# Russian River Biological Opinion Status and Data Report Year 2013-2014

## December 2014

Winter photo of backwater pond constructed in 2013 as part of the first mile of Dry Creek habitat enhancement.

SONOMA COUNTY WATER AGENCY

sonomacountywater.org

## Suggested Citation

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

## Contributors

**Chapter 1**
David Manning
Jessica Martini-Lamb
Connie Barton

**Chapter 2**
Ann DuBay
Anne Crealock

**Chapter 3**
Jessica Martini-Lamb
Pam Jeane

**Chapter 4**
Jessica Martini-Lamb
Chris Delaney
Jeff Church
Charles Simenstad
Gregg Horton
Justin Smith
David Cook
Andrea Pecharich

**Chapter 5**
David Cuneo
Greg Guensch
Gregg Horton
David Manning

**Chapter 6**
David Cuneo
David Manning

**Chapter 7**
Ben White
David Manning

**Chapter 8**
David Cuneo
Shawn Chase
Steve Koldis
Connie Barton
David Manning

**Chapter 9**
David Cook
Shawn Chase

**Chapter 10**
Gregg Horton
Justin Smith

**Affiliations**

| | |
|---|---|
| Connie Barton, Sr. Environmental Specialist | SCWA |
| Shawn Chase, M.S., Sr. Environmental Specialist | SCWA |
| Jeff Church, Sr. Environmental Specialist | SCWA |
| David Cook, M.A., Sr. Environmental Specialist | SCWA |
| Anne Crealock, M.A., Sr. Environmental Specialist | SCWA |
| Ann DuBay, M.A., Public Information Officer | SCWA |

| | |
|---|---|
| Greg Guensch, M.S., P.E., Water Agency Engineer III | SCWA |
| Gregg, Horton, Ph.D., Principal Environmental Specialist | SCWA |
| Pamela Jeane, P.E., Asst. General Manager | SCWA |
| Steve Koldis, P.E., Water Agency Engineer III | SCWA |
| David Manning, M.S., Environmental Resources Manager | SCWA |
| Jessica Martini-Lamb, Environmental Resources Manager | SCWA |
| Andrea Pecharich, M.S., Environmental Specialist | SCWA |
| Justin Smith, Environmental Specialist II | SCWA |
| Charles Simenstad, M.S., Professor | University of Washington |
| Ben White, Fisheries Biologist | U.S. Army Corps of Engineers |

Table of Contents

Chapter 1: Introduction ..... 2-1
References ..... 2-2
Chapter 2: Public Outreach ..... 2-1
Biological Opinion Requirements ..... 2-1
Water Agency Public Outreach Activities – 2013 ..... 2-1
**Meetings** ..... 2-1
**Stakeholder Process** ..... 2-2
**Other Outreach** ..... 2-3
Chapter 3: Pursue Changes to Decision 1610 Flows ..... 3-1
Permanent Changes ..... 3-2
**Summary Status** ..... 3-4
Temporary Changes ..... 3-4
**Summary Status** ..... 3-4
Chapter 4: Estuary Management ..... 4-1
Chapter 5: Dry Creek Habitat Enhancement, Planning, and Monitoring ..... 5-1
Dry Creek Habitat Enhancement ..... 5-2
Habitat Enhancement Feasibility Study ..... 5-2
Demonstration Project ..... 5-6
Miles 2-3 ..... 5-18
Validation Monitoring ..... 5-19
**Methods** ..... 5-20
**Smolt sampling** ..... 5-23
**Results** ..... 5-23
Juvenile sampling ..... 5-23
Smolt sampling ..... 5-26
Conclusions and Recommendations ..... 5-32
References ..... 5-32
Chapter 6: Tributary Habitat Enhancement ..... 6-1
Grape Creek Habitat Improvement ..... 6-1
**Phase 1** ..... 6-1
**Phase 2** ..... 6-5

Willow Creek Fish Passage Enhancement Project ..... 6-8
Crane Creek Fish Passage Project ..... 6-10
Grape Creek Fish Passage Project ..... 6-13
Wallace Creek Fish Passage Project ..... 6-15
Chapter 7: Coho Salmon Broodstock Program Enhancement ..... 7-1
Chapter 8: Wohler-Mirabel Water Diversion Facility ..... 8-1
Mirabel Fish and Screen Ladder ..... 8-1
**Fish Screen** ..... 8-4
**Fish Ladder** ..... 8-4
**Fisheries Monitoring Components** ..... 8-4
**Education Opportunities** ..... 8-4
**Supporting Components** ..... 8-5
**Construction** ..... 8-5
Mirabel Fisheries Monitoring ..... 8-9
Mirabel Downstream Migrant Trapping ..... 8-9
Methods ..... 8-9
Results ..... 8-10
Chapter 9: Chinook Salmon Spawning Ground Surveys ..... 9-1
Methods ..... 9-4
Results ..... 9-4
Conclusions and Recommendations ..... 9-4
References ..... 9-7
Chapter 10: Synthesis ..... 10-1
Abundance ..... 10-6
Movement and survival ..... 10-10
**Juvenile steelhead movement** ..... 10-12
**Chinook smolt survival** ..... 10-14
**Adult migration** ..... 10-18
Conclusions and Recommendations ..... 10-21
References ..... 10-22

# 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 fifth report for year 2013-2014. Previous annual reports can be accessed at http://www.scwa.ca.gov.

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

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

- Public Outreach.

This report contains status updates for planning efforts, environmental compliance, and outreach but the majority of the technical information we present pertains to monitoring and habitat enhancement. The Biological Opinion requires extensive fisheries data collection in the mainstem Russian River, Dry Creek, and Estuary to detect trends and inform habitat enhancement efforts. The report presents each data collection effort independently and the primary intent of this document is to clearly communicate recent results. However, because Chinook, coho, and steelhead have complex life history patterns that integrate all of these environments, we also present a synthesis section to discuss the interrelated nature of the data. Some monitoring programs are extensions of ongoing Water Agency efforts that were initiated a decade or more before receipt of the Biological Opinion.

## 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 – 2013

### Meetings

*Public Policy Facilitating Committee (PPFC) meeting* - The PPFC met in January 2014 for an update of the 2013 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 Erin Seghesio, NMFS, and, from the Water Agency, Jessica Martini Lamb, Gregg Horton, Dave Manning, Dave Cuneo, Steve Koldis, and Pam Jeane.

*Community Meetings, Events & Tours* – The fifth Russian River Estuary Lagoon Management Community Meeting was held in May 2013 at the Monte Rio Community Center. The meeting included discussions of this summer's Lagoon Management plans, results from 2012 water quality monitoring, what is being learned about harbor seals and other pinnipeds and provided an update on studies of the historic jetty at Goat Rock

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

Beach State Park. Speakers included John Largier and Matt Robart, Bodega Marine Lab and Dane Behrens and Matt Brennan, ESA PWA. Speakers from the Water Agency were Jessica Martini Lamb, Gregg Horton, Justin Smith, David Cook, Jeff Church, 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 June 2013 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 50 people attended the meeting to hear about construction plans for summer 2013 and identification of Miles 2 and 3.

Several tours and events were held in Dry Creek. The USACE and the Water Agency co-hosted a coho release celebration at the Corps Dry Creek Demonstration project in November 2013. Approximately 75 people attended, including members of the press, Lt. Col John Baker, representatives from several water contractors, members of the Dry Creek Band of Pomo Indians, staff from National Marine Fisheries Service and the California Department of Fish and Wildlife and the Friends of Lake Sonoma. Several people accompanied Water Agency staff on a tour of the Dry Creek Vineyard demonstration project.

Tours held for public officials in 2013, coordinated with NMFS, DFG, Corps and Water Agency staff, included Assembly Member Marc Levine; the Director of California's Department of Conservation, Mark Nechodem; California Senate Natural Resources Committee staff member Bill Craven; State Water Resources Control Board member Steve Moore; the Water Advisory Committee and Technical Advisory Committee; Valley of the Moon Water District Board of Directors; Nature Conservancy staff; staff of the State Water Resources Control Board; and CalTrout.

### 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.

The Advisory Group met on April 3, 2013 for a tour of the completed habitat enhancement projects at Quivira Vineyards & Winery and Grape Creek. In 2015, the Advisory Group will be invited to tour the completed Demonstration Project.

### Other Outreach

*Free Media* – Several articles about the Biological Opinion appeared in 2013 in The Press Democrat, the Russian River Times, the West County News and Review, and North Bay Bohemian, and the Russian River Gazette. In 2013, press releases were issued on a Department of Fish and Wildlife grant for the Mirabel fishway improvements, 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 Chinook returns, Dry Creek winter backwater, and 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 2013.

*Materials* – In 2013, the flyer regarding the Dry Creek Demonstration Project was updated several times to reflect different stages of construction and a flyer was developed 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

---

[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.

maintaining a seasonal freshwater lagoon that would likely support increased production of juvenile steelhead and salmon.

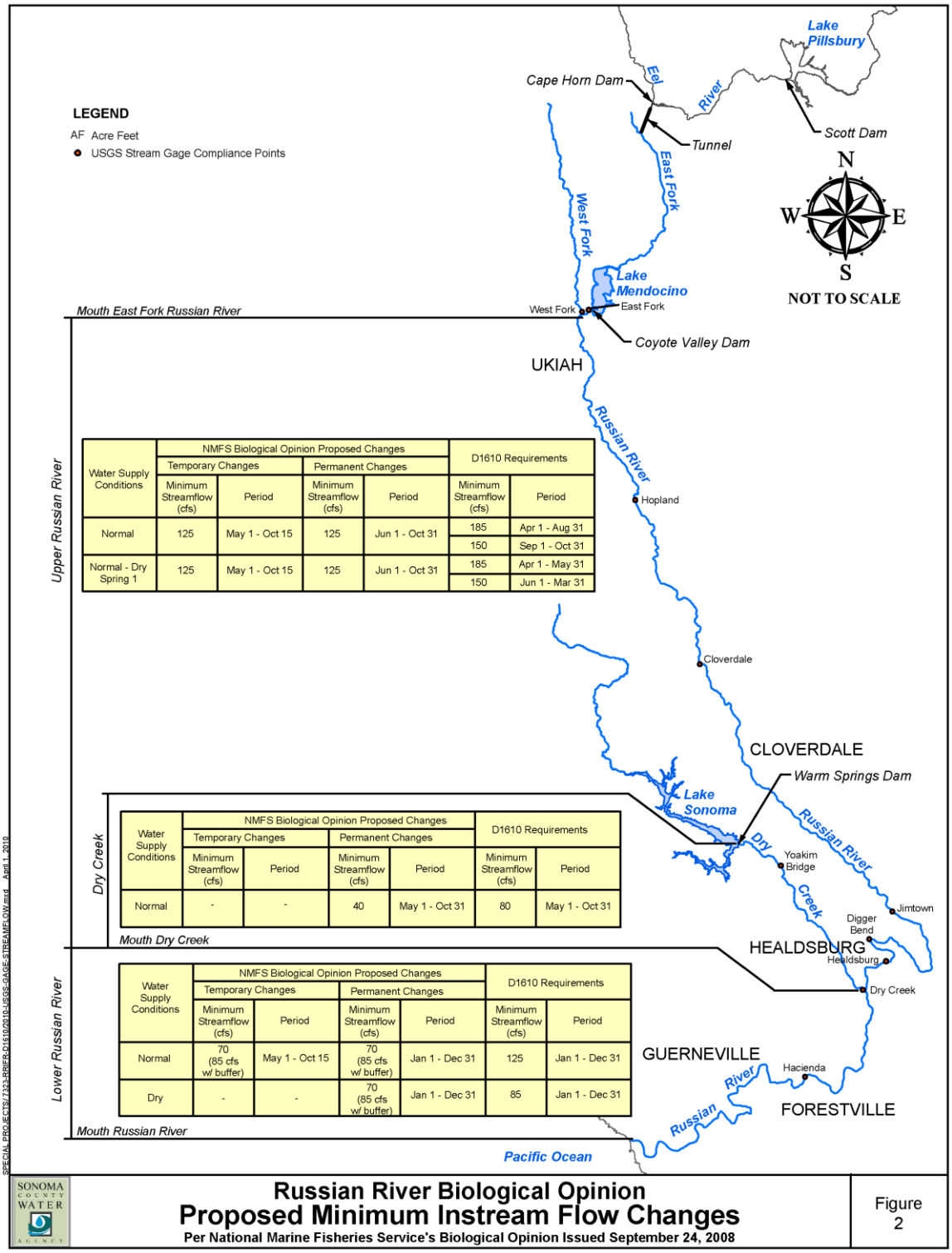
Changes to Decision 1610 are under the purview of the SWRCB, which retained under Decision 1610 the jurisdiction to modify minimum instream flow requirements if future fisheries studies identified a benefit. NMFS recognized that changing Decision 1610 would require a multi-year (6 to 8 years) process 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.




| Water Supply Conditions | NMFS Biological Opinion Proposed Changes | | | | D1610 Requirements | |
|---|---|---|---|---|---|---|
| | Temporary Changes | | Permanent Changes | | | |
| | Minimum Streamflow (cfs) | Period | Minimum Streamflow (cfs) | Period | Minimum Streamflow (cfs) | 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 |

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

| Water Supply Conditions | NMFS Biological Opinion Proposed Changes | | | | D1610 Requirements | |
|---|---|---|---|---|---|---|
| | Temporary Changes | | Permanent Changes | | | |
| | Minimum Streamflow (cfs) | Period | Minimum Streamflow (cfs) | Period | Minimum Streamflow (cfs) | 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.**

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.

### Summary Status

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

## Temporary Changes

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

### Summary Status

The Water Agency petitioned the SWRCB for temporary changes to Decision 1610 on April 4, 2013 (Appendix A-1). The Water Agency filed a Temporary Urgency Change Petition (TUCP) to request that the SWRCB reduce the minimum instream flow requirements for the Russian River in the Water Agency's water-right permits inorder to preserve storage in Lake Mendocino, which was low due to dry spring conditions.

The Water Agency requested that the SWRCB make the following temporary changes to the Decision 1610 minimum instream flow requirements for the period of 180 days from May 1 through October 28:

- (a) for May 1 through June 30, the Decision 1610 requirements for Dry conditions will apply in the main stem Russian River (75 cfs in the Upper Russian River from its confluence with the East Fork to its confluence with Dry Creek and 85 cfs in

the Lower Russian River downstream of its confluence with Dry Creek to the Pacific Ocean);

- (b) if, after July 1 storage in Lake Mendocino is above the Water Agency's calculated critical storage curve (presented in Attachment 2, Instream Flow Analysis for 2013 Temporary Urgency Change Petition), then, the Decision 1610 requirements for Dry water supply conditions will continue to apply;
- (c) if, after July 1 storage in Lake Mendocino drops below the critical storage curve for more than three consecutive days, then, from that date through October 28 the Decision 1610 requirements for Critical water supply conditions will apply in the Russian River (25 cfs in the Upper Russian River from its confluence with the East Fork to its confluence with Dry Creek and 35 cfs in the Lower Russian River downstream of its confluence with Dry Creek to the Pacific Ocean).

To improve its efforts in optimally managing flows in the Russian River, the Water Agency requested that under Dry water supply conditions the minimum instream flow requirements be implemented on a 5-day running average of average daily stream flow measurements with instantaneous flows on the Upper Russian River being no less than 65 cfs and on the Lower Russian River being no less than 70 cfs.

The SWRCB issued an Order approving the Water Agency's TUCP on May 1, 2013 (Appendix A-2). Due to the urgency of storage levels in Lake Mendocino, the SWRCB issued a public notice of the Water Agency's petition on May 6, 2013, following issuing the Order (Appendix A-3). The order included several terms and conditions, including requirements for fisheries habitat monitoring (Terms 3 to 10), preparation of a water quality monitoring plan and summary data report (Terms 11 and 12), 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 updating the SWRCB on the progress of the Santa Rosa Plain Groundwater Management Planning Program (Term 18).

The Order also included Term 17, which required the Water Agency to work with Russian River water users above Dry Creek to evaluate the long-term reliability of Lake Mendocino to meet water supply and environmental water demands. Term 17 required the Water Agency to contact specific Russian River water users to request their participation and provide information regarding their current water demands, future land use changes, and forecasts of water demands. The water supply reliability evaluation and report shall analyze the potential impacts to Lake Mendocino storage due to climate change, future potential land use practices and forecasted water demands to the extent existing information is available or provided by the entities. The evaluation and report shall also include recommendations for future water management practices to improve Lake Mendocino water supply reliability.

Reports to fulfill the terms of the order were prepared and submitted to the SWRCB and are provided in Appendix A-4. The reports included: Provision 12 -Water Quality Monitoring Summary Report; Provision 16 -Water Loss and Water Use Efficiency; and Provision 18 -Progress of Santa Rosa Plain Groundwater Management Planning Program.

Provisions 3 through 10 of the State Water Board Order required the Water Agency to conduct and report on a number of fisheries monitoring projects. The Water Agency and SWRCB consulted with NMFS and CDFW regarding the fisheries monitoring objectives and methods. Projects included monitoring adult Chinook salmon returns at the Mirabel inflatable dam, dive surveys to monitor Chinook in the lower and upper Russian River, dive surveys to measure the relative abundance of juvenile steelhead and native freshwater fish in the upper Russian River, and salmonid downstream migrant trapping operations in Dry Creek, the mainstem of the Russian River at Mirabel Dam and the Russian River estuary near Duncans Mills. Updates of fisheries monitoring data were sent to NMFS and CDFW staff every two weeks per Provision 10 of the State Water Board Order.

The Water Agency conducted weekly bacteriological, nutrient and algal mainstem sampling at six sites Water samples were collected from the following six (6) surface-water sites in the mainstem of the Russian River: Hopland; Comminsky Station; Jimtown Bridge; Diggers Bend; Riverfront Park; and Hacienda.

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. 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. As such, it should be noted that the dilution rates that are utilized to accurately quantify *E. coli* concentrations for comparison to the draft guidelines do not allow for the quantification of total coliform concentrations at a high enough level to compare with the draft guidelines and are instead reported as greater than 2419.6 MPN (>2419.6). The decision to focus on *E. coli* and enterococcus for the analysis of potential water quality impacts and not total coliform concentrations was done in coordination and consultation with North Coast Regional Water Quality Control Board staff.

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.

Monitoring results were posted to the Water Agency website and are provided in Appendix A-4. Water quality monitoring in the Russian River Estuary is further discussed in Chapter 4.

The Water Agency submitted a second Temporary Urgency Change Petition to the SWRCB on December 19, 2013, (Appendix A-5) due to severely low storage levels in Lake Mendocino. On December 18, 2013, the water supply storage level in Lake Mendocino was 28,457 acre-feet. This storage level was 42 percent of the available winter water supply pool and 26 percent of the summer water supply pool. At that time, the low storage was due to the historic dry conditions in the region since January 1, 2013. With only 7.67 inches of rainfall since January 1, the Ukiah area was at just 22.4% of average (34.18 inches) based on records back to 1893.

To address the existing and projected water supply conditions in Lake Mendocino and the risks associated with continuing to set Upper Russian River instream flow requirements using the Decision 1610 hydrological index, which is based on cumulative inflow into Lake Pillsbury, the Water Agency requested that the State Board make the following temporary urgency change to Term 20 of the Water Agency's water right Permit 12947A:

Starting January 1, 2014, the minimum instream flow requirements for the Upper Russian River will be established using an index based on water storage in Lake Mendocino, rather than using the Decision 1610 index, which is based on cumulative inflow into Lake Pillsbury. This temporary change is requested to preserve the Lake Mendocino water supply in case very dry hydrologic conditions continue. Specifically, the Water Agency proposes that the monthly storage values listed below be used, in lieu of cumulative Lake Pillsbury inflow, to determine the water supply conditions that determine which minimum instream flow requirements in Term 20 of Permit 12947A will apply to the Upper Russian River:

a. Dry water supply conditions will exist when storage in Lake Mendocino is less than:

40,000 acre-feet as of January 1

59,000 acre-feet as of February 1

68,000 acre-feet as of March 1

69,500 acre-feet as of March 16

71,000 acre-feet as of April 1

70,000 acre-feet as of April 16

69,000 acre-feet as of May 1

67,500 acre-feet as of May 16

65,000 acre-feet as of June 1

b. Critical water supply conditions exist when storage in Lake Mendocino is less than:

31,000 acre-feet as of January 1

36,000 acre-feet as of February 1

52,000 acre-feet as of March 1

53,000 acre-feet as of March 16

54,000 acre-feet as of April 1

53,000 acre-feet as of April 16

52,000 acre-feet as of May 1

51,000 acre-feet as of May 16

50,000 acre-feet as of June 1

c. Normal water supply conditions exist in the absence of defined dry or critical water supply conditions.

The SWRCB issued an Order approving the Water Agency's TUCP on December 31, 2013 (Appendix A-6). Due to the urgency of storage levels in Lake Mendocino, the SWRCB issued a public notice of the Water Agency's petition on January 3, 2014, following issuing the Order (Appendix A-7).

This Order required the Water Agency to have biweekly meetings with NMFS and CDFW staff to discuss the need for applicable fisheries monitoring activities or changes to the Order and to report back within one week to SWRCB regarding the results of those meetings (Term 2). Ongoing monitoring of water quality conditions at the five multi-parameter datasondes sites along the Russian River was also required (Term 3). Term 4 of the Order required the Water Agency to report on a weekly basis updated information regarding hydrologic conditions in the Russian River, Lake Mendocino storage levels, forecasted precipitation events, Potter Valley inflows, and a summary of the water quality datasondes included in Term 3

# 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 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 2013 annual Outlet Channel Adapative Management Plan was held on March 7, 2013. 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 2013 plan, which includes a summary of physical processes during 2011 and 2012 as Appendices F and G, respectively. The revised plan was in effect for 2013, 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 2013 Outlet Channel Adapative Management Plan (Appendix 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 2013 and provided to NMFS and CDFW. The beach topographic maps are provided in Appendix 2.

ESA prepared the 2014 Russian River Estuary Outlet Channel Adaptive Management Plan (Appendix 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 2014 annual Outlet Channel Adapative Management Plan was held on March 11, 2014. In attendance were staff from the Water Agency, ESA PWA, Bodega Marine Lab, NMFS, CDFW, 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.

As described in Appendix H of the 2014 Outlet Channel Adaptative Management Plan, during the 2013 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 the inlet experienced several closures, an outlet channel was not implemented. The inlet was closed for the majority of the first two months of the management period as a result of two closure events. During this time, each closure ended when lagoon water levels increased, overtopped the beach berm, and scoured a new tidal channel. The first event self-breached in early June before water levels reached 7 ft NGVD, while the second event resulted in lagoon stage above 7 ft NGVD but self-breached in early July before an outlet channel could be implemented. The Estuary remained fully tidal until it closed again in late September. This September-October event was ended with a manual breach on the last day of the management period to provide a pathway for migrating salmonids and to reduce water levels in advance of potential fall precipitation (ESA PWA 2014).

### Lagoon Management Season Closures and Self-Breaches

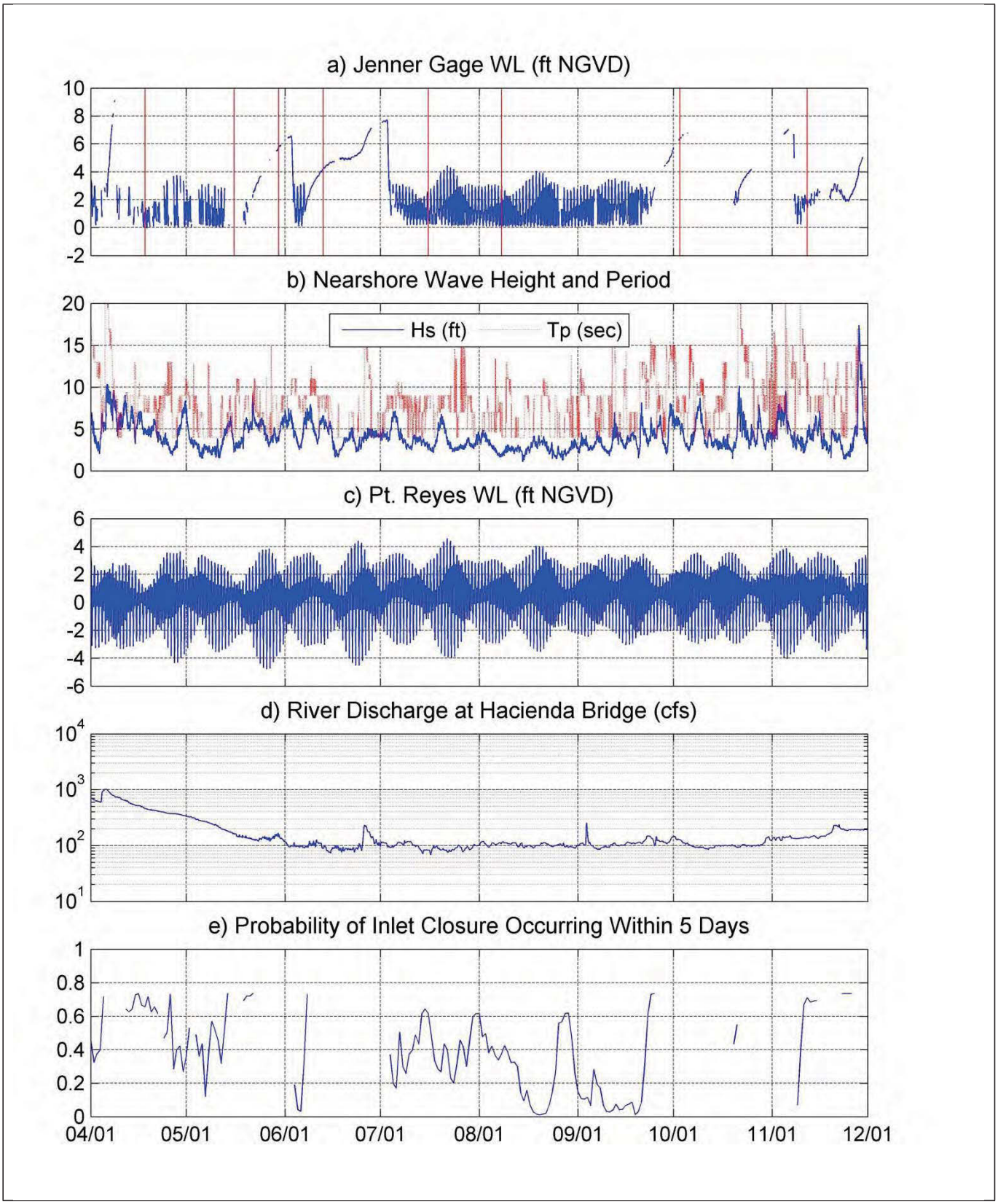
Time series of Estuary water levels, as well as the key forcing factors (waves, tides, and riverine discharge), are shown in Figure 4.1 for the entire management period (ESA PWA 2014). The lagoon water level time series (Figure 4.1a) summarizes the closure events at the beginning of the management period, 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 below 100 $ft^3/s$ at the onset of June and not rising back significantly above 100 $ft^3/s$ until September, with the exception of a short rise in response to a late June rainfall. Flows as low as 85 $ft^3/s$ during the closure in mid-June allowed the lagoon stage to remain steady at approximately 5 ft NGVD for over a week. Immediately following this steady period, a late-season rainstorm briefly increased flows into the lagoon to more than 200 $ft^3/s$, causing the lagoon stage to approach 8 ft NGVD and eventually self-breach. As in prior years, wave energy in the subsequent months of July-September was minimal (Figure 4.1b). The hourly significant wave height only consistently surpassed 8 ft in late September, a likely cause of the last closure event of the management period.

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. Moderately high waves coincided with the closure events in May, June, and October. All closure events also occurred during or shortly after neap tidal periods.

All closure events occurred with the inlet located adjacent to the jetty. In 2012, 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 appeared to be the case for the first closure event of the 2013 management season, which self-breached on June 3 at a stage of roughly 6.5 ft NGVD. The low point in the beach berm that was subsequently overtopped and self-breached also persisted immediately adjacent to the jetty.

However, the same late-June rain storm that increased lagoon stage during the subsequent closure event also coincided with several days of long period swell waves (Hs ~ 5 ft, Tp ~ 15 s) that built up the beach in this location, allowing the lagoon stage to rise to almost 8 ft NGVD (Figure 4.2) before self-breaching in early July. Closure events that occurred later in fall were breached at or below a lagoon stage of 8 ft NGVD.

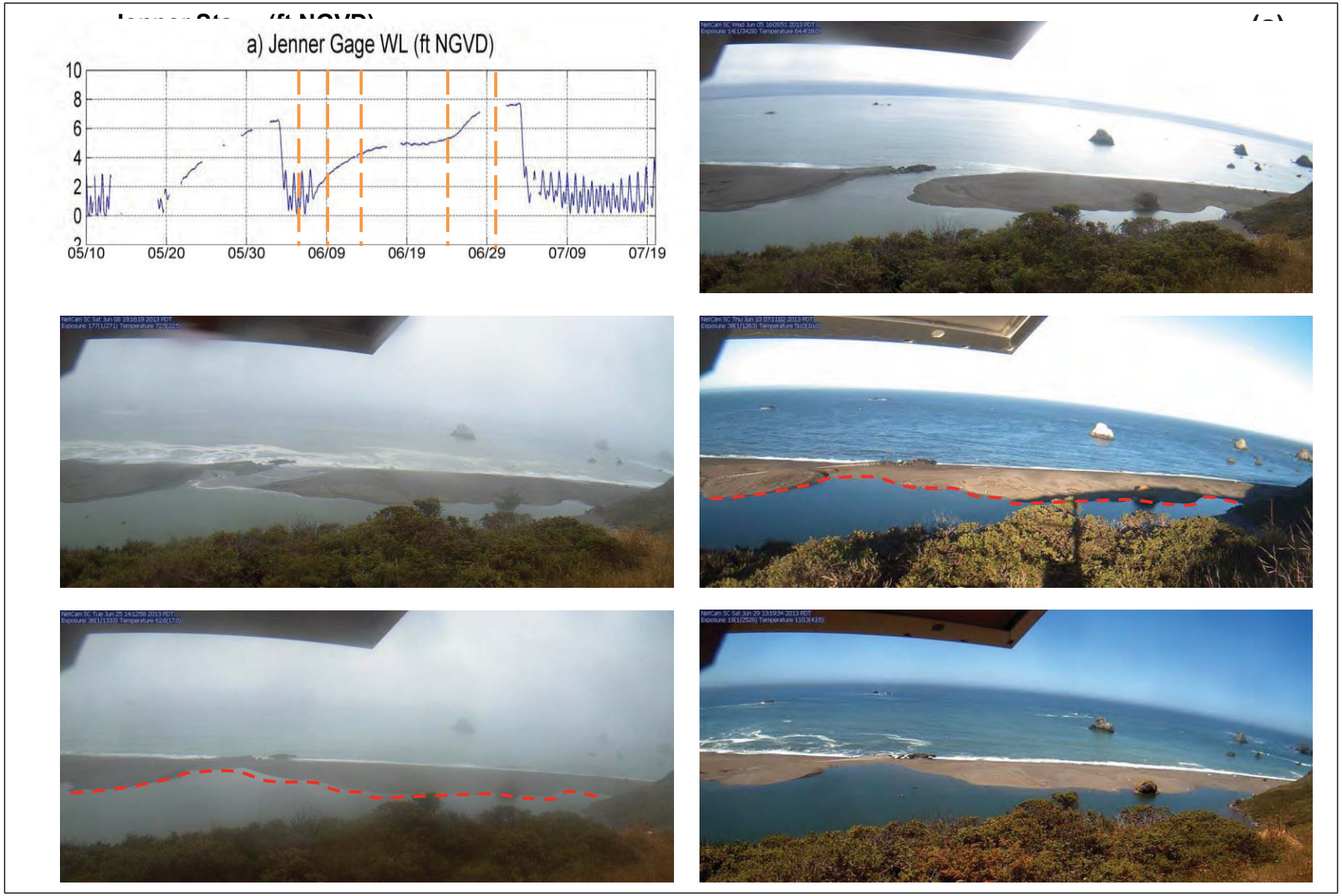
Appendix H of the 2014 Russian River Estuary Outlet Channel Adaptive Management Plan offers lessons learned and recommendations based on 2013 observations of the Estuary, associated physical processes, and the Water Agency's planning for outlet channel management. These are summarized here and may be found in Appendix 3 of this report for fuller context:




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 4.1. Estuary, Ocean, and River Conditions Compared with Closure Probability: April - November 2013**




*13 June shoreline*

**Figure 4.2. Inlet Closure Event in June-July 2013**

SOURCE: Russian River stationary observation camera (BML);
ESA PWA 2014

## CONCEPTUAL MODEL

- The beach north of the inlet saw little change from the 16-18 ft NGVD elevations established in 2012. Near the jetty, the berm was lowered by inlet migration while undergoing beach building.
- The influence of inlet breaching or migration north of the jetty can lead to erosion of a wide swath of beach, several times larger than the width of the channel. An erosion swath of 400-500 was observed following the Water Agency breach on October 15th.
- Similar to the winter of 2011-12, the inlet never migrated north of Haystack Rock during winter 2012-13, 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 $ft^3/s$ for 8 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 2013 at Transect 3 (near Haystack Rock) was smaller than in 2012.
- The interannual decline was larger than changes to beach width at this location within the 2013 management season alone. This may suggest that beach width is more closely tied to seasonal changes in inlet behavior and offshore waves than to shorter-term changes.

## OUTLET CHANNEL FEASIBILITY

- The jetty may shelter the inlet, making closure less likely and also limiting berm growth, which then maintains a low point for self-breaching. When the inlet is in a fully or muted tidal condition, options for management become considerably more difficult to implement.
- Late June closure included a 10-day period when lagoon water levels were nearly constant at approximately 5 ft NGVD because low flows measured at Hacienda Bridge (80-100 $ft^3/s$) and construction of summer dams reduced flows into the estuary to the point that they were balanced by seepage. An unusual early summer rain then boosted discharge to more than 200 $ft^3/s$, causing self-breach at approximately 8 ft NGVD.
- Once lagoon water levels reach the low point of the beach crest elevation, the lagoon self-breached. This behavior highlights the susceptibility of a sand bed outlet channel to scour, limiting conveyance capacity.
- Post-management period, the Water Agency breached the inlet north of Haystack Rock. This alignment was not continued because repeated closure threatened Chinook migration and the enlarged beach berm restricted breaching to within the permitted excavation volume.
- Over the first three years of effort to implement the outlet channel adaptive management plan, only one closure (July 2010), has been suited for outlet channel management action.

COMMUNICATIONS AND PROTOCOLS

- Since a full set of permits was not in effect, the Water Agency was required to seek authorization for each breaching event, which occasionally delayed operations.
- Although the perched lagoon episodes did not evolve to the point that management action was warranted, the Water Agency began planning management actions as soon as the episodes occurred. Planning included heightened observations of inlet conditions by Water Agency staff, email updates to inform the resource management group, and pre-implementation meetings at the project site to refine plans for management action.

MONITORING

- The Water Agency's monthly survey methods were modified to collect specified profiles, such as the beach berm ridge line, wetted edge (beach side), and water edge (estuary side).

### Artificial Breaching

The Water Agency artificially breached (breaching) the barrier beach at the Russian River mouth outside the lagoon management season in 2013. 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.

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. Summaries of pre-project surveys are provided in Appendix 5 for 2013 and 2014. 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 from 2013 through spring 2014 (Table 4.1). The number of late-fall and winter mouth closures was driven by drought conditions that caused the lowest winter river flows in over a century. Rainfall in the Santa Rosa area during 2013 was the lowest on record at 5.7 inches and 18% of

**Table 4.1**. Summary of Russian River barrier beach artificial breachings conducted from 2013 through spring 2014.

| River Closure Date | Breaching Date | Number Days Closed | Jenner Gage Elev. (feet) | Start and End Time* | Excavation (CY) | Location of Pilot Channel |
|---|---|---|---|---|---|---|
| 09/23/2013 | 10/15/2013 | 22 | 7.8 | 0900-1130 | 940 | North near cliffs |
| 10/21/2013 | 11/07/2013 | 17 | 7.4 | 1030-12:30 | 550 | North near cliffs |
| 11/16/2013 | 12/05/2013 | 19 | 7.4 | 1030-1300 | 680 | Near jetty |
| 12/22/2013 | 01/02/2014 | 11 | 7.7 | 1100-1230 | 700 | Near jetty |
| 01/12/2014 | 01/30/2014 | 18 | 7.7 | 1130-1545 | 450 | Near jetty |
| 03/20/2014 | 03/24/2014 | 4 | 9.4 | 0900-0940 | 40 | Near jetty |

*Construction period was from the time the excavator moved on to the beach to the return to the parking lot at Goat Rock State Beach.

normal. These events coincided with typical late-fall energetic swell waves, and each persisted for over a week, since inflows remained lower than 300 $ft^3/s$ through the end of December. In consultation with the resource agencies, the Water Agency conducted its October and November artificial breaches to the north of Haystack Rock. The intent of this alignment was to discourage the inlet from re-establishing next to the jetty. However, after the inlet closed twice north of Haystack Rock, the December artificial breach was implemented closer to the jetty. This December breach location was selected 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 1,000 $yd^3$ (ESA PWA 2014).

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 4.3) 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 3 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 1,000 cubic yards (Table 4.1). Water surfaces elevations within the Estuary declined 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.

**Figure 4.3. Russian River at Goat Rock State Beach. General location of pilot channels excavated on six breaching events, 2013 – spring 2014. Photographs of project construction are from Highway 1 bluff overlook located east of the river mouth along Highway 1.**

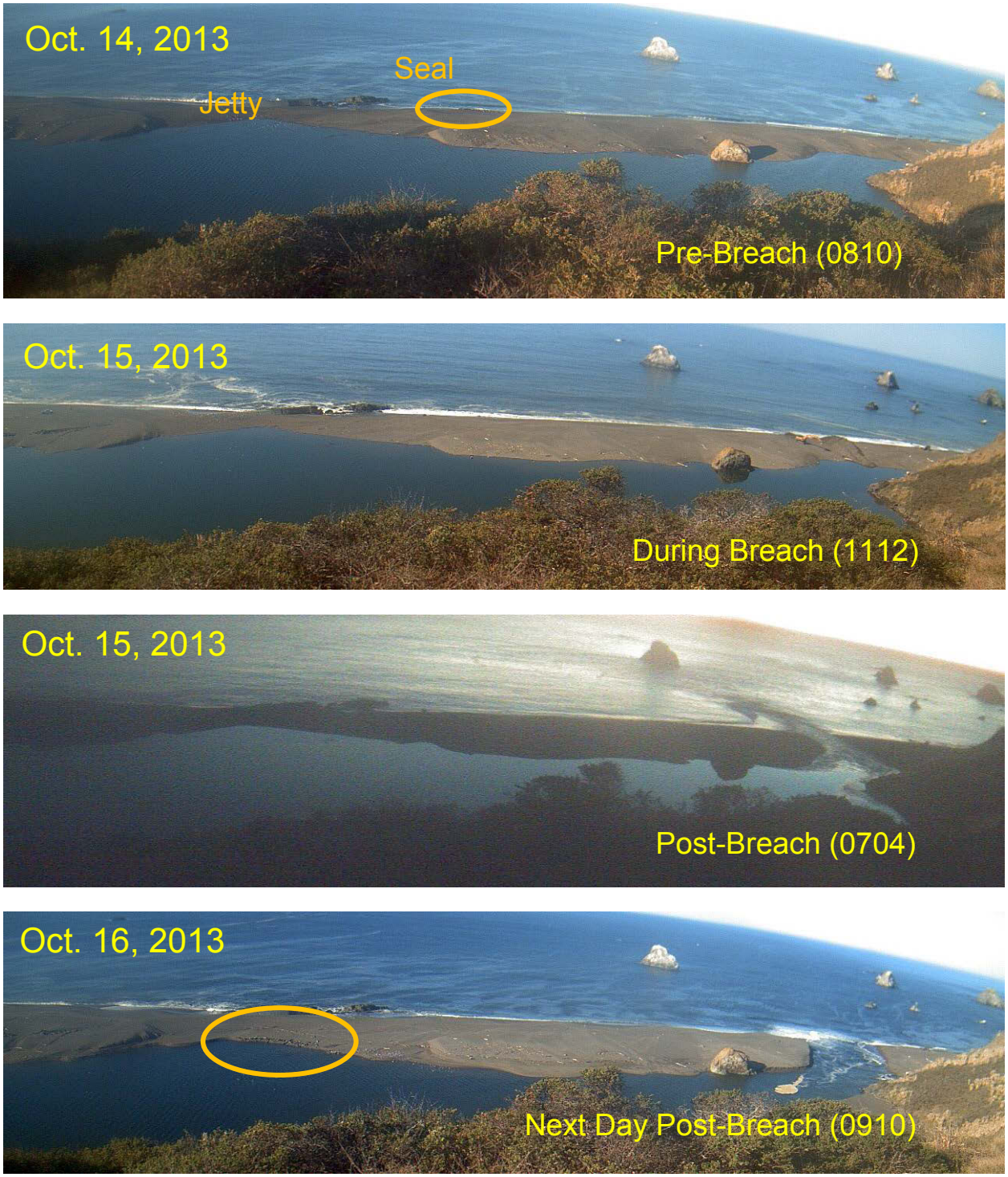



**Figure 4.4. Breaching at the Russian River Estuary mouth, October 15, 2013. Photographs show pre- through post- breaching excavation. Harbor seals at the haulout numbered 101 prior to breaching and 113 on the morning following the breach.**

**Figure 4.5. Breaching at the Russian River Estuary mouth, November 7, 2013. Photographs show pre- through post- breaching excavation. There were 155 harbor seals at an ocean-side haulout prior to breaching and 280 on the morning following the breach on the Estuary side of the beach.**

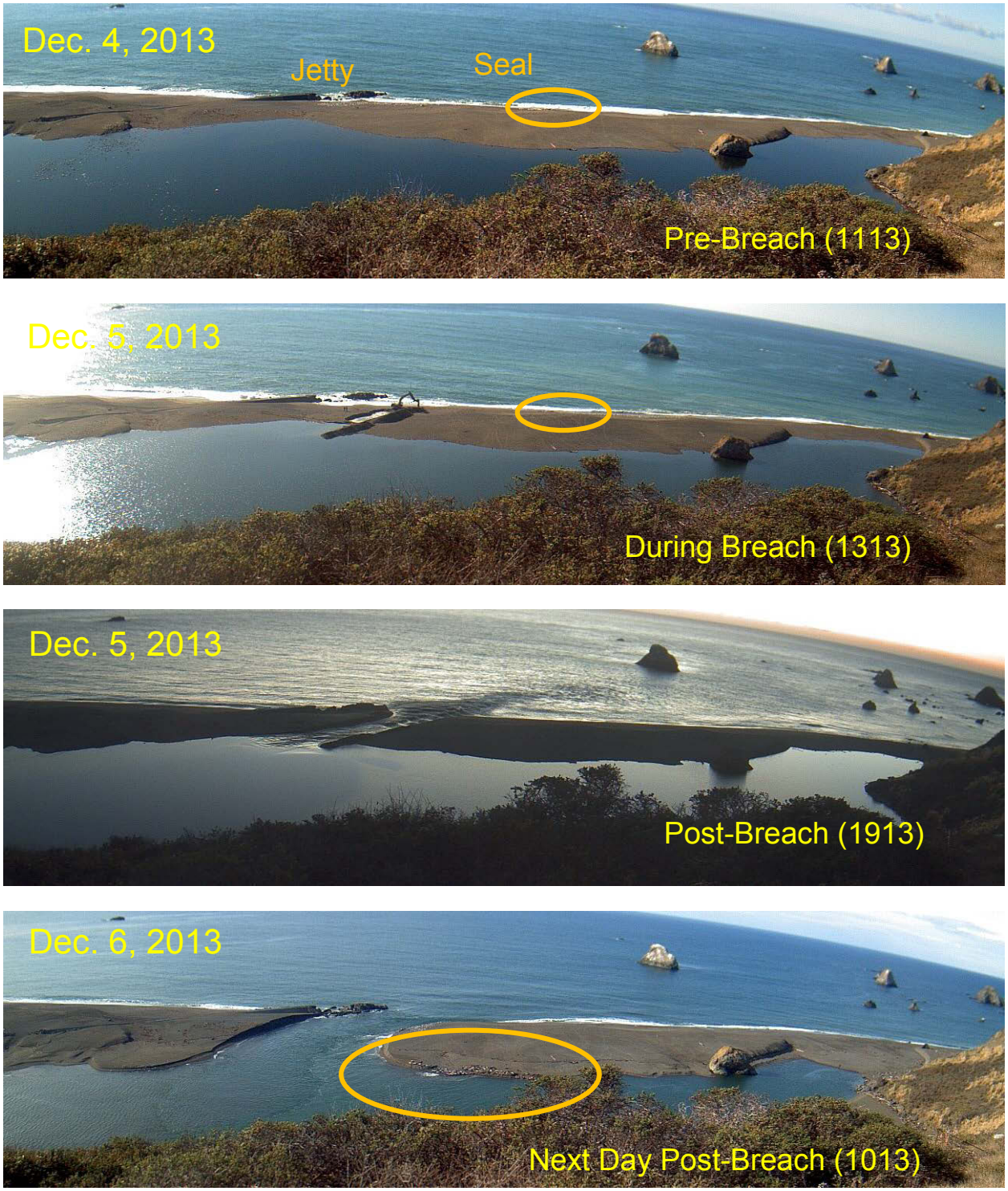



**Figure 4.6. Breaching at the Russian River Estuary mouth, December 5, 2013. Photographs show pre- through post- breaching excavation. There were 79 harbor seals at an ocean-side haulout prior to breaching, 76 harbor seals during breaching activities, and 189 on the morning following the breach on the Estuary side of the beach.**

**Figure 4.7. Breaching at the Russian River Estuary mouth, January 2, 2014. Photographs show pre- through post- breaching excavation. There were 70 harbor seals at an ocean-side haulout prior to breaching, 16 harbor seals during breaching activities, and 199 on the morning following the breach on the Estuary side of the beach.**

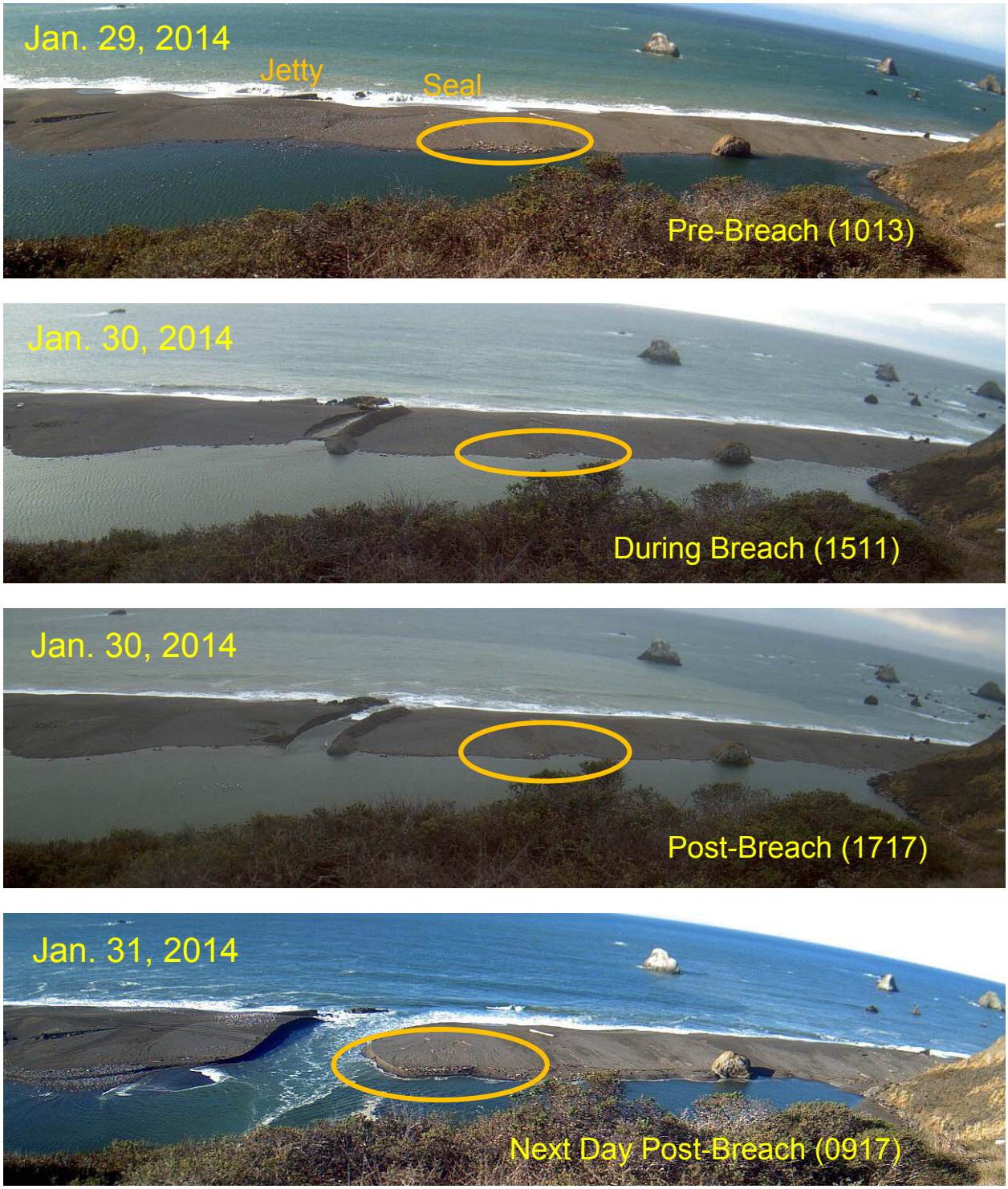



**Figure 4.8. Breaching at the Russian River Estuary mouth, January 30, 2014. Photographs show pre- through post- breaching excavation. There were 157 harbor seals at an Estuary-side haulout prior to breaching, 30 harbor seals during breaching activities, and 261 seals the day following the breach.**

**Figure 4.9. Breaching at the Russian River Estuary mouth, March 24, 2014. Photographs show pre- through post- breaching excavation. There were 101 harbor seals at an Estuary-side haulout prior to breaching at 9:00 am, 30 harbor seals during breaching activities, and 229 seals the day following the breach.**

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 4.4 through 4.9. 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.

### 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 16, 2013, 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 6. A summary of the results of 2013 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, 2013* (SCWA 2014) 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 16, 2013, 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 2013, but only during five of these closure events did the Water Agency artificially breach the sand bar (the fifth breaching event occurred in 2014 and will not be included in this report). The Russian River outlet was closed to the ocean for a total of 104 days (or 28%) in 2013. 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 geophysical 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. Additionally, Water Agency field staff conducting biological and physical monitoring in the Estuary recorded any pinnipeds they encountered hauled out and recorded any disturbance to pinnipeds associated with their activities.

The Russian River Estuary Management and Monitoring Activities in 2013 resulted in incidental harassment (Level B harassment) of 1,351 harbor seals, well under the total 3,130 allowed by NMFS IHA. The Russian River Estuary Management activities in 2012, 2011 and 2010 resulted in incidental harassment (Level B harassment) of 208,

42, and 290 marine mammals, respectively. No other marine mammal species were harassed by Water Agency activities during the current or any previous years.

The water level management activities and biological and geophysical monitoring activities conducted by the Water Agency in 2013 resulted in incidental harassment (Level B harassment) of 1,351 harbor seals, well under the total allowed by NMFS IHA (2013).

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?

A summary of baseline pinniped monitoring concluded that time of year, tidal state and time of day influenced harbor seal abundance at the Jenner haul-out (SCWA 2012). Harbor seals were most abundant on the haul-out in July during their annual molt. 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). Harbor seal abundance at Jenner was also influenced by barrier beach condition. Daily average abundance of seals was lower during bar closed conditions compared to bar open conditions. This effect is likely due to a combination of factors including: increased human disturbance, reduced access to the ocean from the Estuary side of the barrier beach, and the increased disturbance from wave action when seals utilize the ocean side of the barrier beach.

The response of harbor seals at the Jenner haul-out to water level management activities in 2013 (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 and 2013). 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 summer lagoon has only been implemented once (July 2010). However, since the Water Agency began implementing the lagoon outlet channel adaptive management plan a barrier beach has formed during the lagoon management period twelve times, the longest incidence lasting 25 days, with an average duration of nine days. With the additional sustained river outlet closures observed in 2013 during the lagoon management period it is possible to make better informed conclusions about the abundance of seals during the formation of a summer lagoon (Question 3 above). While seal abundance was lower during bar closed conditions, there was also a record high in seal abundance recorded this year. These results indicate that while seal abundance may exhibit a short term decline during bar closed conditions, overall the number of seals utilizing the Jenner haul-out continues to increase. 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. Coupling seal abundance data with human abundance data and disturbance observations leads us to conclude that the increased frequency of disturbances during bar closed conditions is the underlying cause for the short term decline in seal abundance.

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. In order to better understand the underling behaviors that influence the population trends for harbor seals located at Jenner, we propose to conduct a photo-identification study as a means to observe individual seals over time. This year we began a pilot study, and determined that our current observation locations allow us to capture detailed images of seals that can be used to identify individuals based on spot patterns. Analysis of the photographs

collected in 2013 is still underway and more identification photographs continue to be collected when possible during scheduled pinniped surveys.

## 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 (Appendix 4).

No additional work on the jetty study was completed in 2013 as final permits were being acquired. Geophysical field studies began in 2014. No initial results are available, but the jetty study results and final report are anticipated to 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 and is included here (Appendix 7). 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. 2011. Feasibility of alternatives to the Goat Rock State Beach jetty for managing lagoon water surface elevations – a study plan. June 30, 2011.

ESA PWA. 2013. Russian River estuary outlet channel adaptive management plan 2013. Prepared with Bodega Marine Laboratory, University of California at Davis. May 14, 2013.

ESA PWA. 2014. Russian River estuary outlet channel adapative management plan 2014. Prepared with Bodega Marine Laboratory, University of California at Davis. May 15, 2014.

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.

## 4.1 Water Quality Monitoring

Water quality monitoring was conducted in the lower, middle, and upper reaches of the Russian River Estuary, including two tributaries and the maximum backwater area, between the mouth of the river at Jenner and Monte Rio. 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 encompasses the area of the river between Duncans Mills and Monte Rio that is generally outside the influence of saline water, but within the upper extent of inundation and backwatering that can occur during tidal cycles and lagoon formation.

In 2013, the Estuary experienced multiple closures during the monitoring season including three prolonged closures during the management period. These closures occurred for a period of 13 days between 22 May and 3 June 2013, a period of 27 days between 7 June and 3 July 2013, and a period of 22 days between 24 September and 15 October 2013. Four other closures were observed after the lagoon management period during the remainder of the 2013 calendar year. These closures occurred for a period of 18 days between 21 October and 7 November 2013, a period of 9 days between 27 November and 5 December 2013, a period of 6 days between 16 December and 21 December 2013, and a period of 10 days between 24 December and 2 January 2014.

### 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.

Eight stations were established for continuous water quality monitoring, including five stations in the mainstem Estuary, two tributary stations, and one station in the maximum backwater area 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 above Brown's Pool Station. Finally, one mainstem station was located in the maximum backwater area in Monte Rio (Monte Rio Station).

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

Mainstem Estuary monitoring stations up to Brown's Pool were comprised of a concrete anchor attached to a steel cable suspended from the surface by a large buoy (Figure 4.1.2). 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 and Brown's Pool 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 (~1m) and/or 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. 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.

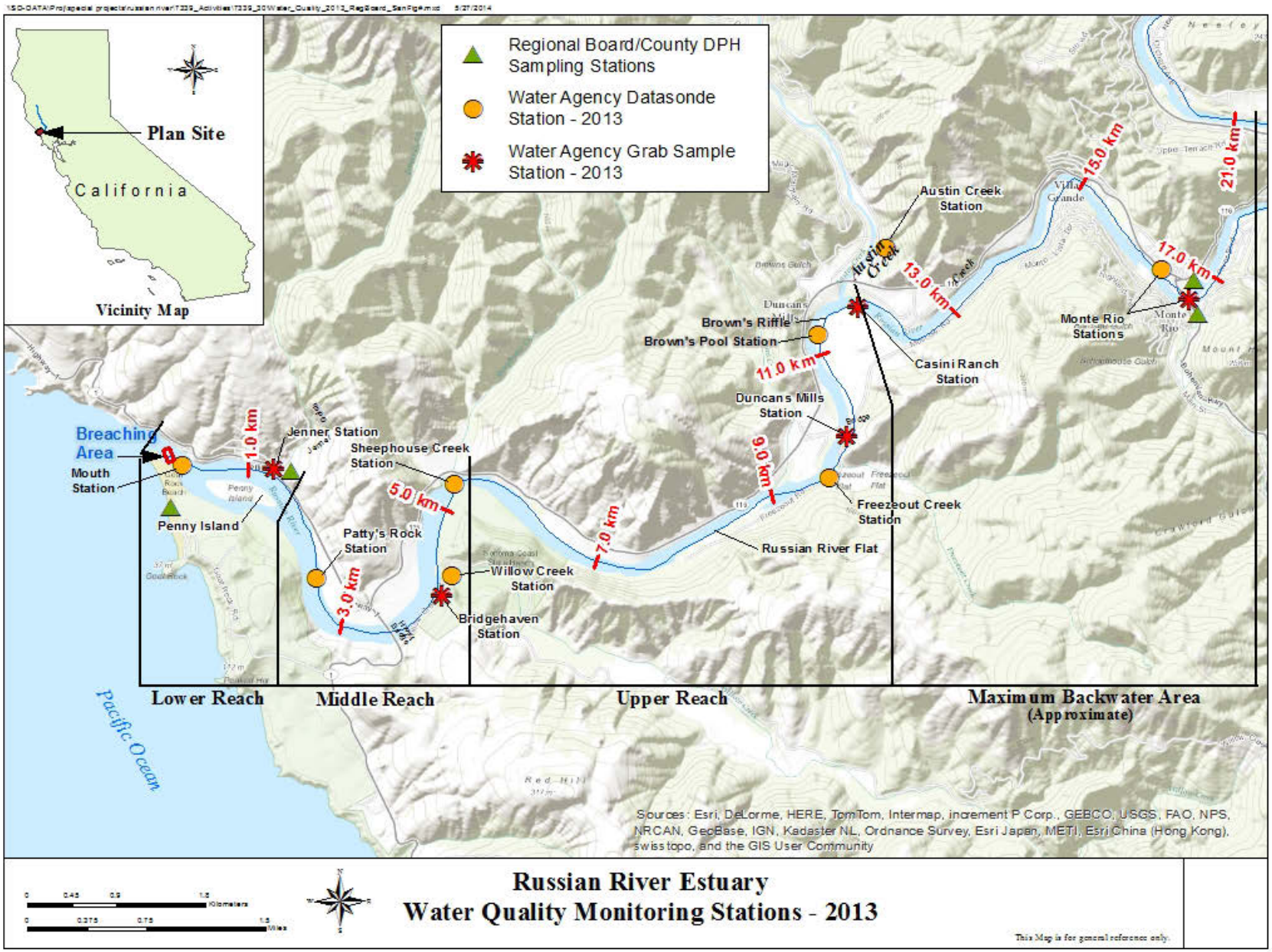



Figure 4.1.1. 2013 Russian River Estuary Water Quality Monitoring Stations.

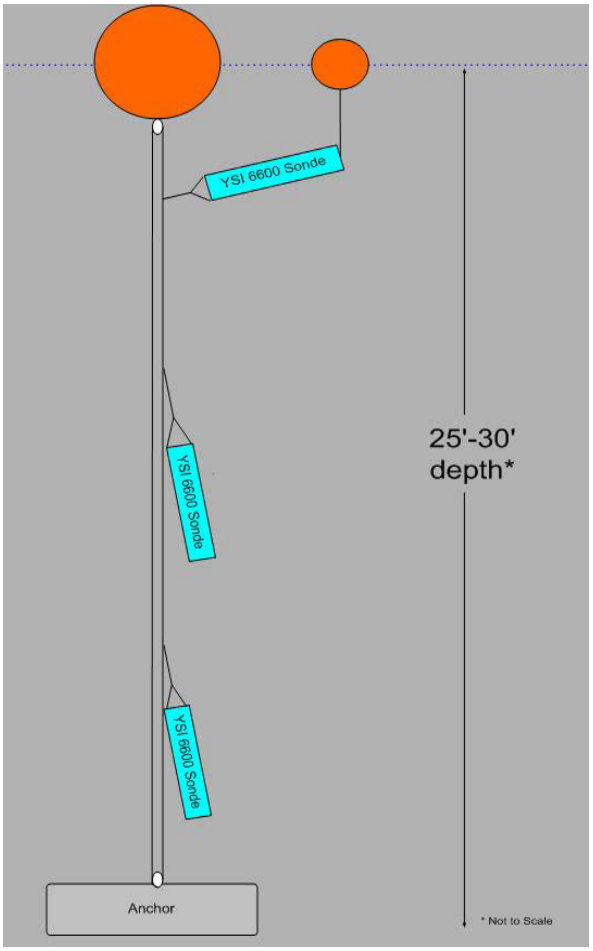



**Figure 4.1.2. Typical Russian River Estuary monitoring station datasonde array.**

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

The Willow Creek station was deployed from January until the end of the December. The Austin Creek station was deployed from April until the end of December. The Mouth, Patty's Rock, Sheephouse Creek, Freezeout Creek, and Brown's Pool stations were deployed from May until the end of December. The Monte Rio station was deployed from mid-May until the end of December. The unusually dry early winter allowed the monitoring to last longer than usual due to lower than average flows in the Russian River.

*Grab Sample Collection*

In 2013, Water Agency staff continued to conduct nutrient and indicator bacteria grab sampling at the five stations established in 2010: the Jenner Boat Ramp (Jenner Station); Bridgehaven at the mouth of Willow Creek (Bridgehaven Station); Moscow Road Bridge in Duncans Mills (Duncans Mills Station); Casini Ranch across from the

mouth of Austin Creek (Casini Ranch Station); and just downstream of the Monte Rio Bridge (Monte Rio Station). Refer to Figure 4.1.1 for grab sampling locations.

Water Agency staff collected grab samples weekly from 14 May to 31 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. 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, *Escherichia coli* (*E. coli*) and *Enterococcus*. These bacteria are considered indicators of water quality conditions that may be a concern for water contact recreation and public health. The results of sampling conducted for total orthophosphate, dissolved organic carbon, total organic carbon, total dissolved solids, and turbidity are included as an Appendix 8; 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 Appendix 8.

### Results

Water quality conditions in 2013 were similar to trends observed in sampling from 2004 to 2012. 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 maximum backwater area to a lesser degree.

Table 4.1.1 presents a summary of minimum, mean, and maximum values for temperature, depth, dissolved oxygen (DO), pH, and salinity recorded at the various

**Table 4.1.1. Russian River Estuary 2013 Water Quality Monitoring Results. Minimum, mean, and maximum values for temperature (°C), depth (m), dissolved oxygen saturation (%), dissolved oxygen concentration (mg/L), hydrogen ion (pH units), and salinity (ppt).**

| Monitoring Station | Temperature | Depth | Dissolved Oxygen | Dissolved Oxygen | Hydrogen Ion | Salinity |
|---|---|---|---|---|---|---|
| ***Sonde*** | (°C) | (m) | (mg/L) | (%) saturation | (pH) | (ppt) |
| **Freezeout Creek** | | | | | | |
| ***Mid-Depth*** | | | | | | |
| May 1, 2013 - December 31, 2013 | | | | | | |
| Min | 4.7 | 3.0 | 0.0 | 0.0 | 7.0 | 0.1 |
| Mean | 18.4 | 3.4 | 8.5 | 90.2 | 8.0 | 3.0 |
| **Max** | **25.6** | **4.2** | **21.0** | **200.8** | **8.9** | **25.4** |
| | | | | | | |
| ***Bottom*** | | | | | | |
| May 1, 2013 - December 31, 2013 | | | | | | |
| Min | 5.0 | 5.5 | 0.0 | 0.0 | 5.2 | 0.1 |
| Mean | 18.9 | 6.7 | 2.9 | 31.2 | 7.1 | 5.9 |
| **Max** | **25.9** | **7.9** | **12.4** | **129.8** | **8.9** | **25.9** |
| | | | | | | |
| **Brown's Pool** | | | | | | |
| ***Bottom*** | | | | | | |
| May 1, 2013 - December 31, 2013 | | | | | | |
| **Min** | 5.2 | 8.3 | 0.0 | 0.2 | 5.7 | 0.1 |
| **Mean** | 16.3 | 9.5 | 5.7 | 56.9 | 7.2 | 0.7 |
| **Max** | **25.1** | **10.1** | **13.1** | **122.1** | **8.4** | **7.2** |
| | | | | | | |
| **Austin Creek** | | | | | | |
| ***Mid-Depth*** | | | | | | |
| April 10, 2013 - December 31, 2013 | | | | | | |
| **Min** | 9.0 | 0.1 | 0.2 | 2.5 | 7.1 | 0.1 |
| **Mean** | 15.0 | 0.5 | 5.6 | 55.9 | 7.6 | 0.2 |
| **Max** | **20.9** | **1.5** | **10.9** | **117.1** | **8.4** | **0.2** |
| | | | | | | |
| **Monte Rio** | | | | | | |
| ***Mid-Depth*** | | | | | | |
| May 22, 2013 - December 31, 2013 | | | | | | |
| **Min** | 5.3 | 1.1 | 6.4 | 77.6 | 7.4 | 0.1 |
| **Mean** | 18.0 | 1.5 | 9.3 | 96.5 | 7.8 | 0.1 |
| **Max** | **27.7** | **2.1** | **13.0** | **128.7** | **8.3** | **0.1** |
| | | | | | | |

| Monitoring Station | Temperature | Depth | Dissolved Oxygen | Dissolved Oxygen | Hydrogen Ion | Salinity |
|---|---|---|---|---|---|---|
| ***Sonde*** | (°C) | (m) | (mg/L) | (%) saturation | (pH) | (ppt) |
| **Mouth** | | | | | | |
| ***Surface*** | | | | | | |
| May 1, 2013 - December 31, 2013 | | | | | | |
| Min | 5.8 | 0.7 | 4.6 | 51.7 | 7.5 | 1.1 |
| Mean | 13.8 | 1.0 | 10.2 | 108.3 | 8.1 | 16.0 |
| **Max** | **25.8** | **1.9** | **29.9** | **329.1** | **8.8** | **33.8** |
| | | | | | | |
| ***Mid-Depth*** | | | | | | |
| May 1, 2013 - December 31, 2013 | | | | | | |
| Min | 7.9 | 2.6 | 3.8 | 43.0 | 7.5 | 2.4 |
| Mean | 13.5 | 3.1 | 9.2 | 105.6 | 8.0 | 28.6 |
| **Max** | **23.3** | **3.7** | **18.7** | **245.0** | **8.4** | **33.7** |
| | | | | | | |
| **Patty's Rock** | | | | | | |
| ***Surface*** | | | | | | |
| May 1, 2013 - December 31, 2013 | | | | | | |
| **Min** | 6.0 | 0.8 | 1.8 | 20.3 | 7.2 | 0.6 |
| **Mean** | 14.7 | 1.0 | 9.7 | 105.1 | 8.1 | 16.3 |
| **Max** | **25.1** | **1.2** | **21.4** | **243.2** | **9.0** | **32.6** |
| | | | | | | |
| ***Mid-Depth*** | | | | | | |
| May 1, 2013 - December 31, 2013 | | | | | | |
| **Min** | 9.4 | 2.8 | 0.3 | 3.9 | 7.0 | 6.0 |
| **Mean** | 13.9 | 3.5 | 8.3 | 96.4 | 7.9 | 28.8 |
| **Max** | **22.1** | **4.2** | **15.3** | **182.2** | **8.5** | **33.4** |
| | | | | | | |
| **Willow Creek** | | | | | | |
| ***Mid-Depth*** | | | | | | |
| January 1, 2013 - December 31, 2013 | | | | | | |
| **Min** | 3.4 | 0.1 | 0.0 | 0.1 | 6.5 | 0.1 |
| **Mean** | 14.6 | 1.0 | 6.6 | 65.7 | 7.6 | 6.2 |
| **Max** | **23.8** | **2.7** | **16.6** | **190.6** | **9.4** | **25.8** |
| | | | | | | |
| **Sheephouse Creek** | | | | | | |
| ***Mid-Depth*** | | | | | | |
| May 1, 2013 - December 31, 2013 | | | | | | |
| **Min** | 8.3 | 2.5 | 0.0 | 0.0 | 7.0 | 0.9 |
| **Mean** | 15.9 | 3.4 | 8.4 | 99.9 | 7.8 | 27.0 |
| **Max** | **22.8** | **3.7** | **17.5** | **169.1** | **9.1** | **31.2** |

**Table 4.1.1 (cont.)**

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 4.1.34. These data gaps may affect minimum, mean, and maximum values of the various constituents monitored in 2013, including temperature, DO, and salinity at the Mouth mid-depth sonde in November, the Mouth surface sonde in late July and September, the Patty's Rock surface sonde in June, the Freezeout Creek mid-depth sonde in June and early July, and the Austin Creek sonde in April. There were more extensive gaps in the 2013 pH data at these stations including: the Mouth mid-depth sonde in early May and from late-September to mid-November; the Mouth surface sonde from late-October through December; the Patty's Rock surface sonde in May and June; the Patty's Rock mid-depth sonde in November; the Willow Creek sonde in July; the Freezeout Creek surface sonde in May;

the Brown's Pool sonde from mid-September through December; and the Austin Creek sonde in April, October, and late-November through December.

Although gaps exist in the 2013 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 ppt, with salinity decreasing from the ocean to the upstream limit of the Estuary, which is considered freshwater at approximately 0.5 ppt (Horne 1994). All of the mid-depth sondes in the lower and middle reaches were located in a predominantly saline environment, whereas the surface sondes were located at the saltwater-freshwater interface (halocline or salt wedge) and recorded both freshwater and saltwater conditions. In the middle reach of the Estuary, salinities can range as high as 30 ppt in the saltwater layer, with brackish conditions prevailing at the upper end of the salt wedge, to less than 1 ppt in the freshwater layer on the surface. The Willow Creek sonde was located just upstream of the confluence with the Russian River, where predominantly freshwater conditions observed in the creek during higher springtime flows transitioned to a brackish environment during lower dry season flows.

In the upper reach, the Estuary typically transitions from predominantly saline conditions to brackish and freshwater conditions in the Heron Rookery area. Upstream, the Freezeout Creek station is located in a predominantly freshwater environment; however, 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 maximum backwater area; however, brackish water was observed to occur during and following barrier beach closures in late 2013.

The Austin Creek and Monte Rio stations are located in the maximum backwater area in freshwater habitat that can become inundated during high tides, barrier beach closures, perched conditions, and lagoon formation. Salinity was not observed at any of the stations in the maximum backwater area during either open or perched conditions in 2013.

### Lower and Middle Reach Salinity

The surface sondes at the Mouth and Patty's Rock stations were suspended at a depth of approximately 1 meter, and experienced frequent hourly fluctuations in salinity during open conditions. These fluctuations are influenced by freshwater inflows, tidal movement and expansion and contraction of the salt wedge. The freshwater layer was

observed to be more persistent at the surface sondes during spring peak flows and under closed barrier beach conditions. Concentrations ranged from 1.1 to 33.8 ppt at the Mouth surface sonde and 0.6 to 32.6 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 16.0 and 16.3 ppt, respectively.

The mid-depth sondes at the Mouth, Patty's Rock, and Sheephouse Creek stations were suspended at a depth of approximately 3 meters, and also experienced frequent fluctuations in salinity during open conditions, though to a lesser degree than their respective surface sondes. Concentrations ranged from 2.4 to 33.7 ppt at the Mouth, 6.0 to 33.4 ppt at Patty's Rock, and 0.9 to 31.2 ppt at Sheephouse Creek (Table 4.1.1). The mid-depth sondes at the Mouth, Patty's Rock, and Sheephouse Creek had mean salinity values of 28.6, 28.8, and 27.0 ppt, respectively. Minimum concentrations were observed to occur during river mouth closures at the Mouth mid-depth sonde in May, June, and October; and at the Patty's Rock mid-depth sonde in May, and June (Figures and 4.1.4). Minimum concentrations at Sheephouse Creek were observed to briefly occur after the barrier beach reopened in early November and early December (Figure 4.1.5).

Salinity concentrations were observed to periodically decrease during closed river mouth conditions in May and June and again in parts of September, October, November and December (Figures 4.1.3 through 4.1.5). In contrast to 2012 when the jetty affected the ability of ocean swells to build a barrier beach, 2013 experienced multiple extended river mouth closures in the early summer and fall (Photos 4.1.1 and 4.1.2). The river mouth was also observed to close several times in the late fall and early winter after the Estuary management period ended.

Declines in salinity during river mouth 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 to pre-closure levels after the river mouth 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.

The Willow Creek station was located in predominantly freshwater habitat through the month of April until spring flows began to recede below 400 cfs in the mainstem Russian River and increased tidal action allowed saline water to migrate to this station. The station was intermittently brackish and freshwater through May until the first river mouth closure, at which point the station remained brackish for the rest of the monitoring period. Salinity concentrations were variable, but gradually increased through the season until flattening out during the two closures in September and October (Figure

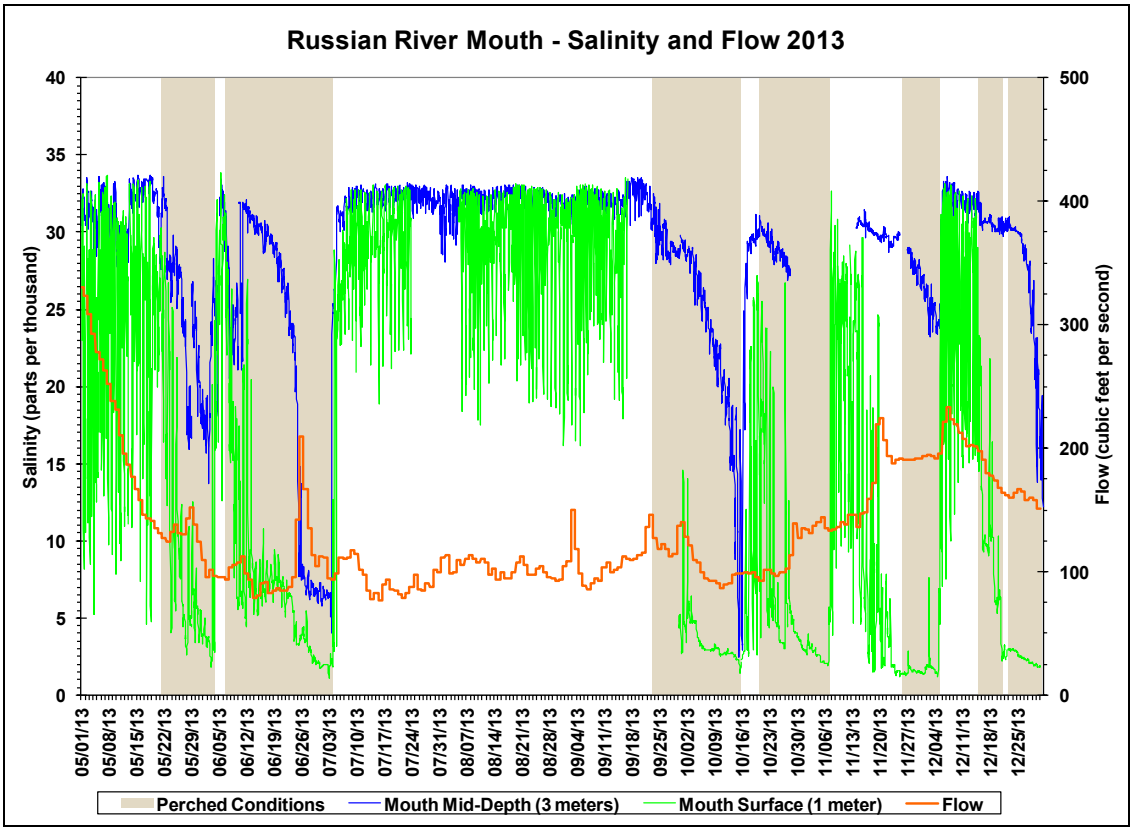



Figure 4.1.3. **2013 Russian River Mouth Salinity and Flow Graph**

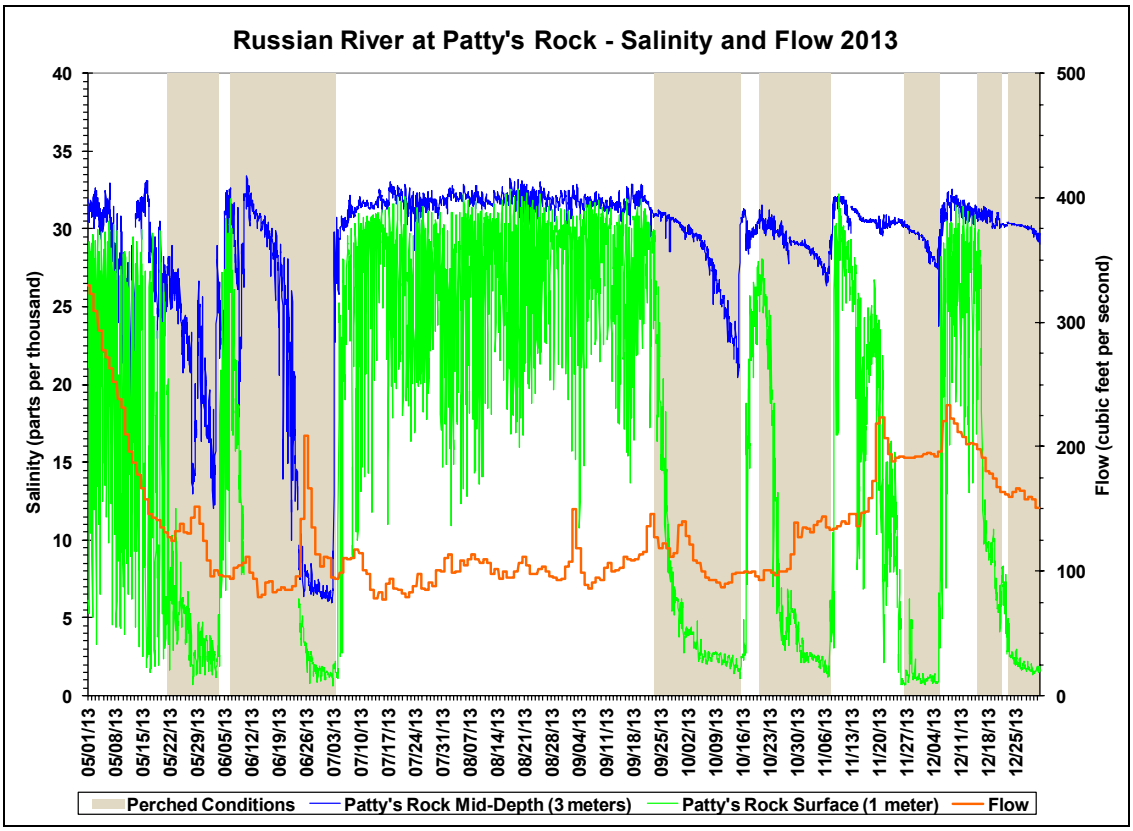



Figure 4.1.4. **2013 Russian River at Patty's Rock Salinity and Flow Graph**

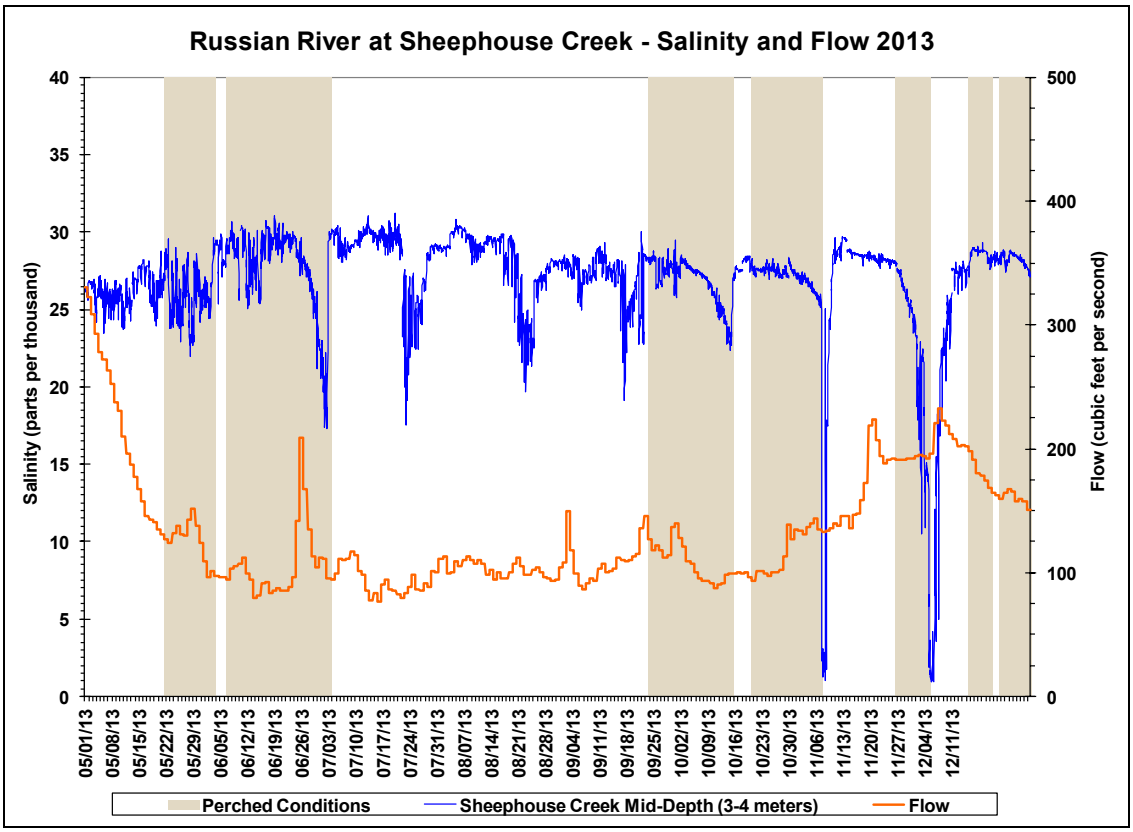



Figure 4.1.5. **2013 Russian River at Sheephouse Creek Salinity and Flow Graph**

Photo 4.1.1. **Russian River Mouth and Jetty from Jenner Overlook – June 13, 2013**

Photo 4.1.2. **Russian River Mouth and Jetty from Jenner Overlook – October 3, 2013**

4.1.6). This variability was due in part to river mouth closures, tidal fluctuations, and decreasing freshwater flows in the creek as well as the mainstem Russian River.

Salinity concentrations were observed to range from 5 to 7 ppt in June and July, increasing to 10 to 12 ppt by the end of September. Salinity concentrations became more stable during the two barrier beach closures in October and began to slightly decline during the closures before decreasing significantly after the barrier beach reopened. Salinity concentrations then remained in the 3 to 7 ppt range until early December when salinity increased to approximatel 24 ppt and remained above 15 ppt through the rest of the calendar year. The mean salinity of the Willow Creek station throughout the year (including data before and after the lagoon management period) was 6.2 ppt, with a minimum concentration of 0.1 ppt, and a maximum concentration of 25.8 ppt (Table 4.1.1).

### Upper Reach Salinity

Two stations were monitored in the upper reach in 2013; 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.

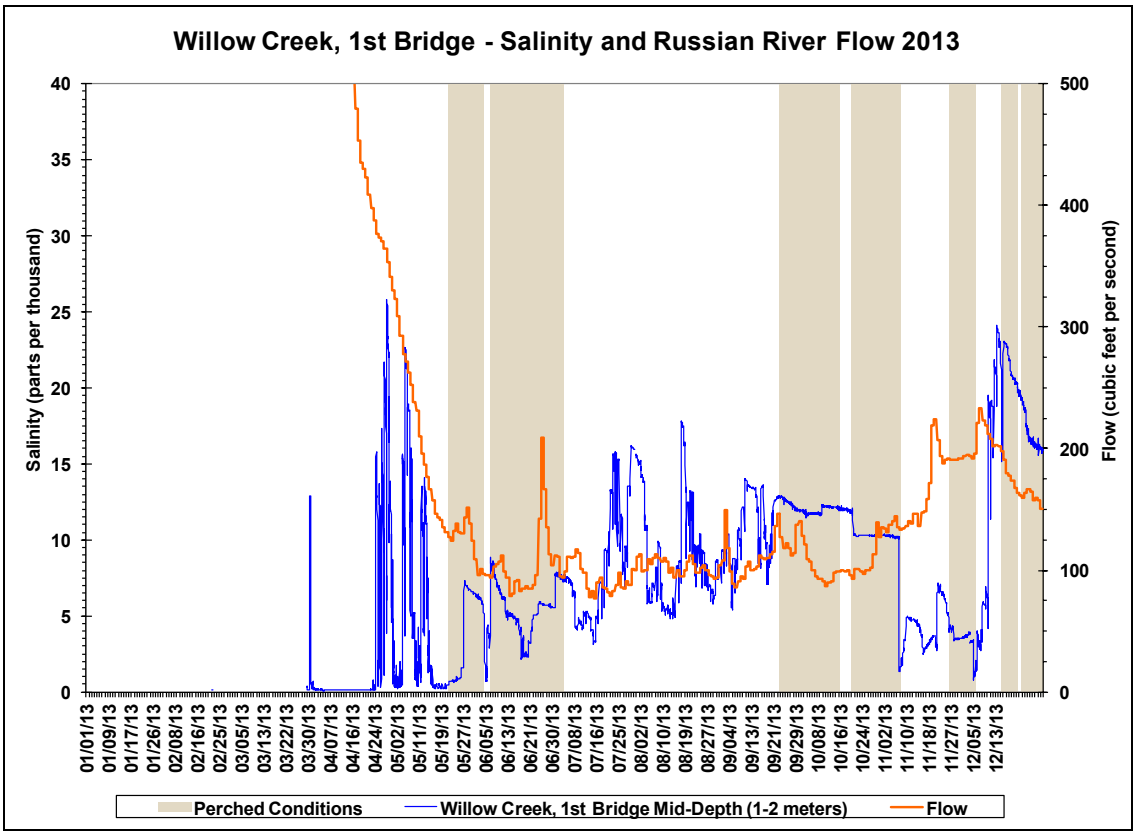



Figure 4.1.6. **2013 Willow Creek Salinity and Russian River Flow Graph**

The Freezeout Creek station is located approximately 9.5 km upstream from the river mouth in a pool approximately 300 meters downstream of the confluence of Freezeout Creek and the mainstem of the river. This station was located in a predominantly freshwater habitat that was subject to elevated salinity levels as the salt wedge migrated up the Estuary during both open and closed conditions (Figure 4.1.8). The elevated salinity levels were predominantly observed at the bottom sonde, though elevated salinity was also seen at the mid-depth sonde during beach closures. The bottom sonde at Freezeout Creek had a mean salinity concentration of 5.9 ppt, and salinity levels that ranged from 0.1 to 25.9 ppt (Figure 4.1.8). The mid-depth sonde at Freezeout Creek had a mean salinity concentration of 3.0 ppt, and salinity levels that ranged from 0.1 to 25.4 ppt (Figure 4.1.8).

The Brown's Pool station is located approximately 11.0 km upstream of the river mouth in a pool that is approximately 9-10 m deep. Brown's Pool is located immediately downstream of the confluence of Austin Creek and the mainstem Russian River at Brown's Riffle, which is approximately 11.2 km upstream of the river mouth. Brown's Riffle is generally considered the demarcation between the Estuary and the maximum backwater area, where salinity levels have not been observed to occur past this point. The sonde station at Brown's Pool was observed to remain predominantly freshwater, with a few exceptions late in the monitoring period during beach closures, and again late in the fall and early winter after the monitoring period ended (Figure 4.1.8).

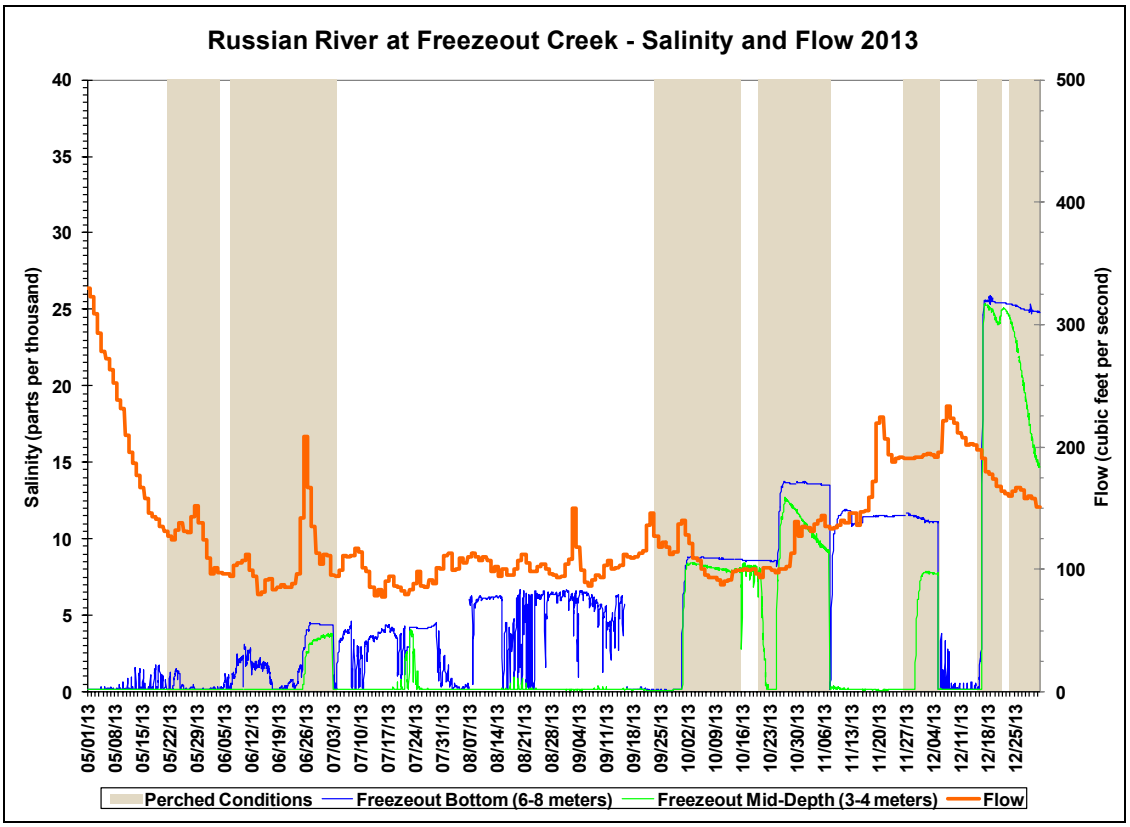



Figure 4.1.7. **2013 Russian River at Freezeout Creek Salinity and Flow Graph**

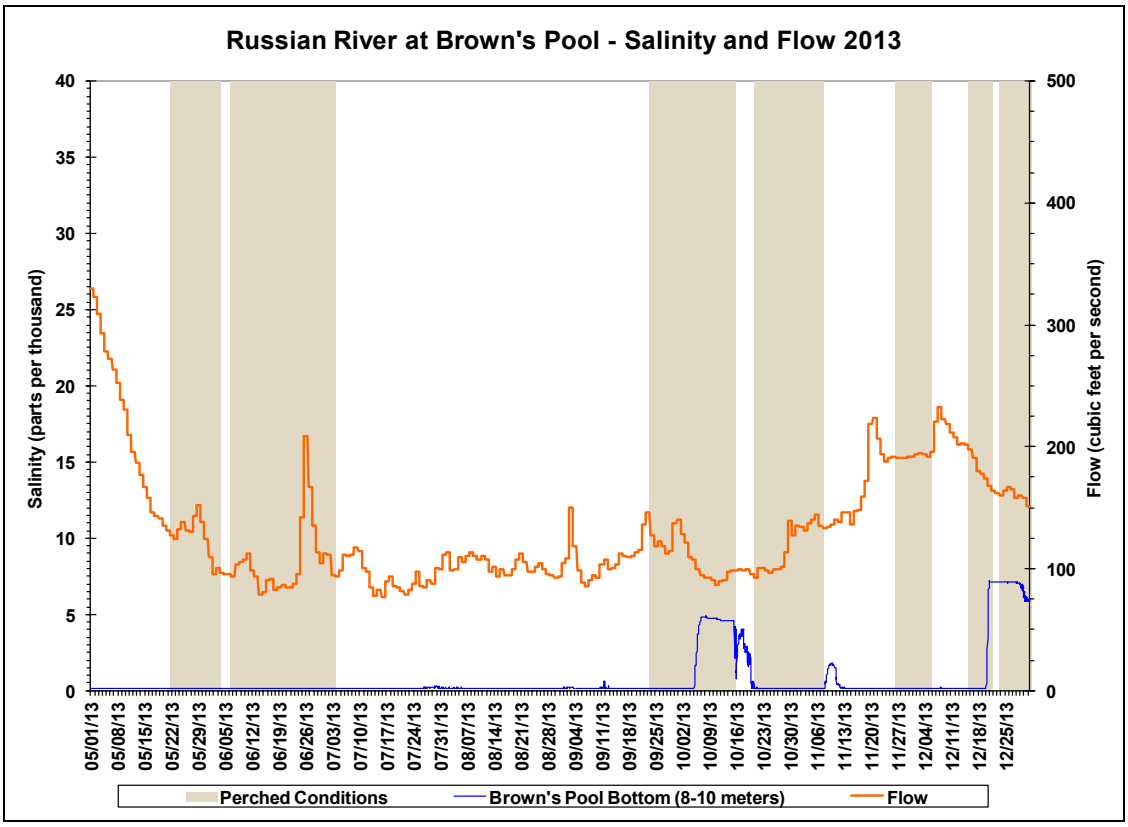



Figure 4.1.8. **2013 Russian River at Brown's Pool Salinity and Flow Graph**

During the barrier beach closure in early October, salinity concentrations at Brown's Pool were observed to increase to approximately 5 ppt. Salinity concentrations were observed to fluctuate after the river mouth reopened on 15 October before returning to freshwater conditions during the next barrier beach closure that began on 21 October. Freshwater conditions remained through the late October closure followed by a brief spike in salinity to approximately 2 ppt after the river mouth reopened on 7 November. The mean salinity concentration observed at Brown's Pool was 0.7 ppt, and the minimum salinity concentration was 0.1 ppt. The maximum salinity concentration of 7.2 ppt was observed to occur after the monitoring period during beach closures in December.

