatcheries), adult Chinook (based on video-DIDSON counts at Wohler-Mirabel) and coho salmon returns (UCCE).

Movement, survival and growth

In 2014 we continued our evaluation of juvenile steelhead and Chinook smolt movement through the lower ~64 km of mainstem Russian. Unfortunately, because of extremely low capture probability at the Mirabel fish trapping site, we were unable to continue efforts to evaluate migration mortality of Chinook smolts as we have in the past (i.e., Manning and Martini-Lamb 2013). Our capabilities to make assessments of movement, however, was enhanced by operation of downstream migrant trap at Mirabel and PIT antenna arrays downstream of the Dry Creek trap site. When PIT-tagged fish left Dry Creek they could potentially be detected on a PIT antenna array near the mouth (rkm=0.4), recaptured at the Wohler-Mirabel fish trap or detected on the Mirabel antenna (rkm ~39.5), detected on the mainstem PIT antenna array in the community of Northwood (rkm 30.5) detected on the PIT antenna array near the upstream extent of the estuary in Duncans Mills (rkm 10.5) or captured at during beach seining samples in the estuary (Figure 1).

In 2014, we PIT-tagged 2,085 individual juvenile steelhead at all downstream migrant traps, combined plus 174 during beach seining sampling in the estuary and 1,060 while backpack electrofishing in mainstem Dry Creek (Table 2). We also PIT-tagged 4,783 Chinook salmon smolts at the Dry Creek fish trap and 777 at the Mirabel fish trap. We physically recaptured 54 PIT-tagged steelhead and 897 Chinook smolts downstream migrant traps, and detected 580 and 1,885 juvenile steelhead and Chinook smolts, respectively, at PIT antenna arrays.

We conclude that a significant number of juvenile steelhead that were captured at downstream migrant traps on Dry Creek and Austin Creek moved out of those tributaries in the spring (Table 3) and movement rates out of the tributary of origin were fast (typically 1 day or less, Table 4). When estimated detection efficiencies of PIT antennas near the mouth of each tributary was used to adjust the observed detections, we estimated 44%% (~600) and 86% (~500) of the steelhead PIT-tagged at Dry Creek and Austin Creek, respectively, exited the stream they were tagged in. Although many juvenile steelhead apparently left Dry Creek in the spring, relatively few were detected at the Mirabel downstream migrant trap (5 individuals) or Duncans Mills antennas (1 individual) suggesting that the bulk of steelhead moving out of Dry Creek may take up residence somewhere between the mouth of Dry Creek and the Mirabel dam.

Growth rates of juvenile steelhead tagged in the estuary and later recaptured in the estuary were notably higher in the lower and middle estuary (~0.85 mm per day) as compared to the upper estuary (0.22 mm per day) (Table 5); however, sample size of recaptures was only 2 in the upper estuary.

Chinook salmon smolts typically moved through the approximate3 km from the Dry Creek trap to the mouth of Dry Creek in one day while the median time to travel the 13 km to Mirabel was 2 days. Time to travel through the lower 28 kilometers of the mainstem to the estuary in Duncans Mills was approximately 4 days. Some growth of Chinook smolts was common between the Dry Creek smolt trap and Mirabel (average 0.24 mm per day).

Table 1. Number of juvenile steelhead that were PIT-tagged and observed with a PIT tag at all Water Agency fish capture sites, 2009-14.

Tributary	Survey	Year	Applied	Observed
Dry Creek	Downstream migrant trap	2009	0	2
		2010	9	2
		2011	0	3
		2012	0	2
		2013	2,704	59
		2014	1,354	36
	Electrofishing	2009	688	94
		2010	789	158
		2011	648	112
		2012	763	202
		2013	694	143
		2014	1,060	168
Mainstem	Downstream migrant trap	2009	17	0
		2010	96	51
		2011	99	1
		2012	315	3
		2013	501	37
		2014	102	7
Mark West Creek	Downstream migrant trap	2012	43	0
		2013	135	11
		2014	18	0
Dutch Bill Creek	Downstream migrant trap	2010	46	0
		2011	23	1
		2012	6	0
		2013	12	0
		2014	21	0
Austin Creek	Downstream migrant trap	2010	997	113
		2011	500	30
		2012	1,639	568
		2013	1,749	10
		2014	590	23
Estuary	Beach seining	2009	68	4
		2010	241	41
		2011	88	18
		2012	85	15
		2013	43	4
		2014	174	29
		Total	***16,317***	***1,947***

