

Monitoring Steelhead Populations in the San Joaquin Basin - *Oncorhynchus mykiss* Monitoring and Research Gap Analysis

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Background

Oncorhynchus mykiss are distributed throughout most watersheds in the California Central Valley (Williams 2006). Although the effective population size of California Central Valley *O. mykiss* is still relatively high with significant genetic structure among populations (Nielson et al. 2003), the proportion of fish that adopt an anadromous life-history (i.e., steelhead) has steadily declined over past decades (Williams et al. 2016). Indeed, the anadromous form of this species is often in low abundance throughout the Central Valley, particularly in the San Joaquin Basin (Williams et al. 2016), which led to their listing as threatened under the Endangered Species Act (ESA) in 1998 (Volume 63 Federal Register, 13347-13371) and reaffirmed in 2006 (Volume 71 Federal Register, 834-862).

The continued decline of steelhead population numbers highlights the need for coordinated research and monitoring of *O. mykiss*. Towards this aim, the California Department of Fish and Wildlife led an effort in 2008 to characterize historical and ongoing *O. mykiss* monitoring programs in the California Central Valley (Eilers 2010). Through this review, Eilers (2010) identified a suite of monitoring programs generating data on *O. mykiss*, but determined that monitoring was not standardized, often designed for Chinook salmon (*Oncorhynchus tshawytscha*) populations, and inadequate for assessing population viability (Lindley et al. 2007). Specifically, a total 63 *O. mykiss* monitoring programs were identified during the review, but only eight projects were reported to monitor *O. mykiss* with meaningful confidence, and none could generate abundance or production estimates for juvenile *O. mykiss*. Overall, monitoring coverage was generally limited to streams

that also supported populations of Chinook salmon. As a result, the Central Valley Steelhead (*O. mykiss*) Monitoring Plan was developed to identify actions needed to provide population data for the assessment of steelhead recovery (Eilers et al. 2010). Recommendations included adult abundance monitoring in the mainstem Sacramento River, distribution monitoring using spatially balanced sampling across the Central Valley, and monitoring in priority streams within the Northwestern California, Basalt and Porous Lava, Northern Sierra Nevada, and Southern Sierra Nevada Diversity Groups (NMFS 2014).

Several years after the completion of the Central Valley Steelhead Monitoring Plan, a series of related monitoring projects, identified as the Central Valley Steelhead Monitoring Program (CVSMP), were initiated on the Sacramento River and its tributaries. These projects include the mainstem Sacramento River mark-recapture project, Sacramento River tributary mark-recapture monitoring, upper Sacramento River tributary escapement monitoring, and hatchery broodstock and angler harvest sampling. The program utilizes a variety of methods including large wire fyke traps, rotary screw traps, Passive Integrated Transponder (PIT) tag arrays, acoustic monitoring, resistance board weirs, and hook and line sampling with the goals of establishing Sacramento River basin-wide adult abundance estimates for wild and hatchery origin *O. mykiss*, producing adult *O. mykiss* abundance estimates for select streams, and determining the spatial distribution of *O. mykiss* in the Central Valley. In addition, many population monitoring projects in priority streams outside of the CVSMP continue and in some cases have been expanded to encompass the entire *O. mykiss* immigration and spawning period.

2020 Gap Analysis

In the fall of 2020, a small group of state and federal scientists initiated a follow-up review from Eilers 2010. The primary purpose of this review is to identify where gaps in our monitoring network and approach have been filled and where gaps persist (i.e., '2020 gap analysis'). These gaps may represent physical monitoring elements like infrastructure (e.g., rotary screw traps [RST], PIT tag antennas), gaps in spatial or temporal scope of monitoring, and/or intellectual gaps (e.g., theoretical drivers of life-history expression). Identifying persistent gaps in our monitoring network will enable managers to optimize resource allocation, thus strengthening our system-wide *O. mykiss* research and monitoring program.

The 2020 gap analysis team contacted over 50 researchers with knowledge of *O. mykiss* research and monitoring that has been, or is currently being, implemented in over 30 Central Valley streams and rivers (Figure 1, Appendix A). This effort enabled the gap analysis team to characterize new *O. mykiss* monitoring in

Sacramento and San Joaquin tributaries (Appendix A), and initiate data compilation from Central Valley hatchery programs (Table 1) and ongoing monitoring programs (see example below). The majority of the new research and monitoring effort stems from the initiatives outlined in the CVSMP as described above. However, over the last decade new research and monitoring has been implemented or planned in several San Joaquin tributaries including the Calaveras and Stanislaus Rivers (Appendix A).

