Fish Assemblage Inventory and Monitoring 2013–2014

Final Monitoring and Analysis Plan Report

SAN JOAQUIN RIVER
RESTORATION PROGRAM

January 2017

Fish Assemblage Inventory and Monitoring 2013–2014

SAN JOAQUIN RIVER
RESTORATION PROGRAM

January 2017

San Joaquin River Restoration Program: Fish Assemblage Inventory and Monitoring, 2013–2014

Prepared by:

Jarod Hutcherson[1], Shaun Root[1], Don Portz[1,3*], Crystal Castle[2], Jerrad Goodell[2,4], Michelle Workman[2,5], Charles Hueth[1], and Zachary Sutphin[1] .

[1] U.S. Bureau of Reclamation, Technical Science Center, Denver, CO 80225
[2] U.S. Fish and Wildlife Service, 850 S. Guild Ave, Suite 105, Lodi CA 95240
[3] Current address: U.S. Bureau of Reclamation, 2800 Cottage Way, Sacramento, CA 95825
[4] Current address: U.S. Bureau of Land Management, 170 South 500 East, Vernal, UT 84078
5 Current address: East Bay Municipal Utility District, 1 Winemasters Way, Lodi, CA 95240
* To whom correspondence should be addressed: dportz@usbr.gov

January 2017

EXECUTIVE SUMMARY

A primary goal of the San Joaquin River Restoration Program is to restore and maintain fish populations in "good condition" in the mainstem San Joaquin River below Friant Dam to the confluence with the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish. As a means to quantify success of any restoration effort, it is necessary to first define baseline biotic and abiotic conditions for post-treatment comparison. To quantify a baseline for fish assemblage and distribution, and develop standard procedures and methodology to support a long-term fish monitoring program, a Fish Assemblage Inventory and Monitoring Study (I&M) was conducted from 2012 to 2014. The I&M was an interagency effort (U.S. Fish and Wildlife Service and Bureau of Reclamation), and consisted of sampling up to 19 sites seasonally (October, January, March/April, June) within all reaches of the Restoration Area. A diverse multiple-method sampling approach was used to promote the capture of multiple species and life-stages among habitat types. Sampling methods included boat and backpack electrofishing, seining, and trammel netting. In addition, water quality (*i.e.*, dissolved oxygen, temperature, conductivity, and turbidity) was recorded during sampling occasions, and additional data were obtained from the California Data Exchange Center website from sensors within the Restoration Area. Results of fish sampling suggest native fish were generally more restricted in distribution than nonnative fish, and catch-per-unit-effort (CPUE) was lower, in most cases, for native fish than nonnative fish throughout all reaches. Water quality results indicate temperature, conductivity, and turbidity tend to increase upstream to downstream. While the current distribution and presence of species has been useful for restoration planning purposes, detecting moderate changes in CPUE in response to future restoration efforts, using the current data as a baseline, may prove difficult because of the level of measured uncertainty. Additionally, data were collected during drought years and may not accurately reflect fish assemblages across other conditions. Additional baseline sampling will be required to represent other water year types and to refine the sampling methods to minimize both potential bias and uncertainty.

The preferred citation for this report is:

Hutcherson, J., S. Root D. Portz, C. Castle, J. Goodell, M. Workman, C. Hueth, and Z. Sutphin. 2017. Fish Assemblage Inventory and Monitoring 2013–2014. San Joaquin River Restoration Program, Final Monitoring and Analysis Plan Report. Bureau of Reclamation, Denver, Colorado.

TABLE OF CONTENTS

Page

Figures

Tables

1.0 INTRODUCTION

In 1988, a coalition of environmental groups, led by the Natural Resources Defense Council (NRDC), filed a lawsuit challenging the renewal of long-term water service contracts between the United States and the Central Valley Project Friant Division Long-Term Contractors. After more than 18 years of litigation of this lawsuit, known as NRDC *et al.* vs. Rodgers *et al.*, 2006, a settlement was reached. The stipulation of the Settlement establishes two primary goals: (1) Restoration – to restore and maintain fish populations in "good condition" in the mainstem San Joaquin River (SJR) below Friant Dam to the confluence of the Merced River (Restoration Area), including naturally reproducing and self-sustaining populations of salmon and other fish and (2) Water Management – to reduce or avoid adverse water supply impacts on all of the Friant Division long-term contractors that may result from the Interim and Restoration Flows provided for in the Settlement. To accomplish the Restoration Goal, the San Joaquin River Restoration Program (SJRRP) established a total of five population goals (SJRRP 2010), which included the establishment of a "balanced, integrated and adaptive community of fishes having a species composition and functional organization similar to what would be expected in the Sacramento-San Joaquin Province (Moyle 2002)."

Historically, the San Joaquin Province supported a total of 19 native fish species, including fall- and spring-run Chinook Salmon (*Oncorhynchus tshawytscha*; McBain and Trush 2002; Moyle 2002). However, approximately 42% (n=8) of these native species are considered uncommon, rare, or extirpated within the Restoration Area (SJRRP 2010). Increasing native fish imperilment has been attributed to dewatered stream reaches, altered flow and thermal regimes, channelization and levee development, poor water quality, artificial barriers, and the presence of non-native fish species (McBain and Trush 2002; Moyle 2002). As a result, the SJRRP is engaged in implementing a considerable amount of river restoration to re-establish the native fish assemblage(s) within the Restoration Area. Therefore, the SJRRP will need an understanding of the fish assemblage prior to restoration actions being implemented to determine their effectiveness and assess the achievement of the Restoration Goal over time.

Fishery and aquatic resource assessments were initially conducted by the California Department of Fish and Game (now California Department of Fish and Wildlife; CDFW) from 2003–05 to inventory the existing fish assemblage prior to the implementation of river restoration (CDFW 2007). Before restoration activities are implemented, additional studies using a more robust fish sampling effort across seasons and flow conditions to properly assess the fish assemblage are warranted. In general, standardized time-series data are critical for assessing management actions because fish assemblages may take several years to respond to such actions (Bonar *et al.* 2009). Likewise, natural temporal variation is frequently present in any system, increasing the need for such time-series data (Underwood 1992). To sample the entire fish assemblage in the Restoration Area, a variety of gear types may be used to maximize the capture efficiency among fish species, fish sizes, and habitats (Curry and Munkittrick 2005; Lavigne *et al.* 2008; Guy *et al.* 2009). Some common gear types used for river fish sampling include boat and backpack electrofishing, seining, trammel netting, gill netting, trawling, and snorkeling.

Standardized river sampling is often conducted on a reach scale, with reaches established to represent specific fish and habitat characteristics (Curry *et al.* 2009).

In 2012, the U.S. Bureau of Reclamation (USBR) and U.S. Fish & Wildlife Service (USFWS) developed a Fish Assemblage Inventory and Monitoring (I&M) study plan—an approach using common gear types to obtain baseline seasonal fish assemblage information within the five reaches of the Restoration Area. The approach was implemented, and sampling was conducted during two consecutive sampling seasons: 2012–13 (SJRRP 2013) and 2013–14. This report describes the methods and results for the second year of I&M efforts. As habitats are improved to meet the Restoration Goal, these data can be used to evaluate changes in the fish assemblage and inform management decisions regarding the restoration process.

2.0 METHODS

2.1 Study Area

The I&M sampling occurred throughout the Restoration Area from Friant Dam to the confluence of the San Joaquin and Merced rivers (~ 150 river miles [RM]). The Restoration Area was stratified into five reaches representing unique physical habitats (Figure 1; SJRRP 2010).

Figure 1.—Map of the San Joaquin River Restoration Area and associated Reaches. The area encompasses the San Joaquin River below Friant Dam to the confluence of the Merced River. The yellow circles identify the associated Restoration Reach, and the dashed lines identify the boundary between reaches.

Reach 1.—Friant Dam (~ RM 267.5) to Gravelly Ford (~ RM 228.9), subdivided into Reach 1A: Friant Dam to State Route (SR) 99 (~ RM 243.1) and Reach 1B: SR 99 to Gravelly Ford (Figures 2–3). In general, Reach 1A is characterized by a single channel, with cobble or bedrock substrate, perennial flow, with low conductivity, clear water flowing out of Millerton Lake. Major structures in this reach include rock weirs within Lost Lake Recreation Area (Fresno County), and several areas downstream where in-river or side channel habitat are affected by current or past mining operations. In Reach 1B, substrate changes from cobble and bedrock to sand. Like downstream stretches of Reach 1A, Reach 1B also contains in-river side channel habitat affected by mining operations (RM 234–232). Reach 1B is generally a single channel, though large, deep bodies of water are present where abandoned in-river mine pits exist.

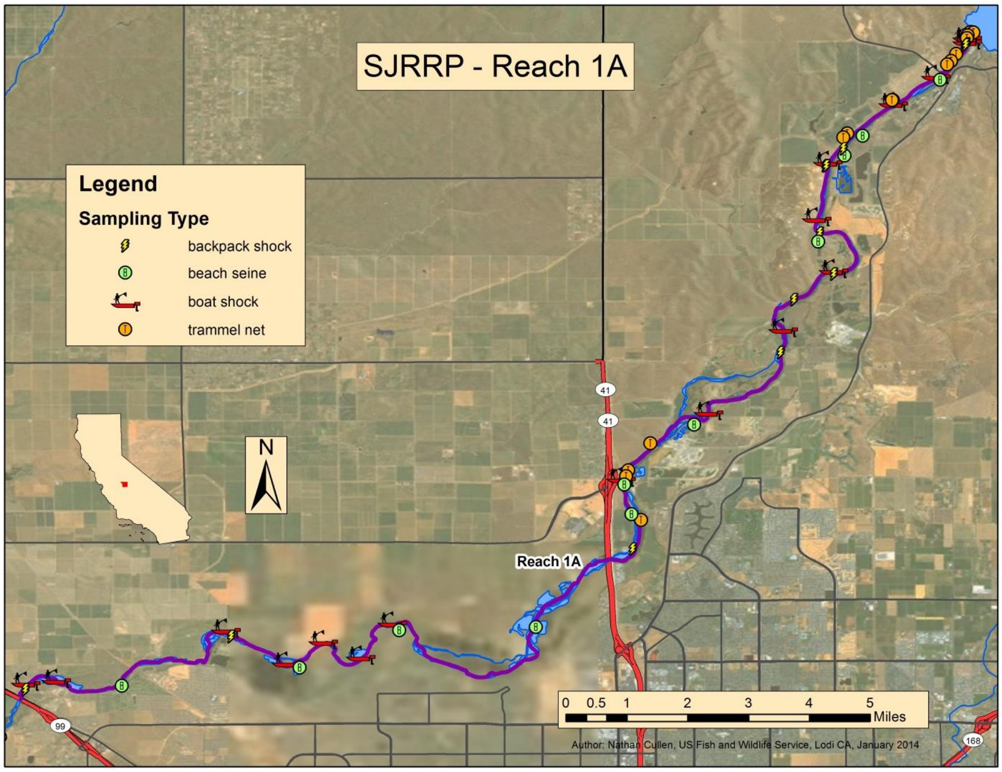

Figure 2.—Map of Reach 1A and associated sampling sites.

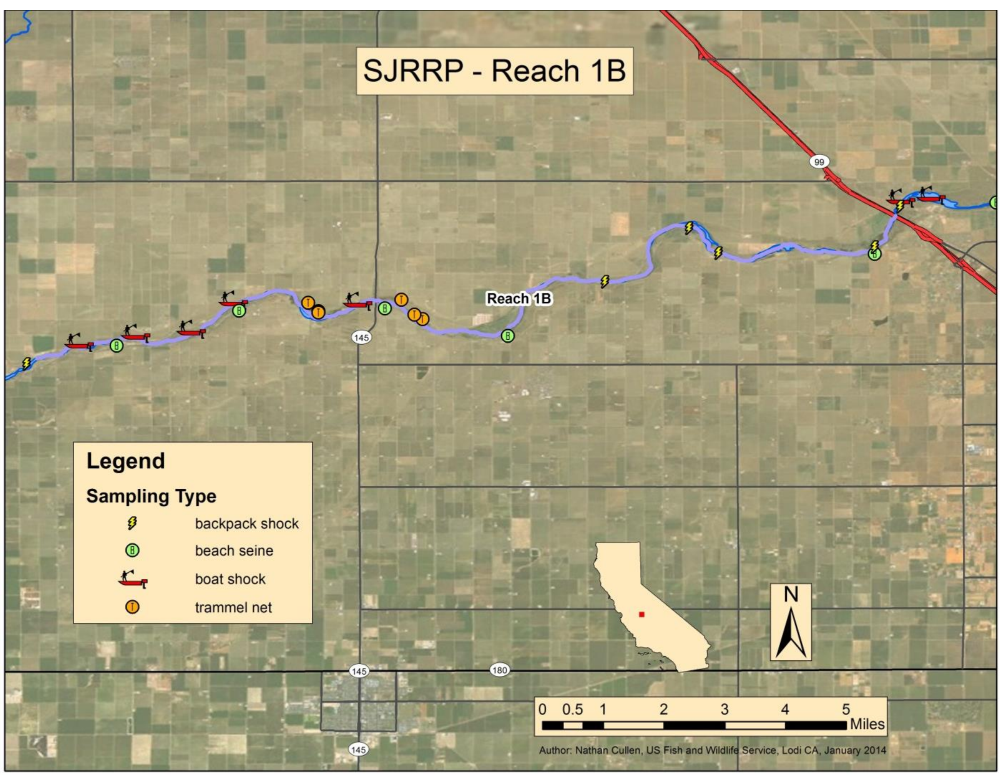

Figure 3.—Map of Reach 1B and associated sampling sites.