### Maximum Backwater Area Salinity

Two stations were located in the maximum backwater area, including one tributary station in lower Austin Creek and one mainstem Russian River station located in Monte Rio (Figure 4.1.1). Neither of these two stations were observed to have salinity levels above normal background conditions expected in freshwater habitats, during both open Estuary conditions and closed beach conditions (Figures 4.1.9 and 4.1.10). 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 Monte Rio station had a mean, maximum and minimum salinity concentration of 0.1 ppt.

*Temperature*

During open estuary conditions, mainstem water temperatures were reflective of the halocline, with lower mean and maximum temperatures typically being observed in the saline layer at the bottom and mid-depth sondes compared to temperatures recorded in the freshwater layer at the mid-depth and surface sondes (Figures 4.1.11 through 4.1.18). The differences in temperatures between the underlying saline layer and the overlying freshwater layer can be attributed in part to the source of saline and fresh water. During open estuary conditions, the Pacific Ocean, where temperatures are typically around 10 degrees C, is the source of saltwater in the Estuary. Whereas, the mainstem Russian River, with water temperatures reaching as high as 26 degrees C in the interior valleys, is the primary source of freshwater in the Estuary.

During closed Estuary conditions, increasing temperatures associated with fresh/saltwater stratification were observed to occur (Figures 4.1.11 through 4.1.13). 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 4.1.1 and 4.1.12). Stratification based heating has also been observed to result in higher temperatures in the mid-depth saline layer compared to the bottom layer

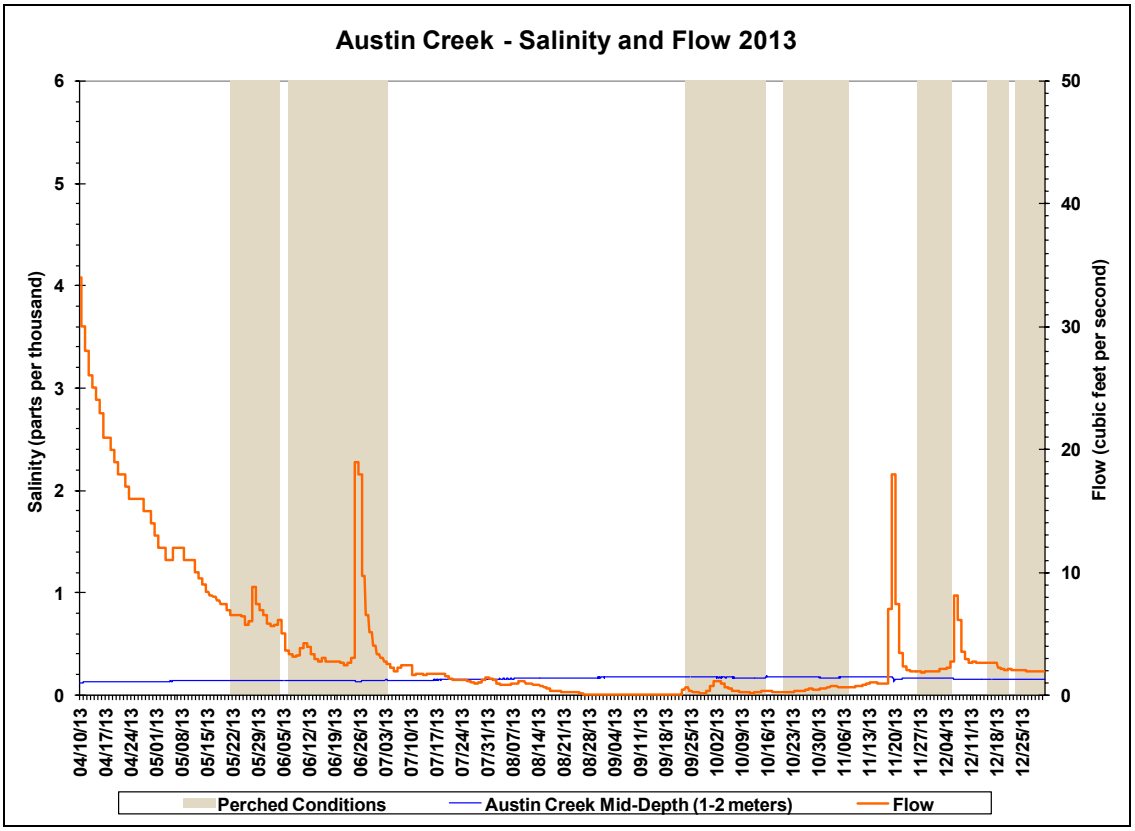



Figure 4.1.9. **2013 Austin Creek Salinity and Flow Graph**

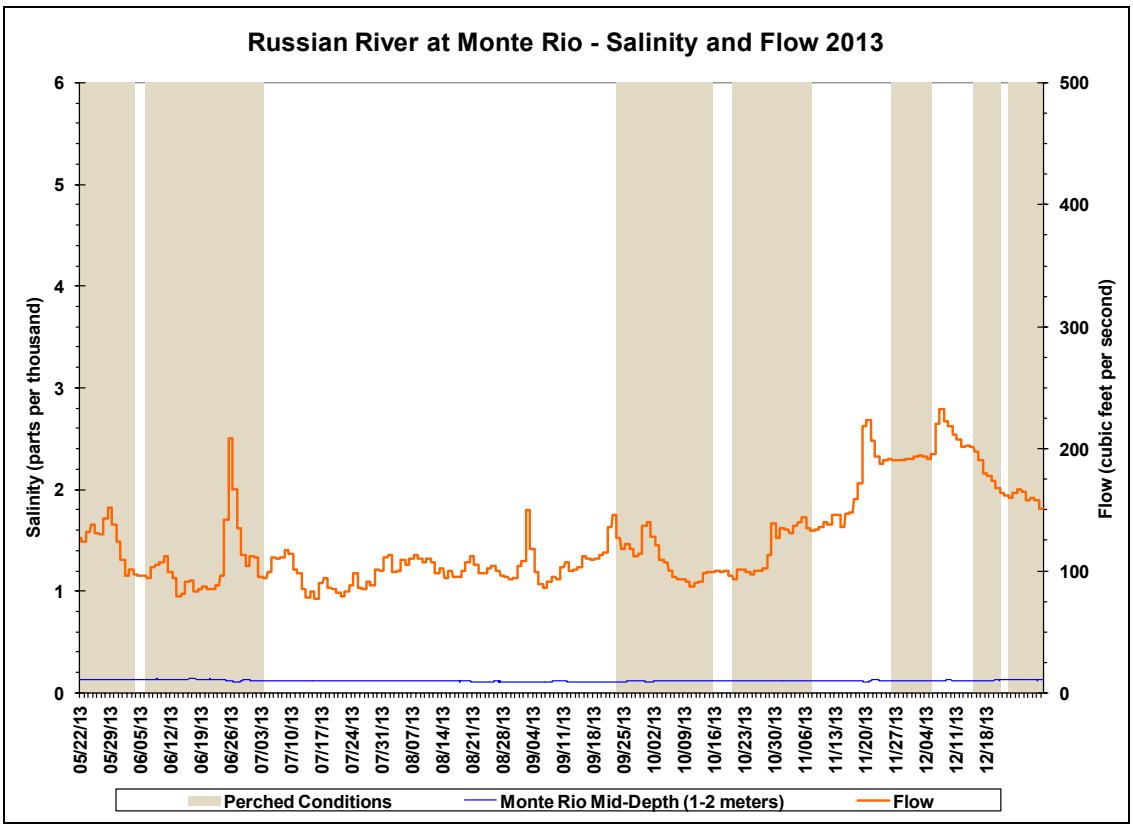



Figure 4.1.10. **2013 Russian River at Monte Rio Salinity and Flow Graph**

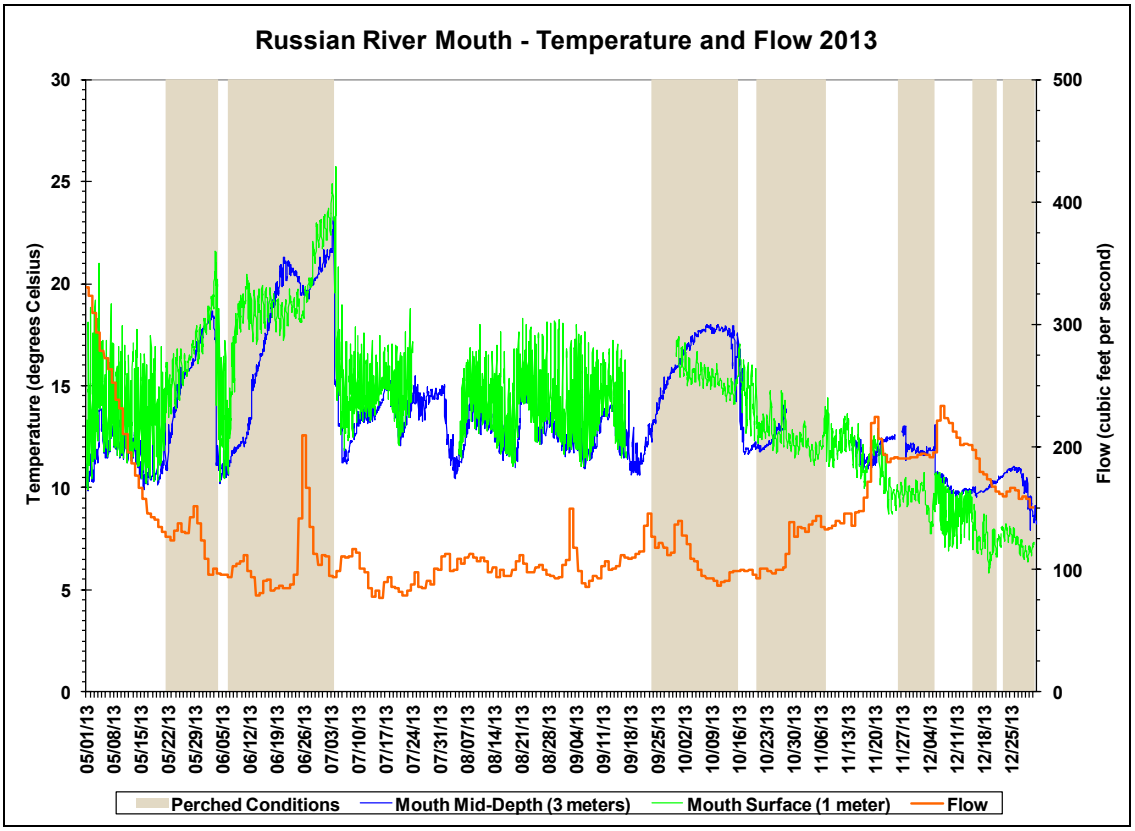



Figure 4.1.11. **2013 Russian River Mouth Temperature and Flow Graph**

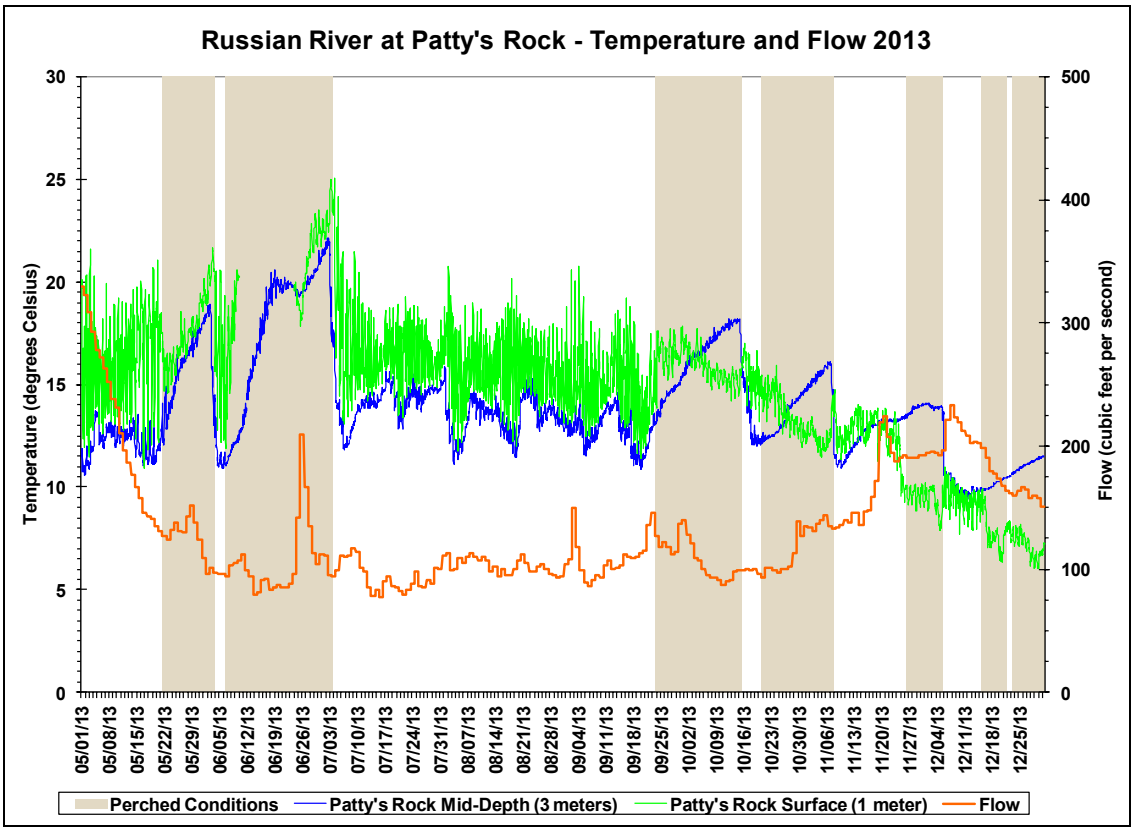



Figure 4.1.12. **2013 Russian River at Patty's Rock Temperature and Flow Graph**

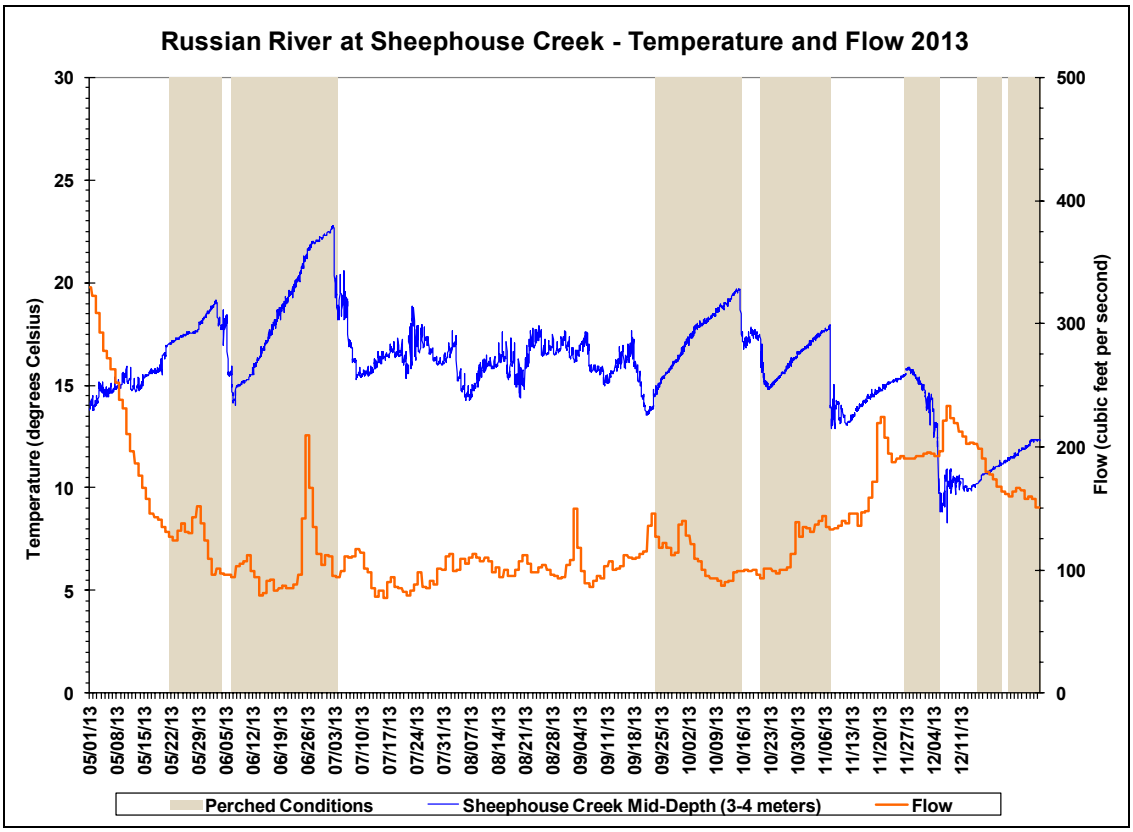



Figure 4.1.13. **2013 Russian River at Sheephouse Creek Temperature and Flow Graph**

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 25.7 and 25.1 °C at the Mouth and Patty's Rock, respectively. Whereas, the mid-depth sondes were located primarily in saltwater and had maximum temperatures of 23.3, 22.1, and 22.8 °C at the Mouth, Patty's Rock, and Sheephouse Creek, respectively (Table 4.1.1). The surface sondes had mean temperatures of 13.8 and 14.7 °C and minimum temperatures of 5.8 and 6.0 °C at the Mouth and Patty's Rock, respectively (Table 4.1.1). The mid-depth sondes had mean temperatures of 13.5, 13.9, and 15.9 °C, and minimum temperatures of 7.9, 9.4, and 8.3 °C at the Mouth, Patty's Rock, and Sheephouse Creek, respectively (Table 4.1.1). The minimum temperature values are lower than previous years, and this is likely attributable to the sondes remaining deployed longer than previous years. This was possible due to lower than average rainfall and river flows in the late fall/early winter that allowed sondes to remain deployed through the end of the calendar year.

The Willow Creek station had a maximum temperature of 23.8 °C, which occurred in the afternoon of 15 August in brackish water and open conditions (Table 4.1.1). The mean

temperature was 14.6 °C, and the minimum temperature was 3.4 °C. Willow Creek had freshwater conditions prior to the monitoring season that became intermittently brackish as flows dropped below 500 cfs in early April (Figure 4.1.6). The station transitioned to a predominantly brackish habitat during the first barrier beach closure in mid-May and remained brackish through early fall. Though the average salinity trend was increasing over the summer months, there were fluctuations as saline water migrated up and down stream with the tides and during barrier beach closures. 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 4.1.14). This was most apparent following barrier beach closures in September and October when warm brackish water was observed to signficantly decrease in temperature after freshwater and/or a fresh source of tidally migrating brackish water migrated to the station (Figure 4.1.14).

### 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 25.9 °C, a mean temperature of 18.9 °C, and a minimum temperature of 5.0 °C (Table 4.1.1). The mid-depth sonde had a maximum temperature of 25.6 °C, a mean temperature of 18.4 °C, and a minimum temperature 4.7 °C. Minimum temperatures occured in freshwater during open conditions in December (Figure 4.1.15). The maximum temperature at both Freezeout Creek sondes was observed to occur in freshwater conditions on 3 July shortly after the barrier beach self-breached. The barrier beach had been closed for approximately 27 days and temperatures at the Freezeout Creek station were fairly stable even as the site became brackish during the latter half of the closure (Figure 4.1.7). However, once the river mouth reopened, temperatures were observed to briefly spike as the cooler brackish water was replaced by warmer freshwater from upstream (Figure 4.1.15). Temperatures were observed to be fairly stable in the saline layer during closures later in the season as well with minor heating and cooling observed. After September, temperatures were generally warmer in the saline layer compared to the freshwater layer under both open and closed conditions, and is most apparent during the month of November (Figure 4.1.15).

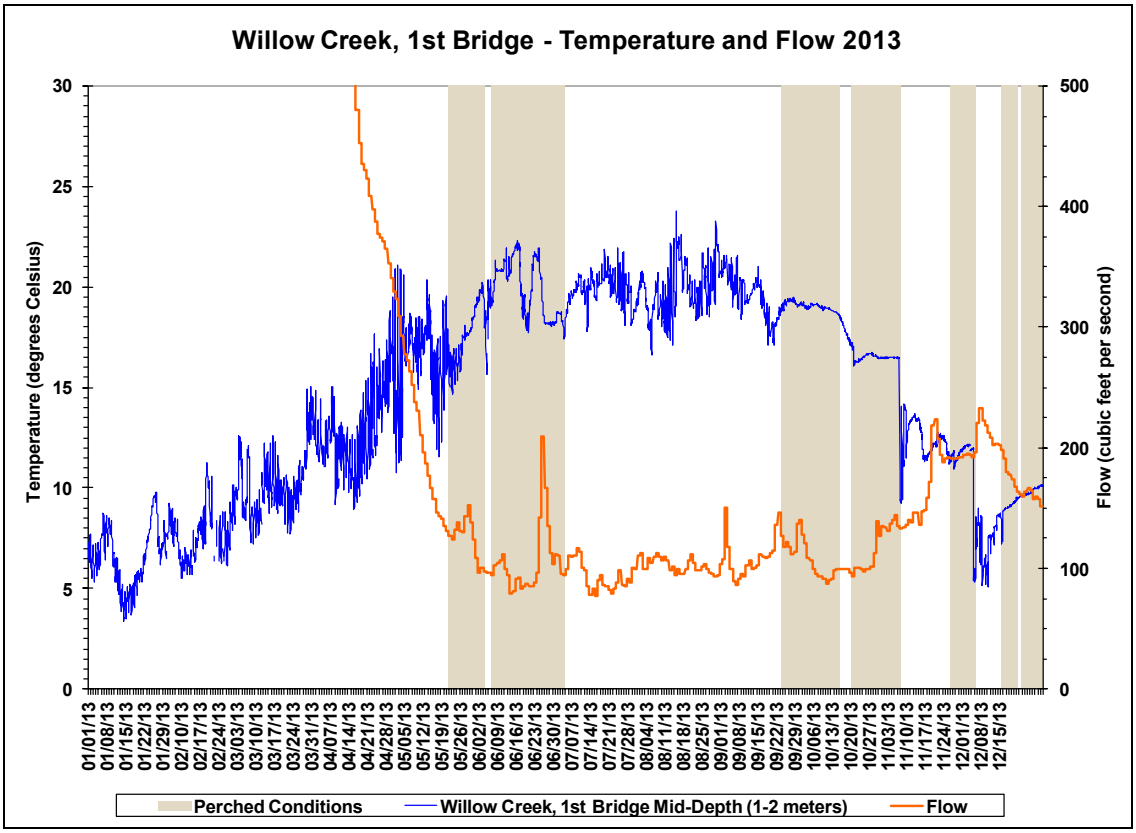



Figure 4.1.14. **2012 Willow Creek Temperature with Russian River Flow**

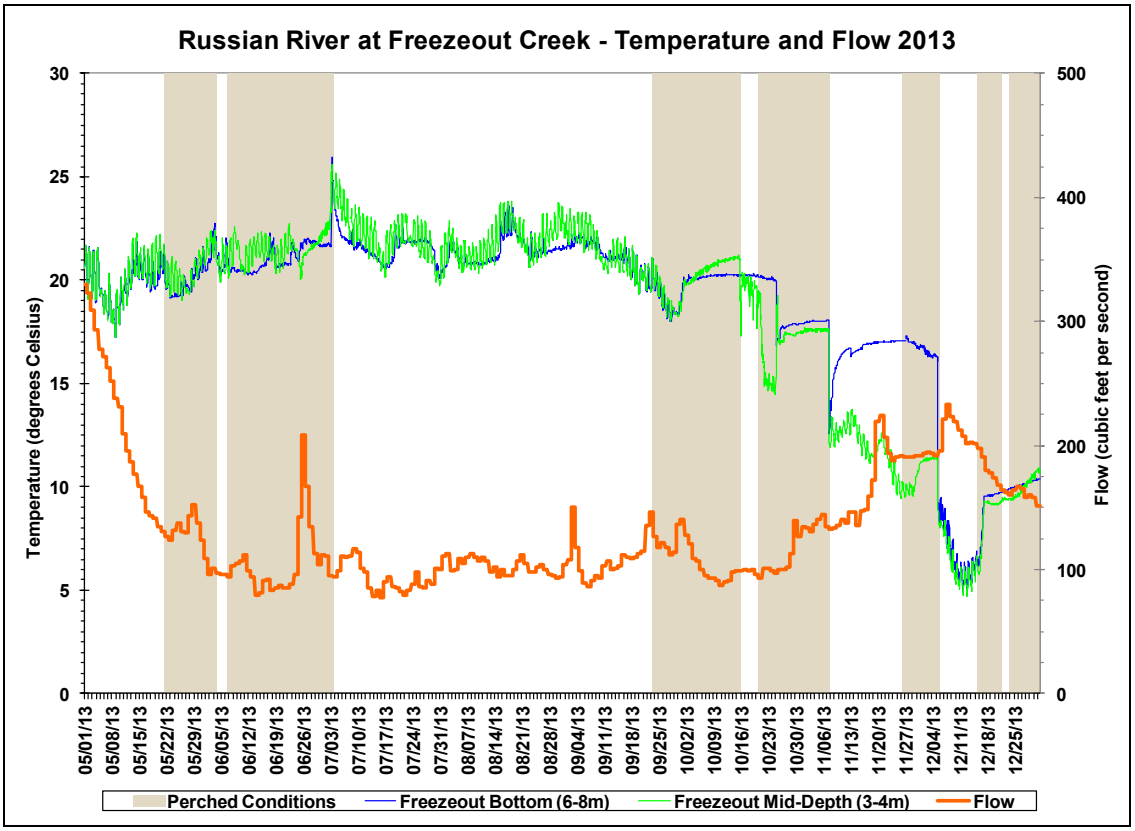



Figure 4.1.15. **2013 Russian River at Freezeout Creek Temperature and Flow Graph**

The bottom sonde at the Brown's Pool station had a maximum temperature of 25.1 °C, a mean temperature of 16.3 °C, and a minimum temperature of 5.2 °C (Table 4.1.1). The minimum temperature at the Brown's Pool station was observed outside of the Estuary monitoring season during the month of December. Temperatures were observed to decrease at the station during the first two barrier beach closures in May and June. However, as the river mouth reopened, warmer freshwater from the maximum backwater area replaced cooler freshwater that was present at the bottom of the pool, resulting in the maximum temperature observed on 3 July (Figure 4.1.16). By contrast, temperatures were observed to increase during the early October closure as warm brackish water migrated to the station and displaced the cooler freshwater. Temperatures were then observed to decrease during the following closure as the brackish water was displaced by cooler freshwater.

### Maximum Backwater Area Temperature

Austin Creek had a maximum temperature of 20.9 °C, a mean temperature of 15.0 °C, and a minimum temperature of 9.0 °C (Table 4.1.1). The Monte Rio station had a maximum temperature of 27.7 °C, a mean temperature of 18.0 °C, and a minimum temperature of 5.3 °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 4.1.17). Closed estuary conditions did not appear to have a significant effect on the temperatures at the Austin Creek or Monte Rio stations. Closed Estuary conditions were consistent with data from previous monitoring efforts at Monte Rio and other monitoring stations within the maximum backwater area (Figure 4.1.18). Slight increases and decreases in water temperature during closure events coincided with increases and decreases in air temperatures (Figure 4.1.17). However, temperatures were also affected by increasing flows from storm events and were observed to increase and decrease depending on the time of year. For instance, temperatures experienced a brief decrease in late-June during a late season storm with increased flows, but increased during a storm event in November (Figure 4.1.17). These differences in temperature response are due to the relative base temperature of the stream in relation to the temperature of the rain from a given storm.

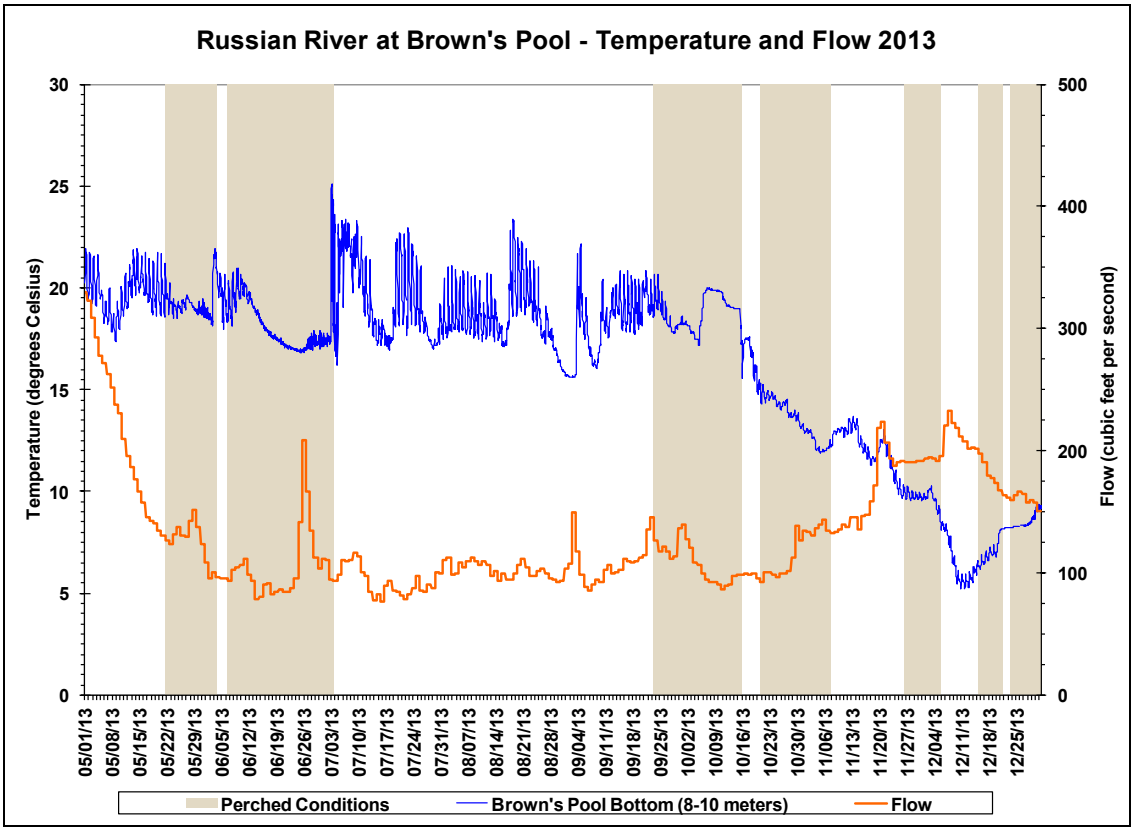



Figure 4.1.16. **2013 Russian River at Brown's Pool Temperature and Flow Graph**

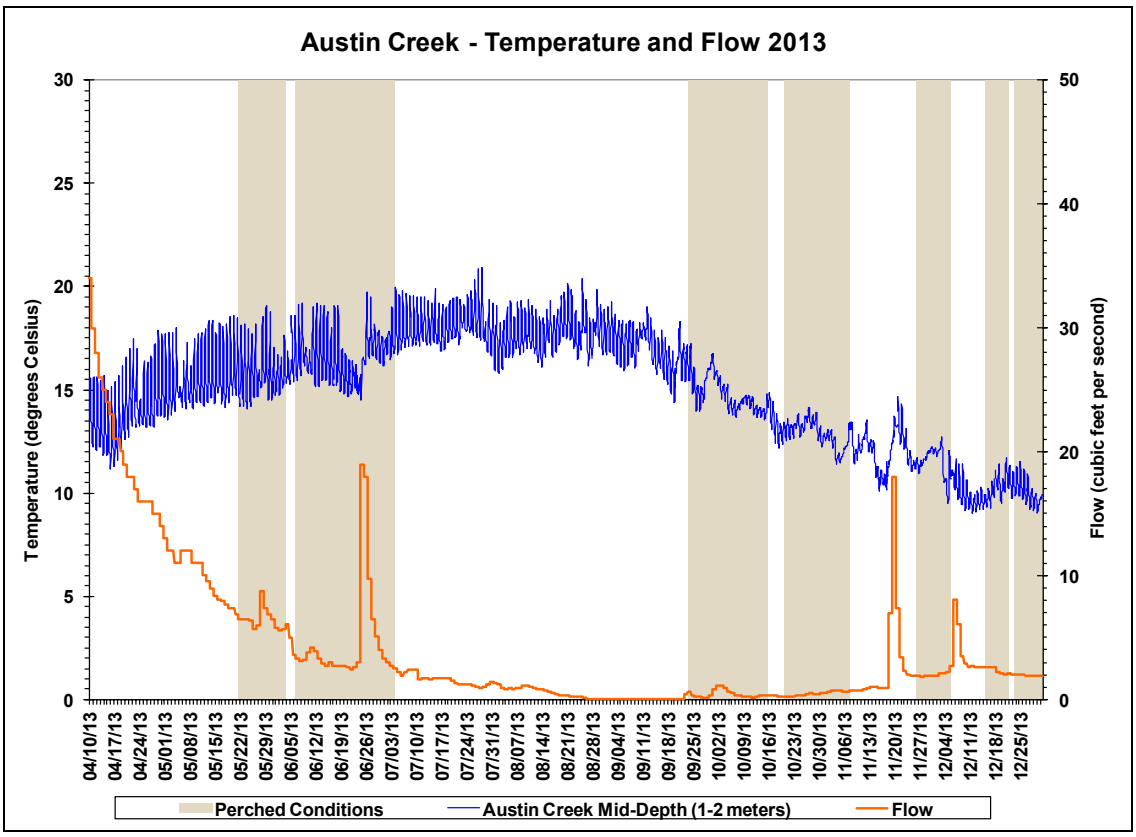



Figure 4.1.17. **2013 Austin Creek Temperature and Flow Graph**

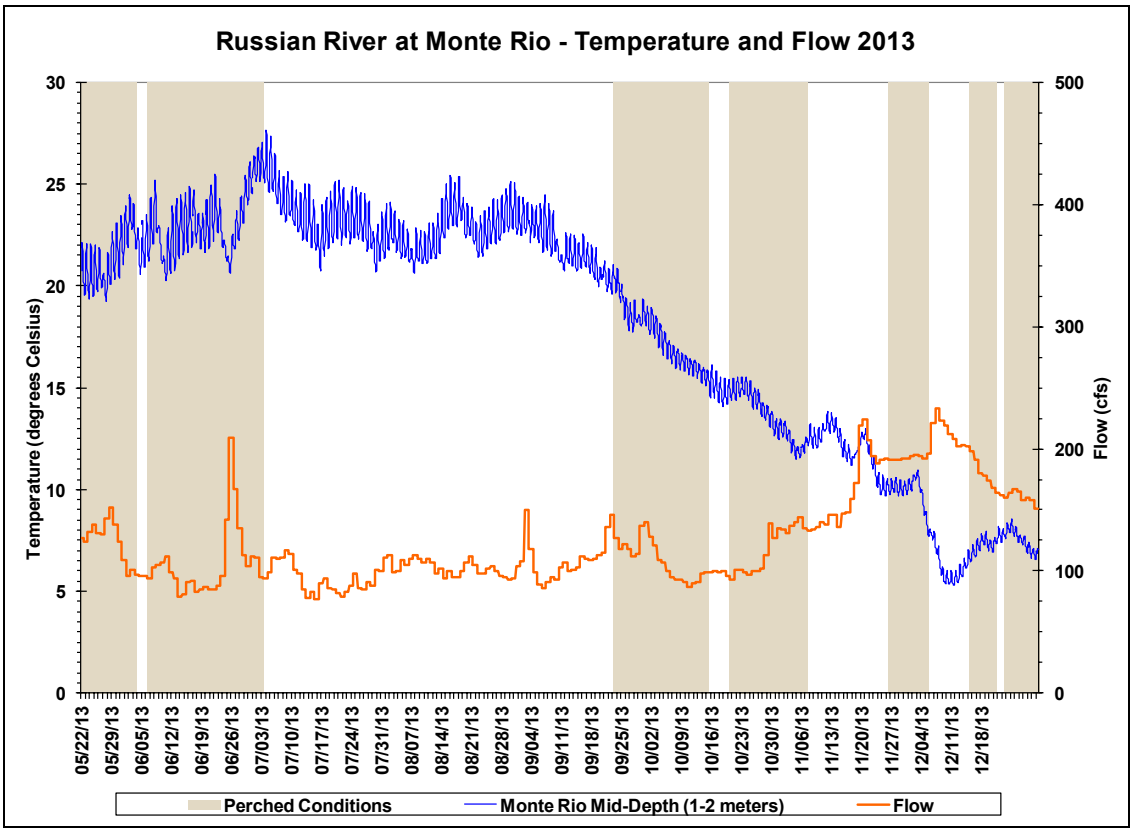



Figure 4.1.18. **2013 Russian River at Monte Rio Temperature and Flow Graph**

*Dissolved Oxygen*

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

DO levels are also a function of nutrients, which can accumulate in water and promote plant and algal growth that both consume and produce DO during photosynthesis and respiration. Estuaries tend to be naturally eutrophic because land-derived nutrients are concentrated where runoff enters the marine environment in a confined channel (NOAA NCSS and IAN 1999). Upwelling in coastal systems also promotes increased productivity by conveying deep, nutrient-rich waters to the surface, where the nutrients can be assimilated by algae. Excessive nutrient concentrations and plant, algal, and bacterial growth can overwhelm eutrophic systems and lead to a reduction in DO levels that can affect the overall ecological health of the Estuary.

Dissolved oxygen concentrations in the lower and middle reaches were generally higher at the surface sondes compared to the mid-depth sondes at a given sampling station (Table 4.1.1). More frequent supersaturation conditions at the surface sondes and periodic hypoxic conditions at the mid-depth sondes generally contributed to this difference. Supersaturation and hypoxic events were observed during open and closed conditions (Figures 4.1.19 through 4.1.21). Although the mid-depth sondes typically experienced less significant and less frequent supersaturation events than the corresponding surface sondes; mid-depth concentrations were observed to periodically exceed surface concentrations during both open and closed conditions (Figures 4.1.19 and 4.1.20).

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 and anoxic events were observed to occur in the presence of brackish water during open and closed conditions in July, September, October and November. However, hypoxia and anoxia were less likely to occur during open estuary conditions when tidal fluctuations were sufficient to cause water mixing at the station (Figure 4.1.22).

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 in June, and was predominantly brackish at the bottom sonde for most of the Estuary management period (Figure 4.1.7). The Brown's Pool station was observed to remain freshwater during the majority of the Estuary management period, though brackish water was observed to move into Brown's Pool during the Estuary closures in October (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 at Freezeout Creek under the presence of a higher salinity environment than the Brown's Pool station (Figures 4.1.23 and 4.1.24).

DO concentrations in the upper reach saline layer were also observed to be lower during both 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,

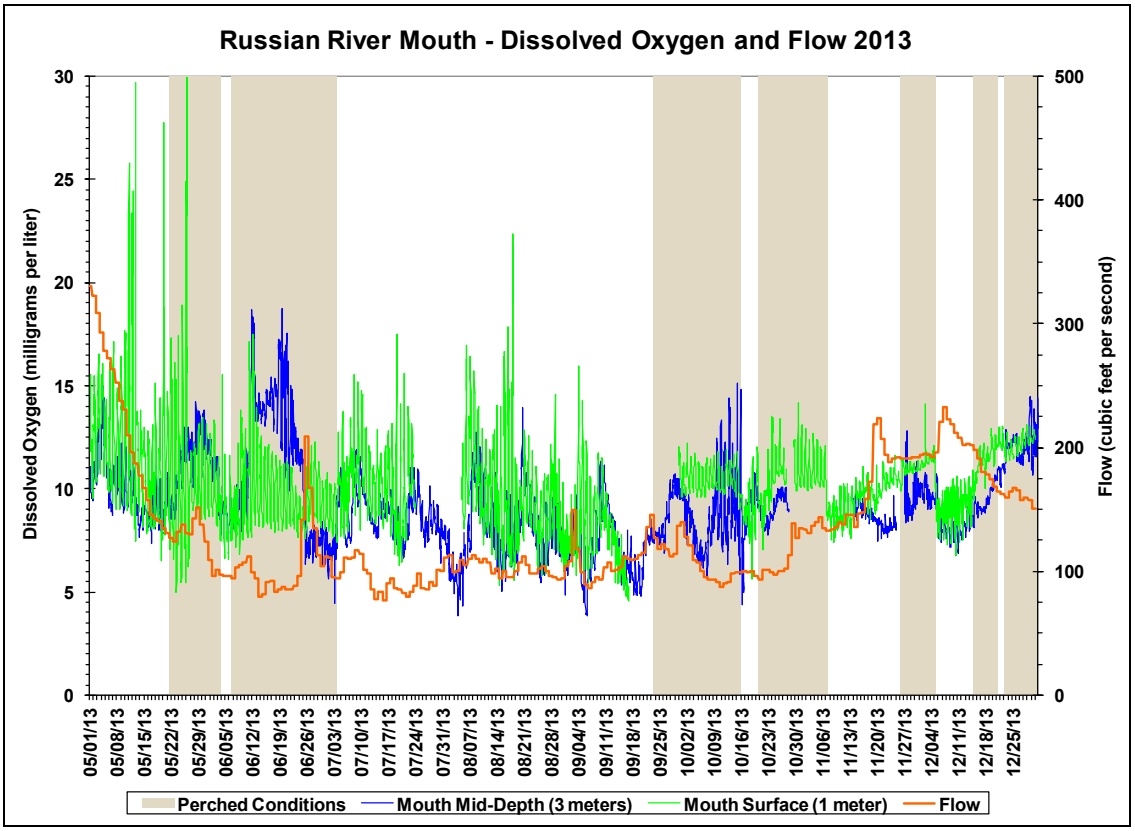



Figure 4.1.19. **2013 Russian River Mouth Dissolved Oxygen and Flow Graph**

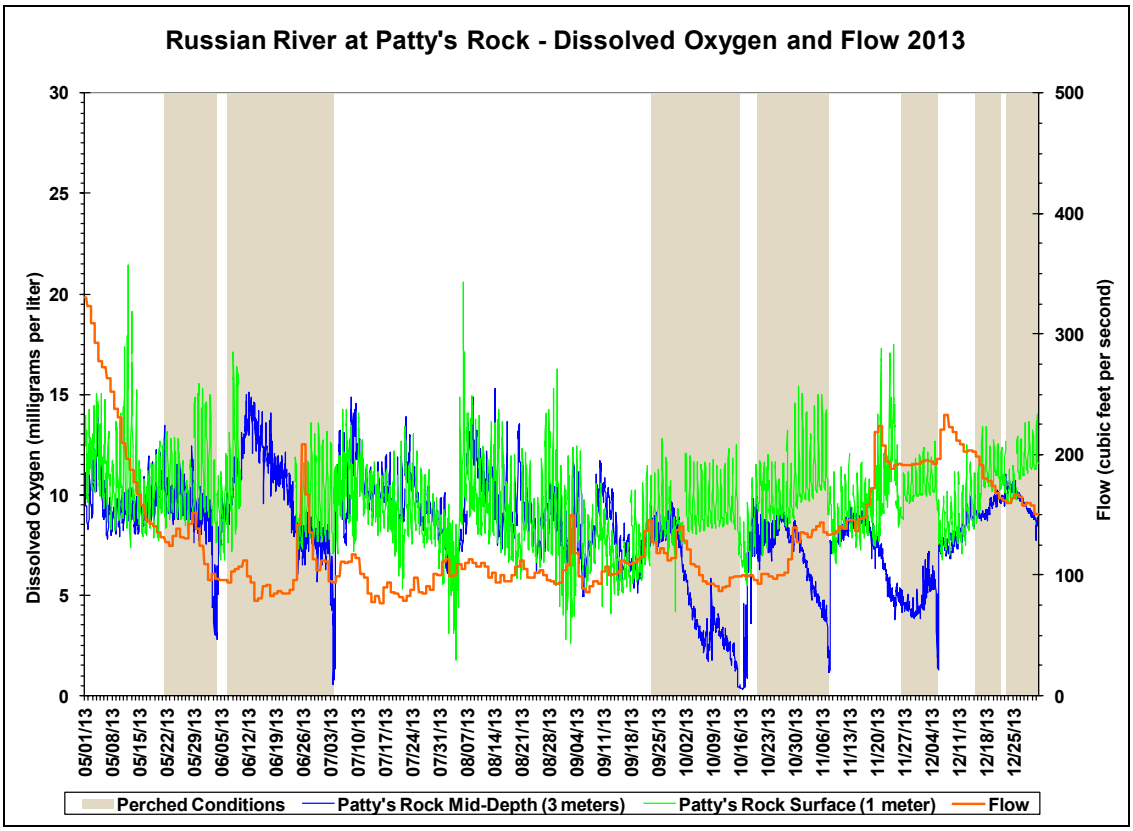



Figure 4.1.20. **2013 Russian River at Patty's Rock Dissolved Oxygen and Flow Graph**

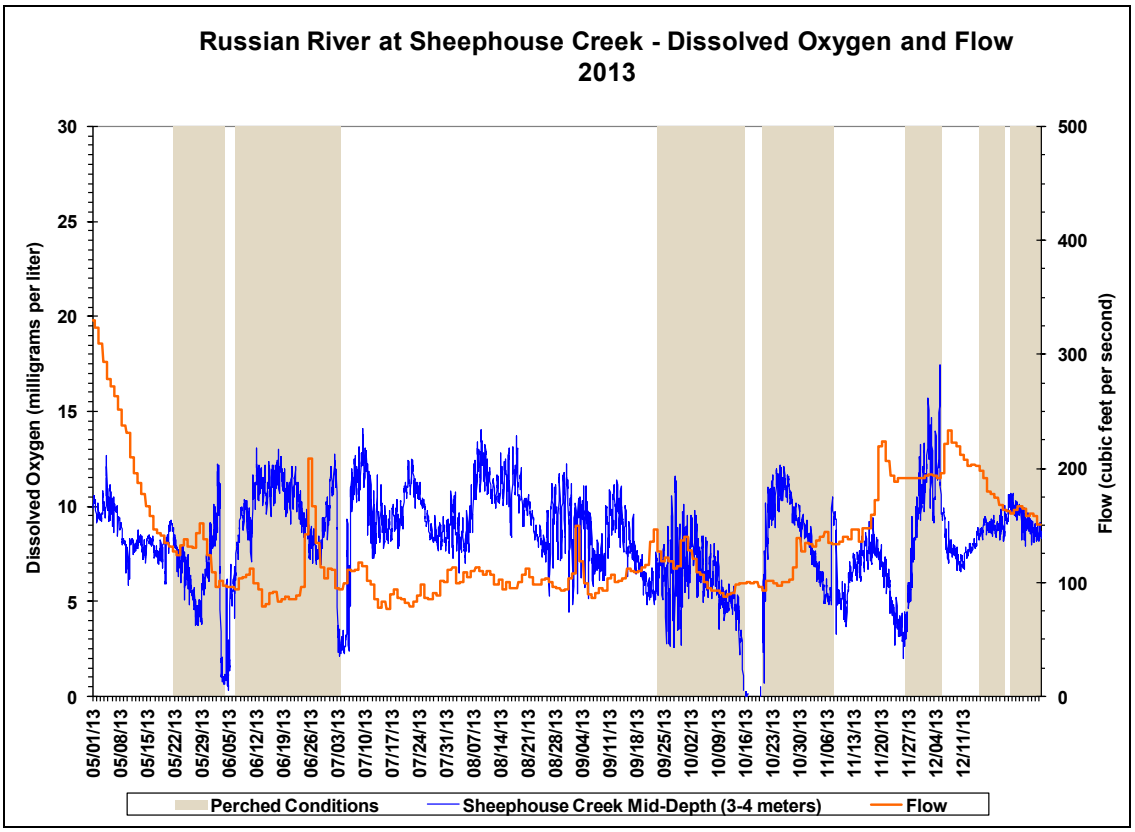



Figure 4.1.21. **2013 Russian River at Sheephouse Creek Dissolved Oxygen and Flow Graph**

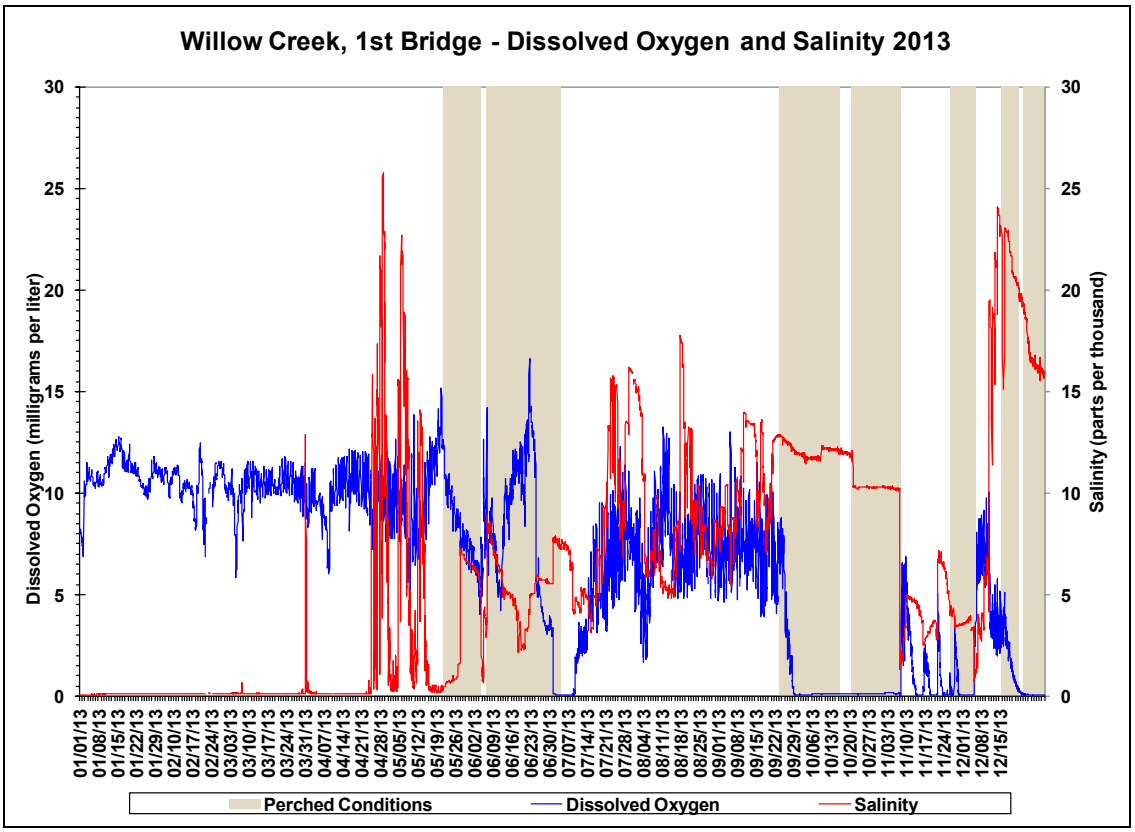



Figure 4.1.22. **2013 Willow Creek Dissolved Oxygen and Salinity Graph**

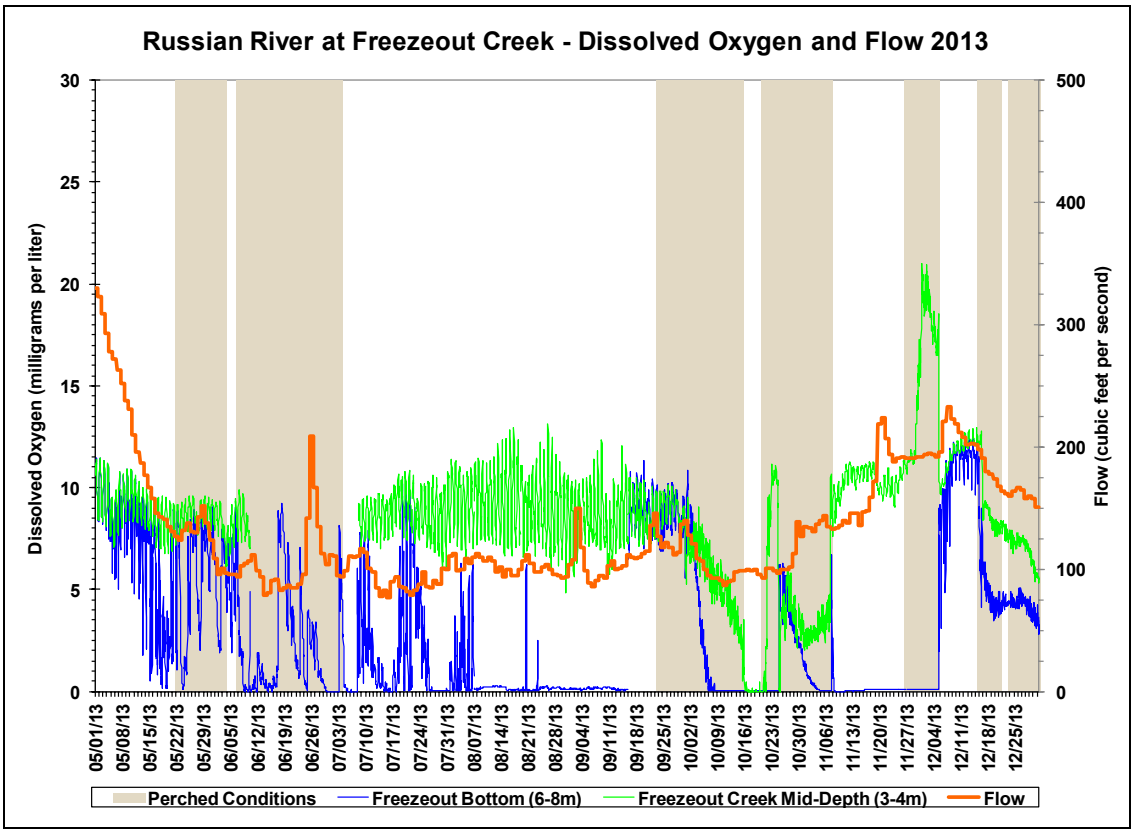



Figure 4.1.23. **2013 Russian River at Freezeout Creek Dissolved Oxygen and Flow Graph**

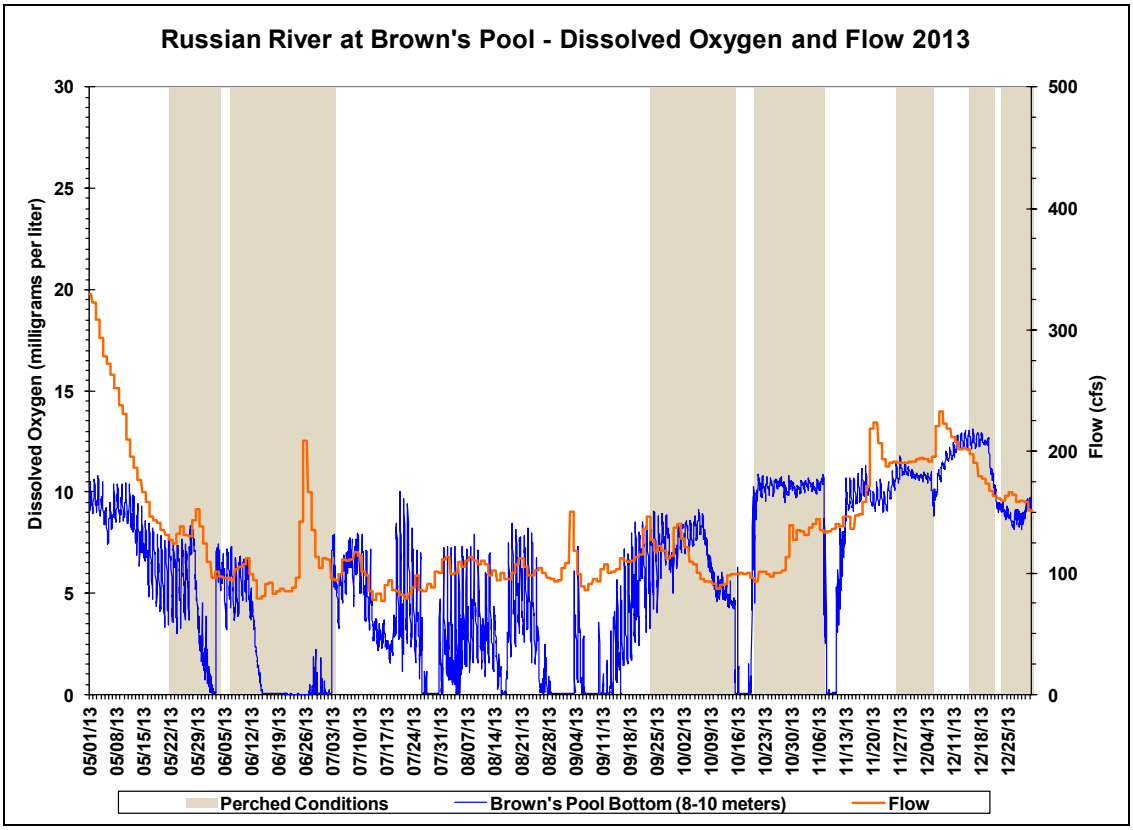



Figure 4.1.24. **2013 Russian River at Brown's Pool Dissolved Oxygen and Flow Graph**

hypoxic conditions, and to a lesser degree, anoxic conditions observed (Figures 4.1.19 through 4.1.21).

The surface sondes were generally observed to have higher mean, maximum, and minimum DO concentrations when compared to the mid-depth sondes (Table 4.1.1). The surface sondes at the Mouth and Patty's Rock had mean DO concentrations of 10.2 and 9.7 mg/L, respectively. The mid-depth sondes had mean DO concentrations of 9.2, 8.3, and 8.4 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 4.1.19 and 4.1.20). The Mouth and Patty's Rock surface sondes had minimum DO concentrations of 4.6 and 1.8 mg/L (Table 4.1.1). These minimum concentrations were observed during open conditions, though the Mouth surface sonde also experienced mildly hypoxic conditions during the Estuary closure in May (Figure 4.1.19).

Short-term hypoxic and/or anoxic events previously observed during open conditions at mid-depth sondes in 2009 and 2012 were not as significant during the 2013 monitoring season, however conditions were observed to become mildly hypoxic in early August and early September (Figure 4.1.19 through 4.1.21). DO concentrations at the Patty's Rock and Sheephouse Creek mid-depth sondes were also observed to decline to hypoxic and anoxic levels during and following closed conditions (Figures 4.1.20 and 4.1.21).

Corresponding minimum concentrations of DO at the mid-depth sondes were 3.8, 0.3, and 0.0 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 observed during the early and mid seasons at the Mouth and Patty's Rock stations surface sondes fluctuated considerably, while the mid-depth sondes at all three lower Estuary stations (the Mouth, Patty's Rock, and Sheephouse Creek) did not appear to fluctuate to the same degree as the surface sondes (Figures 4.1.19 through 4.1.21). This increased variability of DO concentrations at the surface sondes is most likely attributable to changes in the circulation and stratification patterns in the saline and freshwater layers at each given station, however algal blooms may contribute to the supersaturation conditions observed.

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 degrees C, but only 8.2 mg/L at 24 degrees C. Consequently, these two temperature values roughly represent the range of temperatures typically observed in the Estuary.

The most significant supersaturation events were generally observed during open estuary conditions at the surface sondes and during closed estuary conditions at the mid-depth sondes, however the Mouth surface sonde also experienced significant supersaturation during the first barrier beach closure in May (Figures 4.1.19 through 4.1.21).

The Mouth surface sonde had a maximum DO concentration of 29.9 mg/L, which corresponded to 329% saturation. The maximum DO concentration at the Patty's Rock surface sonde was 21.4 mg/L, or 243% saturation (Table 4.1.1). Maximum DO concentrations at the mid-depth sondes were approximately 18.7 mg/L (245%) at the Mouth, 15.3 mg/L (182%) at Patty's Rock, and 17.5 mg/L (169%) at Sheephouse Creek, respectively (Table 4.1.1). The Mouth mid-depth maximum DO occurred on 19 June during a prolonged Estuary closure (Figure 4.1.19). The Patty's Rock mid-depth maximum DO occurred on 14 August under open Estuary conditions (Figure 4.1.20). The Sheephouse Creek mid-depth maximum DO occurred on 2 December during a closure event (Figure 4.1.21).

The Willow Creek sonde had a minimum DO concentration of 0.0 mg/L, a mean DO concentration of 6.6 mg/L, and a maximum DO concentration of 16.6 mg/L (191%) (Table 4.1.1). Minimum values were observed to occur in brackish water during and following Estuary closures in July, and most significantly during an extended period of anoxia that occurred during Estuary closures in September and October (Figure 4.1.22). Conversely, the maximum DO value was observed during a prolonged Estuary closure on 22 June (Figure 4.1.22).

### Upper Reach DO

The Freezeout Creek bottom sonde had a minimum concentration of 0.0 mg/L, a mean DO concentration of 2.9 mg/L, and a maximum concentration of 12.4 mg/L (130%) (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 8.5 mg/L, and a maximum concentration of 21.0 mg/L (201%) (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 4.1.23). The Freezeout Creek bottom sonde was observed to be primarily brackish during this period, with concentrations typically between 5 and 15 ppt. Salinity concentrations fluctuated frequently between brackish and freshwater

conditions during open conditions, often on a daily basis. DO typically fluctuated with changing salinity concentrations, becoming depressed in saline water and recovering in freshwater (Figure 4.1.23).

The Freezeout Creek mid-depth sonde was also observed to have brackish conditions during the monitoring season, though to a lesser degree than the bottom sonde. These brackish conditions were between 5 and 15 ppt, similar to the bottom sonde, though they 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 in October and early November (Figure 4.1.23). Conversely, DO concentrations became supersaturated at the mid-depth sonde during the late November closure as fresh saline water migrated into the area and mixed with or replaced the freshwater layer (Figure 4.1.23).

The Brown's Pool bottom sonde had a minimum concentration of 0.0 mg/L, a mean DO concentration of 5.7 mg/L, and a maximum concentration of 13.1 mg/L (122%) (Table 4.1.1). DO concentrations at the sonde fluctuated with river flows, circulation patterns, closed Estuary conditions, and the presence or absence of brackish water. The bottom sonde recorded anoxic conditions during Estuary closures in May and June in the presence of freshwater (Figure 4.1.24). Conversely, anoxic conditions were observed in October and November in the presence of brackish water immediately following Estuary breaching (Figure 4.1.24).

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. Freezeout Creek mid-depth during the late November 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 0.2, 5.6, and 10.9 (117%) mg/L, respectively (Table 4.1.1). Similar to previous monitoring seasons, DO concentrations in 2013 gradually declined through the summer months as flows decreased and mixing was significantly reduced (Figure 4.1.25). Flows became intermittent in August (measured at less than 2 cfs at the upstream USGS gauging station) and the sonde was then in an isolated pool where DO concentrations became hypoxic. Minimum values at Austin Creek were observed in October during an Estuary closure, and briefly in early November immediately after the barrier beach reopened (Figure 4.1.25). Freshwater inflow was intermittent during both events.

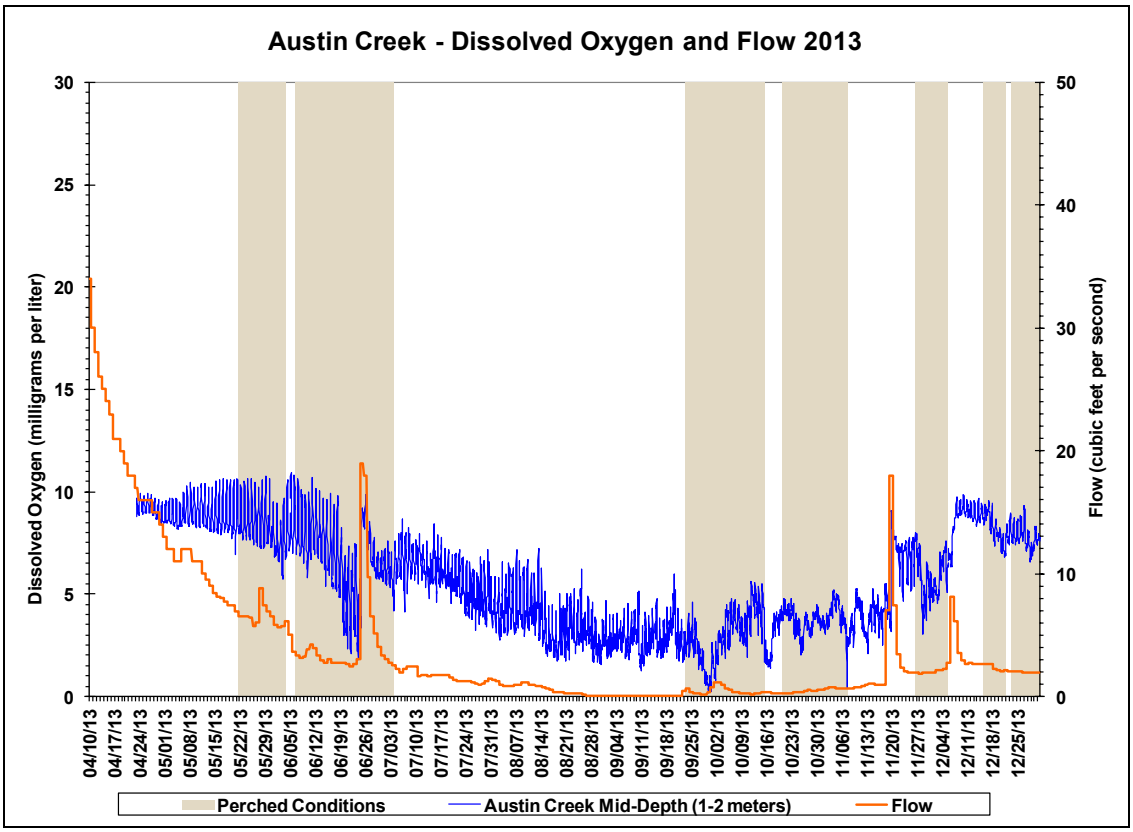



Figure 4.1.25. **2013 Austin Creek Dissolved Oxygen and Flow Graph**

Flows in Austin Creek increased to approximately 18 cfs during a brief storm event in November and re-established surface flows between the isolated pools. DO concentrations were observed to increase, however concentrations would not fully recover to springtime levels until a second storm event occurred in early December (Figure 4.1.25). DO response to estuary closures was variable. Concentrations declined during closures in June and early October, but were also observed to increase during the same early October closure as well as during the late November closure. However, increasing storm flows may have contributed to the increases seen during the late November closure (Figure 4.1.25).

The Monte Rio station had a minimum concentration of 6.4 mg/L, a mean DO concentration of 9.3 mg/L, and a maximum concentration of 13.0 mg/L (129%) (Table 4.1.1). The minimum DO concentration occurred on 4 July immediately following the end of a prolonged Estuary closure (Figure 4.1.26). DO concentrations inititally remained stable during the June closure (Figure 4.1.26), but increased and then decreased following a late storm event and increasing water temperatures (Figure 4.1.18). It is likely that warm freshwater with a lower oxygen content moved into the area from upstream following the storm. 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 4.1.26).

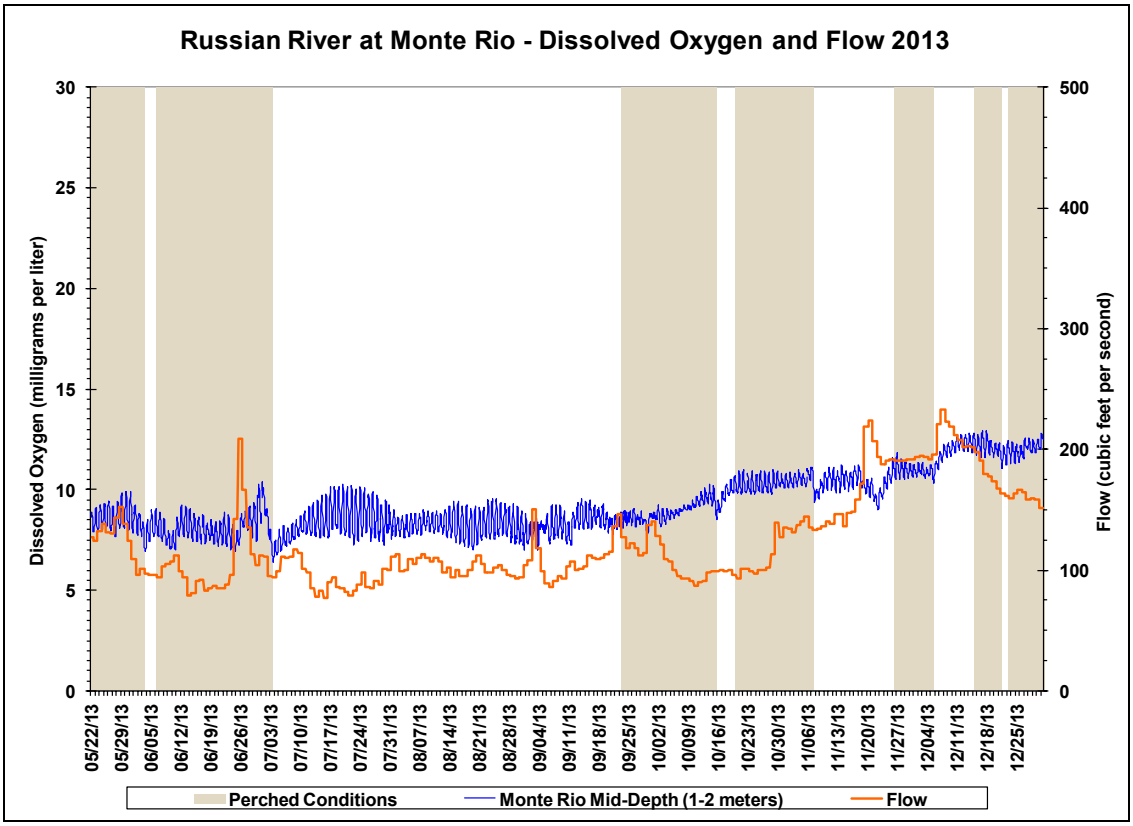



Figure 4.1.26. **2013 Russian River at Monte Rio Dissolved Oxygen and Flow Graph**

*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, 7.9, and 7.8 pH observed at the Mouth, Patty's Rock, and Sheephouse Creek, respectively (Figures 4.1.27 through 4.1.29). The Mouth and Patty's Rock surface sondes were also consistent, with a mean pH value of 8.1 pH recorded at both sondes (Table 4.1.1).

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. Maximum pH values at the mid-depth sondes were observed to be 8.4, 8.5, and 9.1 pH at the Mouth, Patty's

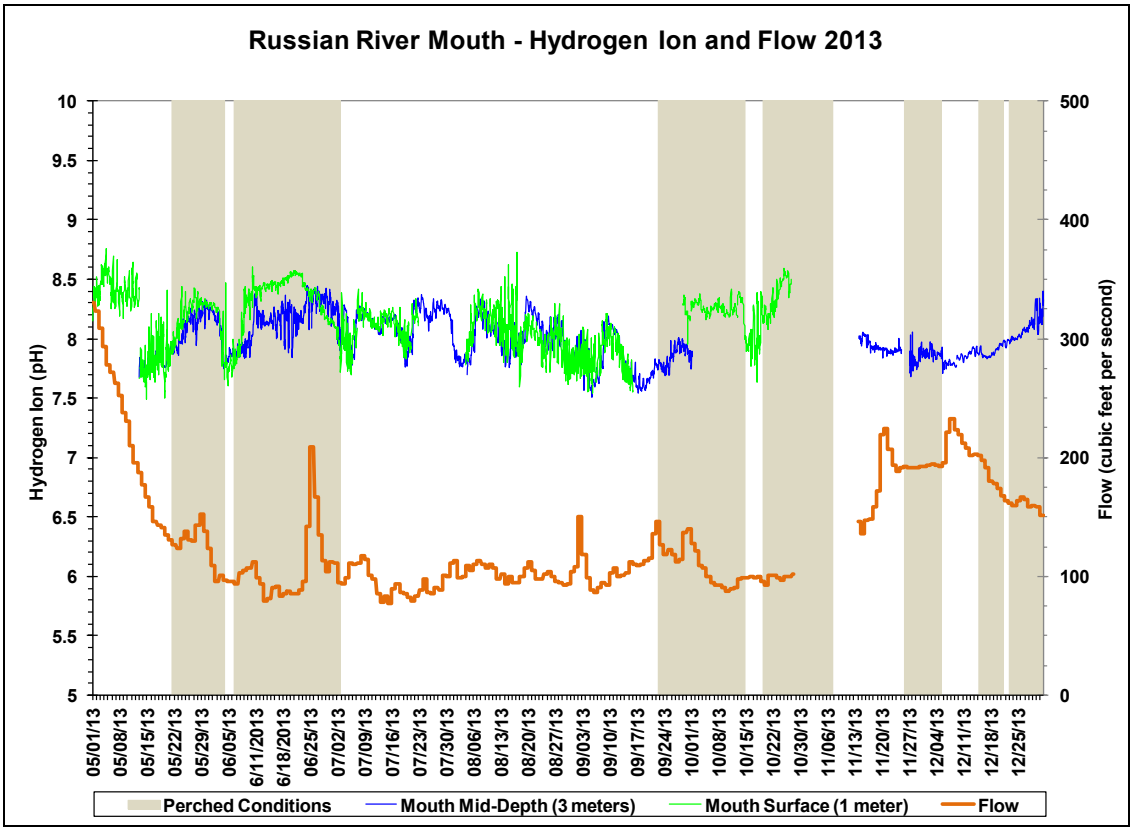



Figure 4.1.27. **2013 Russian River Mouth Hydrogen Ion and Flow Graph**

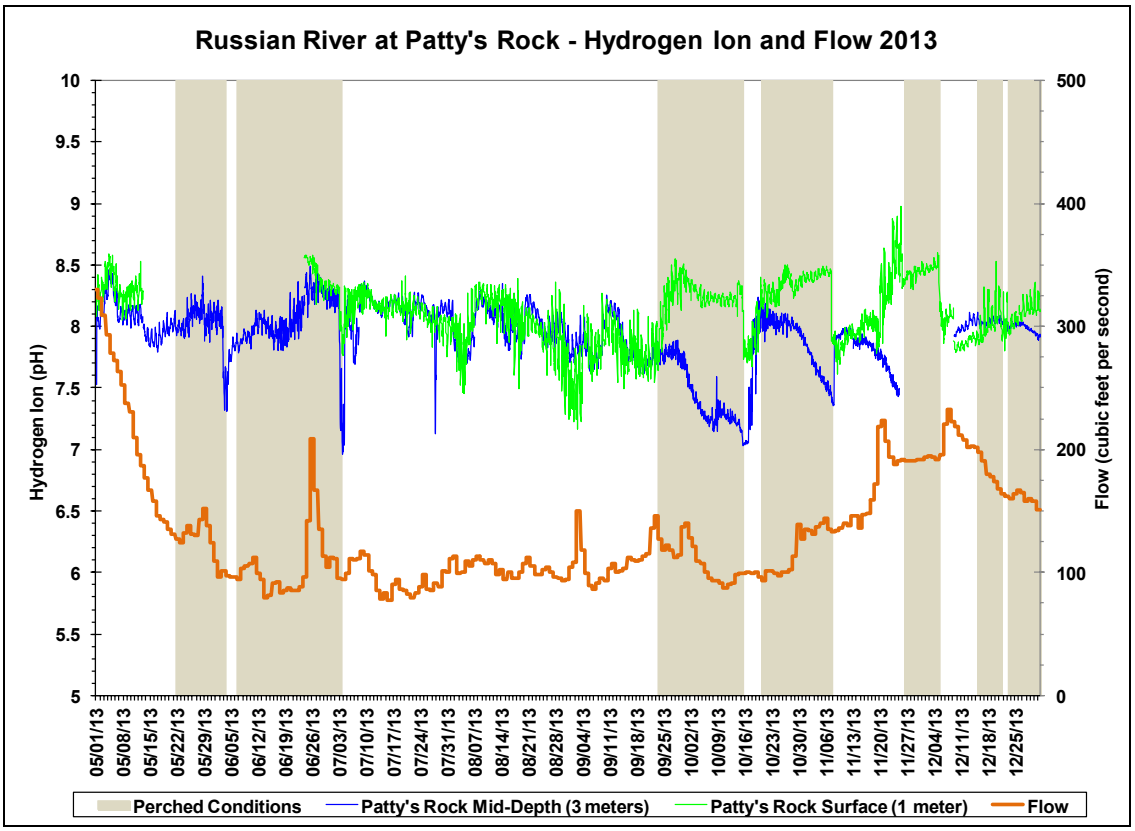



Figure 4.1.28. **2013 Russian River at Patty's Rock Hydrogen Ion and Flow Graph**

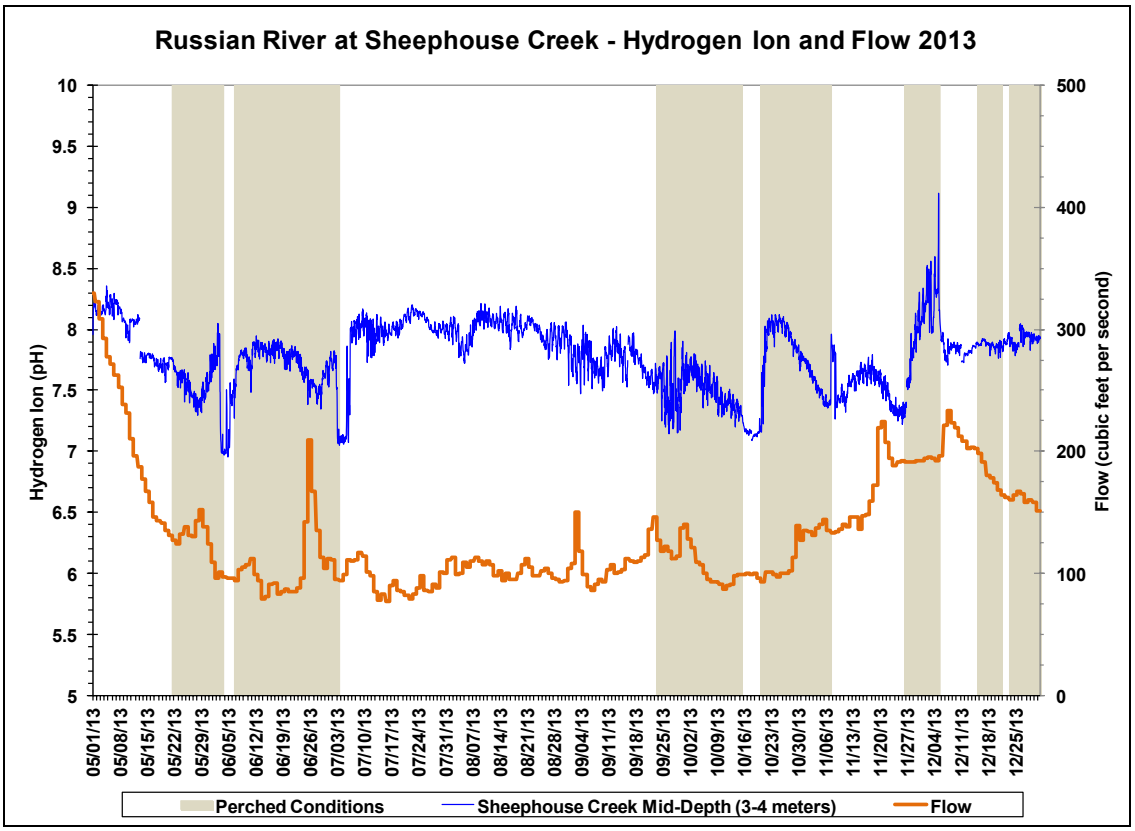



Figure 4.1.29. **2013 Russian River at Sheephouse Creek Hydrogen Ion and Flow Graph**

Rock, and Sheephouse Creek, respectively. While maximum pH values at the Mouth and Patty's Rock surface sondes were observed to be 8.8 and 9.0 pH, respectively. Minimum pH values at the mid-depth sondes were 7.5, 7.0, 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 7.5 and 7.2 pH at the Mouth and Patty's Rock, respectively.

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 4.1.27 through 4.1.29).

The Willow Creek station had a minimum pH value of 6.5, a mean pH value of 7.6, and a maximum pH value of 9.4 (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 4.1.22 and 4.1.33). The spikes in pH values observed during the May and June closures occurred during periods of DO supersaturation (Figures 4.1.22 and 4.1.30).

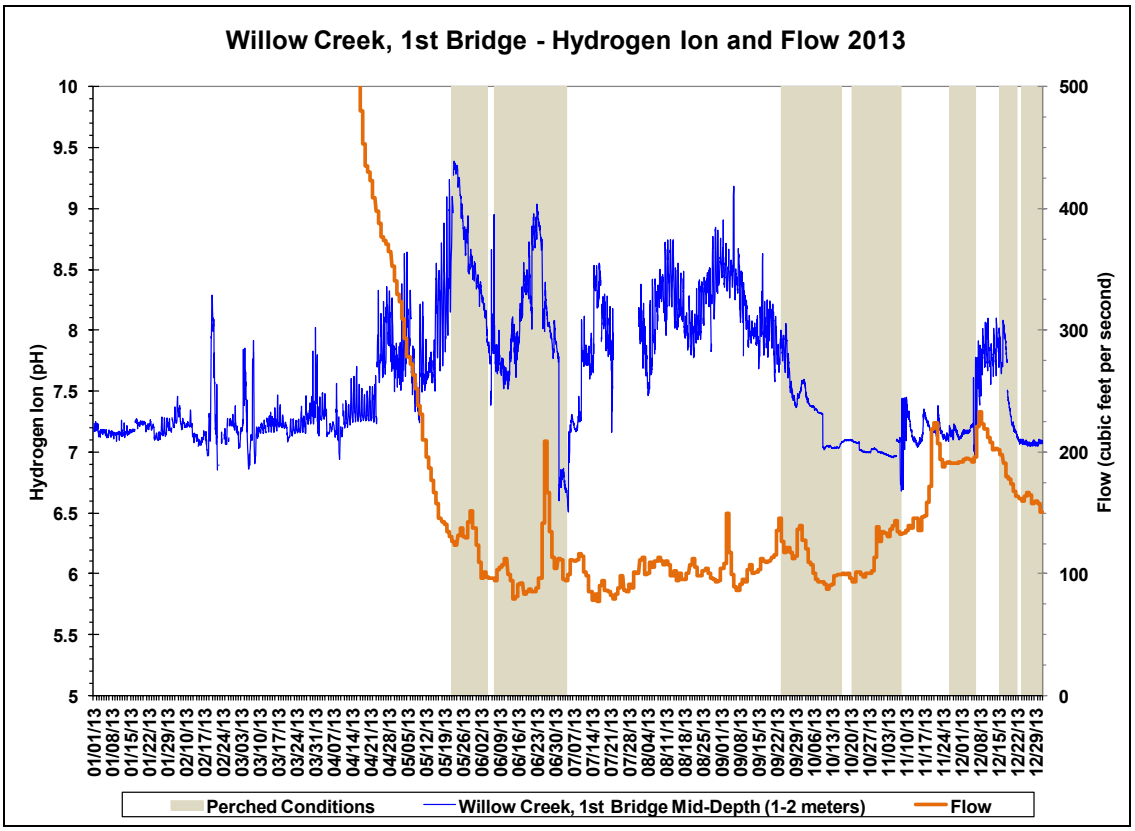



Figure 4.1.30. **2013 Willow Creek Hydrogen Ion and Flow Graph**

## Upper Reach pH

The Freezeout Creek bottom sonde recorded a minimum pH value of 5.2, a mean pH value of 7.1, 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 8.0, and a maximum pH value of 8.9 (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 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 4.1.23 and 4.1.31).

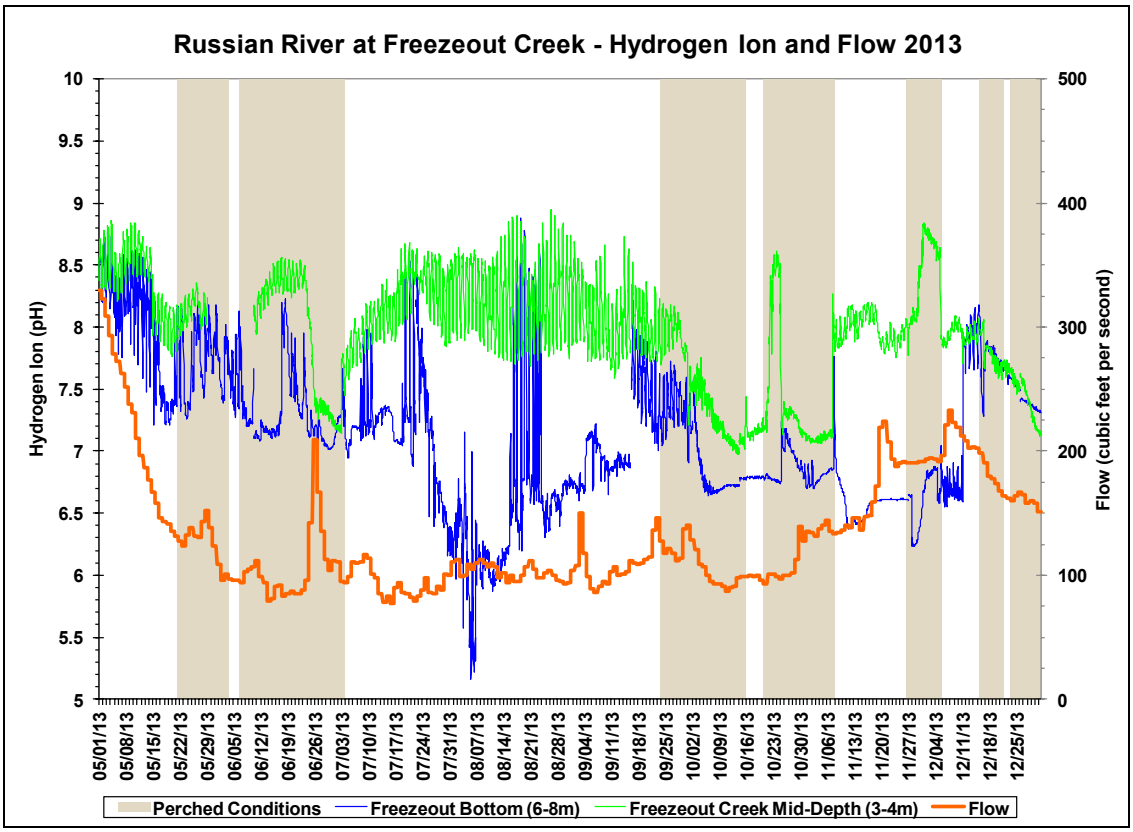



Figure 4.1.31. **2013 Russian River at Freezeout Creek Hydrogen Ion and Flow Graph**

Water Agency staff were unable to rectify pH probe problems at the Brown's Pool station during the latter portion of the monitoring season. As such, there is only valid pH data from May until mid-September. The minimum pH value recorded during this period was 5.7, the average pH value during this period was 7.2, and the maximum pH value during this period was 8.4 (Table 4.1.1). The minimum pH value was observed in freshwater during open Estuary conditions on 3 September (Figure 4.1.32). This minimum value was observed to occur at the end of a six day anoxic event (Figure 4.1.24). The maximum pH value was recorded under open Estuary conditions on 4 May, when the flow was approximately 300 cfs and DO concentrations were elevated (Figure 4.1.24).

### Maximum Backwater Area pH

The Austin Creek sonde had a minimum pH value of 7.1, a mean pH value of 7.6, and a maximum pH value of 8.4 (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 4.1.25 and 4.1.33). Minimum pH values were observed during open Estuary conditions in mid-August while flow was intermittent and DO levels were depressed in the isolated pool (Figure 4.1.33). The maximum pH value was observed on 29 May, during closed Estuary conditions and a supersaturation event (Figures 4.1.25 and 4.1.33).