Table 2. Number of Chinook salmon smolts that were PIT-tagged and observed with a PIT tag at all Water Agency fish capture sites, 2011-14.

Tributary	Survey	Year	Applied	Observed
Dry Creek	Downstream migrant trap	2011	1,847	242
		2012	1,326	110
		2013	3,671	439
		2014	4,786	641
Mainstem	Downstream migrant trap	2011	0	45
		2012	0	36
		2013	0	202
		2014	777	256
Estuary	Beach seining	2011	0	1
		2012	0	4
		2013	0	4
		2014	0	7
		Total	***12,407***	***1,987***

Table 3. Number of PIT-tagged juvenile steelhead individuals recaptured or detected by location of tagging. Numbers on diagonal indicate the number of fish tagged (if applicable) at each location and numbers in parentheses refer to recapture/redetection at the same location. Tributaries and locations are sorted from downstream to upstream (top to bottom and left to right) so numbers left of the diagonal indicate downstream movement while numbers right of the diagonal indicate upstream movement. Note that 'na' means not calculated because the location was a PIT antenna array.

		RECAPTURE or DETECTION SITE												
		Estuary				**Austin Creek**		**Dutch Bill Creek**	**Mainstem Northwood**	**Mark West Creek**	**Mainstem (Mirabel)**		**Dry Creek**	
DETECTION or TAGGING SITE		**Lower seine**	**Middle seine**	**Upper seine**	**PIT (10.5)**	**PIT (0.5)**	**DSMT (1.1)**	**DSMT (0.3)**	**PIT (30.7)**	**DSMT (4.5)**	**DSMT (39.7)**	**PIT (39.9)**	**PIT (0.4)**	**DSMT (3.3)**
Estuary	**Lower seine**	78 (21)			2	1								
	Middle seine		53 (1)		1									
	Upper seine			42 (2)	23	1								
	PIT (10.5)				na									
Austin Creek	**PIT (0.5)**					na								
	DSMT (1.1)			1	33	290	590							
Dutch Bill Creek	**DSMT (0.3)**				2			21	1					
Mainstem (Northwood)	**PIT (30.7)**								na					
Mark West Creek	**DSMT (4.5)**									18 (0)				
Mainstem (Mirabel)	**DSMT (39.7)**								2		102 (1)			
	PIT (39.9)										1	na	1	
Dry Creek	**PIT (0.4)**												na	
	DSMT (3.3)				1						5	10	244	1354 (22)

Table 4. Median (and range in parentheses) of number of days between tagging and recapture or detection of PIT-tagged juvenile steelhead individuals. Numbers on diagonal indicate the median and range for fish tagged at each location and recapture at the same location. Tributaries and locations are sorted from downstream to upstream (top to bottom and left to right) so numbers left of the diagonal indicate downstream movement while numbers right of the diagonal indicate upstream movement. Note that 'na' means not calculated because the location was a PIT antenna array.