Reach 2.—Gravelly Ford (~ RM 228.9) to Mendota Dam (~ RM 204.7; Figure 4), subdivided into Reach 2A: Gravelly Ford to the Chowchilla Bypass Bifurcation Structure (~ RM 216) and Reach 2B: Chowchilla Bypass Bifurcation Structure to Mendota Dam (Figure 4). Reach 2 is generally a wide, shallow, braided channel with sandy substrate. Primary structures in Reach 2 include Chowchilla Bypass Bifurcation Structure, San Mateo Crossing, and Mendota Pool. Several water inputs and withdrawals are present in Mendota Pool, including Fresno Slough and the Delta-Mendota Canal. Towards Mendota Pool, riverbed material shifts from sand to fine sediments, and aquatic vegetation (*e.g.*, *Typha*) is more abundant.

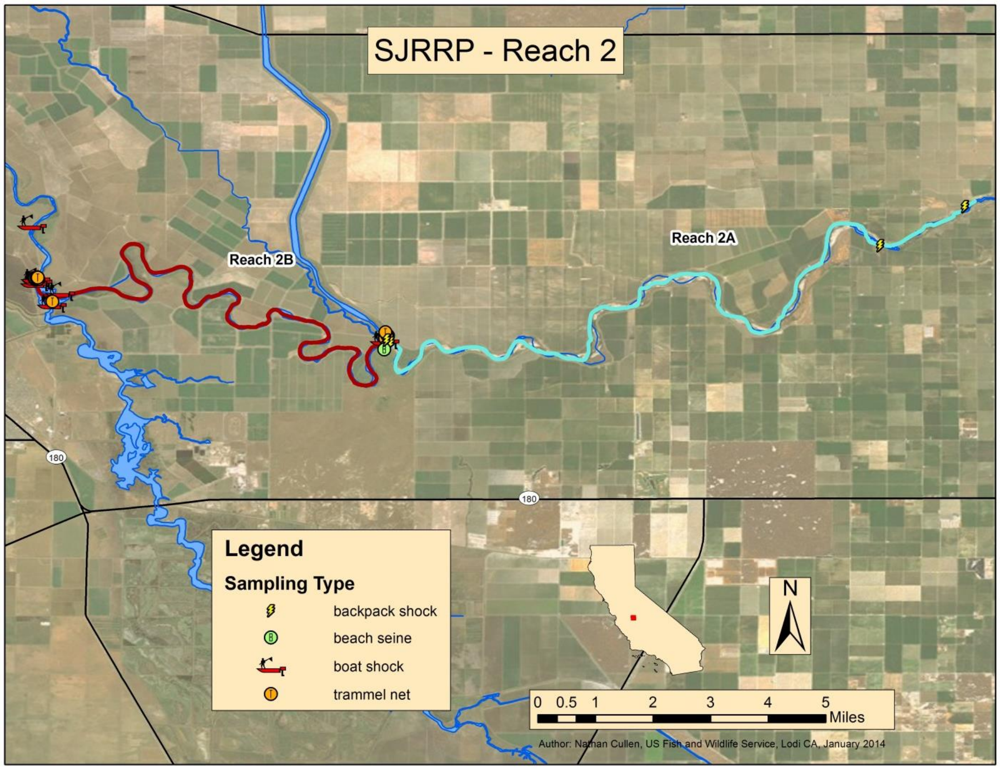

Figure 4.—Map of Reach 2 and associated sampling sites.

Reach 3.—Mendota Dam (~ RM 204.7) to Sack Dam (~ RM 182; Figure 5). Reach 3 is primarily a sandy bottomed, braided channel with limited streamside vegetation. Most of the river flows through agricultural land, except where it borders Firebaugh (~ RM 193–197). Sampling in this Reach was from below Mendota Dam to Firebaugh and at Sack Dam. At Sack Dam, water from the SJR was diverted into the Arroyo Canal during the sampling period.

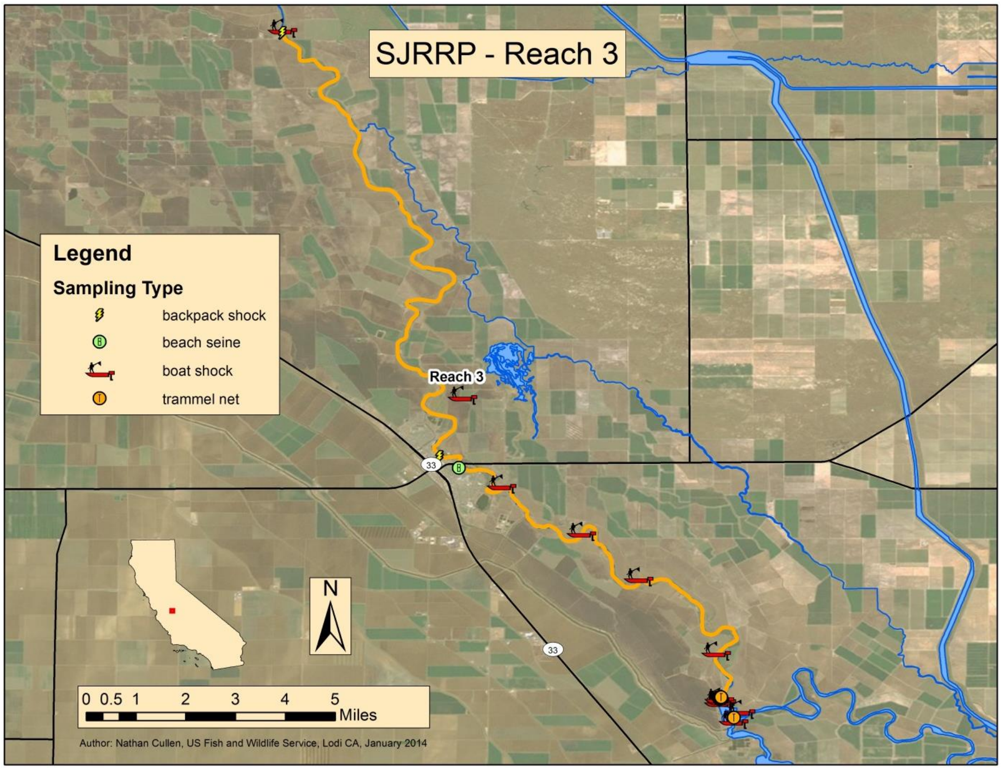

Figure 5.—Map of Reach 3 and associated sampling sites.

Reach 4.—Sack Dam (~ RM 182) to confluence with the Eastside Bypass (~ RM 135.8; Figure 6). Reach 4 is subdivided into three sections: Reach 4A, Reach 4B1, and Reach 4B2. Reach 4A extends from Sack Dam to the Sand Slough control structure. Reach 4B1 is from the Sand Slough control structure to the Mariposa Bypass, and Reach 4B2 extends from here to the confluence with the Eastside Bypass. Most of the upstream area of Reach 4 is bordered by agricultural land, though, downstream of RM 151 the SJR resides in the boundaries of San Luis National Wildlife Refuge. Reach 4 has no flow during most of the year because of the diversion in Reach 3 into the Arroyo Canal. Some water seepage occurred at Sack Dam, though waters in Reach 4 were generally limited to rainfall and agricultural return during 2013–14 sampling.

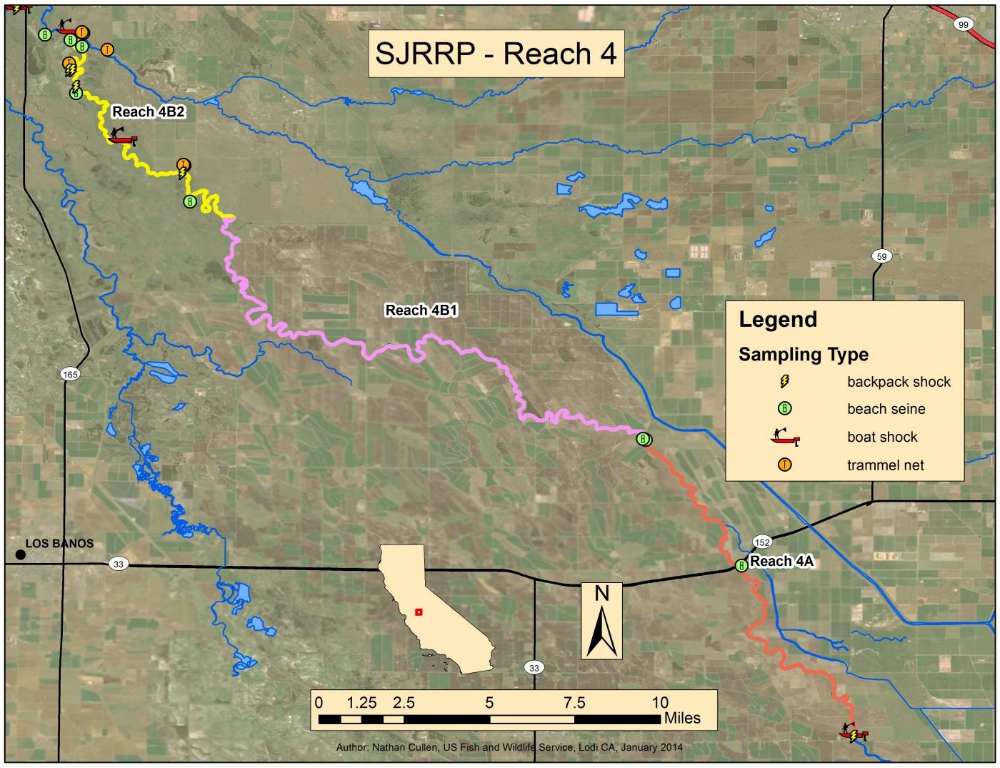

Figure 6.—Map of Reach 4 and associated sampling sites.

Reach 5.—Confluence with the Eastside Bypass (~ RM 135.8) to the confluence with the Merced River (~ RM 118; Figure 7). In addition to agriculture runoff from Reach 4, Reach 5 receives agriculture and refuge return flows through the Eastside Bypass and Mud and Salt sloughs. Reach 5 passes through San Luis National Wildlife Refuge, then through state land including Great Valley Grasslands State Park and Freemont Ford State Recreation Area.

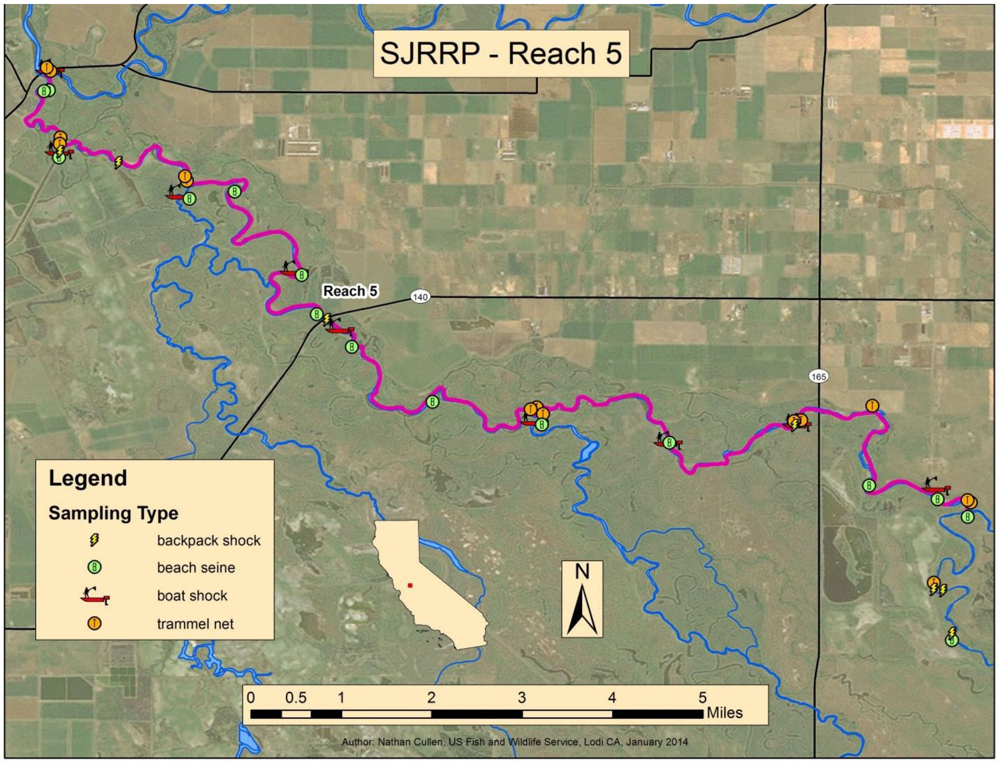

Figure 7.—Map of Reach 5 and associated sampling sites.

2.2 Site Selection

Fixed-point sample sites were qualitatively selected during June 2012 pilot data collection efforts. Site selection was largely driven by site access and landowner permission, though an emphasis was placed on site representation with respect to the habitats types in each reach (*e.g.*, riffle, run, glide, pool). Additionally, *a priori* knowledge of the river by field staff, and an understanding of the habitat types previously described (CDFW 2007) assisted in the non-randomized site selection within each reach. The number and distribution of sample sites varied among the reaches during the 2013–14 field season (Figures 2–7; Tables 1–4). Specifically, sampling sites were more highly concentrated in Reach 1 and 5 relative to other reaches. Sampling sites were greater in Reach 1 because this reach contained the most habitat diversity (*e.g.*, runs, riffles, pools, glides), whereas sites in Reach 5 were more abundant based on the presence of high variability with respect to water quality (*e.g.*, temperature, conductivity, turbidity; SJRRP 2013). However, Reach 5 sampling was limited in June 2014 because of the Critical Dry water year type resulting in a lack of water in this reach. Fewer sampling sites occurred in Reach 2 and 3, relative to Reach 1 and 5, because much of the riverine habitat was relatively uniform. Conversely, the number of sampling sites in Reach 4 was limited because of the lack of water resulting from river diversions into the Arroyo Canal at Sack Dam.