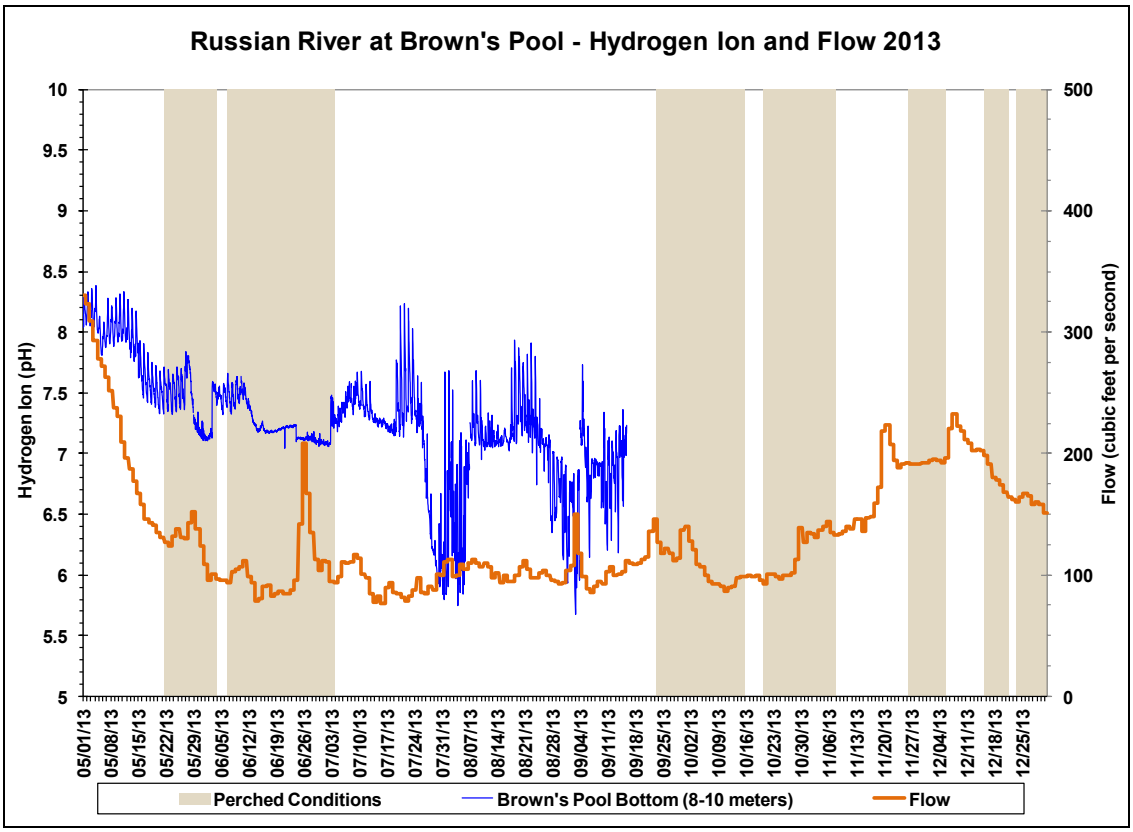



Figure 4.1.32. **2013 Russian River at Brown's Pool Hydrogen Ion and Flow Graph**

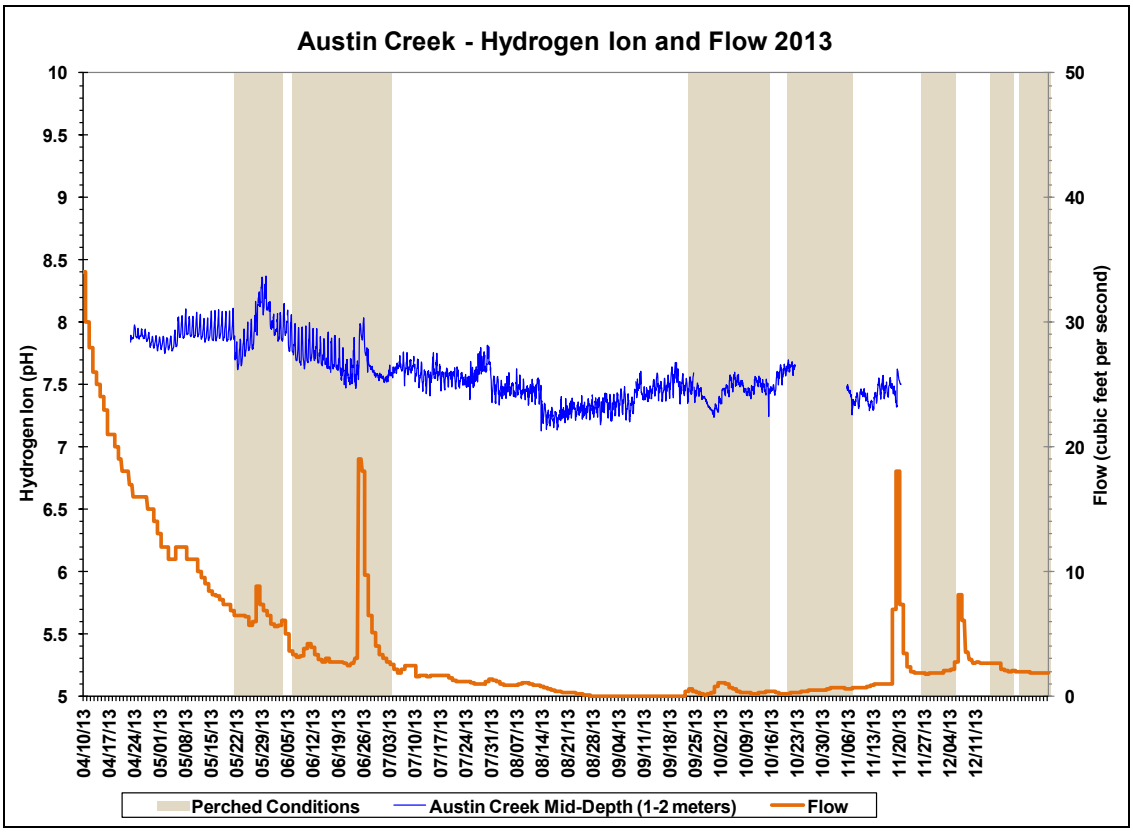



Figure 4.1.33. **2013 Austin Creek Hydrogen Ion and Flow Graph**

The Monte Rio sonde recorded a minimum pH value of 7.4, a mean pH value of 7.8, and a maximum pH value of 8.3 (Table 4.1.1). Again, the sonde here recorded pH values that were generally observed to vary with increases and decreases of DO concentrations. The minimum pH value at Monte Rio was recorded on 4 July, the day after the Estuary breached and began draining (Figure 4.1.34). DO concentrations were also observed to temporarily decrease after the Estuary reopened and it is likely that warm freshwater with a lower oxygen content moved into the area from upstream as the Estuary drained (Figure 4.1.26) The maximum pH value at the Monte Rio station was recorded on 30 May under closed Estuary conditions and during a supersaturation event (Figures 4.1.26 and 4.1.34). 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 4.1.34).

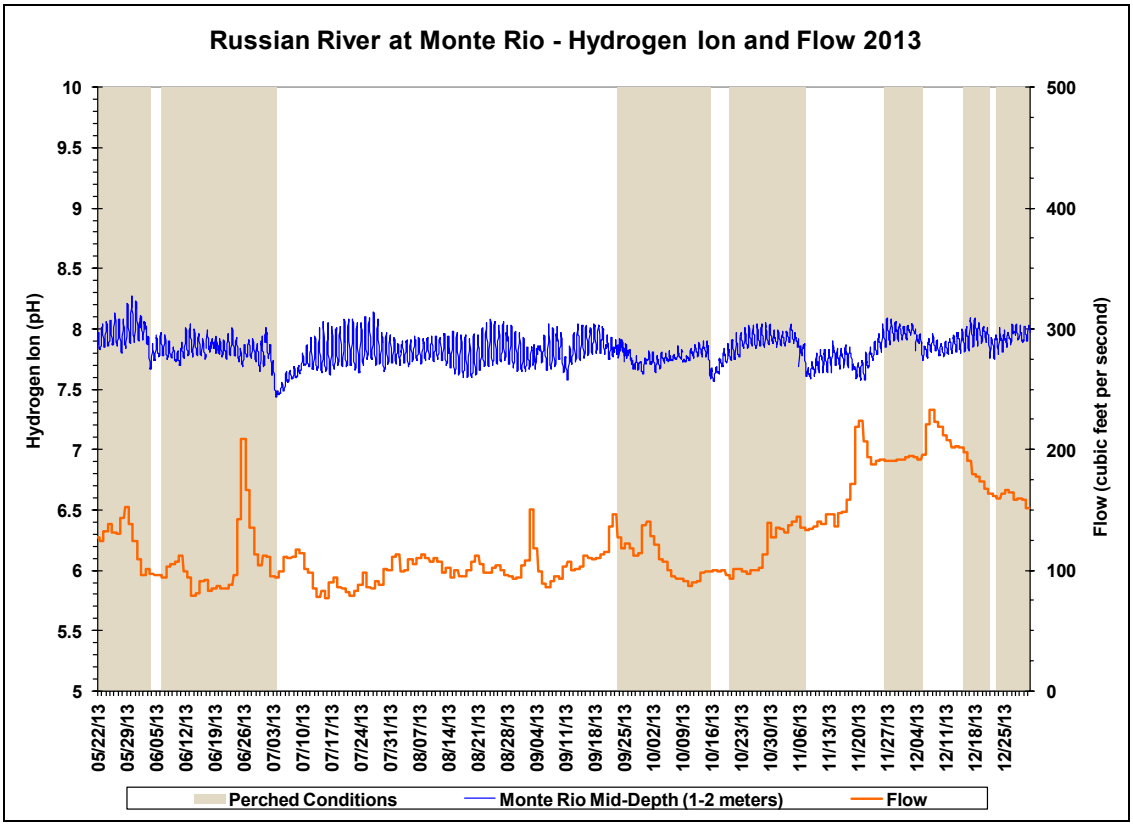



Figure 4.1.34. **2013 Russian River at Monte Rio Hydrogen Ion and Flow Graph**

*Grab Sampling*

Grab sampling was conducted at five mainstem stations from Jenner to Monte Rio (Figure 4.1.1). Sampling was generally conducted weekly from 14 May until 31 October when the Estuary was open. Additional focused sampling was conducted during or after Estuary closures, as well as during summer dam removal in October, where Water Agency staff would collect three samples in ten days (Tables 4.1.2 through 4.1.7). Samples collected and analyzed for nutrients, *chlorophyll a*, and indicator bacteria are discussed below. Other sample results including organic carbon, dissolved solids, and

Table 4.1.2. **2013 Jenner Station Grab Sample Results**

| Jenner Boat Ramp* | Temperature | Total Nitrogen*** | Phosphorus, Total | Turbidity | Chlorophyll-a | Total Coliforms (Colilert) | E. coli (Colilert) | Enterococcus (Enterolert) | USGS 11467000 RR near Guerneville (Hacienda)**** | |
|---|---|---|---|---|---|---|---|---|---|---|
| MDL** | | | 0.020 | 0.020 | 0.000050 | 20 | 20 | 2 | Flow Rate | Estuary |
| Date | °C | mg/L | mg/L | NTU | mg/L | MPN/100mL | MPN/100mL | MPN/100mL | (cfs) | Conditions |
| 5/14/2013 | 18.2 | **1.5** | **0.054** | **3.8** | 0.00023 | >2419.6 | 19.5 | 12.5 | 177 | Open |
| 5/21/2013 | 17.2 | **0.45** | **0.063** | **16** | **0.0021** | >2419.6 | 112.6 | **66.9** | 131 | Open |
| 5/28/2013 | 16.1 | 0.32 | **0.050** | 1.6 | **0.0033** | >2419.6 | **1986.3** | **145.0** | 142 | Closed |
| 5/30/2013 | 17.0 | 0.24 | **0.047** | **2.4** | **0.0021** | >2419.6 | **>2419.6** | **214.3** | 138 | Closed |
| 6/4/2013 | 19.2 | 0.35 | **0.053** | **3.1** | **0.0023** | >2419.6 | 70.3 | 18.9 | 97 | Open |
| 6/11/2013 | 17.5 | 0.36 | **0.056** | 1.4 | **0.0036** | >2419.6 | 16.4 | 14.4 | 112 | Closed |
| 6/13/2013 | 17.7 | 0.28 | **0.053** | 2.2 | **0.0020** | >2419.6 | 73.3 | **104.3** | 94 | Closed |
| 6/18/2013 | 17.8 | 0.24 | **0.043** | 2.2 | **0.0025** | >2419.6 | 3.0 | 31.8 | 83 | Closed |
| 6/25/2013 | 17.8 | 0.36 | **0.050** | **4.4** | **0.0039** | >2419.6 | 95.7 | **1413.6** | 142 | Closed |
| 7/2/2013 | 22.2 | **0.48** | **0.044** | 2.1 | **0.0019** | >2419.6 | 63.8 | **73.3** | 110 | Closed |
| 7/9/2013 | 17.7 | 0.35 | **0.043** | 1.8 | **0.0036** | >2419.6 | 6.3 | **579.6** | 109 | Open |
| 7/11/2013 | 18.2 | 0.21 | **0.051** | 2.0 | **0.0023** | 2419.6 | 2.0 | **136.7** | 101 | Open |
| 7/16/2013 | 16.5 | 0.21 | **0.051** | 2.1 | 0.0016 | >2419.6 | 6.1 | **110.6** | 77 | Open |
| 7/23/2013 | 17.6 | 0.24 | **0.040** | 2.1 | **0.0049** | >2419.6 | <1.0 | 53.7 | 83 | Open |
| 7/30/2013 | 15.4 | 0.24 | **0.036** | 0.9 | **0.0020** | >2419.6 | 29.6 | 42.8 | 101 | Open |
| 8/6/2013 | 15.8 | 0.24 | **0.037** | 1.4 | **0.0042** | >2419.6 | 7.3 | 21.1 | 105 | Open |
| 8/13/2013 | 16.0 | 0.18 | **0.031** | 1.2 | 0.00053 | >2419.6 | 3.1 | <1.0 | 98 | Open |
| 8/20/2013 | 16.8 | **0.42** | **0.040** | 1.3 | **0.0061** | >2419.6 | 3.1 | 55.4 | 107 | Open |
| 8/27/2013 | 16.6 | 0.33 | **0.032** | 0.56 | 0.0011 | >2419.6 | 4.1 | 2.0 | 100 | Open |
| 9/3/2013 | 15.7 | **0.43** | **0.038** | 2.0 | **0.0023** | >2419.6 | 1.0 | 25.9 | 150 | Open |
| 9/10/2013 | 15.8 | **0.38** | **0.043** | **3.1** | **0.0036** | >2419.6 | 43.7 | **108.1** | 93 | Open |
| 9/17/2013 | 15.7 | **1.5** | **0.038** | 1.9 | 0.0014 | >2419.6 | 5.1 | 58.8 | 110 | Open |
| 9/24/2013 | 14.5 | 0.28 | **0.035** | 1.1 | **0.0061** | >2419.6 | 4.1 | 13.4 | 127 | Open |
| 9/26/2013 | 13.7 | **0.47** | **0.048** | 1.6 | **0.0049** | >2419.6 | 34.6 | 52.1 | 122 | Closed |
| 10/1/2013 | 16.4 | 0.33 | **0.026** | 1.0 | **0.0042** | 372.4 | 36.8 | **325.5** | 140 | Closed |
| 10/3/2013 | 14.1 | 0.24 | **0.035** | 1.5 | **0.0032** | >2419.6 | 157.6 | **344.8** | 121 | Closed |
| 10/8/2013 | 13.9 | **0.86** | **0.029** | 1.3 | **0.0032** | >2419.6 | 21.8 | **365.4** | 93 | Closed |
| 10/15/2013 | 14.8 | 0.35 | **0.038** | 1.8 | **0.0024** | >2419.6 | 9.8 | 34.5 | 99 | Closed |
| 10/17/2013 | 15.1 | **0.57** | **0.062** | **2.8** | **0.0021** | >2419.6 | 1.0 | 50.4 | 100 | Open |
| 10/22/2013 | 12.7 | 0.24 | **0.060** | 1.3 | **0.0027** | >2419.6 | 15.8 | 34.5 | 101 | Closed |
| 10/24/2013 | 12.4 | 0.35 | **0.035** | 0.92 | **0.0026** | 71.7 | 19.7 | 9.5 | 99 | Closed |
| 10/29/2013 | 11.9 | 0.24 | **0.033** | 1.9 | **0.0043** | 1732.9 | 25.6 | 42.8 | 113 | Closed |
| 10/31/2013 | 11.4 | 0.18 | **0.029** | 1.2 | **0.0054** | >2419.6 | 12.2 | **62.0** | 127 | 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.

*** Total nitrogen is calculated through 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.

**** United States Geological Survey (USGS) 11467000 RR near Guerneville (Hacienda) 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

Table 4.1.3. **2013 Bridgehaven Station Grab Sample Results**

| Bridgehaven* | Temperature | Total Nitrogen*** | Phosphorus, Total | Turbidity | Chlorophyll-a | Total Coliforms (Colilert) | E. coli (Colilert) | Enterococcus (Enterolert) | USGS 11467000 RR near Guerneville (Hacienda)**** | |
|---|---|---|---|---|---|---|---|---|---|---|
| MDL** | | | 0.020 | 0.020 | 0.000050 | 20 | 20 | 2 | Flow Rate | Estuary |
| Date | °C | mg/L | mg/L | NTU | mg/L | MPN/100mL | MPN/100mL | MPN/100mL | (cfs) | Conditions |
| 5/14/2013 | 20.0 | **0.56** | **0.056** | **2.9** | 0.00023 | 1986.3 | 9.7 | 6.0 | 177 | Open |
| 5/21/2013 | 19.2 | **0.52** | **0.11** | **12** | **0.011** | 1732.9 | 12.0 | 19.7 | 131 | Open |
| 5/28/2013 | 17.6 | **0.42** | **0.054** | 2.0 | **0.0035** | 2419.6 | 71.4 | 20.1 | 142 | Closed |
| 5/30/2013 | 18.6 | 0.28 | **0.042** | 2.3 | **0.0024** | 1986.3 | **248.1** | **73.3** | 138 | Closed |
| 6/4/2013 | 18.5 | **0.55** | **0.058** | **2.9** | 0.0012 | >2419.6 | 32.7 | **365.4** | 97 | Open |
| 6/11/2013 | 18.8 | 0.18 | **0.051** | 2.0 | **0.0047** | >2419.6 | 26.2 | 9.6 | 112 | Closed |
| 6/13/2013 | 19.3 | 0.28 | **0.049** | 1.6 | **0.0037** | 2419.6 | 63.1 | 6.2 | 94 | Closed |
| 6/18/2013 | 18.5 | 0.24 | **0.042** | 1.4 | 0.0014 | >2419.6 | 34.5 | **95.9** | 83 | Closed |
| 6/25/2013 | 17.2 | 0.21 | **0.058** | **2.4** | **0.0033** | >2419.6 | **1046.2** | **387.3** | 142 | Closed |
| 7/2/2013 | 22.3 | **0.41** | **0.046** | 1.9 | **0.0032** | >2419.6 | 63.8 | 3.1 | 110 | Closed |
| 7/9/2013 | 17.6 | 0.35 | **0.043** | 1.5 | 0.00079 | >2419.6 | 121.1 | 45.0 | 109 | Open |
| 7/11/2013 | 19.0 | 0.24 | **0.045** | 1.3 | 0.00076 | >2419.6 | 23.5 | 48.9 | 101 | Open |
| 7/16/2013 | 17.3 | 0.24 | **0.066** | 1.6 | **0.0032** | >2419.6 | 3.0 | **62.4** | 77 | Open |
| 7/23/2013 | 17.8 | 0.24 | **0.044** | 1.7 | **0.0030** | >2419.6 | 24.3 | 32.3 | 83 | Open |
| 7/30/2013 | 16.0 | 0.24 | **0.038** | 1.4 | **0.0024** | >2419.6 | 3.0 | **82.3** | 101 | Open |
| 8/6/2013 | 17.4 | 0.21 | **0.033** | 1.4 | 0.0016 | >2419.6 | 4.1 | 6.3 | 105 | Open |
| 8/13/2013 | 17.1 | 0.24 | **0.038** | 1.5 | 0.00053 | >2419.6 | 5.2 | 6.2 | 98 | Open |
| 8/20/2013 | 19.1 | **0.38** | **0.041** | 1.6 | **0.012** | >2419.6 | 13.4 | 42.2 | 107 | Open |
| 8/27/2013 | 17.1 | 0.36 | **0.035** | 0.77 | **0.0029** | >2419.6 | 9.8 | 7.4 | 100 | Open |
| 9/3/2013 | 17.1 | **0.42** | **0.040** | 1.3 | **0.0088** | >2419.6 | 6.3 | 11.4 | 150 | Open |
| 9/10/2013 | 16.7 | 0.24 | **0.032** | 0.69 | **0.0031** | >2419.6 | 32 | 185 | 93 | Open |
| 9/17/2013 | 17.1 | **0.42** | **0.045** | 1.7 | **0.011** | >2419.6 | 5.2 | 39.3 | 110 | Open |
| 9/24/2013 | 16.5 | **0.91** | **0.081** | 1.9 | **0.0080** | >2419.6 | 25.3 | 21.3 | 127 | Open |
| 9/26/2013 | 14.3 | **0.40** | **0.040** | 1.3 | **0.0029** | >2419.6 | 193.5 | **85.7** | 122 | Closed |
| 10/1/2013 | 17.0 | 0.21 | **0.034** | 0.92 | **0.0035** | >2419.6 | 39.9 | **118.7** | 140 | Closed |
| 10/3/2013 | 14.7 | 0.25 | **0.037** | 1.4 | **0.0011** | >2419.6 | 50.4 | **77.6** | 121 | Closed |
| 10/8/2013 | 13.4 | 0.35 | **0.025** | 1.1 | **0.0019** | >2419.6 | 18.5 | **71.2** | 93 | Closed |
| 10/15/2013 | 14.5 | 0.35 | **0.034** | 1.3 | **0.0019** | 1203.3 | 9.7 | 22.6 | 99 | Closed |
| 10/17/2013 | 15.0 | **0.59** | **0.060** | 1.3 | 0.0014 | >2419.6 | 5.2 | 32.6 | 100 | Open |
| 10/22/2013 | 12.6 | **0.38** | **0.044** | 1.3 | 0.00067 | >2419.6 | 28.5 | 26.2 | 101 | Closed |
| 10/24/2013 | 13.2 | 0.35 | **0.038** | 0.96 | **0.0067** | 325.5 | 48.8 | 28.7 | 99 | Closed |
| 10/29/2013 | 12.4 | 0.24 | **0.037** | 1.3 | **0.0061** | >2419.6 | 30.1 | 45.0 | 113 | Closed |
| 10/31/2013 | 11.5 | 0.18 | **0.029** | 0.65 | **0.0044** | 1299.7 | 7.5 | 42.8 | 127 | 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.

*** Total nitrogen is calculated through 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.

**** United States Geological Survey (USGS) 11467000 RR near Guerneville (Hacienda) 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

## Table 4.1.4. 2013 Duncans Mills Station Grab Sample Results

| Duncans Mills* | Temperature | Total Nitrogen*** | Phosphorus, Total | Turbidity | Chlorophyll-a | Total Coliforms (Colilert) | E. coli (Colilert) | Enterococcus (Enterolert) | USGS 11467000 RR near Guerneville (Hacienda)**** | |
|---|---|---|---|---|---|---|---|---|---|---|
| MDL** | | | 0.020 | 0.020 | 0.000050 | 20 | 20 | 2 | Flow Rate | Estuary |
| Date | °C | mg/L | mg/L | NTU | mg/L | MPN/100mL | MPN/100mL | MPN/100mL | (cfs) | Conditions |
| 5/14/2013 | 20.8 | **0.46** | **0.057** | 1.7 | **0.0022** | 1732.9 | 10.7 | 1.0 | 177 | Open |
| 5/21/2013 | 21.6 | 0.37 | **0.044** | 1.7 | **0.0033** | 1732.9 | 12 | 3.1 | 131 | Open |
| 5/28/2013 | 19.5 | 0.34 | **0.044** | 1.4 | **0.0063** | 1299.7 | 21.6 | 60.2 | 142 | Closed |
| 5/30/2013 | 21.2 | 0.18 | **0.043** | 1.8 | **0.0068** | 1203.3 | 46.4 | 37.9 | 138 | Closed |
| 6/4/2013 | 20.5 | **0.51** | **0.059** | 1.8 | **0.0052** | 1732.9 | 34.5 | 12.1 | 97 | Open |
| 6/11/2013 | 20.4 | 0.24 | **0.048** | 1.6 | **0.0080** | 2419.6 | 29.9 | 30.5 | 112 | Closed |
| 6/13/2013 | 21.3 | 0.18 | **0.053** | 1.5 | **0.0048** | 1986.3 | 199.6 | 28.5 | 94 | Closed |
| 6/18/2013 | 20.9 | 0.18 | **0.054** | 1.2 | **0.0043** | >2419.6 | 11 | 18.7 | 83 | Closed |
| 6/25/2013 | 19.7 | 0.21 | **0.066** | 1.5 | **0.0067** | >2419.6 | 47.3 | 12.1 | 142 | Closed |
| 7/2/2013 | 24.1 | **0.40** | **0.040** | 2.2 | **0.0035** | >2419.6 | 78.5 | **178.9** | 110 | Closed |
| 7/9/2013 | 22.2 | **0.39** | **0.077** | 1.4 | **0.0028** | >2419.6 | 20.3 | 3.0 | 109 | Open |
| 7/11/2013 | 22.4 | 0.21 | **0.075** | 1.3 | **0.0025** | >2419.6 | 9.7 | 8.4 | 101 | Open |
| 7/16/2013 | 20.3 | 0.18 | **0.057** | 1.2 | **0.0036** | >2419.6 | 10.9 | 14.2 | 77 | Open |
| 7/23/2013 | 21.9 | 0.21 | **0.043** | 1.4 | **0.0020** | >2419.6 | 21.3 | 48.2 | 83 | Open |
| 7/30/2013 | 19.5 | 0.21 | **0.036** | 1.1 | 0.0012 | 2419.6 | 5.2 | 41.7 | 101 | Open |
| 8/6/2013 | 20.3 | 0.33 | **0.033** | 1.5 | 0.0012 | 2419.6 | 3.1 | 39.3 | 105 | Open |
| 8/13/2013 | 19.9 | 0.21 | **0.033** | 1.4 | 0.0012 | 1413.6 | 2.0 | 25.0 | 98 | Open |
| 8/20/2013 | 17.6 | 0.36 | **0.037** | 1.6 | 0.0016 | 1986.3 | 18.7 | **62.7** | 107 | Open |
| 8/27/2013 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 100 | Open |
| 9/3/2013 | 18.9 | 0.28 | **0.041** | 1.3 | 0.0016 | 179.3 | 2.0 | 25.6 | 150 | Open |
| 9/10/2013 | 20.0 | 0.21 | **0.034** | 1.4 | 0.0016 | 1986.3 | 13.2 | 48 | 93 | Open |
| 9/17/2013 | 18.9 | 0.28 | **0.030** | 0.92 | 0.00057 | 648.8 | 5.2 | 19.5 | 110 | Open |
| 9/24/2013 | 18.3 | **0.38** | **0.036** | 1.3 | 0.0011 | 579.4 | 3.1 | 21.1 | 127 | Open |
| 9/26/2013 | 17.9 | 0.30 | **0.029** | 1.1 | 0.00053 | >2419.6 | 29.2 | **68.9** | 122 | Closed |
| 10/1/2013 | 19.0 | 0.21 | **0.030** | 0.83 | 0.00084 | 1413.6 | 36.4 | **69.7** | 140 | Closed |
| 10/3/2013 | 17.1 | 0.18 | **0.027** | 1.0 | 0.00084 | 1046.2 | 42.6 | 60.2 | 121 | Closed |
| 10/8/2013 | 15.5 | 0.26 | **0.024** | 1.2 | 0.0011 | >2419.6 | 26.2 | **104.3** | 93 | Closed |
| 10/15/2013 | 16.0 | 0.35 | **0.039** | 1.2 | **0.0085** | 1732.9 | 5.2 | 46.4 | 99 | Closed |
| 10/17/2013 | 15.1 | **0.45** | **0.038** | 1.0 | 0.00082 | >2419.6 | 6.3 | 6.3 | 100 | Open |
| 10/22/2013 | 14.5 | 0.36 | **0.025** | 1.3 | 0.00067 | >2419.6 | 27.5 | 7.4 | 101 | Closed |
| 10/24/2013 | 14.7 | 0.14 | **0.023** | 0.78 | 0.00081 | 727.0 | 13.2 | **106.3** | 99 | Closed |
| 10/29/2013 | 13.9 | 0.24 | **0.024** | 0.76 | 0.00092 | 980.4 | 42.0 | 21.1 | 113 | Closed |
| 10/31/2013 | 13.8 | 0.10 | **0.025** | 0.69 | **0.0028** | 816.4 | 3.1 | 6.2 | 127 | 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.

*** Total nitrogen is calculated through 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.

**** United States Geological Survey (USGS) 11467000 RR near Guerneville (Hacienda) 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

## Table 4.1.5. 2013 Casini Ranch Station Grab Sample Results

| Casini Ranch* | Temperature | Total Nitrogen*** | Phosphorus, Total | Turbidity | Chlorophyll-a | Total Coliforms (Colilert) | E. coli (Colilert) | Enterococcus (Enterolert) | USGS 11467000 RR near Guerneville (Hacienda)**** | |
|---|---|---|---|---|---|---|---|---|---|---|
| MDL** | | | 0.020 | 0.020 | 0.000050 | 20 | 20 | 2 | Flow Rate | Estuary |
| Date | °C | mg/L | mg/L | NTU | mg/L | MPN/100mL | MPN/100mL | MPN/100mL | (cfs) | Conditions |
| 5/14/2013 | 21.3 | **0.46** | **0.057** | **2.8** | **0.0028** | 1732.9 | 7.4 | 3.1 | 177 | Open |
| 5/21/2013 | 21.4 | 0.30 | **0.048** | 2.3 | **0.0042** | 1732.9 | 8.5 | <1.0 | 131 | Open |
| 5/28/2013 | 20.0 | 0.28 | **0.044** | **2.5** | **0.0055** | >2419.6 | 55.7 | **98.5** | 142 | Closed |
| 5/30/2013 | 21.5 | 0.21 | **0.045** | **2.6** | **0.0053** | 2419.6 | 45.0 | **101.4** | 138 | Closed |
| 6/4/2013 | 20.7 | 0.37 | **0.053** | 2.0 | **0.0049** | 1413.6 | 17.5 | 4.1 | 97 | Open |
| 6/11/2013 | 20.8 | 0.14 | **0.049** | 0.95 | **0.0047** | 2419.6 | 22.8 | 36.4 | 112 | Closed |
| 6/13/2013 | 21.8 | 0.21 | **0.061** | 1.9 | **0.0043** | 1299.7 | 24.1 | 18.3 | 94 | Closed |
| 6/18/2013 | 21.6 | 0.18 | **0.058** | 1.4 | **0.0027** | 1732.9 | 16 | 24.1 | 83 | Closed |
| 6/25/2013 | 20.2 | 0.21 | **0.054** | 1.7 | **0.0058** | >2419.6 | 29.5 | **146.7** | 142 | Closed |
| 7/2/2013 | 24.8 | 0.35 | **0.059** | **2.4** | **0.0030** | >2419.6 | 35.9 | 34.5 | 110 | Closed |
| 7/9/2013 | 22.1 | **0.39** | **0.080** | 2.3 | **0.0033** | >2419.6 | 6.3 | 13.0 | 109 | Open |
| 7/11/2013 | 22.6 | 0.18 | **0.082** | 1.5 | **0.0028** | >2419.6 | 5.1 | 20.3 | 101 | Open |
| 7/16/2013 | 20.3 | 0.18 | **0.058** | 1.2 | **0.0025** | >2419.6 | 2.0 | **80.5** | 77 | Open |
| 7/23/2013 | 22.5 | 0.34 | **0.050** | 1.5 | 0.0014 | 2419.6 | 25.9 | 30.7 | 83 | Open |
| 7/30/2013 | 19.6 | 0.18 | **0.039** | 0.85 | 0.0014 | 1732.9 | 4.1 | 53.7 | 101 | Open |
| 8/6/2013 | 20.1 | 0.22 | **0.033** | 1.2 | 0.00065 | 204.6 | 3.1 | 20.9 | 105 | Open |
| 8/13/2013 | 20.5 | 0.29 | **0.035** | 1.2 | 0.00067 | 613.1 | 3.1 | 16.1 | 98 | Open |
| 8/20/2013 | 20.8 | 0.28 | **0.033** | 1.4 | 0.0014 | 686.7 | 9.6 | 47.1 | 107 | Open |
| 8/27/2013 | 21.5 | 0.32 | **0.030** | 0.22 | 0.00089 | 214.3 | 3.1 | 8.6 | 100 | Open |
| 9/3/2013 | 20.0 | 0.21 | **0.050** | 1.3 | 0.0012 | 1553.1 | 7.5 | 10.7 | 150 | Open |
| 9/10/2013 | 19.7 | 0.24 | **0.048** | **2.4** | 0.00093 | 1119.9 | 10.9 | 30.9 | 93 | Open |
| 9/17/2013 | 20.0 | 0.34 | **0.028** | 1.2 | 0.00042 | 435.2 | 4.1 | 12.6 | 110 | Open |
| 9/24/2013 | 17.8 | 0.24 | **0.026** | 1.2 | 0.00066 | 461.1 | 4.1 | 4.1 | 127 | Open |
| 9/26/2013 | 18.5 | 0.22 | **0.029** | 1.4 | 0.00013 | 816.4 | 21.8 | 10.8 | 122 | Closed |
| 10/1/2013 | 19.6 | 0.18 | **0.032** | 1.2 | 0.00056 | 1119.9 | 55.6 | **142.1** | 140 | Closed |
| 10/3/2013 | 18.5 | 0.18 | **0.025** | 2.2 | 0.00056 | 1986.3 | 165.8 | **686.7** | 121 | Closed |
| 10/8/2013 | 16.0 | 0.28 | 0.020 | 0.87 | 0.0011 | 770.1 | 24.1 | 58.3 | 93 | Closed |
| 10/15/2013 | 16.4 | **0.43** | **0.041** | 0.90 | **0.0032** | 648.8 | 6.2 | **61.3** | 99 | Closed |
| 10/17/2013 | 15.5 | **0.48** | **0.034** | 1.1 | 0.00027 | 461.1 | 8.6 | 13.5 | 100 | Open |
| 10/22/2013 | 14.5 | **0.40** | **0.030** | 1.1 | 0.00013 | 461.1 | 15.8 | 5.1 | 101 | Closed |
| 10/24/2013 | 14.8 | 0.18 | **0.023** | 0.71 | 0.00040 | 224.7 | 26.2 | **148.3** | 99 | Closed |
| 10/29/2013 | 14.1 | 0.21 | **0.025** | 0.78 | 0.00061 | 488.4 | 32.4 | 32.7 | 113 | Closed |
| 10/31/2013 | 13.8 | 0.32 | **0.030** | 0.67 | **0.0021** | 547.5 | 36.4 | 19.5 | 127 | 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.

*** Total nitrogen is calculated through 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.

**** United States Geological Survey (USGS) 11467000 RR near Guerneville (Hacienda) 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

## Table 4.1.6. 2013 Monte Rio Station Grab Sample Results

| Monte Rio* | Temperature | Total Nitrogen*** | Phosphorus, Total | Turbidity | Chlorophyll-a | Total Coliforms (Colilert) | E. coli (Colilert) | Enterococcus (Enterolert) | USGS 11467000 RR near Guerneville (Hacienda)**** | |
|---|---|---|---|---|---|---|---|---|---|---|
| MDL** | | | 0.020 | 0.020 | 0.000050 | 20 | 20 | 2 | Flow Rate | Estuary |
| Date | °C | mg/L | mg/L | NTU | mg/L | MPN/100mL | MPN/100mL | MPN/100mL | (cfs) | Conditions |
| 5/14/2013 | 21.5 | 0.33 | **0.047** | **3.0** | **0.0028** | 1553.1 | 7.5 | 5.2 | 177 | Open |
| 5/21/2013 | 21.5 | 0.34 | **0.051** | **3.6** | **0.0035** | 1986.3 | 6.3 | 6.2 | 131 | Open |
| 5/28/2013 | 19.4 | 0.37 | **0.050** | **2.7** | **0.0038** | >2419.6 | 33.1 | 45.9 | 142 | Closed |
| 5/30/2013 | 21.4 | 0.21 | **0.043** | **2.8** | **0.0048** | 1203.1 | 62.0 | 51.2 | 138 | Closed |
| 6/4/2013 | 21.7 | 0.35 | **0.057** | **4.0** | **0.0052** | 1732.9 | 25.6 | 21.1 | 97 | Open |
| 6/11/2013 | 21.0 | 0.18 | **0.056** | 2.3 | **0.0025** | 1986.3 | 31.8 | 18.9 | 112 | Closed |
| 6/13/2013 | 21.8 | 0.18 | **0.056** | **2.7** | **0.0019** | 2419.6 | 37.4 | 32.8 | 94 | Closed |
| 6/18/2013 | 22.1 | 0.24 | **0.054** | **2.4** | **0.0048** | 1986.3 | 20.9 | 45.4 | 83 | Closed |
| 6/25/2013 | 21.0 | 0.14 | **0.052** | 2.3 | **0.0064** | 2419.6 | 64.5 | **158.5** | 142 | Closed |
| 7/2/2013 | 25.9 | **0.45** | **0.066** | 1.9 | **0.0032** | >2419.6 | 79.8 | **70.8** | 110 | Closed |
| 7/9/2013 | 23.3 | 0.24 | **0.088** | **2.6** | **0.0025** | >2419.6 | 8.6 | **2419.6** | 109 | Open |
| 7/11/2013 | 23.7 | 0.28 | **0.073** | 1.8 | **0.0019** | 1732.9 | 5.2 | **920.8** | 101 | Open |
| 7/16/2013 | 21.7 | 0.18 | **0.050** | 1.6 | 0.0017 | 2419.6 | 4.1 | **517.2** | 77 | Open |
| 7/23/2013 | 22.6 | 0.28 | **0.038** | 1.30 | 0.0014 | 1203.3 | 9.7 | 11.8 | 83 | Open |
| 7/30/0213 | 20.5 | 0.18 | **0.025** | 1.4 | **0.0018** | 980.4 | 7.5 | 13.5 | 101 | Open |
| 8/6/2013 | 21.1 | 0.14 | **0.028** | 1.2 | 0.00091 | 365.4 | 3.1 | 4.1 | 105 | Open |
| 8/13/2013 | 21.5 | 0.18 | **0.033** | 2.1 | 0.00053 | 770.1 | 10.9 | 17.1 | 98 | Open |
| 8/20/2013 | 21.8 | 0.18 | **0.027** | 1.6 | 0.0012 | 1299.7 | 8.4 | 9.6 | 107 | Open |
| 8/27/2013 | 21.8 | 0.21 | **0.027** | 0.46 | 0.00064 | 1553.1 | 4.1 | 3.0 | 100 | Open |
| 9/3/2013 | 19.7 | 0.18 | **0.051** | 1.8 | 0.0011 | 980.4 | 8.5 | 13.2 | 150 | Open |
| 9/10/2013 | 21.1 | 0.14 | **0.026** | 1.8 | 0.0011 | 1986.3 | 6.3 | 13.5 | 93 | Open |
| 9/17/2013 | 19.7 | 0.35 | **0.024** | 1.3 | 0.00028 | 866.4 | 20.1 | 20.1 | 110 | Open |
| 9/24/2013 | 18.2 | 0.21 | **0.024** | 1.8 | 0.00080 | 727 | 14.5 | 19.5 | 127 | Open |
| 9/26/2013 | 17.1 | 0.14 | **0.044** | 1.8 | 0.00040 | 1203.3 | 11.0 | 20.1 | 122 | Closed |
| 10/1/2013 | 18.5 | 0.18 | **0.026** | 1.6 | 0.00028 | 1732.9 | 116.9 | **190.4** | 140 | Closed |
| 10/3/2013 | 16.4 | 0.28 | **0.027** | 1.5 | 0.00028 | 1986.3 | 166.4 | **228.2** | 121 | Closed |
| 10/8/2013 | 14.8 | 0.35 | **0.022** | 1.2 | 0.00080 | 2419.6 | **579.4** | **67.7** | 93 | Closed |
| 10/15/2013 | 15.6 | **0.59** | **0.041** | 0.79 | 0.0011 | 1299.7 | 111.2 | **137.6** | 99 | Closed |
| 10/17/2013 | 14.9 | **0.69** | **0.031** | 0.79 | 0.00068 | 344.8 | 10.9 | 10.7 | 100 | Open |
| 10/22/2013 | 14.5 | **0.44** | **0.034** | 0.89 | 0.00013 | 233.3 | 8.6 | 13.1 | 101 | Closed |
| 10/24/2013 | 14.9 | 0.30 | **0.027** | 0.91 | 0.00040 | 111.2 | 4.1 | 17.1 | 99 | Closed |
| 10/29/2013 | 13.7 | 0.21 | **0.036** | 1.0 | 0.00046 | 435.2 | 19.7 | 36.4 | 113 | CLosed |
| 10/31/2013 | 12.8 | 0.25 | **0.030** | 0.74 | 0.00061 | 365.4 | 73.2 | 22.3 | 127 | 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.

*** Total nitrogen is calculated through 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.

**** United States Geological Survey (USGS) 11467000 RR near Guerneville (Hacienda) 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

**Table 4.1.7. The total number of sampling trips per monitoring season and the total number of samples taken in the Russian River Estuary 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 |

turbidity are not discussed, but are included as Appendix 8 to the report. Grab sampling for the same constituents was also conducted weekly at six stations in the mainstem of the Russian River from Hopland to Hacienda. Results from this sampling are not discussed in this report, but are also included as Appendix 8.

### *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 8).

Total nitrogen concentrations were observed to exceed the recommended USEPA levels predominantly at Jenner and Bridgehaven, and periodically at Duncans Mills, Casini Ranch and Monte Rio (Tables 4.1.2 through 4.1.6). It should be noted that Jenner Boat Ramp and Bridgehaven are the two most downstream stations and were typically brackish, with specific conductance values ranging from 2149 µS/cm to 28450 µS/cm at the Jenner Boat Ramp ,and values ranging from 460 µS/cm to 26454 µS/cm at Bridgehaven. 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 93 cfs to 177 cfs. The number of total nitrogen exceedances varied from station to station, with a low of four exceedances at the Monte Rio Station (Table 4.1.6) to a high of 12 exceedances at the Bridgehaven Station (Table 4.1.3). Jenner was observed to have ten exceedances, including two high values of 1.5 mg/L collected on 14 May and 17 September during open conditions (Table 4.1.2). Bridgehaven was observed to have a maximum concentration of 0.91 mg/L collected on 24 September during open conditions with flows at approximately 127 cfs (Table 4.1.3). The Duncans Mills Station had six exceedances, including a high value of 0.51 mg/L collected on 4 June during open conditions with flows at approximately 97 cfs (Table 4.1.4). Casini Ranch had five exceedances, including a high value of 0.48 mg/L collected on 17 October during open conditions with flows at approximately 100 cfs (Table 4.1.5). The Monte Rio Station had a maximum concentration of 0.69 mg/L that was also collected on 17 October (Table 4.1.6). Some of the lowest total nitrogen values observed at all five stations occurred when flows were as low as 77 cfs during open conditions on 16 July. Conversely, every station was observed to exceed the criteria after the Estuary reopened in mid-October (Figure 4.1.35).

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, with one exception. The only non-exceedance of total phosphorus during the 2013 monitoring season was at the Casini Ranch station and the concentration was 0.020 mg/L (Table 4.1.5). The maximum total phosphorus values recorded were 0.063 mg/L on 21 May at the Jenner Boat Ramp, 0.11 mg/L on 21 May at Bridgehaven, 0.077 mg/L on 9 July at Duncans Mills, 0.082 mg/L on 11 July at Casini Ranch, and 0.088 mg/L on 9 July at the Monte Rio (Tables 4.1.2 to 4.1.6). Exceedances occurred in fresh and brackish water, during open and closed Estuary conditions, and in river flows ranging from 77 cfs to 177 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 4.1.36).

*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

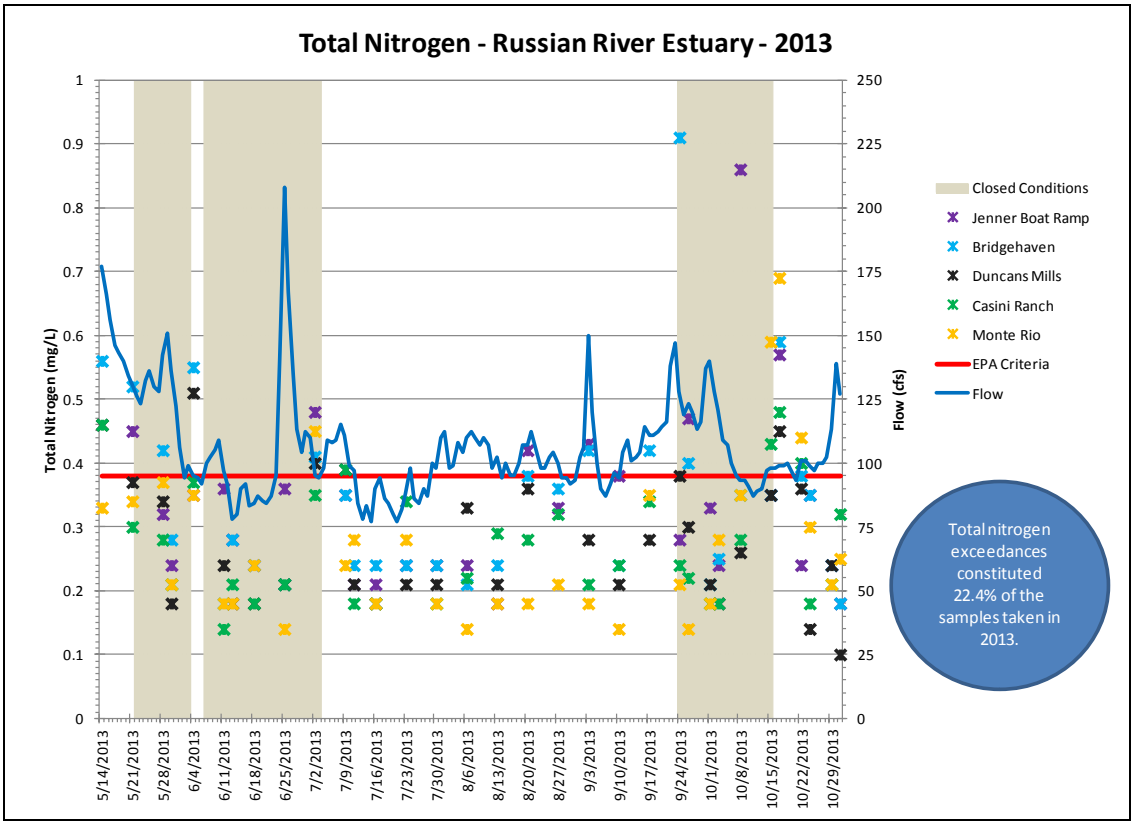



Figure 4.1.35. **2013 Russian River Grab Sampling Results for Total Nitrogen**

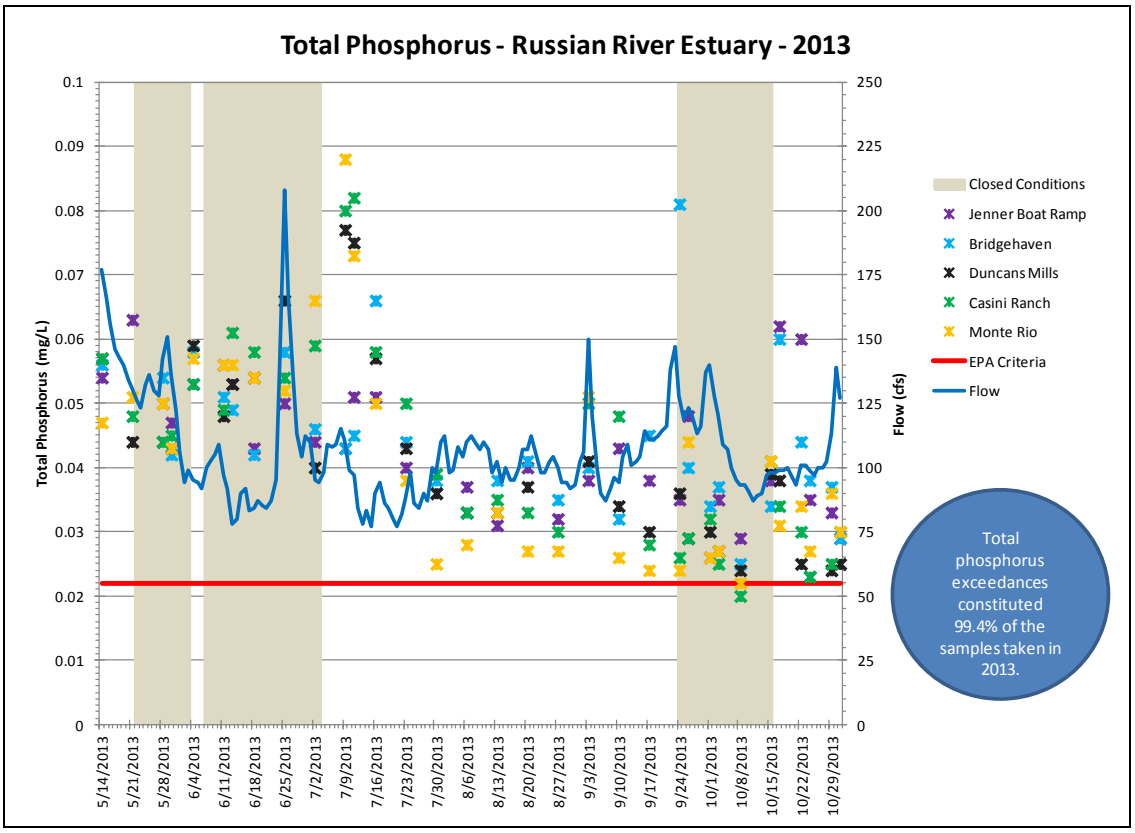



Figure 4.1.36. **2013 Russian River Grab Sampling Results for Total Phosphorus**

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 USEPA 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 the Bridgehaven station on three sampling events (Tables 4.1.2 through 4.1.6). These three sampling events occurred on 21 May, 20 August, and 17 September with *Chlorophyll-a* concentrations of 0.011 mg/L, 0.012 mg/L, and 0.011 mg/L, respectively (Table 4.1.3). *Chlorophyll-a* concentrations were observed to exceed the USEPA criteria of 0.0018 mg/L at the Jenner Boat Ramp and the Bridgehaven stations throughout the monitoring season, while the exceedances at the Duncans Mills, Casini Ranch and Monte Rio stations were generally observed to occur during the first half of the monitoring season (Figure 4.1.37).

The maximum *Chlorophyll-a* concentrations were 0.0061 mg/L at the Jenner Boat Ramp on 20 August and 24 September, 0.012 mg/L at the Bridgehaven station on 20 August, 0.0085 mg/L at the Duncans Mills station on 15 October, 0.0058 mg/L at the Casini Ranch station on 25 June, and 0.0064 mg/L at the Monte Rio station on 25 June (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 77 cfs to 177 cfs (Figure 4.1.37).

*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 and Bridgehaven grab sample stations are located in areas that are predominantly brackish water, whereas the three upstream grab sample stations are located in predominantly freshwater habitat (Duncans Mills, Casini Ranch, and Monte Rio).

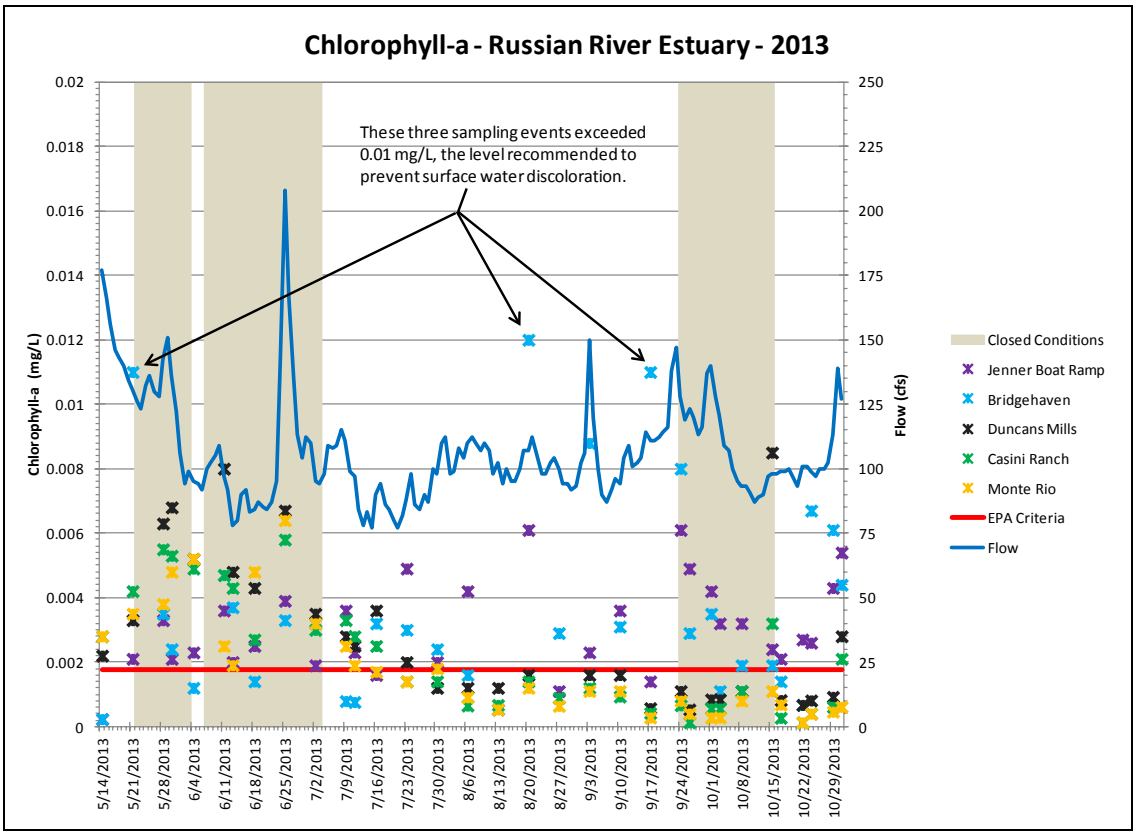



Figure 4.1.37. 2013 Russian River Grab Sampling Results for Chlorophyll-a

*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. As such, it should be noted that the dilution rates that are utilized to accurately quantify *E. coli* concentrations for comparison to the draft guidelines do not allow for the quantification of total coliform concentrations at a high enough level to compare with the draft guidelines and are instead reported as greater than 2,419.6 MPN (>2,419.6). 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 artificial breaching of the barrier beach to address potential water quality concerns to public health.

Sampling results in 2013 indicate that there is variation in indicator bacteria levels both spatially throughout the Estuary and temporally at each grab sample monitoring station throughout the monitoring season (Tables 4.1.2 to 4.1.6). The *Enterococcus* exceedances occurred during both open and closed Estuary conditions, however, *E. coli* exceedances were only noted during Estuary closures during the 2013 monitoring season.

The recommended *E. coli* guideline of 235 MPN/100 ml was exceeded twice each at the Jenner Boat Ramp and Bridgehaven stations, and once at the Monte Rio station (Figure 4.1.38). The exceedances at the Jenner Boat Ramp station measured 1,986.3 MPN on 28 May and >2,419.6 MPN on 30 May, both of which occurred during an Estuary closure (Table 4.1.2). The exceedances at the Bridgehaven station measured 248.1 MPN on 30 May, and 1,046.2 MPN on 25 June, both of which also occurred during Estuary closures (Table 4.1.3). The exceedance at the Monte Rio station measured 579.4 MPN on 8 October, during a closure of the Estuary (Table 4.1.6).

All five grab sampling stations measured at least one *Enterococcus* exceedance during the 2013 monitoring season (Figure 4.1.39). These exceedances were seen both during open Estuary conditions and closed Estuary conditions, as well as during varying flow regimes. There were eleven exceedances measured at the Jenner Boat Ramp station, with the largest exceedance measuring 1,413.6 MPN on 25 June with a closed Estuary (Table 4.1.2). There were three exceedances measured at the Bridgehaven station, with the largest exceedance being 387.3 MPN on 25 June with a closed Estuary (Table 4.1.3). There were three exceedances observed at the Duncans Mills station, with the largest exceedance being 178.9 MPN on 2 July during an Estuary closure (Table 4.1.4). There were five exceedances at the Casini Ranch station, with the largest exceedance measuring 686.7 MPN on 3 October during a closed Estuary (Table 4.1.5). There were seven exceedances at the Monte Rio station, with the largest measuring 2,419.6 MPN on 9 July during open Estuary conditions (Table 4.1.6).

### Conclusions and Recommendations

Water quality conditions observed during the 2013 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. As flows in the Russian River decrease through spring, the salt layer typically migrates upstream.

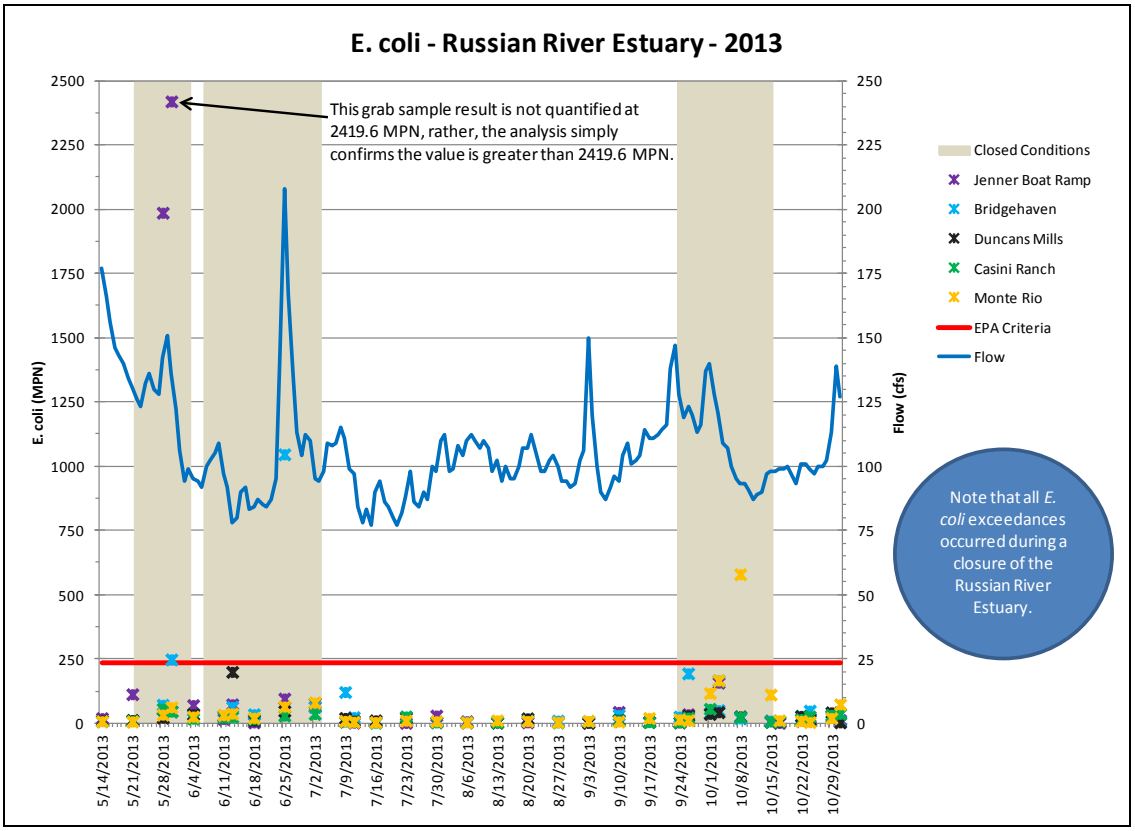



Figure 4.1.38. **2013 Russian River Grab Sampling Results for E. coli**

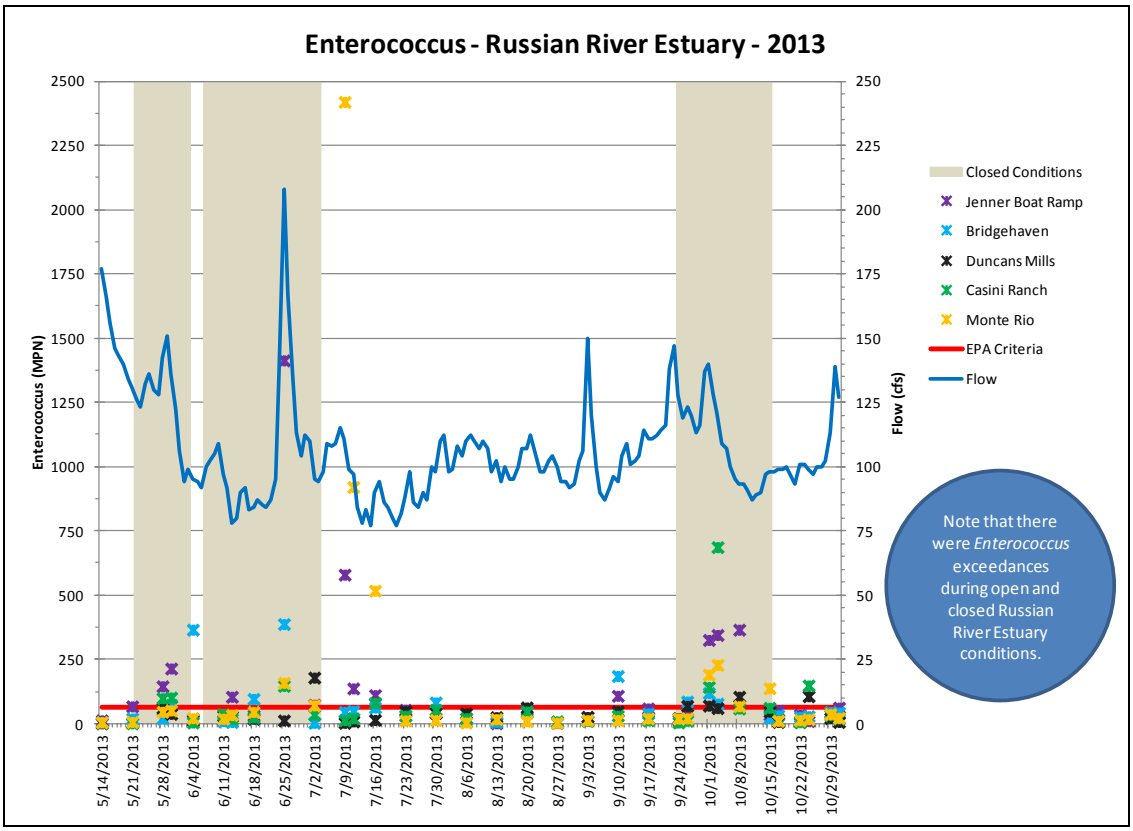



Figure 4.1.39. **2013 Russian River Grab Sampling Results for Enterococcus**

Due to prolonged drought conditions in the winter and spring of 2013, mainstem Russian River flows decreased earlier in the season than in 2011 and 2012, but salinity migration patterns were fairly similar to those prior monitoring years. Likewise, water quality conditions during prolonged river mouth closures in 2013 were 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 typically experiences an increase in salinity as brackish water migrates into the area coupled with temperature increases. Conditions observed in the saline layer during the 2013 monitoring season were no exception.

Temperature, pH, and dissolved oxygen patterns during the 2013 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 in 2009.

Perhaps the most notable observation during the 2013 monitoring season was that brackish water was observed at the Brown's Pool station (Figure 4.1.8). Brackish water had not been observed by Water Agency staff prior to the 2013 monitoring season, however Water Agency staff had only 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, where brackish water has been previously observed to occur.

Brackish water was first observed migrating upstream into Brown's Pool on 5 October, during an extended estuary closure that lasted twenty two days between 24 September and 15 October. A maximum salinity concentration of 4.88 ppt was observed on 8 October and brackish water was observed to remain at the station until 20 October, six days after the river mouth re-opened.

Brackish water was also observed at Brown's Pool between 8 November and 11 November, immediately following an Estuary closure that lasted eighteen days from 21 October to 7 November. The presence of salinity during this period is likely due to the restoration of tidal influence and mixing of the water in the Estuary. The maximum salinity during this period of time was observed as 1.82 ppt; noticeably less than in October.

Brackish water migrated to Brown's Pool again on 20 December, four days after the Estuary closed on 16 December. Brown's Pool remained brackish as the river mouth self-breached on 21 December, closed on 24 December, and was breached by Water Agency staff on 1 January 2014. Brackish water continued to persist at Brown's Pool

through several more closures until the station was removed just prior to a large storm on 8 February 2014. The maximum salinity observed during this time was 16.3 ppt on 27 January 2014; noticeably more than the prior brackish conditions in October and November 2013.

On 23 January, 2014, Water Agency staff conducted vertical profiles at several pools in the maximum backwater area while brackish water was present at Brown's Pool. These profiles were conducted downstream from Brown's Pool and upstream of Brown's Pool to determine the upstream extent of salinity migration in the Maximum Backwater Area (Need a Figure and river miles/km). Brackish water was observed at Moscow Road Bridge and Brown's Pool, which are both located downstream of Brown's Riffle and the confluence of Austin Creek with the mainstem Russian River. However, brackish water was not observed in pools at Laurel Dell, Villa Grande, or Monte Rio, 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.

It is possible that the occurrence of brackish water in Brown's Pool is common during dry fall, winter, or drought conditions. Further data collection during a variety of water years is necessary to confirm this possibility. Additional discussion and analysis of salinity migration at the Brown's Pool station during the winter of 2014 will be provided in the 2014 Monitoring Report.

Until then, a graphical representation of the maximum salinity levels recorded at various stations in the Russian River Estuary between 2009 and 2013 is being presented to illustrate the known extent of salinity in the Estuary (Figure 4.1.40). The sondes included in this figure 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 meter depths for the Mouth, Patty's Rock, Sheephouse Creek, and Heron Rookery stations, six to seven meters depth at the Freezeout Creek station, eight to ten meters depth at the Brown's Pool station, and one to two meters at the Monte Rio station. In the upper reaches of the Estuary and Maximum Backwater Area, 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 Maximum Backwater Area the monitoring station is located.

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 in 2013 was higher than had been recorded before (keep in mind that the values in the graph are maximums and not means; mean values would not clearly illustrate that brackish water was witnessed at Brown's Pool in 2013). Note, however, that a continuously monitoring sonde was not deployed at the Brown's Pool station until the 2013 monitoring season. Further continuous monitoring could explain if the occurrence of brackish water in the Brown's

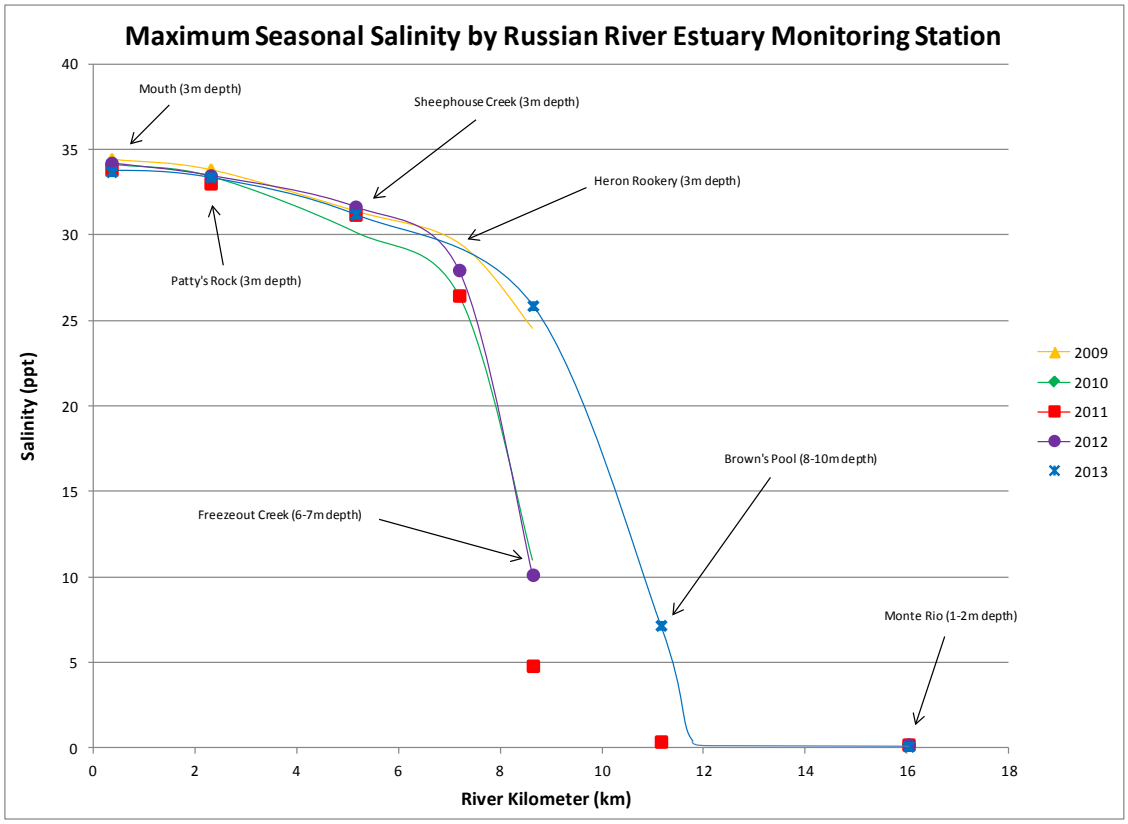



**Figure 4.1.40. The maximum salinities at monitoring stations throughout the Russian River Estuary between the years of 2009 and 2013.**

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 2013 grab sampling effort in the Russian River Estuary was effective at collecting a larger set of data than in previous 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 during each monitoring season since the implementation of the Biological Opinion in 2009.

The 2013 grab sampling effort observed Total Phosphorus exceedances for every sample with only one exception; a sample taken at the Casini Ranch station on 8 October 2013. This is not uncommon in the Russian River 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 2013 were also similar to percentages observed

**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 |

in previous monitoring 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.

The *E. coli* exceedances since the implementation of the Biological Opinion in 2009 until 2013 can be seen in Table 4.1.9. Percentages of exceeded samples are similar among sampling seasons. Note that the samples analyzed in 2009 and 2010 were analyzed using the multiple tube fermentation technique and samples from 2011 through 2013 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, a level that is below CDPH Guidelines (for 2010 and a portion of 2011), and it is impossible to establish criteria exceedances in this case.

**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 2013. Note that for 2009-2010, the analyzing method was multiple tube fermentation, and for 2011-2013 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 |

Data collected through the grab sampling effort in 2013 by the Water Agency appear similar to data collected between 2009 and 2012. 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.

### 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 2011-12. Sonoma County Water Agency, Santa Rosa, CA. p. 208

National Oceanic and Atmospheric Administration National Centers for Coastal Ocean Science (NCCOS) and the Integration and Application Network (IAN). 1999. National Estuarine Eutrophication Assessment.

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 Invertebrate Monitoring and Salmonid Diet Analysis

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, the Water Agency will determine 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 evaluate 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 will focus 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. The monitoring effort will involve systematic sampling and analysis of zooplankton, epibenthic, and benthic invertebrate species" (NMFS 2008, page 254).

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 short-term estuary closure and re-opening events.

### 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). Salmonid diet samples are 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, Bridgehaven and Moscow Bridge to represent the lower, middle , and upper estuary reaches, respectively. 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.

In addition, prey resource availability sampling occurs 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 1.2.2). Each of the sites includes three, lateral transects across the Estuary (Figures 1.2.3a-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.

To the degree possible, all fish designated for diet analysis are gastric lavaged and released according to the University of Washington animal care protocols. Stomach lavage follows Foster (1977) and Light et al (1983). Diet contents are preserved in 10% formalin for later laboratory processing. As per Water Agency fisheries protocols (see Beach Seining section below), fork lengths and weights are taken from each fish. Each fish is scanned for a passive integrated transponder (PIT) tag and tagged if no previous PIT tag was detected.

*Prey Resource Availability*

Benthic infauna and epibenthos prey resource sampling was conducted once per month in the Lagoon Management Period during open, tidal (baseline) conditions. If barrier beach closure or outlet channel implementation results in a closure, epibenthos and benthic infauna are sampled at 7 and 14 days after closure. Following an extended closure of 14 days or more, prey resource availability sampling would continue beginning at day 14 and every three weeks after and include benthic infauna, epibenthos, and zooplankton resource availability sampling as described below. In 2012 and 2013, 816 and 696 individual samples were collected, respectively (Tables 4.2.1 and 4.2.2).

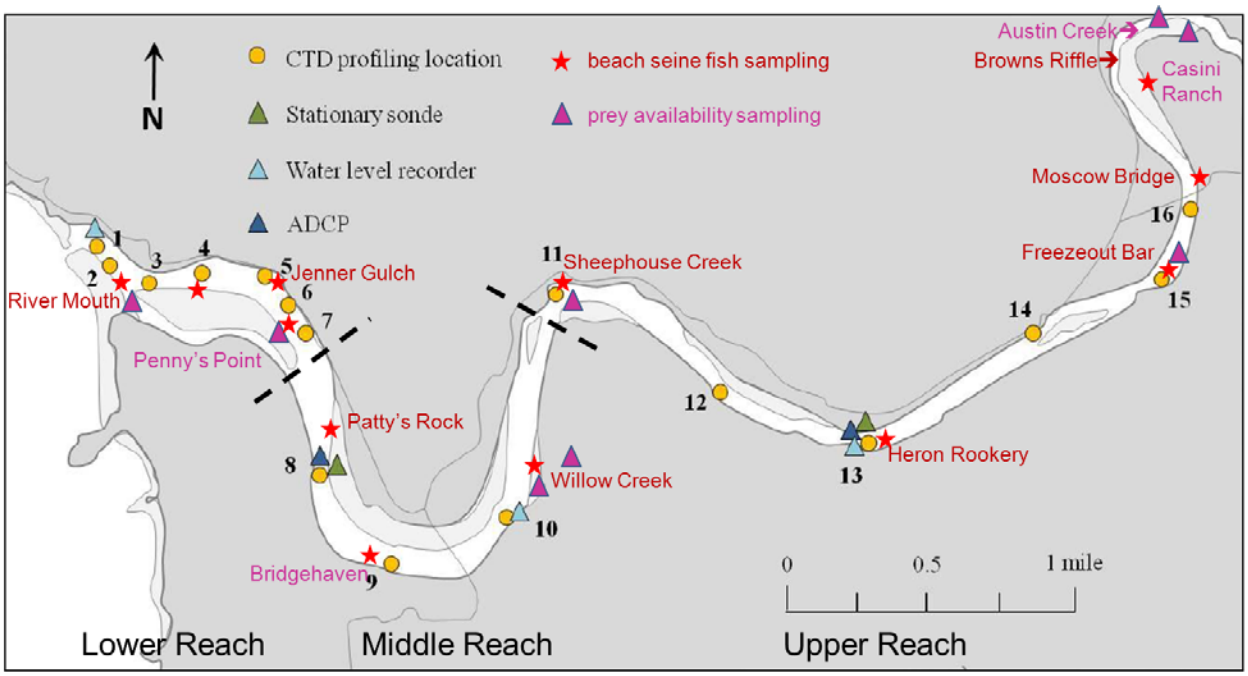



**Figure 4.2.1. Locations of sampling stations for juvenile salmon diet (seining location) and prey resource availability (benthic infauna, epibenthos, zooplankton) in three reaches of the Russian River Estuary. Mapping sites include previously sampled locations..**

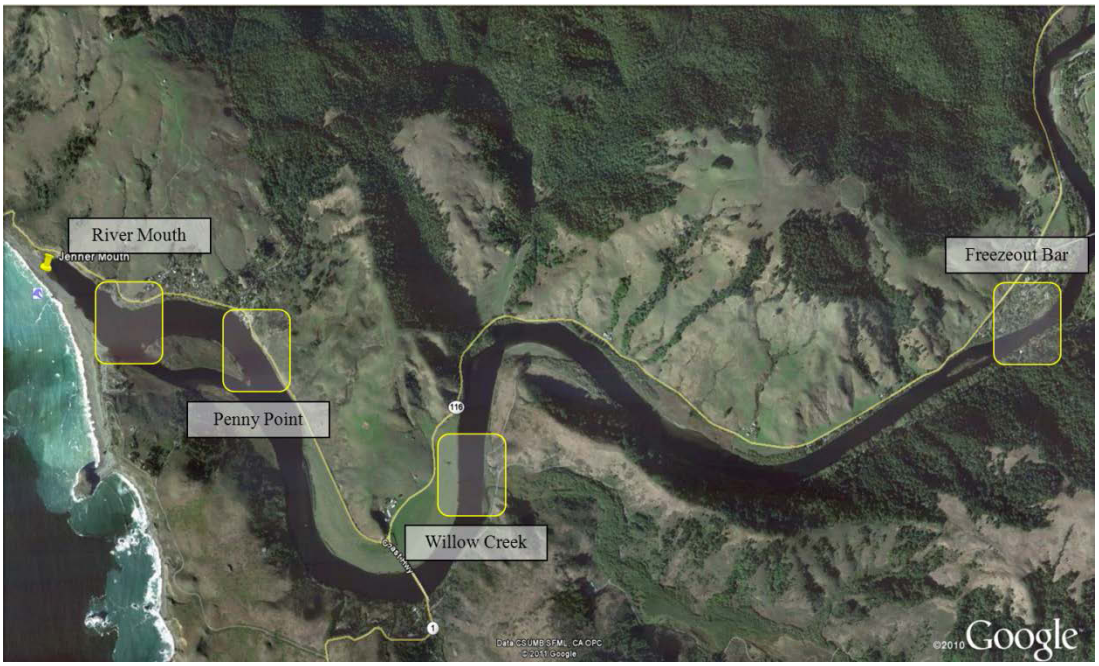



**Figure 4.2.2. Distribution of juvenile salmonid prey resource availability sampling sites in the Russian River Estuary.**

(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 4.2.3a-b. Distribution of juvenile salmonid prey availability sampling transects and techniques at the River Mouth site 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 4.2.3c-d. Distribution of juvenile salmonid prey availability sampling transects and techniques at the River Mouth site in the Russian River Estuary: (a) River Mouth; (b) Penny Point; (c) Willow Creek; and (d) Freezeout Bar.**

**Table 4.2.1. 2012 Invertebrate Sampling in the Russian River Estuary.**

| Date | Mouth Condition | Water Level (ft) (10am-2pm) | Number of Samples by Type | | | | |
|---|---|---|---|---|---|---|---|
| | | | Benthic Core | Sled-Channel | Epi-Benthic net to shore | Zooplankton Haul | Fall-Out Trap |
| River Mouth | | | | | | | |
| 29 May | Muted Tides (leading to closure) | 1.1 - 0.6 | 12 | 9 | 5 | 3 | 5 |
| 25 Jun | Muted Tides (after opening) | 2.5 - 2.4 | 12 | 9 | 5 | 3 | 5 |
| 23 Jul | Muted Tides (after opening) | 1.9 - 2.0 | 12 | 9 | 5 | 3 | 5 |
| 20 Aug | OPEN | 0 - 2.3 | 12 | 9 | 5 | 3 | 5 |
| 10 Sep | OPEN | 1.2 - 0.6 | 12 | 9 | 5 | 3 | 5 |
| 8 Oct | CLOSED (first day of closure) | 2.1 | 12 | 9 | 5 | 3 | 5 |
| Penny Point | | | | | | | |
| 29 May | Muted Tides (leading to closure) | 1.1 - 0.6 | 12 | 9 | 5 | 3 | 5 |
| 25 Jun | Muted Tides (after opening) | 2.5 - 2.4 | 12 | 9 | 5 | 3 | 5 |
| 23 Jul | Muted Tides (after opening) | 1.9 - 2.0 | 12 | 9 | 5 | 3 | 5 |
| 20 Aug | OPEN | 0 - 2.3 | 12 | 9 | 5 | 3 | 5 |
| 10 Sep | OPEN | 1.2 - 0.6 | 12 | 9 | 5 | 3 | 5 |
| 8 Oct | CLOSED (first day of closure) | 2.1 | 12 | 9 | 5 | 3 | 5 |
| Willow Creek | | | | | | | |
| 29 May | Muted Tides (leading to closure) | 1.1 - 0.6 | 12 | 9 | 5 | 3 | 5 |
| 25 Jun | Muted Tides (after opening) | 2.5 - 2.4 | 12 | 9 | 5 | 3 | 5 |
| 23 Jul | Muted Tides (after opening) | 1.9 - 2.0 | 12 | 9 | 5 | 3 | 5 |
| 20 Aug | OPEN | 0 - 2.3 | 12 | 9 | 5 | 3 | 5 |
| 10 Sep | OPEN | 1.2 - 0.6 | 12 | 9 | 5 | 3 | 5 |
| 8 Oct | CLOSED (first day of closure) | 2.1 | 12 | 9 | 5 | 3 | 5 |
| Freezeout | | | | | | | |
| 29 May | Muted Tides (leading to closure) | 1.1 - 0.6 | 12 | 9 | 5 | 3 | 5 |
| 25 Jun | Muted Tides (after opening) | 2.5 - 2.4 | 12 | 9 | 5 | 3 | 5 |
| 23 Jul | Muted Tides (after opening) | 1.9 - 2.0 | 12 | 9 | 5 | 3 | 5 |
| 20 Aug | OPEN | 0 - 2.3 | 12 | 9 | 5 | 3 | 5 |
| 10 Sep | OPEN | 1.2 - 0.6 | 12 | 9 | 5 | 3 | 5 |
| 8 Oct | CLOSED (first day of closure) | 2.1 | 12 | 9 | 5 | 3 | 5 |
| **Subtotal by sample type** | | | 288 | 216 | 120 | 72 | 120 |
| **Total # of Samples** | | | | | | | 816 |

**Table 4.2.2. Prey resource availability samples collected in 2013. Samples were collected at four locations under varied river mouth conditions.**

| Date | Mouth Condition | Water Level at Jenner Gage (ft) (10am-2pm) | Number of Samples by Type | | | |
|---|---|---|---|---|---|---|
| | | | Benthic Core | Sled Channel | Epi-Benthic net to shore | Zooplankton Haul |
| River Mouth | | | | | | |
| 21 May | Muted Tides (leading to closure) | 1.9 | 12 | 9 | 5 | 3 |
| 26 Jun | CLOSED (19th day of closure event) | 6.4 | 12 | 9 | 5 | 3 |
| 23 Jul | OPEN | 0.5 - 1.7 | 12 | 9 | 5 | 3 |
| 20 Aug | OPEN | 1.6 - 2 | 12 | 9 | 5 | 3 |
| 23 Sep | OPEN (day before closure event) | 2 | 12 | 9 | 5 | 3 |
| 7 Oct | CLOSED (14th day of closure event) | 7.1 | 12 | 9 | 5 | 3 |
| Penny Point | | | | | | |
| 21 May | Muted Tides (leading to closure) | 1.9 | 12 | 9 | 5 | 3 |
| 26 Jun | CLOSED (19th day of closure event) | 6.4 | 12 | 9 | 5 | 3 |
| 23 Jul | OPEN | 0.5 - 1.7 | 12 | 9 | 5 | 3 |
| 20 Aug | OPEN | 1.6 - 2 | 12 | 9 | 5 | 3 |
| 23 Sep | OPEN (day before closure event) | 2 | 12 | 9 | 5 | 3 |
| 7 Oct | CLOSED (14th day of closure event) | 7.1 | 12 | 9 | 5 | 3 |
| Willow Creek | | | | | | |
| 21 May | Muted Tides (leading to closure) | 1.9 | 12 | 9 | 5 | 3 |
| 26 Jun | CLOSED (19th day of closure event) | 6.4 | 12 | 9 | 5 | 3 |
| 23 Jul | OPEN | 0.5 - 1.7 | 12 | 9 | 5 | 3 |
| 20 Aug | OPEN | 1.6 - 2 | 12 | 9 | 5 | 3 |
| 23 Sep | OPEN (day before closure event) | 2 | 12 | 9 | 5 | 3 |
| 7 Oct | CLOSED (14th day of closure event) | 7.1 | 12 | 9 | 5 | 3 |
| Freezeout | | | | | | |
| 21 May | Muted Tides (leading to closure) | 1.9 | 12 | 9 | 5 | 3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 26 Jun | CLOSED (19th day of closure event) | 6.4 | 12 | 9 | 5 | 3 |
| 23 Jul | OPEN | 0.5 - 1.7 | 12 | 9 | 5 | 3 |
| 20 Aug | OPEN | 1.6 - 2 | 12 | 9 | 5 | 3 |
| 23 Sep | OPEN (day before closure event) | 2 | 12 | 9 | 5 | 3 |
| 7 Oct | CLOSED (14th day of closure event) | 7.1 | 12 | 9 | 5 | 3 |
| **Subtotal by sample type** | | | **288** | **216** | **120** | **72** |
| **Total # of Samples** | | | | | | **696** |

*Benthic Infauna*—Replicate core samples (0.0024-$m^2$ PVC core inserted 10 cm in to 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 perpendicular to shore and then pulled along the bottom back to shore by an individual onshore. This is replicated five times per site (once at each transect and then once between Transects 1 and 2 and also between Transects 2 and 3). The epibenthic sled is equipped with a 0.125-$m^2$ opening, 1-m long 500-µm Nitex mesh net towed behind the boat against the current. The sled is lowered from 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, the sled is retrieved. 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.

*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.

*Sampling Completed*

Monthly sampling was completed from May through October 2012 and 2013. Table 4.2.1 provides a summary of sampling completed. Invertebrate sampling was completed under a range of open and closed river mouth conditions. Table 4.2.2 also provides a summary of river mouth conditions and water surface elevation ranges in the Estuary.

*Sample Processing and Analyses*

Stomach contents from juvenile salmon are 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 are identified to species level, except for insects which are indentified to family level. Any invertebrate collected during prey sampling and not found to be part of the steelhead diet is identified to order or family level. Each of the identified prey taxa are counted (for numerical composition) and weighed (for gravimetric [biomass] composition) and the frequency of occurrence. The state of total stomach content biomass is 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) is 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.

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

### Results

Samples collected during the 2012 and 2013 Lagoon Management Periods 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, 19$^{th}$ 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, 14$^{th}$ 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 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 2011(Manning and Martini-Lamb 2011 and 2012, Martini-Lamb and Manning 2011).

No fish diet analyses were conducted from the 2012 and 2013 sampling.

*Benthic Infauna*—Despite the four week gap in sampling dates, the predominant prey taxa in the benthos was remarkably consistent in composition and among reaches between May and June 2012 (Figure 4.2.4). The common amphipods (*Ameriocorophium spinicorne*, *A. simpsoni*, *Eogammarus confervicolus*) and isopods (*Gnorinmospheroma insulare*) occurred in mean densities of ~500-15,000 organisms m$^{-2}$ prominently in the lower three sampling sites, and particularly dense (10,000-15,000 m$^{-2}$) at the Willow Creek site. Insect larvae (Chironomidae) occurred primarily in the upper (Freezeout Bar) reach.