Table 1. California Central Valley hatchery trapping data gathered for 2020 *O. mykiss* gap analysis organized by Diversity Group and Johnson et al. 2017 regions (see maps below). The California Central Valley Steelhead Distinct Population Segment (DPS) includes steelhead from the Coleman National Fish Hatchery Program, the Feather River Fish Hatchery Program, and the Mokelumne River Hatchery Program.

Diversity Group/Region	Hatchery Name	Hatchery Location	Life stage	Duration
Southern Sierra Nevada	Mokelumne River Fish Hatchery	Lower Mokelumne River	Adult	1964-2001
Southern Sierra Nevada	Mokelumne River Fish Hatchery	Lower Mokelumne River	Juvenile & Adult	2002-present
American River Mainstem	Nimbus Fish Hatchery	Lower American River	Adult	1955-1986
American River Mainstem	Nimbus Fish Hatchery	Lower American River	Juvenile & Adult	1986-present
Feather River Mainstem	Feather River Fish Hatchery	Lower Feather River	Adult	1968-1999
Feather River Mainstem	Feather River Fish Hatchery	Lower Feather River	Juvenile & Adult	2000-present
Basalt and Porous Lava	Coleman National Fish Hatchery	Battle Creek	Adult	1990-present

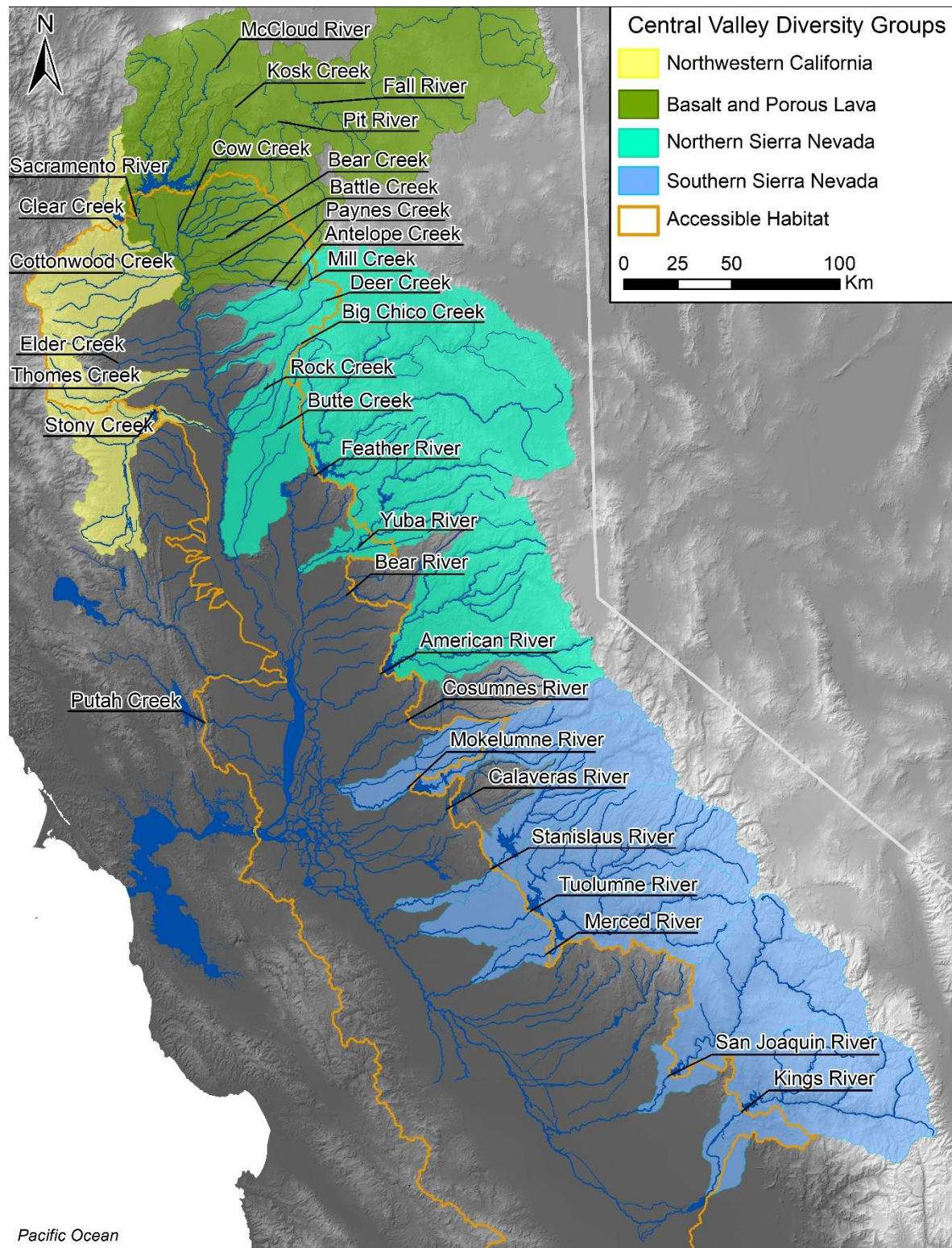


Figure 1. Map illustrating the location of target watersheds in the 2020 gap analysis and distribution within Central Valley diversity groups. For a complete list of watersheds and monitoring activities see Appendix A.

Knowledge Gaps and Next Steps

Although progress has been made towards coordinating Central Valley *O. mykiss* research and monitoring, our ability to quantify demographics and vital rates, or generate a steelhead juvenile production estimate remains limited. Current monitoring efforts are skewed towards watersheds in the Northern Sierra Nevada, and Basalt and Porous Lava Diversity Groups (Figure 1, Appendix A). Although there are new monitoring efforts underway in the San Joaquin Basin and Southern Sierra Nevada Diversity Group, these programs have been developed and implemented independent of one another. Further, the data generated from these programs is often difficult to access by the public and/or is unavailable. As such, there is a clear need to develop a plan for coordinating *O. mykiss* research and monitoring in this region and integrating the data they generate.

Preliminary Analysis