Table 1.—Total sample locations, by Restoration Reach, during raft electrofishing efforts in the San Joaquin River, CA, October 2013–June 2014.

Reach	Oct.	Jan.	Mar./Apr.	June
1A	16	18	17	17
1B	5	5	5	5
2	5	4	3	4
3	8	8	8	8
4	1	1	1	1
5	8	9	9	0
Total:	**43**	**45**	**43**	**35**

Table 2.—Total sample locations, by Restoration Reach, during backpack electrofishing efforts in the San Joaquin River, CA, October 2013–June 2014.

Reach	Oct.	Jan.	Mar./Apr.	June
1A	13	13	13	11
1B	5	6	4	2
2	4	4	3	4
3	1	1	1	1
4	2	2	4	2
5	4	4	4	2
Total:	**29**	**30**	**29**	**22**

Table 3.—Total sample locations, by Restoration Reach, during seining efforts in the San Joaquin River, CA, October 2013−June 2014.

Reach	Oct.	Jan.	Mar./Apr.	June
1A	11	11	11	11
1B	5	5	4	4
2	1	1	1	1
3	1	1	1	1
4	6	6	6	5
5	12	12	12	8
Total:	**36**	**36**	**35**	**30**

Table 4.—Total sample locations, by Restoration Reach, during trammel netting efforts in the San Joaquin River, CA, October 2013–June 2014.

Reach	Oct./Nov.	Jan.	Mar./Apr.	June
1A	14	14	14	14
1B	6	6	6	6
2	9	9	6	9
3	4	4	4	4
4	4	5	4	4
5	10	14	15	1
Total:	**47**	**52**	**49**	**38**

2.3 Sampling Methods

Several sampling methods were used during I&M sampling. Sampling methods were selected based on habitat type as well as availability of access for each sampling method. Electrofishing was conducted by boat and backpack. In addition, fish were actively collected by seining and passively collected with trammel nets. All sampling gears were deployed during daylight hours for safety reasons. Quarterly surveys using each of these gear types took place in October–November 2013, January 2014, March–April 2014, and June 2014. Sample sites were surveyed once during each quarter.

2.3.1 Raft Electrofishing

Raft electrofishing was selected to cover larger sections of river in a shorter duration than possible by other methods, and allowed sampling a variety of habitat types, as well as deeper and faster flowing waters where the use of other equipment (*e.g.*, seining, backpack electrofishing) was not practical. Also, raft electrofishing permitted sampling sections of river that were not accessible, either due to restricted landowner access or otherwise inaccessible by vehicle, preventing equipment transport to the river.

Personnel, consisting of an operator responsible for raft navigation and electrofishing controls, and two crew members responsible for fish collection, surveyed Restoration Reaches using a Smith-Root SR-17 electrofishing raft with a 5.0 GPP electrofisher (Smith-Root Inc., Vancouver, WA). The raft-mounted electrofishing unit automatically adjusts pulse width (1–6 ms) based on user specified inputs, including: voltage type (alternating current [AC]/direct current [DC]), output voltage (Low: AC/DC 50–500 volts [V], or High: 0–1000 V AC), percent of power output, and pulse frequency (pulses/second). The low range (0–500 V, pulsed DC) was almost always selected, though the high range was infrequently used in upstream reaches with low water conductivity (< 50 µS/cm; microSiemens/centimeter). Maximum current by the 5.0 GPP electrofisher is 16 amperes (A), but amperage was maintained 3–8 A during shocking activities.

Electrofishing transects were sampled for an average of 839 (standard deviation [SD] = 302) seconds; during a single downstream pass. While electrofishing, the operator typically directed the raft in a zig-zag pattern in an attempt to sample the thalweg and both shorelines. During electrofishing, power output (as a percentage of total output, as well as pulses/s) was adjusted based on observations of fish behavior and water conductivity. Optimal fish response was galvanotaxis towards the anode, as opposed to galvanonarcosis which could preclude collection in deep or turbid water and potentially increase injury to fish. During operation, as fish entered the netting perimeter of the raft, they were collected and placed in an onboard livewell. Start and end coordinates (Universal Transverse Mercator [UTM]) were recorded for each sampling transect using a handheld Global Positioning System (GPS) unit. The following electrofishing data were recorded: total shock time, current type (AC/DC), voltage range, percent output (0–100%), amperage, and pulse frequency. Additionally, water quality data were recorded for each sample transect, including: temperature (degrees Celsius [°C]), dissolved oxygen (DO; mg/L), and conductivity (µS/cm).

2.3.2 Backpack Electrofishing

Backpack electrofishing was selected for shallow, near-shore areas, particularly in areas too shallow or too vegetated for deploying trammel nets or seining, as well as higher velocity shallow areas (*i.e.*, riffles). A Smith-Root LR-24 backpack electrofisher was used in habitats with complex structure and shallow depths. In pool and glide habitats, electrofishing was conducted in an upstream direction with a netter following the shocker. In riffle habitats, a block net was set at the most downstream end of the habitat and electrofishing was conducted downstream into a block net. Single-pass pulsed-direct current was used at all sites. Amperage (0.1–3.5 A; range), frequency (30–50 Hz), duty cycle (15 percent), and voltage settings (75–475 V) were determined before starting and set at minimum power levels needed to induce galvanotaxis in fish. GPS location and the following site parameters were recorded: estimated cloud cover (percent), precipitation (presence/absence), wind, water velocity (m/s), and habitat type. Shock time and physical measurements, including transect length, width, and depth, were recorded. Additionally, water quality data were recorded for each sample transect, including: temperature (°C), DO (mg/L), and conductivity (µS/cm).

2.3.3 Seining

Beach seining was conducted in shallow, near-shore areas containing little current and devoid of snags. The benefit of seining is that a large area can be sampled within a short time period, and smaller fish, which electrofishing can bias against, are captured with a greater frequency (Wiley and Tsai 1983; Murphy and Willis 1996).

Beach seining was conducted using 15.2 m × 1.2 m (50 ft × 4 ft), 3.2mm (1/8 in) delta-mesh nets (knotless nylon netting; H. Christiansen Co., Duluth, MN). Seines were dyed green to reduce visibility to fish. Two people set the seine parallel to the shore, while attempting not to disturb the area to be sampled. If sampling flowing water, the seine was always deployed from the downstream end. The appropriate open width and distance from shore were determined by site conditions (*e.g.*, depth, debris, current). The seine was then continuously moved towards shore, keeping the lead line on the bottom. Once the seine net was pulled to shore, the net was removed from the water and fish collected. Markers were dropped where the edges of the seine met the shoreline, defining the close width of the sample. To determine sampling area, the distance the net was deployed from the bank (length), open (start) width, and close (end) width were measured (Figure 8). Starting depth and mid-seine depth were measured. End depth was always zero as the seine was pulled onto shore. Total volume sampled was calculated as the area of the trapezoid times the average of the three depth measurements. Site-specific data was recorded, similar to that of backpack shocking.

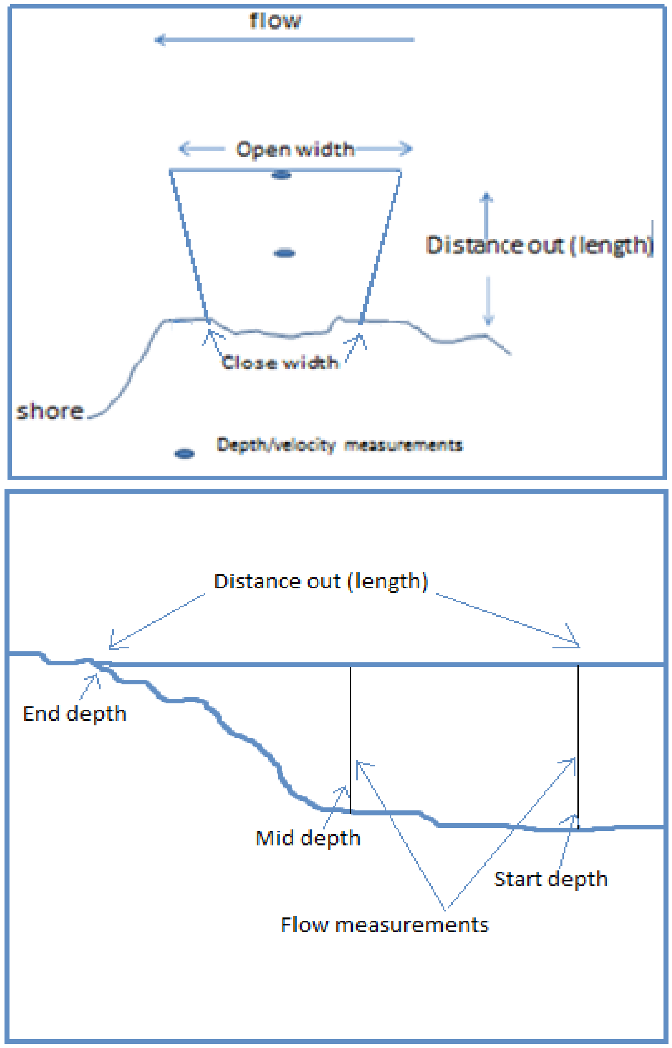

Figure 8.—Depiction of seine deployment and measured dimensions. The aerial view of the seining dimensions is presented on top; cross-sectional area on the bottom.

2.3.4 Trammel Netting

Trammel nets were typically deployed in pools or deeper areas that were not effectively sampled by raft electrofishing or other sampling methods. Trammel nets (H. Christiansen Co., Duluth, MN) were 11.4–30.5 m (37.5–100 ft.) long and 0.9–1.8 m (3–6 ft.) tall. The exterior mesh had 250 mm (10 in) spacing and the interior mesh had 25 mm (1 in) spacing. Trammel nets were generally deployed from watercraft (*i.e.*, Jon boat or kayak), in pools and glides (water generally greater than 1.2 m in depth), and often near structures (*e.g.*, rock weirs, dams, abandoned in-river gravel pits). Nets were either tied to overhanging vegetation near shore and extended into the sample area or suspended in the water column, extending upwards from the substrate with a series of buoys and weights. Net orientation, with respect to the flow varied across sites; however, individual nets were typically set in the same manner across sample seasons. Nets were retrieved the following day, with a nominal sample period of 24 h. Upon retrieval, fish were removed from the nets. Other details recorded included coordinates (UTM), net size, and total set duration from deployment to withdrawal. Because site locations and sampling time for trammel netting and raft electrofishing overlapped, water quality and weather conditions were comparable.

2.4 Fish Processing

Concluding each sampling period for each gear type, all fish captured were generally identified to species (in some instances, small fish or hybrids were identified only to genus), measured for fork length (FL) to the nearest mm, weighed (g), and returned to the river. Fish < 10 g or < 50 mm were generally not weighed because field conditions prevented accurate measurement with available equipment (*e.g.*, wind, excess water, accuracy of scale). When large numbers of fish were captured, a subset was measured and weighed and the remaining fish were enumerated—when an age class of any given species was present in higher numbers, measuring a subset of fish provided adequate data for statistical analysis while reducing holding time/stress of captured fish.

2.5 Data Analysis

2.5.1 Water Quality and Flow Data

To help provide a representation of water conditions, upstream to downstream in the SJR during sampling seasons, data were queried from the California Department of Water Resources' (DWR) Data Exchange Center (CDEC; http://cdec.water.ca.gov/index.html) and were combined with data collected during raft electrofishing events. This data was used to best represent the overall water quality conditions of the river, nearest the thalweg (as opposed to margin or off-channel habitat that may fluctuate to a greater extent). Only data collected in the mainstem SJR is presented. Some collection sites, for example, began in waterways that terminated in the mainstem but were not considered mainstem SJR (*e.g.*, Salt Slough, Mud Slough, Newman Wasteway); at other locations, marginal data not have been representative of the thalweg, and could potentially skew general trends from upstream to downstream. Flow data from the CDEC website were supplied via 13 sensors (3 DWR, 5 USBR, 4 US Geological Survey [USGS], and 1 jointly operated by DWR and USGS; Appendix A) in the Restoration Area. Temperature (°C), conductivity (µS/cm), and flow (cfs) were organized by river mile (RM) and are presented in the Results section. While dissolved oxygen (DO; mg/L) was collected during raft electrofishing, a faulty probe was later identified and, as a result, this data is not reported.

2.5.2 Fish Distribution and Catch per Unit Effort

Species detection was organized by Restoration Reach across all sampling methods in order to identify species distribution through the Restoration Area. In addition, age class of fish, by species, was also organized in a similar manner. Since little historical data is available regarding size classes of fish in the SJR Restoration Area, and fish growth can vary according region, age class was loosely based on maximum first-year growth of each species indicated in Moyle (2002). For those fish with short life spans (~ 1–2 yr) and maturing within the first year, size at spawning was used as the metric to separate age class.

Catch per unit effort (CPUE) was selected as an index of fish density to evaluate the variability in fish assemblage and occupancy over time and space. In addition, CPUE allows within-reach comparison, by sampling method, while accounting for the uneven distribution of sampling events (*e.g.*, varying electrofishing times between transects or net-set times), or size differences of nets or sample area.