In contrast to 2012, benthos densities and distributions changed between the muted tides and closed conditions in May and June 2013, respectively (Figures 4.2.5 and 4.2.6). Most taxa, except for capitellid polychaetes, virtually disappeared from the lower reach (River Mouth). Amphipods and isopods that occurred in mean densities 10,000-30,000 m$^{-2}$ in May (note two to three times higher than in 2012) were typically <1000 m$^{-2}$ in June and their distribution shifted up-estuary, in the Penny Point and Willow Creek sampling sites. In July and August, when the Estuary was open, benthic organisms remained typically <1000 m$^{-2}$ and remained concentrated in the middle two reaches of the Estuary, except for capitellid and nereid polychaetes in the lowest reach (Figures 4.2.7 and 4.2.8). As in 2012, mean densities tended to be highest at Willow Creek. By late September, mean densities were extremely low and most taxa occurred predominantly at the Willow Creek sampling site (Figure 4.2.9). Polychaetes were the only, marginally abundant taxa, occurring in the lower reach. Even though the Estuary

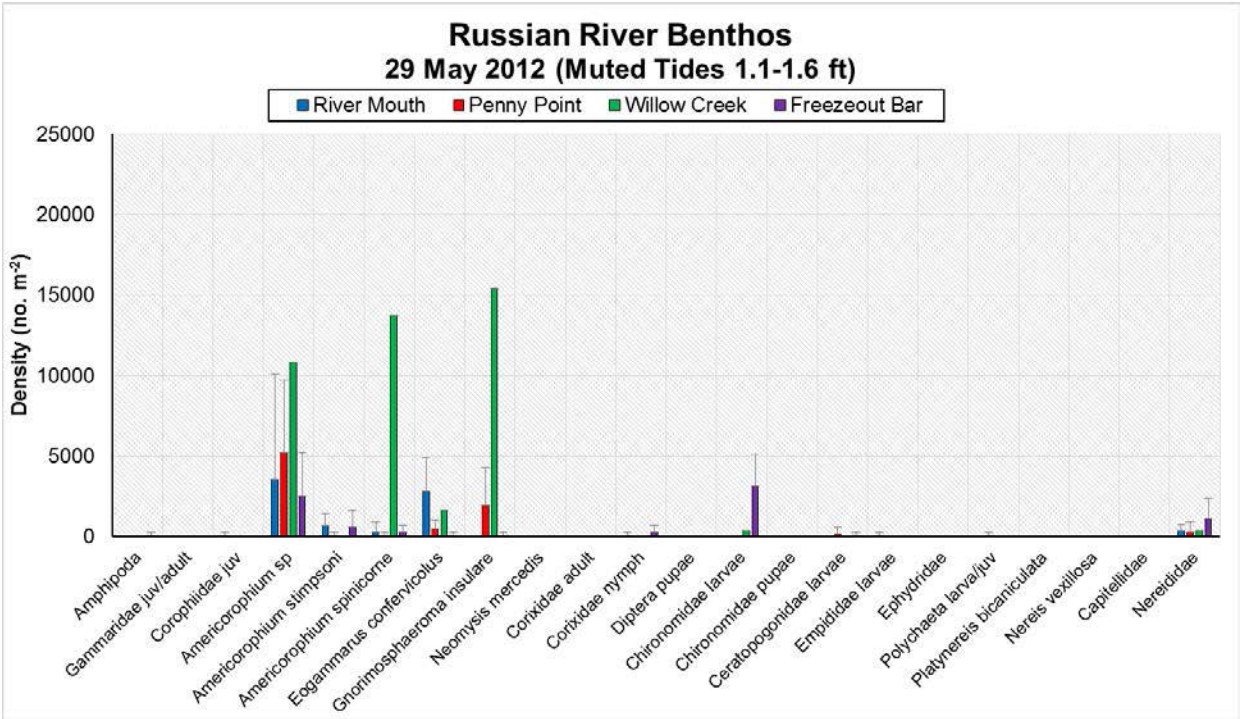



**Figure 4.2.4. Mean density (+1 s.d. error bar) of benthic infauna from four sampling sites of Russian River estuary on 29 May 2012; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

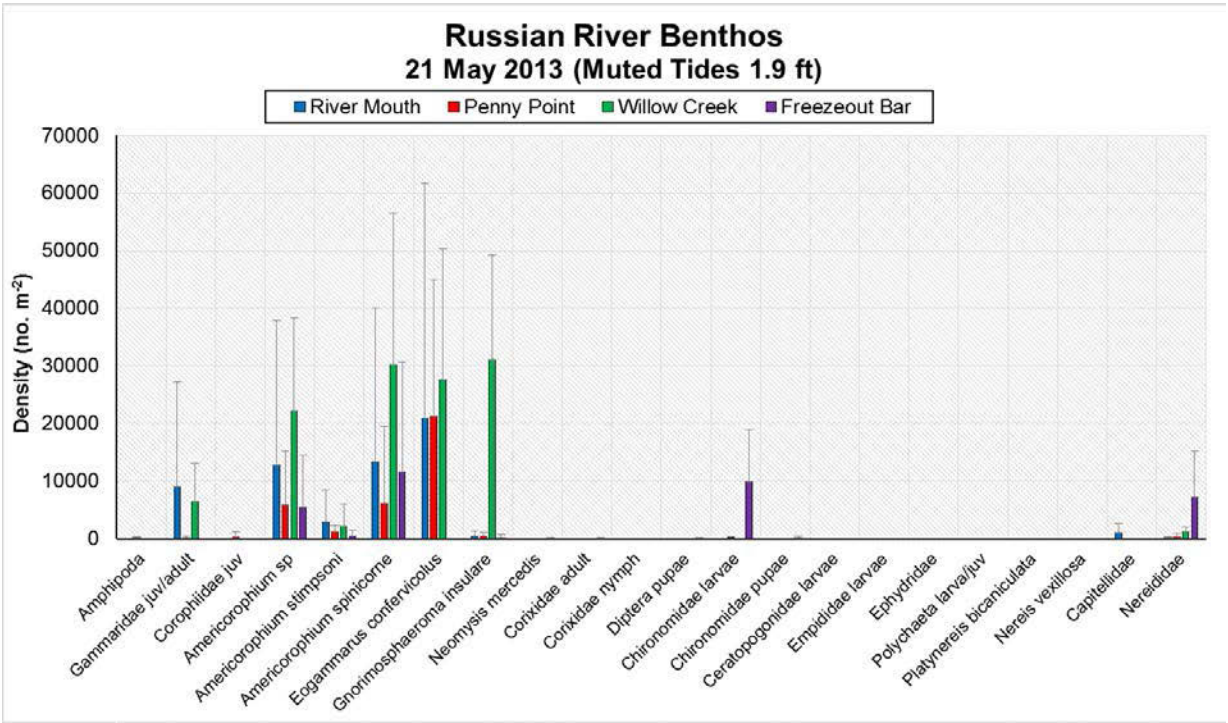



**Figure 4.2.5. Mean density (+1 s.d. error bar) of benthic infauna from four sampling sites of Russian River estuary on 21 May 2013; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

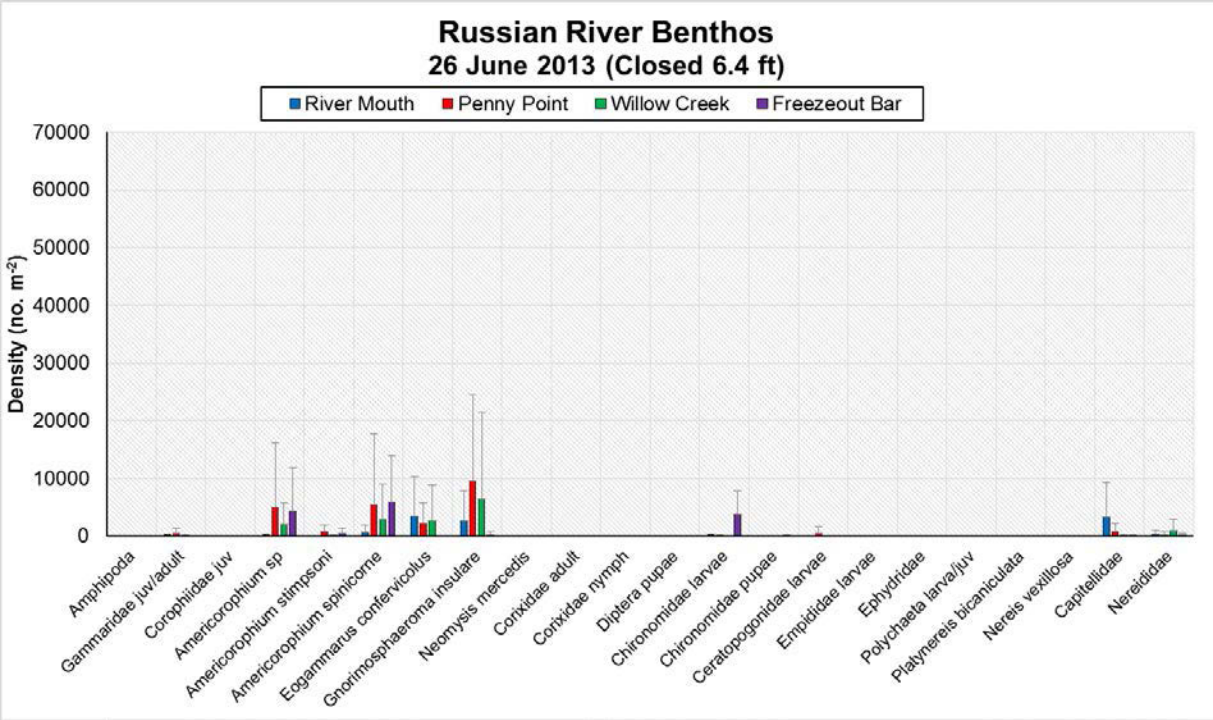



**Figure 4.2.6. Mean density (+1 s.d. error bar) of benthic infauna from four sampling sites of Russian River estuary on 26 June 2013; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

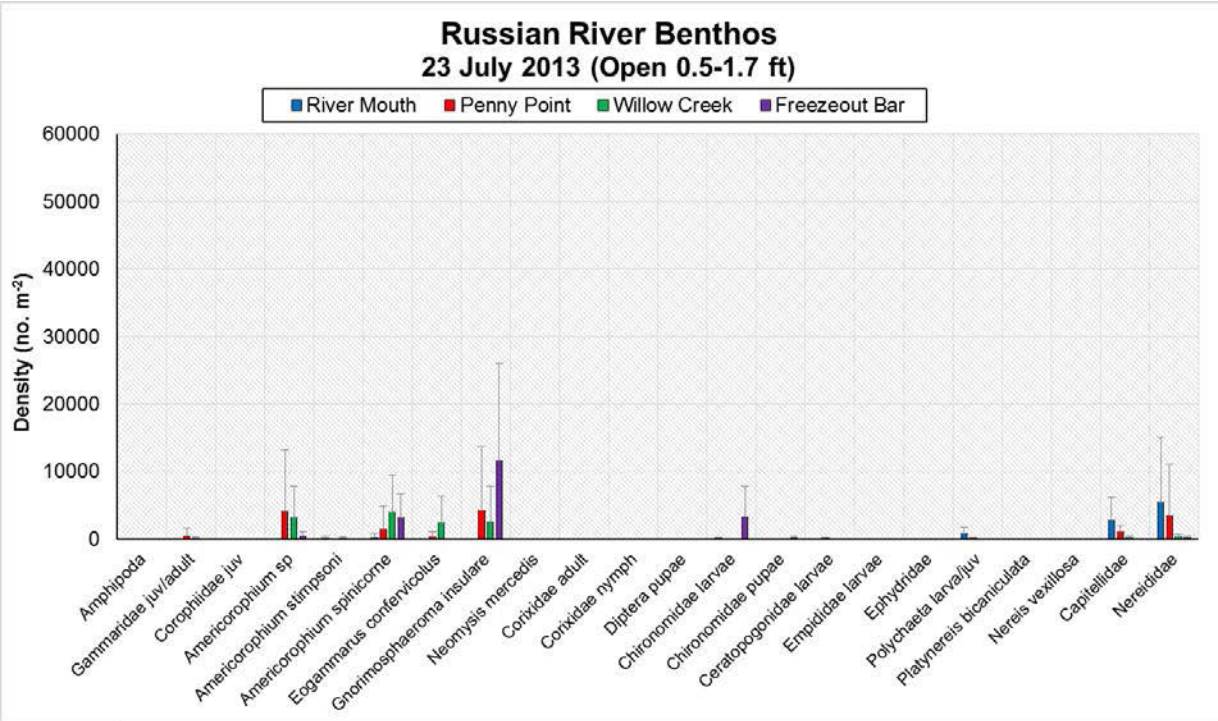



**Figure 4.2.7. Mean density (+1 s.d. error bar) of benthic infauna from four sampling sites of Russian River estuary on 23 July 2013; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

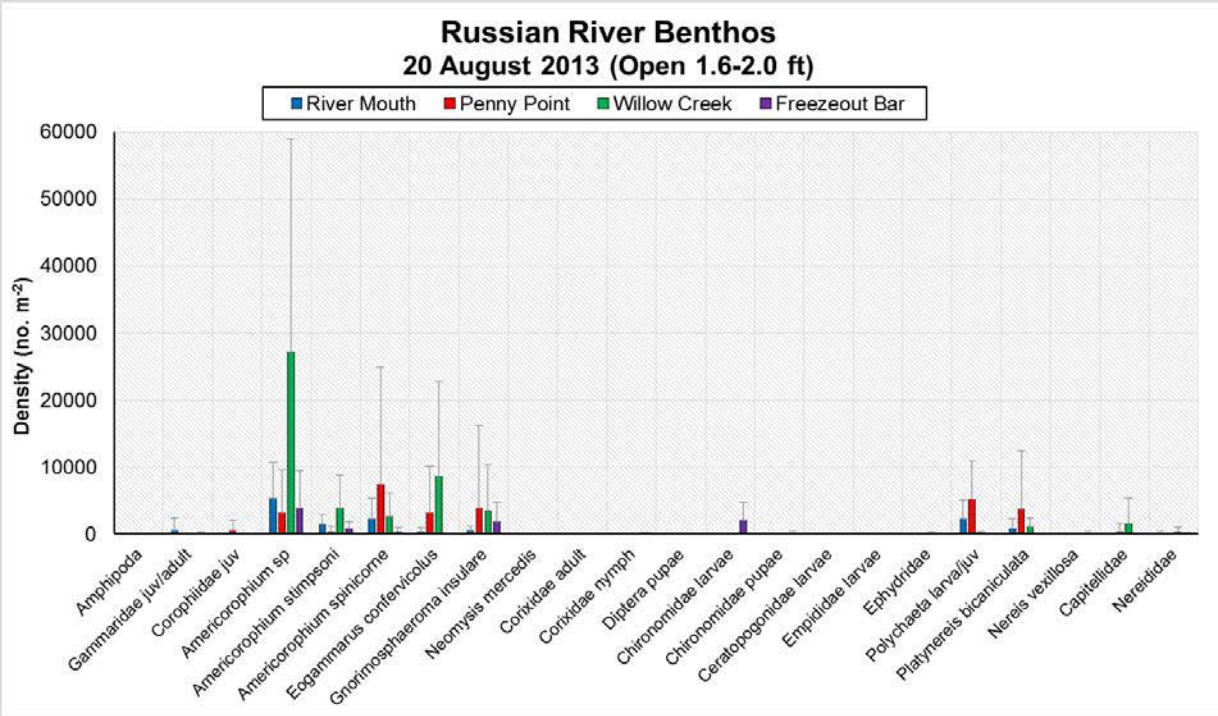



**Figure 4.2.8. Mean density (+1 s.d. error bar) of benthic infauna from four sampling sites of Russian River estuary on 20 August 2013; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

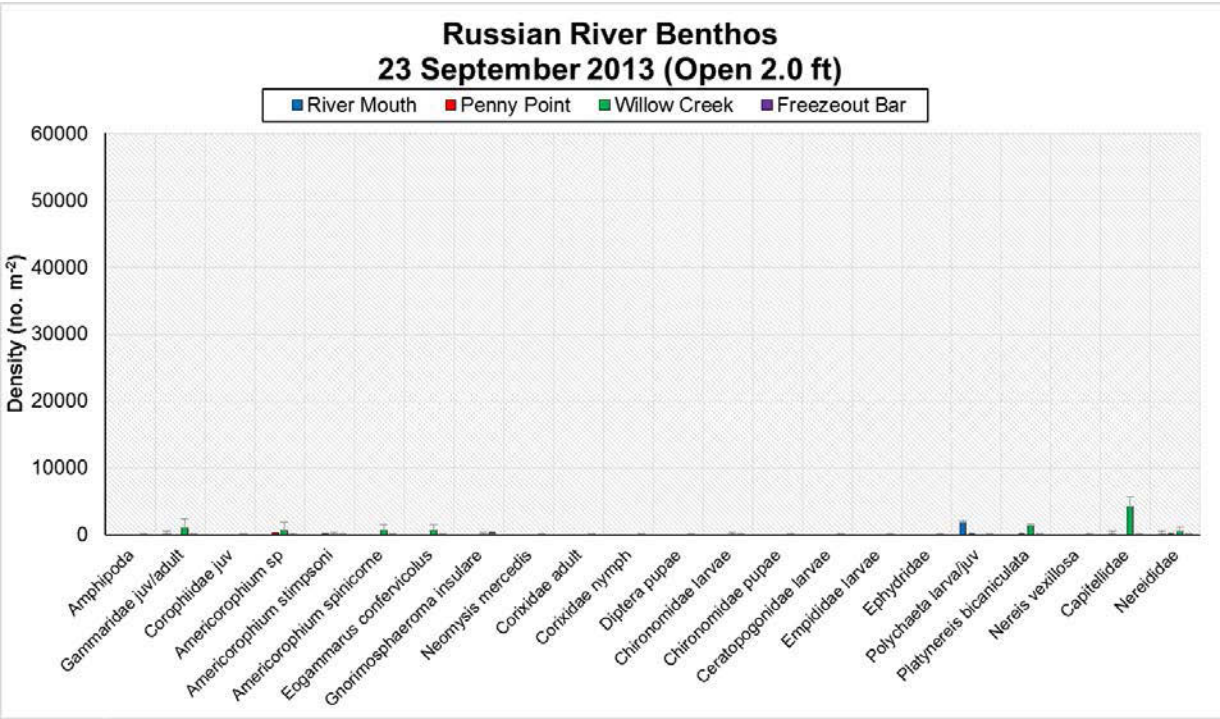



**Figure 4.2.9. Mean density (+1 s.d. error bar) of benthic infauna from four sampling sites of Russian River estuary on 23 September 2013; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

was closed only 14 days after the late September sampling, there was no detectable change other than further diminishment or disappearance of many taxa and *A. spinicorne* and *G. insulare* occurrence in low densities at Freezeout Bar (Figure 4.2.10).

*Epibenthos*—The epibenthic net samples within 10 m of the high water level, at whatever estuary water surface elevation; thus, it is most indicative of a shift in prey organism distribution as a function of estuary water level and volume. The difference between the 29 May and 25 June 2012 samples, as described above for the benthos, both represented muted tide conditions. Prey taxa composition was relatively similar between the two dates, although the mean density of insects (corixid nymphs and chironomid larvae) had increased to over 500 organism $m^{-2}$ and amphipods and mysids had increased to 300-400 $m^{-2}$ at Willow Creek (Figures 4.2.11 and 4.2.12). These relatively subtle changes likely represent population increases of turnovers over the month interval between sampling. Estuary status and water levels were not measurably different between the September and October 2012 sampling—open vs. first day of closure—and in both months amphipods, isopods and mysids in relatively similar densities <500 $m^{-2}$ and were distributed primarly at River Mouth, while the corixid and chironomid insects occurred in the upper reach at Freezeout Bar (Figures 4.2.13 and 4.2.14).

Despite comparatively lower mean densities in May and June 2013 than in 2012, epibenthos net collections indicated that amphipods, isopods and mysids that are

common prey of juvenile steelhead and Chinook salmon occurred in similar mean densities and Estuary reaches despite a 4.3 ft difference in water level after 14 days of closure (Figures 4.2.15 and 4.2.16). In both months, the highest prey availability (500-750 $m^{-2}$ mean density) was of corixid beetles at the Freezeout Bar site. This pattern implies that there may not be a significant shift of prey composition among reaches but that they readily occupy the shallow water at the shifting estuary margins. Interestingly, by 23 July, when the Estuary was back open and the water level had dropped to 0.5-1.7 ft, mean densities of prey organisms were exceedingly low (<50 $m^{-2}$) throughout the Estuary (Figure 4.2.17).

In contrast to the epibenthic net collections, sampling with the epibenthic sled in the channel thalweg provided an indication of prey availiability in the deeper sections of the channel, and may be more effective at sampling mysids. Contrasts in Estuary conditions may also indicate whether prey are particularly concentrated in the center of the channels during low, open estuary conditions. Collections from the commonly muted tide conditions in May and June 2012 indicated relatively common epibenthic taxa composition and densities, with both mysids and corixid beetles being most dense at Freezeout Bar (Figures 4.2.18 and 4.2.19). The isopod *G.insulare* was also concentrated in the channels, in mean densities of 200-500 m-2, in all reaches.

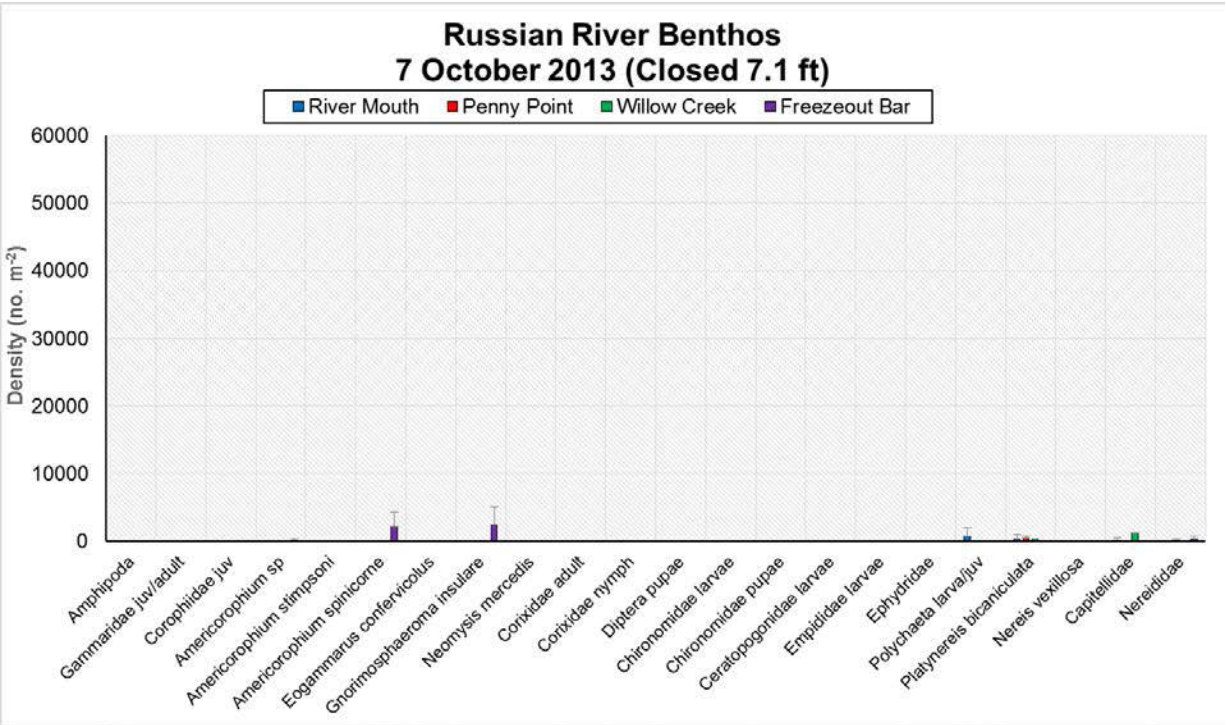



**Figure 4.2.10. Mean density (+1 s.d. error bar) of benthic infauna from four sampling sites of Russian River estuary on 7 October 2013; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

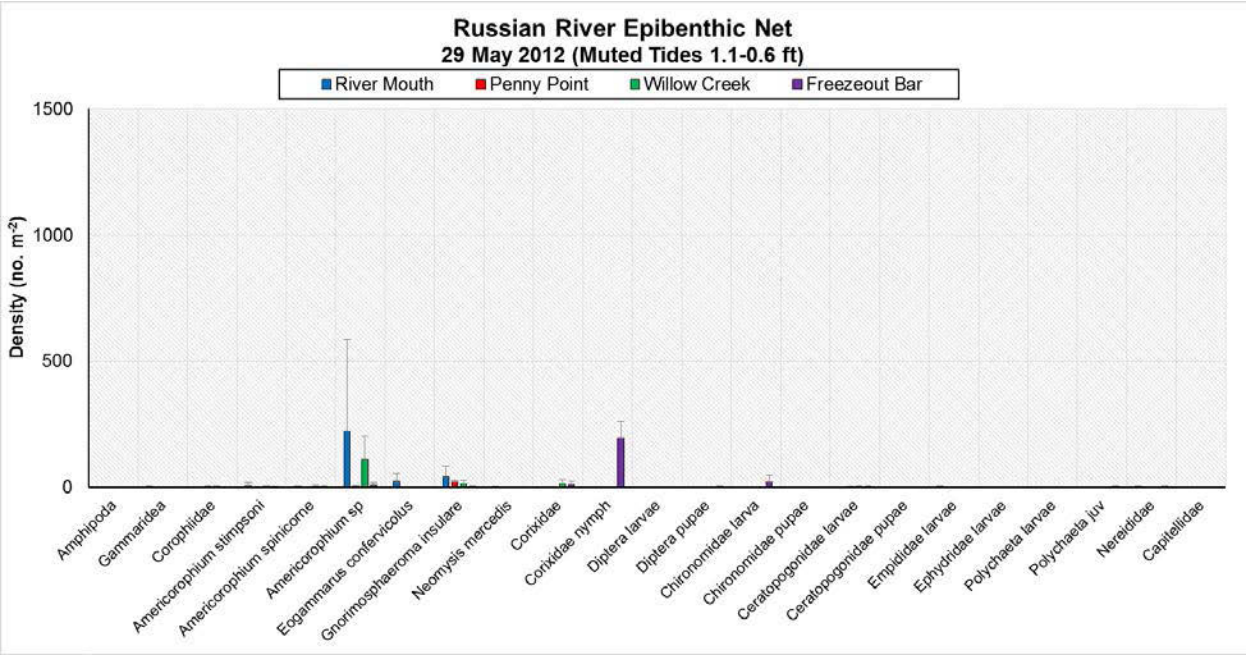



**Figure 4.2.11. Mean density (+1 s.d. error bar) of epibenthic organisms in shallow water near shore in four reaches of Russian River estuary on 29 May 2012; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

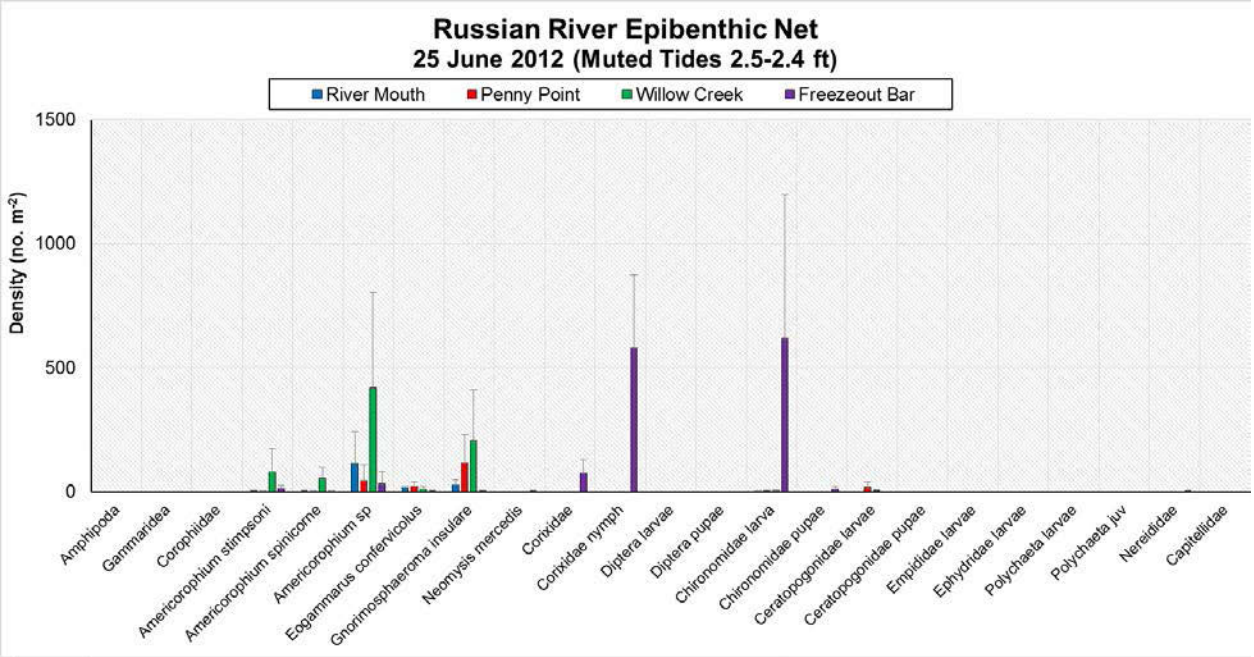



**Figure 4.2.12. Mean density (+1 s.d. error bar) of epibenthic organisms in shallow water near shore in four reaches of Russian River estuary on 25 June 2012; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

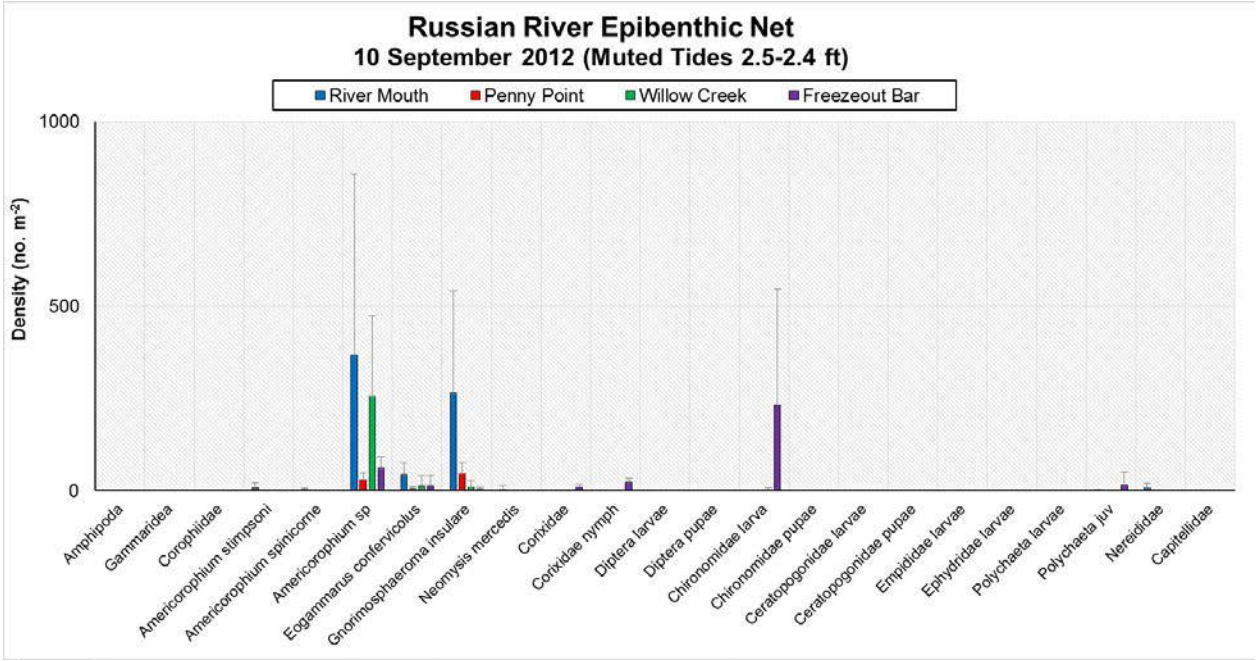



**Figure 4.2.13. Mean density (+1 s.d. error bar) of epibenthic organisms in shallow water near shore in four reaches of Russian River estuary on 10 September 2012; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

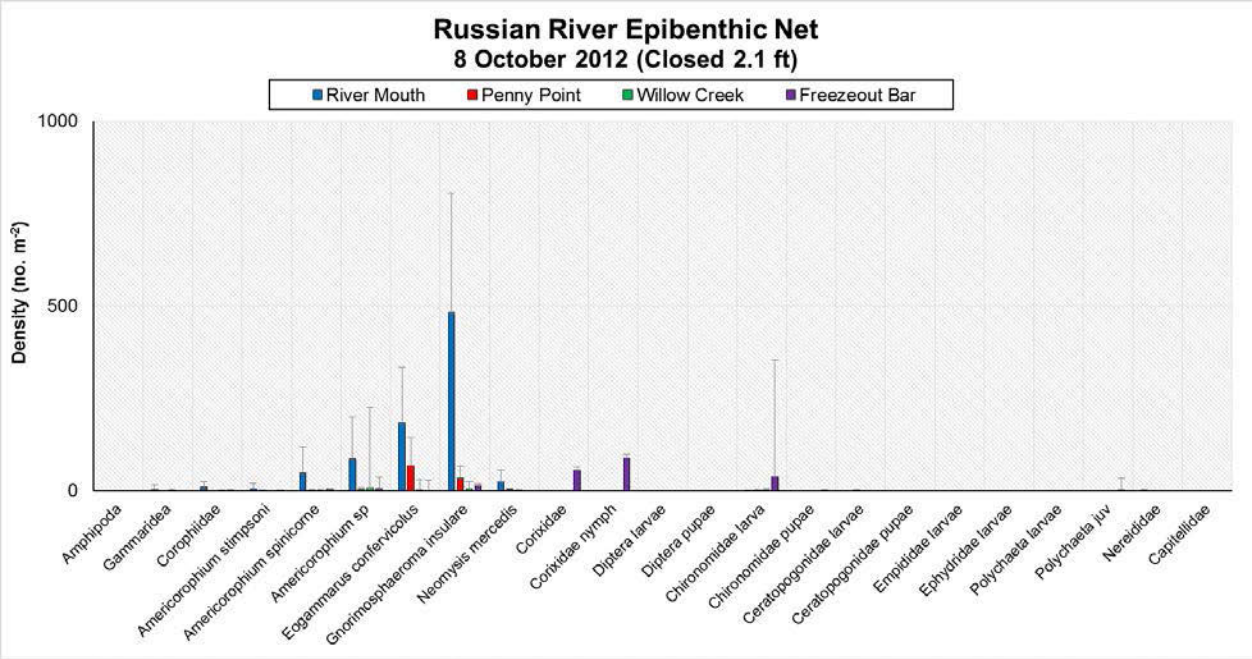



**Figure 4.2.14. Mean density (+1 s.d. error bar) of epibenthic organisms in shallow water near shore in four reaches of Russian River estuary on 8 October 2012; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

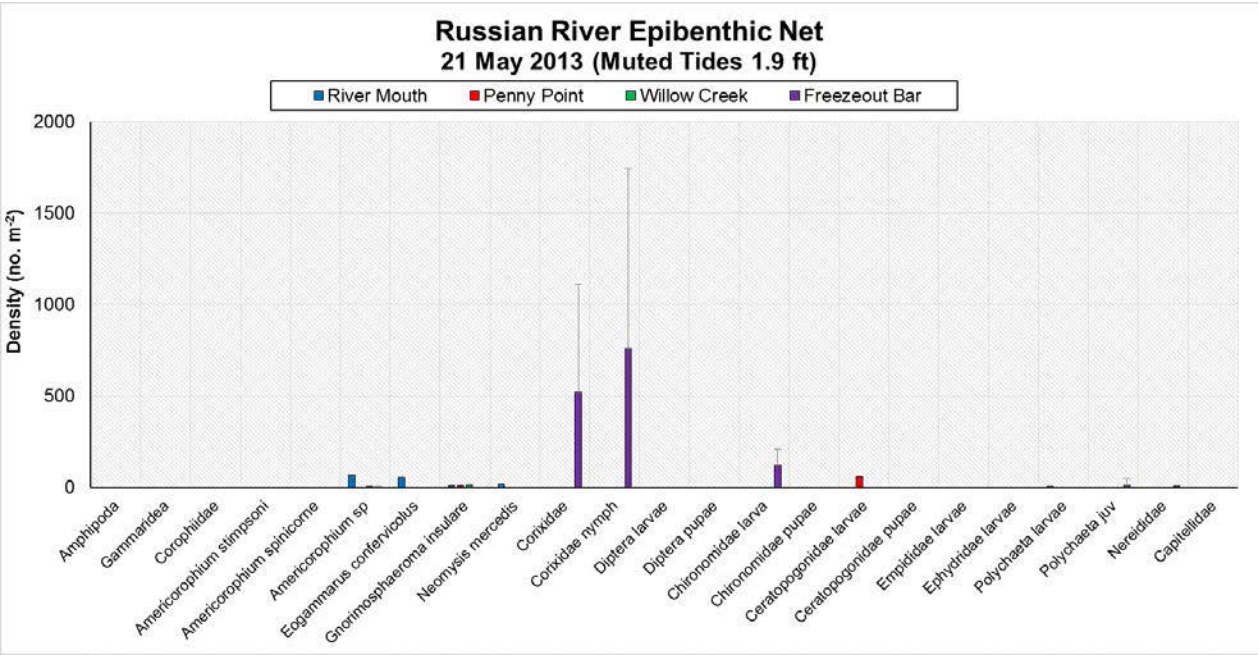



**Figure 4.2.15. Mean density (+1 s.d. error bar) of epibenthic organisms in shallow water near shore in four reaches of Russian River estuary on 21 May 2013; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

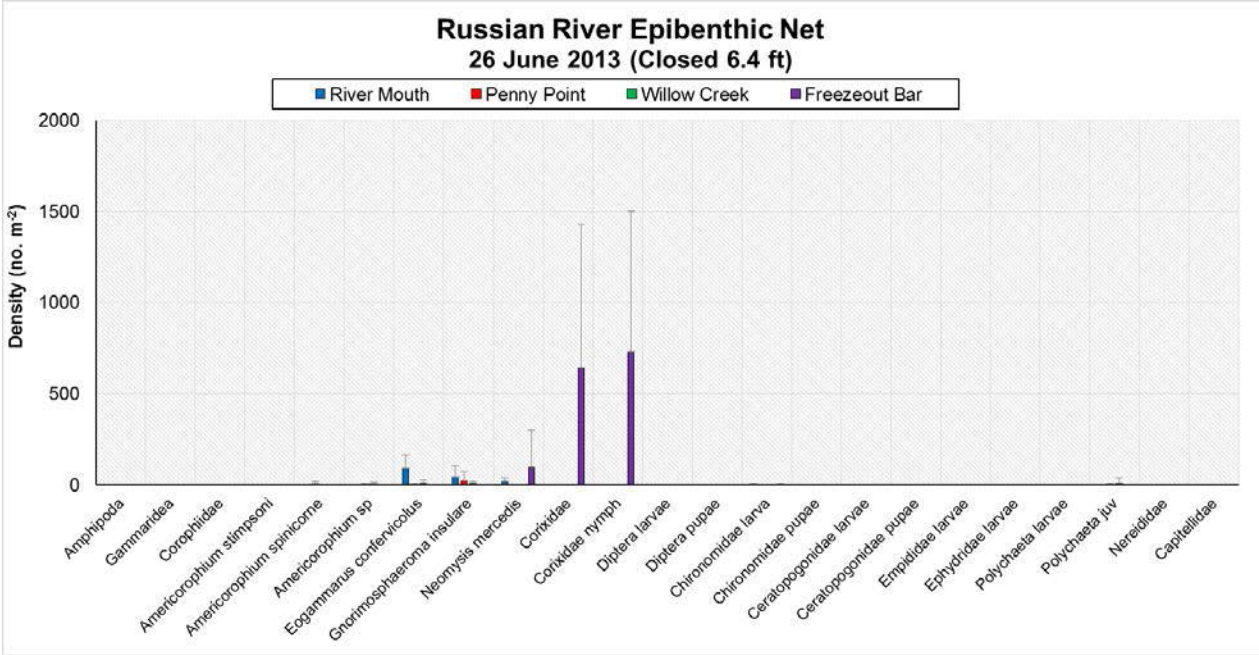



**Figure 4.2.16. Mean density (+1 s.d. error bar) of epibenthic organisms in shallow water near shore in four reaches of Russian River estuary on 26 June 2013; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

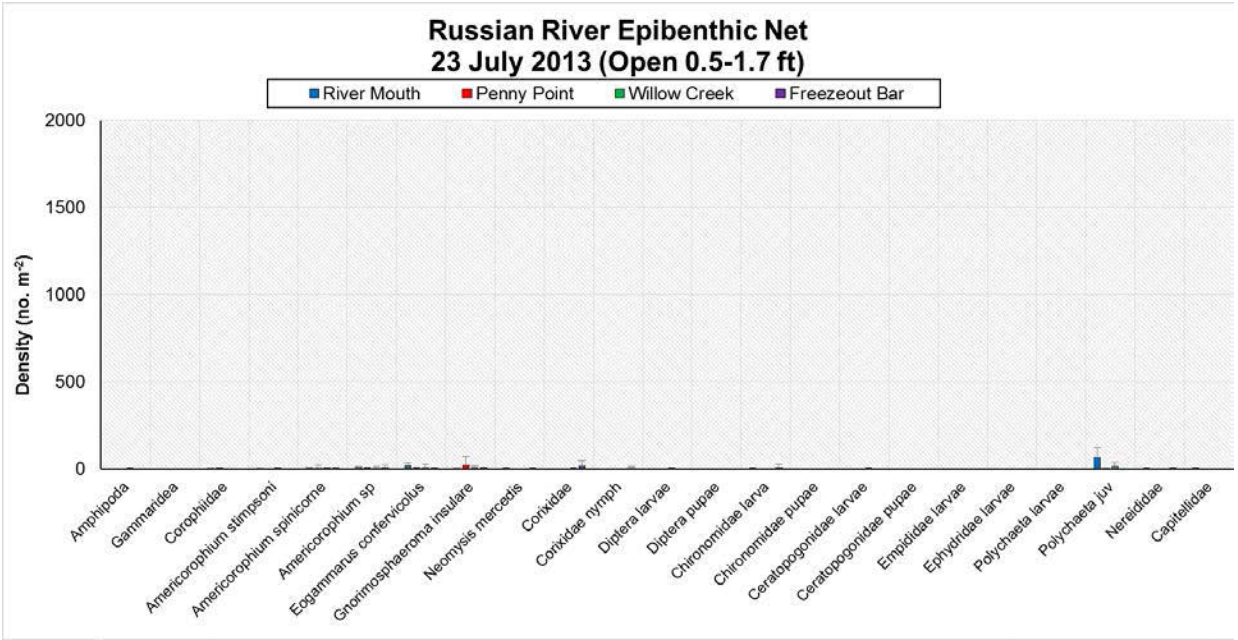



**Figure 4.2.17. Mean density (+1 s.d. error bar) of epibenthic organisms in shallow water near shore in four reaches of Russian River estuary on 23 July 2013; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

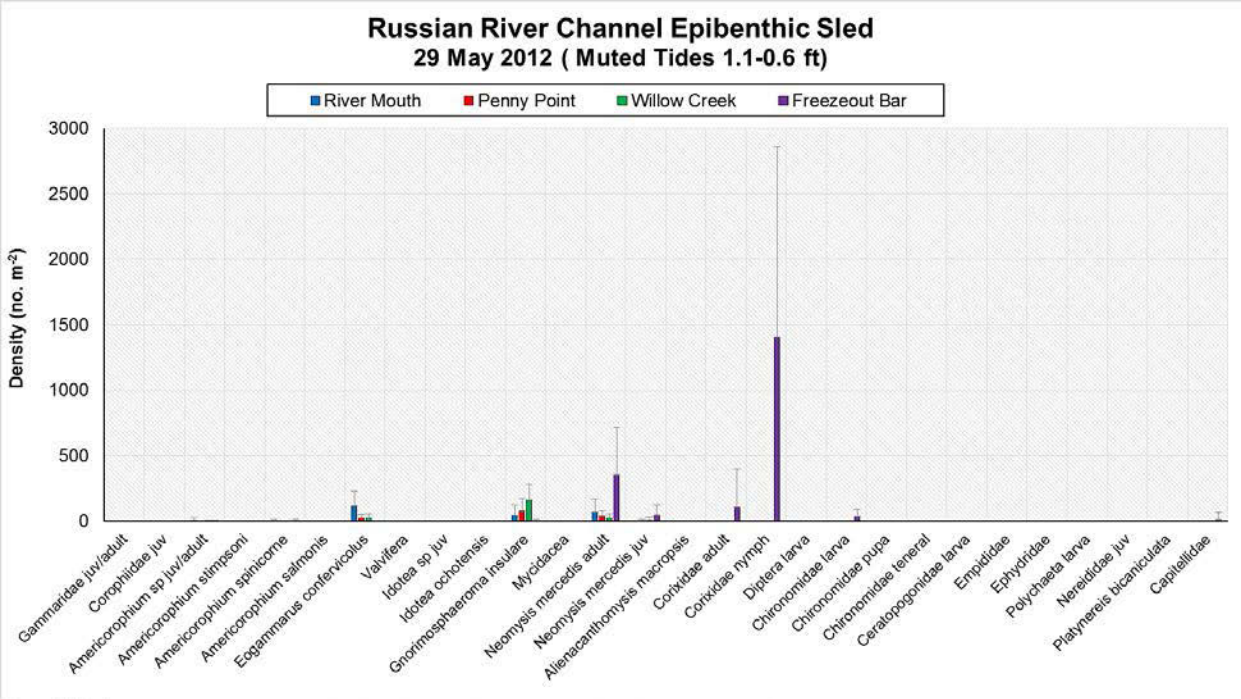



**Figure 4.2.18. Mean density (+1 s.d. error bar) of epibenthic organisms along the channel thalweg in four reaches of Russian River estuary on 29 May 2012; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

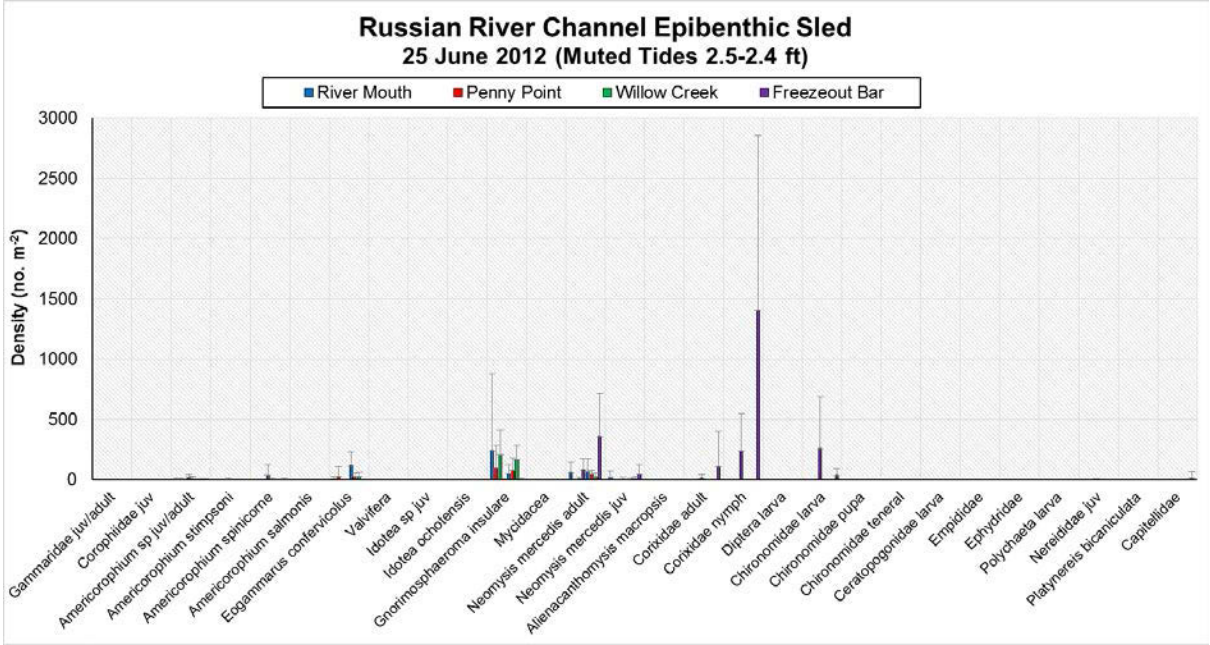



**Figure 4.2.19. Mean density (+1 s.d. error bar) of epibenthic organisms along the channel thalweg in four reaches of Russian River estuary on 25 June 2012; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

As described for the epibenthic net collections in shallow water, taxa composition, mean densities and distribution across most estuarine reaches were almost identical in September and October 2012, commensurate with the relatively common water levels (Figures 4.2.20 and 4.2.21).

In contrast to results from the shallow water epipenthic sampling between the contrasting estuary conditions and water levels in May and June 2012, mean densities and estuary distributions were significantly different between May (muted tides leading to closure) and June (19$^{th}$ day of closure) in 2013 (Figures 4.2.22 and 4.2.23). The most notable differences were in the decline in the amphipod *E. confervicolus* at Patty Point and in the adult *Neomysis mercedis* mysids from Freezeout Bar with the closure event. Amphipods also tended to appear more in the lowest reach with the closure. Unlike the shallow water epibenthic net collections, all taxa had become particularly sparse (<50 $m^{-1}$) throughout the Estuary in July (Figure 4.2.24).

*Zooplankton*—As explained for the benthic and epibenthic assemblages above, differences in the September and October 2012 estuary conditions contrasted in only one day closure and a foot higher water elevation. There were some differences in numerical composition (e.g., more dominance by polychaete larve throughout all four reaches) and mean organism density (e.g., increased densities of polychates and tintinids [ciliates], especially at Penny Point; Figures 4.2.25-4.2.28), these were more likely a temporal change in populations than attributable to the Estuary closing.

Temporal changes in zooplankton compostion and density between May (muted tides), June (closed after 19 days) and July (open) 2013 may be more indicative of changes in estuary condition (Figures 4.2.29-4.2.34). The calanoid copepod*, Eurytemora affinis*, dominated the zooplankton assemblage in the lower two reaches of the Estuary in May, when the Estuary was leading to closure. Barnacle larvae were the only other predominant taxa in the lower estuary but freshwater cyclopoid copepods, harpacticoid copepods and other taxa were found up estuary. After the extended closure in June, *E. affinis* had expanded up estuary and mean densities increased almost to ~8X (as high as 34,000 organisms $m^{-3}$) in the upper reach (Figures 4.2.31 and 4.2.32). Polychaete larvae were the only other prominent taxa, only at River Mouth. Once the Estuary had opened back up, samples from July were quite diverse and represented mixtures of marine copepods and euryhaline taxa throughout the lower three reaches (Figures 4.2.33 and 4.2.34). Only the upper reach, at Freezeout Bar, retained a freshwater/oligohaline zooplankton assemblage similar to that documented in May, but including persisting *E. affinis*. Densities were low, <3000 organisms $m^{-3}$, throughout.

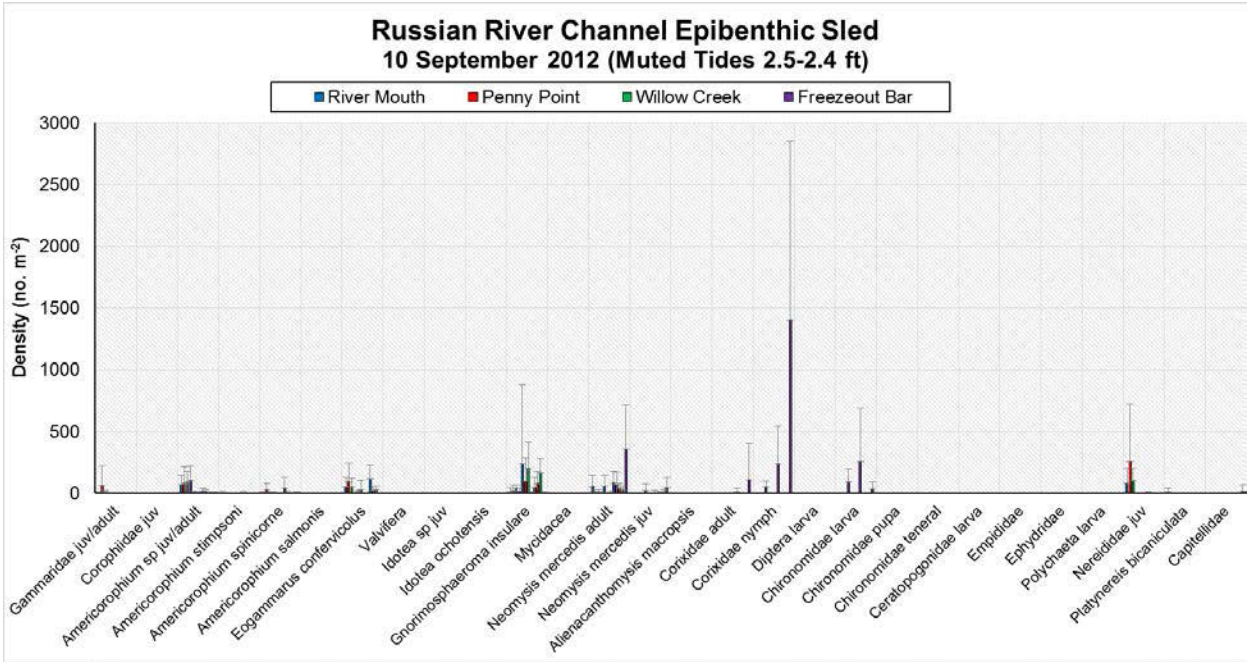



**Figure 4.2.20. Mean density (+1 s.d. error bar) of epibenthic organisms along the channel thalweg in four reaches of Russian River estuary on 10 September 2012; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

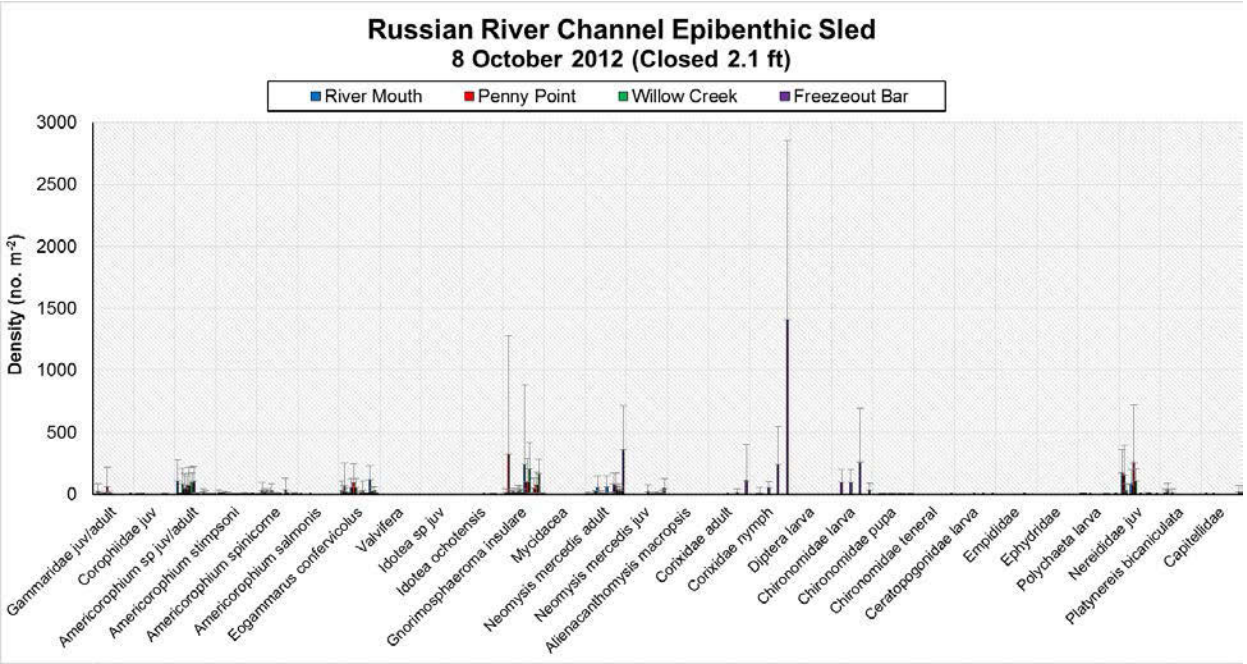



**Figure 4.2.21. Mean density (+1 s.d. error bar) of epibenthic organisms along the channel thalweg in four reaches of Russian River estuary on 8 October 2012; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

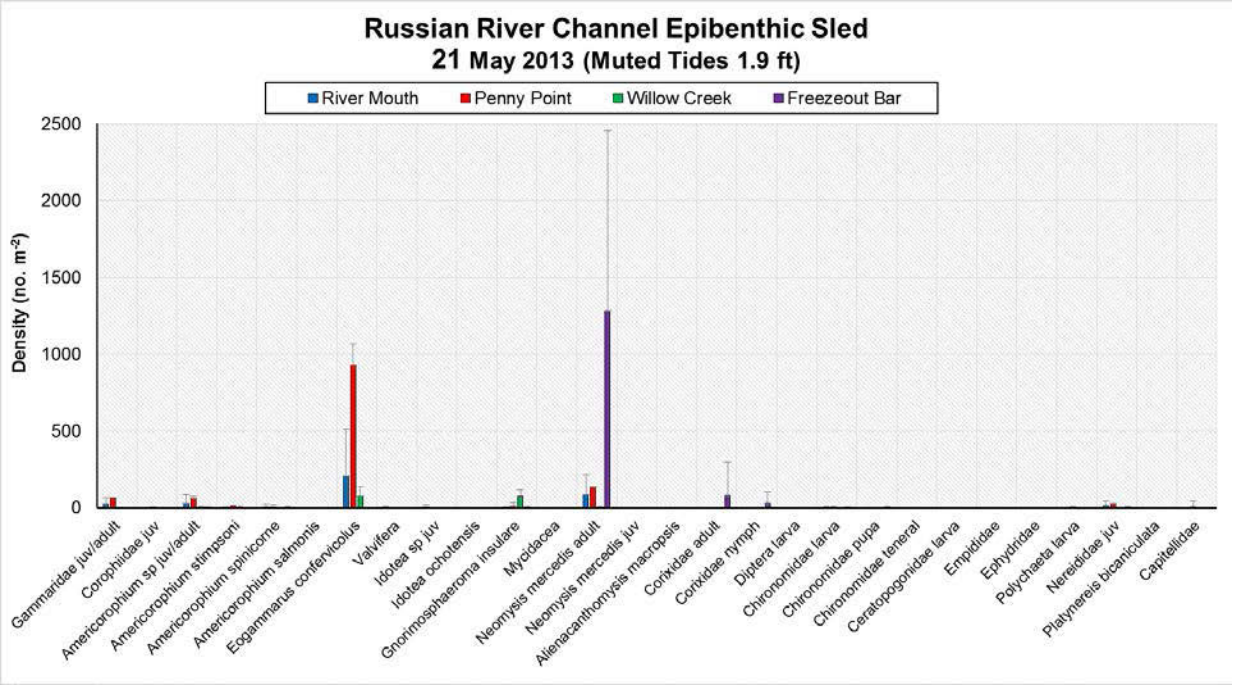



**Figure 4.2.22. Mean density (+1 s.d. error bar) of epibenthic organisms along the channel thalweg in four reaches of Russian River estuary on 21 May 2013; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

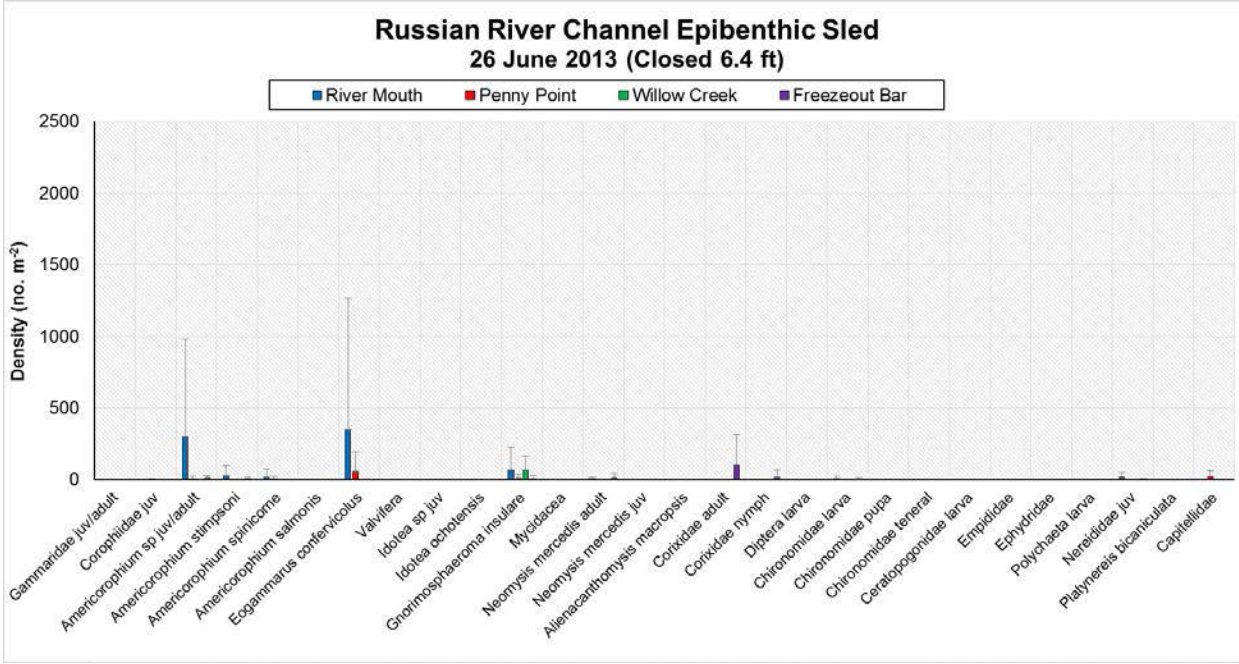



**Figure 10. Mean density (+1 s.d. error bar) of epibenthic organisms along the channel thalweg in four reaches of Russian River estuary on 21 May 2013; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

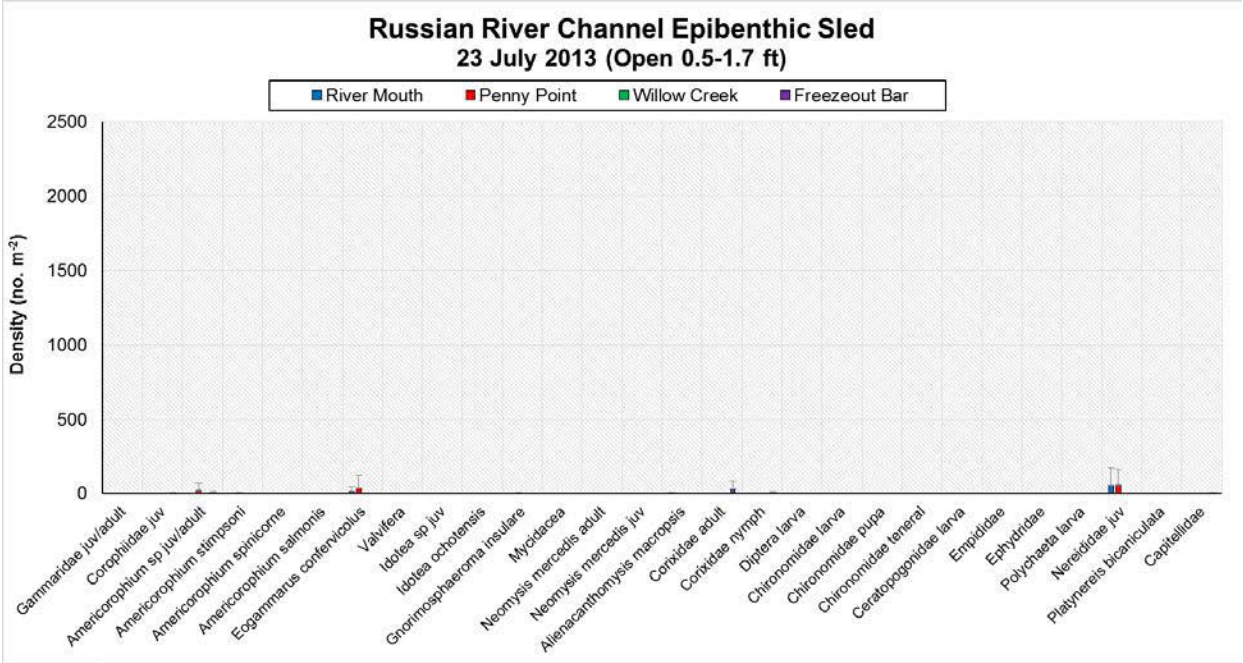



**Figure 4.2.24. Mean density (+1 s.d. error bar) of epibenthic organisms along the channel thalweg in four reaches of Russian River estuary on 23 July 2013; taxa displayed are confined to documented prey of juvenile steelhead and Chinook salmon in the Estuary.**

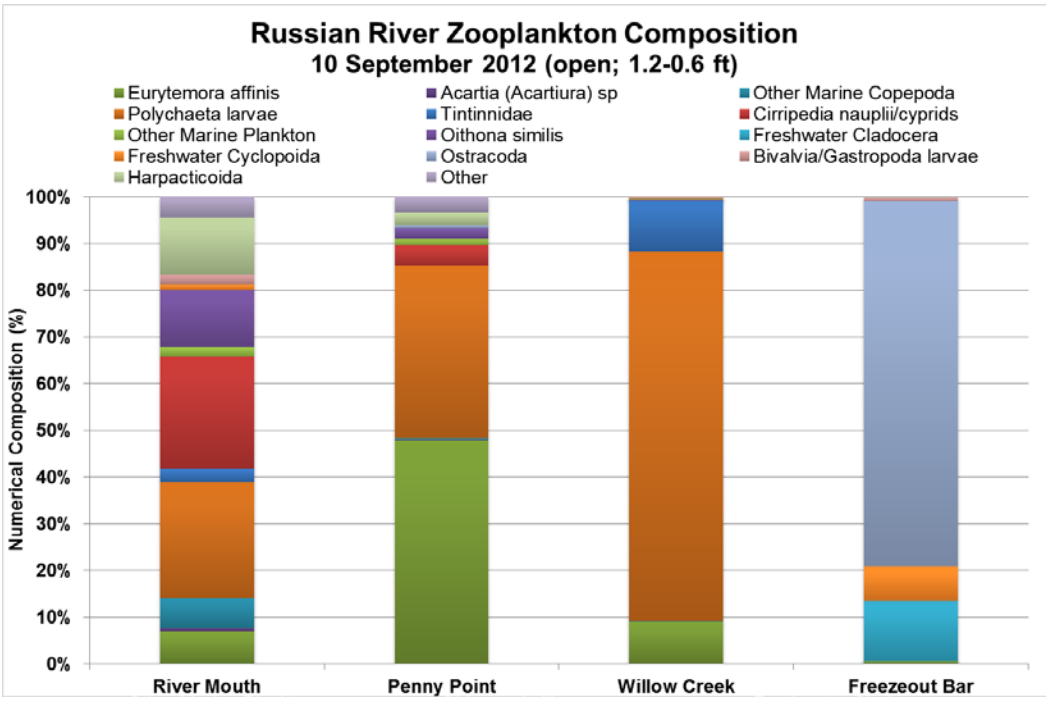



**Figure 4.2.25. Numerical composition of planktonic zooplankton in four reaches of Russian River estuary on 10 September 2012 Although many taxa were identified to species, some have been grouped into broader taxa categories for ease of interpretation.**

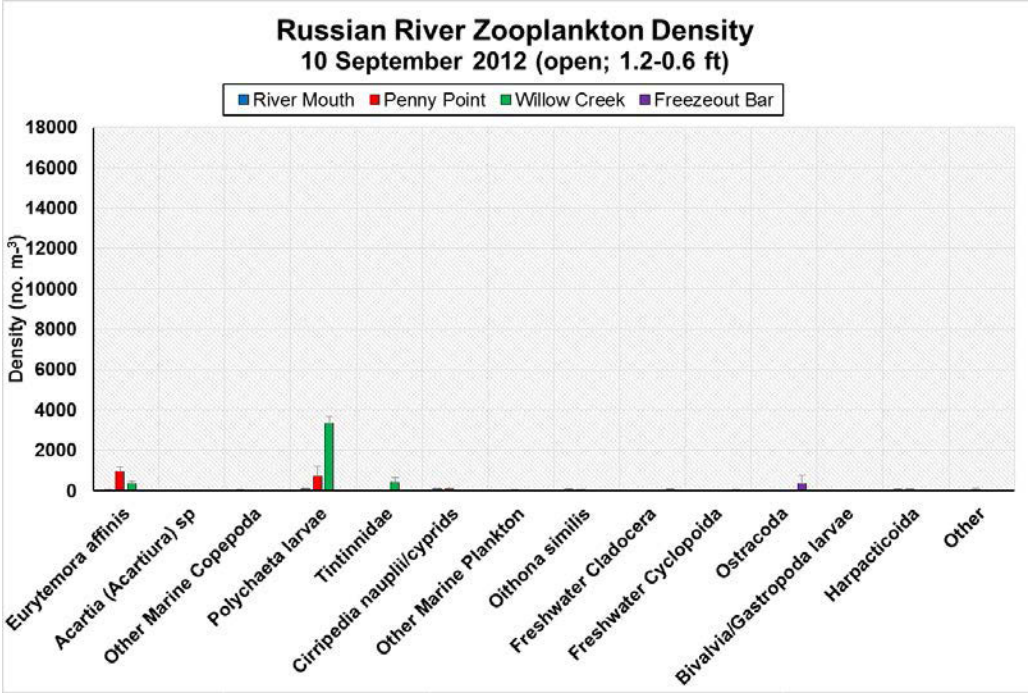



**Figure 4.2.26. Mean density (+1 s.d. error bar) of planktonic zooplankton in four reaches of Russian River estuary on 10 September 2012. Although many taxa were identified to species, some have been grouped into broader taxa categories for ease of interpretation.**

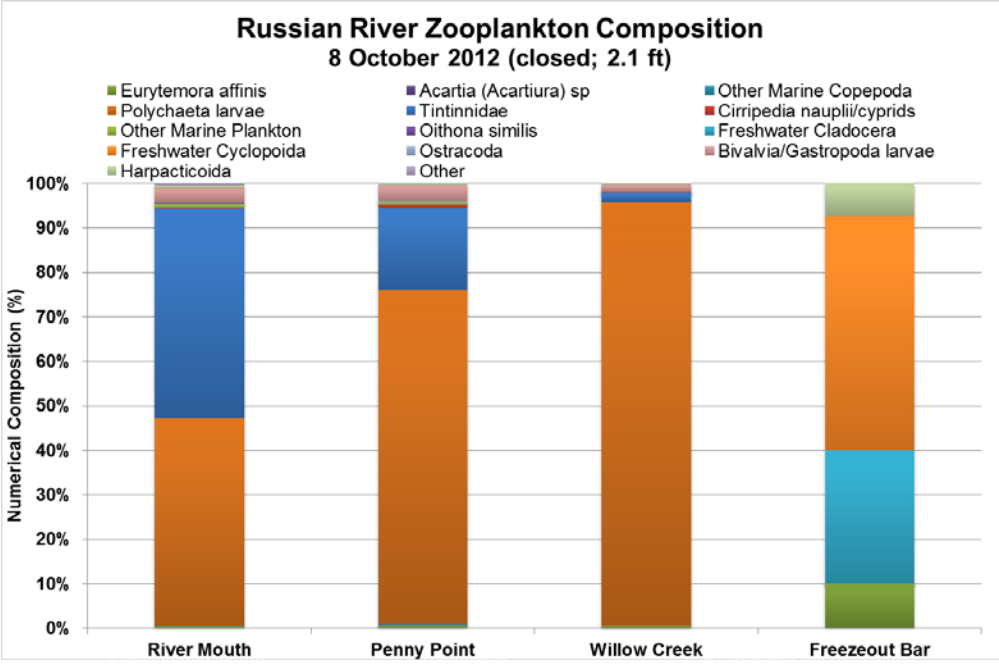



**Figure 4.2.27. Numerical composition of planktonic zooplankton in four reaches of Russian River estuary on 8 October 2012 Although many taxa were identified to species, some have been grouped into broader taxa categories for ease of interpretation.**

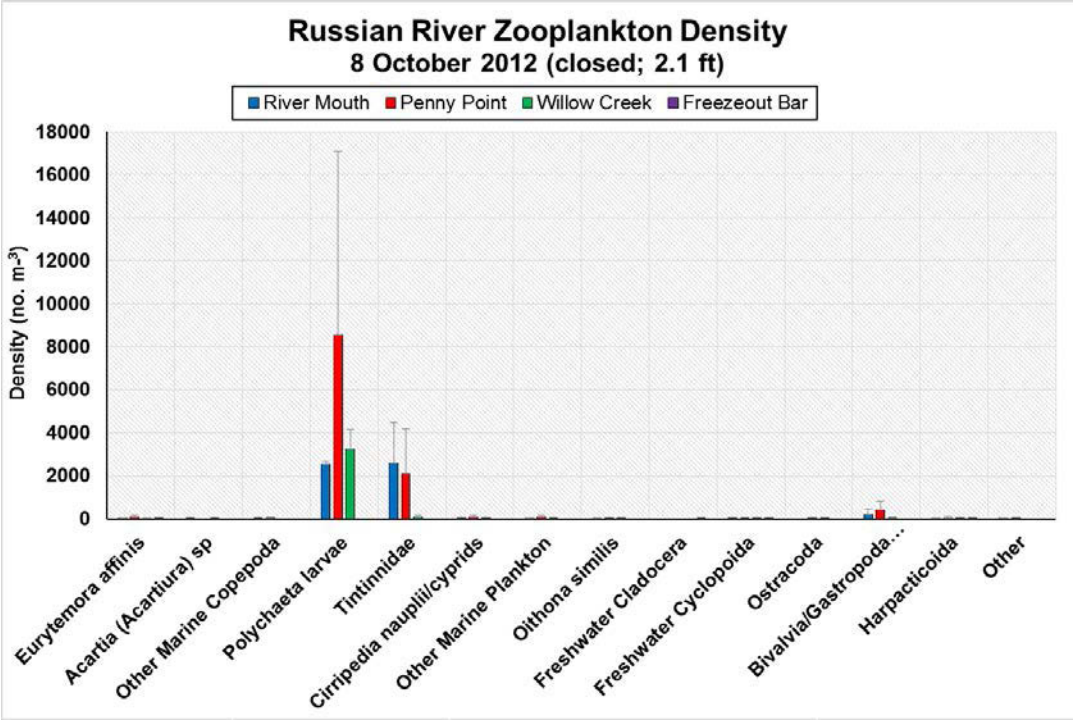



**Figure 4.2.28. Mean density (+1 s.d. error bar) of planktonic zooplankton in four reaches of Russian River estuary on 8 October 2012. Although many taxa were identified to species, some have been grouped into broader taxa categories for ease of interpretation.**

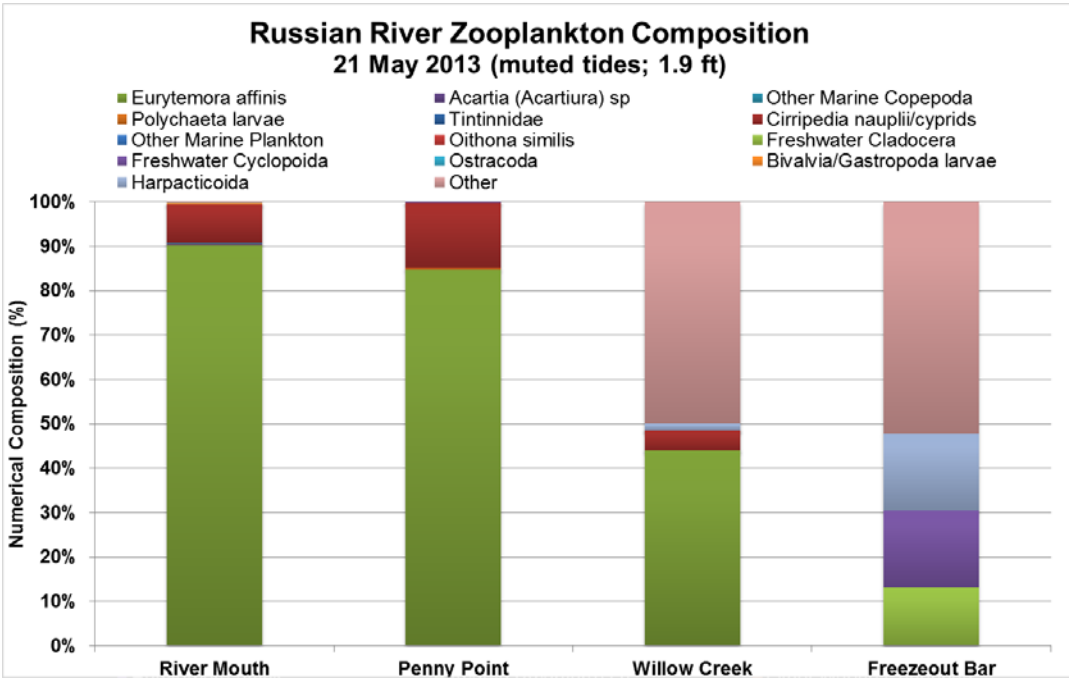



**Figure 4.2.29. Numerical composition of planktonic zooplankton in four reaches of Russian River estuary on 21 May 2012 Although many taxa were identified to species, some have been grouped into broader taxa categories for ease of interpretation.**

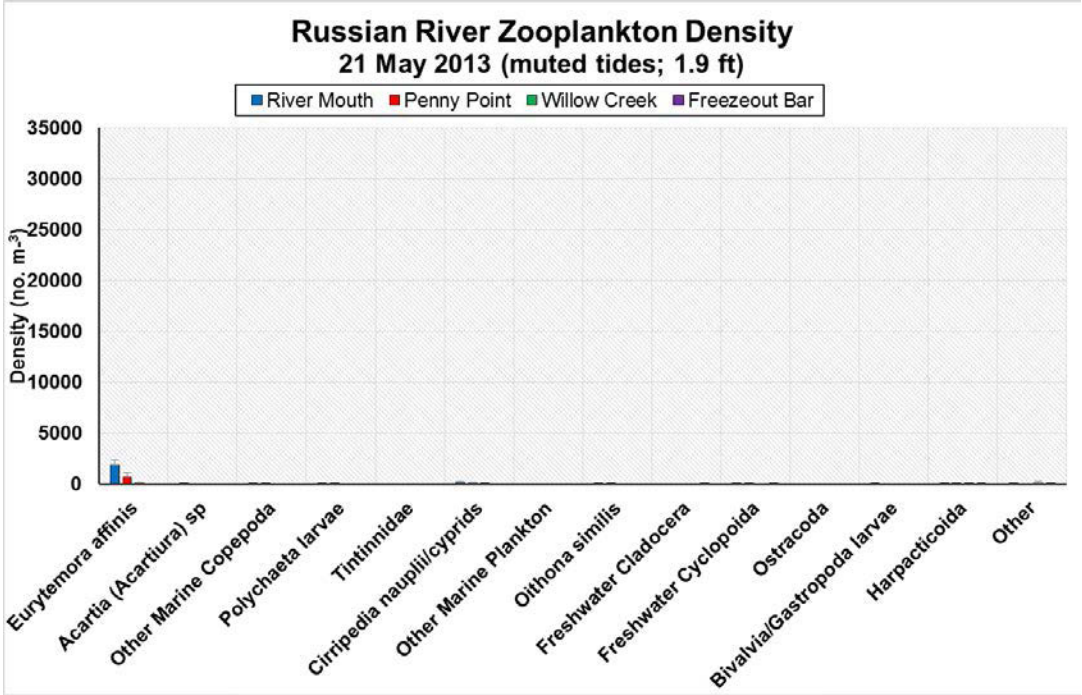



**Figure 4.2.30. Mean density (+1 s.d. error bar) of planktonic zooplankton in four reaches of Russian River estuary on 21 May 2013. Although many taxa were identified to species, some have been grouped into broader taxa categories for ease of interpretation.**

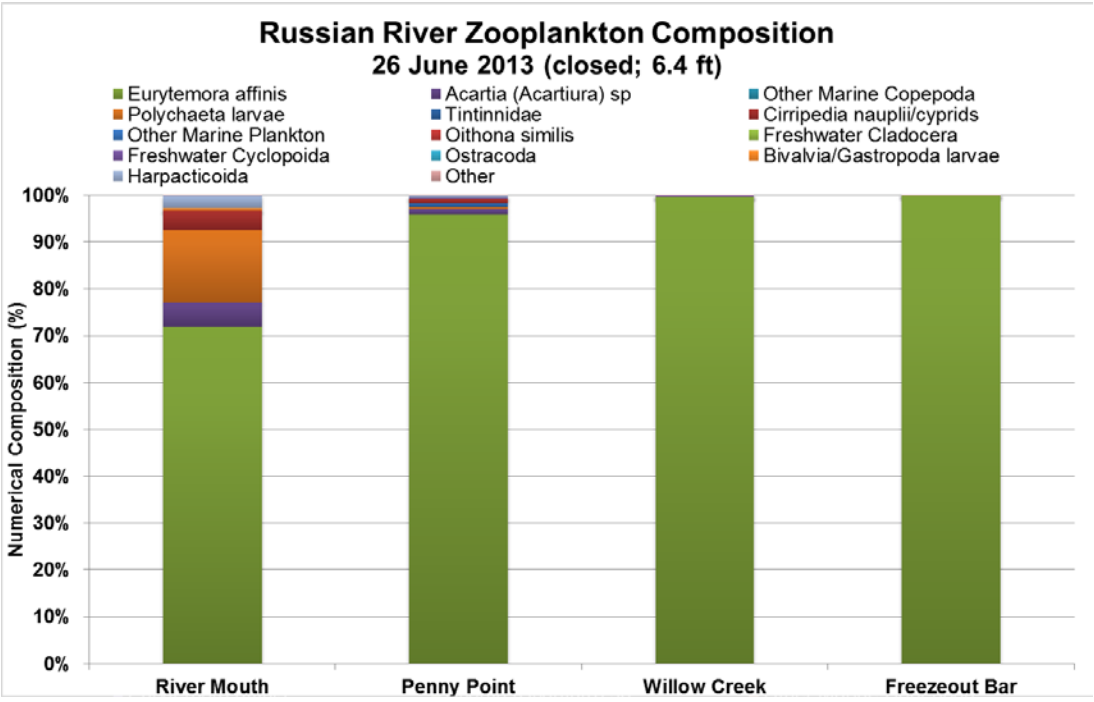



**Figure 4.2.31. Numerical composition of planktonic zooplankton in four reaches of Russian River estuary on 26 June 2013. Although many taxa were identified to species, some have been grouped into broader taxa categories for ease of interpretation.**

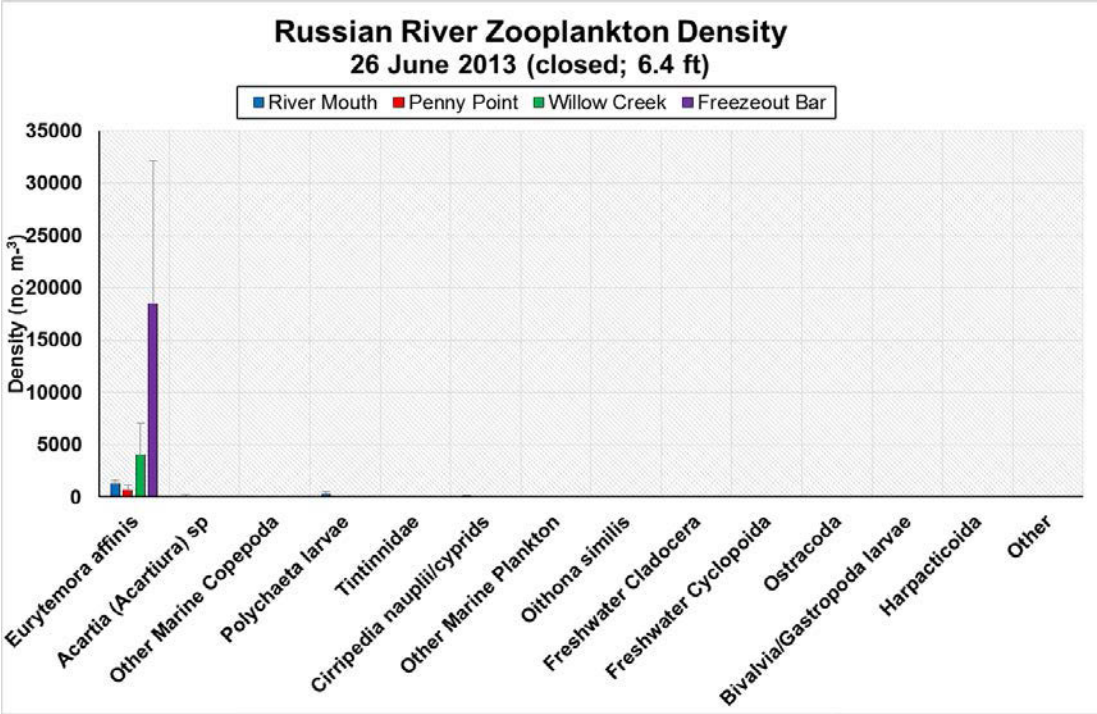



**Figure 4.2.32. Mean density (+1 s.d. error bar) of planktonic zooplankton in four reaches of Russian River estuary on 26 June 2013. Although many taxa were identified to species, some have been grouped into broader taxa categories for ease of interpretation.**

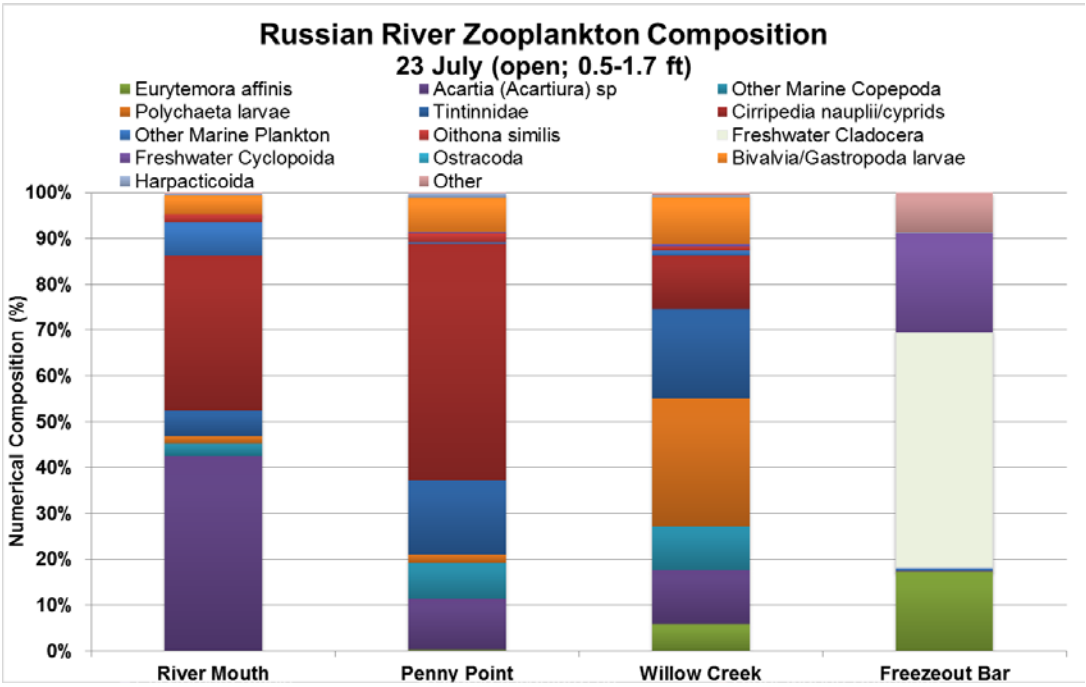



**Figure 4.2.33. Numerical composition of planktonic zooplankton in four reaches of Russian River estuary on 23 July 2013. Although many taxa were identified to species, some have been grouped into broader taxa categories for ease of interpretation.**

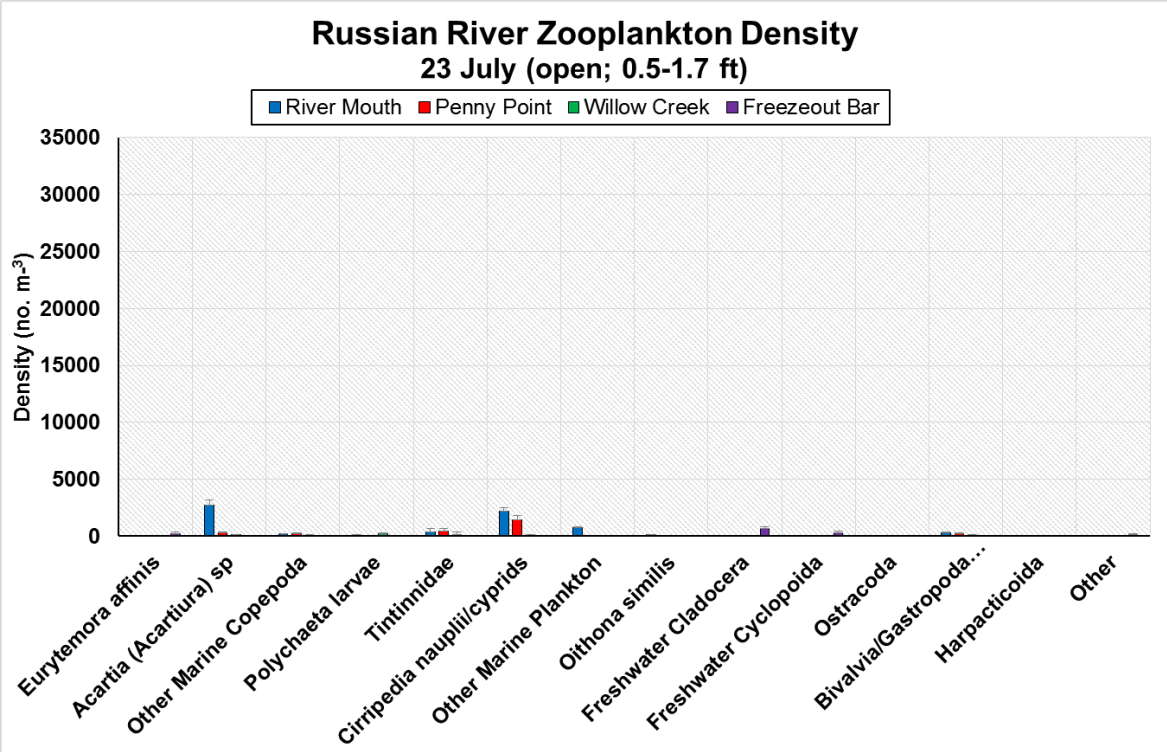



**Figure 4.2.34. Mean density (+1 s.d. error bar) of planktonic zooplankton in four reaches of Russian River estuary on 23 July 2013. Although many taxa were identified to species, some have been grouped into broader taxa categories for ease of interpretation.**

## References


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.

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.

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 2010-11. Sonoma County Water Agency, Santa Rosa, CA. p. 208

Manning, D.J. and J. Martini-Lamb, editors. 2012. Russian River Biological Opinion status and data report year 2011-12. Sonoma County Water Agency, Santa Rosa, CA. p. 208

## 4.3 Downstream Migrant Trapping

The Reasonable and Prudent Alternative (RPA) 2 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 passive integrated transponder (PIT)-tagging activities at selected sites upstream of the Estuary (Figure 4.3.1):

- Austin Creek;
- Dutch Bill Creek;
- Mark West Creek;
- Mainstem Russian River at Mirabel; and
- Dry Creek.

Stationary PIT antenna arrays were operated in the following locations:

- Upstream end of the Russian River estuary in Duncans Mills (riverkm 10.46);
- Near the mouth of Austin Creek (riverkm 0.5);
- Mainstem Russian River at Northwood (riverkm 19.16); and
- Near the mouth of Dry Creek (riverkm 0.36).

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 River, are presented elsewhere in this report.

### Methods

In 2013 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 2012, fish were physically captured at downstream migrant traps (rotary screw trap, funnel trap or pipe trap), 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.

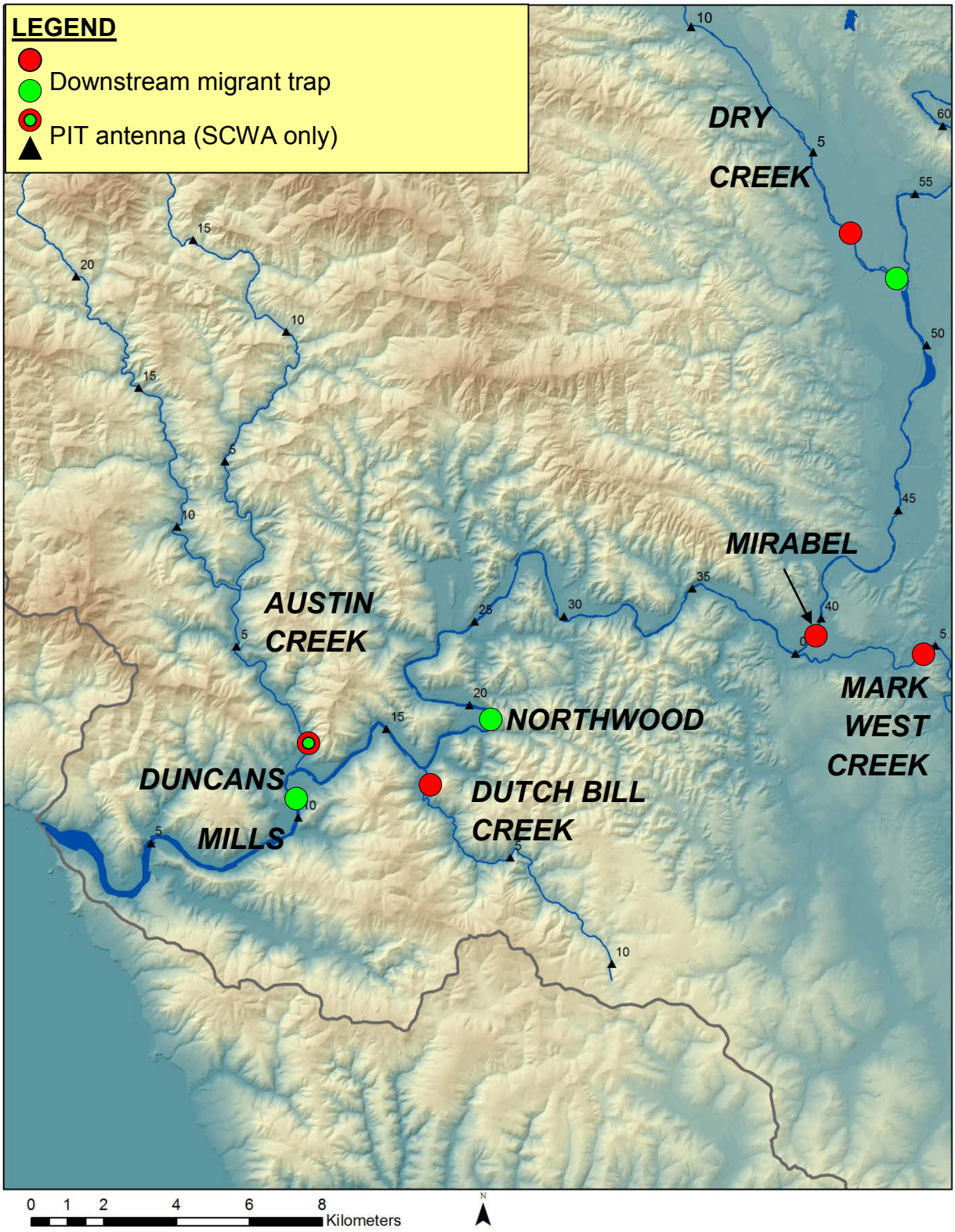



**Figure 114.3.1. Map of downstream migrant detection sites in the lower Russian River, 2013. Numbered dots along stream courses represent distance (km) from the mouth of each stream.**

*Estuary/Lagoon PIT antenna systems*

A flat plate antenna array (designed to lay flat on the stream bottom) was used in the upper Russian River estuary near the town of Duncans Mills (riverkm 10.46) to detect fish entering the Estuary. In 2013, 5 flat plate antennas were installed and operating before the beginning of the downstream migrant trapping season. Between April 15 and April 16, we installed an additional 7 antennas for a total of 12 antennas at this single location (Figure 4.3.2). The 12 antennas remained in place for the remainder of 2013 except for brief periods when antenna maintenance was necessary. Despite the fact that the array spanned the Estuary, detection of PIT-tagged individuals passing the site was less than 100%.