Integrating *O. mykiss* monitoring datasets across regions and programs will foster and accelerate learning opportunities. For example, the 2020 gap analysis provided an opportunity to compile and conduct preliminary analyses on monitoring data from the U.S. Fish and Wildlife Service Delta Juvenile Fish Monitoring Program (DJFMP). These survey data were used to assess the seasonal presence of *O. mykiss* in the Bay-Delta. In this example, the likelihood of *O. mykiss* presence in the DJFMP surveys was compared over space and time (Figure 2). Likelihood of presence is defined here as the proportion of years in which a survey caught *O. mykiss* in a given month. Data were compared before and after the implementation of 100% hatchery marking in 1998. Collectively, *O. mykiss* are most likely present in the Delta from January through May and least likely present from July through December (especially after 1998). While these data have had minimal processing (i.e., no efficiency work has been conducted with *O. mykiss*), interesting spatial patterns emerge. For instance, we see a protracted presence of *O. mykiss* in the northern and central Delta (Sacramento and Chipps Island trawls, and Lower Sacramento, Northern Delta, and Southern Delta seine regions) where there have been individuals caught almost year-round. Compare this to the southern Delta and San Joaquin River where *O. mykiss* were observed mainly from March through May with very low presence surrounding those months. Since 1998, these surveys have remained relatively consistent with year-round sampling, so differences in presence observed in Figure 2 are not a result of differences in sampling schedules. However before implementing year-round sampling in the mid-1990s (except at the Mossdale trawl site, which started in 2003), interpreting the likelihood of *O. mykiss* presence outside of the Chinook migratory season should be done with caution. An

interesting extension to this work would be to compare the temporal presence of *O. mykiss* along the migratory pathways. Differences between the Sacramento and San Joaquin River basins should be evident and could help elucidate important drivers of *O. mykiss* outmigration in the Central Valley using more appropriate analytical techniques that account for detection, such as occupancy modeling.