Before CPUE was calculated, fish were grouped two ways: by native and nonnative species, and by family (*e.g.*, Catostomidae, Salmonidae, Moronidae). Furthermore, for family grouping, Centrarchidae were further divided into two subgroups: *Lepomis/Pomoxis* (sunfish/crappie) and *Micropterus* (black bass). Cyprinidae were subdivided into native (*e.g.*, Hitch, *Lavinia exilicauda*, Sacramento Pikeminnow, *Ptychocheilus grandis*) and nonnative (*e.g.*, Common Carp, *Cyprinus carpio*, Red Shiner, *Cyprinella lutrensis*) groups. Fish with few representative species were broadly grouped into an "Other" category. Fish in this category included Bigscale Logperch (*Percina macrolepida*), Inland Silverside (*Menidia beryllina*), Shimofuri Goby (*Tridentiger bifasciatus*), shad *spp.* (American Shad, *Alosa sapidissima*, and Threadfin Shad, *Dorosoma petenense*), and Western Mosquitofish (*Gambusia affinis*). Native and nonnative species distribution is presented in the Results; CPUE based on family groupings is presented in Appendix B.

Because inherent bias exists among sampling methods (Murphy and Willis 1996; Bonar et al. 2009) and capture efficiency may vary seasonally by species (Pope and Willis 1996), average CPUE was calculated among samples for each reach, method (*i.e.*, raft electrofishing, backpack electrofishing, seining, trammel netting), and season by $\frac{1}{n}\sum_{i=1}^{n} f(x)_{(\text{method})}$, where:

$f(x)_{\text{electrofishing}} = \frac{x_c}{t_i}$, where x_c = number of fish in group c (*e.g.*, family, native/nonnative fish), t = shock time (s) for transect i, and n = total shocking transects within the defined Restoration Reach. Units for CPUE are fish/minute shock time;

$f(x)_{\text{seining}} = \frac{x_c}{\text{m}_i^3}$, where x_c = number of fish captured in group c, m_i^3 = volume of water in sample i, and n = total seining events within the defined Restoration Reach. Units for CPUE are fish captured/m^3;

$f(x)_{\text{trammel net}} = (\frac{x_c/\text{m}_i^2}{t_n})$, where x_c = number of fish captured in group c, m_i^2 = area of the net used during net sampling event i, and n = total netting events within the defined Restoration Reach. Units for CPUE are reported as fish captured/m^2 (net area)/day

The primary assumptions of comparing the average CPUE values are that (1) the same fixed sites within a reach are sampled evenly across years and seasons, (2) methods do not vary at each site, (3) detection probabilities do not vary (*i.e.*, are constant) at each site, and (4) that sites sampled represent the entire reach.

3.0 RESULTS

3.1 Water Quality and Flow Data

During all sampling periods, except January, recorded river temperatures generally increased downstream through the Restoration Area (Figure 9). From Reach 3 downstream, temperatures regularly exceeded 20°C in all sample months except January 2014. The highest temperatures occurred in June 2014, with temperatures in Reach 5 peaking at ~27°C. Unlike the other sample periods, temperatures in January 2014 were generally similar throughout the Restoration Area (range of 4.4°C across all reaches). The greatest fluctuation in recorded temperatures occurred in June 2014 (12.6–27.2°C, range 14.6°C). Temperatures varied from 11.3–24.7°C in March/April 2014 (range 13.4°C) and temperatures varied from 12.5–21.3°C (range 8.8°C) in October 2013. Across all sampling periods, temperatures at Friant Dam were least variable (8.2–13.5°C, range 5.3°C), while temperatures in Reach 5, were most variable (9.1–27.2°C, range 18.1°C). Across all sample periods, conductivity increased upstream to downstream (Figure 10).

Across all sampling seasons, recorded flows generally decreased from Friant Dam to Sack Dam (Figure 11), where nearly all of the SJR was diverted into the Arroyo Canal. Conversely, recorded flows increased from Stevenson to the confluence with the Merced River, where agricultural water is returned to the river in Reach 5. In Reach 1–4, recorded flows were greatest in June 2014 and lowest in April 2014. Flows in Reach 5 were similar across all sampling seasons, except for June 2014. In June, flows were low, and in-river sensors were no longer accurately recording.

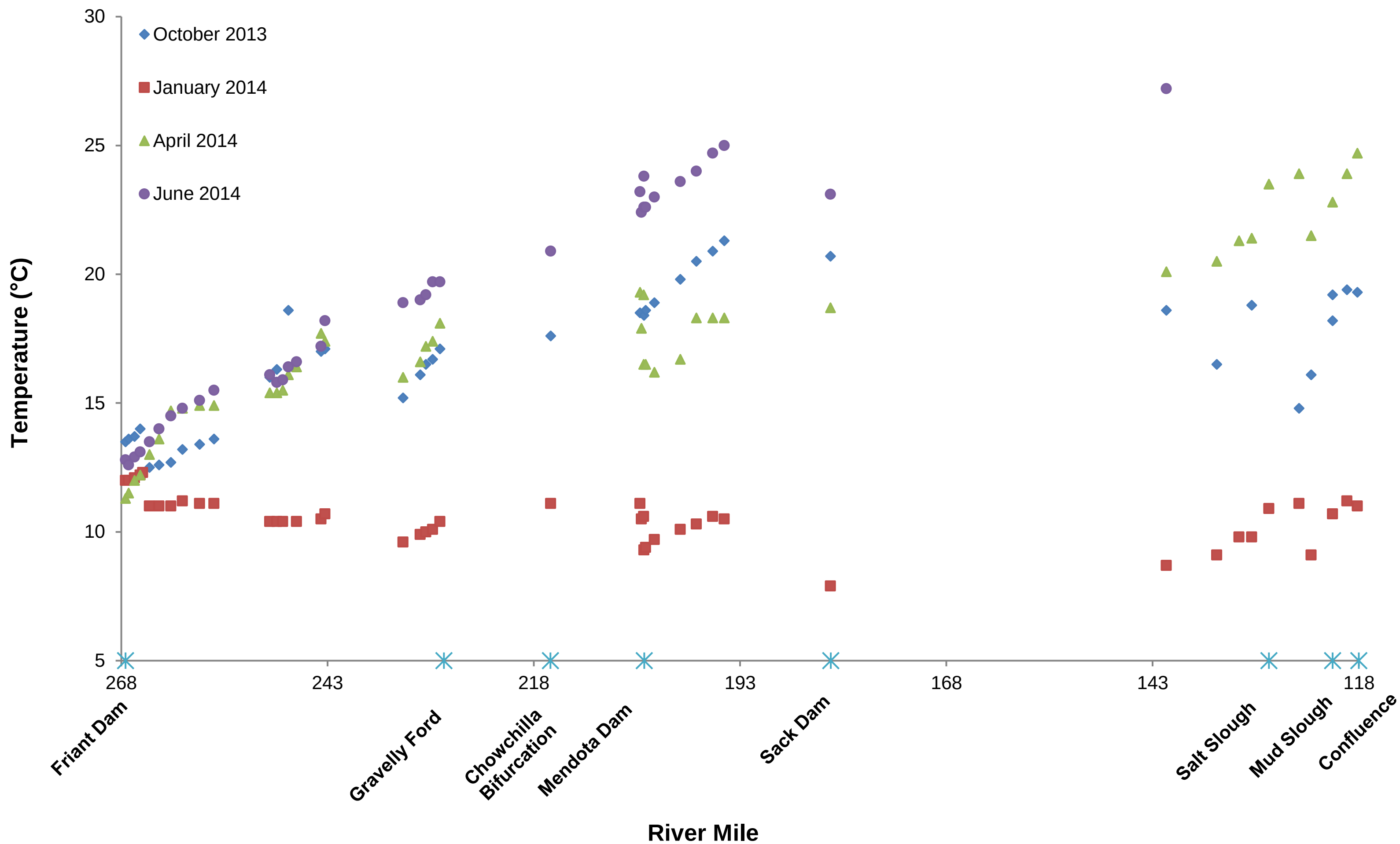

Figure 9.—Water temperature (°C) in the San Joaquin River during raft electrofishing efforts during October 2013, January, April, and June 2014. "X" markers on x-axis denote locations and description, respective to river mile, of structures or features in the Restoration Area.

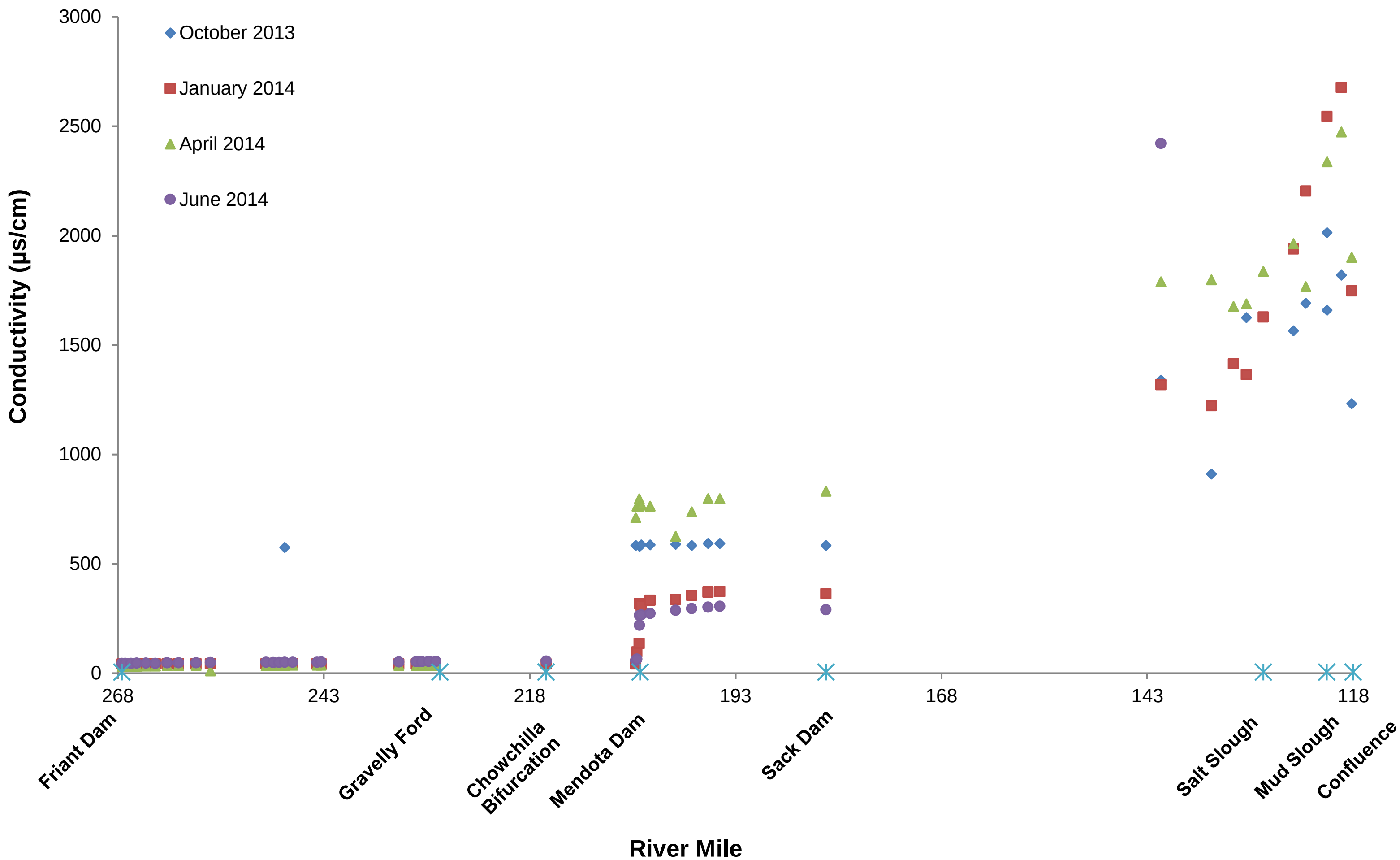

Figure 10.—Conductivity (µS/cm) in the San Joaquin River during raft electrofishing efforts during October 2013, January, April, and June 2014. "X" markers on x-axis denote locations and description, respective to river mile, of structures or features in the Restoration Area.