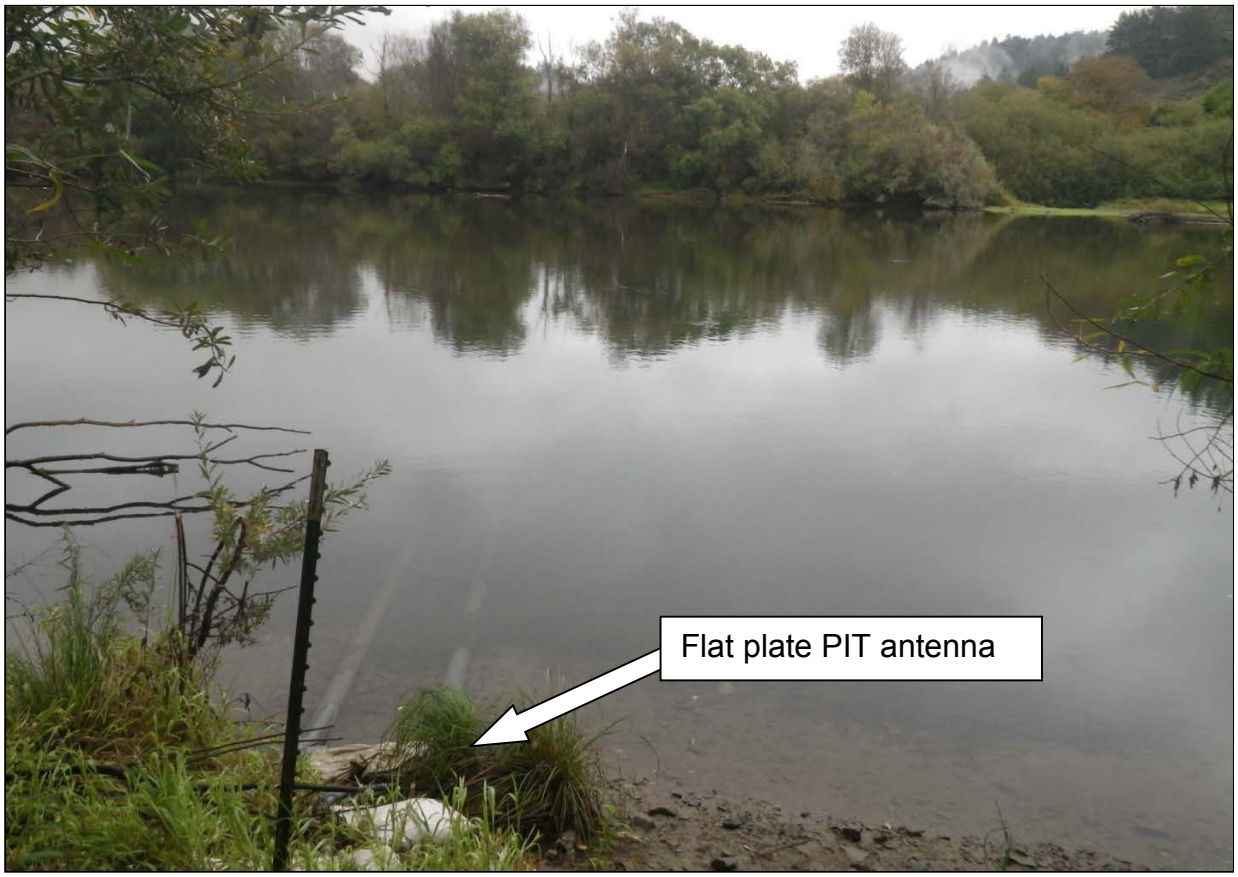



**Figure 124.3.2. First flat plate antenna in the 12 antenna array at Duncans Mills.**

For the first time in 2013, a flat plate PIT antenna 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 lower 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 of

the river channel, 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 4.3.1) 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 4.3.1). The Water Agency operated three types of downstream migrant traps in 2013: rotary screw trap, funnel trap and pipe trap, depending on the stream, water depth, and velocity (Figure 4.3.3). 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 ($\pm$1 mm) and weighed ($\pm$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 capture of steelhead YOY and parr $\geq$60 mm in fork length. Growth data collected from fish originally PIT-tagged in lower river traps then recaptured during beach seining surveys is covered in the Chapter 10 - *Synthesis* chapter of this report.

### *Austin Creek*

A funnel trap was installed on Austin Creek on April 17. To increase trap efficiency, wood-frame/plastic-mesh weir panels were installed to direct fish and flow into the screw trap (Figure 4.3.4). By early May, the funnel trap was not fishing effectively due to low stream velocities; therefore, on May 9 the funnel trap was replaced with a pipe trap that fished through the end of the trapping season on June 18. The funnel trap consisted of wood-frame/plastic-mesh weir panels, a funnel net and a wooden live box. The pipe trap consisted of the same materials except that the funnel net was replaced with a 7 m long, 15 cm diameter pipe. Trapping continued until surface flow in lower Austin Creek was no longer contiguous and daily catches of steelhead dropped rapidly (Table 4.3.1).

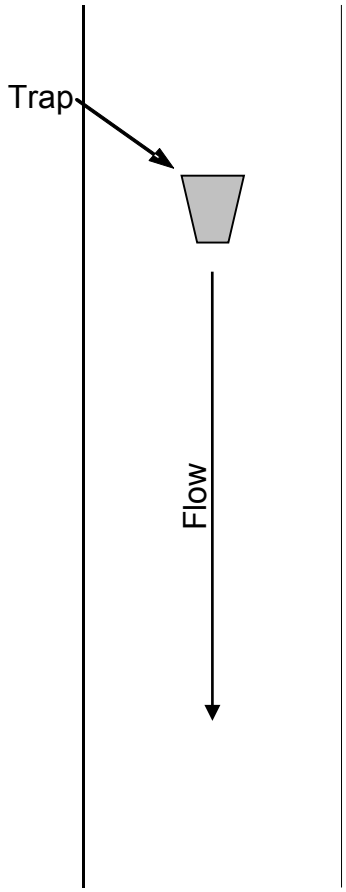
Because of concern over delaying fish migration, PIT-tagged fish were not released upstream of the trap. Therefore we were unable to measure trap efficiency and construct a population estimate. However we continued to PIT-tag juvenile steelhead and operate a PIT-tag antenna downstream of the trap. A dual antenna PIT antenna

**Austin Creek:** funnel trap (fished 4/17-5/8) and switched to a pipe trap (5/9-6/18).

**Dutch Bill Creek:** Pipe trap (4/18-5/26).

**Mark West Creek:** Rotary screw trap (fished 3/28-5/21) switched to pipe trap (fished 5/22-7/2).

**Figure 134.3.3. Photographs of downstream migrant traps operated by the Water Agency (Austin, Dutch Bill, and Mark West Creeks). See other sections of this report for details regarding operation of the Mirabel and Dry Creek traps.**




**1. Methods:**

Capture and PIT-tag juvenile steelhead, then release newly tagged fish downstream.

**2. Estimating antenna efficiency:**

Of the PIT-tagged fish detected on the downstream antenna in the array (antenna B), what proportion were also detected on the upstream antenna (antenna A)?

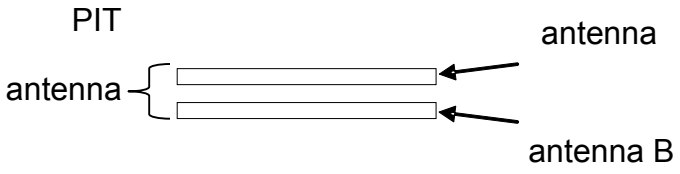



**Figure 144.3.4. Diagram illustrating the relative location of the downstream migrant trap and PIT antenna array operated on Austin Creek and outline of how antenna efficiency was estimated.**

**Table 34.3.1. Installation and removal dates, and total number of days fished for lower river monitoring sites operated by the Water Agency in 2013.**

| Monitoring site (gear type) | Installation date | Removal date | Number of days fished |
|---|---|---|---|
| Duncans Mills (PIT antenna array)[1] | continuous (not removed) | continuous (not removed) | Entire downstream migration season |
| Austin Creek (DSMT) | 4/17 | 6/18 | 63 |
| Northwood (PIT antenna array) | 5/20 | 7/27 | 68 |
| Dutch Bill Creek (DSMT) | 4/18 | 5/26 | 32 |
| Mark West Creek (DSMT) | 3/28 | 7/2 | 81 |
| Mirabel (DSMT) | 3/27 | 7/31 | 101 |
| Dry Creek (DSMT) | 3/26 | 7/31 | 118 |

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

array was installed on April 13, approximately 0.2 km downstream of the rotary screw trap in order to detect PIT-tagged steelhead moving out of Austin Creek. The PIT antenna array was located approximately 0.5 km upstream from the mouth of Austin Creek 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.

### 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 18. The trap was fished until the completion of trapping operations on May 26 when stream flow in lower Dutch Bill Creek became disconnected (Table 4.3.1).

### Mark West Creek

A five foot rotary screw trap was installed on Mark West Creek approximately 4.8 km upstream of the mouth on March 28. On May 21 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 July 2 when fish captures dropped off rapidly (Table 4.3.1).

### Mainstem Russian River at Mirabel

Two rotary screw traps (one 5 foot and one 8 foot 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) from March 27 to July 31 (Table 4.3.1). The purpose of this trap was to fulfill a broader set of objectives in the Russian River Biological Opinion than what is described in the current section of this report. However, one of the objectives was to provide a

source of PIT-tagged steelhead juveniles that may enter the Estuary and be detected during downstream monitoring efforts. Therefore, we report the number of steelhead that we applied PIT tags to at the Mirabel downstream migrant trapping site in the *Results* section. Other methods and results related to the Mirabel fish trapping effort are detailed in the *Wohler-Mirabel Water Diversion Facility* chapter of this report.

### Dry Creek

A 5-foot rotary screw trap was installed at the West Side Road crossing (approximately 3.3 km upstream of the confluence with the Russian River) on March 26 and removed on July 31. Similar to Mirabel, the Dry Creek trap is operated to fulfill a broader set of objectives in the Russian River Biological Opinion. The Water Agency began PIT-tagging steelhead at this location for the first time in 2013. The effort was intended to increase our understanding of whether juvenile steelhead from Dry Creek use the Russian River estuary prior to smoltification. We also operated a multiple PIT-antenna array near the mouth of Dry Creek (river km 0.36) to satisfy objectives related to Coastal Monitoring Plan implementation. This effort proved useful for detecting PIT-tagged steelhead as they emigrated from Dry Creek. The results of steelhead tagging in Dry Creek will be reported in the *Results* section, but for detailed downstream migrant trapping information in Dry Creek see the *Dry Creek Habitat Enhancement, Planning, and Monitoring* chapter of this report.

#### Results

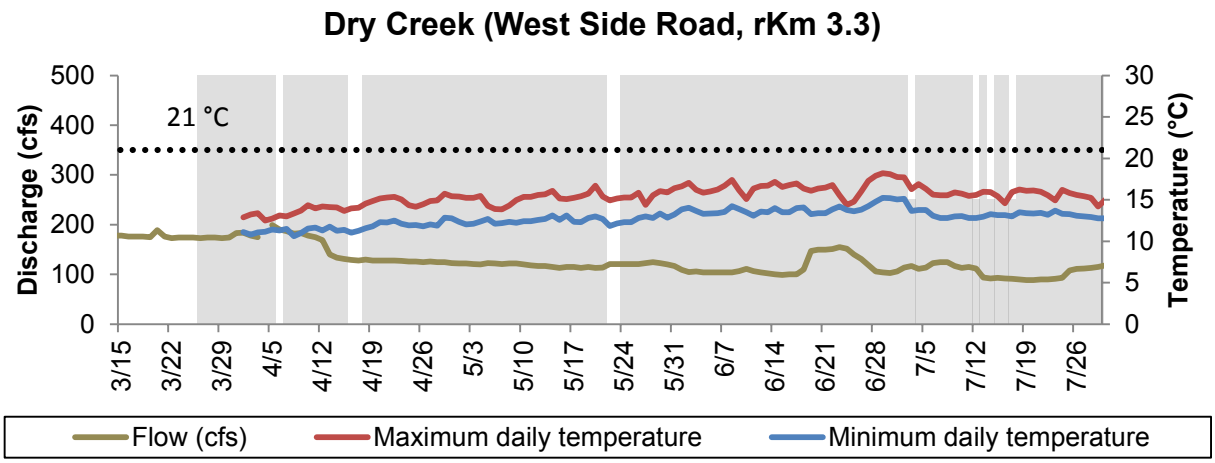
Stream flow largely dictates when downstream migrant traps can be installed (Figure 4.3.5). Our sampling period most likely encompassed a high portion of the juvenile steelhead movement period, but we probably missed a substantial portion of the steelhead smolt migration period.

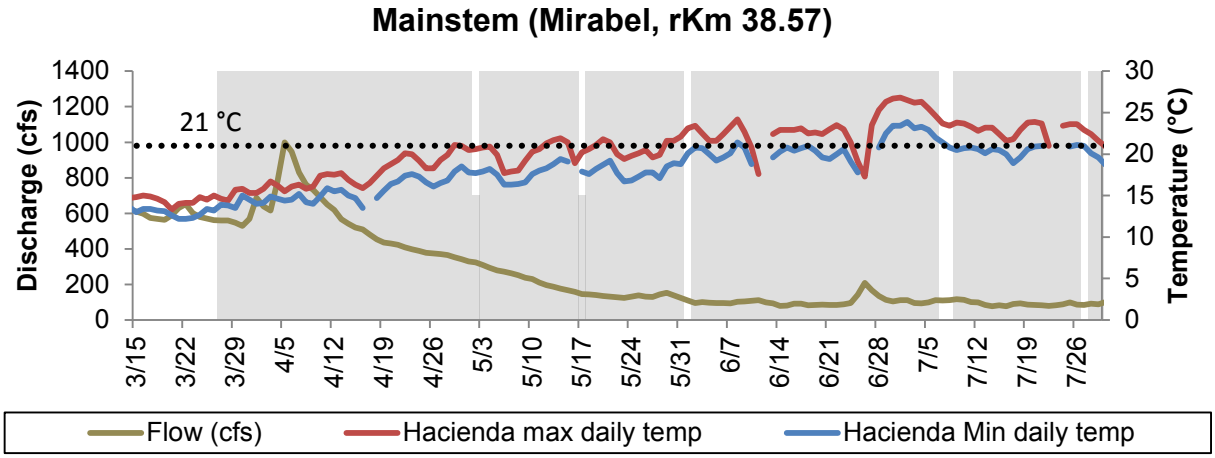
*Estuary/Lagoon PIT antenna systems*

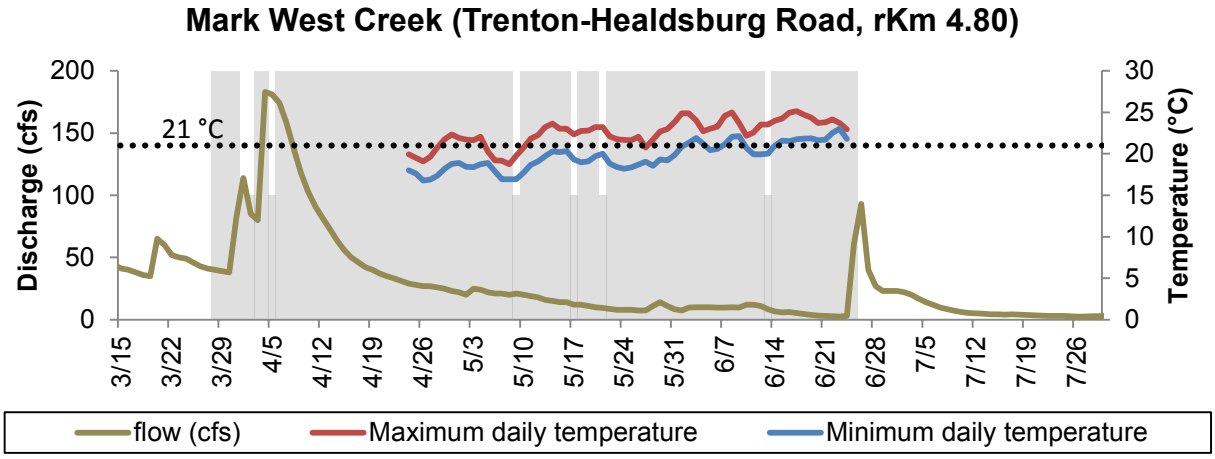
### Steelhead

Steelhead were most frequently encountered in Dry and Austin Creeks while only 97 steelhead were captured in Dutch Bill Creek (Figure 4.3.6). Of the 5,101 juvenile steelhead that were PIT-tagged in downstream migrant traps in 2013, 472 (9.2%) were detected on the PIT antenna array at Duncans Mills (Table 4.3.2). 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 more steelhead in 2013 (total=5,101) than in prior years (Table 4.3.3).


Dry Creek (West Side Road, rKm 3.3)
Discharge (cfs)
Temperature (°C)
21 °C
500
400
300
200
100
0
30
25
20
15
10
5
0
3/15
3/22
3/29
4/5
4/12
4/19
4/26
5/3
5/10
5/17
5/24
5/31
6/7
6/14
6/21
6/28
7/5
7/12
7/19
7/26
Flow (cfs)
Maximum daily temperature
Minimum daily temperature


Mainstem (Mirabel, rKm 38.57)
Discharge (cfs)
Temperature (°C)
21 °C
1400
1200
1000
800
600
400
200
0
30
25
20
15
10
5
0
3/15
3/22
3/29
4/5
4/12
4/19
4/26
5/3
5/10
5/17
5/24
5/31
6/7
6/14
6/21
6/28
7/5
7/12
7/19
7/26
Flow (cfs)
Hacienda max daily temp
Hacienda Min daily temp


Mark West Creek (Trenton-Healdsburg Road, rKm 4.80)
Discharge (cfs)
Temperature (°C)
21 °C
200
150
100
50
0
30
25
20
15
10
5
0
3/15
3/22
3/29
4/5
4/12
4/19
4/26
5/3
5/10
5/17
5/24
5/31
6/7
6/14
6/21
6/28
7/5
7/12
7/19
7/26
flow (cfs)
Maximum daily temperature
Minimum daily temperature

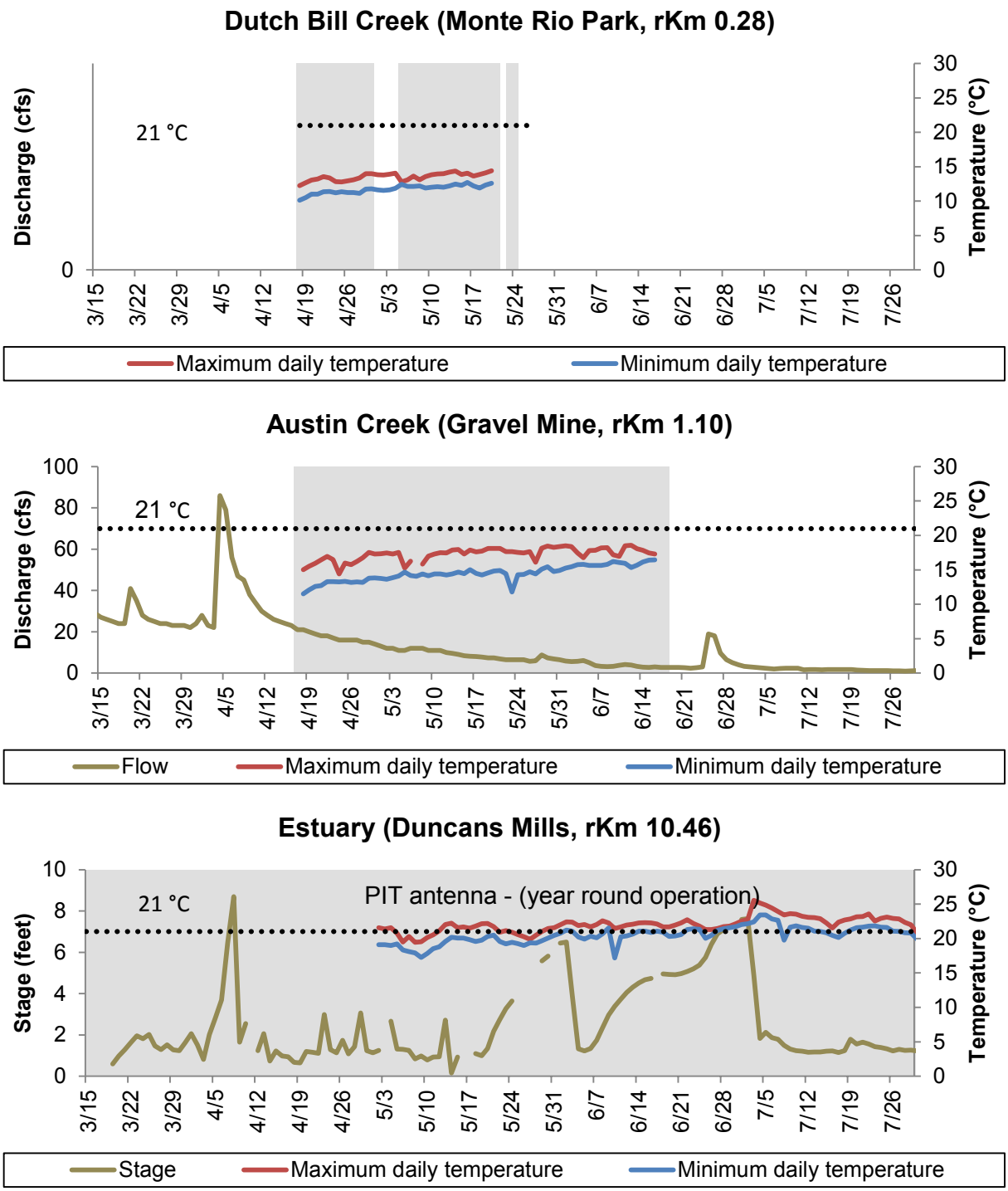
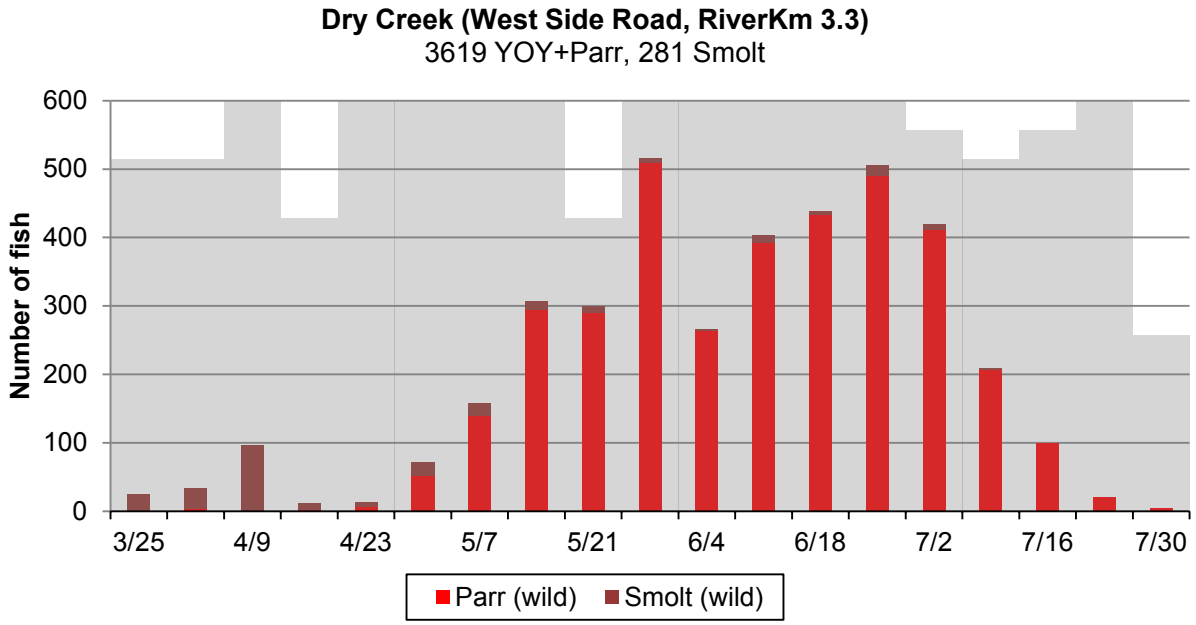
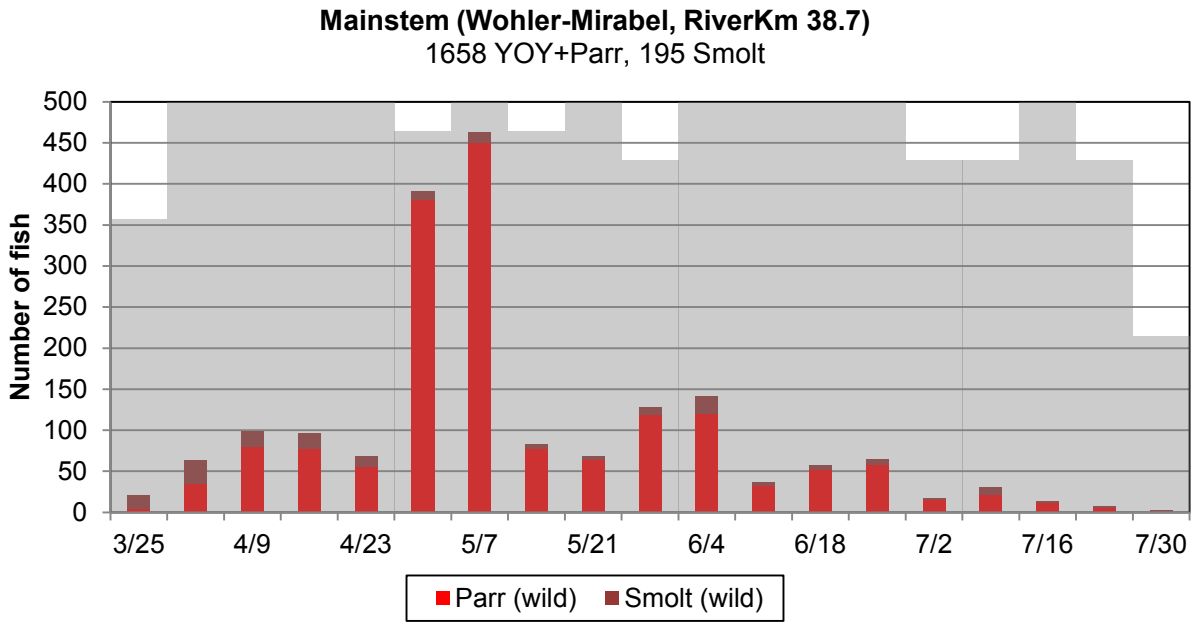
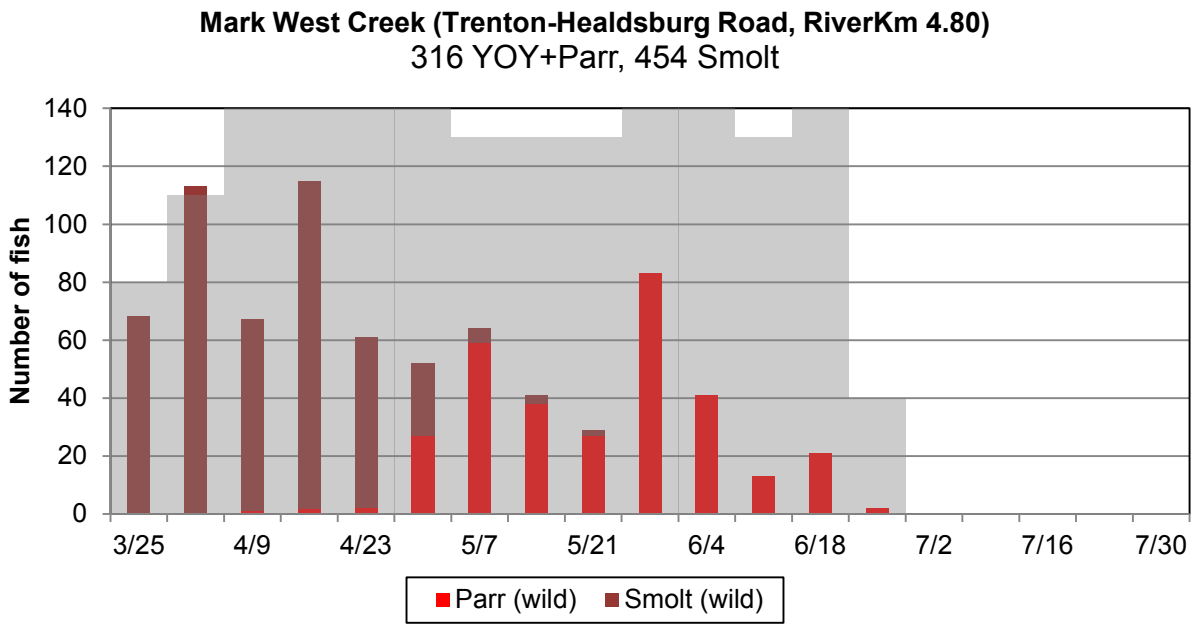
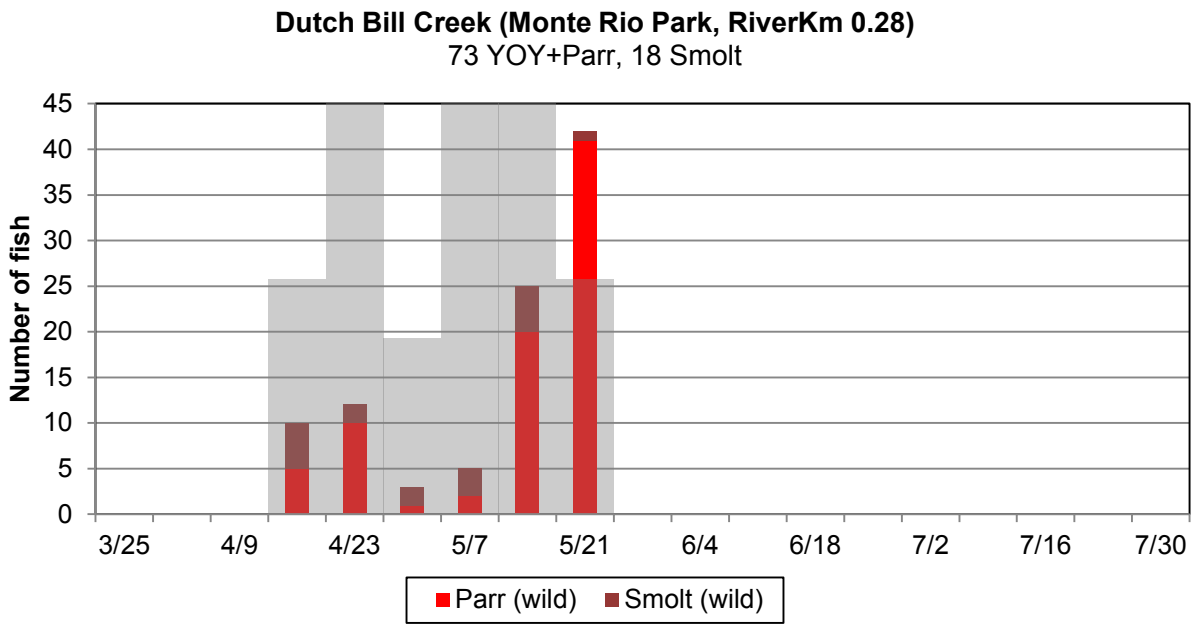



**Figure 154.3.5. Environmental conditions at downstream migrant detection sites from March 15 to July 31. Gray shading indicates the proportion of each day that each facility was operated and discharge data are from the USGS gage at Haceinda (mainstem, 11467000), the USGS gage at Trenton-Healdsburg Road (Mark West Creek, 11466800) 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 can not be measured, weighed or PIT tagged).**


Dry Creek (West Side Road, RiverKm 3.3)
3619 YOY+Parr, 281 Smolt
Number of fish
600
500
400
300
200
100
0
3/25
4/9
4/23
5/7
5/21
6/4
6/18
7/2
7/16
7/30
Parr (wild)
Smolt (wild)


Mainstem (Wohler-Mirabel, RiverKm 38.7)
1658 YOY+Parr, 195 Smolt
Number of fish
500
450
400
350
300
250
200
150
100
50
0
3/25
4/9
4/23
5/7
5/21
6/4
6/18
7/2
7/16
7/30
Parr (wild)
Smolt (wild)


Mark West Creek (Trenton-Healdsburg Road, RiverKm 4.80)
316 YOY+Parr, 454 Smolt
Number of fish
140
120
100
80
60
40
20
0
3/25
4/9
4/23
5/7
5/21
6/4
6/18
7/2
7/16
7/30
Parr (wild)
Smolt (wild)


Dutch Bill Creek (Monte Rio Park, RiverKm 0.28)
73 YOY+Parr, 18 Smolt
Number of fish
45
40
35
30
25
20
15
10
5
0
3/25
4/9
4/23
5/7
5/21
6/4
6/18
7/2
7/16
7/30
Parr (wild)
Smolt (wild)

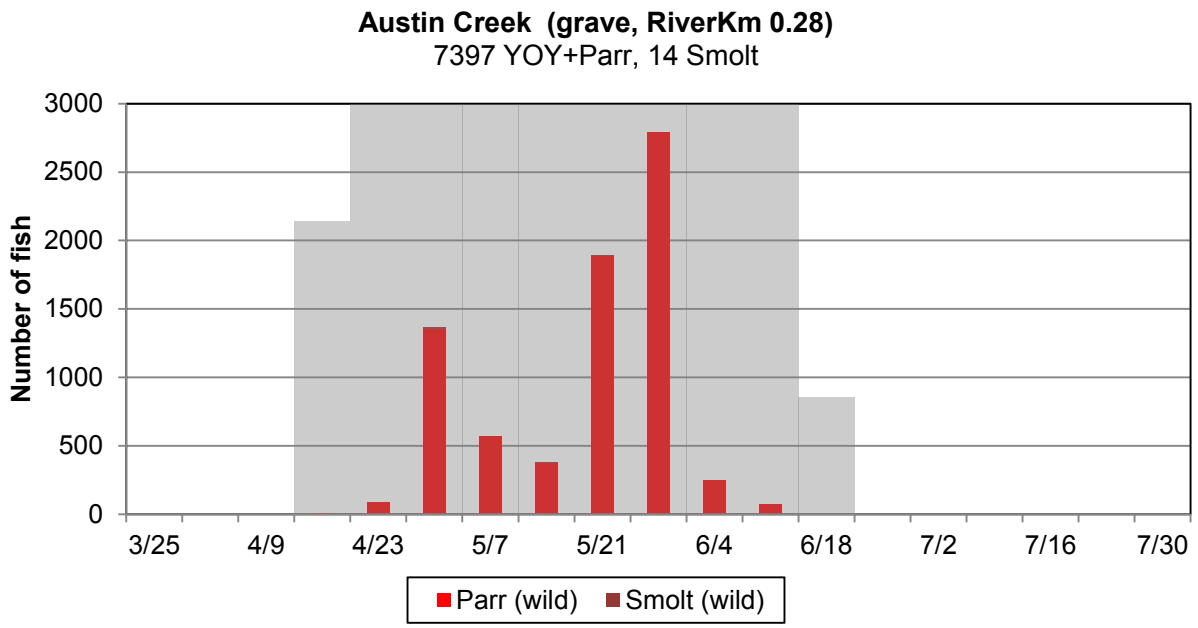



**Figure 164.3.6. Weekly capture of steelhead by life stage at lower river downstream migrant trapping sites, 2013. Gray shading indicates portion of each week trap was fishing. Note the different vertical scale among plots for each site.**

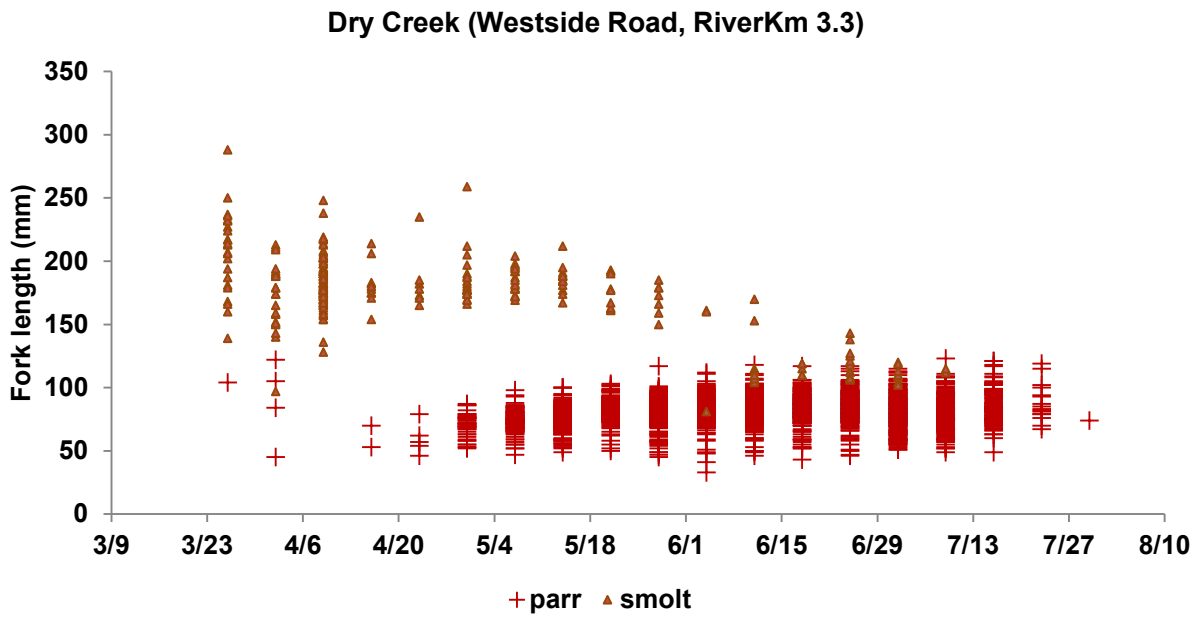
**Table 44.3.2. The number of steelhead captured at downstream migrant traps, the number PIT tagged and the number detected on the Duncans Mills PIT tag detection systems, 2013.**

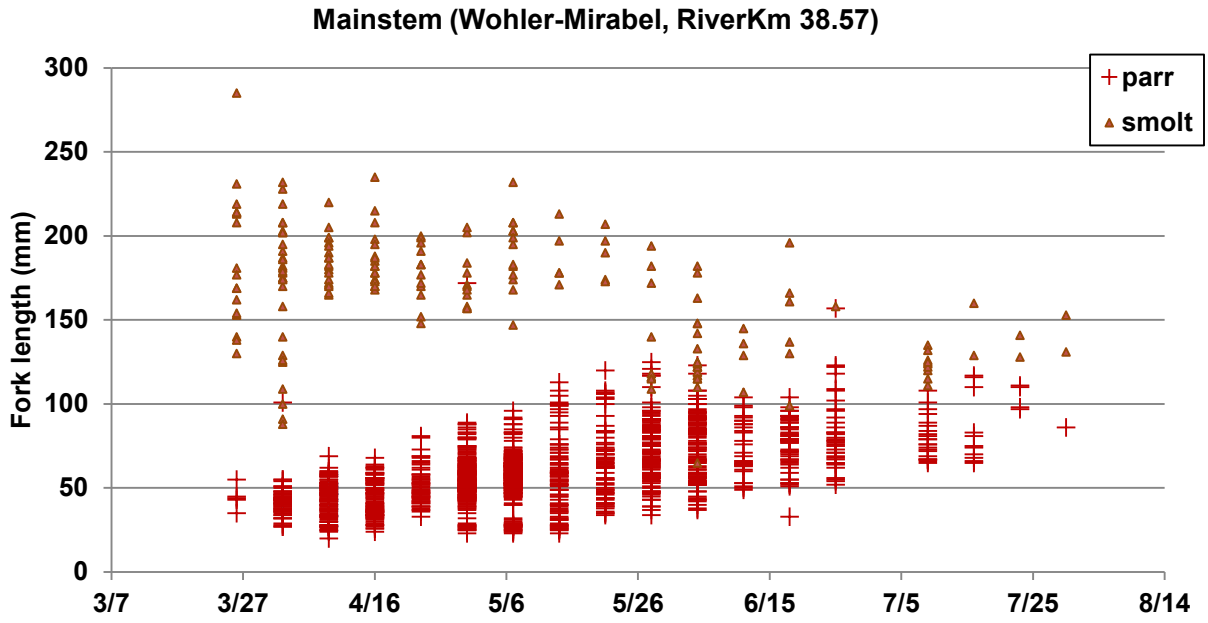
| Site | Number Captured | PIT Tagged | Detected at Duncans Mills |
|---|---|---|---|
| Dry Creek | 3,893 | 2,704 | 6 (0.2%) |
| Mainstem | 2,573 | 501 | 1 (0.2%) |
| Mark West Creek | 799 | 135 | 1 (0.7%) |
| Dutch Bill Creek | 97 | 12 | 2 (17%) |
| Austin Creek | 7,411 | 1,749 | 463 (26%) |

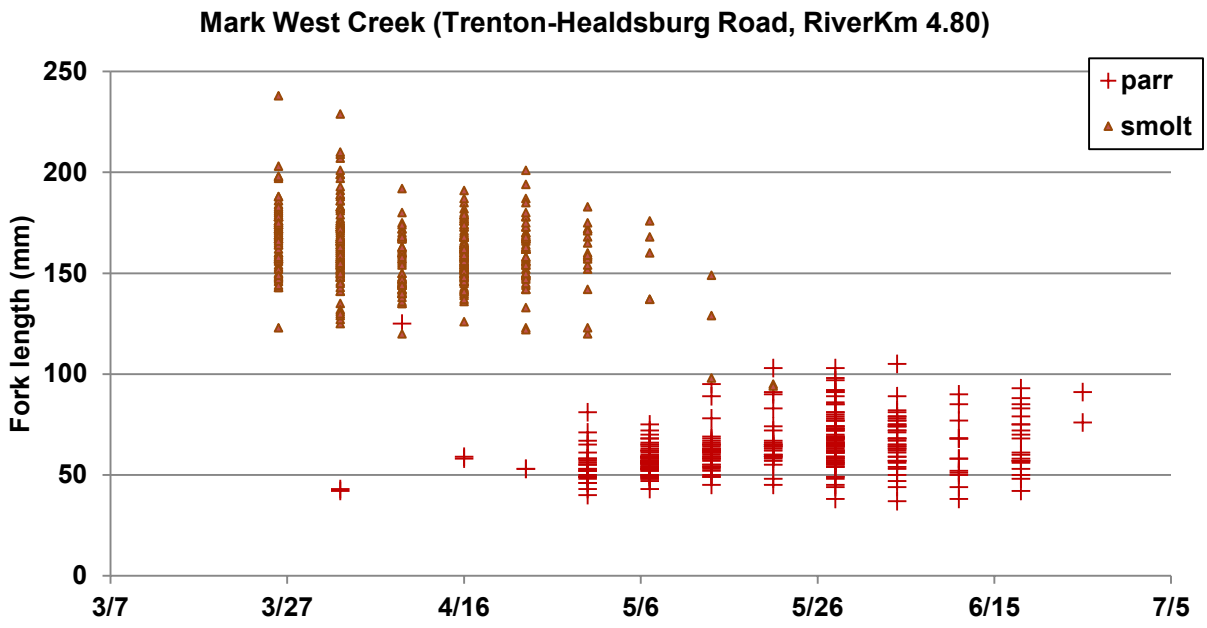
Table 54.3.3. Number of steelhead juveniles PIT-tagged at downstream migrant monitoring traps, 2009-2013.

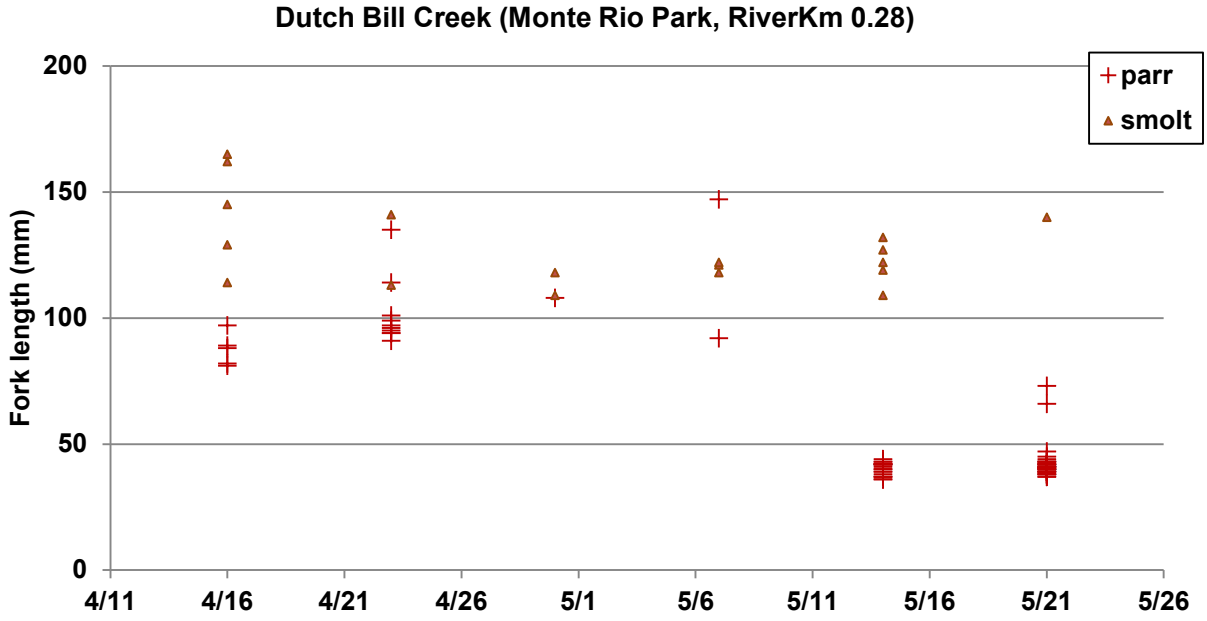
| Site | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|
| Dry Creek | No tagging | No tagging | No tagging | No tagging | 2,704 |
| Mainstem (Mirabel) | 17 | 96 | 100 | 312 | 501 |
| Mark West Creek | Not fished | Not fished | Not fished | 43 | 135 |
| Green Valley Creek | No tagging | 17 | 0 | Not fished | Not fished |
| Dutch Bill Creek | Not fished | 46 | 23 | 6 | 12 |
| Austin Creek | Not fished | 997 | 500 | 1,639 | 1,749 |
| Estuary fyke net | 4 | No trapping | No trapping | No trapping | No trapping |
| **Total** | **21** | **1,156** | **623** | **2,000** | **5,101** |

Of the 1,749 steelhead PIT-tagged at Austin Creek, a minimum of 463 moved downstream because they were detected on the downstream PIT antenna array in Duncans Mills. Of those 463 individuals, 399 were also detected on the Austin Creek antenna array resulting in an estimated site efficiency at Austin Creek of 86.2% (399/463). A total of 1,335 individual steelhead juveniles were detected on the Austin Creek PIT tag antennas. Based on this antenna efficiency, the expanded count of PIT-tagged juveniles that likely left Austin Creek and entered the Estuary is 1,549 (1335/0.86) which represents 88.6% of the total number of steelhead juveniles PIT-tagged in Austin Creek in 2013 (1,549/1,749). Based on weekly length frequency distributions (Figure 4.3.7), we estimate that the total number of YOY captured in Austin Creek in 2013 that were ≥60 mm fork length was 4,216. Therefore, assuming the rate of emigration from Austin Creek was similar for PIT-tagged and non-PIT-tagged fish, we estimate that a minimum total of 88.6% (3,735 individuals) that were ≥60 mm in fork length emigrated from Austin Creek in 2013. Because trap efficiency was not estimated in 2013, this is a minimum number. The Austin Creek trap catch and population estimate has varied over the three years estimates have been possible (2010-12), but the estimated emigration rate (proportion of PIT-tagged YOY ≥60 mm that emigrated) has remained fairly similar among years (Table 4.3.4).


Dry Creek (Westside Road, RiverKm 3.3)
Fork length (mm)
350
300
250
200
150
100
50
0
3/9
3/23
4/6
4/20
5/4
5/18
6/1
6/15
6/29
7/13
7/27
8/10
parr
smolt


Mainstem (Wohler-Mirabel, RiverKm 38.57)
Fork length (mm)
300
250
200
150
100
50
0
3/7
3/27
4/16
5/6
5/26
6/15
7/5
7/25
8/14
parr
smolt


Mark West Creek (Trenton-Healdsburg Road, RiverKm 4.80)
Fork length (mm)
250
200
150
100
50
0
3/7
3/27
4/16
5/6
5/26
6/15
7/5
parr
smolt


Dutch Bill Creek (Monte Rio Park, RiverKm 0.28)
Fork length (mm)
200
150
100
50
0
4/11
4/16
4/21
4/26
5/1
5/6
5/11
5/16
5/21
5/26
parr
smolt

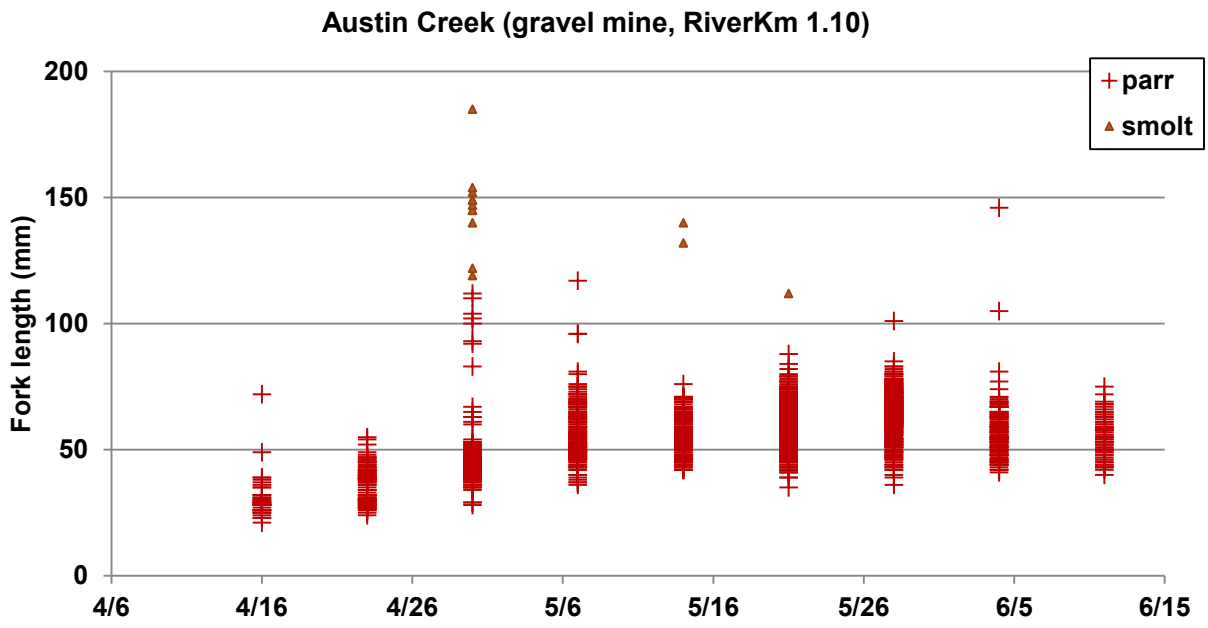


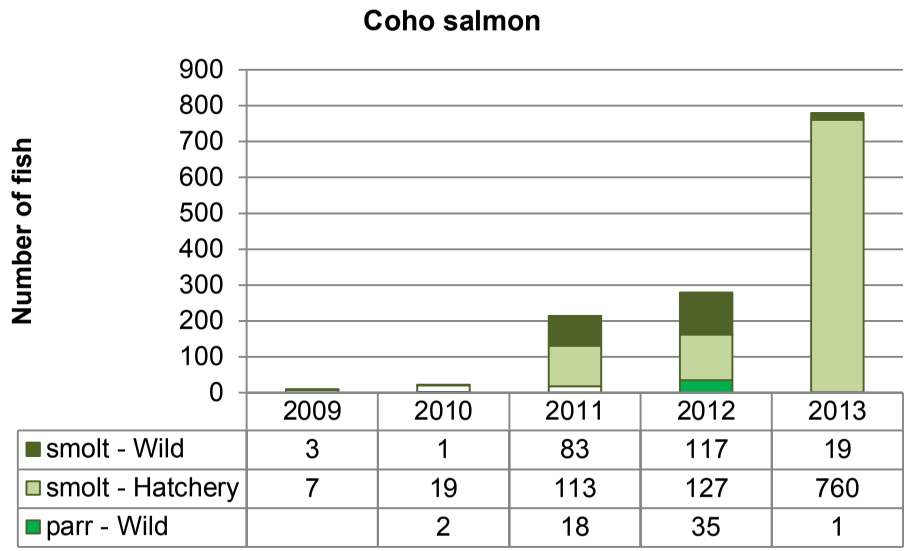

Figure 174.3.7. Weekly fork lengths of steelhead captured at lower river downstream migrant trap sites, 2013.

**Table 64.3.4. 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 |
|---|---|---|---|---|
| Number PIT-tagged YOY released upstream of trap | 765 | 324 | 1,356 | 0 |
| Number PIT-tagged YOY released downstream of trap | 195 | 2 | 162 | 1,746 |
| Number PIT-tagged YOY detected on antenna array that were tagged in Austin Creek | 547 | 131 | 574 | 1,335 |
| Number PIT-tagged YOY released upstream & detected on antenna array | 389 | 131 | 486 | 0 |
| Number released upstream & recaptured in trap & detected on antenna | 47 | 8 | 196 | 0 |
| **ESTIMATED TRAP EFFICIENCY** | **12.1%** | **6.1%** | **40.3%** | **N/A** |
| Number YOY+parr detected on both antennas in array | 241 | 93 | 85 | 399 |
| Number YOY+parr detected on downstream antenna only | 288 | 178 | 129 | 463 |
| **ESTIMATED ANTENNA EFFICIENCY** | **83.6%** | **52.2%** | **65.9%** [1] | **86.2%** [1] |
| Number YOY captured and PIT-tagged | 960 | 324 | 1,518 | 1,746 |
| Total number of YOY captured (≥60 mm only) | 2,617 | 453 | 2,341 | 4,216 |
| **ESTIMATED NUMBER OF PIT-TAGGED YOY EMIGRANTS (≥60 mm only)** | **632** | **251** | **759** | **1,549** |
| **ESTIMATED PROPORTION OF PIT-TAGGED YOY THAT EMIGRATED (≥60 mm only)** | **65.8%** | **77.5%** | **50%** | **88.5%** |
| **ESTIMATED POPULATION SIZE OF YOY AT TRAP** | **21,628** | **7,426** | **5,804** | **N/A** |
| **ESTIMATED NUMBER OF YOY IN POPULATION THAT EMIGRATED** | **14,231** | **5,755** | **2,901** | **N/A** |

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

In 2013, smaller numbers of juvenile steelhead were captured at Mirabel, Mark West and Dutch Bill creeks (Figure 4.3.6), meaning that fewer numbers of juvenile steelhead were PIT-tagged (Table 4.3.3). Fork lengths of fish caught at these traps show at least three year classes with steelhead YOY present at each of the trapping locations (Figure 4.3.7). 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 at Mirabel has shown an increasing trend since 2009 (Figure 4.3.9), with no apparent similar trend at other trap locations (Figure 4.3.8 through 4.3.12).



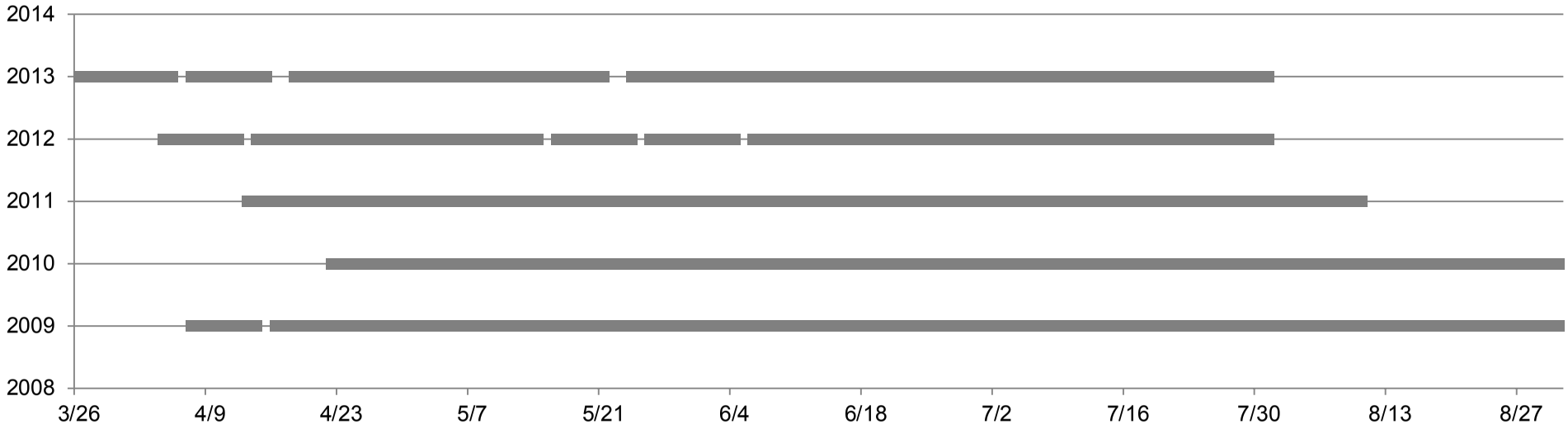
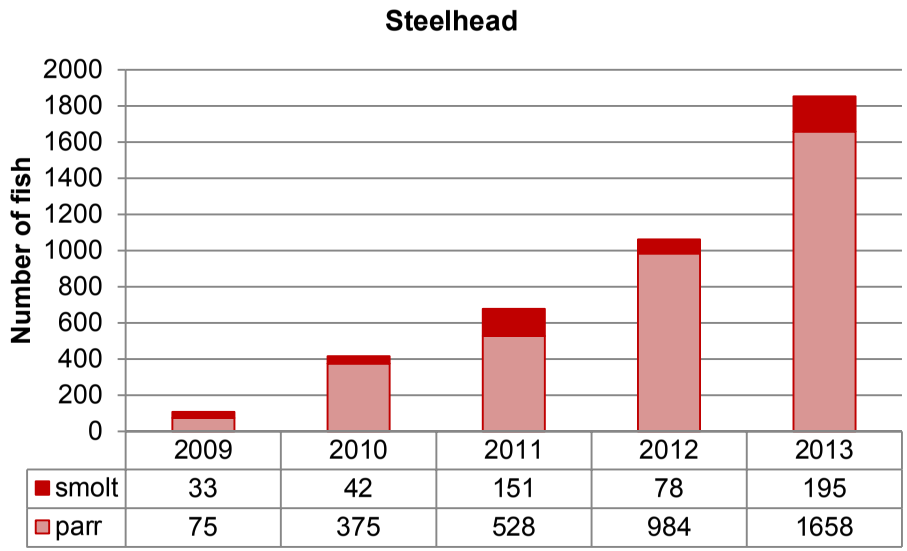
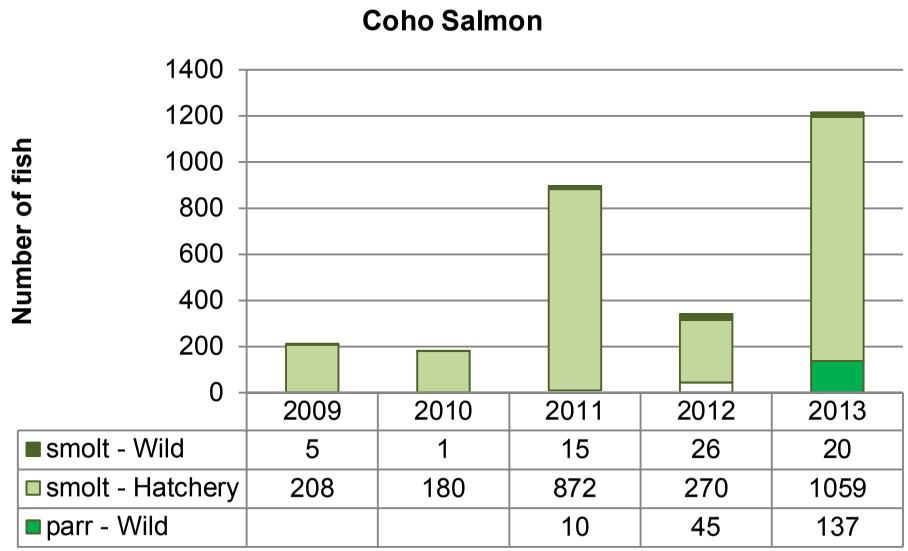




**Figure 184.3.8. Number of steelhead and coho salmon captured by life stage and origin at the Dry Creek downstream migrant trap, (upper panels) and duration and timing of trap operation (lower panel), 2009-2013.**



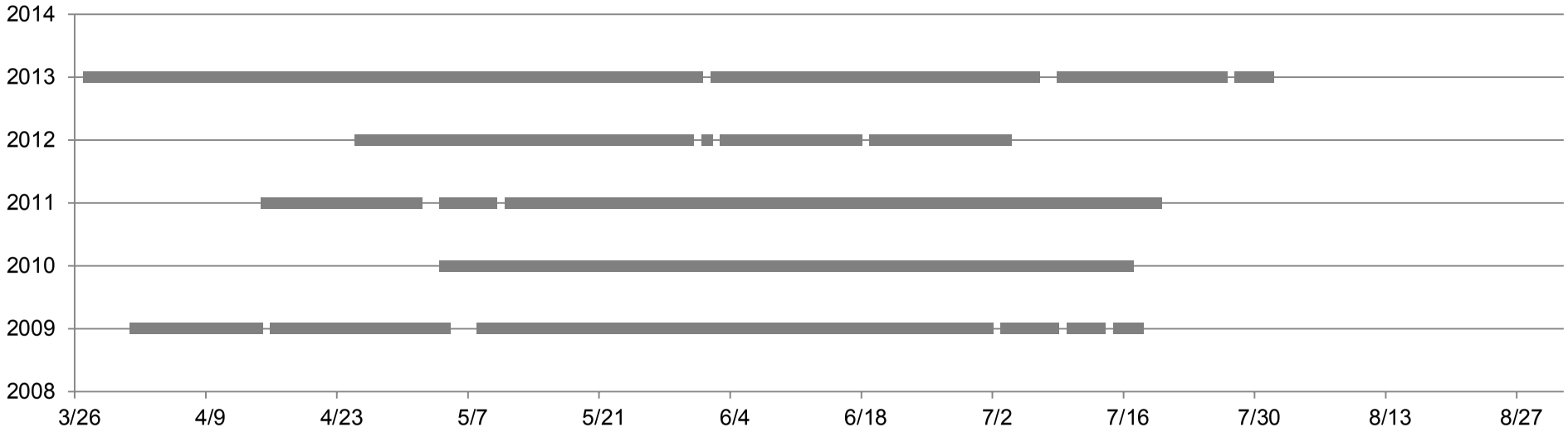
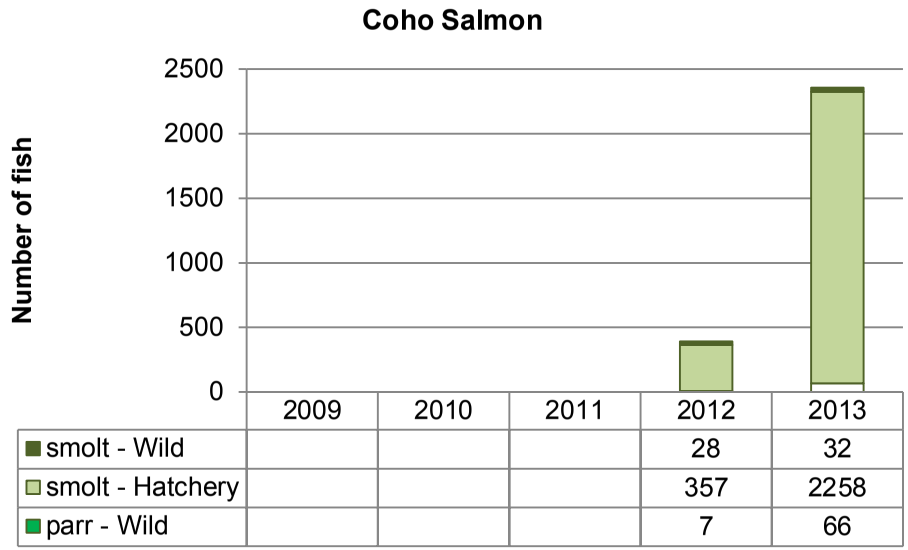




**Figure 194.3.9. Number of steelhead and coho salmon captured by life stage and origin at the mainstem Russian River (Mirabel) downstream migrant trap, (upper panels) and duration and timing of trap operation (lower panel), 2009-2013.**



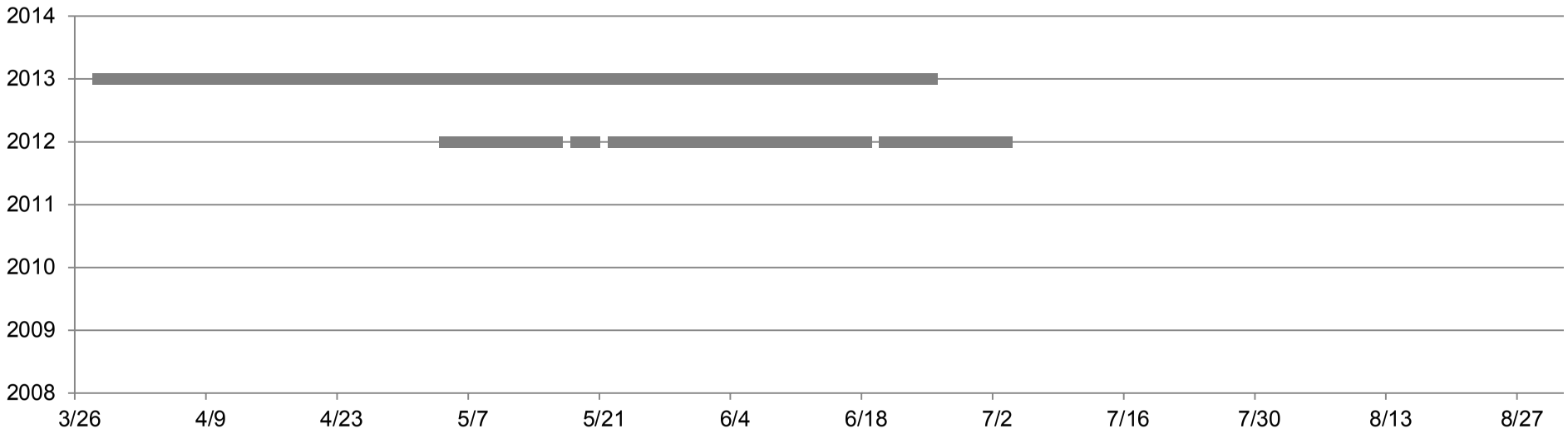
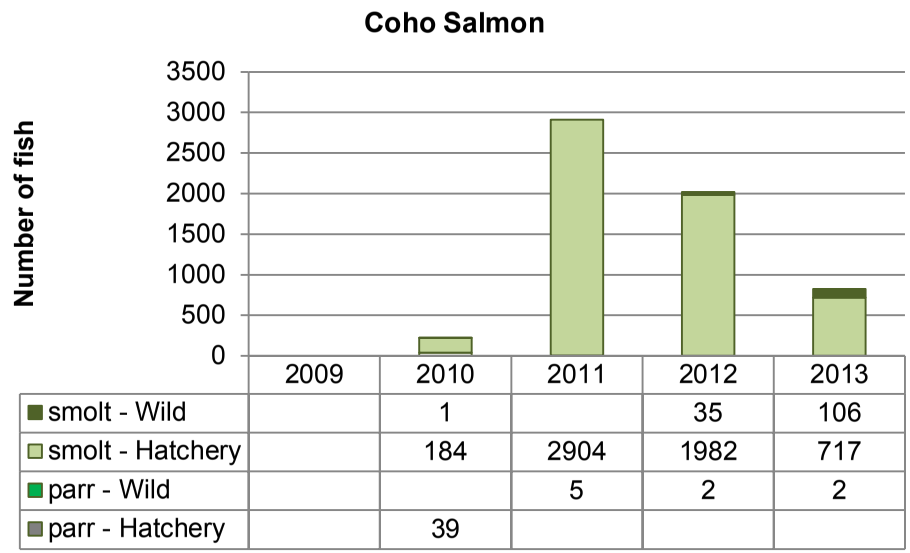




**Figure 204.3.10. Number of steelhead and coho salmon captured by life stage and origin at the Mark West Creek downstream migrant trap, (upper panels) and duration and timing of trap operation (lower panel), 2010-2013.**



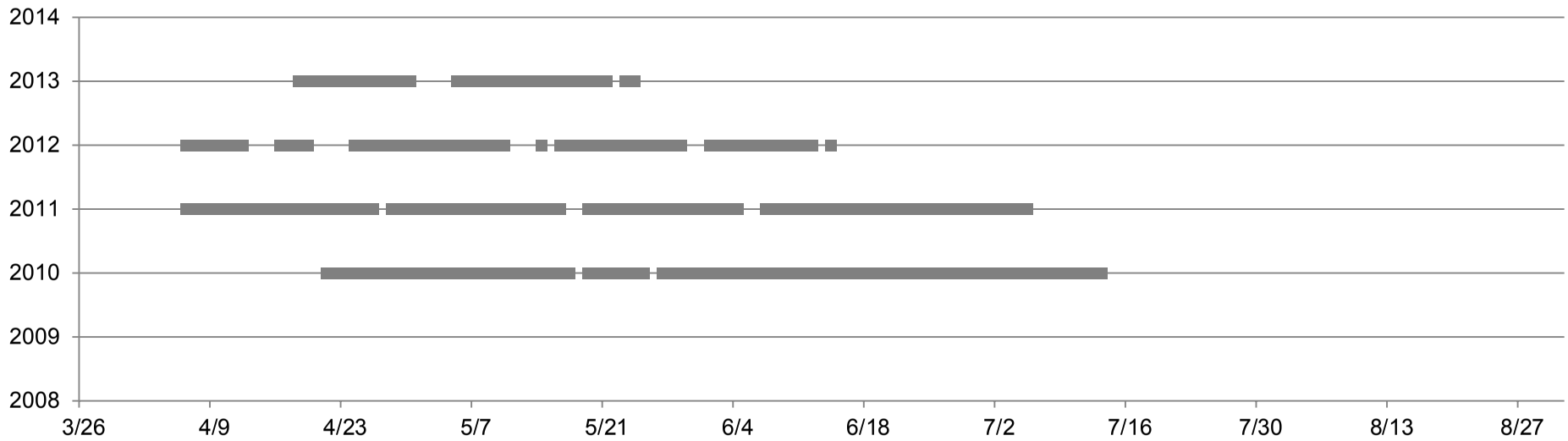
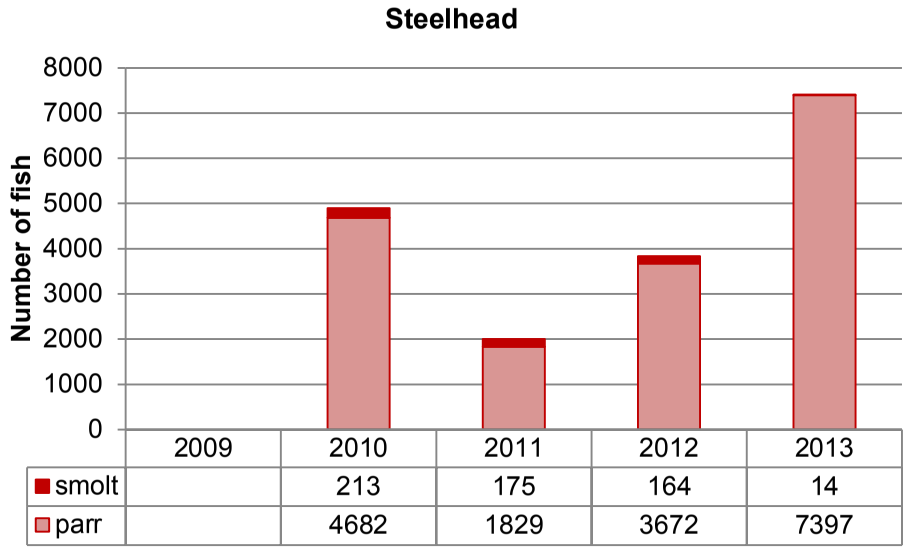
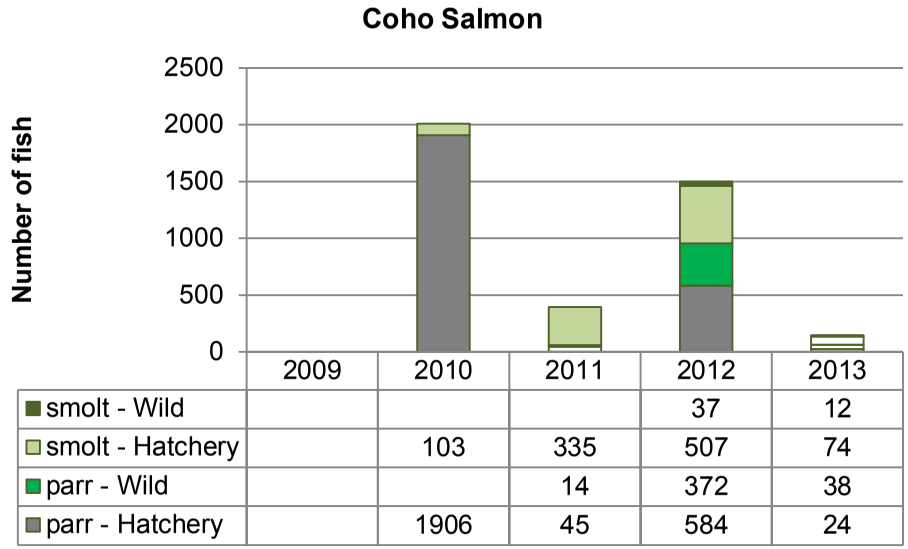




**Figure 214.3.11. Number of steelhead and coho salmon captured by life stage and origin at the Dutch Bill Creek downstream migrant trap, (upper panels) and duration and timing of trap operation (lower panel), 2010-2013.**



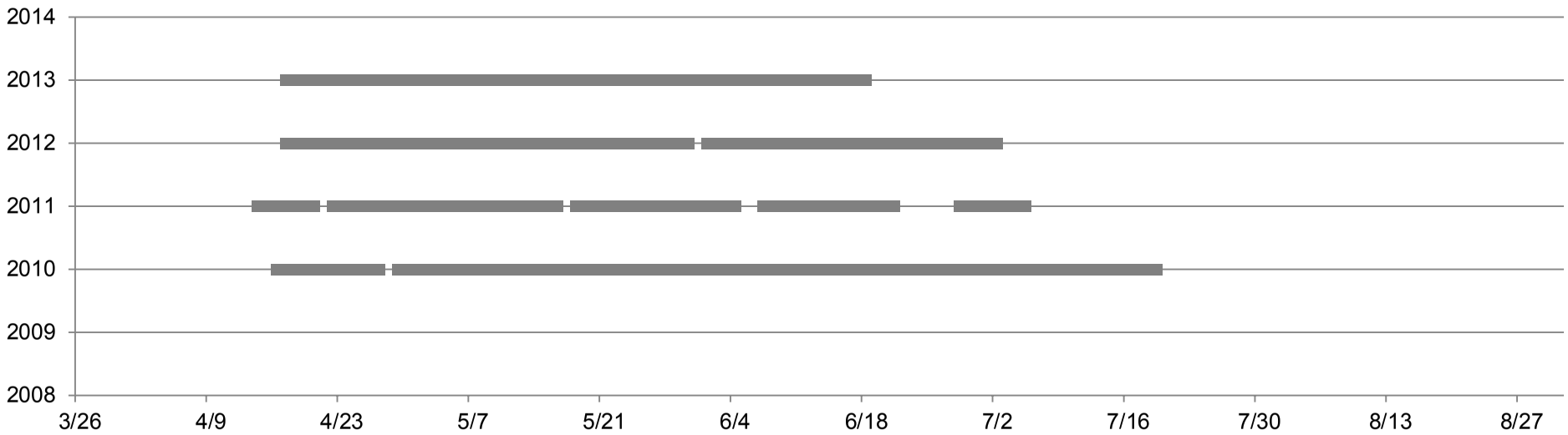




**Figure 224.3.12. Number of steelhead and coho salmon captured by life stage and origin at the Austin Creek downstream migrant trap, (upper panels) and duration and timing of trap operation (lower panel), 2010-2013.**

Only 22 of the 2,704 juvenile steelhead PIT-tagged on Dry Creek were detected at the Northwood antenna array while 6 were detected at the Duncans Mills antenna array. This was despite the fact that 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). 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.

### Coho Salmon

At Mirabel 1,059 hatchery smolts, 20 wild smolts, and 137 wild parr were captured (Figure 4.3.9 and Figure 4.3.13). At Mark West Creek 2,258 hatchery coho smolts, 32 wild coho smolts, and 66 wild coho parr were detected at the trap (Figure 4.3.10 and Figure 4.3.13). A total of 717 hatchery and 106 wild coho smolts were captured at the Dutch Bill Creek trap which was the highest total of any of the trap sites operated in 2013 (Figure 4.3.11 and Figure 4.3.13). At Austin Creek 74 hatchery coho smolts, 12 hatchery parr, and 38 wild parr were captured (Figure 4.3.12 and Figure 4.3.13). 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 4.3.14). 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 2013.

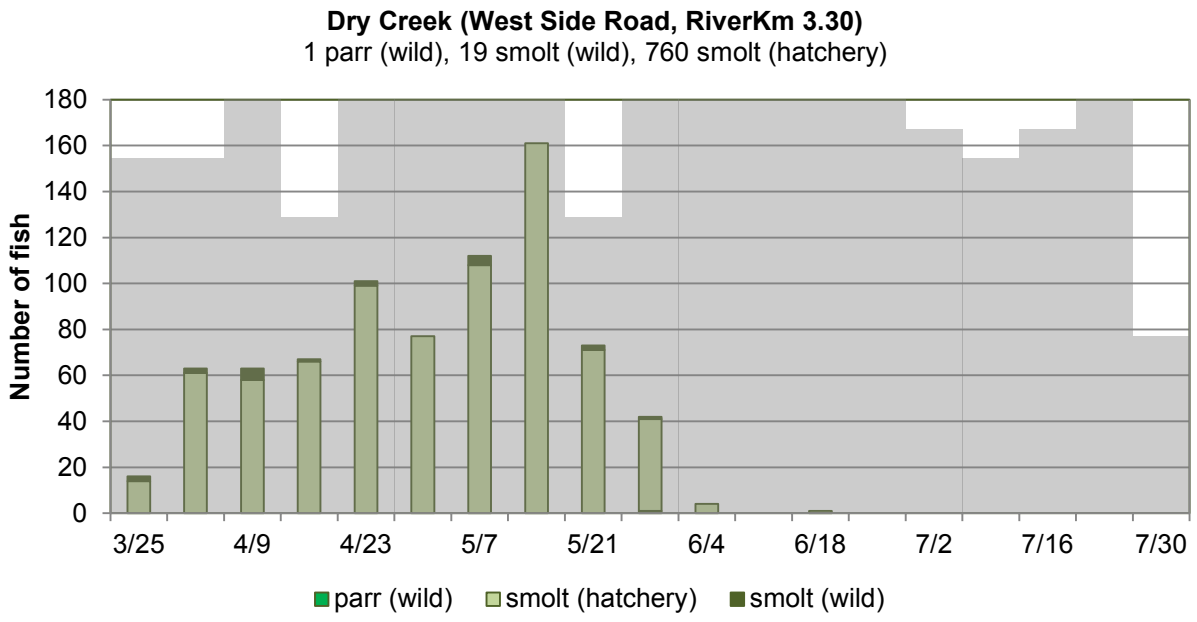
### Chinook Salmon

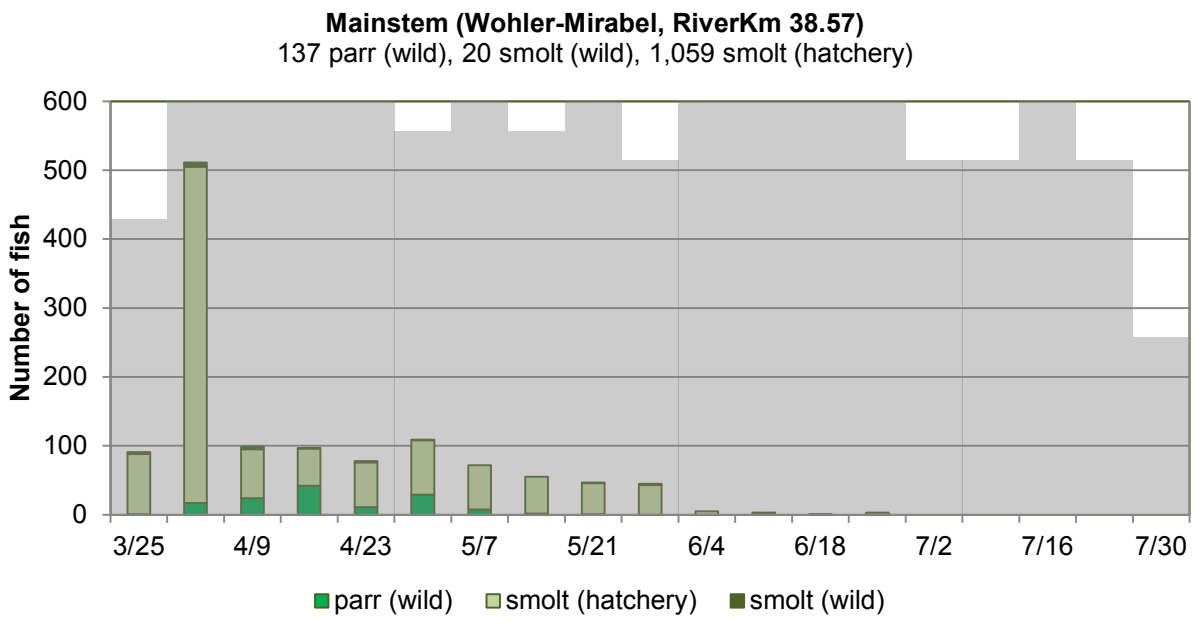
In 2013 relatively few Chinook salmon smolts were captured in Austin Creek, Dutch Bill Creek, and Mark West Creek (135, 0 and 156 respectively). For more details on characteristics of Chinook smolts captured at Mirabel and Dry Creek see the Wohler-Mirabel Water Diversion Facility and the Dry Creek Habitat Enhancement, Planning, and Monitoring chapters of this report.

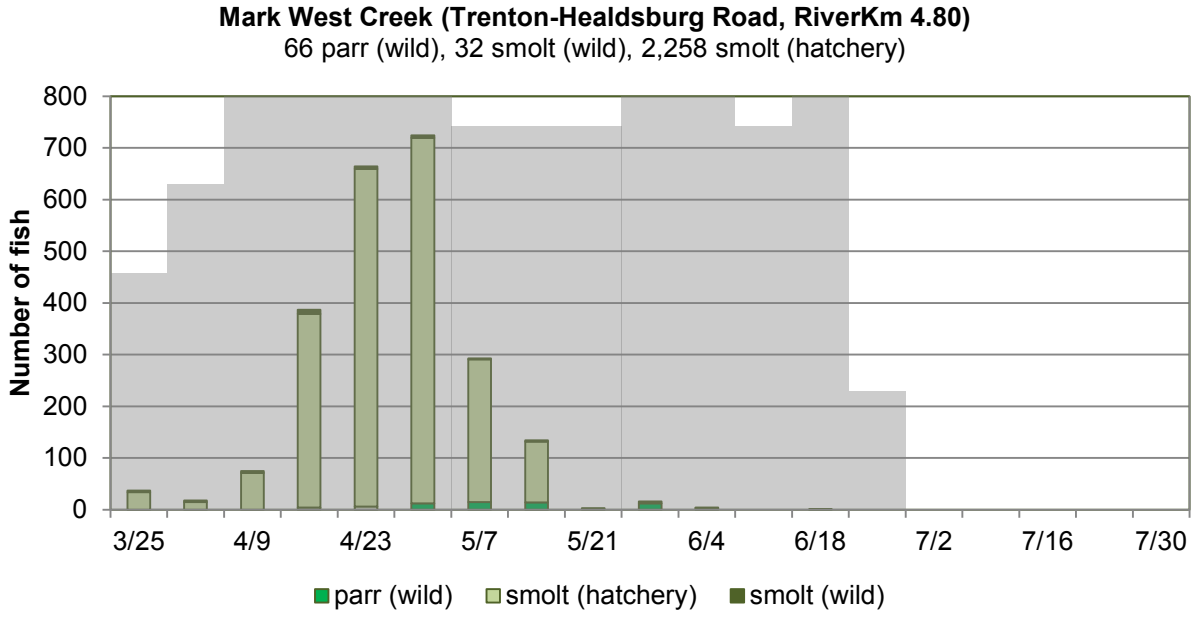
#### Conclusions and Recommendations

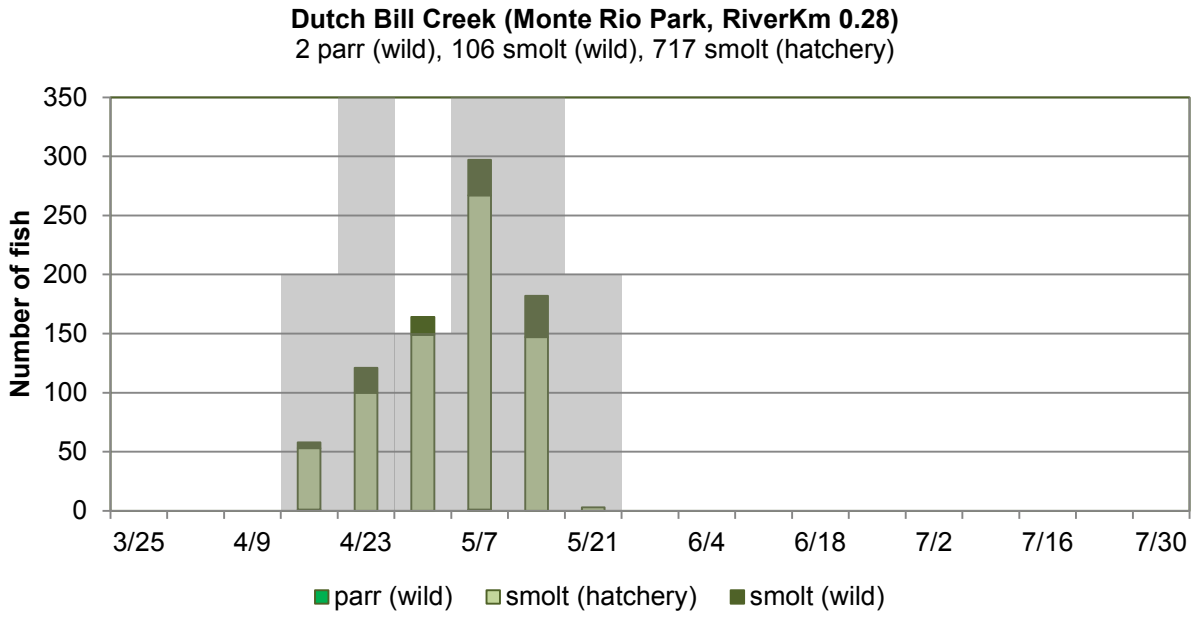
Russian River Biological Opinion objectives regarding the timing of Estuary entry are partially met by using PIT-tag detections from the paired antenna array in lower Austin Creek where antenna efficiency estimates are possible and where fish moving past that array have effectively entered the Estuary. Approximately 26.5% of the steelhead YOY that were PIT-tagged at Austin Creek were later detected on the antenna array at Duncans Mills. The number of steelhead YOY originating in Austin Creek that enter the Estuary is significant (Table 4.3.4) but it is only one of the many possible tributaries that could be contributing steelhead to the Estuary. 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 26.5% of 3,351 = 887 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, Mark West or Mirabel and in 2013 only 4 steelhead parr tagged at these sites were detected on the Duncans Mills antenna.