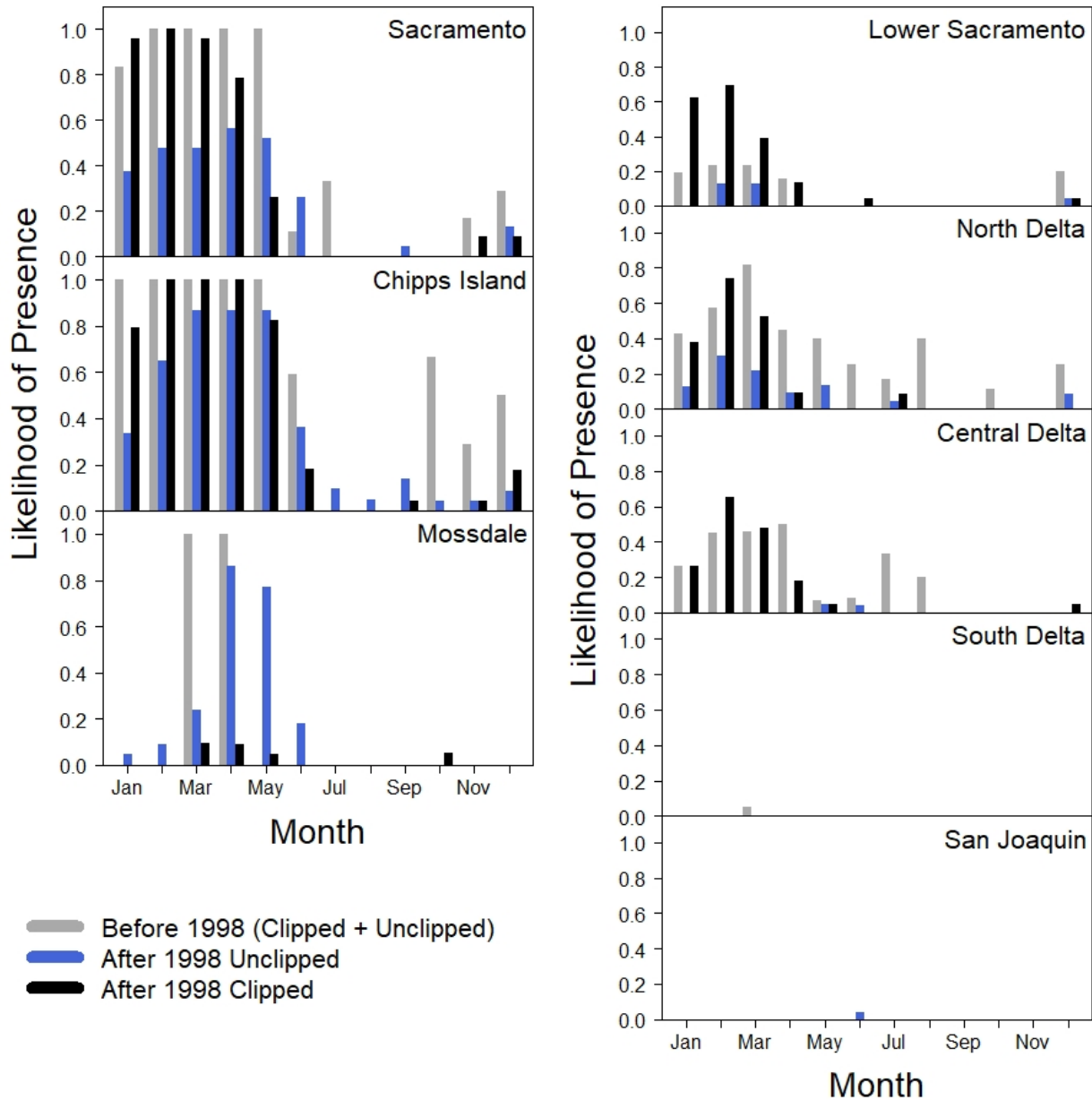


Figure 2. Likelihood of *O. mykiss* presence in the DJFMP surveys before and after implementation of 100% marking of hatchery releases in 1998. Sample stations are ordered from north to south, left panels are trawl locations and right panels are beach seine regions. Likelihood of presence is defined here as the proportion of

years in which a survey caught *O. mykiss* in a given month. Please note that in years before 1998 surveys were often not conducted year-round (see Table and text).

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Appendices

Appendix A. Preliminary compilation of sampling efforts identified during the 2020 *O. mykiss* gap analysis. The table is organized by NOAA Diversity Group and Johnson et al. 2017 regions for the mainstem Sacramento River. Note the NMFS 2014 Recovery Plan sometimes lists Mokelumne River in the Northern Sierra Nevada diversity group, but it is considered to be in the Southern Sierra Nevada Diversity Group.