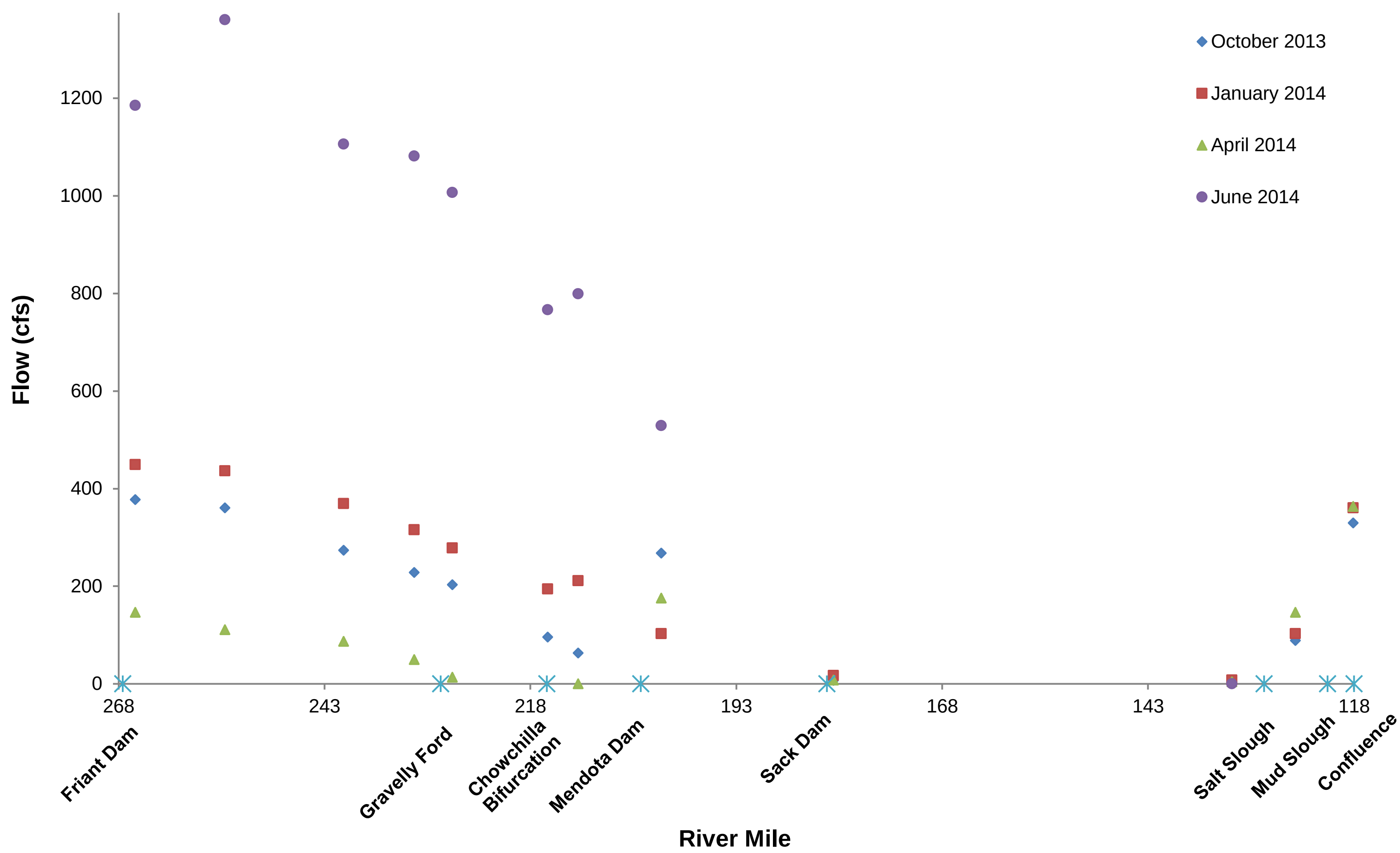

Figure 11.—Average daily flow (CFS) in San Joaquin River (SJR) during Inventory and Monitoring surveys in October 2013, January, April, and June 2014. Daily averages calculated from 15-min interval values recorded at thirteen sensors in SJR, maintained by California Department of Water Resources, U.S. Geological Survey, and Bureau of Reclamation. "X" markers on x-axis denote locations and description, respective to river mile, of structures or features in the Restoration Area.

3.2 Fish Distribution and Catch per Unit Effort

Across the four sampling methods, 26,597 fish were captured in the 2013–14 field season, comprising 37 species (Table 5). The size distribution of the fish, captured by method, suggests that the methods used did capture fish across a variety of size and age classes (Figure 12). Of the 37 species of fish captured, 12 were native (Appendix C). Generally, native fish occurred most frequently in upstream reaches, while nonnative fish were more frequently encountered in downstream reaches. Specifically, lamprey (*Lampetra spp.*), Rainbow Trout (*Oncorhynchus mykiss*), Sacramento Pikeminnow, and Threespine Stickleback (*Gasterosteus aculeatus*) were exclusively found in Reach 1. Prickly Sculpin (*Cottus asper*) were found from Reach 1A to Reach 4. Sacramento Sucker (*Catostomus occidentalis*) were found in all reaches, during at least one of the sampling efforts from October 2013–June 2014. Hitch occurred in Reach 2, 3, and 5. Sacramento Blackfish (*Orthodon microlepidotus*) were captured in Reach 3–5. Tule Perch (*Hysterocarpus traskii*), were captured in Reach 3. Unlike the 2012–13 sampling season, no Sacramento Splittail (*Pogonichthys macrolepidotus*) were captured during 2013–14 survey efforts.

At least one species from the following families was found in Reach 1–5: Centrarchidae (including *Lepomis*, *Micropterus*, and *Pomoxis spp.*), Ictaluridae, non-native Cyprinidae, and Poeciliidae (mosquitofish). Striped Bass (*Morone saxatilis*) and Bigscale Logperch were found in Reach 3–5. Inland Silverside were found in Reach 2, 4, and 5. Shad were found in Reach 2, 4, and 5. A Shimofuri Goby was found in Reach 3 and 4. With regards to age class distribution, native fish distribution of age-0 and age-1+ was more restricted. While several species of non-native fish were present as both age-0/1+ (*i.e.*, Bluegill, Largemouth Bass, Mosquitofish, Redear Sunfish, and Spotted Bass) across all five Restoration Reaches, only Prickly Sculpin were found in more than two Restoration Reaches. Several native species were only encountered as age-1+: Hitch, Sacramento Blackfish, and Tule Perch.

In general, native fish CPUE decreased downstream through the Restoration Area for all methods (Figures 13–16). Conversely, nonnative fish CPUE increased from upstream to downstream. In a similar manner, nonnative fish CPUE in downstream reaches was generally greater than native fish CPUE in upstream reaches. This suggests a higher rate of capture/encounter for nonnative fish than native fish. There were no apparent seasonal differences in CPUE in the data.

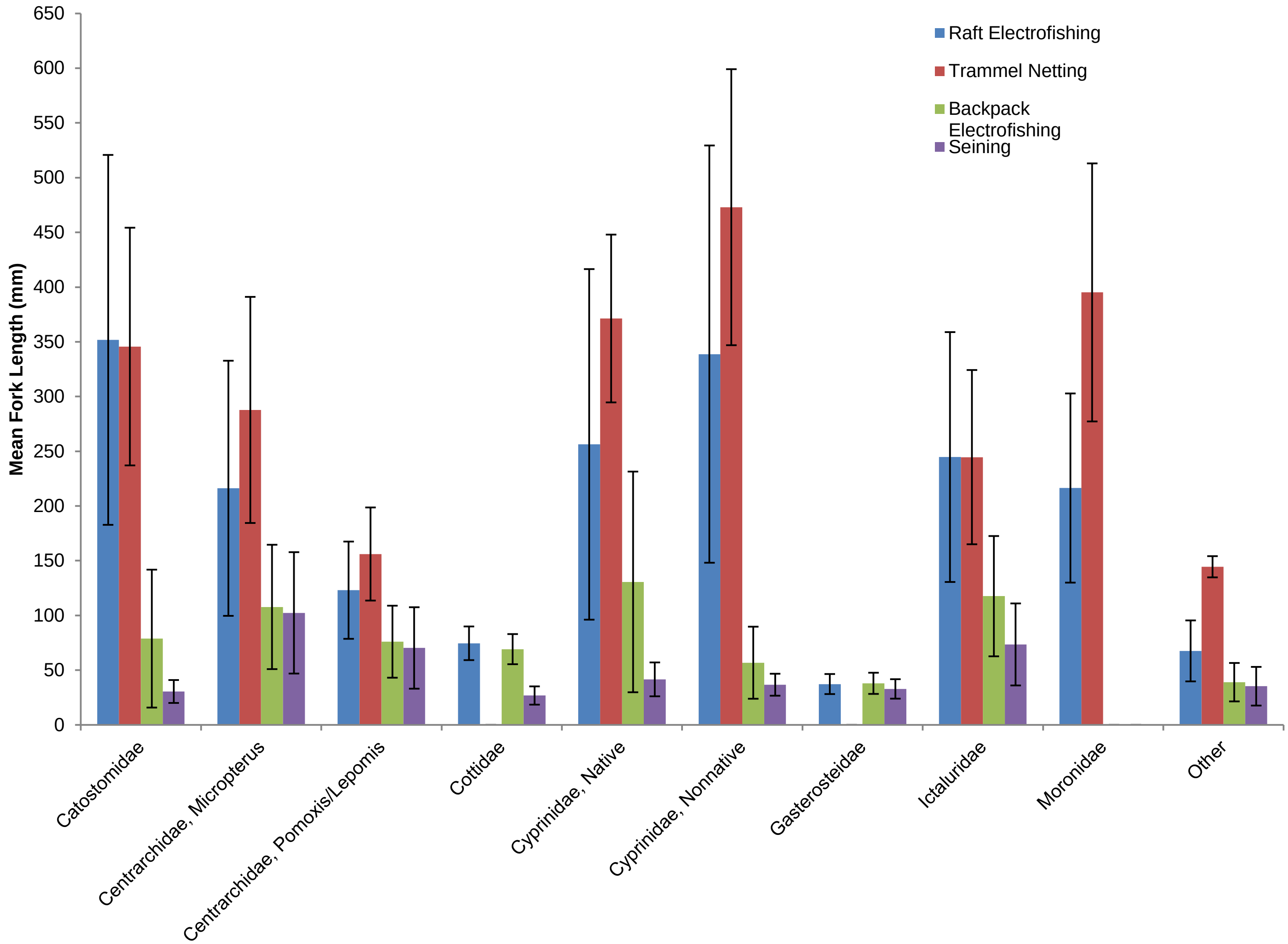

Figure 12.—Fork length (mm; mean ± SD) for fish captured, by method, during 2013–14 fish assemblage inventory and monitoring efforts in the upper San Joaquin River, CA.

Table 5.—Species detection in restoration reaches during 2013–14 sampling season, across sampling methods.

Species:	Reach 1A	Reach 1B	Reach 2	Reach 3	Reach 4	Reach 5
American Shad			Sp			
Bigscale Logperch				F W Sp	F W Su	F W Sp Su
Black Bass	F W Sp Su	F W Sp	W Su	F W Sp Su	W Su	W Su
Black Bullhead	F W Su	F	F W	Su	F W Su	W Sp
Black Crappie	F W	W	F W Su	W Su	F W Sp Su	F W Sp
Bluegill	F W Sp Su	F W Sp Su	F W Sp Su	F W Sp Su	F W Sp Su	F W Sp Su
Brook Lamprey	F W Sp Su					
Brown Bullhead			F W Su	W	F W Su	
Channel Catfish		F W Sp Su	F W Su	F W Sp Su	F Sp Su	F W Sp
Chinook Salmon	F Sp Su	Sp			W	
Common Carp	F W Sp Su	F W Sp Su	F W Sp Su	F W Sp Su	F W Sp Su	F W Sp Su
Fathead Minnow					F Sp Su	F W Sp Su
Golden Shiner	F	W Sp	F W Sp Su	Sp	F Sp Su	F W Sp Su
Goldfish			F W Sp Su	F W Sp Su	Sp Su	F W Sp
Green Sunfish	F W Sp Su	F W Sp Su	F W Sp Su	W Sp Su	Su	F W Sp
Hitch			Sp Su	F		Sp
Hybrid Centrarchid	F W		W		W	W Sp
Inland Silverside			F Su		F W Sp Su	F W Sp Su
Largemouth Bass	F W Sp Su	F W Sp	F W Sp Su	F W Sp Su	F W Sp Su	F W Sp Su
Mosquitofish	F W Sp	F W Sp	F W Sp Su	F	F W Sp Su	F W Sp Su
Pacific Lamprey	F W					
Prickly Sculpin	F W Sp Su	F W Sp	W	W Sp Su	F W Su	
Pumpkinseed						W
Rainbow Trout	F W Sp					
Red Shiner					F W Sp Su	F W Sp Su
Redear Sunfish	F W Sp	F W Sp Su	F W Sp Su	F W Sp Su	F W Su	F W Sp
Riffle Sculpin	F Sp					
Sacramento Blackfish				Sp Su	F W Sp Su	F W Sp
Sacramento Pikeminnow	F W Sp Su	Su				
Sacramento Sucker	F W Sp Su	F W Sp Su	W Su	F W Sp Su		F W Sp
Sculpin spp.				W		
Shimofuri Goby				Sp	Su	
Spotted Bass	F W Sp Su	F W Sp Su	F W	F W Sp Su	F W Sp Su	F W Sp
Striped Bass	F		F Sp Su	F		F W Sp
Threadfin Shad			Sp Su		F	F Sp Su
Threespine Stickleback	F W Sp Su					
Tule Perch			W	F		
Warmouth		Sp			F W Sp	W
White Catfish	F W Sp Su	Sp	F W Sp Su	F W Sp Su	F W Sp Su	F W Sp Su
Yellow Bullhead			Sp	Sp		

F=October/W=January/Sp=March/April/Su=June

Table 6.—Species detection, by age class, and across sampling methods, by Restoration Reach during 2013–14 sampling season.