While the PIT-tag antenna at Duncans Mills spanned the Russian River for much of the 2013 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 effect detection probability. Brackish water occasionally


Dry Creek (West Side Road, RiverKm 3.30)
1 parr (wild), 19 smolt (wild), 760 smolt (hatchery)
Number of fish
180
160
140
120
100
80
60
40
20
0
3/25
4/9
4/23
5/7
5/21
6/4
6/18
7/2
7/16
7/30
parr (wild)
smolt (hatchery)
smolt (wild)


Mainstem (Wohler-Mirabel, RiverKm 38.57)
137 parr (wild), 20 smolt (wild), 1,059 smolt (hatchery)
Number of fish
600
500
400
300
200
100
0
3/25
4/9
4/23
5/7
5/21
6/4
6/18
7/2
7/16
7/30
parr (wild)
smolt (hatchery)
smolt (wild)


Mark West Creek (Trenton-Healdsburg Road, RiverKm 4.80)
66 parr (wild), 32 smolt (wild), 2,258 smolt (hatchery)
Number of fish
800
700
600
500
400
300
200
100
0
3/25
4/9
4/23
5/7
5/21
6/4
6/18
7/2
7/16
7/30
parr (wild)
smolt (hatchery)
smolt (wild)


Dutch Bill Creek (Monte Rio Park, RiverKm 0.28)
2 parr (wild), 106 smolt (wild), 717 smolt (hatchery)
Number of fish
350
300
250
200
150
100
50
0
3/25
4/9
4/23
5/7
5/21
6/4
6/18
7/2
7/16
7/30
parr (wild)
smolt (hatchery)
smolt (wild)

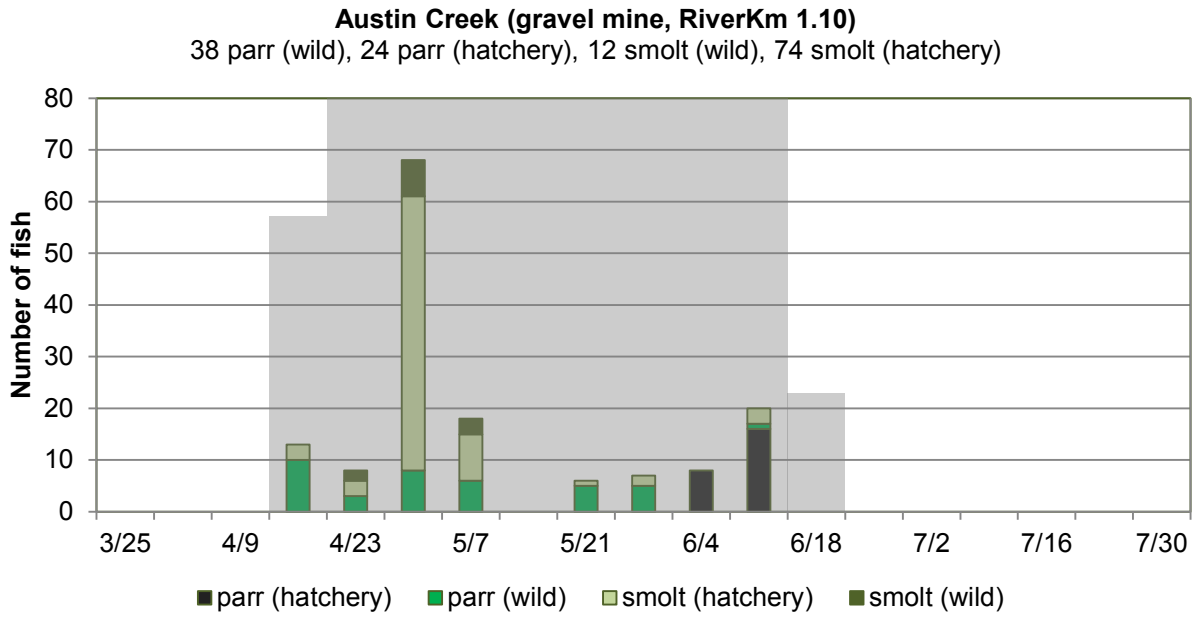
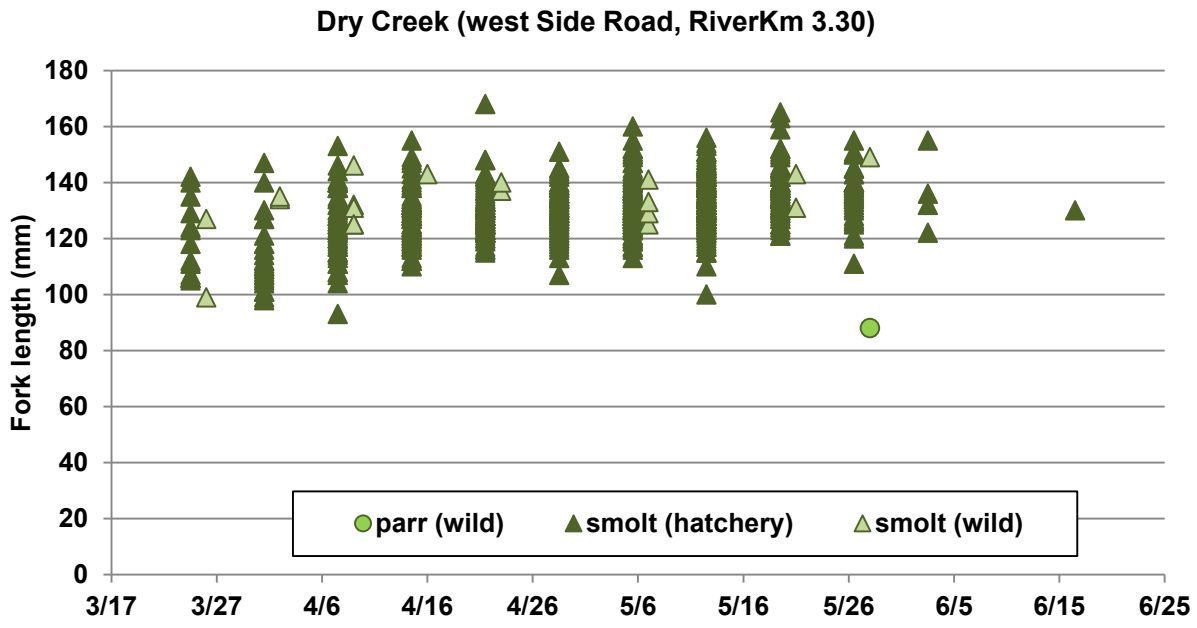
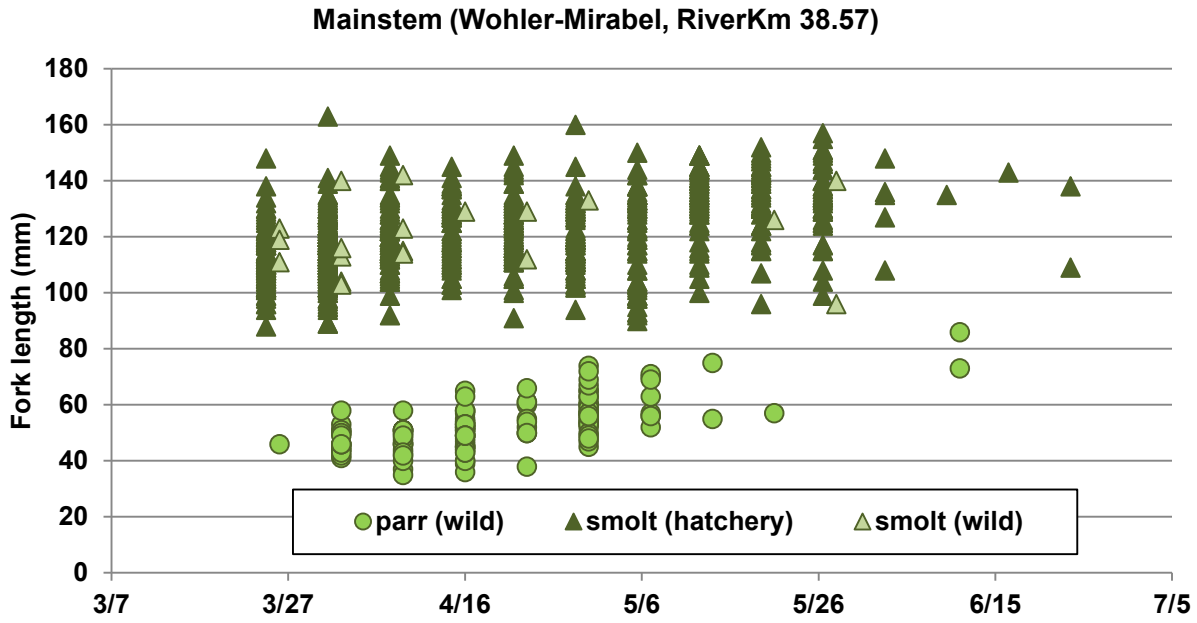
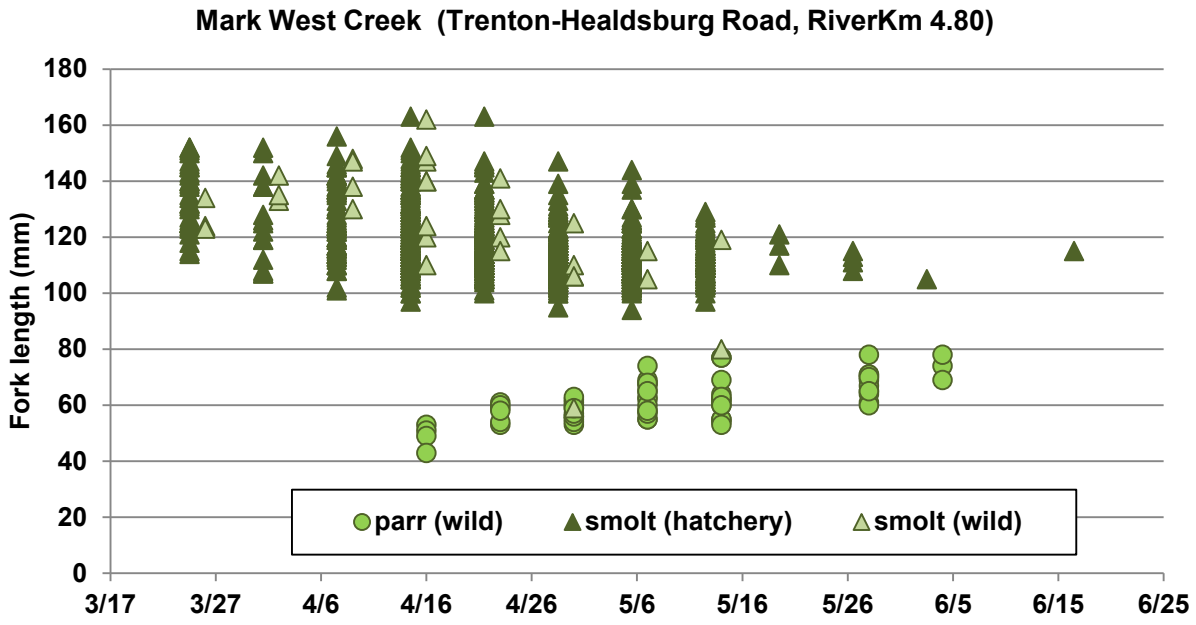
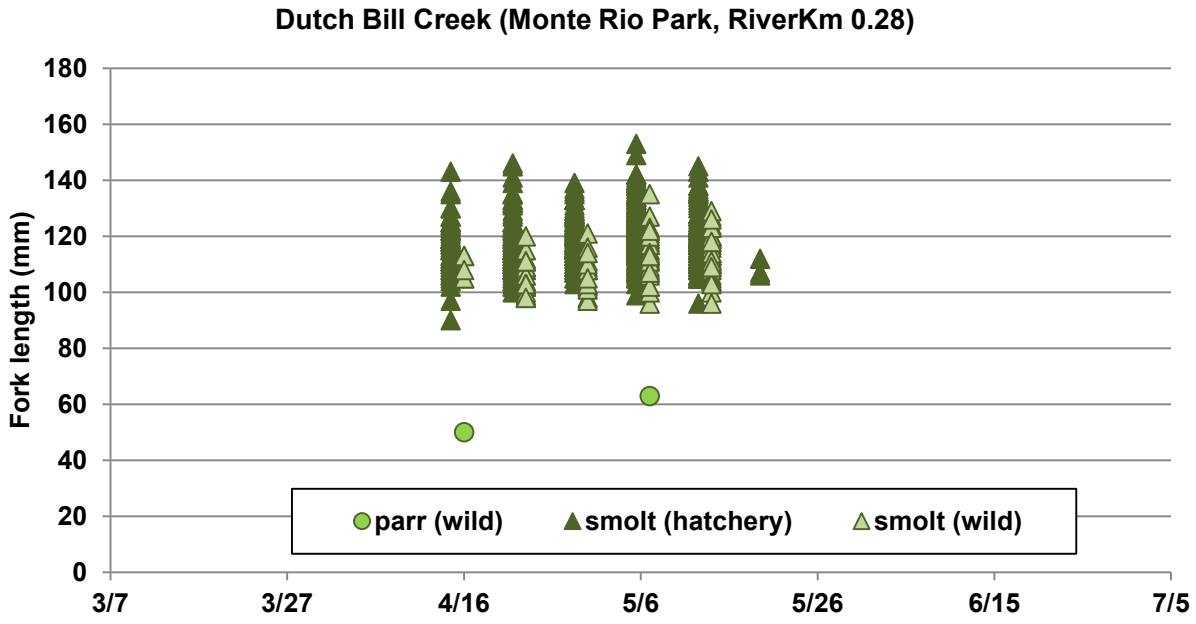



**Figure 234.3.13. Weekly capture of coho salmon by life stage at lower river downstream migrant trapping sites, 2013. Gray shading indicates portion of each week trap was fishing. Note the different vertical scale among plots for each site.**


Dry Creek (west Side Road, RiverKm 3.30)
Fork length (mm)
180
160
140
120
100
80
60
40
20
0
3/17
3/27
4/6
4/16
4/26
5/6
5/16
5/26
6/5
6/15
6/25
parr (wild)
smolt (hatchery)
smolt (wild)


Mainstem (Wohler-Mirabel, RiverKm 38.57)
Fork length (mm)
180
160
140
120
100
80
60
40
20
0
3/7
3/27
4/16
5/6
5/26
6/15
7/5
parr (wild)
smolt (hatchery)
smolt (wild)


Mark West Creek (Trenton-Healdsburg Road, RiverKm 4.80)
Fork length (mm)
180
160
140
120
100
80
60
40
20
0
3/17
3/27
4/6
4/16
4/26
5/6
5/16
5/26
6/5
6/15
6/25
parr (wild)
smolt (hatchery)
smolt (wild)


Dutch Bill Creek (Monte Rio Park, RiverKm 0.28)
Fork length (mm)
180
160
140
120
100
80
60
40
20
0
3/7
3/27
4/16
5/6
5/26
6/15
7/5
parr (wild)
smolt (hatchery)
smolt (wild)

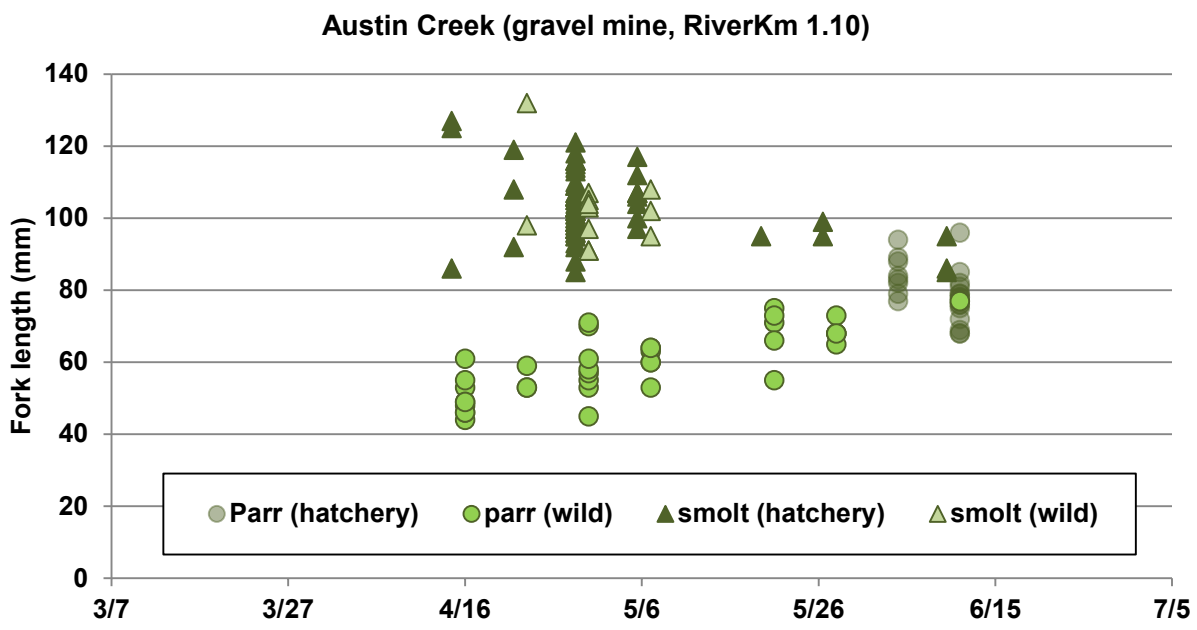



Figure 244.3.14. Weekly fork lengths of coho salmon captured at lower river downstream migrant trap sites, 2012

occurs at the antenna site which cause decreases in antenna read range. Water depth is variable and is often deeper than the detection field of some antennas. Collectively, these limitations all result in decreases in 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). Regardless of these issues, PIT-tagging 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 are being made 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 P.

## 4.4 Fish Sampling – Beach Seining

The Water Agency has been sampling the Russian River Estuary since 2004 - prior to issuance of the Biological Opinion. An Estuary fish survey methods study was completed in 2003 (Cook 2004). To provide context to data collected in 2013, 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). Salmonids were identified as wild or hatchery stock indicated by a clipped adipose fin (hatchery coho salmon were no longer clipped after spring 2013). Tissue and scale samples were collected from some steelhead. Fish were allowed to recover in aerated buckets prior to release. Also, juvenile steelhead greater than 60 mm fork length were marked by surgically implanting a passive integrated transponder (PIT) tag. PIT tags provide a unique identification to each fish. All captured steelhead were scanned with a PIT tag receiver to detect recaptured fish.

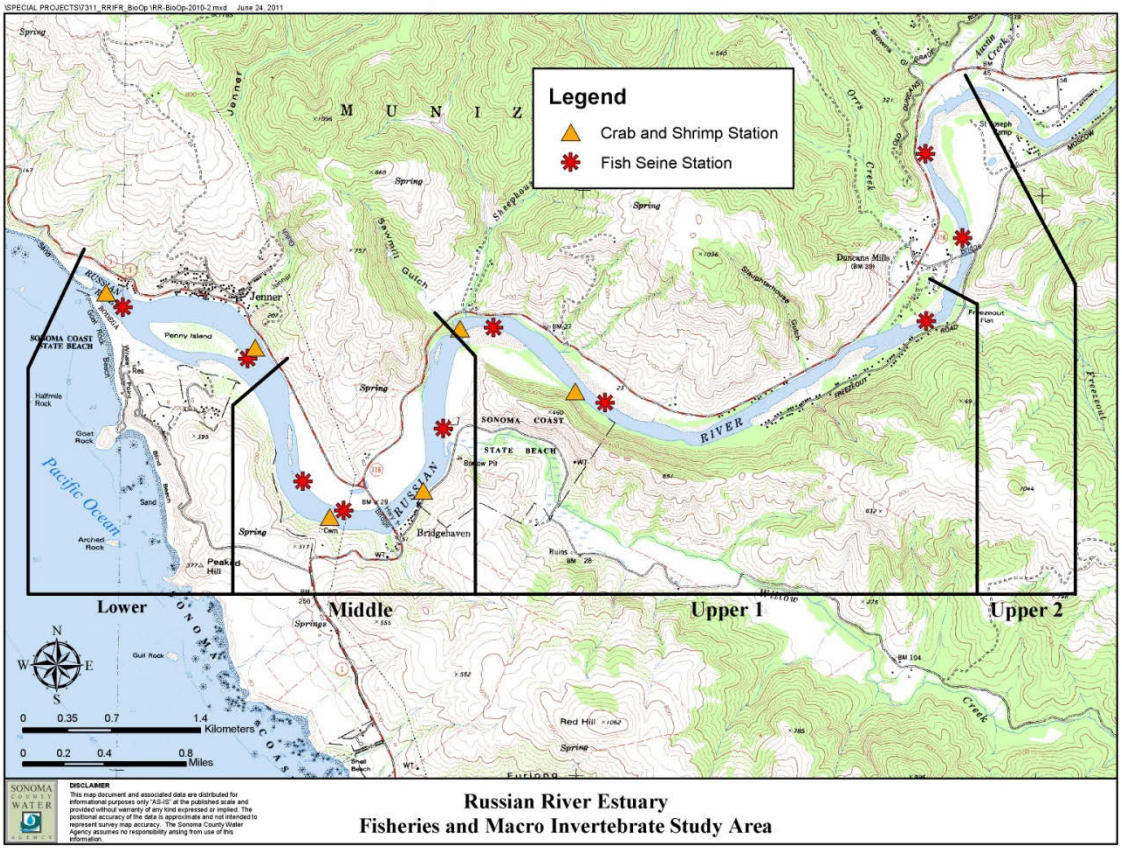



**Figure 4.4.1. Russian River Estuary fisheries seining study reaches and sample sites, 2013. No macro invertebrate studies were conducted during this year.**

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.

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

fish patterns. Fish seining stations 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 2013 are summarized in Table 4.4.1. During the 10 years of study, over 180,000 fish comprised of 50 species were caught in the Estuary. In 2013, seine captures consisted of 6,898 fish comprised of 28 species. No new fish species were detected in the Estuary during 2013 fish seining.

The distribution of fish in the Estuary is, in part, based on a species preference for or tolerance to salinity (Figure 4.4.2). In general, the influence of cold seawater from the ocean results in high salinity levels and cool temperatures in the Lower Reach transitioning to warmer freshwater in the Upper Reach from river inflows (Figure 4.4.3). For more detail please refer to water quality in Chapter 4.1. Fish commonly found in the Lower Reach were marine and estuarine species including 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 2013, a total of 67 steelhead were captured (Table 4.4.1) in 150 seine sets. The resulting CPUE was 0.45 fish/set (Figure 4.4.4). In comparison, during 2012, a total of 76 steelhead were captured in 300 seine sets for a CPUE of 0.25 fish/set. The highest CPUE for all study years was 1.66 fish/set in 2008. All steelhead captured in 2013 were wild, except two hatchery fish.

Table 4.4.1. Total fish caught by beach seine in the Russian River Estuary, 2013. Each station was sampled monthly during May, June, and September for a total of 150 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 | | | | | | | | | 9 |
| | Chinook salmon | 51 | 15 | | 13 | 10 | 14 | 3 | 5 | | | 111 |
| | coho salmon | 1 | | | | | | | 10 | | 2 | 13 |
| | steelhead | | | | 1 | 1 | 30 | 1 | 24 | 2 | 8 | 67 |
| **Estuarine** | bay pipefish | 2 | 1 | | 2 | 3 | 4 | | | | | 12 |
| | shiner surfperch | | | | | | | 2 | | | | 2 |
| | staghorn sculpin | 28 | 26 | 1 | 1 | 169 | | | | | | 225 |
| | starry flounder | 1 | | | | | 1 | 3 | 3 | | 1 | 9 |
| | topsmelt | 2 | | | | | | | | | | 2 |
| **Freshwater** | black crappie | | | | | | | | | | | |
| | bluegill | | | | | | | | | 1 | | 1 |
| | California roach | | | | | | | | 75 | 199 | 61 | 335 |
| | common carp | | | | | | | | | | | |
| | cyprinid sp | | | | | | | | | | | |
| | fathead minnow | | | | | | | | | | | |
| | green sunfish | | | | | | | | | 1 | 1 | 2 |
| | hardhead | | | | | | | | | | | |
| | hitch | | | | | | | | | 14 | | 14 |
| | largemouth bass | | | | | | | | | 2 | | 2 |
| | mosquitofish | | | | | | | | | 1 | | 1 |
| | Russian River tule perch | | | | | 1 | | | 35 | 109 | 21 | 166 |
| | Sacramento blackfish | | | | | | | | | | | |
| | Sacramento pikeminnow | | | | | 3 | | 14 | 51 | 151 | 61 | 280 |
| | Sacramento sucker | | | 5 | 73 | 103 | 23 | 306 | 52 | 177 | 427 | 1166 |
| | 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 | 1 | | | | | | | | | | 1 |
| | cabezon | 26 | | | | | | | | | | 26 |
| | English sole | 43 | | | | | | | | | | 43 |
| | northern anchovy | | | | | | | | | | | |
| | Pacific herring | 4 | 16 | | | | | | | | | 20 |
| | Pacific sanddab | 13 | 1 | | | 1 | | | | | | 15 |
| | poacher sp. | | | | | | | | | | | |
| | saddleback gunnel | | | | | | | | | | | |
| | sebastes sp. | 19 | 1 | | | | | | | | | 20 |
| | sharpnose sculpin | | | | | | | | | | | |
| | silver spotted sculpin | | | | | | | | | | | |
| | surf smelt | 163 | | | 2 | | | | | | | 165 |
| | 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 | 2 | 7 | 1 | 4 | 5 | 3 | 32 | 29 | 9 | 14 | 106 |
| | threespine stickleback | 134 | 50 | 13 | 45 | 720 | 49 | 1506 | 272 | 1072 | 223 | 4084 |
| **Total** | | **490** | **127** | **20** | **141** | **1016** | **124** | **1867** | **556** | **1738** | **819** | **6898** |

*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.

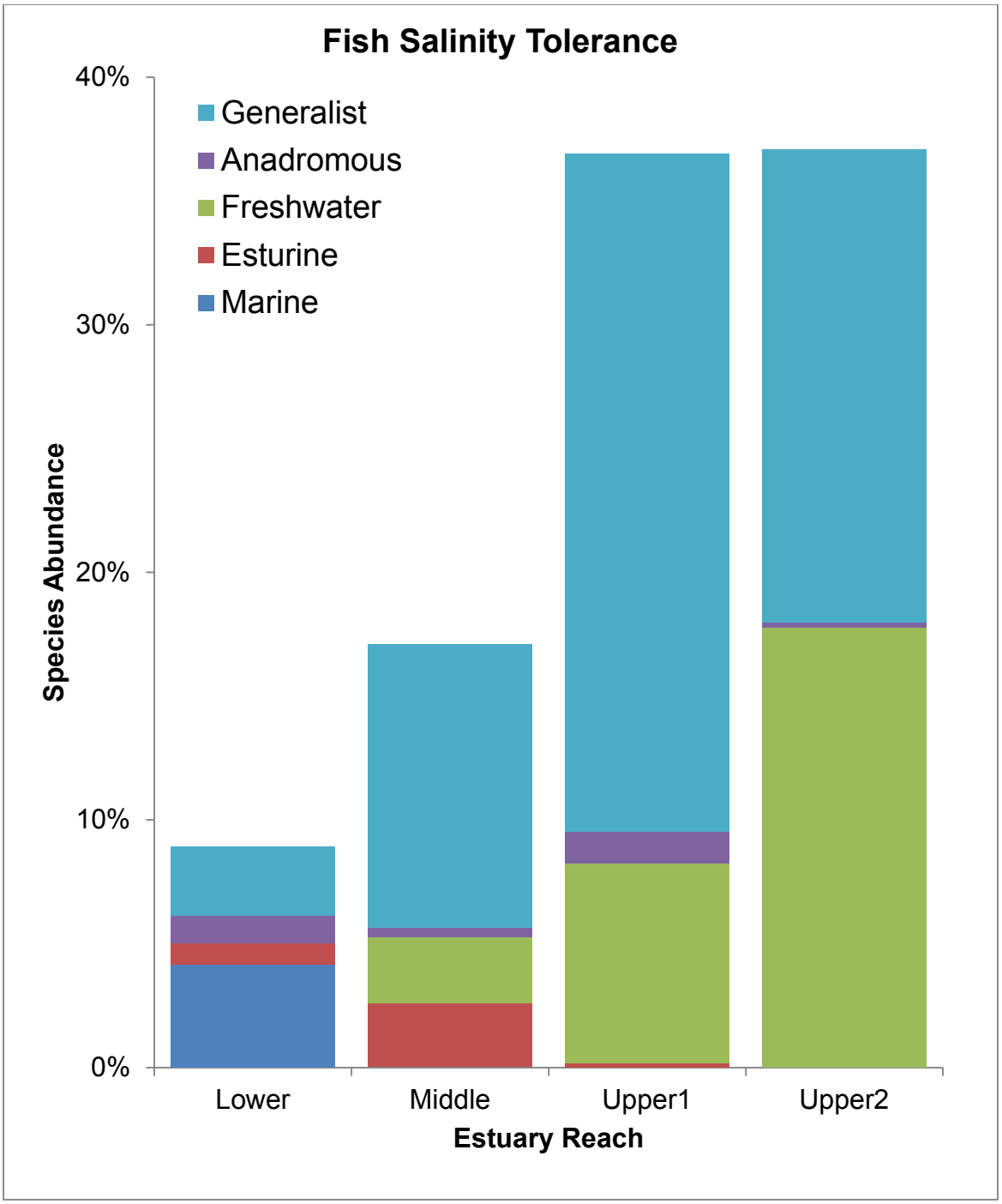



**Figure 4.4.2. Distribution of fish in the Russian River Estuary based on salinity tolerance and life history, 2013. Data is from monthly seining during May, June, and September. Groups include: generalist species that occur in a broad range of habitats; species that are primarily anadromous; freshwater 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.**

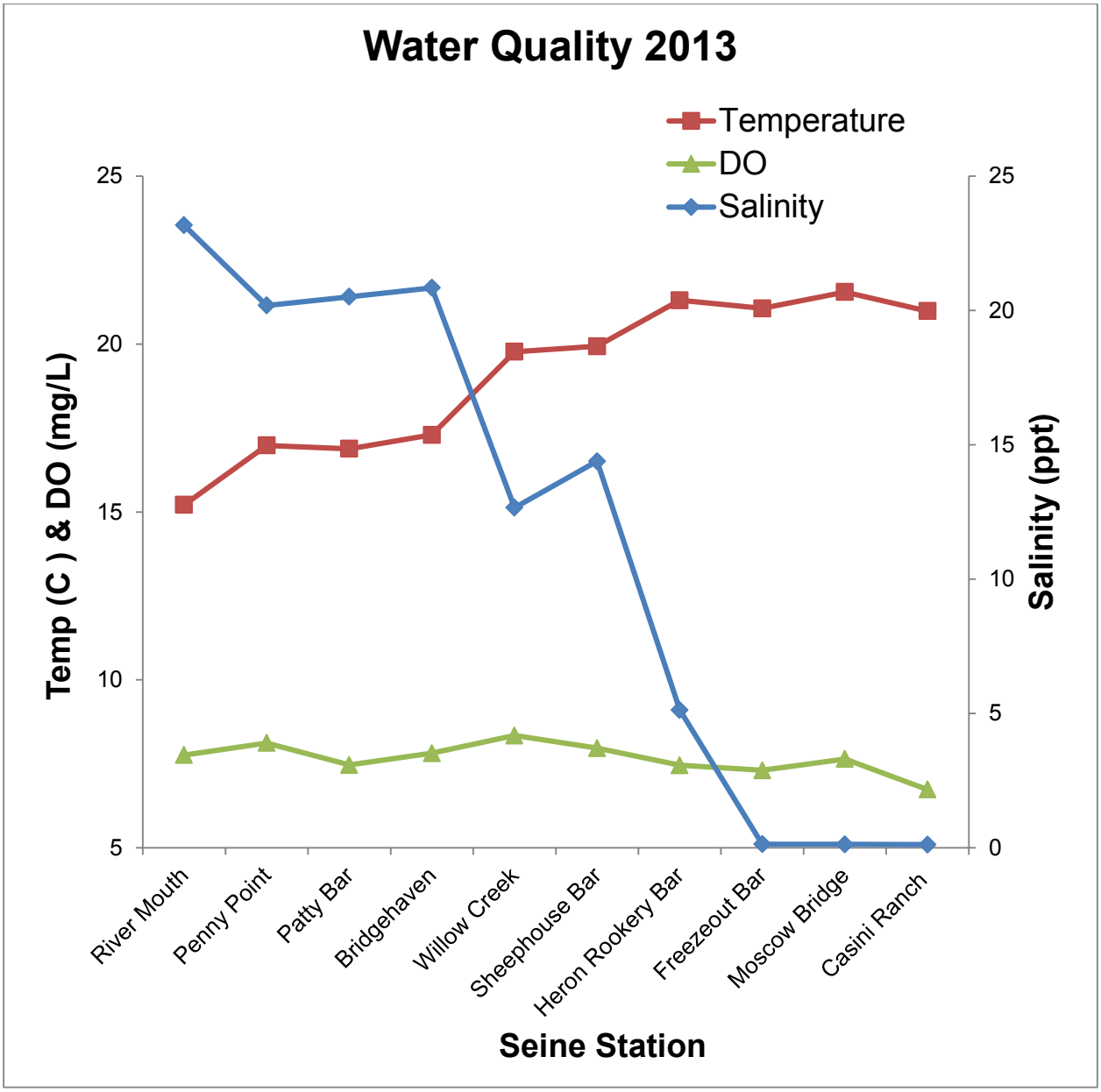



**Figure 4.4.3. Generalized water quality conditions at fish seining stations in the Russian River Estuary, 2013. Values are averages collected at 0.5 m intervals in the water column during beach seining events from May, June, and September. Salinity values are in parts per thousand (ppt), dissolved oxygen (DO) milligrams per liter (mg/L), and water temperature Celsius (C).**

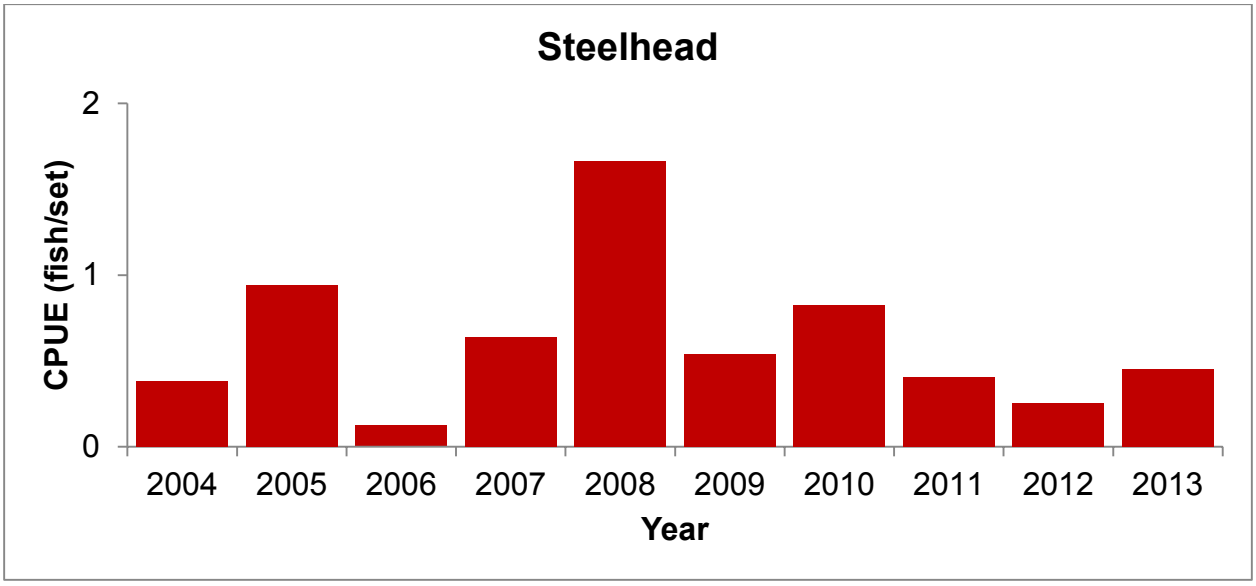



**Figure 4.4.4. Annual abundance of juvenile steelhead captured by beach seine in the Russian River Estuary, 2004 to 2013. Samples are from 96 to 300 seine sets conducted yearly between May and October.**

The seasonal abundance of steelhead captured varied annually in the Estuary (Figure 4.4.5). Juvenile steelhead were captured during May and June 2013 and not in September. The highest steelhead abundances are typically in June and August. During 2013, steelhead captures were highest during June at 0.74 fish/set. No surveys were conducted in August 2013. The highest capture abundance among all study years was in August at 4.3 fish/set and June at 4.2 fish/set in 2008.

Since seining surveys began in 2004, steelhead appear to have a patchy distribution and vary in abundance in the Estuary (Figure 4.4.6). In 2004 and 2006, relatively low numbers of steelhead were captured and only in the Middle and Upper1 Reaches (Upper2 Sub-Reach sampling began in 2010). While in 2005, juvenile steelhead were caught throughout most of the Estuary. Over all years surveyed, captures were typically highest in the Upper Reach with a high of 6.9 fish/set in the Upper1 Sub-Reach in 2008. During 2013 steelhead were captured in all study reaches, except the Lower Reach, in relatively low numbers. Captures were highest in the Upper1 Sub-Reach at 0.92 fish/set, followed on 0.16 fish/set in the Upper2 Sub-Reach.

The temporal and spatial distribution of juvenile steelhead in the Estuary in 2013 was strongly influenced by large captures in the Upper2 Reach in May and June (Figure 4.4.7). None to very few steelhead were captured in the Middle and Lower Reaches. Most captured juvenile steelhead were age 0+ parr or age 1+ smolts and ranged in size from 50 mm to 216 mm fork length. The seasonal sizes of juvenile steelhead are shown in Figure 4.4.8. Estuary steelhead in May appeared to consist of age 1+ smolts or pre-smolts and a few young-of-the-year less than 70 mm fork length (Figure 4.4.8). During June Estuary steelhead were likely few young-of-the-year and age 1+ juveniles. Based on growth rates discussed below, September steelhead captures were likely young-of-the-year parr.

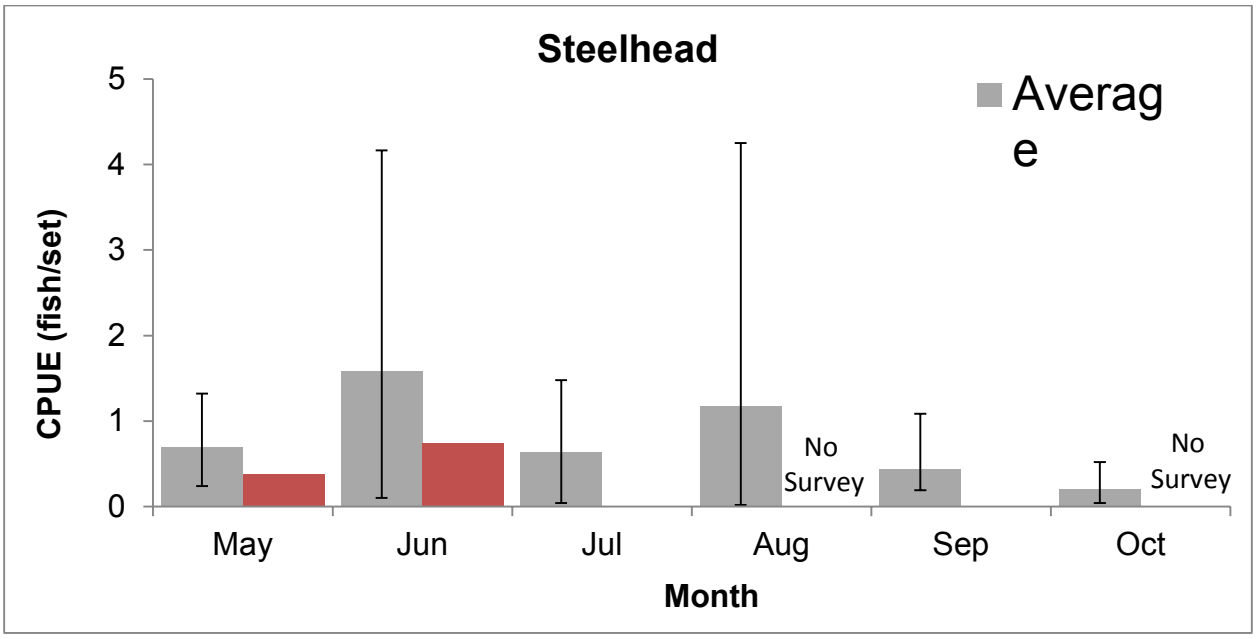



**Figure 4.4.5. Seasonal abundance of juvenile steelhead captured by beach seine in the Russian River Estuary, 2004-2013. Seining events consisted of 21 to 50 seine sets approximately monthly. October surveys began in 2010. Data from 2004 to 2012 were averaged and whiskers indicate minimum and maximum values.**

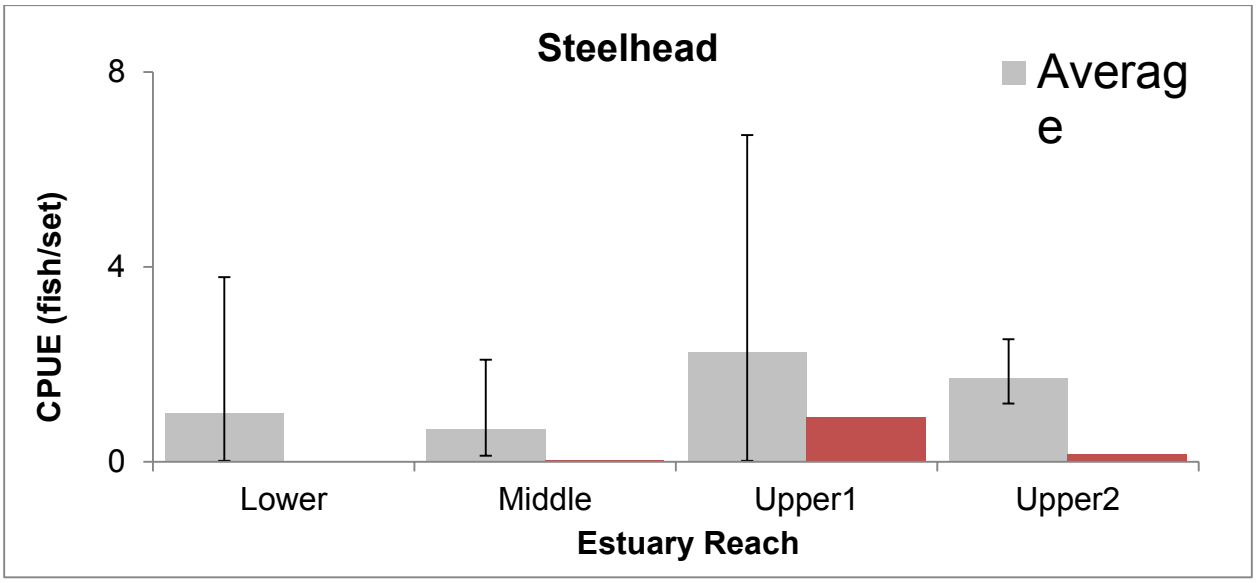



**Figure 4.4.6. Distribution of juvenile steelhead captured by beach seine in the Russian River Estuary, 2004-2013. Fish were sampled by beach seine consisting of 96 to 300 sets annually. During 2013 survey were conducted in May, June, and September. No surveys were conducted in the Upper2 Sub-Reach (Casini Ranch and Moscow Bridge stations) from 2004 to 2009. Data from 2004 to 2010 were averaged and whiskers indicate minimum and maximum values.**

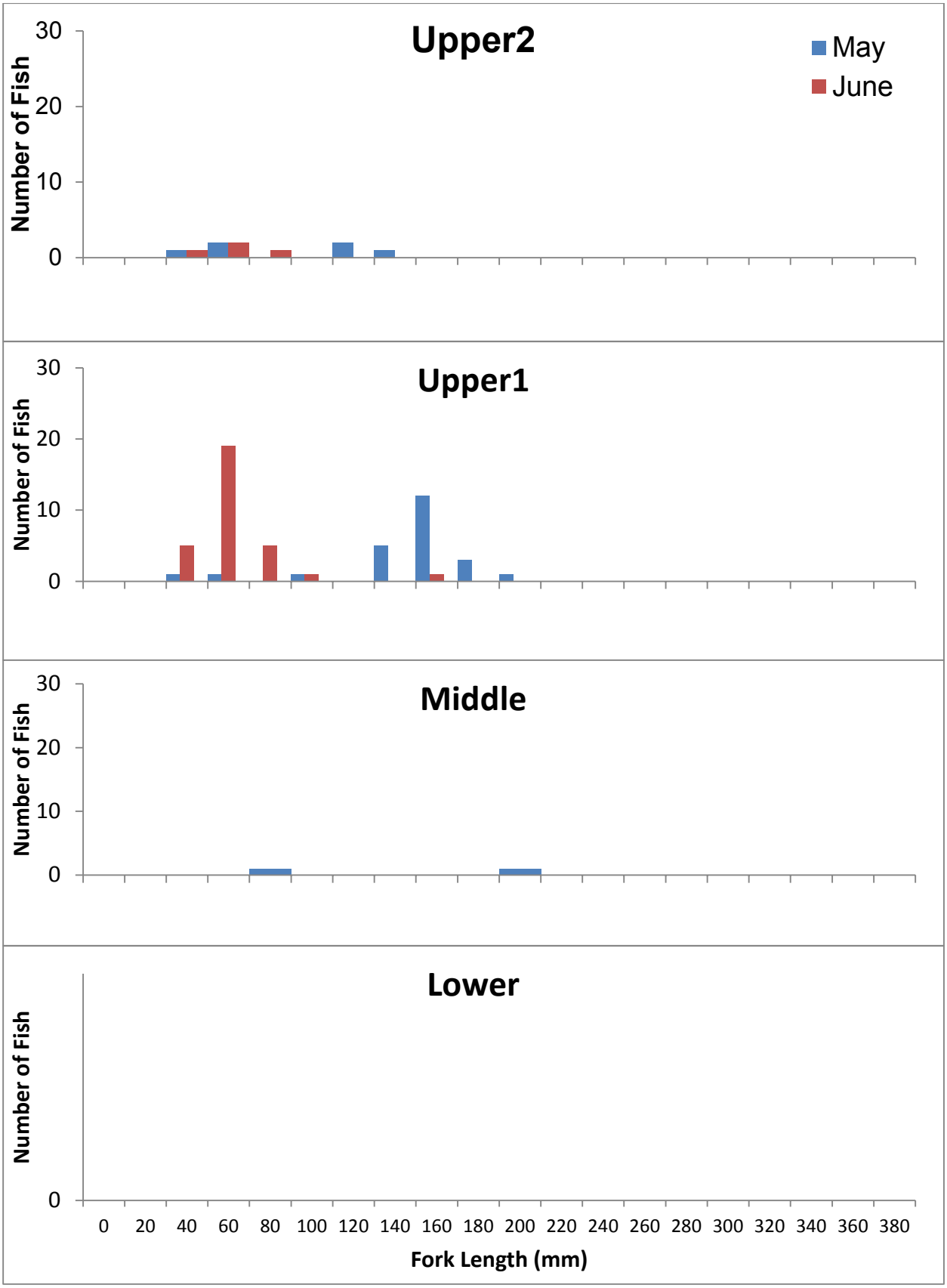



**Figure 4.4.7. Length frequency of juvenile steelhead captured by beach seine in the Russian River Estuary, 2013. Fish captures are grouped by Estuary reach and month. No steelhead were captured during September.**

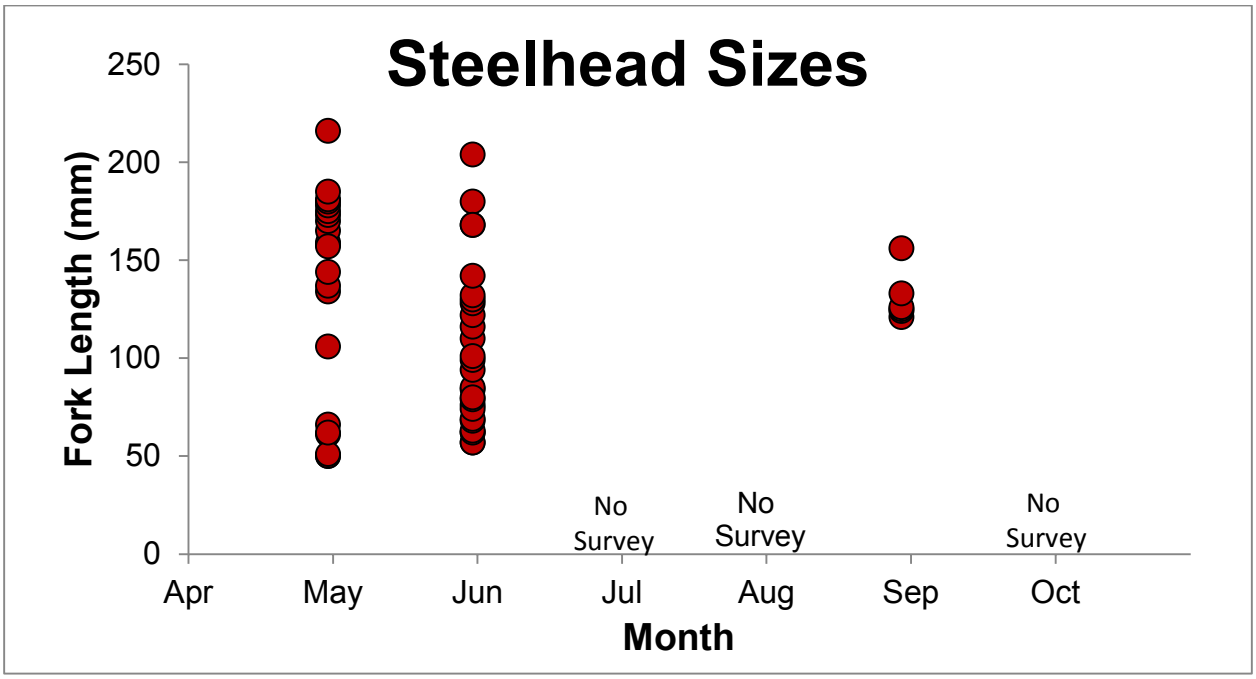



Figure 4.4.8. Juvenile steelhead sizes captured by beach seine in the Russian River Estuary, 2013.

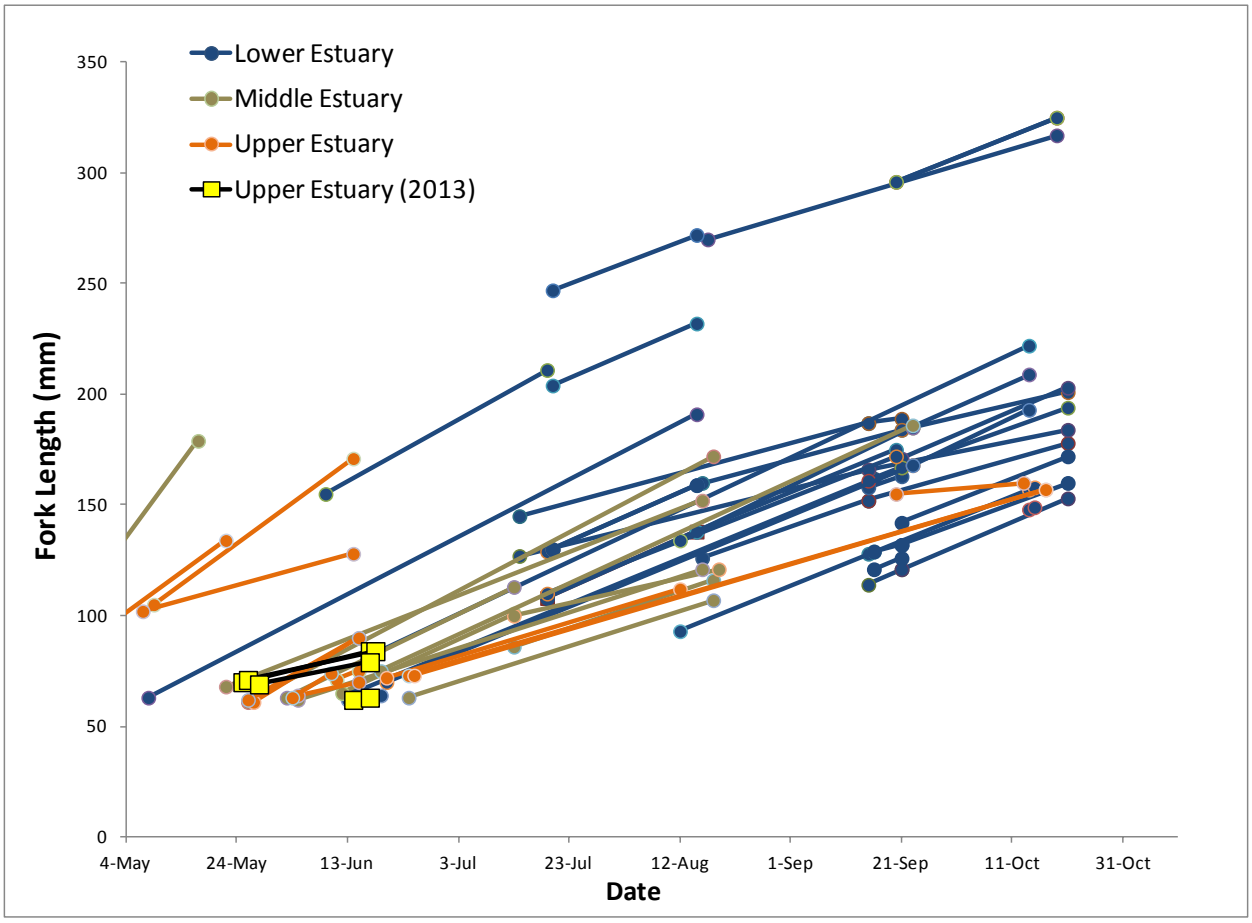



Figure 4.4 9. Growth rates of juvenile steelhead in the Estuary, 2010-2013. Fish were either PIT tagged in the Estuary or upstream and then recaptured in the Estuary. All fish from 2013 shown separately.

In 2014, 43 juvenile steelhead captured during Estuary seining surveys were implanted with a PIT tag. Also, 1,749 juvenile steelhead where PIT-tagged in Austin Creek during downstream migrant trapping studies and another 4,042 juveniles in the upper Russian River watershed and Wohler rotary trap station (see Chapter 10 – Synthesis). Of the total 5,854 tagged fish in the Russian River watershed, four were later recaptured in the Estuary. All of these fish were tagged in Austin Creek and recaptured in the upper Estuary at Freezeout Bar or Casini Ranch stations. The average growth rate of steelhead recaptured in the Estuary in 2013 was 0.5 mm/day (n = 4). Growth rates in the Upper Estuary from 2010 to 2012 were 1.2 mm/day (n = 15).

### Chinook Salmon

A total of 111 Chinook salmon smolts were captured by beach seine in the Estuary during 2013 (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 smolts was in 2008 at 4.6 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 2013 were highest during June at 2.0 fish/set. No smolts were captured late in the survey season in September. Chinook salmon smolts were distributed throughout the Estuary with captures at most sample stations and all reaches annually, except Upper2 Reach in 2013 (Figure 4.4.12). There were four Chinook smolts PIT-tagged in Dry Creek from June 3-12, 2013, that were recaptured in the Estuary (Sheephouse Bar and Bridgehaven stations). These smolts ranged in size from 80 to 96 mm fork length and had an average growth rate of 0.4 mm/d.

### 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 smolt captured in the Estuary was a single fish in 2006. In 2011 there was a marked increase in captures at 263 coho smolt 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 2013 the total captures of coho smolts was 13 for a CPUE of 0.09 fish/set. The relatively low coho 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 smolts were captured during May (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. in 2013 coho were detected in the Lower, Upper1, and Upper2 Reaches. All captured smolts in 2013 had a clipped adipose fin indicating they originated from the Coho Salmon Captive Broodstock Hatchery Program. This program began stocking coho in local streams in 2004.

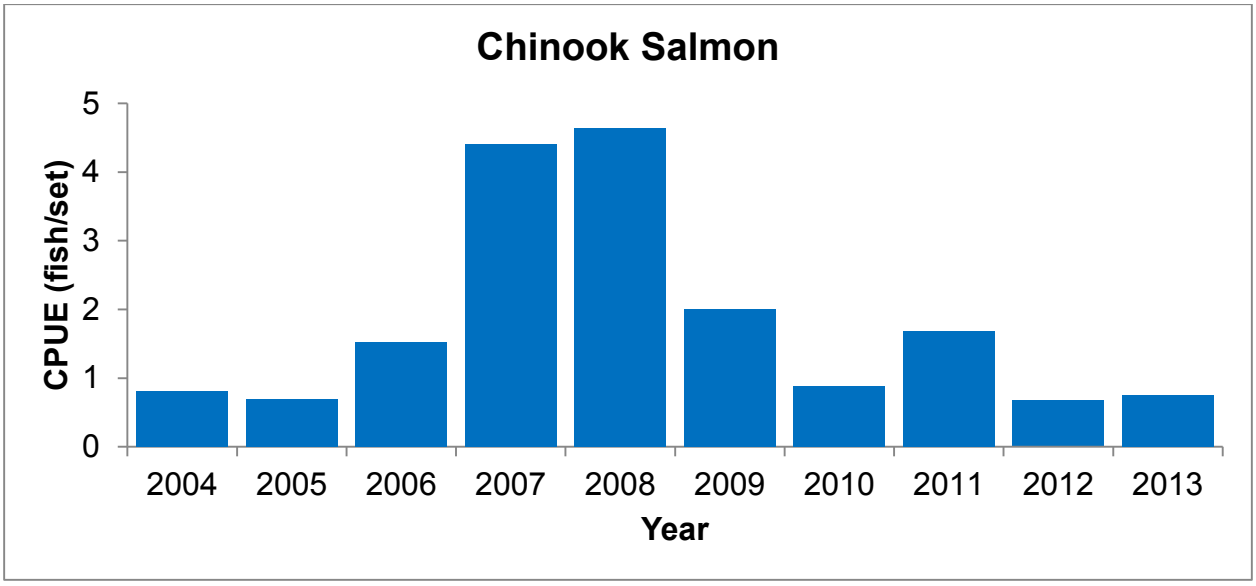



**Figure 4.4.10. Annual abundance of Chinook salmon smolts captured by beach seine in the Russian River Estuary, 2004-2013. Samples are from 96 to 300 seine sets yearly between May and October.**

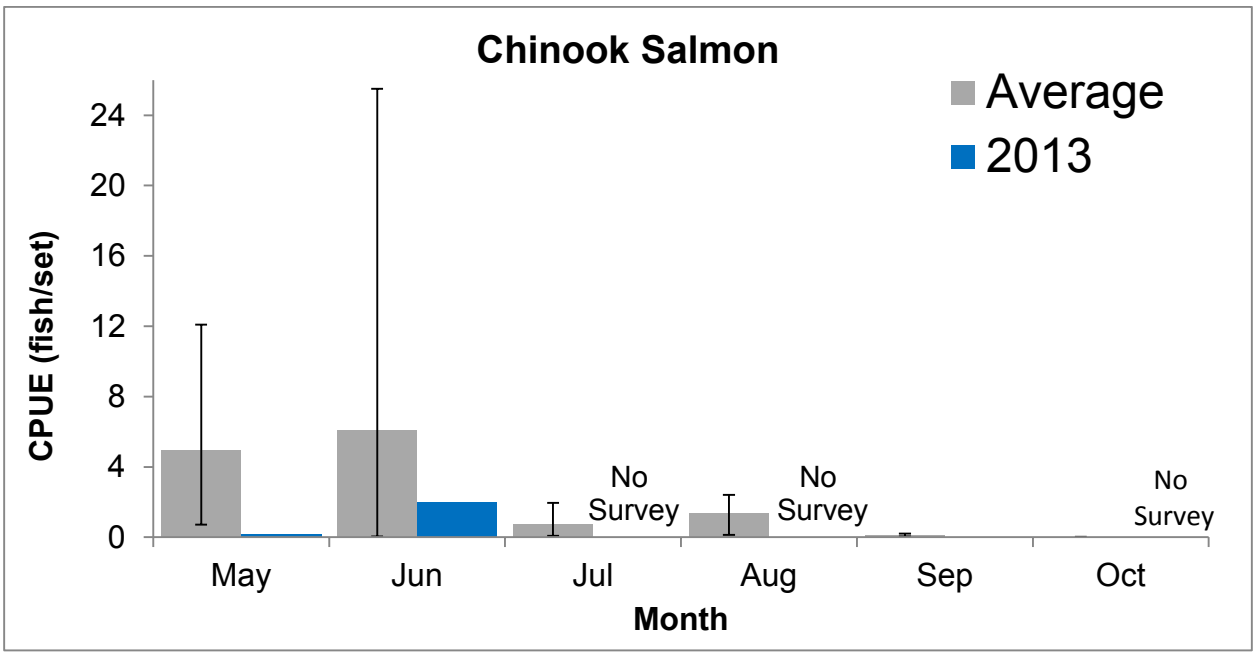



**Figure 4.4.11. Seasonal abundance of Chinook salmon smolts captured by beach seine in the Russian River Estuary, 2004-2013. Seining events consisted of 21 to 50 seine sets approximately monthly. October surveys began in 2010. Data from 2004 to 2011 were averaged. Whiskers indicate minimum and maximum values above the below the average.**

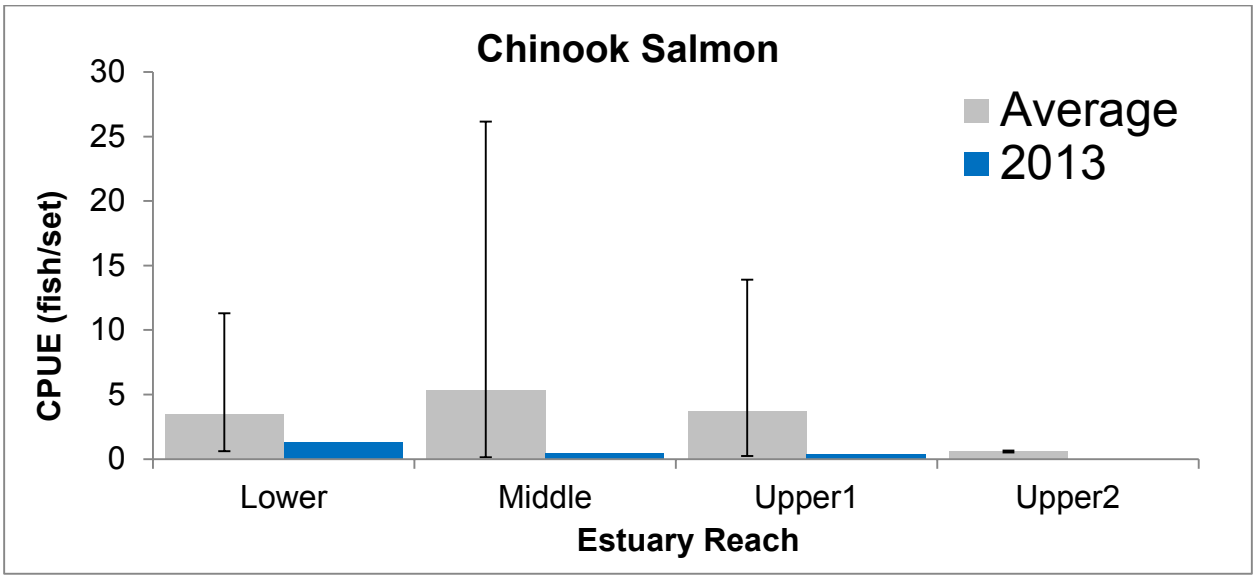



Figure 4.4.12. Spatial distribution of Chinook salmon smolts in the Russian River Estuary, 2004-2013. Fish were sampled by beach seine consisting of 96 to 300 sets annually. Data from 2004 to 2012 were averaged. Whiskers indicate minimum and maximum values above the below the average. No surveys were conducted in the Upper2 Sub-Reach (Casini Ranch and Moscow Bridge stations) from 2004 to 2009.

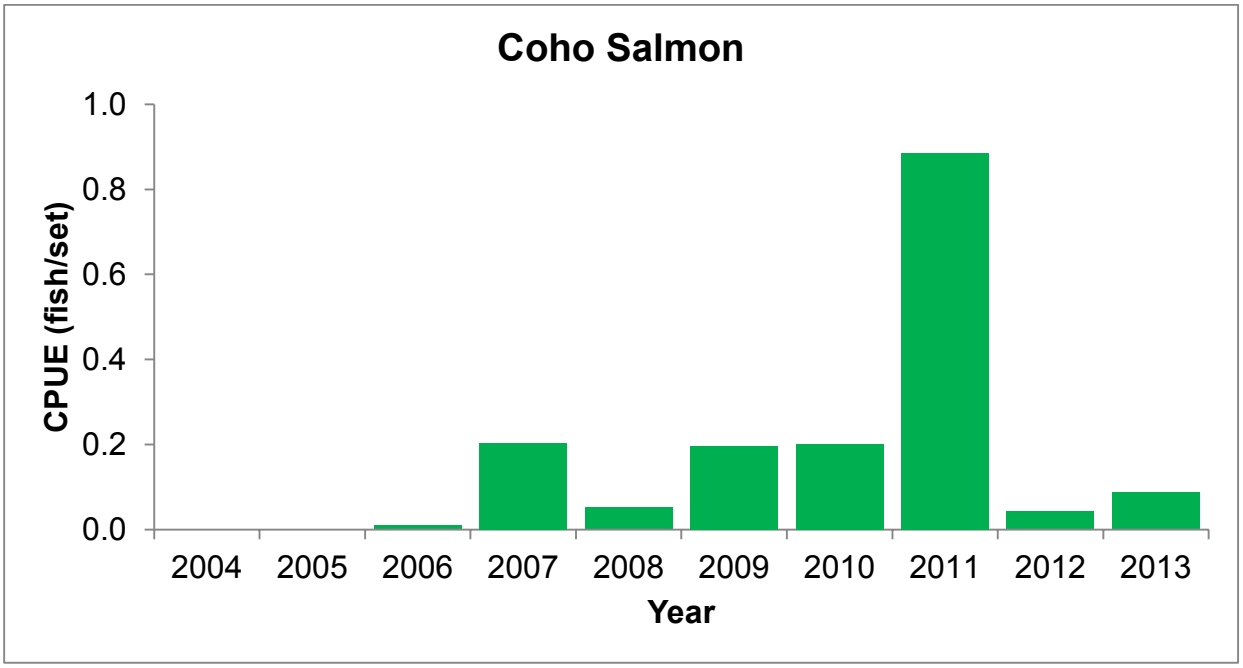



Figure 4.4.13. Annual abundance of coho salmon smolts captured by beach seine in the Russian River Estuary, 2004 to 2013. Samples are from 96 to 300 seine sets yearly from May to October.

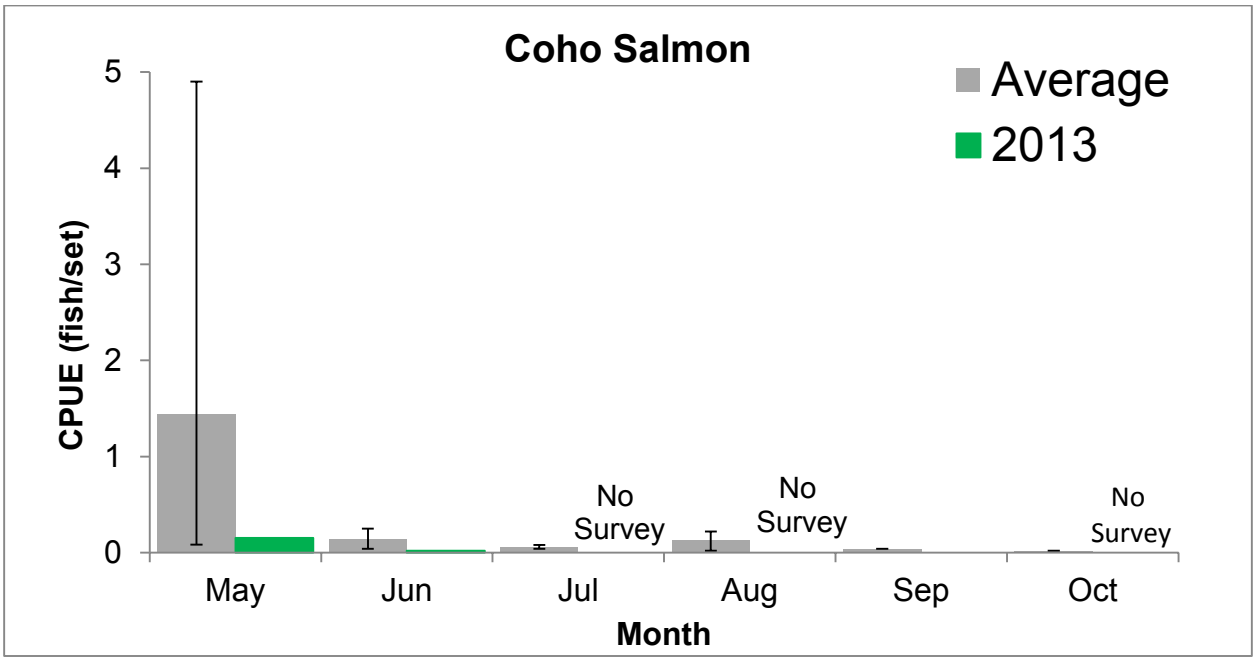



**Figure 4.4.14. Seasonal abundance of coho salmon smolts captured by beach seine in the Russian River Estuary, 2004-2013. Seining events consisted of 21 to 50 seine sets approximately monthly. October surveys began in 2010. Data from 2004 to 2012 were averaged. Whiskers indicate minimum and maximum values above the below the average.**

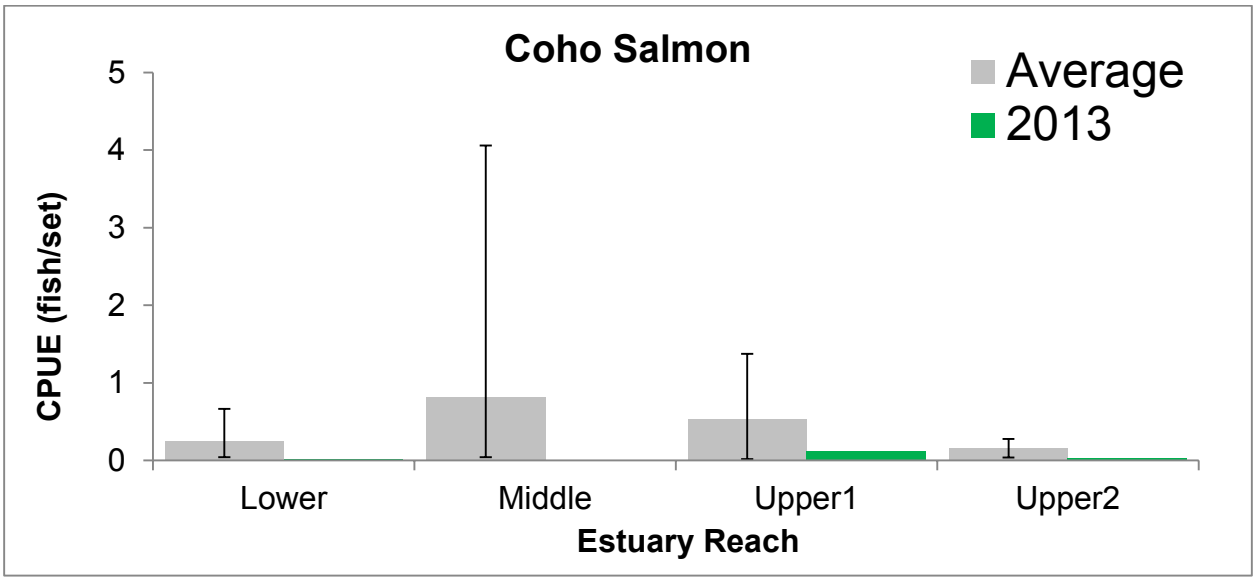



**Figure 4.4.1115. Spatial distribution of coho salmon smolts in the Russian River Estuary, 2004-2013. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the Upper2 Sub-Reach (Casini Ranch and Moscow Bridge stations) from 2004 to 2009. Data from 2004 to 2012 were averaged. Whiskers indicate minimum and maximum values above the below the average.**

Three of the Estuary-captured coho were PIT-tagged hatchery fish (Mariska Obedzinski, UC extension, unpublished data). Two coho were released as smolts into Dutch Bill Creek on May 21, 2013, and were caught one day later during seining at Freezeout Bar station with fork lengths of 114 and 126 mm. The third coho stayed in freshwater for at least 343 days before entering the Estuary. This coho was stocked as a parr in Green Valley Creek on June 13, 2012, then was caught during electrofishing surveys in the creek on September 20, 2012, with a fork length of 76 mm fish (Mariska Obedzinski, UC extension, unpublished data). It was detected moving downstream in lower Green Valley Creek at an antenna station on May 18 and 20, 2013. Then two days later on May 22 it passed the Duncans Mills antenna station and was captured at Freezeout Bar seining station with a fork length of 96 mm. Between May 20 and 22 this smolt migrated downstream in the Russian River over 27 rkm.

### 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 2013 was 0.1 fish/set, which is the lowest since surveys began (Figure 4.4.16). The highest captures were 24.3 fish/set in 2006. The low abundance was likely influenced by the reduced seining effort in 2013 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. Shad were distributed throughout the Estuary but were most abundant in the Upper1 and Upper2 Sub-Reaches where fresh and slightly brackish waters occur (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.

Topsmelt is a common fish in the Russian River Estuary. However, the abundance of topsmelt in the Estuary has decreased since a peak in 2006 with a CPUE of 13.4 fish/set (Figure 4.4.18). The CPUE in 2013 was lowest recorded at 0.01 fish/set. Typically, the catch of topsmelt peaks in July and August. But no surveys were conducted in 2013 during these months. Topsmelt were distributed in the Lower and Middle Reaches, where brackish water conditions are common, and were seldom captured upstream where tidal influences are low (Figure 4.4.19).

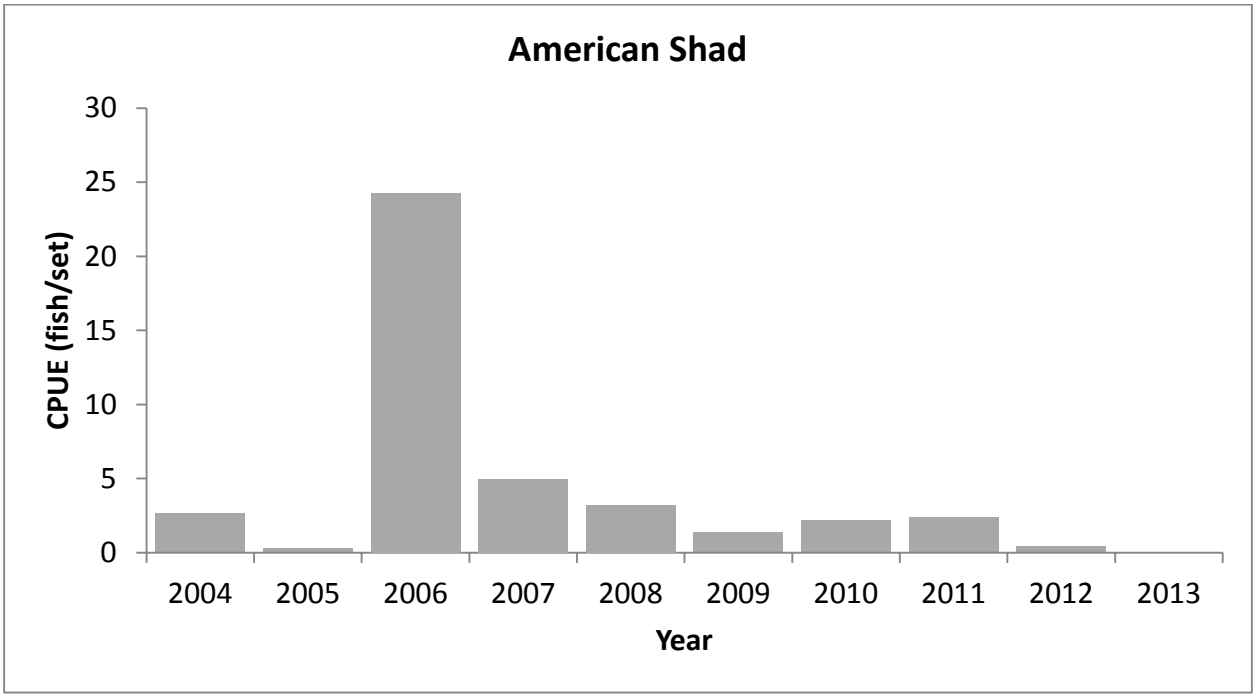



**Figure 4.4.16. Annual abundance of juvenile American shad captured by beach seine in the Russian River Estuary, 2004-2013. Samples are from 96 to 300 seine sets yearly from May to October.**

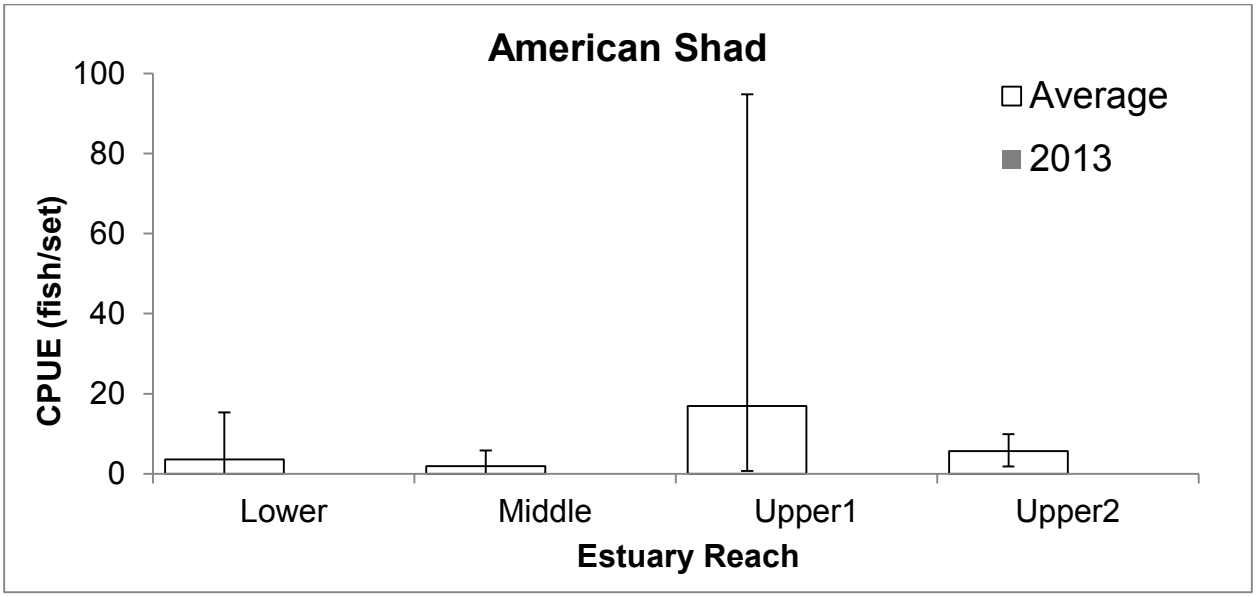



**Figure 4.4.17. Spatial distribution of juvenile American shad in the Russian River Estuary, 2004-2013. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the Upper2 Reach during 2004 and 2009. Data from 2004 to 2012 were averaged. Whiskers indicate minimum and maximum values above the below the average.**

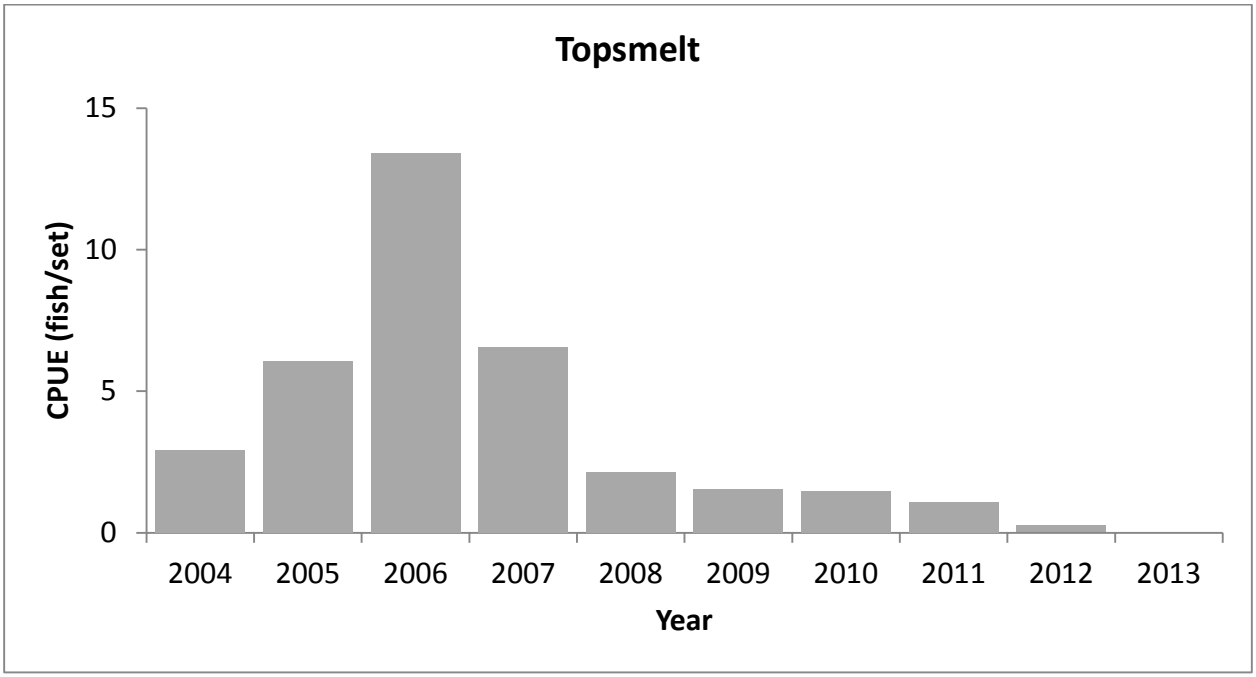



**Figure 4.4.18. Annual abundance of topsmelt captured by beach seine in the Russian River Estuary, 2004-2013. Samples are from 96 to 300 seine sets yearly from May to October.**

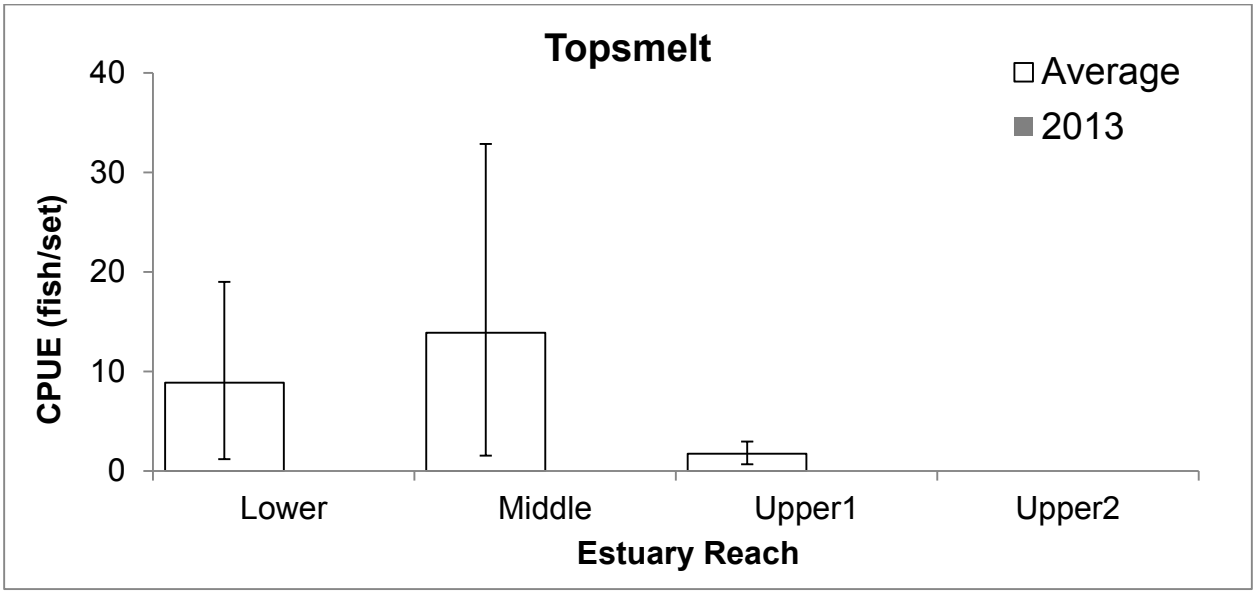



**Figure 4.4.19. Spatial distribution of topsmelt in the Russian River Estuary, 2004-2013. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the Upper2 Reach during 2004 and 2009. Data from 2004 to 2012 were averaged. Whiskers indicate minimum and maximum values above the below the average.**

### 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 2013 was the lowest on record at 0.1 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). Flounders were captured in all the study reaches, except in the Middle Reach, in 2013 at very low numbers. Starry flounder have been detected as far as Austin Creek at the upstream end of the Estuary (Cook 2006).

#### Willow Creek Fish Studies

A preliminary evaluation of the distribution, abundance, and habitat conditions for fish in lower Willow Creek was completed in 2013. Fish and water quality surveys were conducted in the tidal portion of the creek from the confluence with the Russian River Estuary upstream approximately 500 m (Figure 4.4.22 and Table 4.4.2). Six seining stations were surveyed five times between June and August 2013. Fish capture and processing methods were similar to Estuary seining methods, except a 100 foot long by 4 foot high seine was deployed by hand. Also, water quality data at stations was recorded at 0.25 m intervals in the water column.

The water quality conditions in the Willow Creek study area was highly variable. During low tide most of the study area was dewatered, except for a few pools. Water conditions near the creek mouth were characteristic of the Russian River Estuary with warm fresh and brackish water. Water in the upper study area was stratified with a warm freshwater layer at the surface and cooler brackish anoxic layer at the bottom. A super heated mid-column layer was also observed occasionally. This stratification is characteristic of water conditions found during prolonged mouth closures in the Estuary. Figure 4.4.23

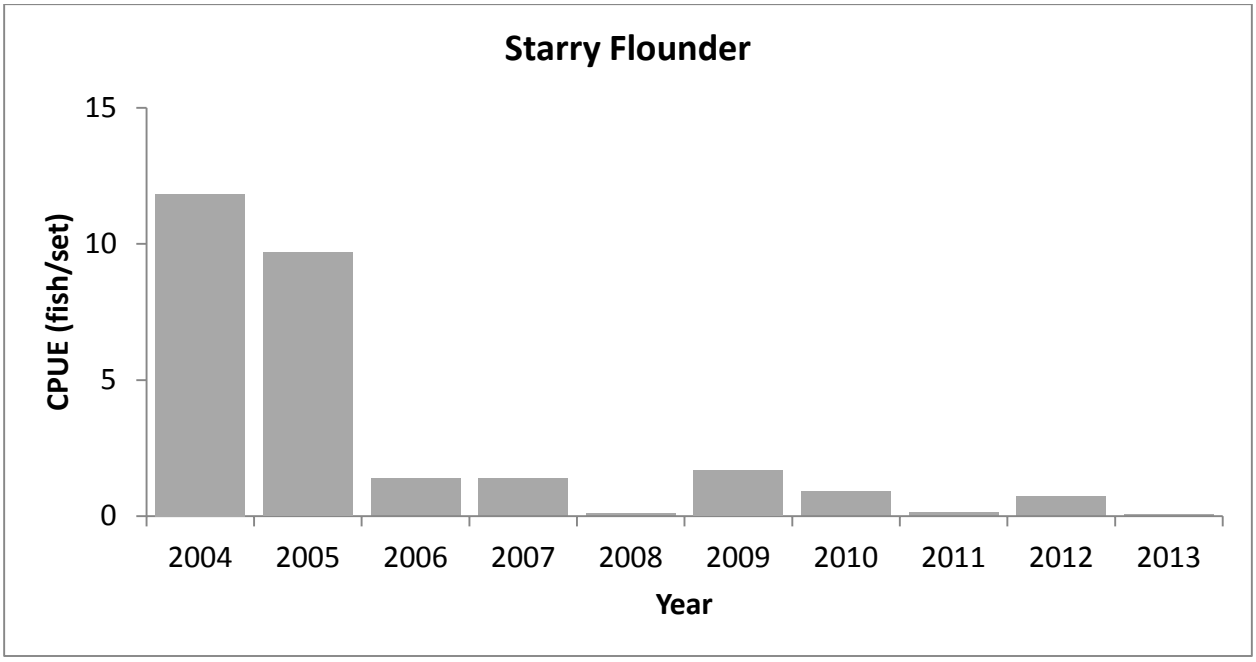



**Figure 4.4.20. Annual abundance of juvenile starry flounder captured by beach seine in the Russian River Estuary, 2004-2013. Samples are from 96 to 300 seine sets yearly from May to October.**

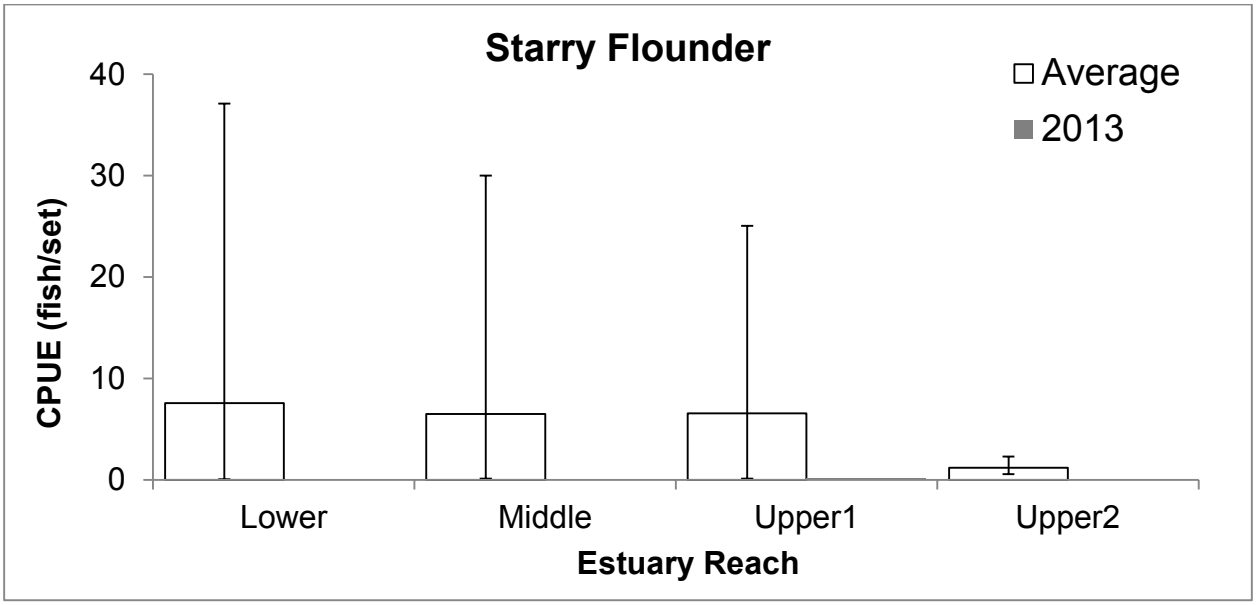



**Figure 4.4.21. Spatial distribution of juvenile starry flounder in the Russian River Estuary, 2004-2013. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the upper Estuary during 2004 and 2009. Data from 2004 to 2012 were averaged. Whiskers indicate minimum and maximum values above the below the average.**

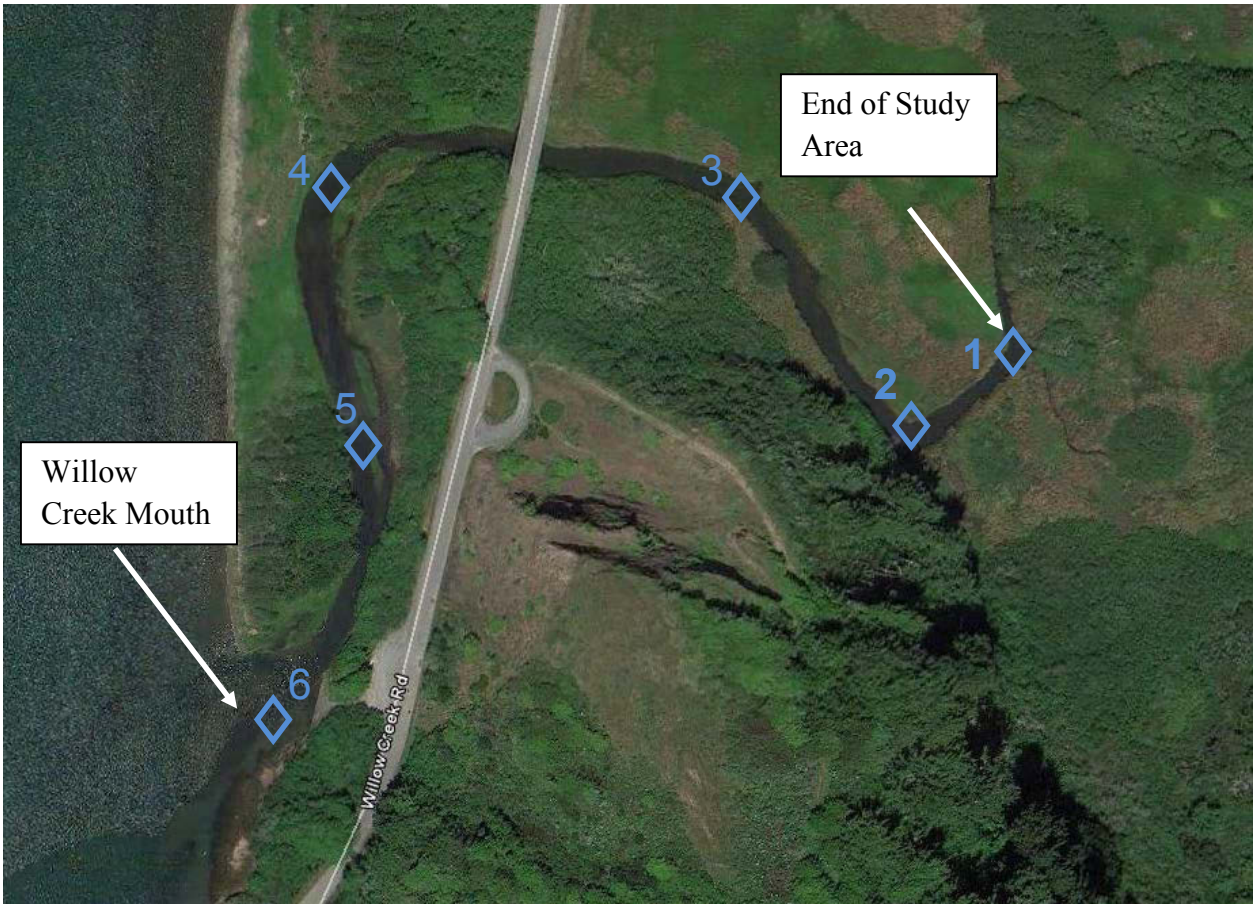



**Figure 4.4.22. Willow Creek study area, 2013. Six seining and water quality stations were sampled five times from May to August 2013.**

**Table 4.4.2. Fish captures by seine in lower Willow Creek, 2013.**

| | Seining Captures | | | | | |
|---|---|---|---|---|---|---|
| **Species** | **13-Jun** | **9-Jul** | **24-Jul** | **8-Aug** | **27-Aug** | **Total** |
| California roach | | 1 | 1 | | | 2 |
| Chinook salmon | 1 | | | | | 1 |
| Coho salmon | 1 | 2 | | | 6 | 9 |
| Mosquitofish | | 2 | | 15 | | 17 |
| Prickly sculpin | | 12 | 22 | 18 | 7 | 59 |
| Sacramento pikeminnow | | 3 | 17 | | 41 | 61 |
| Sacramento Sucker | | 10 | 43 | 11 | 2 | 66 |
| Shiner surfperch | | | | | 4 | 4 |
| Steelhead | | 2 | | | | 2 |
| Threespined stickleback | | 314 | 324 | 317 | 247 | 1202 |
| **Total** | **2** | **346** | **407** | **361** | **307** | **1423** |

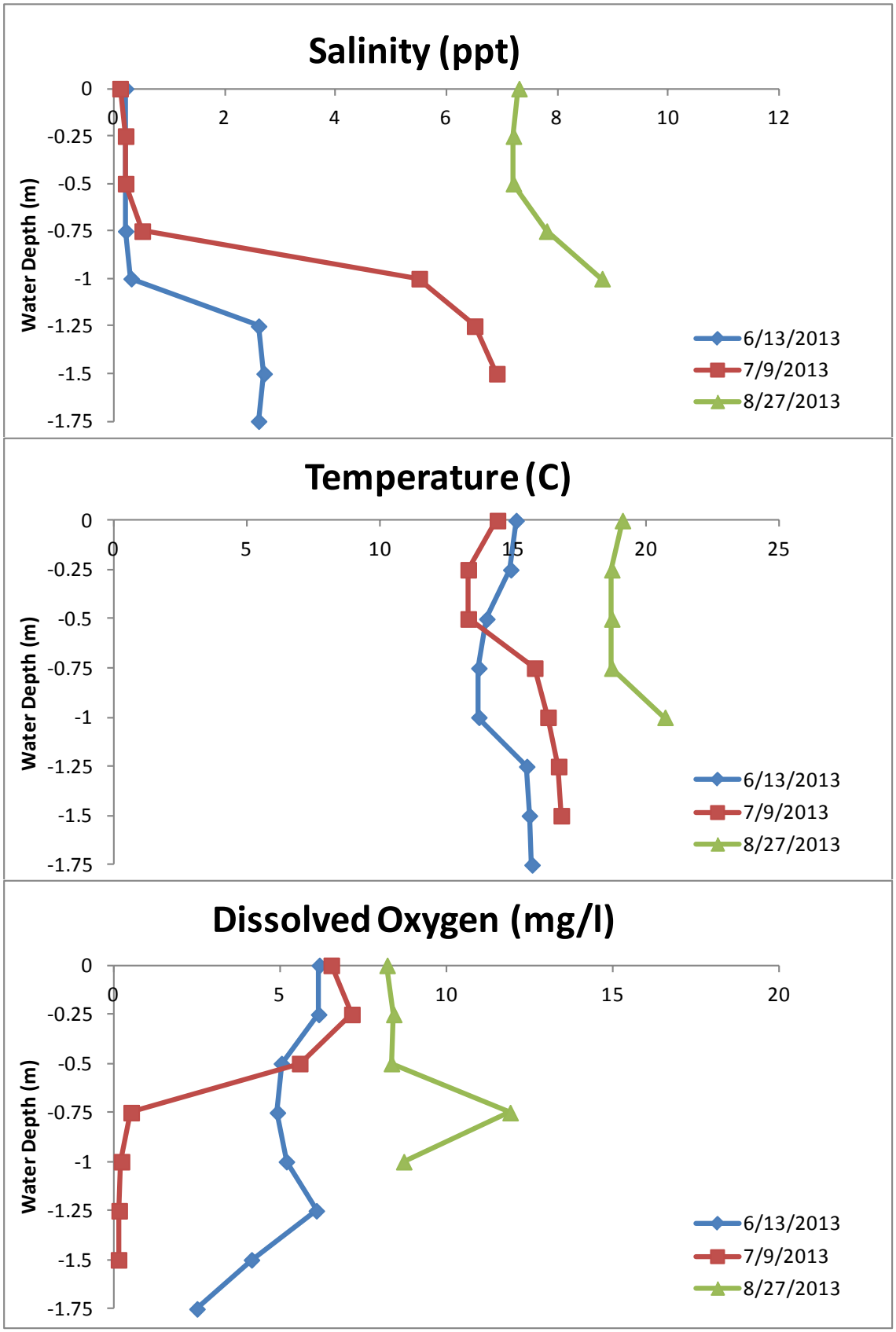



**Figure 4.4.23. Water conditions at Willow Creek Station 1, summer 2013. This station is the upper most site and where coho smolts and a juvenile steelhead were captured on the dates shown.**

shows examples of water profile conditions at Station 1 where coho smolts were captured. A total of 1,423 fish consisting of 10 species were detected in Willow Creek, including three salmonid species (Table 4.4.2). One Chinook salmon smolt was captured at Willow Creek mouth at the Russian River (Station 6). One juvenile steelhead and nine coho salmon smolts were captured at the two upstream sites (Stations 1 and 2). The coho included both hatchery and wild fish. These coho where found as late as August, which is an unusual time for smolts to be moving and when water temperatures can be lethal in the Russian River. The source of these coho is unclear; it is not known if they originated upstream in Willow Creek or migrated down the Russian River and then entered Willow Creek. Given the harsh water quality conditions in the lower Willow Creek observed throughout most of the study area, there is limited rearing habitat for salmonids, although steelhead and salmon were found.