Diversity Group/Region	Location	Core Population	Life stage	Sampling Method	Years
Southern Sierra Nevada	Calaveras River	Core 1	Juvenile & Subadult	Rotary Screw Trap	2002 – present
Southern Sierra Nevada	Calaveras River	Core 1	Adult	Video	2017 – present
Southern Sierra Nevada	Calaveras River	Core 1	Adult	Redd Surveys	2014 – present
Southern Sierra Nevada	Calaveras River	Core 1	Juvenile & Adult	Snorkel Surveys	2011 – present
Southern Sierra Nevada	Calaveras River	Core 1	Juvenile & Subadult	Angling (Hook & Line)	2019 – present
Southern Sierra Nevada	Calaveras River	Core 1	Juvenile & Subadult	Backpack Electrofishing	2019 – present

Diversity Group/Region	Location	Core Population	Life stage	Sampling Method	Years
Southern Sierra Nevada	Calaveras River	Core 1	Juvenile & Subadult	Seine	2019 – present
Southern Sierra Nevada	Tuolumne River	Core 2	Juvenile & Adult	Seine	1986 – present
Southern Sierra Nevada	Tuolumne River	Core 2	Juvenile & Adult	Rotary Screw Trap	1995 – present
Southern Sierra Nevada	Tuolumne River	Core 2	Juvenile & Adult	Weir	2009 – present
Southern Sierra Nevada	Tuolumne River	Core 2	Juvenile & Adult	Redd Survey	2012 – present
Southern Sierra Nevada	Tuolumne River	Core 2	Juvenile & Adult	Snorkel Survey	1982 – present
Southern Sierra Nevada	Stanislaus River	Core 2	Juvenile	Rotary Screw Trap	1993, 1995, 1996, 1998 – present
Southern Sierra Nevada	Stanislaus River	Core 2	Juvenile & Adult	Weir	2003 – present
Southern Sierra Nevada	Stanislaus River	Core 2	Juvenile & Adult	Snorkel Surveys	2002 – present
Southern Sierra Nevada	Merced River	Core 2	Juvenile & Adult	Snorkel Survey	2014 – 2015
Southern Sierra Nevada	Merced River	Core 2	Juvenile	Weir	2012
Southern Sierra Nevada	Merced River	Core 2	Juvenile	Rotary Screw Trap	1999 – 2006
San Joaquin River	Mossdale	NA	Juvenile	Trawl	1988 – present

Diversity Group/Region	Location	Core Population	Life stage	Sampling Method	Years
San Joaquin River	upstream of Merced River Confluence	NA	Adult	Electrofishing	2012 – 2014, 2017 – 2020
San Joaquin River	upstream of Merced River Confluence	NA	Adult	Fyke Trap	2012 – 2014, 2017 – 2020
Tidal Delta, Estuary & Bays	Napa River	NA	Juvenile	Rotary Screw Trap	2009 – present
Tidal Delta, Estuary & Bays	Napa River	NA	Juvenile	PIT Tagging	2013 – present
Tidal Delta, Estuary & Bays	Alameda Creek	NA	Adult	Redd Survey	2000 – present
Tidal Delta, Estuary & Bays	Alameda Creek	NA	Juvenile	Rotary Screw Trap	2013 – present
Tidal Delta, Estuary & Bays	Alameda Creek	NA	Juvenile & Adult	Fyke Trap	2013 – present
Tidal Delta, Estuary & Bays	Alameda Creek	NA	Juvenile & Adult	Snorkel Survey	2000 – present
Tidal Delta, Estuary & Bays	Alameda Creek	NA	Juvenile & Adult	Electrofishing	2000 – present

Diversity Group/Region	Location	Core Population	Life stage	Sampling Method	Years
Tidal Delta, Estuary & Bays	Alameda Creek	NA	Juvenile & Adult	PIT Tagging	2013 – present
Tidal Delta, Estuary & Bays	Alameda Creek	NA	Juvenile & Adult	Scale & Tissue Sampling	2002, 2004 – present
Tidal Delta, Estuary & Bays	Alameda Creek	NA	Adult	Mark Recapture	2003, 2009, 2018
Tidal Delta, Estuary & Bays	Alameda Creek	NA	Juvenile & Adult	Predation	2004, 2005
Tidal Delta, Estuary & Bays	Suisun Creek	NA	Juvenile & Adult	Electrofishing	1999 – 2001, 2016 – 2020
Northwestern California	Putah Creek	Core 2	Juvenile & Adult	Snorkel Survey	2016, 2018, 2020
Northwestern California	Putah Creek	Core 2	Juvenile & Adult	Electrofishing	1991, 1993 – 2000, 2001 – 2008, 2010 – 2020
Northwestern California	Putah Creek	Core 2	Juvenile & Adult	Rotary Screw Trap	2016 – 2019
Northwestern California	Putah Creek	Core 2	Juvenile	Fyke Trap	2020