Species:	Reach 1A	Reach 1B	Reach 2	Reach 3	Reach 4	Reach 5
American Shad			1+			
Bigscale Logperch				1+	1+	0/1+
Black Bullhead	1+	1+	1+	1+	1+	1+
Black Crappie	0	1+	0/1+	1+	1+	1+
Bluegill	0/1+	0/1+	0/1+	0/1+	0/1+	0/1+
Brown Bullhead			1+	1+	0/1+	
Channel Catfish		0/1+	1+	0/1+	1+	0/1+
Chinook Salmon	0/1+	0			1+	
Common Carp	1+	1+	0/1+	1+	1+	0/1+
Fathead Minnow					0/1+	0/1+
Golden Shiner	0/1+	0/1+	0/1+	1+	0/1+	0/1+
Goldfish			1+	0/1+	1+	0/1+
Green Sunfish	0/1+	0/1+	1+	1+	1+	0/1+
Hitch			1+	1+		1+
Inland Silverside			0		0/1+	0/1+
Lamprey spp	0/1+					
Largemouth Bass	0/1+	0/1+	0/1+	0/1+	0/1+	0/1+
Mosquitofish	0/1+	0/1+	0/1+	0/1+	0/1+	0/1+
Prickly Sculpin	0/1+	0/1+	1+	0/1+	0/1+	
Pumpkinseed						1+
Rainbow Trout	0/1+					
Red Shiner					0/1+	0/1+
Redear Sunfish	0/1+	0/1+	0/1+	0/1+	0/1+	0/1+
Riffle Sculpin	0/1+					
Sacramento Blackfish				1+	1+	1+
Sacramento Pikeminnow	0/1+	1+				
Sacramento Sucker	0/1+	0/1+	0/1+	1+		1+
Shimofuri Goby				1+	1+	
Spotted Bass	0/1+	0/1+	0/1+	0/1+	0/1+	0/1+
Striped Bass	1+		1+	1+		1+
Threadfin Shad			0/1+		0/1+	0/1+
Threespine Stickleback	0/1+					
Tule Perch			1+	1+		
Warmouth		1+			0/1+	0/1+
White Catfish	1+	1+	1+	0/1+	0/1+	0/1+
Yellow Bullhead			1+	1+		

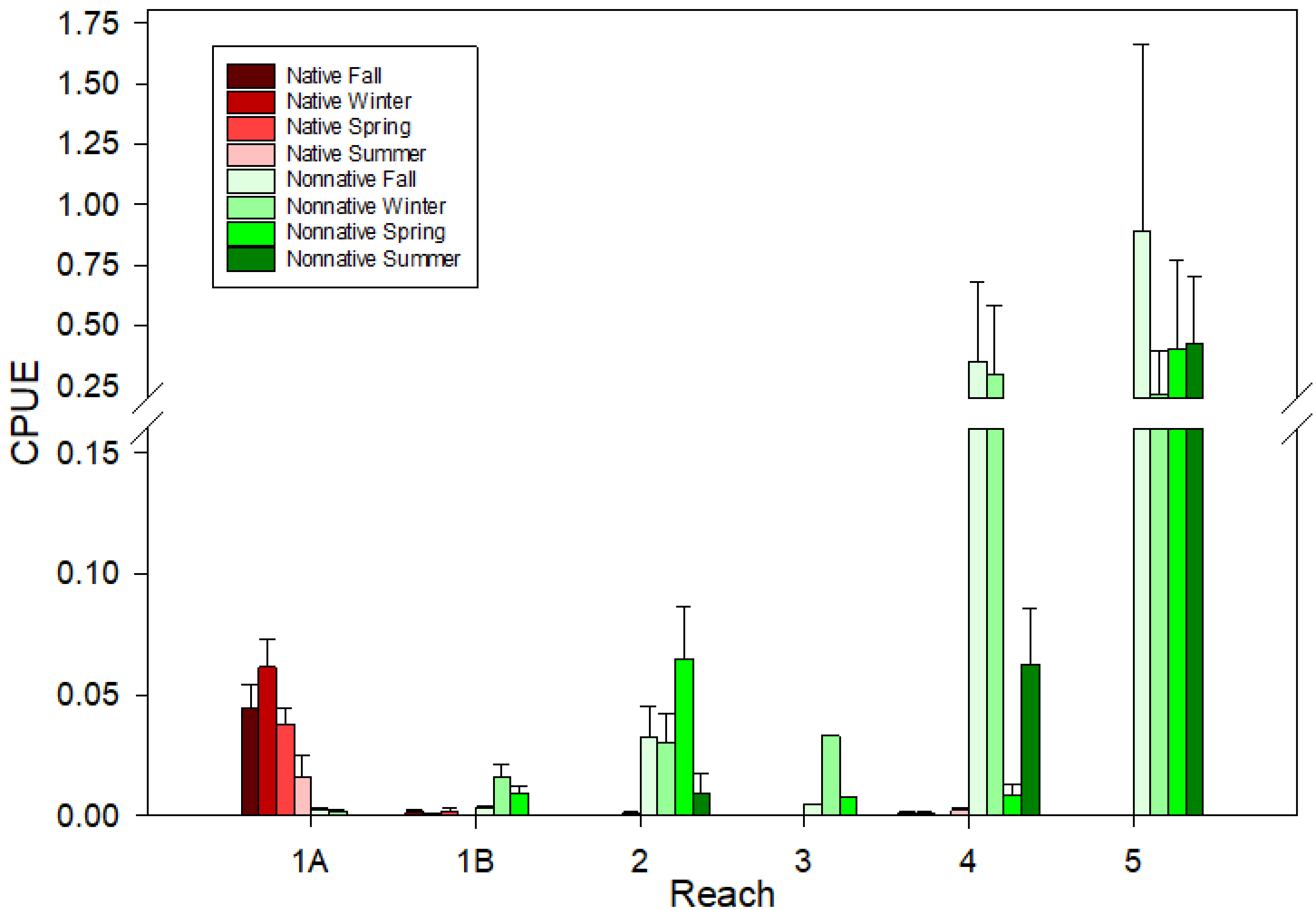

Figure 13.—Catch per unit effort (CPUE; mean ± SE) for backpack electrofishing, by reach and season, during 2013–14 fish assemblage inventory and monitoring efforts in the upper San Joaquin River, CA.

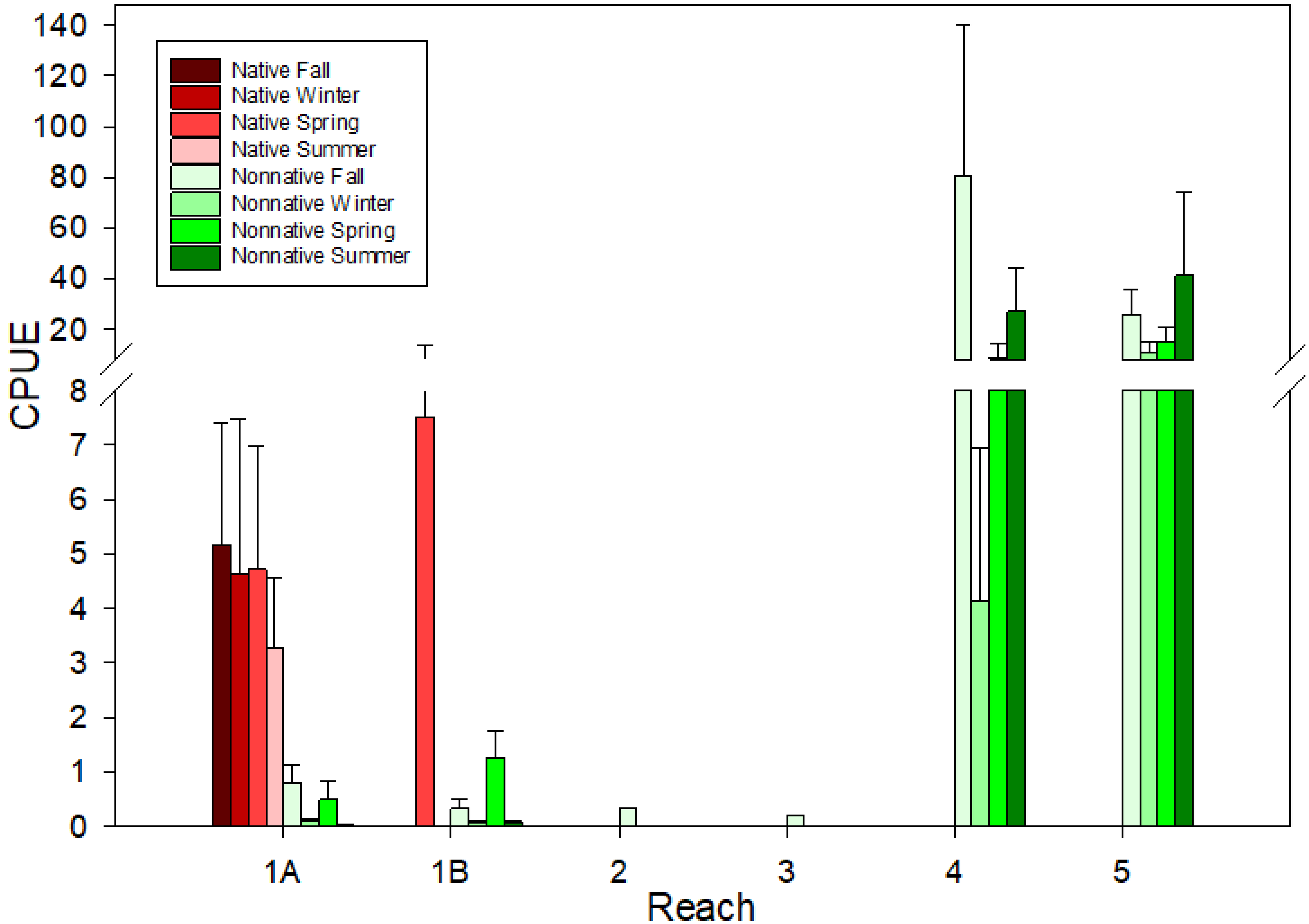

Figure 14.—Catch per unit effort (CPUE; mean ± SE) for seining, by reach and season, during 2013–14 fish assemblage inventory and monitoring efforts in the upper San Joaquin River, CA.

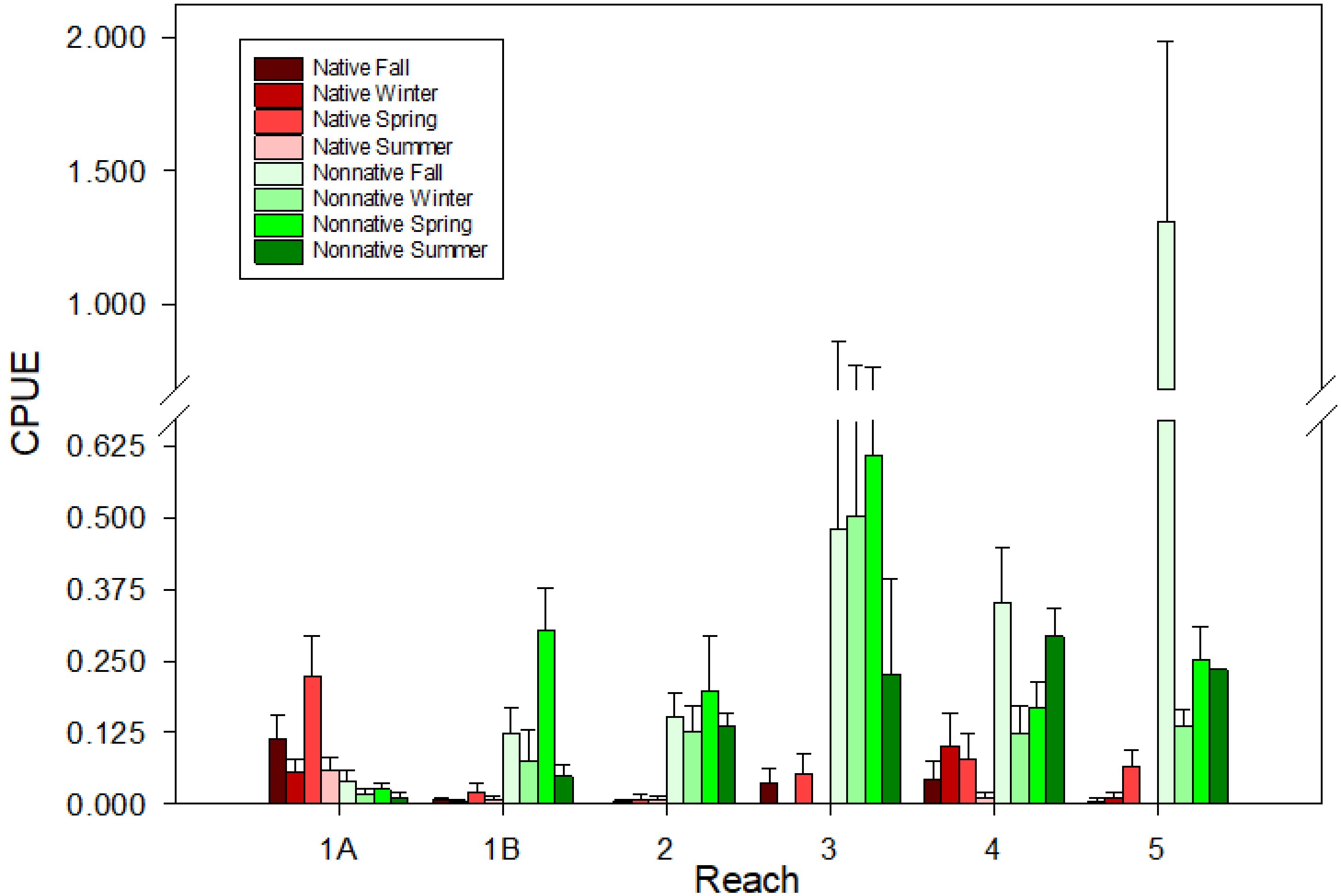

Figure 15.—Catch per unit effort (CPUE; mean ± SE) for trammel netting, by reach and season, during 2013–14 fish assemblage inventory and monitoring efforts in the upper San Joaquin River, CA.