### Conclusions and Recommendations

*Fish Sampling - Beach Seining*

The results of Estuary fish surveys from 2004 to 2013 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 2013 fish studies contribute to the ten-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 when seining surveys were conducted in May, June, and September (excluding July, August, and October).

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.

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 synthesis in Chapter 10 provides a discussion about trends in abundance but the fluctuation in abundance of steelhead

annually is likely attributed to the variability in adult spawner population size (i.e. cohort abundance), residence time of young steelhead before out-migration, and schooling behavior that affects susceptibility to capture by seining. Chinook salmon smolts spent less than half the summer rearing in the Estuary and were usually absent after July. Based on the detection of these smolts at most seining stations, they appear to use most estuarine habitats as they migrate to the ocean. In comparison, steelhead were found during the entire summer and were often found in the Upper Reach of the Estuary. However, there are sites in the Middle and Lower Estuary (e.g., Jenner Gulch confluence) where steelhead are consistently found.

### 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.

# 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).

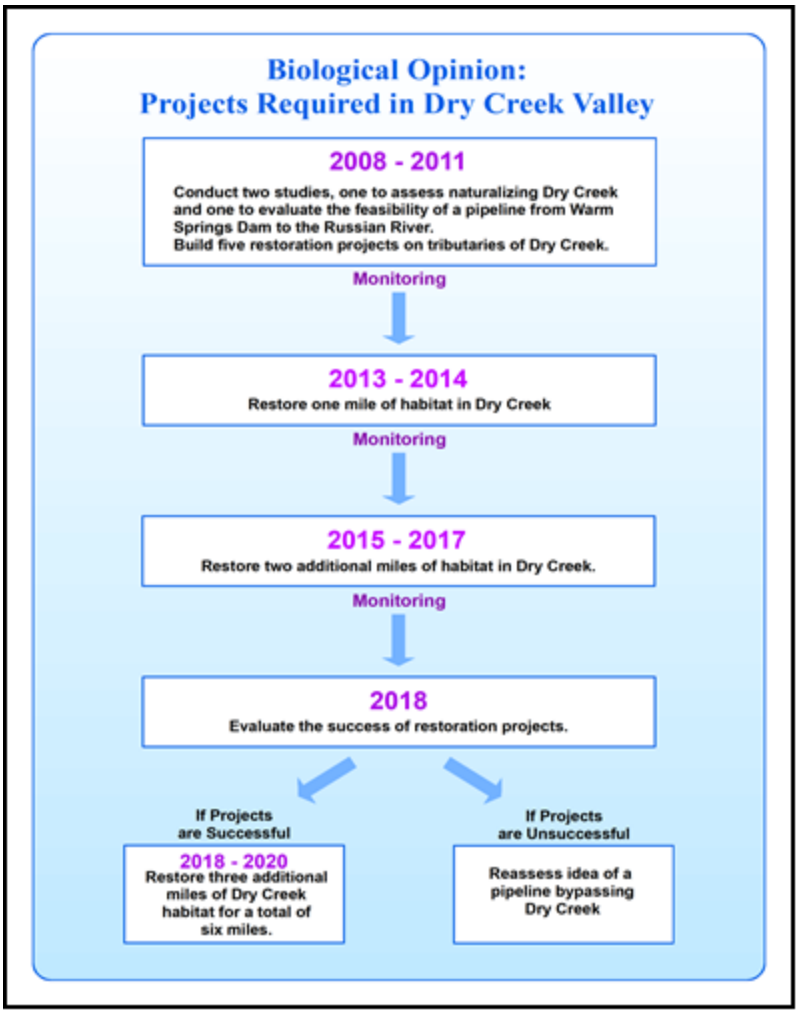



Figure 5.1.1. Timeline for implementation of Biological Opinion projects on Dry Creek.

## 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 indundations 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.

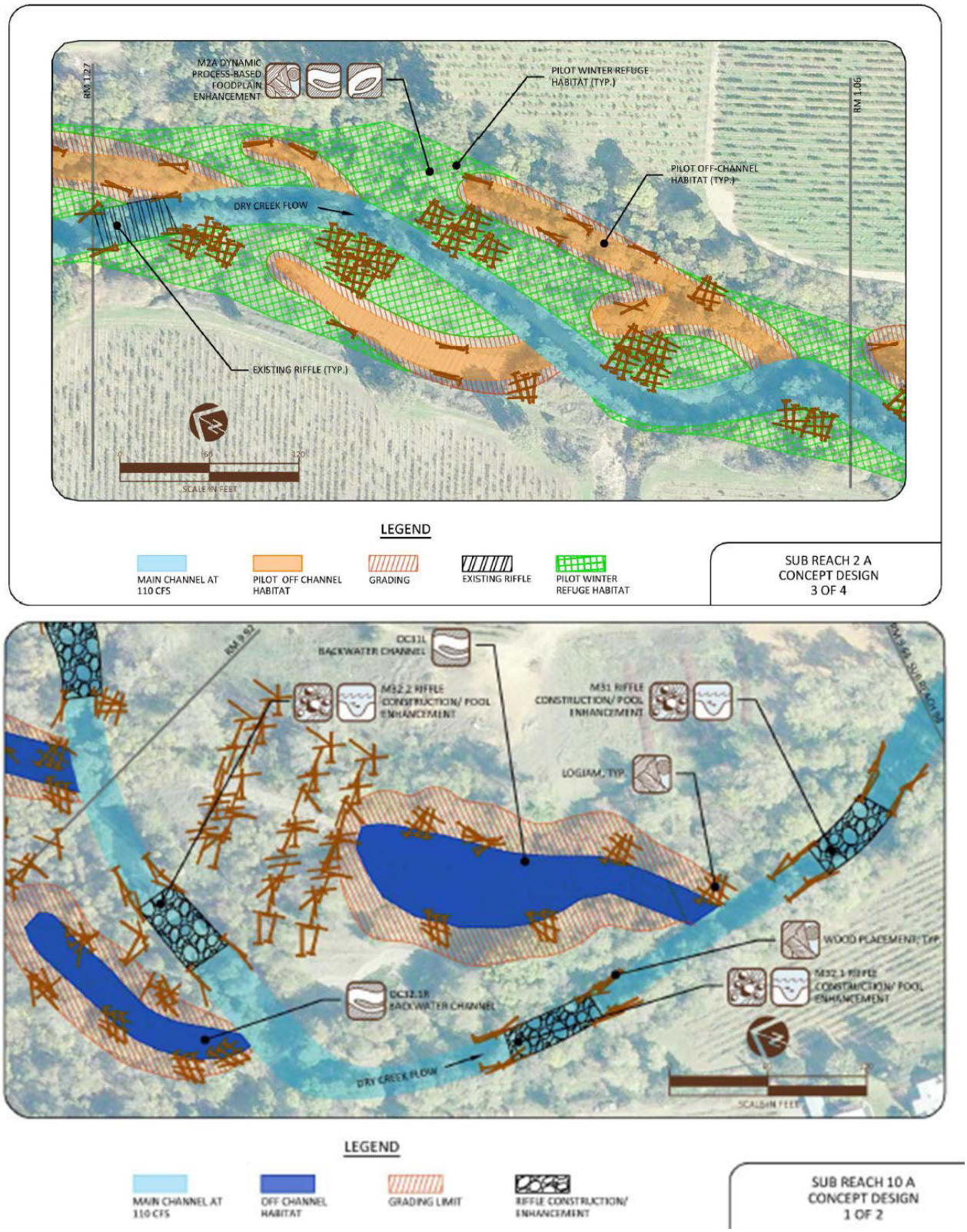



**Figure 5.1.2. Examples of habitat enhancement conceptual designs for two Dry Creek subreaches. The top panel, Reach 10A, illustrates proposed summer habitat enhancements using a static "constructed" habitat approach. Reach 2A, lower panel, is close the confluence of Dry Creek and the mainstem Russian River. In**

this highly dynamic environment, a "process" based approach that creates pilot habitat features the stream can adjust over time is proposed.

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

| Segment | Ranking Tier | (Sub) Reach | Coho Potential Coho Rearing Habitat Score | Winter Refuge & Rearing Habitat Score | Total Potential Habitat Score | Predicted Continuity Score |
|---|---|---|---|---|---|---|
| Upper | Tier I | 14a | High | Medium | High | High |
| | | 13b | Medium | Medium | Medium | High |
| | | 15 | Medium | Low | Low | High |
| | | 14b | Medium | Low | Low | High |
| | Tier II | 12b | Low | High | Medium | High |
| | | 13a | Low | Low | Low | High |
| | | 12a | Low | Low | Low | High |
| Middle | Tier I | 8b | High | Medium | High | Medium |
| | | 4a | High | Low | High | High |
| | | 5a | High | Low | High | Medium |
| | | 4b | High | Low | Medium | Medium |
| | | 8a | Medium | High | High | High |
| | | 5b | Medium | Medium | High | Medium |
| | | 10a | Medium | Low | Medium | High |
| | | 10b | Medium | Low | Medium | Medium |
| | | 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 |

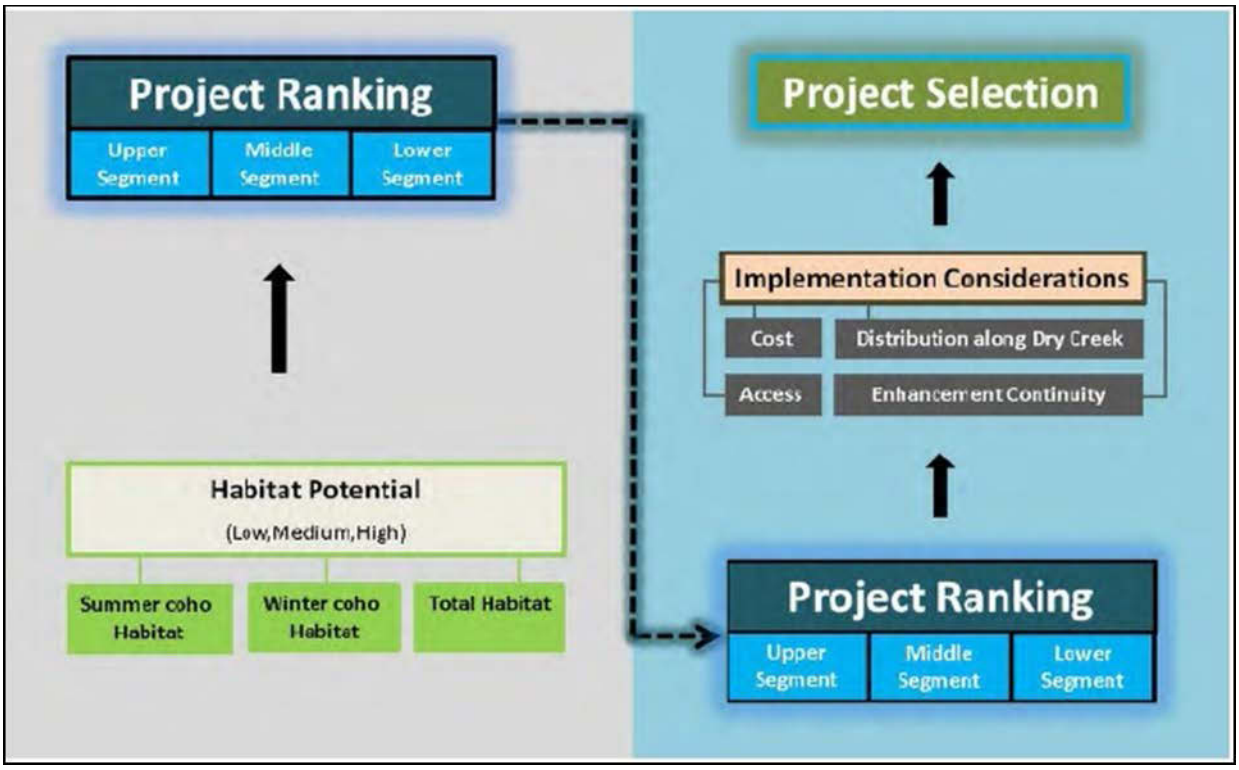



**Figure 5.1.3. Conceptual depiction of habitat project prioritization approach. The left side of the figure represents the first phase of the prioritization process which includes ranking of the enhancement subreaches based solely on their inherent potential for habitat enhancement. The second phase, 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 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.

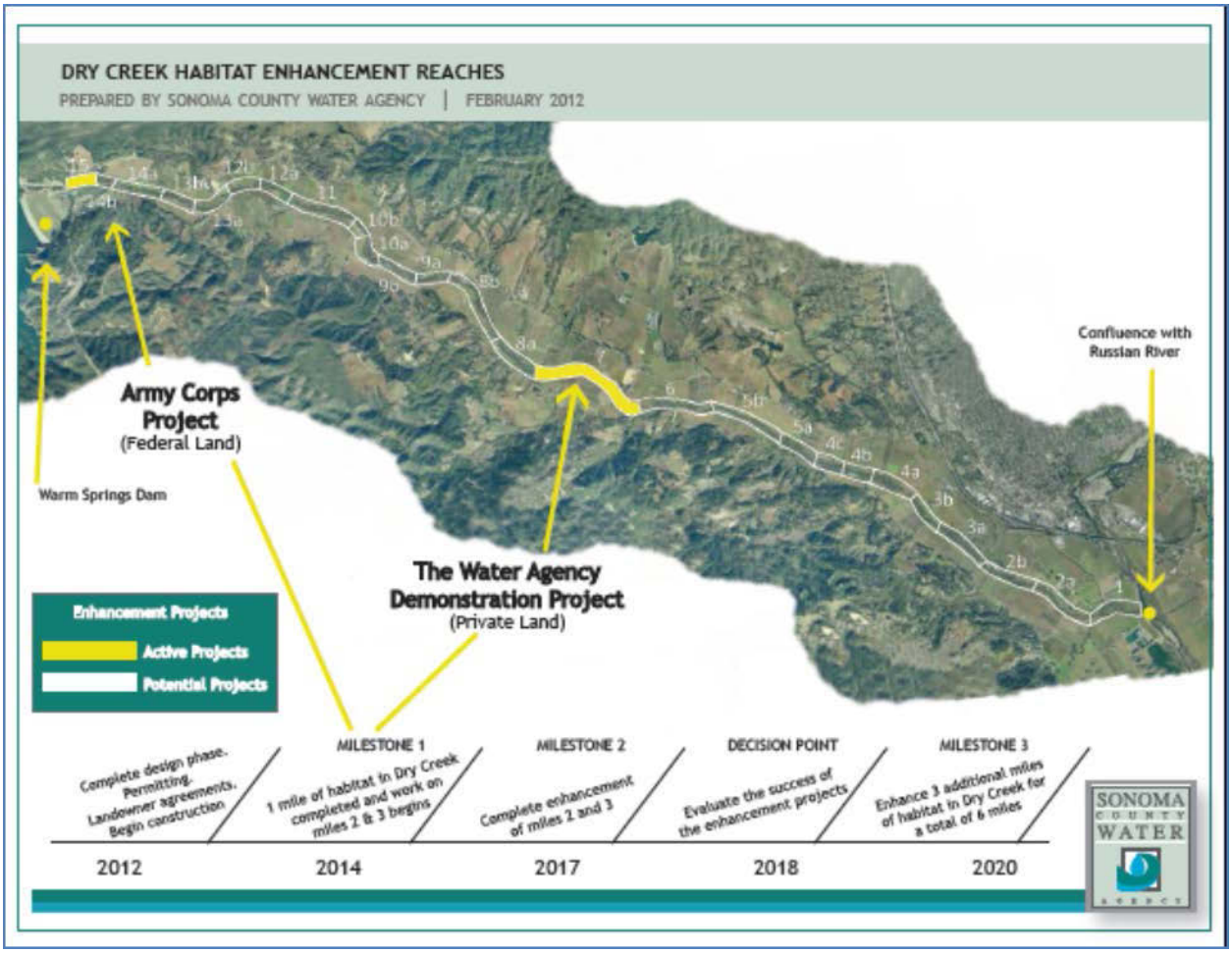



**Figure 5.1.4. The location of Water Agency and Army Corps of Engineers Dry Creek habitat enhancement projects to meet Biological opinion milestones.**

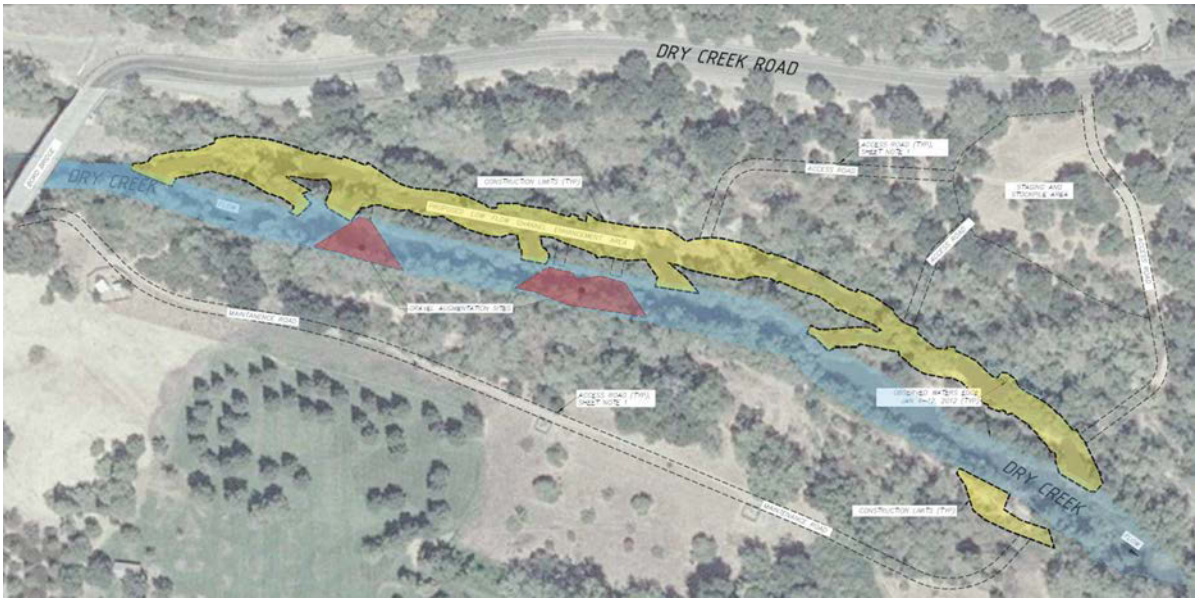



**Figure 5.1.5. The Army Corps of Engineers Dry Creek Reach 15 habitat enhancement project. The blue shows the existing flow of Dry Creek. The yellow area shows the side channel area constructed in 2013. The red area shows instream gravel augmentation areas constructed implemented as part of the Reach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

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

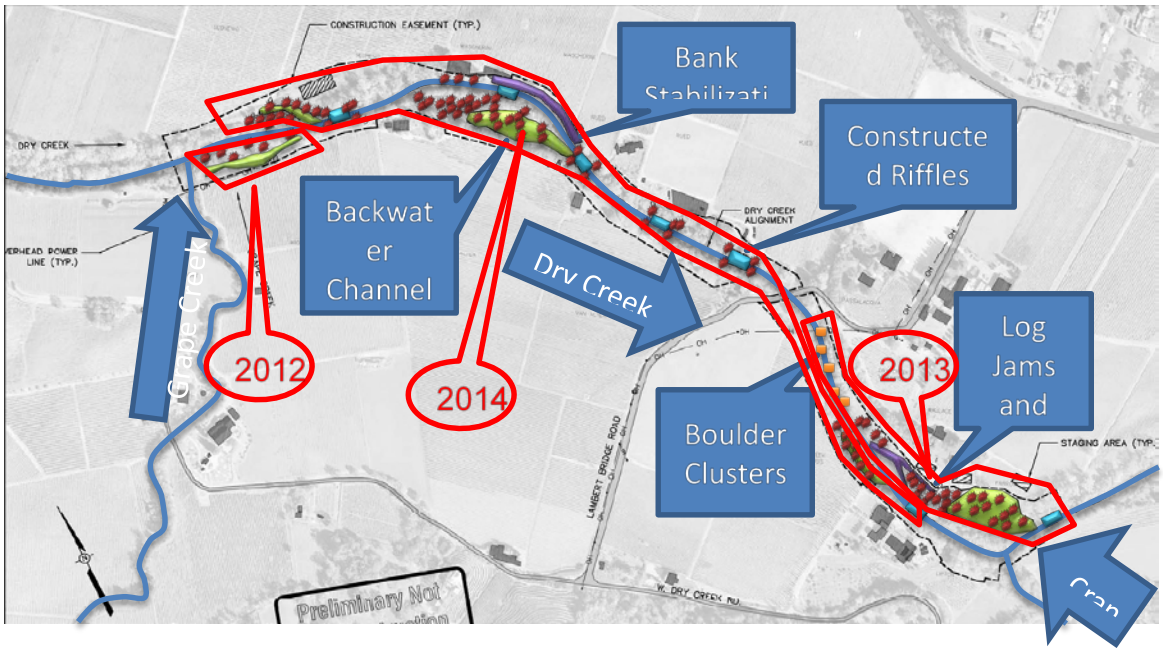



**Figure 5.1.6. The Water Agency's Demonstration Project. The blue shows the existing flow of Dry Creek. The red outlines indicate the areas constructed in 2012 and 2013 and the areas scheduled for construction in 2014.**

**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.**

## Miles 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 is in the process of conducting studies for the CEQA documentation as well as developing engineering designs for the Miles 2 and 3 of the Dry Creek habitat enhancement work.

## 5.2: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 2013. 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. Some preliminary effectiveness monitoring data have been collected. Those data will be reported in future reports. Plans for effectiveness monitoring are outlined in the AMP.

In the Russian River Biological Opinion status and data report year 2009-10 (Manning and Martini-Lamb 2011), the Water Agency outlined six possible metrics that could be considered for validation monitoring of juvenile salmonids with respect to eventual habitat enhancements in the mainstem of Dry Creek: habitat use, abundance (density), size, survival, growth and fidelity. In 2009-2010, 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 adaptive management plan described above (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).

In the AMP, three spatial scales of validation monitoring for juvenile salmonids for mainstem Dry Creek have been identified: site/feature, reach, and entire mainstem. The AMP further suggests the appropriate target life stage and temporal scale of monitoring for each spatial scale (Table 5.2.1). During the current pre-construction monitoring phase, validation monitoring has been at the site and reach scale in the form of juvenile sampling to estimate size and growth, survival, emigration and population density for steelhead as well as at the stream (mainstem Dry Creek) scale to begin the task of establishing long term smolt population trends for coho salmon. As projects are constructed, we plan to begin implementing finer spatial scale sampling to estimate use of newly constructed features by juvenile salmonids.

**Table 5.2.1. 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 tool(s) |
|---|---|---|---|---|
| Site/feature | Juvenile (non-smolt) | Habitat use, abundance (density), size, growth | Post-construction | Snorkeling, electrofishing, PIT tags and antennas |
| Reach | Juvenile (non-smolt) | Abundance (density), size, survival, growth, fidelity | Pre-construction (baseline) vs. post-construction | Electrofishing, PIT tags and antennas |
| Mainstem Dry Creek | Smolt | Abundance | Ongoing to capture long-term trend | Downstream migrant trap, PIT antennas |

## Methods

### *Juvenile sampling*

In 2013, we continued the focus begun in 2009 and continued in 2010-2012 of sampling at the reach scale by making multiple backpack electrofishing passes through relatively long stream sections in an attempt to estimate over-summer survival, emigration and size/growth for juvenile steelhead in the upper, middle and lower reaches of mainstem Dry Creek. As in 2008-2012, we also sampled shorter sections within the middle reach stream section that has been targeted for the first mile of habitat enhancements in mainstem Dry Creek (the "demonstration project") in order to estimate over-summer growth and population density in early autumn (Figure 5.2.1). All of the stream sections sampled in 2013 were similar to those sampled in previous years (Figure 5.2.1). Although our primary target species for the eventual habitat enhancement work is coho salmon, steelhead juveniles are also federally threatened in the Russian River and are currently the only salmonid species present in the summer that are abundant enough to estimate the aforementioned parameters in a meaningful way.

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

Reach-scale sampling involved selecting stream sections that could be reasonably sampled with a backpack electrofishing unit. Sampling began by first bounding the downstream end of selected stream sections with a paired PIT antenna array from mid-summer to early autumn, capturing individual juvenile salmonids with a backpack electrofisher and dipnets in late July/early August, PIT-tagging fish that were ≥60 mm and re-sampling the same sections with a backpack electrofisher in late September/early October. In 2013, the only site where we operated a PIT antenna array

for true survival estimation was in in the lower reach of Dry Creek (Figure 5.2.1). The antenna arrays consisted of two antennas in close proximity (~8 m) to one another so that efficiency for each array could be estimated. For PIT-tagged individuals that were captured in late July then again in autumn (i.e., recaptured), we calculated over-summer growth rates (mm of change in fork length per day). We used the multistate-robust-design model in program MARK (White and Burnham 1999) to estimate over-summer survival and emigration as well as population abundance in early fall by simultaneously estimating the efficiency of each PIT antenna array (Horton et al. 2011). Fall re-sampling actually consisted of two passes through each section. Because these two re-sampling passes were spaced close together in time (2 days apart), we could reasonably assume that survival and emigration probability between these two passes were 1 and 0, respectively. Another important assumption of the multistate-robust-design model is that all fish are equally available for recapture on subsequent sampling occasions. A common way this assumption is violated is by previously-tagged individuals emigrating from the sampling area between sampling occasions. If this assumption is violated, section fidelity would remain confounded with true survival meaning that the parameter being estimated would be apparent survival as opposed to true survival. In order to address this issue, we decoupled emigration from mortality by locating a paired PIT antenna array at the downstream boundary of the stream section sampled so that PIT-tagged fish moving downstream out of the section could be detected. A consequence of this design requirement on Dry Creek, however, was that in particularly deep or swift habitat where the sampling efficacy of backpack electrofishing gear is low and wading conditions are often unsafe, the choice of contiguous sample sections where PIT antenna arrays could be located at downstream section boundaries was limited. Within each reach sampled, the location of capture for each individual was recorded to the nearest 46 m.

*Site-scale sampling* Site-scale sampling involved defining relatively shorter contiguous sites, capturing individual juvenile steelhead with a backpack electrofisher in late July/early August, PIT-tagging fish that were ≥60 mm and re-sampling the same sections in late September/early October followed 2 days later by a recapture pass through each section. For PIT-tagged individuals that were captured in late July then again in autumn, we calculated over-summer growth rates (mm of change in fork length per day). From the paired sampling events in early autumn, we used the Petersen mark recapture model to estimate end of summer abundance at these three sites. Provided recapture probability, mortality and the proportion of fish leaving the section between the marking and recapture events is the same for the marked group as it is for the unmarked group, the abundance estimates from the paired mark and recapture events in early autumn should be unbiased (White et al. 1982).

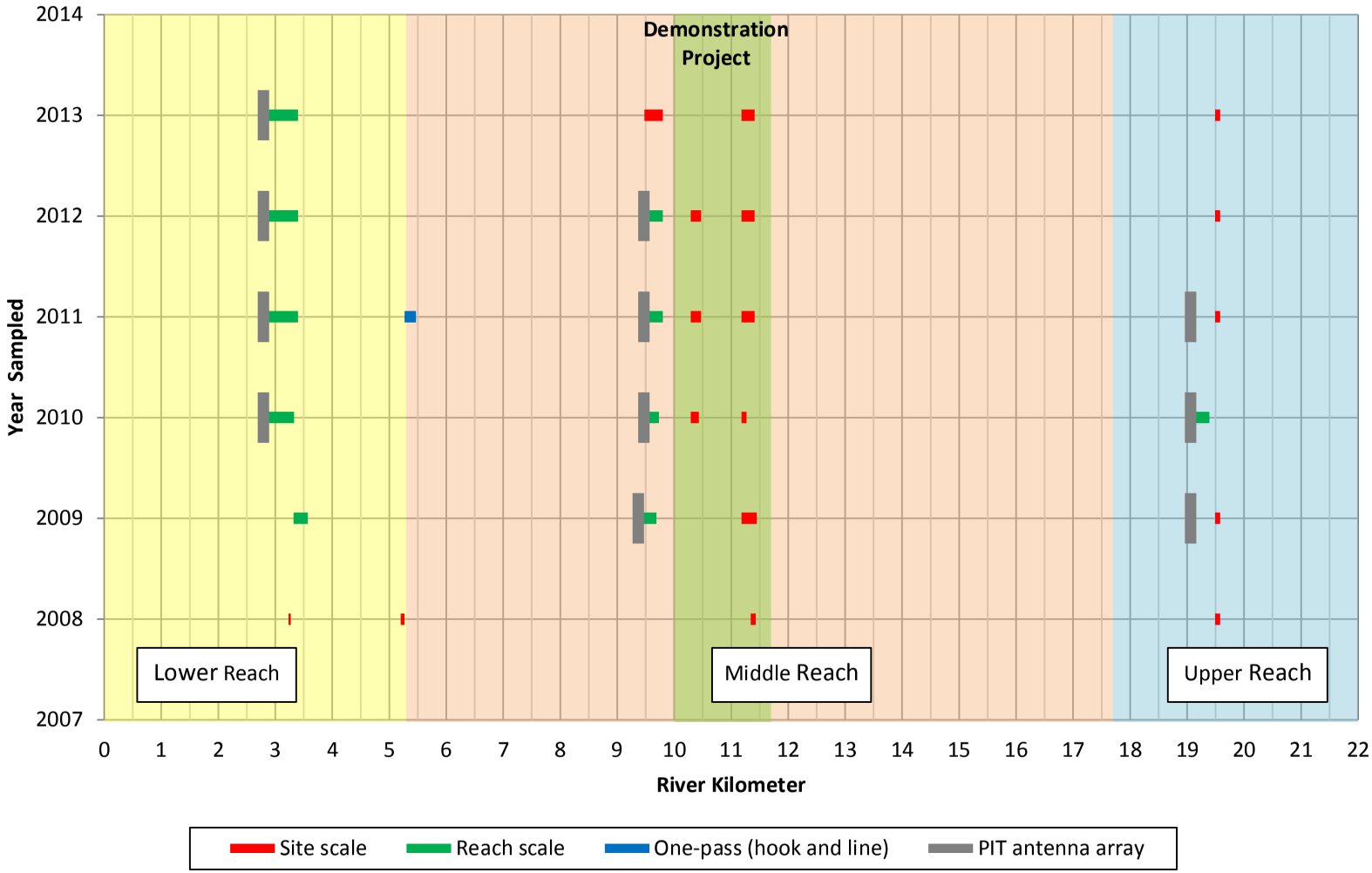



**Figure 5.2.1. Years sampled and river kilometer (from the mouth) where juvenile steelhead populations were sampled in mainstem Dry Creek, 2008-2013. Line length for each site is scaled to the length of stream sampled. Data collected at the site scale were analyzed using mark-recapture (either a multiple-pass 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 2011-13 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").**

### Smolt sampling

A rotary screw trap with a 1.5 m diameter cone was anchored to the Westside Road bridge, located 3.3 km upstream from the confluence of Dry Creek and the Russian River. Wooden-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 ($\geq$60 mm) were finclipped and released approximately 100 m upstream of the trap for the purpose of estimating population abundance using program DARR (Bjorkstedt 2005). Between Monday and Thursday each week, up to an additional 50 Chinook smolts were also 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., Mirabel trap, 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).

## Results

### Juvenile sampling

We captured a total of five wild coho YOY (four in the middle reach and one in the upper reach) were captured 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 5.2.2). 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 5.2.3).

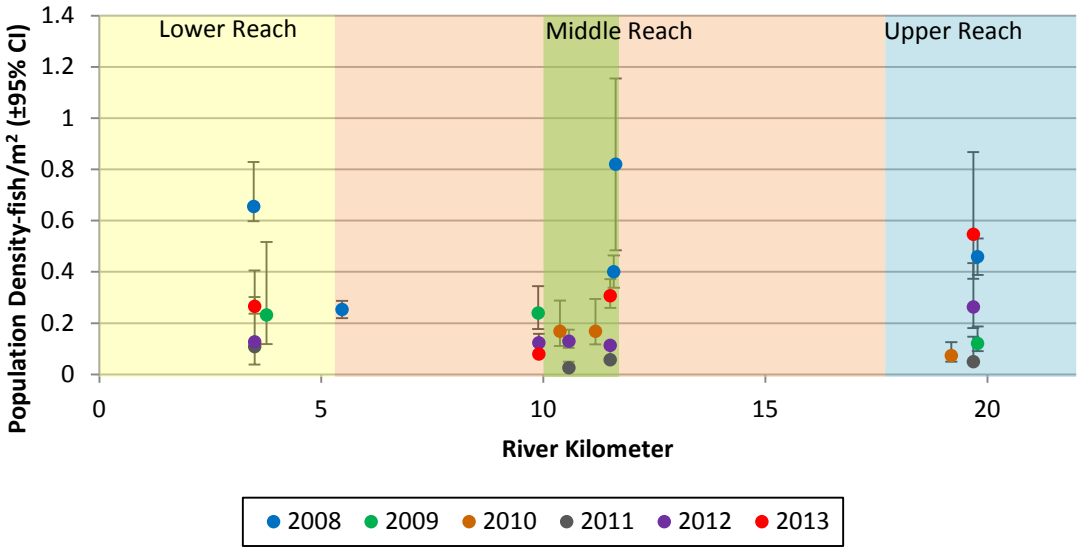



**Figure 5.2.2. Estimated density of juvenile steelhead in mainstem Dry Creek, 2008-2013. Estimates are from a variety of approaches all based on mark-recapture models.**

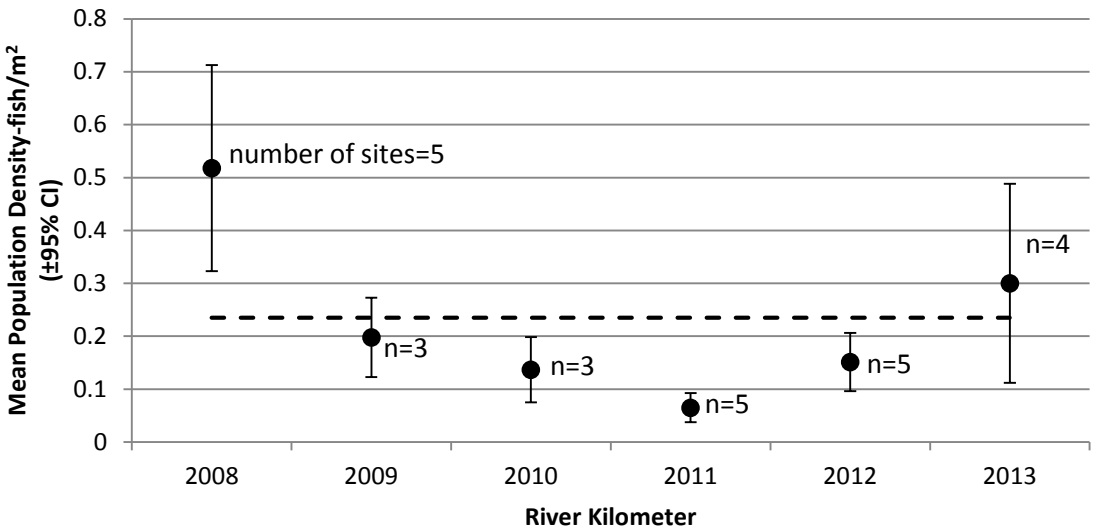



**Figure 5.2.3. Mean juvenile steelhead density among all sites sampled within a year in mainstem Dry Creek, 2008-2013. "n" refers to the number of sites sampled. Dashed line is the six year average density.**

The monthly true survival estimate of juvenile steelhead in 2013 from the lower reach was 0.60 which was similar to previous years (Figure 5.2.4). Nearly 30% of the fish were estimated to have emigrated (Figure 5.2.5).

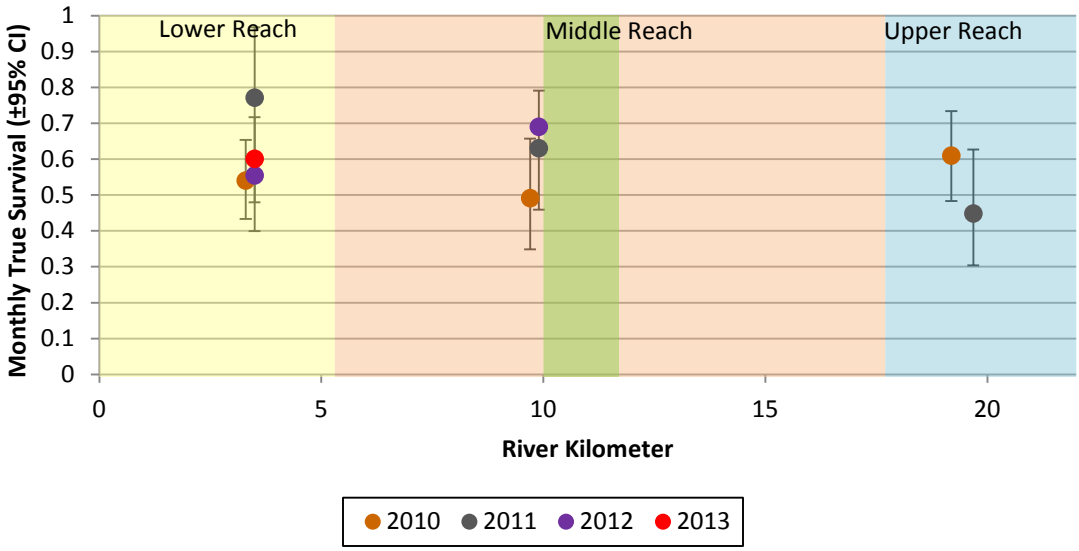



Figure 5.2.4. Estimated monthly true survival of juvenile steelhead from mainstem Dry Creek, 2010-2013.

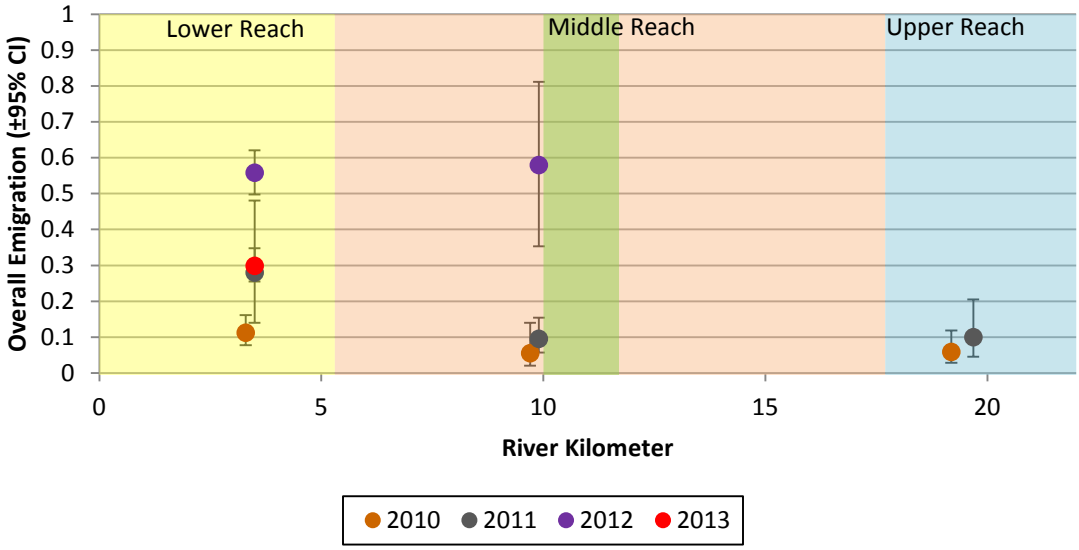



Figure 5.2.5. Estimated overall reach-specific emigration of juvenile steelhead from mainstem Dry Creek, 2010-2013.

The overall mean size of coho salmon YOY captured in 2013 was 91 mm. Sample size (n=4) was too low to evaluate the data for differences in mean size among reaches.

Mean individual growth rates of juvenile steelhead in 2013 was significantly higher in the upper reach as compared to the middle and upper reaches (Figure 5.2.6). This is somewhat of a departure from the pattern in previous years of the middle reach exhibiting growth rates more similar to those observed in the lower reach as opposed to the upper reach (Manning and Martini-Lamb 2011; Martini-Lamb and Manning 2011).

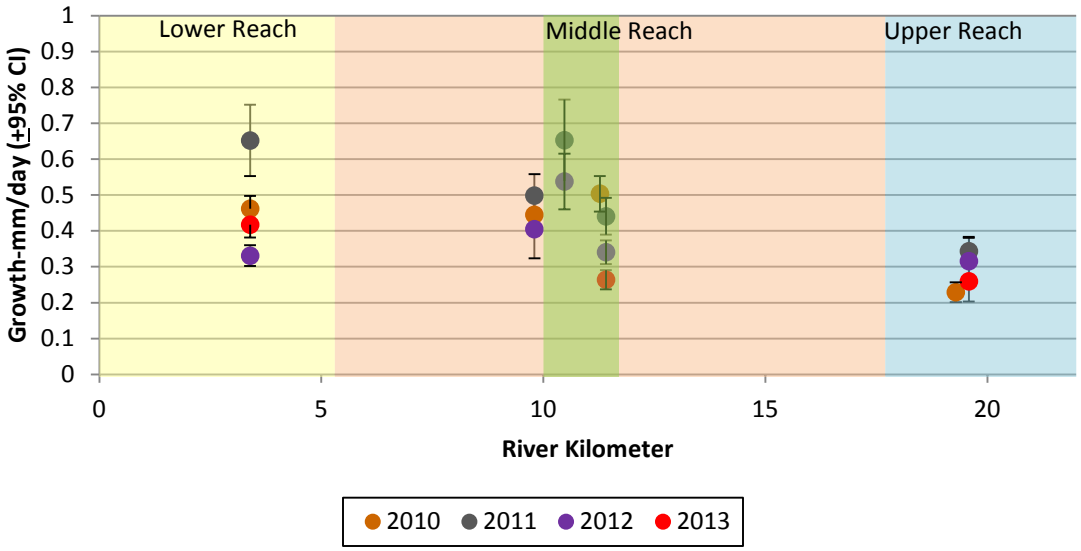



**Figure 5.2.6. Estimated growth rates of juvenile steelhead from mainstem Dry Creek, 2010-2013. Estimates are from individual growth rates calculated as the change in fork length (mm) per day of PIT-tagged fish between initial tagging in late July/early August and recapture in late September/early October.**

### Smolt sampling

We installed the rotary screw trap on March 25 following the recession of high flows. 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 26 until it was removed on July 31.

The peak capture of Chinook smolts (1,546) occurred during the week of 5/14 (Figure 5.2.7) which was the same week as the peak trap catch in 2012. Based on the estimated average weekly capture efficiency (range: 4% to 34%, Figure 5.2.8 upper panel), the resulting population size of Chinook salmon smolts passing the Dry Creek trap between April 4 and July 30 was 236,344 (±95%CI: 21,568, Figure 5.2.8 lower panel).

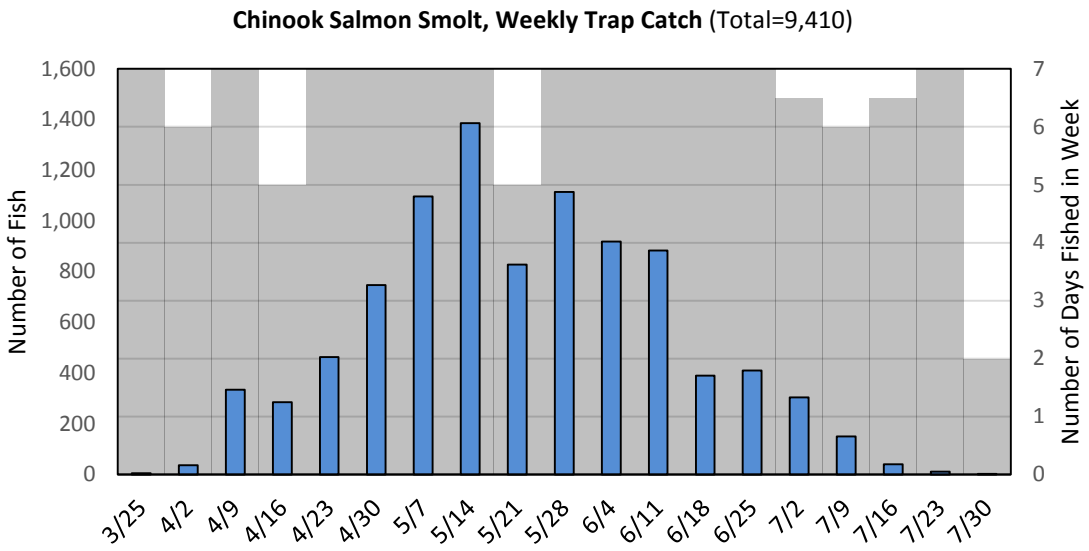
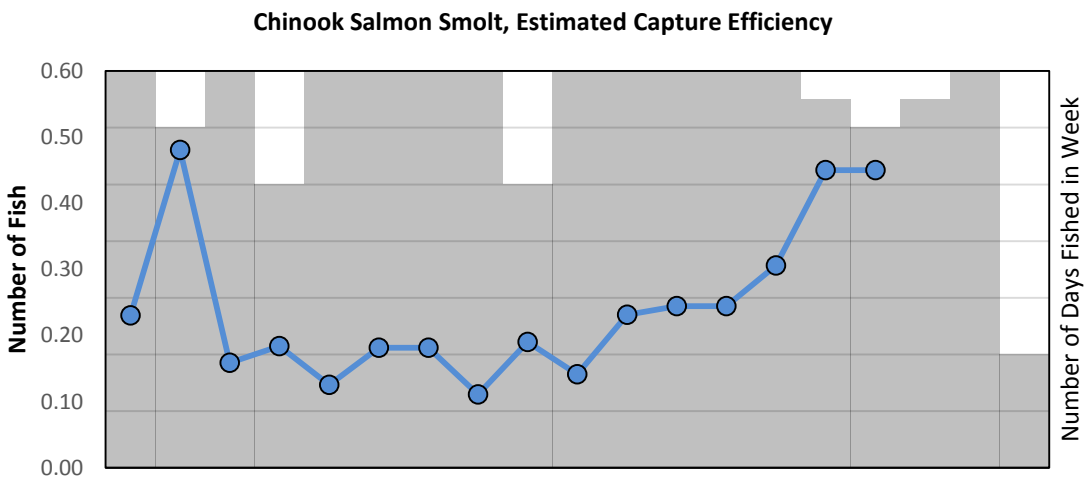



**Figure 7. Weekly trap catch of Chinook salmon smolts in the Dry Creek rotary screw trap, 2013. The number of days each week the trap was fished is represented by the shaded area.**



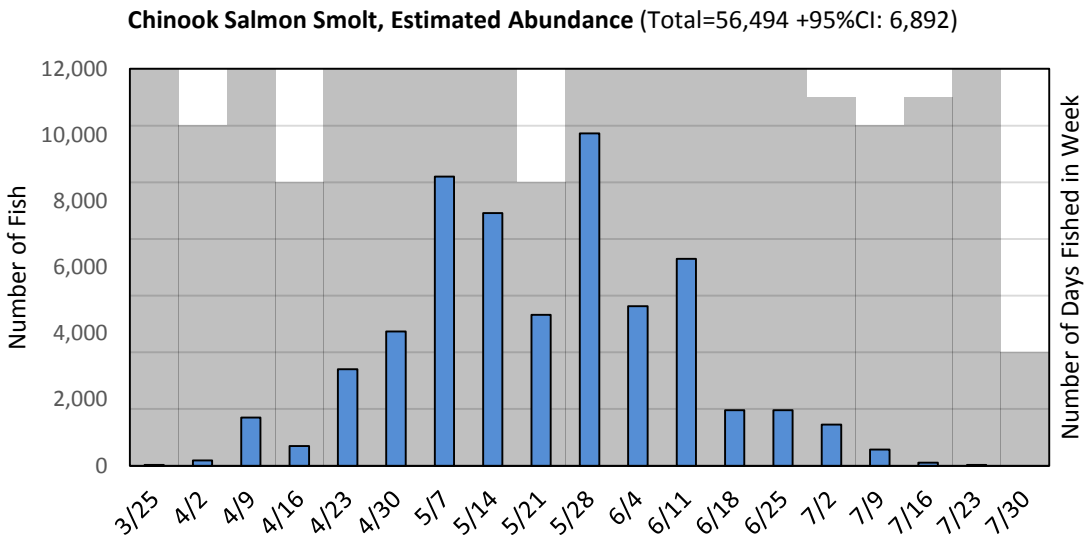
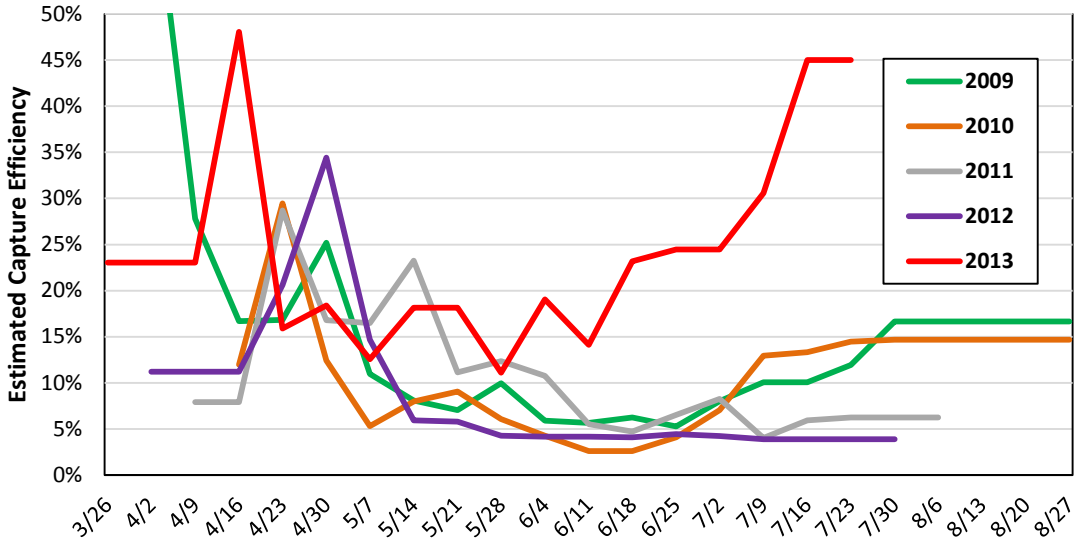



**Figure 8. Estimated average weekly capture efficiency (upper panel) and population estimate of Chinook salmon smolts in the Dry Creek rotary screw trap (lower panel), 2013. Estimates are from DARR (Bjorkstedt 2005). The number of days of each week the trap was fished is represented by the shaded area.**

The estimated pattern in weekly trap efficiency was markedly higher in 2013 than in any of the four previous years. However, abundance was lower than any of the previous years (Figure 5.2.9).



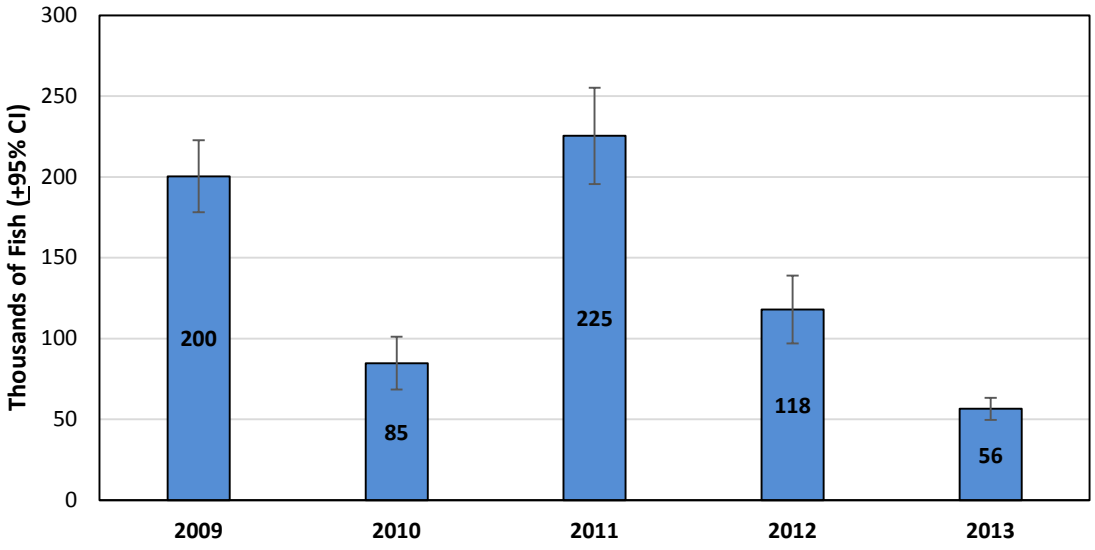



**Figure 9. Estimated average weekly capture efficiency (upper panel) and population estimate of Chinook salmon smolts (x1000) produced from the Dry Creek watershed upstream of Westside Road smolt trap site (lower panel), 2009-2013.**

Coho were the least abundant of the 3 salmonid species captured. Steelhead parr capture increased and remained high throughout the month of June before a declining sharply in July (Figure 5.2.10).

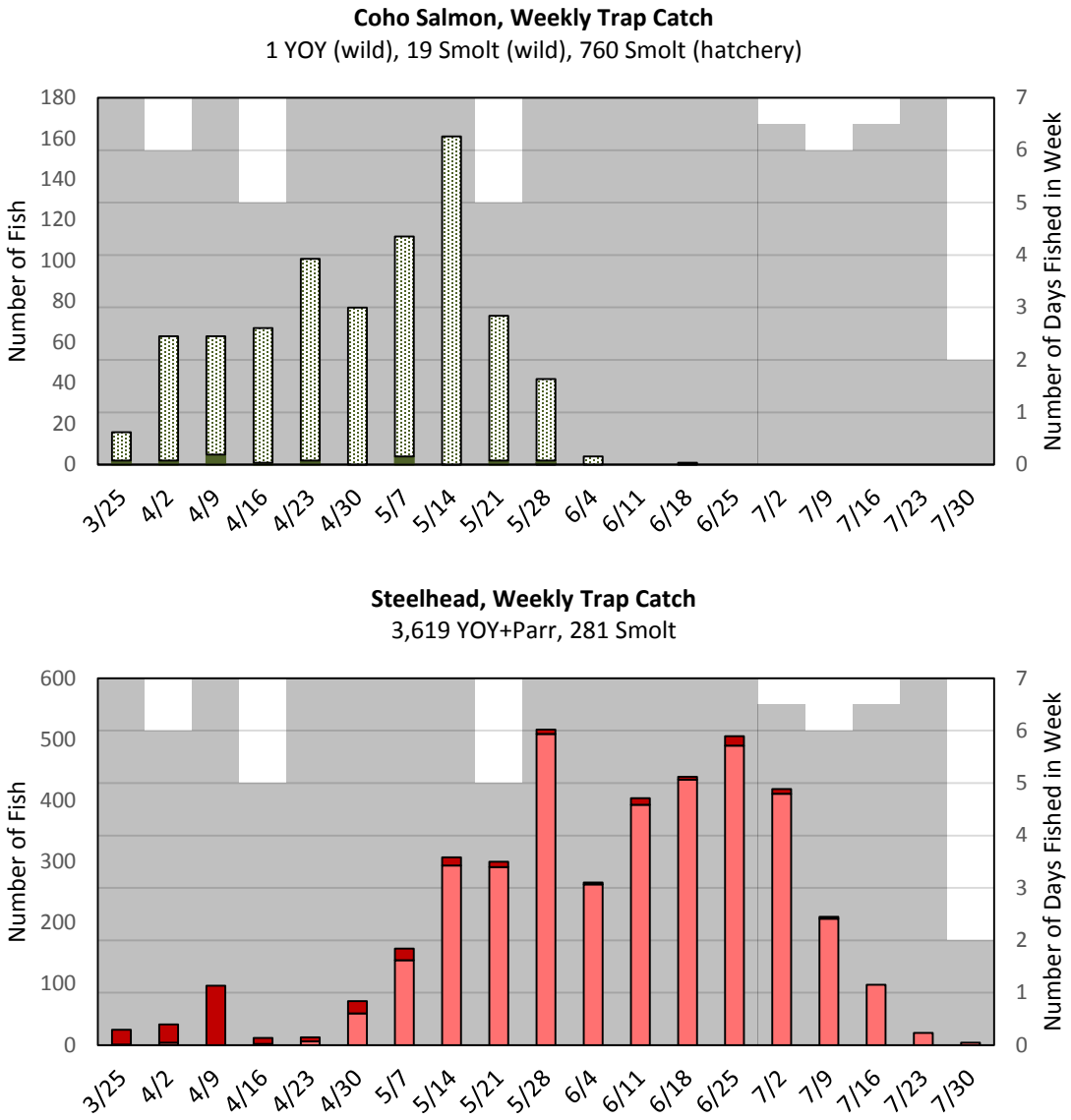



**Figure 10. Weekly trap catch of juvenile coho salmon and steelhead in the Dry Creek rotary screw trap, 2012.**

The weekly sizes of all salmonids captured at the Dry Creek trap (with the exception of steelhead smolts) showed evidence of growth during the course of the trapping season in 2013 (Figure 5.2.11).

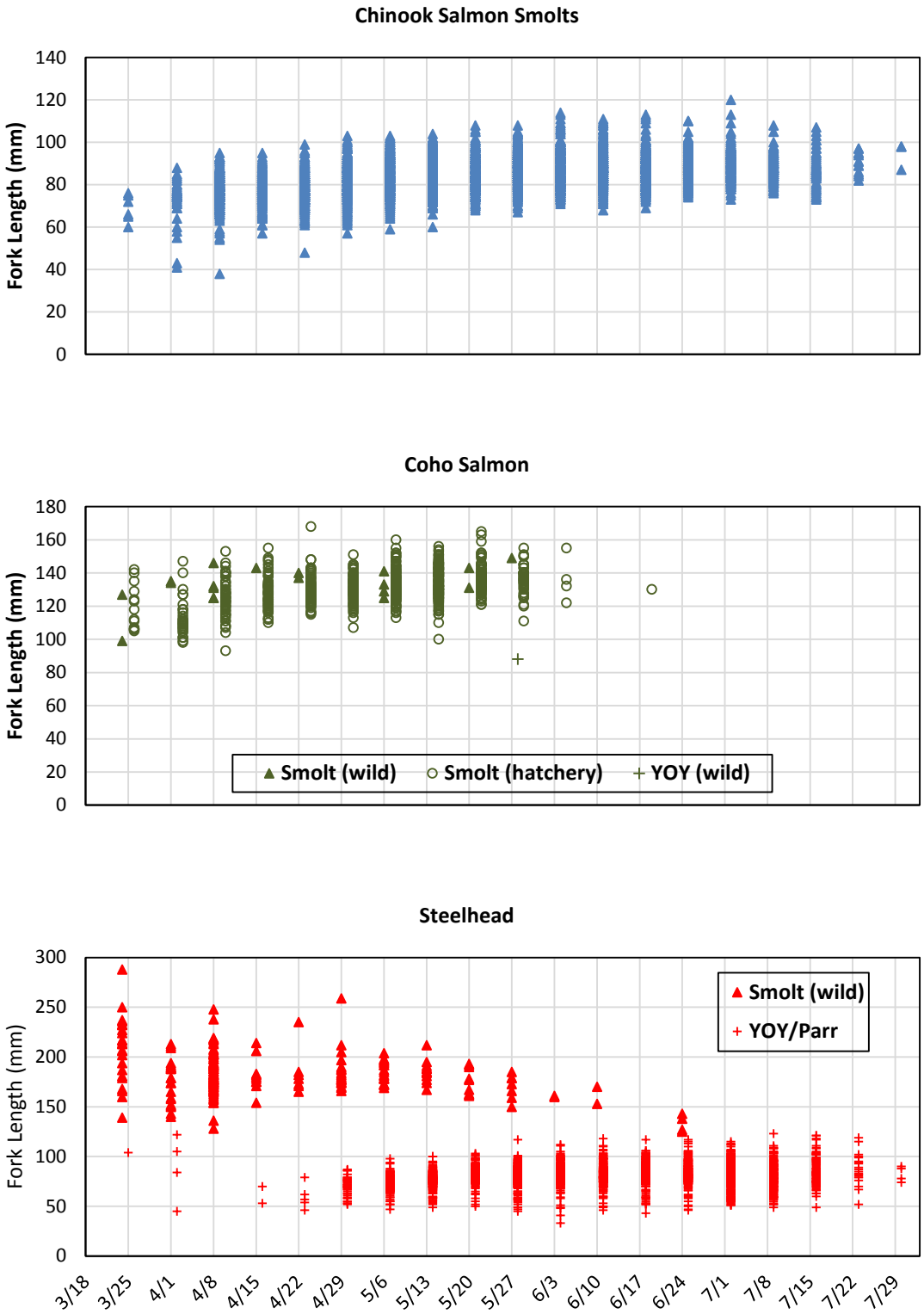



Figure 11. Fork lengths of juvenile salmonids captured in the Dry Creek rotary screw trap by week, 2013.

## Conclusions and Recommendations

The importance of establishing a clear baseline as we move into the habitat enhancement phase of the Dry Creek project cannot be overstated. We recommend continuation of monitoring at the reach-scale (electrofishing/PIT tagging) and stream-scale (downstream migrant trapping) over time so that we can understand whether changes in population metrics are due to eventual habitat enhancements as opposed to natural population variability from external drivers. An added monitoring scale in 2014 and beyond will be sampling at the site/feature scale so that once habitat enhancements are implemented we will be able to evaluate fish responses to those projects in a meaningful way. We expect that PIT tags and PIT antennas along with direct observation through snorkel surveys in newly-created and newly-enhanced reaches will form the basis for that site-scale work. Planned evaluation of secondary metrics such as macroinvertebrate community dynamics and juvenile salmonid diet studies will be important companion data for understanding baseline conditions that currently structure salmonid populations in mainstem Dry Creek.

## References

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.

Horton, G. E., B. L. Letcher, and W. L. Kendall. 2011. A multistate capture–recapture modeling strategy to separate true survival from permanent emigration for a passive integrated transponder tagged population of stream fish. Transactions of the American Fisheries Society, 140: 320-333.

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.

# Chapter 6 : 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 bneccessary 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 abondon 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 passgae caused by a bedrock outrcropping 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 outrcropping 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.

## Wallace Creek Fish Passage Project

Wallace Creek Fish Passage Project consists of the modification of a concrete box culvert where Wallace Creek flows under Mill Creek Road (Figure 6.20). 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 has 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 has abandoned efforts to construct the Wallace Creek Fish Passage Project and is working with the National Marine Fisheries Service on an alternative as a substitute for the Wallace Creek Fish Passage Project.

**Figure 6.20. Wallace Creek Fish Passage Project – Flat culvert invert proposed for modification**

# 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).

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.

# Chapter 8 : Wohler-Mirabel Water Diversion Facility

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

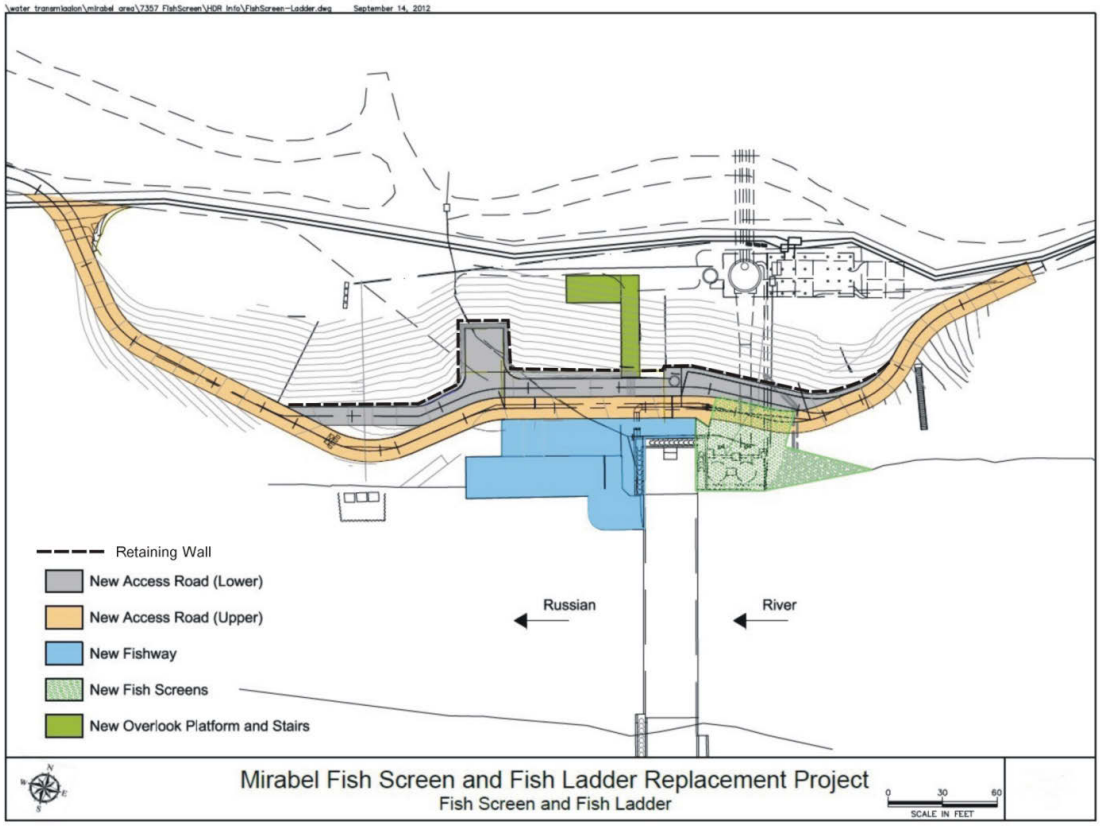



Figure 8.1

Figure 8.2

## 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

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. Depending upon construction progress, installation of this temporary cofferdam may be necessary during the summer of 2015. Construction activities will continue throughout the winter/spring and will likely be completed during the summer of 2015.

**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 2015, but the goal of no longer using the old screens by September 2014 as required under the Russian River Biological Opinion was met.**

## Mirabel Fisheries Monitoring

2013 marked the 14th year that fishery studies have been conducted at the Wohler-Mirabel site. Although this report details the findings of the 2013 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 2013, 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 2013, the traps were deployed on March 26 at a flow of 562 cfs, and fished through the morning of July 27 at a flow of 90 cfs (flows recorded at the Hacienda Gauge).

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 2013, a mark-recapture study was initiated on March 27 (first day of trapping) and conducted through July 25 in an attempt to estimate the number of juvenile Chinook salmon emigrating past the dam. This study has been initiated each year since 20011 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 100 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.

## Results

In 2013, a total of 25 species including 14,139 individual fish were captured (excluding larval suckers and cyprinids, Table 8.3.1). The catch included 12 species native to the Russian River. Three species, Chinook salmon, (wild) steelhead, and coho salmon (hatchery and wild) accounted for 74 percent of the total catch.

### Chinook salmon

A total of 6,709 juvenile Chinook salmon were captured in 2013. Chinook smolts were captured from the first day of sampling through the last day (March 26 – July 27) (Table 8.3.2). Excluding 2009 and 20102, overall trapping efficiency has ranged from 6.2 to 11.4 percent. In 2013, 3,891 Chinook salmon smolts were marked and released upstream of the dam. Of these, 359 (9.2 percent) were recaptured. Based on the DARR estimator (Bjorkstedt 2008), the 2013 mark-recapture estimate was 167,832 (±17,320) juvenile Chinook salmon migrating past the trapping site during the mark-recapture study (Table 8.3.3). Chinook salmon emigration typically peaks in April and May, before slowly declining from June into July (Figure 8.3.1).

[1] Excluding 200 and 2006 when high streamflows curtailed downstream migrant trapping
[2] The traps performed poorly due to changes in river morphology and the operation of the dam

Average fork lengths for Chinook salmon ranged from 67 mm in late March to 98 mm by late July (Figure 8.3.2). Weekly average fork lengths in 2013 closely matched the 14 year average for the Wohler fish trap.

## Steelhead

For the season, 983 wild (natural origin) steelhead parr were captured, most of which were likely YOY based on length-frequency data (Table 8.3.4, Figure 8.3.3). In addition, 79 wild origin steelhead smolts were captured between April 26 and June 27 (Table 8.3.5). In 2013, 501 PIT tags were applied to steelhead captured at Mirabel (results of the PIT tag monitoring are discussed in the Synthesis chapter of this report.

Steelhead smolts ranged in length from 136 to 263 mm FL, averaging 178.6 mm FL overall. Since 2000, the average size of steelhead smolts has ranged from 161 to 185 mm FL.

**Table 8.3.1. Summary of Mirabel Dam rotary screw operations from 2000 to 2013.**

| 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;<br>May 28, 29 | 47 |
| **2002** | March 1 | June 27 | April 16 | April 16 | 118 |
| **2003** | March 1 | July 3 | May 23 | March 15-19;<br>April 13-21;<br>April 24-May 11;<br>May 23 | 92 |
| **2004** | April 1 | July 1 | April 8 | April 8 | 91 |
| **2005** | April 15 | June 30 | May 26 | May 19-23;<br>May 27-31 | 67 |
| **2006** | May 4 | May 24 | May 11 | May 12-15 | 17 |
| **2007** | March 21 | June 28 | March 28 | March 30;<br>May 30 | 98 |
| **2008** | March 20 | June 26 | April 11 | Apil 11-13;<br>May 17-18;<br>June 10, 16, 24 | 91 |
| **2009** | April 1 | July 17 | July 8 | April 15;<br>May 5-7;<br>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;<br>June 2, 18 | 67 |
| **2013** | March 26 | July 27 | May 2 | July 7;<br>July 8 | 124 |

**Table 8.3.2. Weekly capture of Chinook salmon at the Wohler trapping site, 2000 – 2013.**[1]

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26-Feb | | | 45 | 332 | | | | | | | | | | |
| 5-Mar | | | 74 | 841 | | | | | | | | | | |
| 12-Mar | | | 319 | 89 | | | | | | | | | | |
| 19-Mar | | | 181 | 169 | | | | 257 | 114 | | | | | |
| 26-Mar | | | 797 | 346 | | | | 940 | 80 | 6 | | | | 190 |
| 2-Apr | 41 | | 908 | 377 | 82 | | | 730 | 224 | 257 | | | | 290 |
| 9-Apr | 158 | | 757 | 176 | 115 | 446 | | 564 | 100 | 236 | | 263 | | 478 |
| 16-Apr | 154 | 122 | 2,279 | 17 | 672 | 848 | | 1,011 | 866 | 190 | | 815 | | 419 |
| 23-Apr | 204 | 720 | 2,992 | 60 | 1,911 | 618 | | 759 | 1,161 | 159 | | 269 | 165 | 177 |
| 30-Apr | 169 | 1,338 | 4,337 | 0 | 1,845 | 353 | | 1,148 | 315 | 67 | 86 | 628 | 170 | 480 |
| 7-May | 121 | 1,154 | 1,780 | 50 | 1,631 | 132 | 69 | 782 | 258 | 149 | 451 | 1,732 | 567 | 517 |
| 14-May | 174 | 226 | 2,056 | 508 | 552 | 222 | 46 | 880 | 381 | 123 | 187 | 2,820 | 415 | 525 |
| 21-May | 106 | 76 | 1,755 | 690 | 158 | 35 | 217 | 698 | 91 | 55 | 158 | 2,967 | 256 | 500 |
| 28-May | 92 | 64 | 704 | 1,461 | 150 | 419 | 67 | 503 | 107 | 64 | 268 | 1,802 | 130 | 674 |
| 4-Jun | 66 | 22 | 192 | 530 | 125 | 541 | | 857 | 60 | 42 | 145 | 924 | 287 | 408 |
| 11-Jun | 47 | | 93 | 374 | 31 | 136 | | 268 | 94 | 30 | 155 | 372 | 87 | 161 |
| 18-Jun | 19 | | 46 | 186 | 88 | 156 | | 45 | 19 | 9 | 324 | 437 | 87 | 627 |
| 25-Jun | 10 | | 4 | 86 | 26 | 55 | | 38 | 8 | 2 | 441 | 226 | 134 | 499 |
| 2-Jul | | | | 3 | | | | | | 8 | 71 | 49 | 9 | 131 |
| 9-Jul | | | | | | | | | | 1 | 72 | 33 | | 182 |
| 16-Jul | | | | | | | | | | 1 | 10 | 12 | | 63 |
| 23-Jul | | | | | | | | | | | | | | 24 |
| | | | | | | | | | | | | | | 5 |
| **Total** | **1,361** | **3,722** | **19,319** | **6,295** | **7,386** | **3,961** | **399** | **9,480** | **3,878** | **1,399** | **2,368** | **13,349** | **2,307** | **6,350** |

[1]Please note that the dates when the traps were deployed and the length of time that the traps were operated differs significant between years (see Table 8.3.1).

**Table 8.3.3. Estimated number of juvenile Chinook salmon that passed the Mirabel Dam site, based on mark-recapture trap efficiency testing, from 2001 to 2013.**

| Year | Number of days studied | Number marked | Number recaptured | Overall efficiency | Seasonal estimate[1] | 95% CI |
|---|---|---|---|---|---|---|
| **2001** | 34 | 525 | 60 | 11.4 | 19,473 | 5,022 |
| **2002** | 76 | 2,778 | 253 | 9.1 | 225,135 | 37,028 |
| **2003** | 26 | 1,072 | 90 | 8.4 | 45,699 | 18,218 |
| **2004** | 40 | 1,631 | 120 | 7.4 | 91,352 | 17,652 |
| **2005**[2] | 0 | N/A | N/A | N/A | N/A | N/A |
| **2006**[2] | 0 | N/A | N/A | N/A | N/A | N/A |
| **2007** | 76 | 3,201 | 203 | 6.3 | 149,329 | 28,722 |
| **2008** | 42 | 1,321 | 88 | 6.7 | 43,774 | 16,768 |
| **2009** | 51 | 709 | 20 | 2.8 | 41,663 | 10,208 |
| **2010** | 69 | 1,881 | 76 | 4.0 | 109,540 | 47,463 |
| **2011** | 62 | 2,763 | 172 | 6.2 | 37,5662 | 85,676 |
| **2012** | 67 | 1,761 | 121 | 6.9 | 57,828 | 10,680 |
| **2013** | 125 | 5,743 | 359 | 6.3 | 167,832 | 17,320 |

[1] Includes fish captured outside of the mark-recapture study period
[2] High streamflows limited sampling in 2005 and 2006.

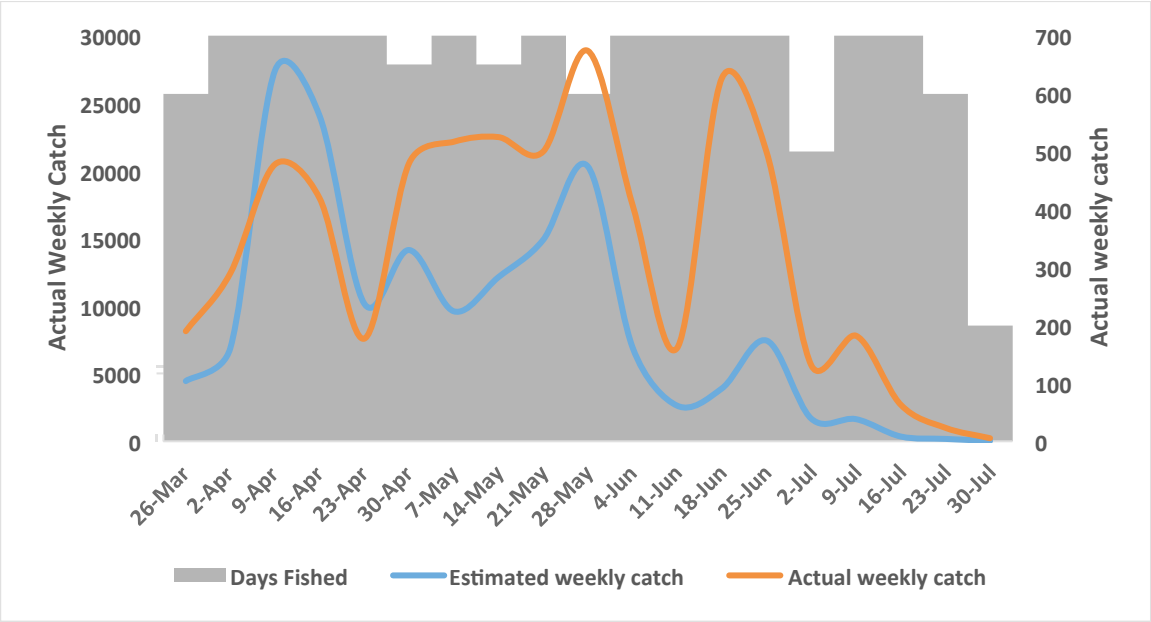



**Figure 8.3.1. Weekly estimated and actual catches at the Mirabel Dam downstream migrant trap, 2012.**

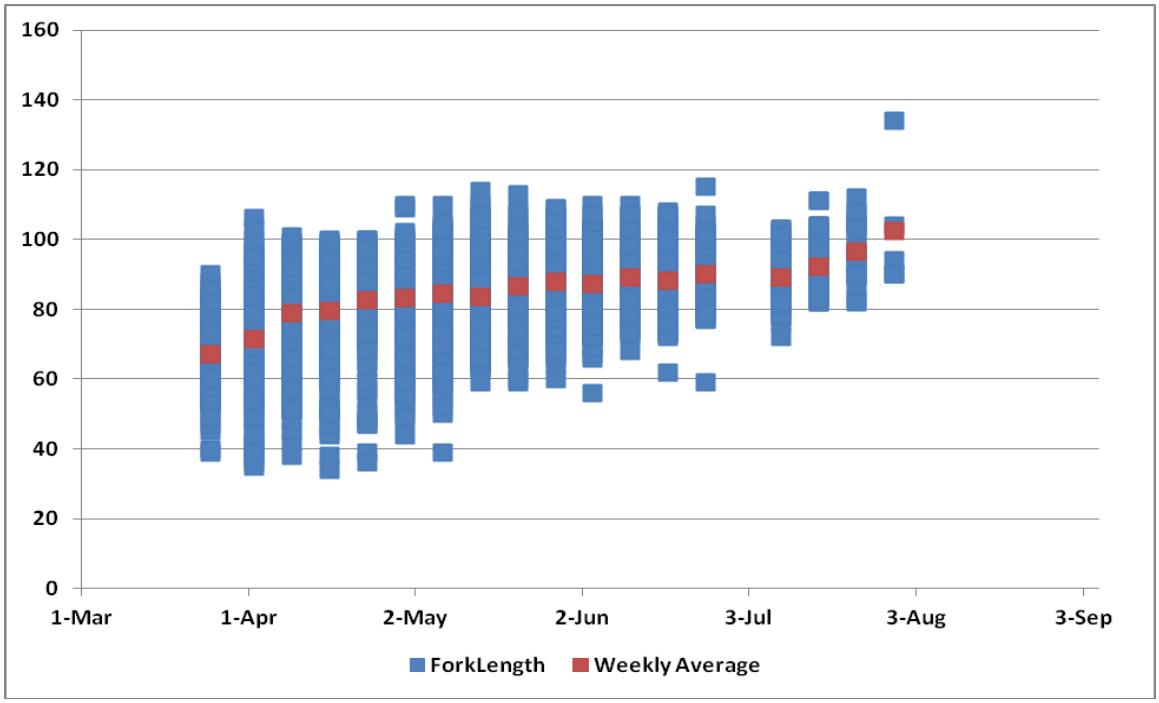



**Figure 8.3.2. Weekly average fork lengths of Chinook salmon smolts measured at the Mirabel Dam trap site in 2013.**

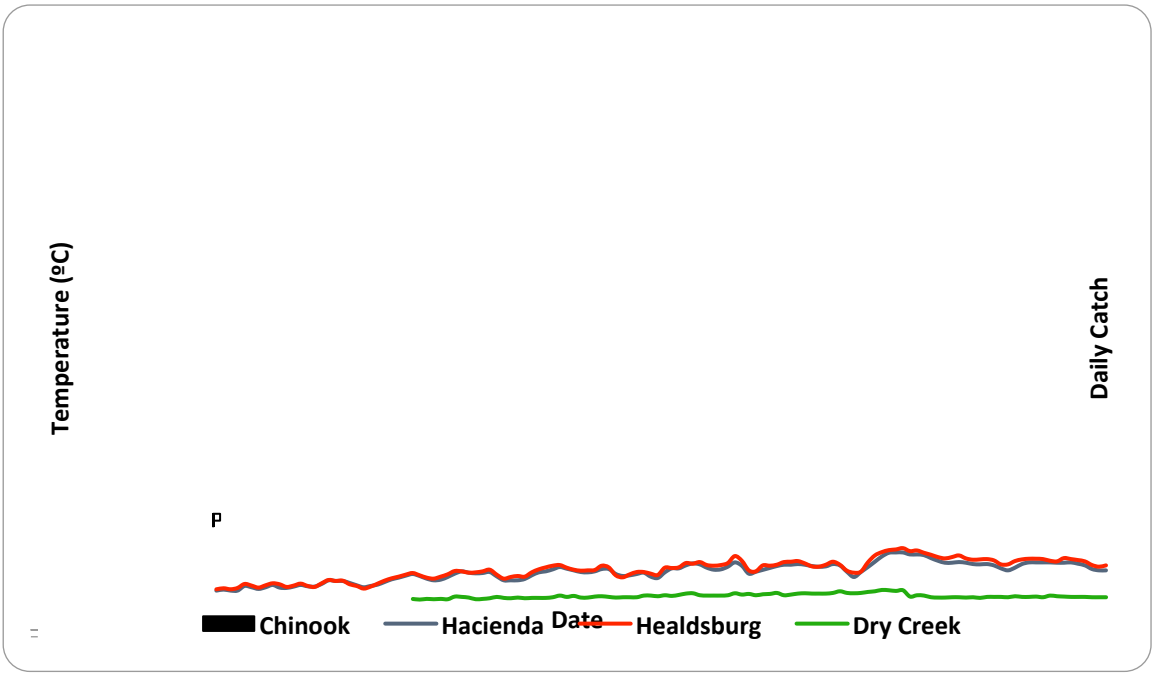



**Figure 8.3.3. Daily catch of Chinook salmon and the average daily temperatures recorded at the Diggers Bend, Hacienda, and Dry Creek USGS stream guages, 2013.**

Table 8.3.4. Weekly catch of steelhead young-of the year (age 0+) and parr (age 1+) at the Mirabel Dam trapping site, 2000 – 2013.

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| 30-Apr | 224 | 4 | 658 | 0 | 10 | 523 | 14 | 58 | 118 | 11 | 33 | 13 | 40 | 380 |
| 7-May | 30 | 13 | 756 | 22 | 3 | 354 | 12 | 164 | 133 | 7 | 36 | 168 | 140 | 450 |
| 14-May | 49 | 23 | 976 | 74 | 1 | 75 | 182 | 157 | 52 | 3 | 39 | 55 | 399 | 78 |
| 21-May | 80 | 34 | 1315 | 246 | 1 | 25 | 26 | 185 | 101 | 8 | 81 | 62 | 114 | 64 |
| 28-May | 74 | 32 | 806 | 223 | 2 | 110 | -- | 173 | 59 | 6 | 60 | 58 | 67 | 124 |
| 4-Jun | 102 | 26 | 467 | 55 | 2 | 136 | -- | 684 | 76 | 2 | 26 | 119 | 91 | 134 |
| 11-Jun | 40 | -- | 164 | 29 | 1 | 40 | -- | 176 | 50 | 8 | 41 | 11 | 53 | 34 |
| 18-Jun | 58 | -- | 60 | 28 | 10 | 29 | -- | 5 | 26 | 4 | 22 | 25 | 35 | 53 |
| 25-Jun | 50 | -- | 1 | 2 | 7 | 9 | -- | 22 | 10 | 4 | 25 | 6 | 36 | 60 |
| 2-Jul | -- | -- | -- | 1 | -- | -- | -- | -- | -- | 1 | 8 | 5 | 7 | 15 |
| 9-Jul | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 2 | 1 | -- | 29 |
| 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** |

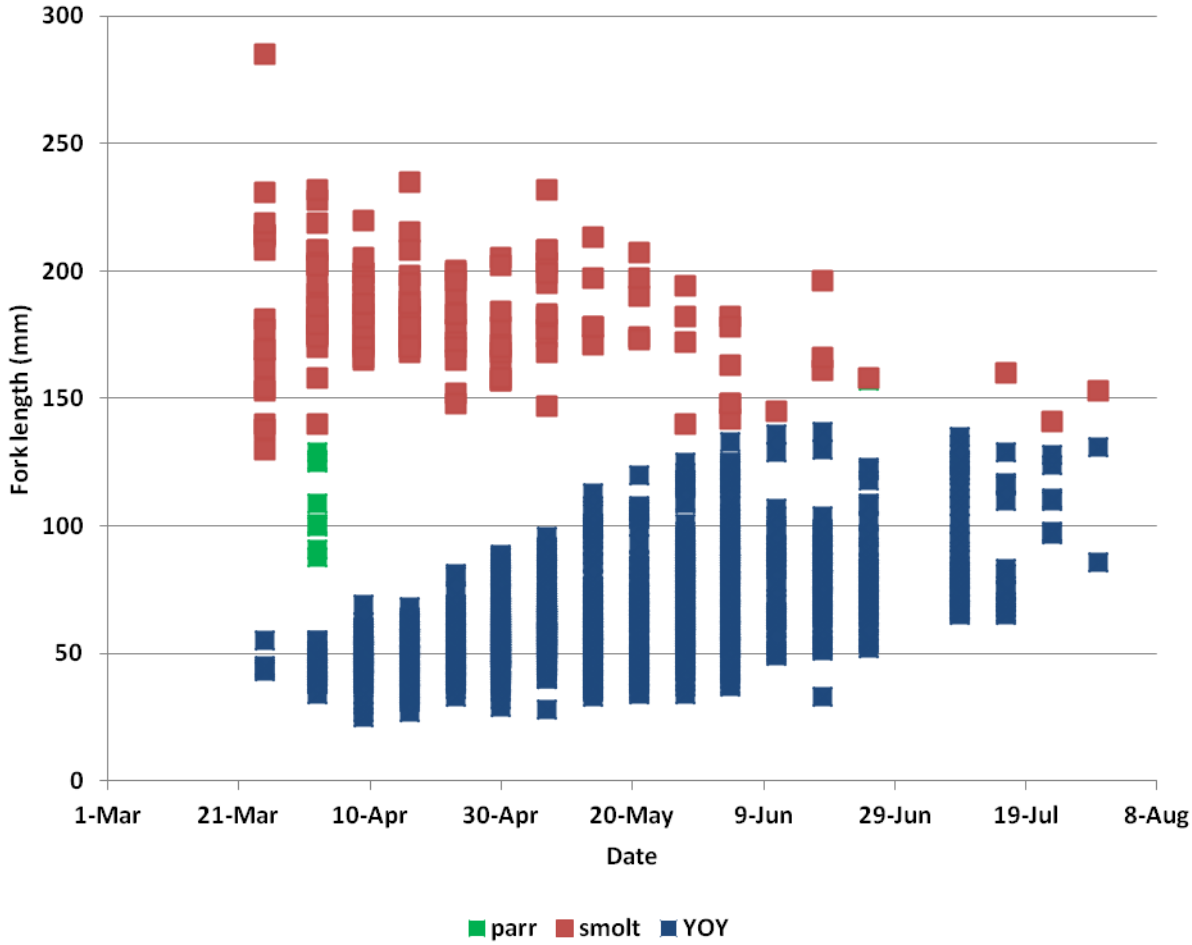



**Figure 8.3.4. Length of steelhead captured in 2013, grouped by week of capture. Blue squares represent young-of-the-year (age 0+), Green squares represent parr (age 1+), and red squares represent smolts (primarily age 2+).**

Table 8.3.5. Weekly catch of wild steelhead smolts at the Mirabel trapping site, 2000 – 2013.