Diversity Group/Region	Location	Core Population	Life stage	Sampling Method	Years
Tidal Delta, Estuary & Bays	Yolo Bypass	NA	Juvenile	Rotary Screw Trap	1998 – present
Tidal Delta, Estuary & Bays	Yolo Bypass	NA	Juvenile	Beach Seine	1998 – present
Tidal Delta, Estuary & Bays	Yolo Bypass	NA	Adult	Fyke Trap	1998 – present
Tidal Delta, Estuary & Bays	Green Valley Creek	NA	Juvenile & Adult	Electrofishing	1999 – 2001, 2016 – 2020
Tidal Delta, Estuary & Bays	San Leandro Creek	NA	Juvenile	TBD	TBD
Tidal Delta, Estuary & Bays	Delta	NA	Juvenile	Beach Seine	1976 – present
Tidal Delta, Estuary & Bays	Chippis Island	NA	Juvenile	Trawl	1976 – present
Tidal Delta, Estuary & Bays	Sherwood Harbor	NA	Juvenile	Trawl	1988 – present
Tidal Delta, Estuary & Bays	Delta	NA	Juvenile	Acoustic Telemetry	2010 – 2016
Tidal Delta, Estuary & Bays	Delta	NA	Juvenile	Electrofishing	2017 – present

Diversity Group/Region	Location	Core Population	Life stage	Sampling Method	Years
Tidal Delta, Estuary & Bays	Delta	NA	Juvenile	Trawl (Enhanced Delta Smelt Monitoring)	2016 – present
Tidal Delta, Estuary & Bays	Suisun Marsh	NA	TBD	TBD	TBD
Tidal Delta, Estuary & Bays	Cache-Lindsey Complex	NA	Juvenile	Electrofishing	TBD
Middle Sacramento River	GCID	NA	Juvenile	Rotary Screw Trap	2013 – present
Middle Sacramento River	Knight's Landing	NA	Juvenile	Rotary Screw Trap	1996 – present
Middle Sacramento River	Tisdale Weir	NA	Juvenile	Rotary Screw Trap	2010 – 2018
Middle Sacramento River	Tisdale Bypass	NA	Juvenile & Adult	Fish Rescue	2016 – present
Basalt and Porous Lava	Bear Creek	NA	Adult	Video	2016 – present
Basalt and Porous Lava	Cow Creek	Core 2	Adult	Video	2011 – present
Basalt and Porous Lava	Red Bluff Diversion Dam	NA	Juvenile	Rotary Screw Trap	1994 – present

Diversity Group/Region	Location	Core Population	Life stage	Sampling Method	Years
Northern Sierra Nevada	Antelope Creek	Core 1	Adult	Redd Survey	2012, 2017, 2018
Northern Sierra Nevada	Antelope Creek	Core 1	Adult	Video	2013 – 2015
Northern Sierra Nevada	Mill Creek	Core 1	Adult	Video	2008 – present
Northern Sierra Nevada	Mill Creek	Core 1	Juvenile	Rotary Screw Trap	1994 – present
Northern Sierra Nevada	Deer Creek	Core 1	Adult	Video	2014 – present
Northern Sierra Nevada	Deer Creek	Core 1	Juvenile	Rotary Screw Trap	1994 – present
Northern Sierra Nevada	Butte Creek	Core 2	Adult	Vaki	2014 – 2016, 2019 – present
Northern Sierra Nevada	Butte Creek	Core 2	Juvenile	Rotary Screw Trap	1995 – present
Northern Sierra Nevada	Butte Creek	Core 2	Juvenile	Fyke Trap	1995 – present
Northern Sierra Nevada	Big Chico Creek	Core 2	Juvenile	Rotary Screw Trap	1995 – 2006
Northern Sierra Nevada	Big Chico Creek	Core 2	Juvenile	Fyke Trap	1995 – 2006
Northern Sierra Nevada	Yuba River	Core 2	Adult	Vaki	2003 – present
Northern Sierra Nevada	Yuba River	Core 2	Adult	Redd Survey	2008 – present