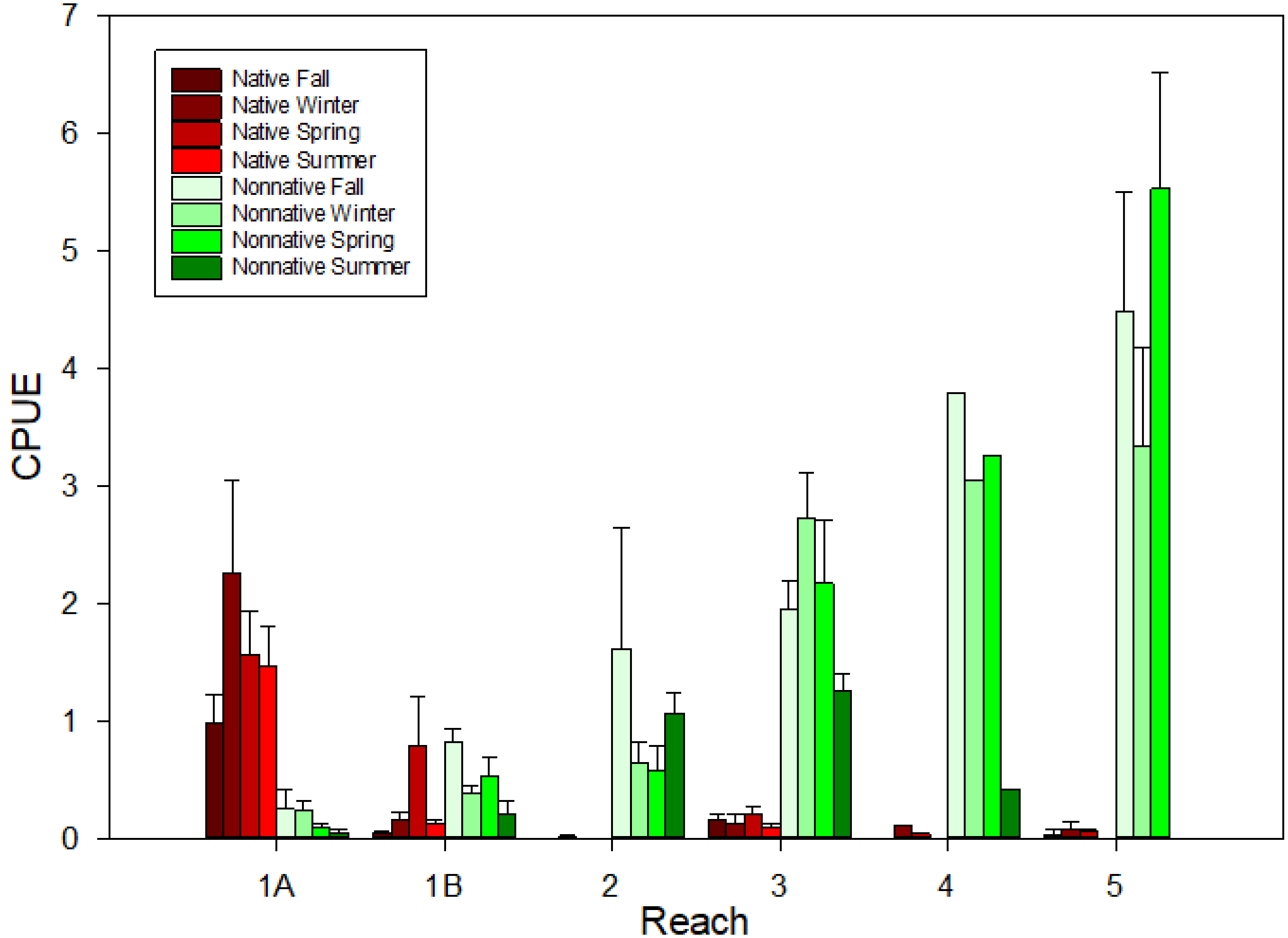

Figure 16.—Catch per unit effort (CPUE; mean ± SE) for raft electrofishing, by reach and season, during 2013–14 fish assemblage inventory and monitoring efforts in the upper San Joaquin River, CA.

4.0 DISCUSSION

This was the second sampling period for I&M efforts. With continued collection of fish assemblage data, the Program can establish a baseline that can be quantitatively measured against successive sampling to detect possible changes in fish community structure. Changes in fish community structure can help evaluate the effectiveness of restoration actions including salmon reintroduction, flow changes, and construction and habitat improvement projects (SJRRP 2010). In general, restoration efforts that lead to salmon reintroduction and reestablishment are hypothesized by the Program to restore native fish populations to good condition (SJRRP 2010). However, it is important to monitor other fish species to test the hypothesis that salmon-oriented restoration will benefit these populations as well.

In general, our results are consistent with previous studies (McBain and Trush 2002; Moyle 2002; CFDW 2007). Native fish were generally more restricted in distribution than nonnative fish within the Restoration Area. Furthermore, native fish CPUE is lower relative to nonnative fish in Reaches 2–5. Figures 13–16 indicate that absolute CPUE is higher for nonnative fish than native fish. However, differences in catchability could account for some of these differences. Both the shocking efficiency in low conductivity waters (of Reach 1 compared to downstream reaches), and the clearer waters could result in higher levels of evasion (Bonar *et al*. 2009). The point here is to suggest that such variables could account for differences in CPUE, and the disparity between native and nonnative CPUE is not necessarily a difference in abundance or encounter rate.

While 12 native species were encountered during 2013–14 sampling efforts, another factor to consider is the distribution of age classes. Though detection of species, particularly by size, can be greatly influenced by sampling methods, we can make some general assumptions by the portrayed distributions (Table 6): if only age-1+ fish are present in a reach, that may indicate these species have moved into the reach or are perhaps only present but not spawning. For instance, Hitch and Sacramento Blackfish were only encountered as age 1+ adults, and only in Reaches downstream of Mendota Dam. Conversely, sampling bias could be the reason age-0 fish were not captured. Likewise, if age-0 and age-1+ fish were encountered, it may suggest spawning populations are present in the indicated reach (*e.g.*, Sacramento Pikeminnow, Rainbow Trout, Threespine Stickleback in Reach 1). However, additional inputs in the various reaches could also introduce species of either age class. These inputs include Millerton Reservoir in Reach 1, Fresno Slough and the Delta-Mendota Canal in Reach 2, and connectivity to lower regions of the SJR and its tributaries in Reach 5, or introductions (*e.g.*, hatchery releases of Rainbow Trout). Because of the limited distribution of native fish within the Restoration Area, the increasing presence or density of native fish in reaches could be used to infer improvements in fish populations (Bayley and Peterson 2001).

Detecting future changes in CPUE may prove difficult because of the uncertainty of current results (*i.e.*, large standard error of CPUE results). Although the standard error may decrease with increased efforts, future efforts should focus on refining current methods to best detect these changes (*e.g.*, increasing sample sites in Reaches that are under-represented) and/or incorporating additional methods under the adaptive management plan for monitoring which could provide information to detect changes in fish distribution. However, increasing sampling to levels needed to detect these changes may prove impractical under current monitoring plans (Paukert 2004). Natural variation occurs normally in populations over time (Underwood 1992). The amount of sampling to detect this variability from natural and stochastic events in the SJR, and differentiate them from the effects of restoration efforts may not be feasible under current sampling protocols.

Other methods of monitoring changes in target species' populations should be considered; for example, mark-recapture studies could be used to determine population metrics (*e.g.*, abundance, survival, recruitment; Pradel 1996), or correspondence analysis could be used to predict species' distribution relative to environmental variables in the Restoration Area (Paukert 2004; Marichetti and Moyle 2001). While current CPUE data may have its limitations, data presented in this study will nonetheless provide a foundation for future efforts and can be incorporated into future monitoring efforts (Maunder *et al.* 2006). In addition, because sampling efforts have only taken place during low water years, additional sampling during normal–high water years should be considered—2012 was a "normal-dry" water year, 2013 was "dry," and 2014 was "critical-high" drought year. Fish distribution under non-drought conditions could be different from our current results (Marchetti and Moyle 2001). Additional sampling under other water-year types should be considered to add to the baseline data; this would provide the opportunity to capture natural variation under such conditions, which may help to distinguish variation as a function of rainfall/river flows from restoration effects.

5.0 LITERATURE CITED

Bayley, P.B. and J.T. Peterson. 2001. An approach to estimate probability of presence and richness of fish species. Transactions of the American Fisheries Society 130: 620–633.

Bonar, S.A., W.A. Hubert, and S.W. Willis, *eds*. 2009. Standard methods for sampling North American freshwater fishes. American Fisheries Society, Bethesda, Maryland. 335p.

Curry, R.A. and K.R. Munkittrick. 2005. Fish assemblage structure in relation to multiple stressors along the Saint John River, New Brunswick, Canada. Pages 505–521 in J.N. Rinne, R.M. Hughes, and B. Calamusso (eds.). Historical changes in large river fish assemblages of the Americas. American Fisheries Society, Symposium 45, Bethesda, Maryland.

[CDFW] California Department of Fish and Game. 2007. San Joaquin River fishery and aquatic resources inventory, September 2003–September 2005. Final Report. Cooperative Agreement 03FC203052.

Guy, C. S., P. J. Bratten, D. P. Herzog, J. Pitlo, and R.S. Rogers. 2009. Warmwater fish in rivers. Pages 59–84 in S. A. Bonar, W. A. Hubert, and D. W. Willis (eds.). Standard methods for sampling North American freshwater fishes. American Fisheries Society, Bethesda, Maryland. 335p.

Lavigne, H.R., R.M. Hughes, R.C. Wildman, S.V. Gregory, and A.T. Herlihy. 2008. Summer distribution and diversity of non-native fishes in the main-stem Willamette River, Oregon, 1944–2006. Northwest Science 82:83–93. NRDC v. Rodgers et al. 2006. Stipulation of Settlement. 80p.

Marchetti, M.P. and P.B. Moyle. 2001. Effects of flow regime on fish assemblages in a regulated California stream. Ecological Applications 11: 530–539.

Maunder, M.N., J.R. Sibert, A. Fonteneau, J. Hampton, P. Kliever, and S.J. Harley. 2006. Interpreting catch per unit effort data to assess the status of individual stocks and communities. ICES Journal of Marine Science 63: 1373–1385.

McBain and Trush, Inc. (eds.). 2002. San Joaquin River Restoration Study Background Report, prepared for Friant Water Users Authority, Lindsay, CA, and Natural Resources Defense Council, San Francisco, California. 1055p.

Moyle, P. B. 2002. Inland fishes of California. University of California Press, Oakland, California. 517p.

Murphy, B.R. and D.W. Willis (eds.) 1996. Fisheries techniques, 2nd ed. American Fisheries Society, Bethesda, Maryland. 732p.

Paukert, C.P. 2004. Comparison of electrofishing and trammel netting variability for sampling native fishes. Journal of Fish Biology 65: 1643–1652.

Pope, K.L. and D.W. Willis. 1996. Seasonal influences on freshwater fisheries sampling data. Reviews in Fisheries Science 4: 57–73.

Pradel, R. 1996. Utilization of capture-mark-recapture for the study of recruitment and population growth rate. Biometrics 52: 703–709.

[SJRRP] San Joaquin River Restoration Program. 2010. Fisheries management plan: a framework for adaptive management in the San Joaquin River Restoration Program. November 2010. 164p.

[SJRRP] San Joaquin River Restoration Program. 2013. Fish Assemblage Inventory and Monitoring, 2012-2013. Annual Report, 59p.

Underwood, A.J. 1992. Beyond BACI: the detection of environmental impacts on populations in the real, but variable, world. Journal of Experimental Marine Biology and Ecology 161:147–178.

Wiley, M.L. and C.F. Tsai. 1983. The relative efficiencies of electrofishing vs. seines in Piedmont streams in Maryland. North American Journal of Fisheries Management 3: 243–253.

APPENDIX A

River Sensors

Table A1.—River sensors and associated information used to provide flow data during 2013–14 study period.
USGS = U.S. Geological Survey; CADWR = California Department of Water Resources, Reclamation = Bureau of Reclamation

Sensor	Description	Operator	Lat.	Lon.	River Mile	Oct Float	Jan Float	Mar/Apr Float	Jun Float
SJF	SJR below Friant Dam	USGS	36.984394	119.724312	266.0	10/22/13	01/07/14	04/01/14	06/03/14
H41	SJR at Hwy 41 Bridge	Reclamation	36.876200	119.793200	255.1	10/08/13	01/09/14	04/02/14	06/04/13
DNB	SJR at Donny Bridge	Reclamation	36.833500	119.965800	240.7	10/08/13	01/09/14	04/02/14	06/04/14
SKB	SJR at Skaggs Bridge (Hwy 145)	Reclamation	36.822900	120.088400	232.1	10/10/13	01/10/14	04/03/14	06/04/14
GRF	SJR at Gravelly Ford	Reclamation	36.798000	120.160000	227.5	10/10/13	01/10/14	04/03/14	06/04/14
SJB	SJR below Bifurcation	Reclamation	36.773000	120.286000	215.9	10/07/13	01/10/14	04/04/14	06/05/14
SJN	SJR at San Mateo Rd	USGS	36.778889	120.306664	212.2	10/07/13	01/10/14	04/03/14	06/05/14
MEN	SJR near Mendota	USGS	36.810505	120.378227	202.1	10/06/13	01/01/14	04/04/14	06/06/14
SDP	SJR near Dos Palos	CADWR	36.994000	120.501500	181.2	10/07/13	01/13/14	04/07/14	06/07/04
SWA	SJR at NR Washington Rd	CADWR	37.115320	120.587000	168.4	10/07/13	01/13/14	04/07/14	06/07/04
SJS	SJR near Stevinson	CADWR	37.295000	120.851000	132.8	10/05/13	01/14/14	04/08/14	06/07/04
FFB	SJR at Freemont Ford Bridge	USGS	37.309940	120.931038	125.1	10/04/13	01/12/14	04/08/14	06/07/04
NEW	SJR above Merced near Newman	USGS & DWR	37.350494	120.977150	118.1	10/04/13	01/12/14	04/08/14	06/07/04

APPENDIX B

Catch-per-unit-effort, by reach and sampling effort

Table B1.—October/November 2013 raft electrofishing catch-per-unit-effort (mean ± SE), by Restoration Reach. "Other" category includes Percidae, Atherinopsidae, Gobiidae, Clupeidae, and Poeciliidae. "NA" for standard error when only one sample site within a reach.