		RECAPTURE or DETECTION SITE												
		Estuary				**Austin Creek**		**Dutch Bill Creek**	**Mainstem Northwood**	**Mark West Creek**	**Mainstem (Mirabel)**		**Dry Creek**	
DETECTION or TAGGING SITE		**Lower seine**	**Middle seine**	**Upper seine**	**PIT (10.5)**	**PIT (0.5)**	**DSMT (1.1)**	**DSMT (0.3)**	**PIT (30.7)**	**DSMT (4.5)**	**DSMT (39.5)**	**PIT (39.7)**	**PIT (0.4)**	**DSMT (3.3)**
Estuary	**Lower seine**	14 (10-88)			48 (9-87)	16^								
	Middle seine		36^		7^									
	Upper seine			16 (16-16)	1 (0-43)	1^								
	PIT (10.5)				na									
Austin Creek	**PIT (0.5)**					na								
	DSMT (1.1)			0^	5 (1-82)	0 (0-29)	na							
Dutch Bill Creek	**DSMT (0.3)**				6^			na	10 (2-18)					
Mainstem (Northwood)	**PIT (30.7)**								na					
Mark West Creek	**DSMT (4.5)**									na				
Mainstem (Mirabel)	**DSMT (39.5)**								14.5 (4-25)		na			
	PIT (39.7)										1^	na	24^	
Dry Creek	**PIT (0.4)**												na	
	DSMT (3.3)				12^						3 (2-5)	2.5 (1-17)	1 (0-206)	na

^Sample size of 1 so no range of days reported.

Table 5. Mean (and range in parentheses) of growth in fork length (mm) per day between tagging and recapture or detection of PIT-tagged juvenile steelhead individuals. Numbers on diagonal indicate the mean and range for fish tagged at each location and recaptured at the same location. Tributaries and locations are sorted from downstream to upstream (top to bottom and left to right) so numbers left of the diagonal indicate downstream movement while numbers right of the diagonal indicate upstream movement. Note that 'na' means not calculated because the location was a PIT antenna array or recapture at the same downstream migrant trap site.

DETECTION or TAGGING SITE		RECAPTURE or DETECTION SITE: Estuary			Austin Creek	Dutch Bill Creek	Mark West Creek	Mainstem (Mirabel)	Dry Creek
		Lower seine	Middle seine	Upper seine	DSMT (1.1)	DSMT (0.3)	DSMT (4.5)	DSMT (39.5)	DSMT (3.3)
Estuary	Lower seine	0.83 (0.40-1.32)							
	Middle seine		0.92^						
	Upper seine			0.22 (0.19-0.25)					
Austin Creek	DSMT (1.1)			na*					
Dutch Bill Creek	DSMT (0.3)								
Mark West Creek	DSMT (4.5)								
Mainstem (Mirabel)	DSMT (39.5)								
Dry Creek	DSMT (3.3)							0.13 (0-0.4)	

^Sample size of 1 so no range of days reported

*One fish that was recaptured on the same day it was tagged therefore it was not re-measured.

Conclusions and Recommendations

In 2014, the Water Agency began to settle on methods that will serve our need to understand the context in which salmon and steelhead populations in the Russian are being affected by Water Agency actions (as outlined in the RPA) as opposed to natural conditions that are simultaneously acting to shape these same populations. Continuation of California Coastal Monitoring Program (Adams et al. 2011) implementation throughout the watershed begun in 2013 by the Water Agency and UCCE should assist in providing a broader context in which to make those assessments. As the Water Agency continues to implement the Russian River Biological Opinion, information on abundance and prevailing conditions fish encounter as they move through the system will be instrumental to our understanding of how various management actions outlined in the RPA translate to benefits for salmonid populations.

The PIT monitoring program employed by the Water Agency and the UCCE are proving to be key tools for overcoming the limitations posed by more traditional sampling methods (e.g., snorkeling, electrofishing, adult traps) that are impossible or problematic to implement in certain portions of the watershed covered by the RPA. We look forward to continued operation of our existing network of PIT antennas with the possibility of an additional array installed in the mainstem between Dry Creek and Mirabel so that we can further partition survival of salmonids as they move downstream.

References

Adams, P. B., and coauthors. 2011. California coastal salmonid population monitoring strategy design and methods. CA Department of Fish and Game, Sacramento, CA. 82 p.

Manning, D.J., and J. Martini-Lamb, editors. 2013. Russian River Biological Opinion status and data report year 2012-13. Sonoma County Water Agency, Santa Rosa, CA. 234 p.