Diversity Group/Region	Location	Core Population	Life stage	Sampling Method	Years
Northern Sierra Nevada	Yuba River	Core 2	Juvenile	Rotary Screw Trap	1999 – present
Southern Sierra Nevada	Mokelumne River	Core 2	Adult	Video	1991 – present
Southern Sierra Nevada	Mokelumne River	Core 2	Adult	Redd Survey	1994 – present
Southern Sierra Nevada	Mokelumne River	Core 2	Juvenile	Rotary Screw Trap & Bypass trap	1991 – present
Southern Sierra Nevada	Mokelumne River	Core 2	Juvenile & Adult	Electrofishing	1997 – 2016
Southern Sierra Nevada	Mokelumne River	Core 2	Juvenile	Beach Seine	1997 – 2016
Northern Sierra Nevada	Bear River	Core 3	TBD	TBD	TBD
Northern Sierra Nevada	Feather River	Core 2	Juvenile	Rotary Screw Trap	1996 – present
Northern Sierra Nevada	Feather River	Core 2	Juvenile	Beach Seine	1999 - 2001, 2008 - 2019
Northern Sierra Nevada	Feather River	Core 2	Juvenile	Electrofishing	2000 – 2001, 2020
Northern Sierra Nevada	Feather River	Core 2	Juvenile & Adult	Snorkel Survey	1998 – present
Northern Sierra Nevada	Feather River	Core 2	Adult	Redd Survey	2003, 2005, 2008 – present

Diversity Group/Region	Location	Core Population	Life stage	Sampling Method	Years
Northern Sierra Nevada	Feather River	Core 2	Juvenile & Adult	Tissue Collection	TBD
Northern Sierra Nevada	Feather River	Core 2	Juvenile & Adult	Angling (Hook & Line)	2016 – present
Northern Sierra Nevada	Feather River	Core 2	Juvenile & Adult	Telemetry	2010 – 2015, 2016 – 2019, 2020 – Present
Northern Sierra Nevada	Feather River	Core 2	Juvenile & Adult	PIT Tagging	2009 – 2011, 2014, 2015, 2016 – present
Northern Sierra Nevada	Feather River	Core 2	Juvenile	Fish Rescue	2000 – 2007, 2013 – 2014, 2017
Northern Sierra Nevada	American River	Core 2	Adults	Redd Survey	2002 – 2005, 2007, 2009 – present
Northern Sierra Nevada	American River	Core 2	Juvenile	Rotary Screw Trap	1992 – present
Northwestern California	Clear Creek	Core 1	Adult	Video	2011 – present
Northwestern California	Clear Creek	Core 1	Adult	Redd Survey	2003 – present

Diversity Group/Region	Location	Core Population	Life stage	Sampling Method	Years
Northwestern California	Clear Creek	Core 1	Juvenile	Rotary Screw Trap	1998 – present
Northwestern California	Cottonwood Creek	Core 2	Adult	Video	2012 – present
Basalt and Porous Lava	McCloud River	NA	Juvenile & Adult	Angling (Hook & Line)	1998, 2013
Basalt and Porous Lava	McCloud River	NA	Juvenile & Adult	Weir Counts	1984 – 1987
Basalt and Porous Lava	McCloud River	NA	Juvenile & Adult	Creel Census	1981, 1982
Basalt and Porous Lava	McCloud River	NA	Juvenile & Adult	Angler Survey	1990 – present
Basalt and Porous Lava	Squaw Valley Creek	NA	Juvenile & Adult	Direct Observation	2013, 2014
Basalt and Porous Lava	Squaw Valley Creek	NA	Juvenile & Adult	Backpack Electrofishing	1986, 1990, 2002
Basalt and Porous Lava	Squaw Valley Creek	NA	Juvenile & Adult	Angling (Hook & Line)	2014
Basalt and Porous Lava	Pit River	NA	Juvenile & Adult	Angling (Hook & Line)	TBD
Basalt and Porous Lava	Pit River	NA	Juvenile & Adult	Angler Survey	1993 – present
Basalt and Porous Lava	Pit River	NA	Juvenile & Adult	Direct Observation	1993, 1995, 1997 – 1999, 2001, 2004, 2007 –

Diversity Group/Region	Location	Core Population	Life stage	Sampling Method	Years
					2010, 2012
Basalt and Porous Lava	Fall River	NA	Juvenile & Adult	Direct Observation	1993, 1995, 1997 – 1999, 2001, 2004, 2007 – 2010, 2012
Basalt and Porous Lava	Fall River	NA	Juvenile & Adult	Creel Census	1983, 1988, 1993, 2012
Basalt and Porous Lava	Fall River	NA	Juvenile & Adult	Boat Electrofishing	1980 – 1986, 1988, 1993
Basalt and Porous Lava	Fall River	NA	Juvenile & Adult	Angler Survey	2003 – present
Basalt and Porous Lava	Hat Creek	NA	Juvenile & Adult	Boat Electrofishing	1980 – 1984, 1988, 1991, 1993, 2012
Basalt and Porous Lava	Hat Creek	NA	Juvenile & Adult	Direct Observation	1993, 1995, 1997 – 1999, 2001,