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| 30-Apr | 21 | 16 | 23 | -- | 10 | 7 | 9 | 14 | 12 | 1 | 4 | 6 | 11 | 11 |
| 7-May | 8 | 9 | 7 | -- | 3 | 3 | 10 | 17 | 4 | 1 | 8 | 27 | 15 | 13 |
| 14-May | 14 | 4 | 9 | 26 | 1 | 1 | 5 | 11 | 0 | 2 | 14 | 54 | 18 | 5 |
| 21-May | 9 | 0 | 9 | 16 | 1 | 3 | 6 | 3 | 1 | 2 | 9 | 17 | 9 | 5 |
| 28-May | 6 | 0 | 3 | 6 | 1 | 0 | -- | 2 | 0 | 0 | 4 | 13 | 2 | 5 |
| 4-Jun | 1 | 1 | 0 | 2 | 2 | 3 | -- | 1 | 0 | 0 | 1 | 9 | 8 | 7 |
| 11-Jun | 4 | -- | 1 | 1 | 1 | 2 | -- | 0 | 0 | 0 | 4 | 2 | 3 | 2 |
| 18-Jun | 2 | -- | 0 | 0 | 2 | 1 | -- | 0 | 0 | 2 | -- | -- | 0 | 5 |
| 25-Jun | 2 | -- | 0 | 0 | 0 | 1 | -- | 0 | 0 | 0 | -- | -- | 2 | 5 |
| 2-Jul | -- | -- | -- | -- | -- | -- | -- | -- | -- | 1 | -- | -- | 0 | 2 |
| 9-Jul | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0 | -- | -- | -- | 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** |

[1]traps were not operated during this week

## Coho salmon

Coho smolts were captured between March 27 (first day of sampling) and June 29 (June 2 for wild coho smolts). For the season, 20 wild smolts, 1,059 hatchery smolts, and 137 wild parr were captured (Table 8.3.6). 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 8.3.5).

**Table 8.3.6. 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.**

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|
| 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 |
| 30-Apr | 1 | 15 | 17 | 3 | 38 | 45 | 52 | 80 |
| 7-May | 1 | 38 | 23 | 26 | 53 | 51 | 83 | 64 |
| 14-May | 1 | 24 | 9 | 23 | 30 | 138 | 48 | 53 |
| 21-May | 0 | 7 | 1 | 9 | 15 | 83 | 15 | 46 |
| 28-May | -- | 1 | 0 | 7 | 21 | 31 | 9 | 45 |
| 4-Jun | -- | 0 | 0 | 1 | 19 | 32 | 7 | 5 |
| 11-Jun | -- | 0 | 0 | 4 | 0 | 11 | 3 | 1 |
| 18-Jun | -- | 0 | 0 | 0 | 3 | 2 | 0 | 1 |
| 25-Jun | -- | 0 | 0 | 0 | 1 | 0 | 0 | 3 |
| 2-Jul | -- | -- | -- | 0 | 0 | 0 | 1 | -- |
| 9-Jul | -- | -- | -- | 0 | 1 | 1 | -- | -- |
| 16-Jul | -- | -- | -- | 0 | -- | -- | -- | -- |
| **Total** | **3** | **108** | **91** | **206** | **181** | **891** | **296** | **780** |

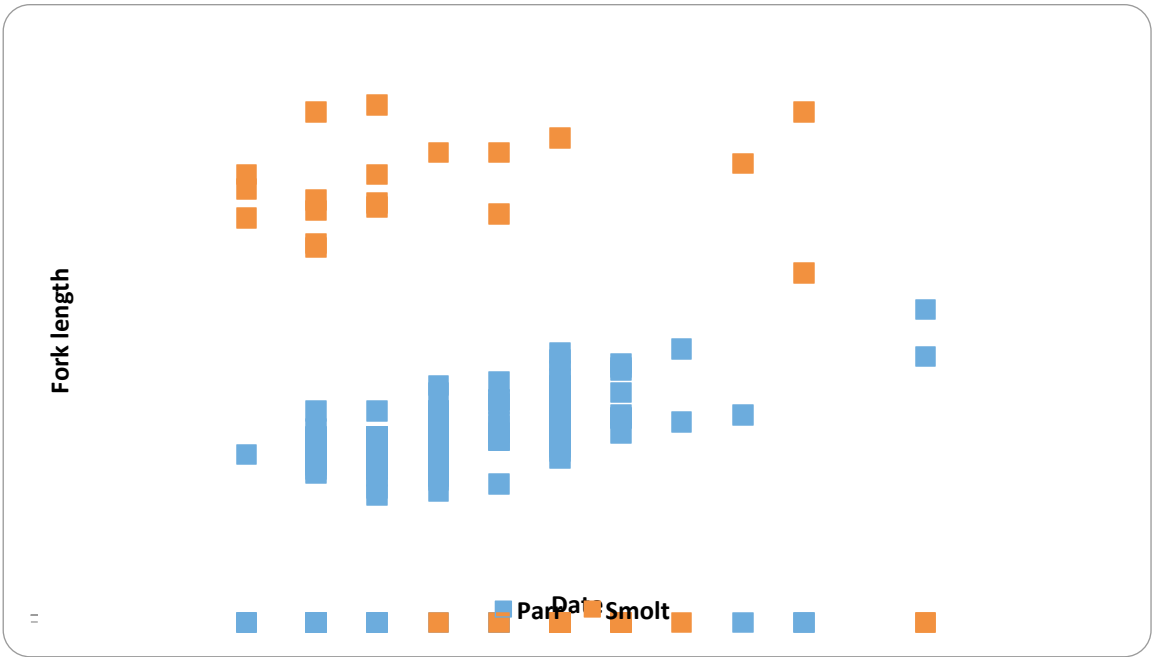



**Figure 8.3.5. Lengths of wild coho salmon captured in 2013 grouped by week of capture. Blue squares represent young-of-the-year (age 0+), and red squares represent smolts (primarily age 1+).**

## 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. Based on capture of Chinook smolts at the Dry Creek downstream migrant trap (see Dry Creek Validation Monitoring section of this report), these late season migrants are likely being produced in Dry Creek. Because water temperatures in the mainstem Russian during the late spring can reach levels that are harmful to juvenile salmonid survival, the timing of smolt emigration through the lower river is potentially a significant factor for later-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 in the upper river likely stimulate mainstem rearing fish to emigrate (Figure 8.3.3). However, in Dry Creek water temperatures are controlled by releases from the dam, and remain cold even during the heat of summer. This modified temperature regime likely dampens natural thermal cues motivating juvenile

salmonids to emigrate. In 2013, 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. As a consequence, a relatively high proportion of fish from Dry Creek are entering the mainstem Russian at a time when water temperatures are detrimental to survival. 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

The Inflatable Dam is approximately 4.0-meter high, 45-m wide, and when fully inflated forms a barrier to upstream migrating fish. Upstream passage around the dam is provided by two Denil-type fish ladders. The dam is typically inflated from early spring through late-fall, depending on water demand and streamflow. In most years, the dam is inflated during the majority of the adult Chinook salmon run and the beginning of the adult coho salmon run. During years with low rainfall in the fall and early winter, the dam may also be inflated during the majority of the coho salmon run, as well as the beginning of the steelhead migration period.

The video counting system was originally designed to asses the effectiveness of the fish ladders at the Wohler Dam (2000-2004). Since the completion of this initial study, the system has been operated to document Chinook salmon escapement to the upper river. Since the vast majority of Chinook salmon spawning habitat lies above the dam, the counting station provides a good estimate of the overall adult Chinook run in the Russian River. However, during periods of high turbidity (generally associated with high streamflows), the cameras are ineffective and some portion of the run is likely missed in some years. Beginning in 2011, a DIDSON (dual-frequency identification sonar) was also installed at the upstream ends of both fish ladders. These units effectively detect and record images of fish passing upstream of the fish ladders during periods of high turbidity. However, with few exceptions, the images of fish passing through the fish ladder cannot be identified to species. In addition, the DIDSON cameras, like the digital cameras, can only operate when the dam is inflated. Therefore, all counts of fish should be regarded as a minimum count.

### Methods

The passage of adult salmonids through the fish ladders was assessed using digital underwater video cameras from September 1 until February 8, 2014, when high stream flows resulted in the deflation of the dam for the season. Each year, metal housings (camera boxes) are installed at the upstream end of each fish ladder. Underwater cameras and lighting systems are located in the boxes, and are operated 24 hours a day, 7 days a week. Video data are stored on a hard drive located in a nearby building. Each morning, video data stored on the hard drive are downloaded for review. Once reviewed, the video footage is copied to DVDs for archival purposes.

Fish were counted as moving upstream once they exited the upstream end of the camera box. For each adult salmonid observed, the reviewer recorded the species (when possible), date, and time of passage out of the ladder. During

periods of low visibility it was not always possible to identify fish to species, although identification to family (e.g., Salmonidae) was often possible. 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. In 2011, the Water Agency deployed separate DIDSON systems (on loan from the Department of Fish and Game) at the upstream end of each fish ladder in order to count fish passing during periods of high turbidity. The DIDSON can “see through” turbidity and record images of fish passing out of the fish ladders. The DIDSON was run continuously as a backup for the video cameras.

## Results

In 2013, the cameras were in operation continuously from September 1 to February 8 (2014) (Table 8.3.7). During the majority of the season, the image quality of the videos was sufficient to identify and count fish passing through the fish ladders. Species observed in the last 14 years include, but are not limited to Chinook and coho salmon, steelhead, Pacific lamprey, American shad, Sacramento pikeminnow, hardhead, Sacramento sucker, common carp, and channel catfish.

### Unknown Salmonids

In 2013, 19 (0.4 %) of all salmonids observed were categorized as an “unknown salmonid” (i.e., these fish possessed the general body shape of an adult salmonid, but could not be identified to species). These 19 unknown salmonids were partitioned into 12 Chinook salmon, 1 coho salmon, and 6 steelhead.

### Chinook

Due to the exceptionally dry conditions experienced during 2013, the video monitoring season was the longest recorded during the 14 years of this project. For the 2013 video monitoring season, 3,154 adult Chinook salmon were observed passing the Inflatable Dam (including “unknown salmonids”). Overall, the 2013 total closely matched the 14 year average for annual counts at this station (Table 8.3.8, Figure 8.3.5).

The date that the first Chinook salmon was observed during video monitoring has ranged from August 20 to October 7 during the 14 years of video monitoring. In

2013, the first Chinook salmon was observed on September 2. However, only five adult Chinook salmon were observed prior to October 1. The peak of the run occurred during early November which was two to three weeks later than the long term average (Table 8.3.8, Figure 8.3.6). The later arrival of the majority of Chinook salmon was likely related to the exceptionally dry conditions experienced in 2013.

**Table 8.3.7. 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) |

[1]The cameras were removed from October 28 through November 1 during a large storm event.

**Table 8.3.8. 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-Aug | 0 | 0 | 0 | -- | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 8-Aug | 0 | 0 | 0 | -- | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 15-Aug | 0 | 0 | 1 | -- | 0 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | -- |
| 22-Aug | 1 | 0 | 8 | -- | 0 | 1 | 0 | 0 | 0 | 0 | -- | -- | -- | -- |
| 29-Aug | 0 | 3 | 7 | 2 | 1 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 5-Sep | 9 | 1 | 18 | 7 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 12-Sep | 38 | 7 | 19 | 20 | 3 | 11 | 2 | 0 | 1 | 0 | 0 | 0 | 2 | 2 |
| 19-Sep | 23 | 12 | 65 | 23 | 8 | 13 | 3 | 0 | 14 | 0 | 3 | 1 | 0 | 1 |
| 26-Sep | 50 | 17 | 1,223 | 181 | 16 | 20 | 7 | 1 | 65 | 0 | 1 | 157 | 70 | 17 |
| 3-Oct | 31 | 240 | 113 | 146 | 42 | 34 | 120 | 7 | 122 | 21 | 669 | 534 | 51 | 44 |
| 10-Oct | 115 | 51 | 628 | 515 | 51 | 114 | 255 | 38 | 109 | 394 | 896 | 390 | 551 | 4 |
| 17-Oct | 81 | 10 | 272 | 232 | 585 | 403 | 531 | 28 | 11 | 362 | 154 | 1070 | 1886 | 8 |
| 24-Oct | 466 | 300 | 153 | 532 | 2284 | 332 | 83 | 87 | 21 | 305 | 286[1] | 273 | 996 | 27 |
| 31-Oct | 63 | 661 | 505 | 2969 | 183 | 632 | 1169 | 250 | 243 | 75 | 95[2] | 223 | 1654 | 315 |
| 7-Nov | 24 | 81 | 2,337 | 1289 | 1164 | 735 | 696 | 115 | 427 | 217 | 174 | 90 | 619 | 739 |
| 14-Nov | 182 | -- | 20 | 47 | 217 | 172 | 472 | 475 | 13 | 229 | 43 | 120 | 851 | 1063 |
| 21 Nov | 200 | -- | 37 | 95 | 57 | 91 | 53 | 60 | 24 | 63 | 113 | 266 | 16[3] | 179 |
| 28 Nov | 111 | -- | 14 | 45 | 59 | 40 | 18 | 105 | 15 | 84 | 76 | 6 | -- | 100 |
| 5-Dec | 19 | -- | 54 | -- | 15 | 0 | -- | 770 | 21 | 20 | 5 | 1 | -- | 172 |
| 12-Dec | 14 | -- | -- | -- | -- | -- | -- | 22 | 8 | 31 | -- | 2 | -- | 125 |
| 19-Dec | 17 | -- | -- | -- | -- | -- | -- | 0 | 13 | 0 | -- | 10 | -- | 73 |
| 26-Dec | 1 | -- | -- | -- | -- | -- | -- | -- | -- | 0 | -- | 15 | -- | 32 |
| 2-Jan | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2 | -- | 53 |
| 9-Jan | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 10 | -- | 50 |
| 16-Jan | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 1 | -- | 28 |
| 23-Jan | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 73 |
| 30-Jan | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 37 |
| 6-Feb | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 10 |
| **Total** | **1,445** | **1,383** | **5,474** | **6,103** | **4,788** | **2,572** | **3,410** | **1,963** | **1,125** | **1,801** | **2,516** | **3,172** | **6,696** | **3,154** |

[1]Dam was deflated for 3 days of this week

[2]Dam was deflated for 2 days of this week

[3]Only one day was sampled during this week

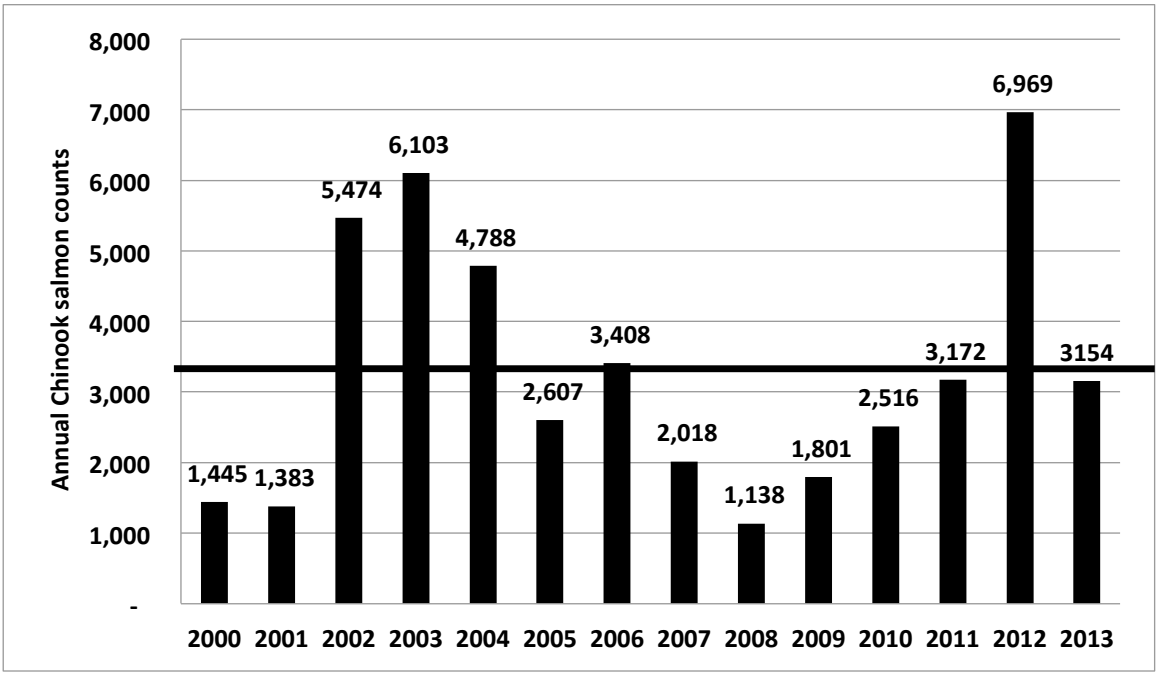



**Figure 8.3.5. Annual adult Chinook salmon minimum counts recorded at the Mirabel Inflatable Dam, 2000 to 2013. Line represents the overall average for the study period (3,263).**

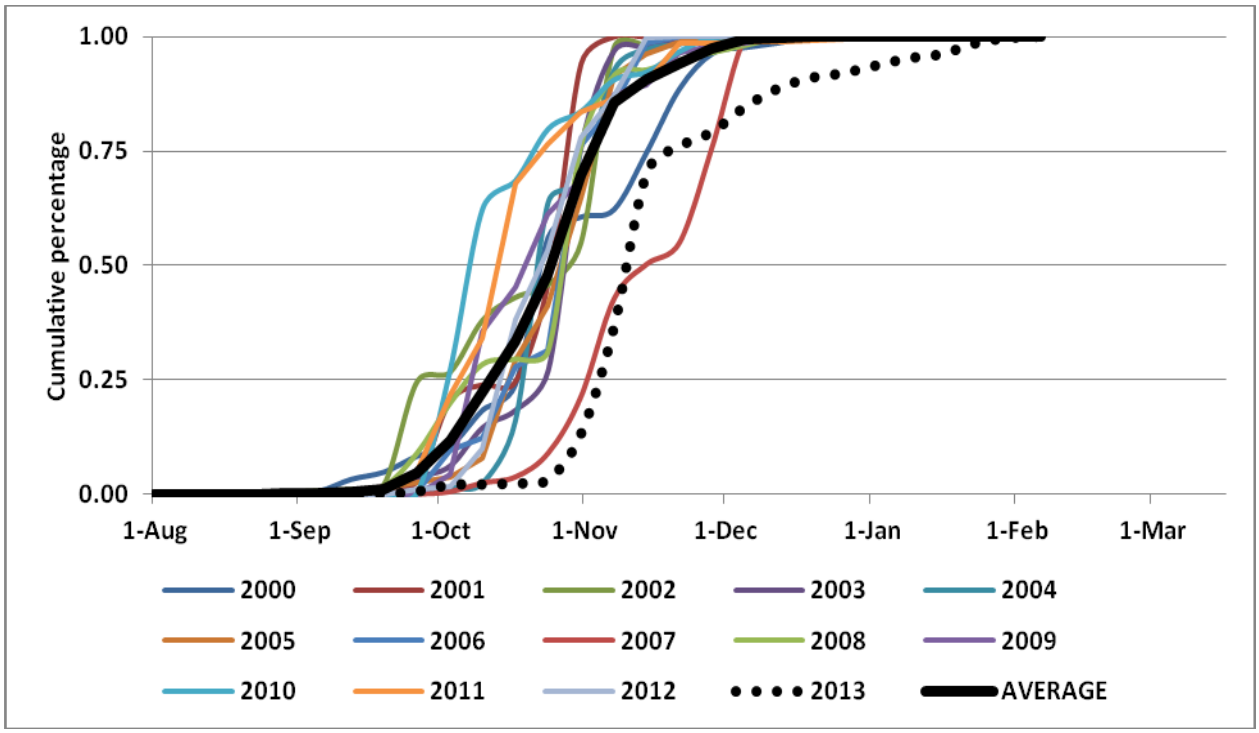



**Figure 8.3.6. Cumulative percentage of the total number of adult Chinook salmon counted at the Mirabel Dam fish ladders each year from 2000 to 2013.**

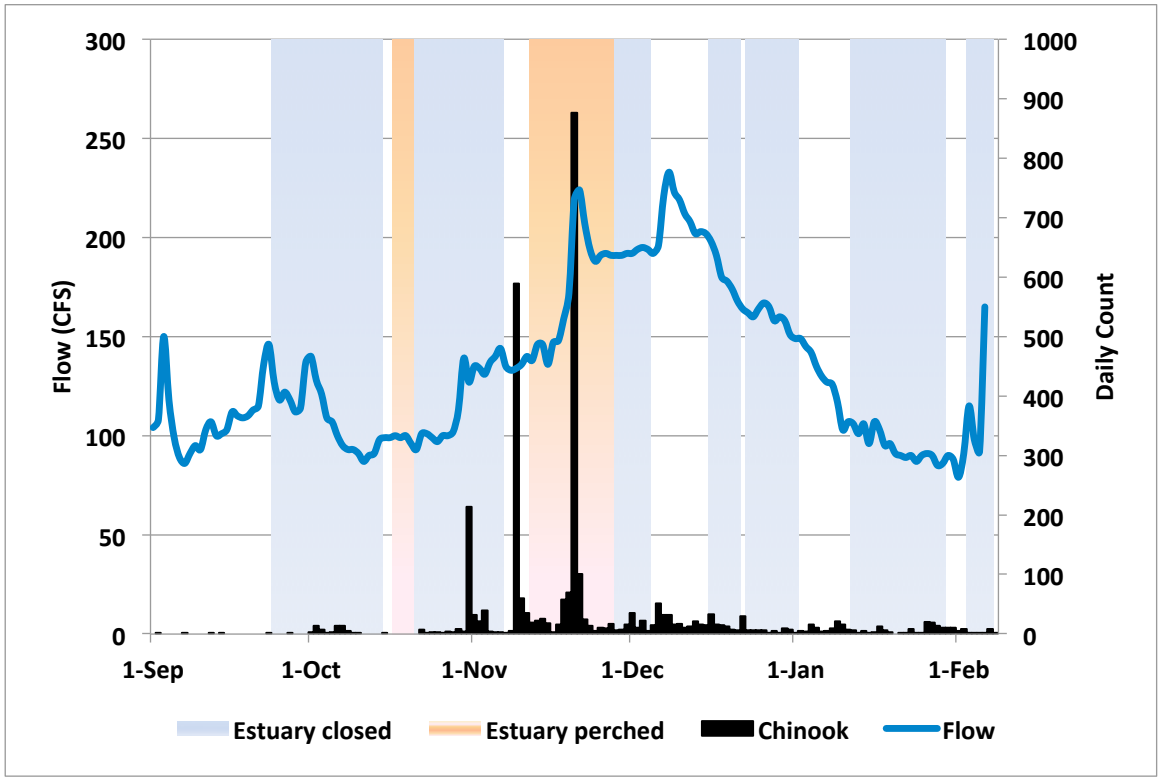



**Figure 8.3.7. Daily Chinook salmon counts at Wohler, mean daily streamflow recorded at the Hacienda gauge, September 1, 2013 through February 7, 2014.**

As with most years, the Chinook run progressed in distinct pulses; during 2013, 53 percent of the run occurred on three separate days. The first pulse was recorded on October 31 (213 fish compared to a daily average of 4 Chinook for over the previous 5 days). The estuary had been closed for 10 days prior to this date. The triggering mechanism appeared to be an increase in streamflow from approximately 100 cfs to approximately 130 cfs (the increase in flow may have been in response to decreased in-river demand). The second pulse followed breaching of the barrier beach at the mouth of the estuary on November 7. Assuming the fish began their upstream journey immediately after the breaching event (the breach was completed at 12:30 p.m.), the leading edge of the Chinook pulse was detected at the counting station within 36 hours of the estuary being breached. Within 48 hours of the breach, 463 Chinook salmon were counted at the dam. In all, the daily count increased from 5 (November 8) to 589 (November 9). Streamflow remained steady at approximately 134 cfs during this period. From November 9 – 15 a total of 1,046 adult Chinook salmon were counted at the dam. The final surge of the Chinook run occurred from November 18 – 20 coinciding with a rain event. The daily count increased from 3 (November 16, 147 cfs) to 57 on November 18 (159 cfs). A rainstorm impacted the area from November 19 – 20, increasing the daily average discharge to 219 cfs. The counts at the Mirabel dam peaked on the November 20 (876 Chinook).

## Coho

In 2013, 156 coho salmon (jacks and adults) were identified on the video system. These images were reviewed by multiple fisheries biologist from the Water Agency, NMFS, and University of California Cooperative Extension/California Sea Grant (UC). One additional coho salmon was prorated from the “unknown salmonid” category for a total estimate of 157. Most of the coho salmon that were positively identified on the video system (142 of 156) were adipose fin clipped indicating that they were returns from the Russian River Coho Salmon Captive Broodstock Program. Coho were observed migrating past the counting stations from September 17 through February 7; however, the second coho was not observed until October 8. The majority (97%) of all (wild and hatchery) coho salmon counted at the Inflatable Dam occurred after November 20. The continued observations of both wild and hatchery reared coho salmon to the system, coupled with the observations of wild coho smolts successfully emigrating during the spring downstream migrant trapping season, provides evidence that the RRCSCBP is having a beneficial impact on the coho salmon population in the Russian River.

## Steelhead

Adult steelhead were observed at the counting station from September 15 through February 7. However, the majority of the adult steelhead run in the Russian River

occurs after Mirabel Dam is deflated; thus, fall video counts are not representative of the run size and cannot be used to estimate steelhead abundance or to compare steelhead runs between years. This fact was highlighted during the 2013/14 extended season where 90 percent of the steelhead were counted after January 21 (849 of 943) (Table 8.3.9). Steelhead were categorized by being of wild, hatchery, or unknown origin. Of the 946 steelhead that could be categorized by origin, 642 were identified as hatchery origin and 304 were identified as wild.

We were unable to correlate timing or triggers to steelhead migration with the breaching of the estuary, an increase in streamflow, or the onset of rain. For example, 83 adult steelhead migrated past the fish counting station at flows as low as 79 cfs (measured at Hacienda). Surprisingly, the largest pulse of steelhead (383 individuals) was observed January 22 – 30 which was 16 days after the estuary closed and two days before the mouth was breached. River flow averaged 88 cfs (range 85 – 91) over a 12 day period when 694 adult steelhead were counted at the Mirabel Dam.

**Table 8.3.9. Fall steelhead counts at the Mirabel Dam fish counting station in the fall of 2000-2013.**

| Date | 2000 | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | 0 |
| 8/8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | 0 |
| 8/15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | 0 |
| 8/22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | 0 |
| 8/29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9/5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 9/12 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9/19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| 9/26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 |
| 10/3 | 1 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 9 | 5 | 2 |
| 10/10 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 1 | 1 | 9 | 8 | 10 | 20 | 1 |
| 10/17 | 0 | 0 | 3 | 0 | 1 | 3 | 0 | 0 | 0 | 19 | 8 | 8 | 1 | 0 |
| 10/24 | 2 | 0 | 1 | 2 | 6 | 3 | 1 | 0 | 1 | 1 | 0 | 5 | 6 | 1 |
| 10/31 | 2 | 0 | 3 | 0 | 0 | 2 | 0 | 0 | 9 | 2 | 5 | 8 | 7 | 2 |
| 11/7 | 1 | 0 | 18 | 4 | 3 | 12 | 6 | 0 | 5 | 8 | 2 | 11 | 3 | 1 |
| 11/14 | 7 | -- | 10 | 18 | 14 | 9 | 25 | 4 | 15 | 2 | 22 | 8 | 87 | 2 |
| 11/21 | 11 | -- | 1 | 17 | 34 | 21 | -- | 15 | 4 | 12 | 36 | 110 | 22 | 16 |
| 11/28 | 56 | -- | 9 | 36 | 97 | 14 | -- | 194 | 35 | 18 | 72 | 36 | -- | 11 |
| 12/5 | 43 | -- | 55 | -- | 52 | -- | -- | 46 | 18 | 33 | 10 | 23 | -- | 12 |
| 12/12 | 178 | -- | -- | -- | -- | -- | -- | -- | 112 | 51 | -- | 60 | -- | 12 |
| 12/19 | 87 | -- | -- | -- | -- | -- | -- | -- | 55 | -- | -- | 78 | -- | 14 |
| 12/26 | 24 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 105 | -- | 3 |
| 1/2 | 45 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 66 | -- | 5 |
| 1/9 | 56 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 80 | -- | 6 |
| 16-Jan | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 11 |
| 23-Jan | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 186 |
| 30-Jan | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 559 |
| 6-Feb | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 103 |
| **TOTAL** | 513 | **0** | **102** | **78** | **207** | **68** | **32** | **260** | **256** | **156** | **163** | **635** | **157** | **948** |

[1]Wild, hatchery, and unknown origin combined.

## Conclusions and Recommendations

The 2013/14 count of 3,154 Chinook salmon was near the long term average (3,263). However, a comparison of the adult Chinook population size between years can be problematic because the sampling periods are not necessarily equal between years (video end dates have ranged from November 13 to February 7) and characteristics of the run-timing can be affected by several factors. For example, we observed adult Chinook salmon passing the fish ladder through February 7 (last day the camera was operated) and an overall later run-timing compared to the long-term average. This delay was likely caused by a combination of low river flows and extended periods of river mouth closure. An additional issue is that prolonged periods of high turbidity have prevented the cameras from operating for a significant amount of time in a few years. Nevertheless, the period the counting system is operated does cover the majority of the Chinook salmon run in most years. Therefore, when viewed over the long term, these counts provide a useful tool for detecting trends in Chinook salmon abundance.

Chinook salmon entering the Russian River can be exposed to suboptimal water temperatures, however most migrate under favorable conditions. Although Chinook salmon have been observed migrating past the Mirabel Dam at temperatures ranging to 22.6°C, in most years approximately 90 percent of the adult Chinook salmon have been observed at the fish counting station after the mean daily temperature (MDT) declines below 17.1°C (Table 8.3.10). Annually, 73 to 97 percent of the fish counted at the Mirabel dam pass after the MDT declines below 15.5°C. The 15.5°C threshold is significant because exposure of migrating adults to temperatures above this point can result in decreased survival of developing embryos (Hinze 1959).

In addition to providing important data on Chinook salmon escapement to the Russian River, the Mirabel fish counting station provides information on at least the first half of the coho run and has been the primary source for documenting the early success of the coho broodstock program. Although the steelhead run occurs primarily after the dam is deflated the data is useful for defining the beginning of the adult steelhead run in addition to other important run characteristics in some years.

We recommend that the video system continue to be augmented with the DIDSON system. The loss of video images due to episodic turbidity events is an ongoing issue with video technology which could be at least partially offset with the use of DIDSON imagery. Although it may not be possible to accurately identify species from the DIDSON images it should be possible to estimate the numbers of each species migrating past the dam by partition the DIDSON images by the percentage of each species identified on video.

## Literature Cited

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.

# 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.

Background information on the natural history of Chinook salmon in the Russian River is presented in the 2011 Russian River Biological Opinion annual report (SCWA 2011). The primary objectives of the spawning ground surveys are to (1) characterize the distribution and relative abundance of Chinook salmon spawning sites, and (2) compare annual results with findings from previous study years.

## Methods

Chinook salmon redd (spawning bed) surveys were conducted in the Russian River from fall 2002 to winter 2013/2014. Typically, the upper Russian River basin and Dry Creek are surveyed (Figure 9.1). The study area includes approximately 114 km of the Russian River mainstem from Riverfront Park (40 rkm), located south of Healdsburg, upstream to the confluences of the East and West Forks of the Russian River (154 rkm) near Ukiah. River kilometer (rkm) is the meandering stream distance from the Pacific Ocean upstream along the Russian River mainstem and for Dry Creek the distance from the confluence with the Russian River upstream. In 2003, the study area was expanded to include 22 rkm of Dry Creek below Warm Springs Dam at Lake Sonoma to the Russian River confluence.

The Chinook salmon spawning ground study consisted of a single-pass survey during the estimated peak of Chinook salmon fall spawning. The Dry Creek and the Russian

River study area were surveyed on December 2, 3, 5, 9, 10, 12, and 18, 2013. A crew of two biologists in kayaks visually searched for redds along the streambed. Riffles with several redds were inspected on foot. The locations of redds were recorded using a global positioning system (GPS). Also, to follow salmon spawning period and determine the peak of spawning activity weekly to bi-monthly surveys were completed along Dry Creek from October 23, 2013 to January 27, 2014. These repeated visits extended into

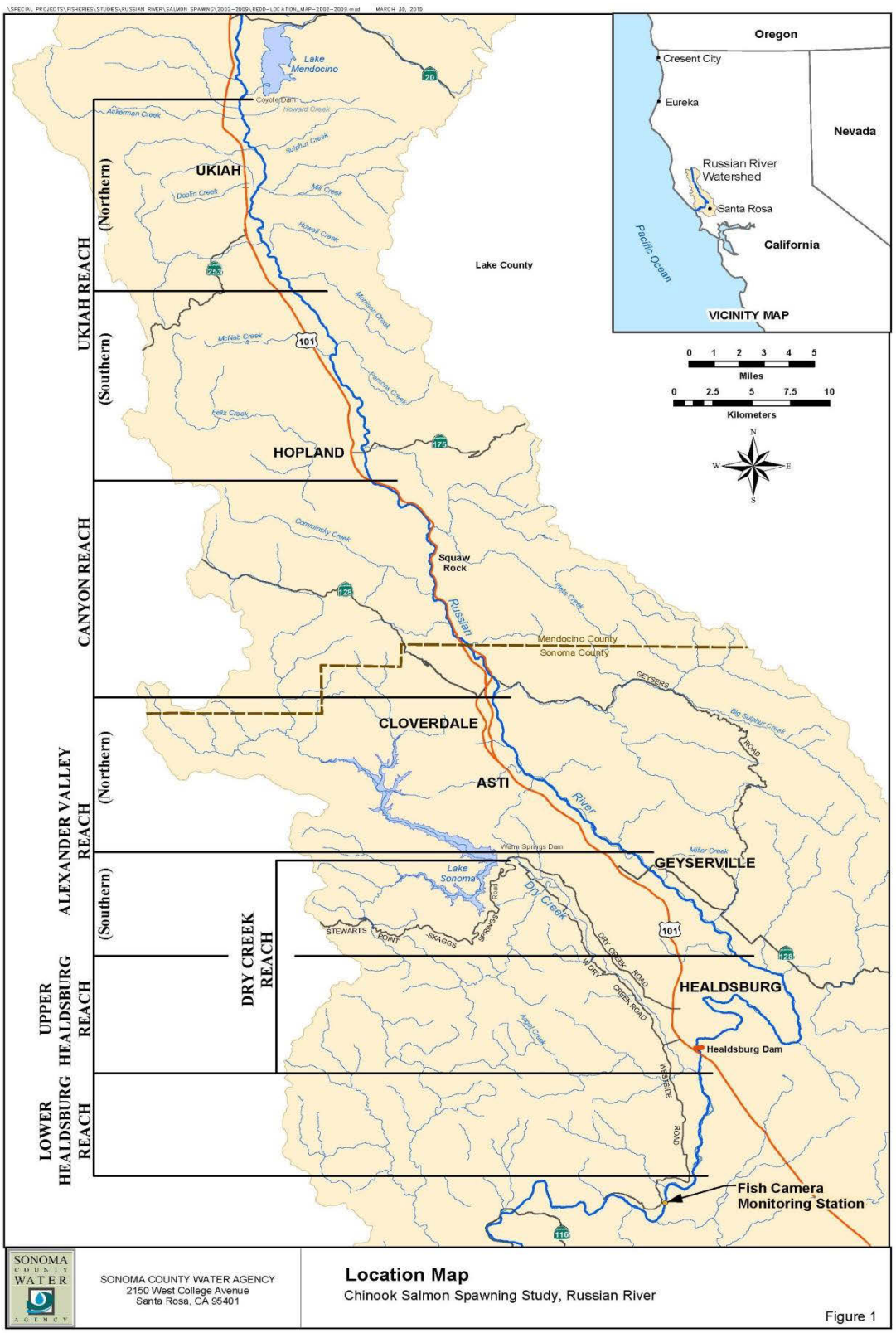



**Figure 9.1. Chinook salmon spawning survey reaches.**

mid-winter due low stream flows from drought. Surveys ended due to increased turbidity from heavy rainfall in early February, which obscured the detection of redds.

## Results

Most of the Chinook salmon spawning typically occurs in the upper Russian River mainstem and Dry Creek (Table 9.1 and Figure 9.2). In 2013, the Russian River mainstem reaches and Dry Creek Reach showed a similar pattern of relative abundance of redds as in previous study years with a general increase in redd numbers in an upstream direction. During 2013, there were 362 redds in the upper Russian River and 325 redds in Dry Creek for a total of 687 redds. Alexander Valley Reach had a total of 163 redds and the highest frequency of redds in the mainstem at 6.2 redds/rkm. In comparison, there were more redds recorded in Dry Creek Reach than Alexander Valley Reach, even though the latter has a longer stream length. During peak spawning activity in Dry Creek there was a frequency of 15.0 redd/rkm, which is the second highest since 2003 at 15.8 redd/rkm.

During repeated redd surveys along Dry Creek the highest report was 325 redds on December 18, 2013 (Figure 9.3). On the next survey on January 14, 2014 the number of observed redds was 80. The last survey on January 27 reported 52 redds. Overall, the Chinook salmon spawning period spanned over three months but the highest spawning activity was observed between November 20 and December 18, 2013. Surveys were discontinued due to winter high flows.

There was a disproportionate occurrence of redds between the Upper and Lower reaches of Dry Creek (Figure 9.3). The Upper Reach contained over five times as many redds compared to the Lower Reach on December 18. The Lower Reach showed a gradual increase in redd numbers during the early spawning period suggesting that there are relatively few optimal spawning riffles in this reach, which are occupied early in the spawning season. In comparison, the Upper Reach showed substantial increases in the number of redds weekly until the peak on December 18.

## Conclusions and Recommendations

In 2013, the primary Chinook salmon spawning areas in the Russian River basin were located on the mainstem from Alexander Valley upstream to Ukiah Valley and in Dry Creek, which is the same pattern observed since 2002. Redds were least abundant in the Lower Healdsburg reach. The total number of redds recorded in all study reaches was 687 redds. Based on the trend of increasing redd abundances in Dry Creek (Figure 9.2) the peak of spawning activity in the Russian River basin was likely in mid December. Combined these observations suggest a moderate spawning run of Chinook salmon during fall 2013 and supports observations from the Mirabel Dam video monitoring of adult Chinook salmon (see Chapter 8).

Table 9. 1. Chinook salmon redd abundances by reach, upper Russian River and Dry Creek, 2002-2013. Redd counts are from a single pass survey conducted during the peak of fall spawning activity. *Survey either not completed or incomplete. Dry Creek value for 2008 is an estimate.

| Reach | Reach (rkm) | Redd Observations 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Redd Count** | | | | | | | | | | | | | |
| Ukiah (Forks-Hwy101) | 33.1 | 511 | 464 | 284 | * | 248 | 118 | 20 | 38 | * | * | 90[2] | 81 |
| Canyon (Hwy101-SulphurCr) | 20.8 | 277 | 190 | 169 | * | 68 | 88 | 36 | 38 | * | * | * | 43 |
| Alexander (SulphurCr-AV Rd) | 26.2 | 163 | 213 | 90 | * | 62 | 131 | 65 | 129 | * | 97 | 185 | 163 |
| Upper Healdsburg (AV Rd-Dry Cr) | 25.6 | 79 | 40 | 8 | * | 23 | 67 | 48 | 38 | * | 66 | 53 | 57 |
| Lower Healdsburg (Dry Cr-Wohler Bridge) | 8.2 | 6 | 0 | 7 | * | 1 | 2 | 9 | 30 | * | 7 | 4 | 18 |
| **Russian River** | **113.9** | **1036** | **907** | **558** | * | **402** | **406** | **178** | **273** | * | **170** | **332** | **362** |
| Dry Creek | 21.7 | * | 256 | 342 | * | 201 | 231 | 65[1] | 223 | 269 | 229 | 362 | 325 |
| **Total** | **135.6** | | **1163** | **900** | * | **603** | **637** | **243** | **496** | **269** | **399** | **694** | **687** |
| **Relative Contribution of Redds** | | | | | | | | | | | | | |
| Russian River (%) | 84.0 | * | 78.0 | 62.0 | * | 66.7 | 63.7 | 73.3 | 55.0 | * | * | * | 52.7 |
| Dry Creek (%) | 16.0 | * | 22.0 | 38.0 | * | 33.3 | 36.3 | 26.7 | 45.0 | * | * | * | 47.3 |
| **Total** | 100.0 | | 100.0 | 100.0 | | 100.0 | 100.0 | 100.0 | 100.0 | | | | 100.0 |

[1]Redd numbers are an estimate.
[2]Redd numbers are presumably an underestimate due to poor survey conditions.

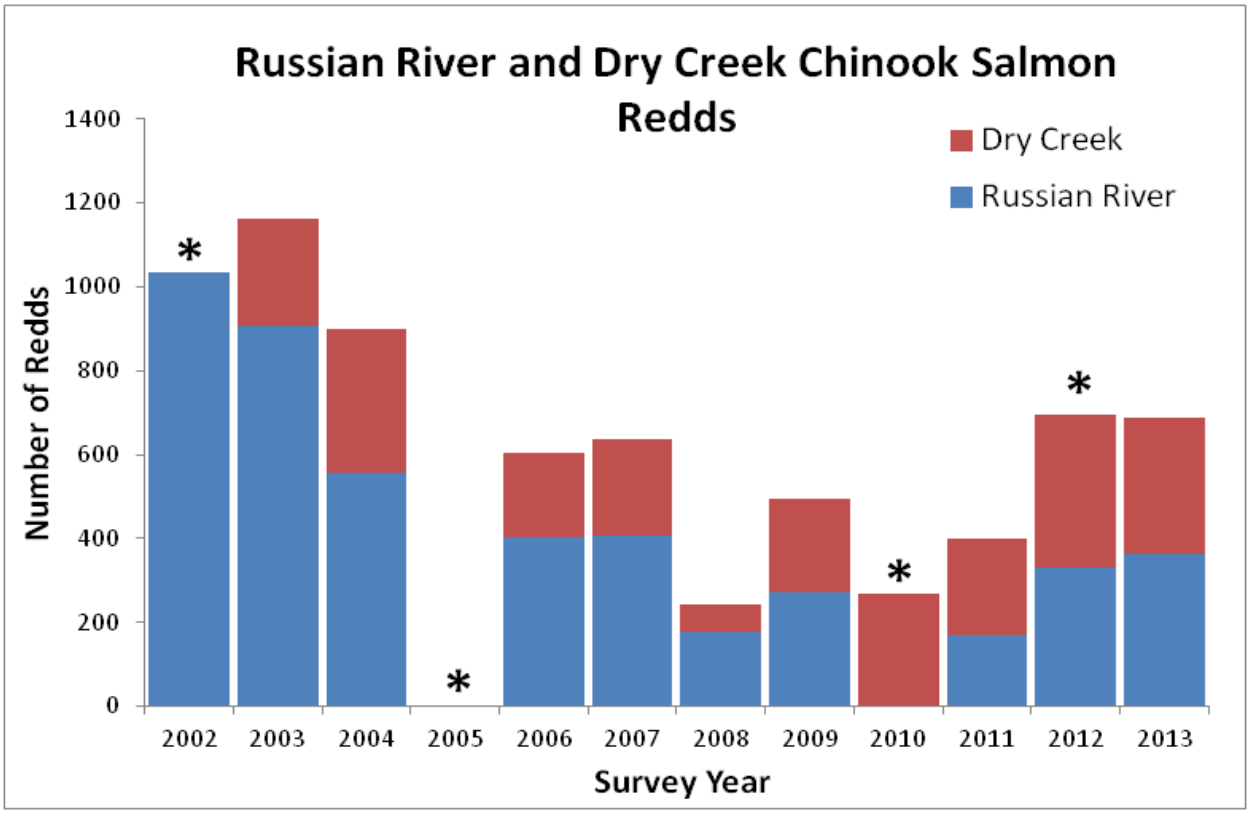



**Figure 9.2. Summary of Chinook salmon redd observations in the upper Russian River mainstem and Dry Creek, 2002-2013. Observations are from single-pass surveys conducted during the peak of spawning activity. *Surveys either not conducted or incomplete.**

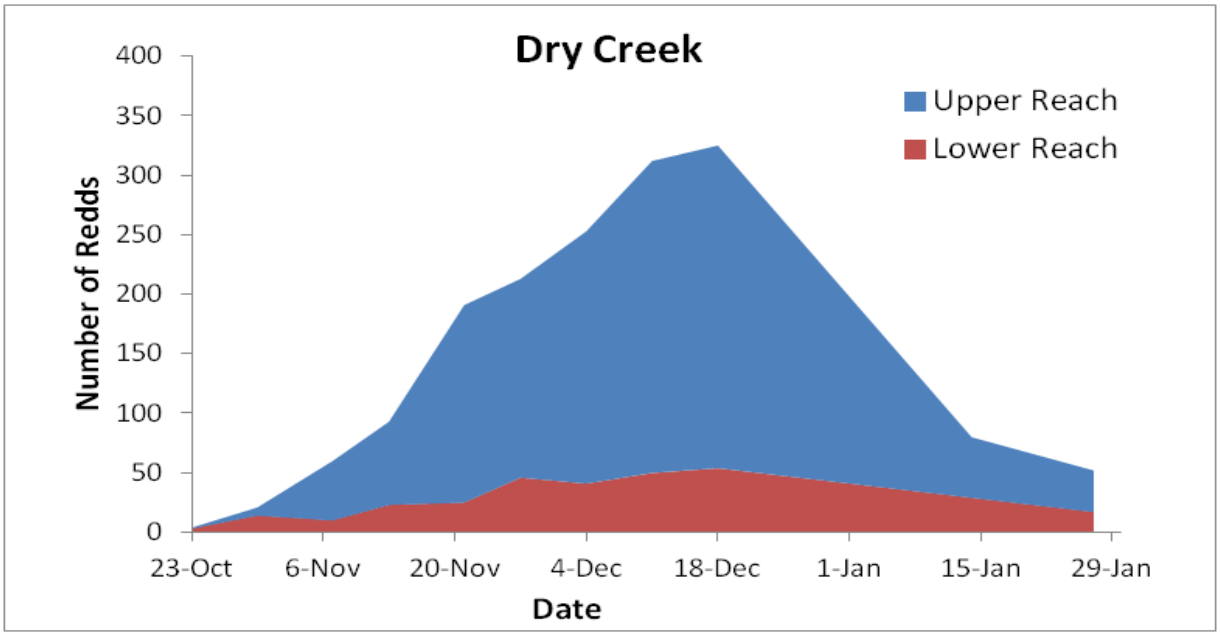



**Figure 9. 3. Chinook salmon redds in reaches of Dry Creek, 2013. The number of redds observed during weekly to bi-monthly surveys are shown. Reaches are the upper Dry Creek from Warm Springs Dam to Lambert Bridge and lower Dry Creek from Lambert Bridge to the Russian River confluence.**

## References

Cook, D. (Sonoma County Water Agency). 2003. Chinook salmon spawning study, Russian River, fall 2002. 9 p. Santa Rosa, (CA): Sonoma County Water Agency.

Sonoma County Water Agency. 2011. Russian River biological opinion status and data report 2009-10. February 28. Santa Rosa (CA): Sonoma County Water Agency.

# Chapter 10 : Synthesis

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 (**Figure 1**) and temporal (**Figure 2**) extent in the Russian River Basin. 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 at our Mirabel underwater video counting station and conducted Chinook spawner surveys on the 119 km of stream length in mainstem Russian River between Ukiah and River front Park and nine repeat Chinook spawner surveys 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 PIT-tagged salmonids near the upstream extent of the tidal portion of the estuary in Duncans Mills; juvenile salmonid sampling using beach seining at ten fixed locations in the estuary; juvenile sampling using backpack electrofishing, PIT tags and PIT antennas at four sites in mainstem Dry Creek. Complementary data on water quality were collected by means of continuously-recording datasondes at 6 sites throughout the estuary/lagoon and from bi-weekly and weekly grab samples at four additional sites. Details regarding the specifics of these monitoring activities are covered in individual chapters of this report.

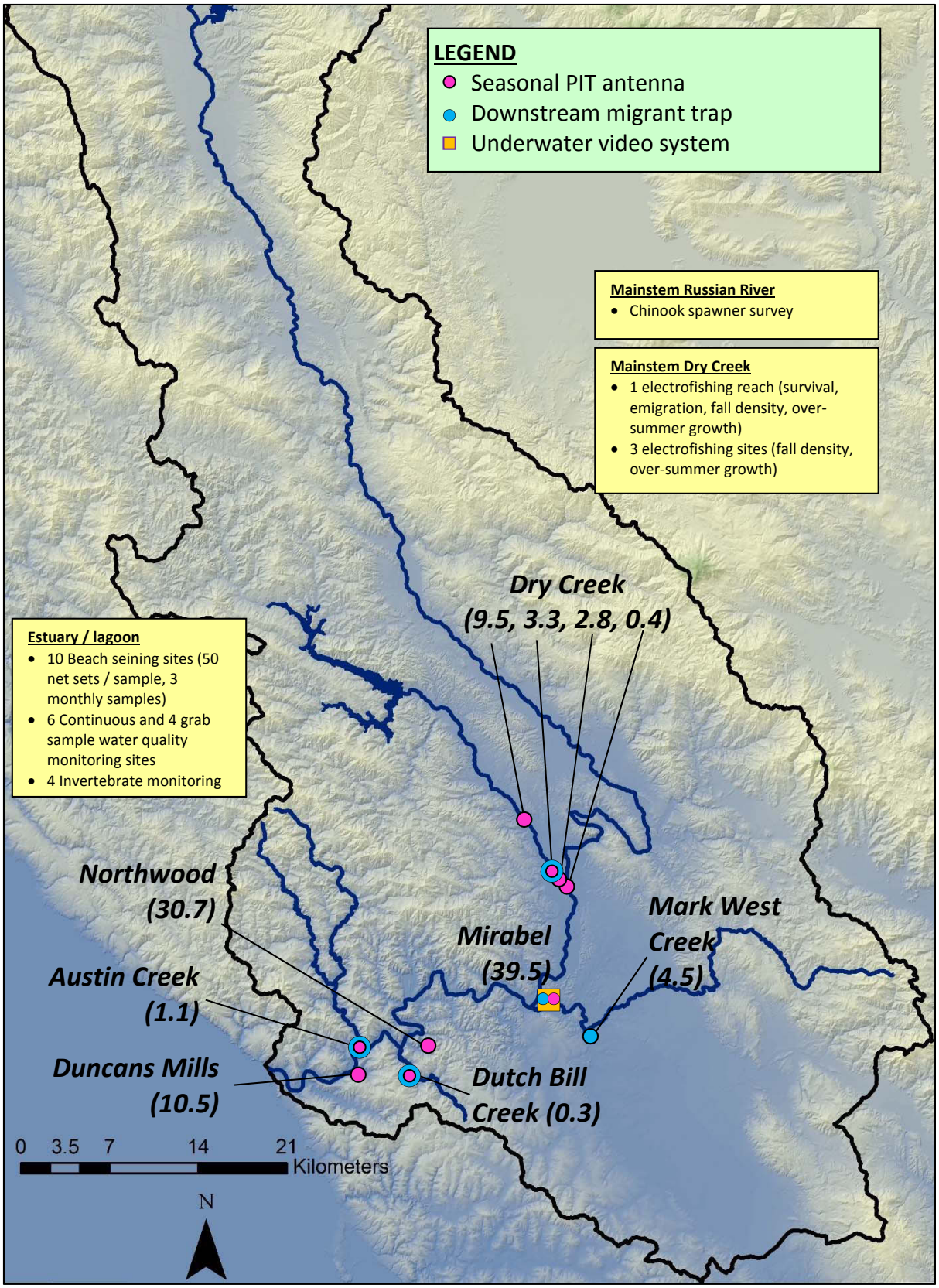



**Figure 1. Spatial extent of fisheries and water quality monitoring related to the Russian River Biological Opinion, 2013. Number in parentheses are the distances in km (rkm) of the site from the mouth of the stream the site is located in.**

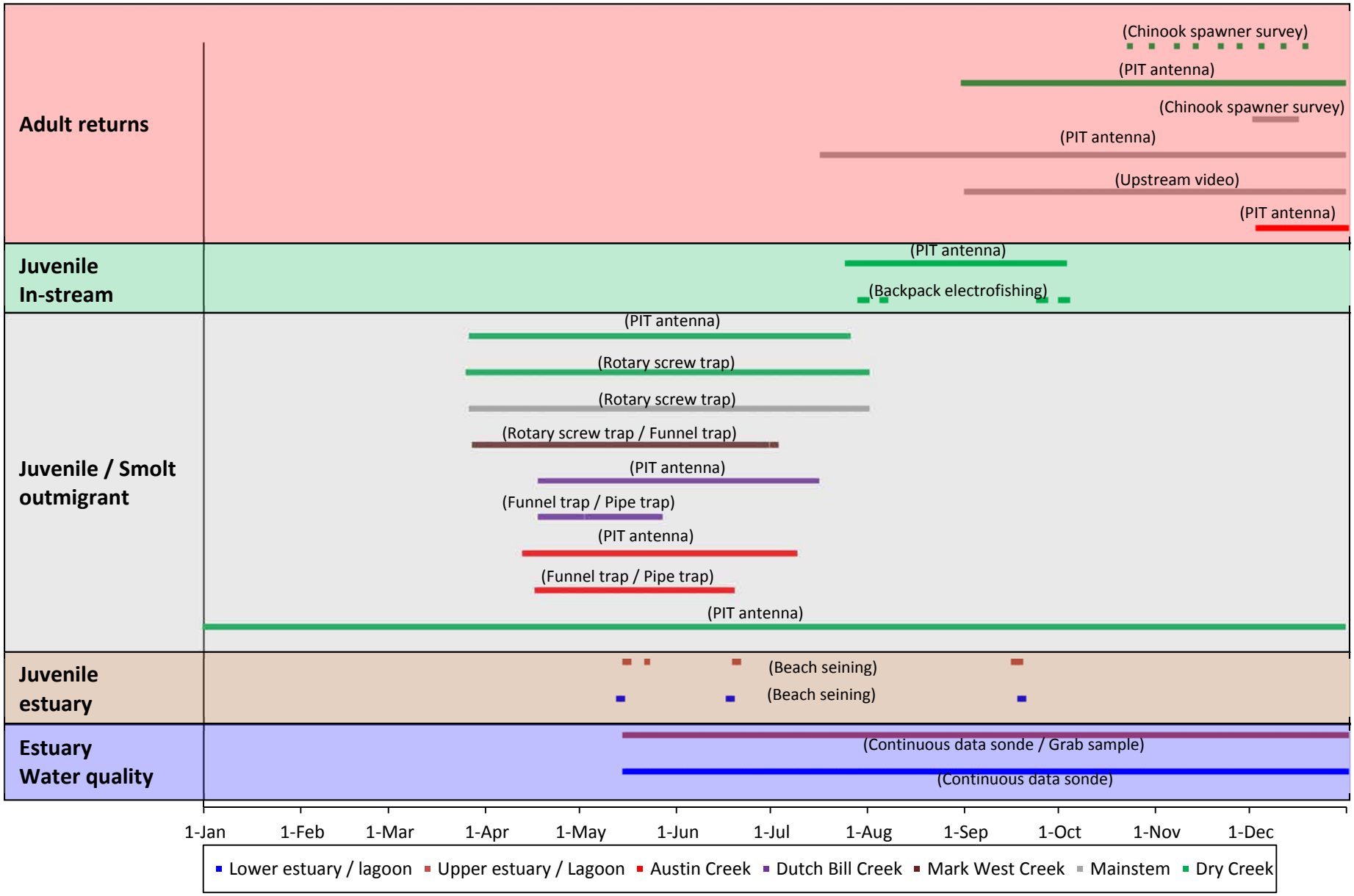



**Figure 2. Temporal and life stage extent of sampling at fisheries and water quality monitoring sites related to the Russian River Biological Opinion, 2013.**

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 2013. The Water Agency used PIT tags and fin-clipping as primary tools for characterizing these metrics. As described in other sections of this report and reports from prior years, PIT-tagged and/or fin-clipped fish were detected 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 survival of Chinook salmon smolts from Dry Creek through the lower mainstem Russian River and estuary. We conclude with a discussion of how prevailing temperature and river mouth closure may influence both smolt and adult migration.

## Abundance

Combined juvenile steelhead downstream migrant trap catch at Dry Creek, Mirabel, Dutch Bill Creek and Austin Creek was higher in 2013 than any of the five years of downstream migrant trapping (2009-2013) at these sites. The increase was most pronounced for Austin Creek (**Table 1**). Indicators of juvenile steelhead density (backpack electrofishing density estimates on Dry Creek and beach-seining CPUE estimates in the estuary) also showed increases relative to recent years (**Figure 3**). Chinook salmon smolt estimates have shown a steady decline in Dry Creek from 2011-2013 and a modest increase at Mirabel when compared to 2012 (**Figure 3**). Captures of wild coho YOY and smolts decreased at all sites except for YOY at Mirabel (**Figure 3**). Juvenile trends roughly matched adult trends for all three species (**Figure 4**).

**Table 1. Number of individual salmonids captured by life stage at downstream migrant traps operated by the Water Agency, 2009-2013.**

| | | Juvenile | | | Smolt | | | |
|---|---|---|---|---|---|---|---|---|
| | | Steelhead | Coho salmon | | Steelhead | Coho salmon | | Chinook salmon |
| Year | Tributary | Wild | Wild | Hatchery | Wild | Wild | Hatchery | Wild |
| 2009 | Dry Creek | 5,258 | 0 | 0 | 219 | 3 | 7 | 21,724 |
| | Mainstem | 75 | 0 | 0 | 33 | 5 | 208 | 1,399 |
| | ***Total*** | ***5,333*** | ***0*** | ***0*** | ***252*** | ***8*** | ***215*** | ***23,123*** |
| 2010 | Dry Creek | 2,049 | 2 | 0 | 33 | 1 | 19 | 5,241 |
| | Mainstem | 375 | 0 | 0 | 42 | 1 | 180 | 2,368 |
| | Green Valley Creek | 67 | 0 | 0 | 27 | 0 | 0 | 0 |
| | Dutch Bill Creek | 58 | 0 | 39 | 5 | 1 | 184 | 4 |
| | Austin Creek | 4,774 | 0 | 1,906 | 232 | | 103 | 24 |
| | ***Total*** | ***7,323*** | ***2*** | ***1,945*** | ***339*** | ***3*** | ***486*** | ***7,637*** |
| 2011 | Dry Creek | 2,879 | 18 | 0 | 72 | 83 | 113 | 20,917 |
| | Mainstem | 528 | 10 | 0 | 151 | 15 | 872 | 13,753 |
| | Green Valley Creek | 3 | 1 | 0 | 1 | 2 | 229 | 16 |
| | Dutch Bill Creek | 31 | 5 | 0 | 47 | 0 | 2,904 | 34 |
| | Austin Creek | 1,829 | 14 | 45 | 175 | 0 | 335 | 48 |
| | ***Total*** | ***5,270*** | ***48*** | ***45*** | ***446*** | ***100*** | ***4,453*** | ***34,768*** |
| 2012 | Dry Creek | 4,706 | 35 | 0 | 56 | 117 | 127 | 8,145 |
| | Mainstem | 984 | 45 | 0 | 78 | 26 | 270 | 2,428 |
| | Mark West Creek | 95 | 7 | 0 | 44 | 28 | 357 | 376 |
| | Dutch Bill Creek | 21 | 0 | 0 | 11 | 35 | 1,952 | 13 |
| | Austin Creek | 3,672 | 372 | 584 | 164 | 37 | 507 | 377 |
| | ***Total*** | ***9,478*** | ***459*** | ***584*** | ***353*** | ***243*** | ***3,213*** | ***11,339*** |
| 2013 | Dry Creek | 3,619 | 1 | | 281 | 19 | 760 | 9,410 |
| | Mainstem | 1,705 | 137 | | 148 | 20 | 1,059 | 6,350 |
| | Mark West Creek | 316 | 66 | | 454 | 32 | 2,258 | 157 |
| | Dutch Bill Creek | 79 | 2 | | 18 | 106 | 717 | |
| | Austin Creek | 7,397 | 38 | 24 | 14 | 12 | 74 | 135 |
| | ***Total*** | ***13,116*** | ***244*** | ***24*** | ***915*** | ***189*** | ***4,868*** | ***16,052*** |

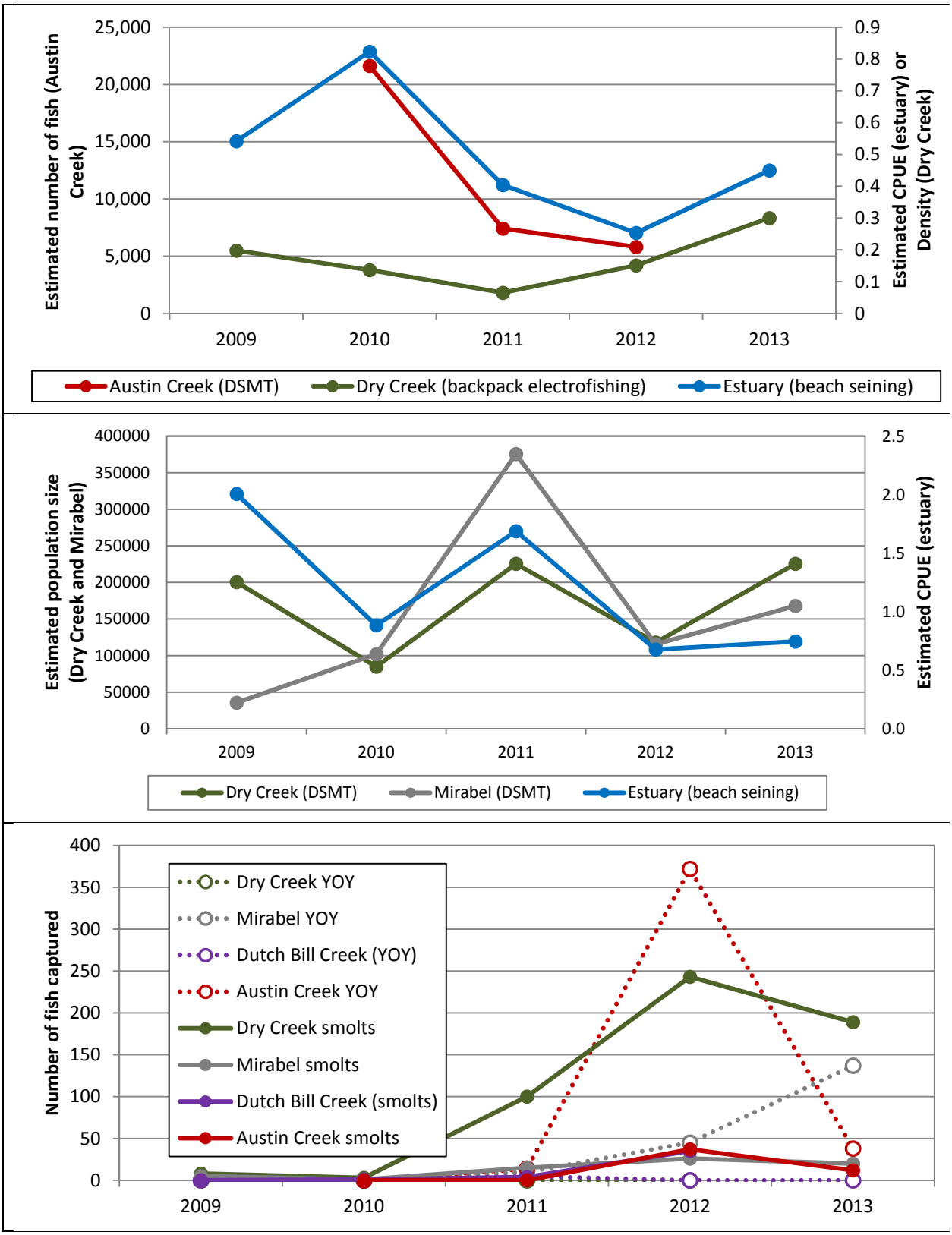



**Figure 3. Indicators of juvenile steelhead (top panel), Chinook smolts (middle panel) and wild coho smolt/YOY trends based on monitoring conducted by the Water Agency, 2009-2013.**

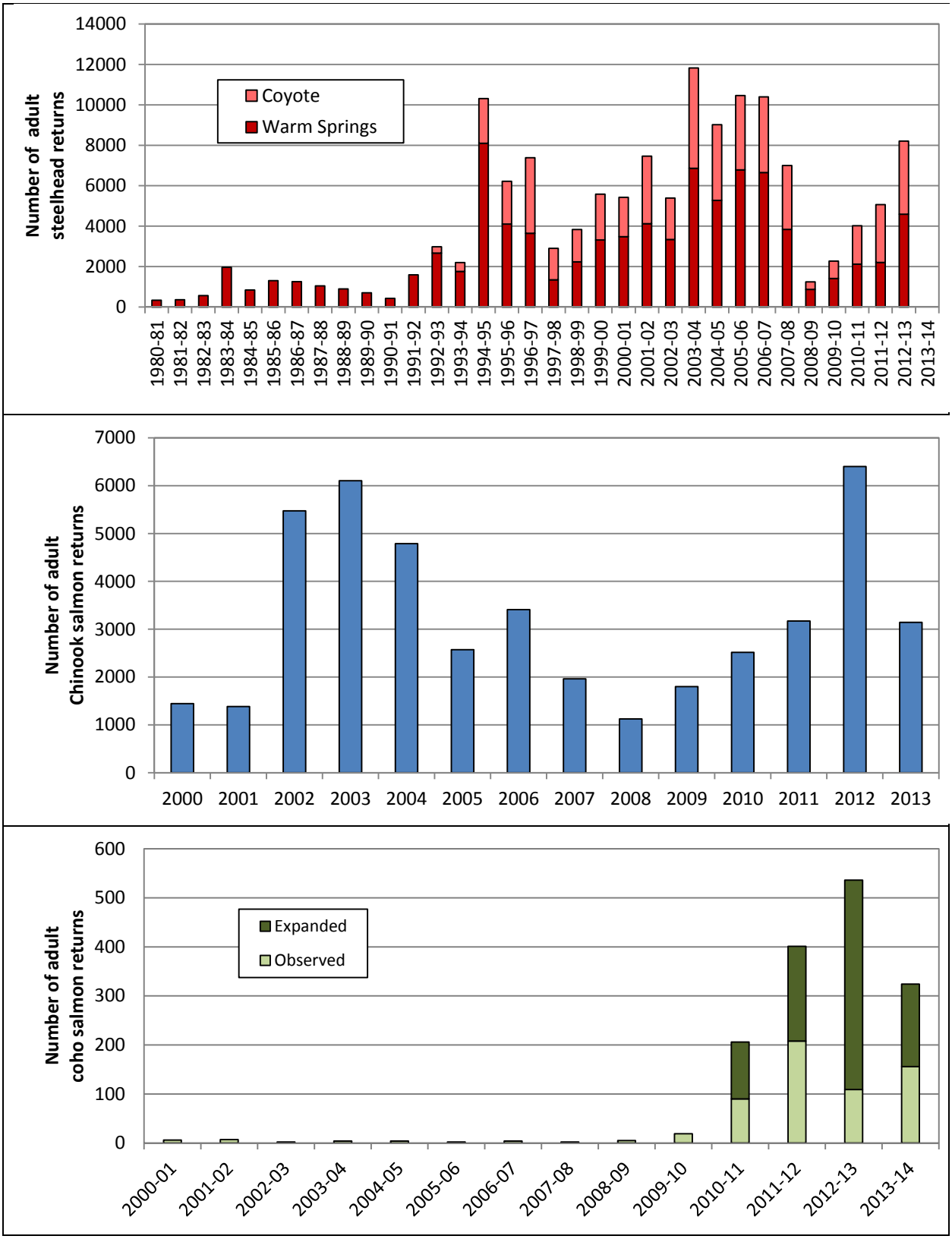



**Figure 4. Indicators of adult steelhead (counted at Russian River hatcheries), adult Chinook (based on underwater video counts at Wohler-Mirabel) and coho salmon returns (source: UCCE Sea Grant Coho Broodstock Monitoring).**

## Movement and survival

In 2013 we continued to build a data set to evaluate how aspects of environmental conditions through the lower ~64 km of mainstem Russian may be affecting downstream movement of juvenile steelhead and Chinook salmon smolts. Our capabilities to make these assessments were enhanced by operation of additional PIT antenna arrays and continuation of PIT-tagging juvenile steelhead at downstream migrant traps on mainstem Russian River at Wohler-Mirabel and tributaries to the lower river. We also continued to PIT-tag Chinook smolts at the Dry Creek fish trap and for the first time in 2013 we PIT-tagged juvenile steelhead at the Dry Creek trap. If and when PIT-tagged steelhead and Chinook 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 (rkm 39.7), detected on the new mainstem PIT antenna array in the community of Northwood (rkm 30.7, newly installed in 2013) and/or the PIT antenna array near the upstream extent of the estuary in Duncans Mills (rkm 10.5) (**Figure 1**).

In 2013, we PIT-tagged 6,036 individual juvenile steelhead at all sites combined (Table2) in addition to 3,671 Chinook salmon smolts at the Dry Creek fish trap. We physically recaptured 246 PIT-tagged steelhead and 200 Chinook smolts at downstream capture sites, and detected 265 and 467 juvenile steelhead and 467 Chinook smolts, respectively, at PIT antenna arrays.

**Table 2. Number of juvenile steelhead that were PIT-tagged and observed with a PIT tag at all Water Agency fish capture sites, 2009-13.**

| 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 |
| | Electrofishing | 2009 | 823 | 104 |
| | | 2010 | 897 | 168 |
| | | 2011 | 801 | 140 |
| | | 2012 | 775 | 202 |
| | | 2013 | 892 | 125 |
| Mainstem | Downstream migrant trap | 2009 | 17 | 0 |
| | | 2010 | 96 | 51 |
| | | 2011 | 99 | 1 |
| | | 2012 | 315 | 3 |
| | | 2013 | 501 | 37 |
| Mark West Creek | Downstream migrant trap | 2012 | 43 | 0 |
| | | 2013 | 135 | 11 |
| Dutch Bill Creek | Downstream migrant trap | 2010 | 46 | 0 |
| | | 2011 | 23 | 1 |
| | | 2012 | 6 | 0 |
| | | 2013 | 12 | 0 |
| Austin Creek | Downstream migrant trap | 2010 | 997 | 113 |
| | | 2011 | 500 | 30 |
| | | 2012 | 1,639 | 568 |
| | | 2013 | 1,749 | 10 |
| Estuary | Beach seining | 2009 | 68 | 4 |
| | | 2010 | 241 | 41 |
| | | 2011 | 88 | 18 |
| | | 2012 | 85 | 15 |
| | | 2013 | 43 | 4 |
| | | ***Total*** | ***12,712*** | ***1,589*** |

**Table 3. Number of Chinook salmon smolts that were PIT-tagged and observed with a PIT tag at all Water Agency fish capture sites, 2011-13.**

| Tributary | Survey | Year | Applied | Observed |
|---|---|---|---|---|
| Dry Creek | Downstream migrant trap | 2011 | 1,847 | 242 |
| | | 2012 | 1,326 | 110 |
| | | 2013 | 3,671 | 439 |
| Mainstem | Downstream migrant trap | 2011 | 0 | 45 |
| | | 2012 | 0 | 36 |
| | | 2013 | 0 | 202 |
| Estuary | Beach seining | 2011 | 0 | 1 |
| | | 2012 | 0 | 4 |
| | | 2013 | 0 | 4 |
| | | ***Total*** | ***11,631*** | ***1,083*** |

### Juvenile steelhead movement

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 4**). When estimated detection efficiencies of PIT antennas near the mouth of each tributary was used to adjust the observed detections, we estimated 87% (~2,400) and 89% (~1,500) of the steelhead PIT-tagged at Dry Creek and Austin Creek, respectively, exited the stream they were tagged in. While this high percentage is consistent with estimates for Austin in recent years, it is somewhat surprising for Dry Creek given the persistent flow of cold water throughout the summer. Although many juvenile steelhead apparently left Dry Creek in the spring, relatively few were detected at the Mirabel downstream migrant trap (17 individuals), Northwood (5 individuals) or Duncans Mills antennas (4 individuals) 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.

Although low in number, there were also some interesting movements of PIT-tagged fish in 2013. One steelhead tagged at the Dry Creek fish trap and another tagged at the Mirabel fish trap were later captured in the Mark West downstream migrant trap. Seventeen steelhead PIT-tagged at the Austin Creek trap were detected at the Northwood antenna approximately 19 km upstream. This evidence is similar to evidence in previous years for juvenile steelhead and coho salmon suggesting that making use of habitat in areas other than the tributary of origin is an important strategy.

**Table 4. Number of PIT-tagged juvenile steelhead detected at by location of tagging. Shaded numbers on diagonal indicate the number of fish tagged (if applicable) at that site. Tributaries and sites are sorted from downstream to upstream (top to bottom and left to right) so numbers below diagonal indicate downstream movement while numbers above diagonal indicate upstream movement.**

| DETECTION / TAGGING SITE | | RECAPTURE SITE | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Estuary | | | Austin Creek | | Dutch Bill Creek | Mainstem Northwood | Mark West Creek | Mainstem (Mirabel) | Dry Creek | |
| | | Lower 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 (0.4) | DSMT (3.3) |
| Estuary | Lower seine | 2 | | | | | | | | | | |
| | Upper seine | | 41 | 9 | | | | | | | | |
| | PIT (10.5) | | | na | | | | | | | | |
| Austin Creek | PIT (0.5) | | | | na | | | | | | | |
| | DSMT (1.1) | | 4 | 472 | 1334 | 1749 | | 17 | | | | |
| Dutch Bill Creek | DSMT (0.3) | | | 2 | 1 | | 12 | | | | | |
| Mainstem (Northwood) | PIT (30.7) | | | | | | | na | | | | |
| Mark West Creek | DSMT (4.5) | | | | | | | | 135 | | | |
| Mainstem (Mirabel) | DSMT (39.5) | | | 1 | | | | | 1 | 501 | | |
| Dry Creek | PIT (0.4) | | | | | | | | 1 | 17 | na | |
| | DSMT (3.3) | | | 6 | 2 | | | 5 | | | 1212 | 2704 |

### Chinook smolt survival

The additional PIT antennas operated in 2013 allowed us to expand our preliminary evaluation of Chinook salmon smolt survival through the lower mainstem Russian River. Because we did not have a method for estimating detection efficiency of the estuary PIT antenna array, we were unable to estimate Chinook smolt survival for the portion of the mainstem between Northwood and Duncans Mills.

In Russian River Biological Opinion annual reports from previous years, we hypothesized that when temperatures in mainstem Russian begin to exceed 19°C, remaining smolts that have not yet left Dry Creek may suffer higher mortality than earlier-migrating members of the same cohort. We hypothesized that a consequence would be lower smolt survival through the mainstem as compared to survival in Dry Creek particularly when water temperatures occur early in the migration season when many fish have not yet emigrated; estimates we assembled for 2013 do indeed support this hypothesis **(Figure 6**). If correct, the impact of elevated water temperature and river mouth closure on Chinook smolt survival was perhaps more significant in 2013 than any other year since 2009 (**Figure 6)**.

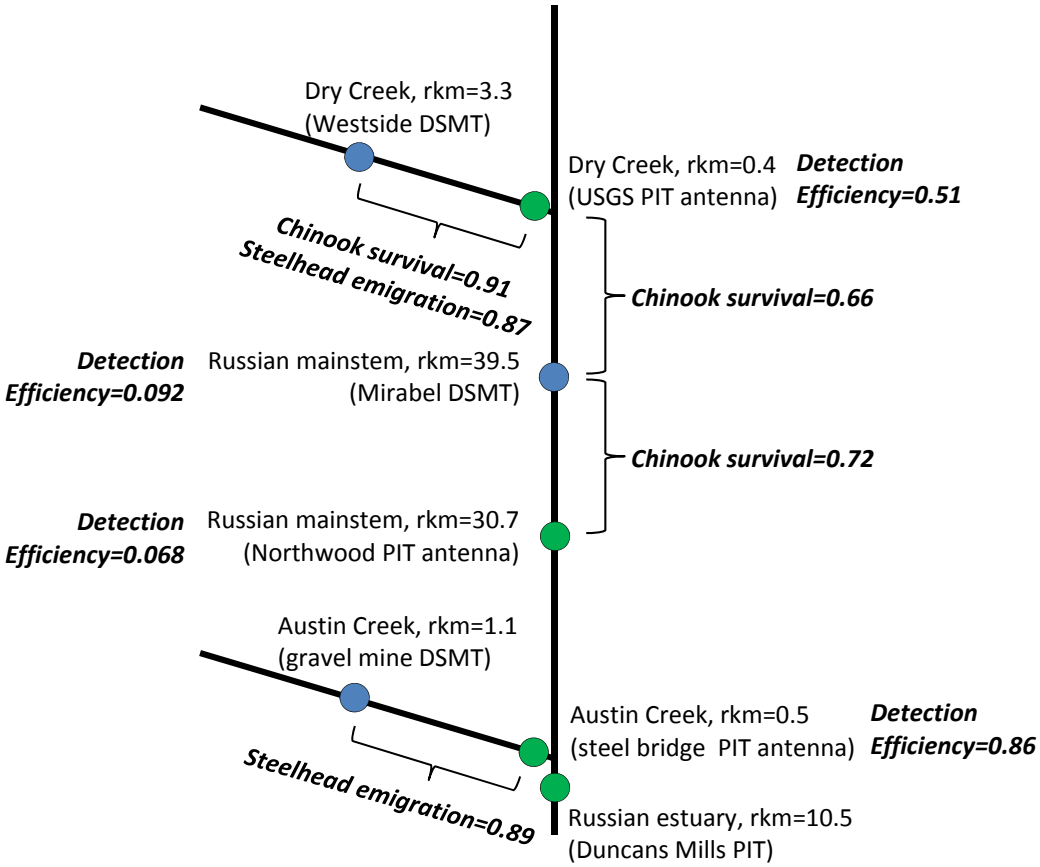



**Figure 5. Schematic of PIT antenna layout (green circles) in relation to downstream migrant trapping (DSMT) sites (blue circles) in Dry Creek and mainstem Russian River, 2013. Estimated emigration from Dry Creek and Austin Creek (juvenile steelhead) and reach-specific survival (Chinook salmon smolts) are from site-specific recapture and detection efficiencies.**

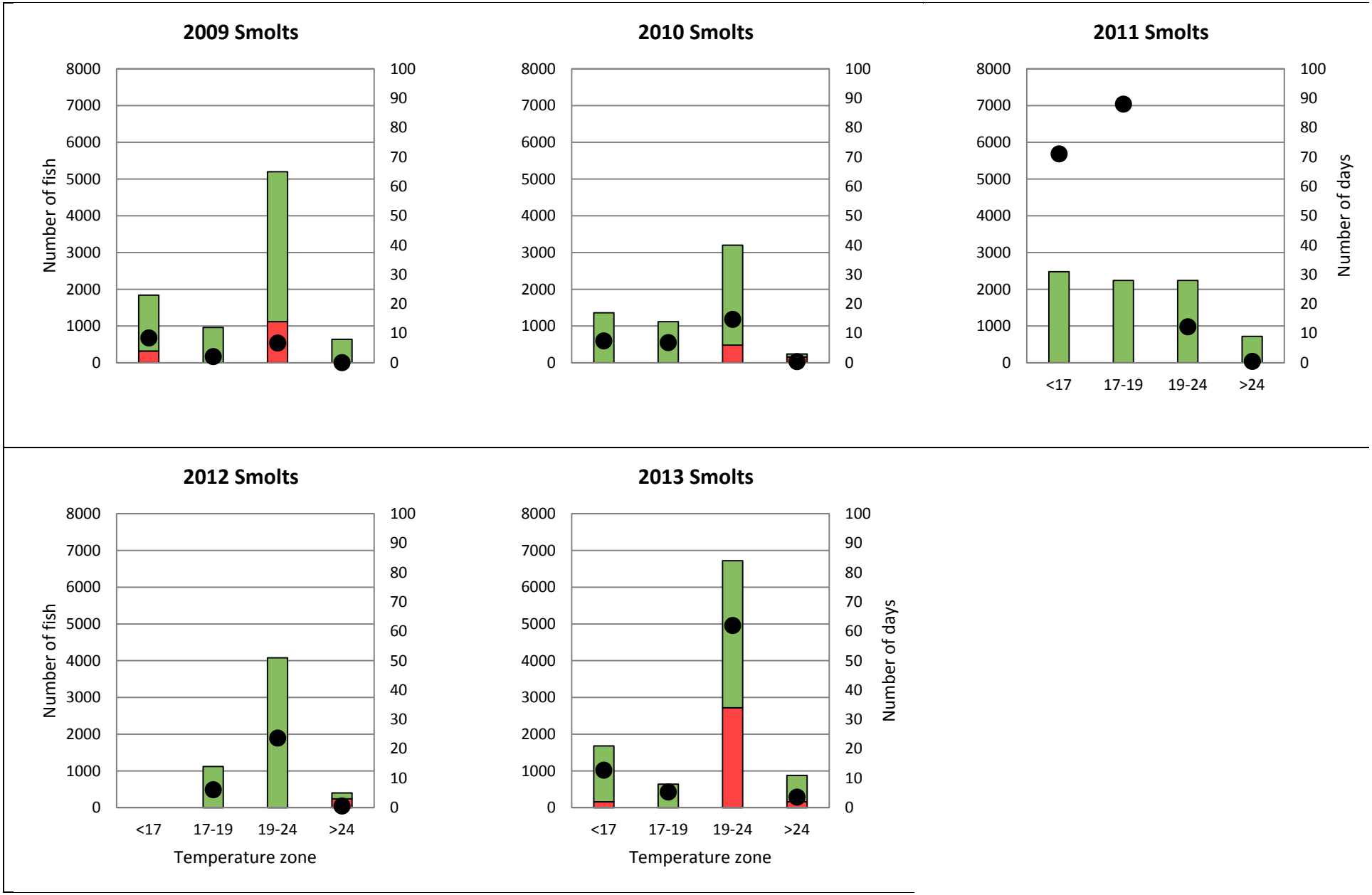



**Figure 6. Number of Chinook smolts captured in each of four temperature zones when the mouth of the river was closed or open, 2009-2013. Temperature bins are from Sullivan et al. (2000) and NCRWQCB (2000) and represent excellent to very poor water temperatures for survival.**

### Adult migration

*Temperature-* Adult Chinook salmon entering the Russian River early in the migration season are often exposed to suboptimal water temperatures. Although Chinook salmon have been observed migrating past the Mirabel Dam at mean daily temperatures (MDT) up to 22.6°C. Annually, 73 to 97 percent of the fish counted at the Mirabel dam pass after the MDT declines below 15.5°C (**Table 5**). This 15.5°C threshold is significant because exposure of migrating adults to temperatures above this point can result in decreased survival of developing embryos (CDWR 1988).

We will use data on timing of adult Chinook river entry in relation to water temperature and river mouth closure to inform decisions regarding flow management and estuary management in the Russian River (**Figure 7**).

**Table 5. Date that the mean daily water temperature declined below 17.1 and 15.5°C and the percentage of the run that counted after this date, 2000-2013.**

| Year | Date temp ≤ 15.5°C | Percentage of Chinook salmon counted on days when temp ≤15.5°C |
|---|---|---|
| 2000 | Oct 22 | 76.4 |
| 2001 | Oct 21 | 72.6 |
| 2002 | Oct 16 | 59.4 |
| 2003 | Oct 30 | 75.3 |
| 2004 | Oct 13 | 96.7 |
| 2005 | Oct 27 | 91.8 |
| 2006 | Oct 18[1] | 82.2[1] |
| 2007 | No data | No data |
| 2008 | Oct 10 | 79.7 |
| 2009 | Oct 28 | 62.2 |
| 2010 | Oct 17 | 62.3 |
| 2011 | Oct 27 | 28.9 |
| 2012 | Oct 14 | 92.8 |
| 2013 | Oct 14 | 97.2 |

[1]Temperature data collection ended on October 18 when MDT = 15.8°C. For this analysis it was assumed that the temperature would have declined below 15.5°C on October 19.
[2]Temperature probe failed therefore no temperature data collected.

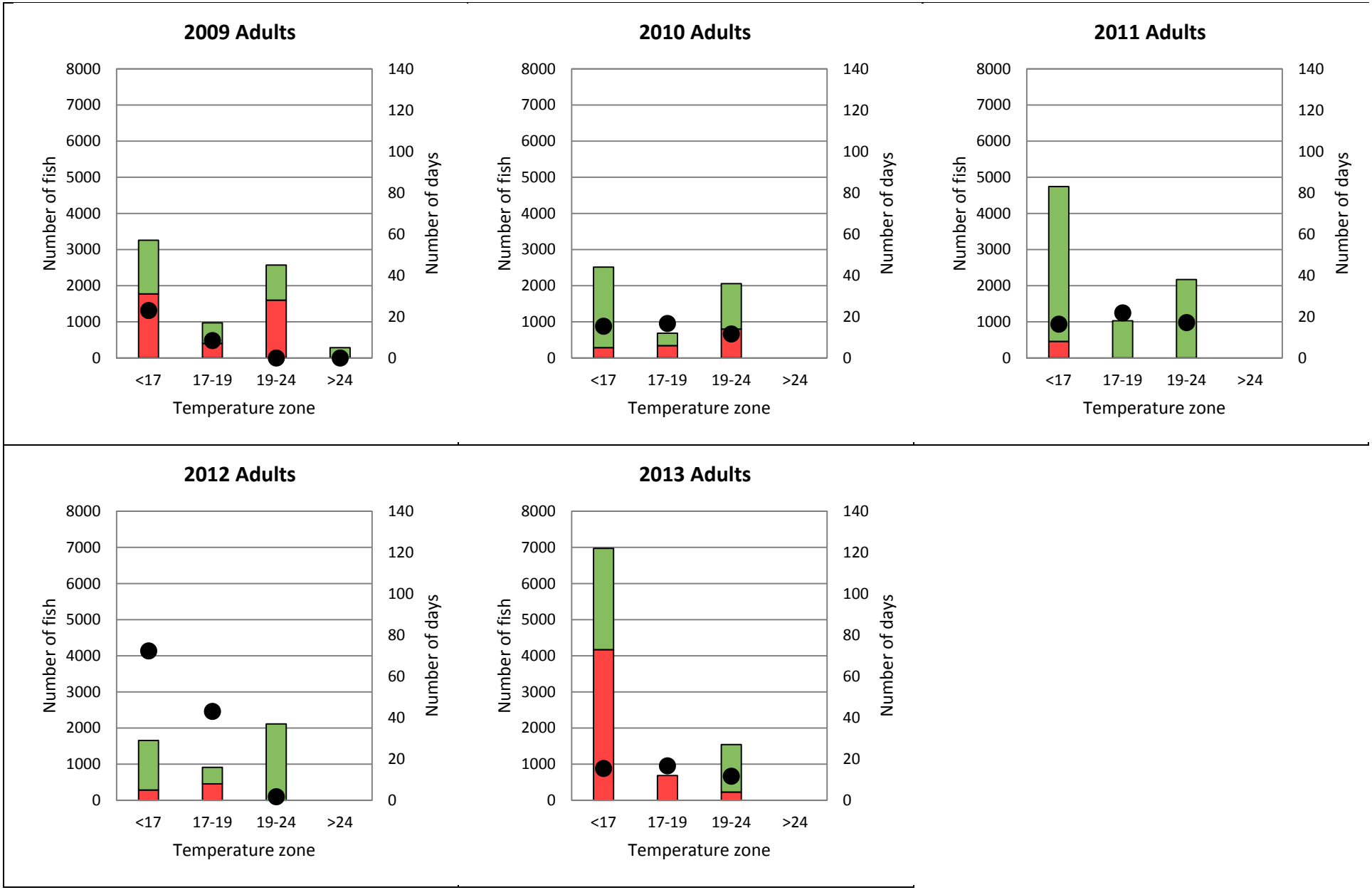



**Figure 7. Number of Chinook adults captured in each of four temperature zones when the mouth of the river was closed or open, 2009-2013. Temperature bins are from Sullivan et al. (2000) and NCRWQCB (2000) and represent excellent to very poor water temperatures for survival.**

*Flow-* A crucial question for resource managers is what minimum flow is required for Chinook salmon to migrate upstream and successfully spawn. Based on the data collected by the Water Agency to date, upstream migration by adult Chinook salmon appears to be regulated not only by water depths in riffles that physically allow upstream migration, but by other motivational cues as well.

Using empirical data collected over the past 14 years, the lowest daily average flow (measured at Hacienda) for which we observed Chinook at our counting station was 79 cfs (5 fish detected on February 1, 2014). However, large numbers of fish have not been observed at flows less than 127 cfs (635 total Chinook salmon with a daily maximum of 53). For example, in 2013 daily adult Chinook counts increased from 53 at 122 cfs, to 97 at 128 cfs and 589 at 134 cfs. Based on this analysis, we conclude that streamflows of at least 80 cfs are “passable” by adult salmonids and flows of approximately 125 cfs are “suitable” for upstream migrating salmonids.

### Conclusions and Recommendations

In 2013, the Water Agency continued to refine methods and approaches for gathering the information necessary to inform the decisions as the RPA is implemented. As the Water Agency continues to implement the Russian River Biological Opinion, information on abundance 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 in the Russian River.

The PIT monitoring program employed by the Water Agency and the University of California Cooperative Extension / Sea Grant 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 expanding our network of PIT antenna monitoring capabilities in the future- particularly at our estuary PIT antenna station at Duncans Mills. We are also evaluating ways to take a broader look at accounting for population-level processes outside of the influence of the Water Agency that are, nevertheless, impacting the steelhead and salmon populations we are working with and therefore should be accounted for when evaluating progress from RPA-implementation. For example, in 2013 the Water Agency and UC began implementation of the California Coastal Monitoring Plan (Adams et al. 2011).

## 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.

California Department of Water Resources (CDWR). 1988. Water temperature effects on Chinook salmon (Oncorhynchus tshawytscha) with emphasis on the Sacramento River: a literature review. Northern District Office Report, Red Bluff, California. 42 pp.

NCRWQCB. 2000. Review of Russian River water quality objectives for protection of salmonid species listed under the Federal Endangered Species Act. North Coast Regional Water Quality Control Board. Santa Rosa, CA. 102 p.

Sullivan, K., and coauthors. 2000. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute. Portland, OR. 192 p.