Diversity Group/Region	Location	Core Population	Life stage	Sampling Method	Years
					2003 – 2012
Basalt and Porous Lava	Hat Creek	NA	Juvenile & Adult	Creel Census	1983, 1988, 1993, 2012
Basalt and Porous Lava	Hat Creek	NA	Juvenile & Adult	Angler Survey	1990 – present
Basalt and Porous Lava	Rock Creek	NA	Juvenile & Adult	Direct Observation	2013
Basalt and Porous Lava	Rock Creek	NA	Juvenile & Adult	Backpack Electrofishing	2018
Basalt and Porous Lava	Potem creek	NA	Juvenile & Adult	Backpack Electrofishing	2018
Basalt and Porous Lava	Kosk Creek	NA	Juvenile & Adult	Backpack Electrofishing	2018
Basalt and Porous Lava	Burney Creek	NA	Juvenile & Adult	Direct Observation	1985, 1994, 1995, 1996, 2006, 2015
Basalt and Porous Lava	Burney Creek	NA	Juvenile & Adult	Backpack Electrofishing	1985
Basalt and Porous Lava	Burney Creek	NA	Juvenile & Adult	Angler Survey	1996 – present
Basalt and Porous Lava	McGill creek	NA	Juvenile & Adult	Backpack Electrofishing	1981, 2018
Basalt and Porous Lava	Screwdriver Creek	NA	Juvenile & Adult	Backpack Electrofishing	2018

Diversity Group/Region	Location	Core Population	Life stage	Sampling Method	Years
Basalt and Porous Lava	Sacramento River (Shasta County)	Core 1	Juvenile & Adult	Direct Observation	1992 – 1999, 2007, 2008, 2018
Basalt and Porous Lava	Sacramento River (Shasta County)	Core 1	Juvenile & Adult	Boat Electrofishing	1980, 1993 – 1998
Basalt and Porous Lava	Sacramento River (Shasta County)	Core 1	Juvenile & Adult	Creel Census	1980, 1986, 1994 – 1997
Basalt and Porous Lava	Sacramento River (Shasta County)	Core 1	Juvenile & Adult	Angler Survey	1994 – present
Basalt and Porous Lava	Scott Camp Creek	NA	Juvenile & Adult	Backpack Electrofishing	2018
Basalt and Porous Lava	Campbell Creek	NA	Juvenile & Adult	Backpack Electrofishing	2018
Basalt and Porous Lava	Middle Salt Creek	NA	Juvenile & Adult	Backpack Electrofishing	2018
Basalt and Porous Lava	Dog Creek	NA	Juvenile & Adult	Backpack Electrofishing	2018
Basalt and Porous Lava	North Fork Slate Creek	NA	Juvenile & Adult	Backpack Electrofishing	2018
Basalt and Porous Lava	Castle Creek	NA	Juvenile & Adult	Backpack Electrofishing	2018
Basalt and Porous Lava	North, Mid & South	NA	Juvenile & Adult	Backpack Electrofishing	2018

Diversity Group/Region	Location	Core Population	Life stage	Sampling Method	Years
	Fork Sacramento River (Siskiyou County)				
Basalt and Porous Lava	Fawn Creek	NA	Juvenile & Adult	Backpack Electrofishing	2018
Basalt and Porous Lava	Gumboot Creek	NA	Juvenile & Adult	Backpack Electrofishing	2018
Basalt and Porous Lava	Soapstone Creek	NA	Juvenile & Adult	Backpack Electrofishing	2018
Basalt and Porous Lava	South Fork Slate Creek	NA	Juvenile & Adult	Backpack Electrofishing	2018
Basalt and Porous Lava	Castle Lake Creek	NA	Juvenile & Adult	Angling (Hook & Line)	1977
Basalt and Porous Lava	Castle Lake Creek	NA	Juvenile & Adult	Backpack Electrofishing	2018
Basalt and Porous Lava	Battle Creek	Core 1	Adult	Video & Sorting	1998 – present
Basalt and Porous Lava	Battle Creek	Core 1	Juvenile	Rotary Screw Trap	1998 – present