CPUE per Reach:	1A	1B	2	3	4	5
Centrarchidae *Lepomis/Pomoxis*	0.048±0.033	0.043±0.031	1.018±0.780	0.628±0.185	3.260±N/A	0.674±0.194
Centrarchidae *Micropterus*	0.182±0.119	0.677±0.104	0.399±0.231	0.628±0.094	0.352±N/A	0.289±0.064
Catostomidae	0.523±0.118	0.041±0.025	0.000±0.000	0.151±0.058	0.000±N/A	0.036±0.036
Nonnative Cyprinidae	0.007±0.007	0.065±0.034	0.097±0.060	0.333±0.106	0.000±N/A	1.997±0.500
Other	0.000±0.000	0.000±0.000	0.034±0.034	0.143±0.097	0.088±N/A	0.718±0.473
Native Cyprinidae	0.038±0.029	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000
Ictaluridae	0.013±0.013	0.040±0.017	0.069±0.044	0.170±0.042	0.088±N/A	0.786±0.383
Cottidae	0.102±0.041	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000
Gasterosteidae	0.296±0.216	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000
Petromyzontidae	0.017±0.014	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000
Mornoidae	0.000±0.000	0.000±0.000	0.000±0.000	0.045±0.038	0.000±N/A	0.025±0.017
Salmonidae	0.009±0.006	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000
Embiotocidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000

Table B2.—January 2014 raft electrofishing catch-per-unit-effort (mean ± SE), by Restoration Reach. "Other" category includes Percidae, Atherinopsidae, Gobiidae, Clupeidae, and Poeciliidae. "NA" for standard error when only one sample site within a reach.

CPUE per Reach:	1A	1B	2	3	4	5
Centrarchidae *Lepomis/Pomoxis*	0.095±0.045	0.034±0.024	0.374±0.210	1.054±0.207	1.063±N/A	1.764±0.807
Centrarchidae *Micropterus*	0.136±0.052	0.279±0.074	0.194±0.029	1.274±0.281	1.170±N/A	0.774±0.230
Catostomidae	0.621±0.150	0.155±0.065	0.000±0.000	0.094±0.075	0.000±N/A	0.081±0.062
Nonnative Cyprinidae	0.007±0.007	0.047±0.021	0.046±0.029	0.338±0.166	0.177±N/A	0.680±0.227
Other	0.000±0.000	0.000±0.000	0.000±0.000	0.022±0.012	0.638±N/A	0.087±0.027
Native Cyprinidae	0.011±0.006	0.000±0.000	0.000±0.000	0.000±0.000	0.106±N/A	0.006±0.006
Ictaluridae	0.009±0.005	0.021±0.021	0.030±0.030	0.037±0.016	0.000±N/A	0.004±0.004
Cottidae	0.029±0.012	0.000±0.000	0.018±0.018	0.031±0.013	0.000±N/A	0.000±0.000
Gasterosteidae	1.524±0.775	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000
Petromyzontidae	0.056±0.024	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000
Mornoidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.023±0.017
Salmonidae	0.020±0.010	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000
Embiotocidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000

Table B3.—March/April 2014 raft electrofishing catch-per-unit-effort (mean ± SE), by Restoration Reach. "Other" category includes Percidae, Atherinopsidae, Gobiidae, Clupeidae, and Poeciliidae. "NA" for standard error when only one sample site within a reach.

CPUE per Reach:	1A	1B	2	3	4	5
Centrarchidae *Lepomis/Pomoxis*	0.029±0.014	0.059±0.026	0.251±0.146	0.613±0.227	1.908±N/A	1.492±0.468
Centrarchidae *Micropterus*	0.051±0.021	0.154±0.048	0.154±0.051	0.736±0.199	0.824±N/A	0.333±0.089
Catostomidae	1.004±0.337	0.771±0.418	0.000±0.000	0.155±0.047	0.000±N/A	0.030±0.020
Nonnative Cyprinidae	0.008±0.006	0.278±0.126	0.113±0.056	0.707±0.156	0.434±N/A	2.804±0.821
Other	0.000±0.000	0.000±0.000	0.056±0.028	0.031±0.018	0.043±N/A	0.330±0.143
Native Cyprinidae	0.013±0.009	0.000±0.000	0.000±0.000	0.005±0.005	0.043±N/A	0.027±0.013
Ictaluridae	0.005±0.005	0.045±0.028	0.000±0.000	0.078±0.037	0.043±N/A	0.538±0.154
Cottidae	0.060±0.016	0.000±0.000	0.000±0.000	0.041±0.041	0.000±N/A	0.000±0.000
Gasterosteidae	0.164±0.140	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000
Petromyzontidae	0.310±0.159	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000
Mornoidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.028±0.015
Salmonidae	0.009±0.007	0.013±0.013	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000
Embiotocidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000

Table B4.—June 2014 raft electrofishing catch-per-unit-effort (mean ± SE), by Restoration Reach. "Other" category includes Percidae, Atherinopsidae, Gobiidae, Clupeidae, and Poeciliidae. "NA" for standard error when only one sample site within a reach. No sample sites in Reach 5, for raft electrofishing during, June 2015 because of low water conditions.

CPUE per Reach:	1A	1B	2	3	4	5
Centrarchidae *Lepomis/Pomoxis*	0.000±0.000	0.036±0.022	0.250±0.086	0.277±0.050	0.139±N/A	N/A±N/A
Centrarchidae *Micropterus*	0.029±0.019	0.167±0.111	0.121±0.050	0.446±0.084	0.093±N/A	N/A±N/A
Catostomidae	0.845±0.307	0.100±0.047	0.000±0.000	0.067±0.020	0.000±N/A	N/A±N/A
Nonnative Cyprinidae	0.006±0.006	0.000±0.000	0.453±0.240	0.345±0.066	0.139±N/A	N/A±N/A
Other	0.000±0.000	0.000±0.000	0.242±0.242	0.000±0.000	0.000±N/A	N/A±N/A
Native Cyprinidae	0.020±0.012	0.022±0.022	0.000±0.000	0.018±0.013	0.000±N/A	N/A±N/A
Ictaluridae	0.012±0.008	0.000±0.000	0.000±0.000	0.190±0.066	0.046±N/A	N/A±N/A
Cottidae	0.095±0.024	0.000±0.000	0.000±0.000	0.013±0.013	0.000±N/A	N/A±N/A
Gasterosteidae	0.403±0.166	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	N/A±N/A
Petromyzontidae	0.094±0.069	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	N/A±N/A
Mornoidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	N/A±N/A
Salmonidae	0.006±0.006	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	N/A±N/A
Embiotocidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	N/A±N/A

Table B5.—October/November 2013 backpack electrofishing catch-per-unit-effort (mean ± SE), by Restoration Reach. "Other" category includes Percidae, Atherinopsidae, Gobiidae, Clupeidae, and Poeciliidae. "NA" for standard error when only one sample site within a reach.

CPUE per Reach:	1A	1B	2	3	4	5
Centrarchidae *Lepomis/Pomoxis*	0.001±0.001	0.000±0.000	0.017±0.012	0.005±N/A	0.199±0.189	0.009±0.005
Centrarchidae *Micropterus*	0.001±0.000	0.002±0.001	0.002±0.002	0.000±N/A	0.011±0.001	0.001±0.001
Catostomidae	0.013±0.005	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000
Nonnative Cyprinidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.091±0.091	0.213±0.203
Other	0.000±0.000	0.001±0.001	0.013±0.004	0.000±N/A	0.051±0.047	0.664±0.571
Native Cyprinidae	0.001±0.001	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000
Ictaluridae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.001±0.001	0.000±0.000
Cottidae	0.018±0.004	0.001±0.001	0.000±0.000	0.000±N/A	0.001±0.001	0.000±0.000
Gasterosteidae	0.012±0.005	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000
Petromyzontidae	0.001±0.001	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000
Salmonidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000

Table B6.—January 2014 backpack electrofishing catch-per-unit effort (mean ± SE), by Restoration Reach. "Other" category includes Percidae, Atherinopsidae, Gobiidae, Clupeidae, and Poeciliidae. "NA" for standard error when only one sample site within a reach.

CPUE per Reach:	1A	1B	2	3	4	5
Centrarchidae *Lepomis/Pomoxis*	0.001±0.000	0.008±0.006	0.022±0.010	0.023±N/A	0.088±0.080	0.013±0.007
Centrarchidae *Micropterus*	0.001±0.001	0.006±0.002	0.004±0.001	0.010±N/A	0.002±0.002	0.003±0.002
Catostomidae	0.017±0.007	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000
Nonnative Cyprinidae	0.000±0.000	0.000±0.000	0.002±0.002	0.000±N/A	0.204±0.204	0.045±0.045
Other	0.000±0.000	0.001±0.001	0.002±0.002	0.000±N/A	0.001±0.001	0.153±0.134
Native Cyprinidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000
Ictaluridae	0.000±0.000	0.001±0.001	0.000±0.000	0.000±N/A	0.001±0.001	0.000±0.000
Cottidae	0.021±0.006	0.000±0.000	0.000±0.000	0.000±N/A	0.001±0.001	0.000±0.000
Gasterosteidae	0.020±0.006	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000
Petromyzontidae	0.003±0.001	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000
Salmonidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000

Table B7.—March/April 2014 backpack electrofishing catch-per-unit effort (mean ± SE), by Restoration Reach. "Other" category includes Percidae, Atherinopsidae, Gobiidae, Clupeidae, and Poeciliidae. "NA" for standard error when only one sample site within a reach.

CPUE per Reach:	1A	1B	2	3	4	5
Centrarchidae *Lepomis/Pomoxis*	0.000±0.000	0.002±0.001	0.046±0.024	0.008±N/A	0.008±0.005	0.008±0.006
Centrarchidae *Micropterus*	0.000±0.000	0.005±0.003	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000
Catostomidae	0.007±0.003	0.001±0.001	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000
Nonnative Cyprinidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.206±0.187
Other	0.000±0.000	0.003±0.003	0.017±0.009	0.000±N/A	0.000±0.000	0.190±0.183
Native Cyprinidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000
Ictaluridae	0.000±0.000	0.000±0.000	0.001±0.001	0.000±N/A	0.000±0.000	0.000±0.000
Cottidae	0.008±0.003	0.001±0.001	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000
Gasterosteidae	0.014±0.004	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000
Petromyzontidae	0.007±0.003	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000
Salmonidae	0.001±0.001	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000

Table B8.—June 2014 backpack electrofishing catch-per-unit effort (mean ± SE), by Restoration Reach. "Other" category includes Percidae, Atherinopsidae, Gobiidae, Clupeidae, and Poeciliidae. "NA" for standard error when only one sample site within a reach.

CPUE per Reach:	1A	1B	2	3	4	5
Centrarchidae *Lepomis/Pomoxis*	0.000±0.000	0.000±0.000	0.006±0.006	0.000±N/A	0.048±0.014	0.010±0.003
Centrarchidae *Micropterus*	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.005±0.005	0.002±0.002
Catostomidae	0.004±0.002	0.000±0.000	0.001±0.001	0.000±N/A	0.000±0.000	0.000±0.000
Nonnative Cyprinidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.007±0.001	0.074±0.070
Other	0.000±0.000	0.000±0.000	0.003±0.003	0.000±N/A	0.002±0.002	0.337±0.206
Native Cyprinidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000
Ictaluridae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.001±0.001	0.000±0.000
Cottidae	0.002±0.001	0.000±0.000	0.000±0.000	0.000±N/A	0.002±0.001	0.000±0.000
Gasterosteidae	0.009±0.007	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000
Petromyzontidae	0.002±0.001	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000
Salmonidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A	0.000±0.000	0.000±0.000

Table B9.—October/November 2013 seining catch-per-unit-effort (mean ± SE). "Other" category includes Percidae, Atherinopsidae, Gobiidae, Clupeidae, and Poeciliidae. "NA" for standard error when only one sample site within a reach.

CPUE per Reach:	1A	1B	2	3	4	5
Centrarchidae *Lepomis/Pomoxis*	0.080±0.052	0.033±0.014	0.258±N/A	0.000±N/A	0.223±0.206	0.112±0.043
Centrarchidae *Micropterus*	0.120±0.080	0.029±0.012	0.086±N/A	0.096±N/A	0.030±0.018	0.018±0.010
Catostomidae	0.863±0.455	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Nonnative Cyprinidae	0.000±0.000	0.000±0.000	0.000±N/A	0.000±N/A	15.023±13.620	17.300±8.505
Other	0.598±0.294	0.265±0.168	0.000±N/A	0.096±N/A	65.433±46.642	8.408±2.236
Native Cyprinidae	0.077±0.055	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Ictaluridae	0.000±0.000	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.014±0.014
Cottidae	0.011±0.011	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Gasterosteidae	4.205±2.008	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Petromyzontidae	0.007±0.007	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Salmonidae	0.000±0.000	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000

Table B10.— January 2014 seining catch-per-unit-effort (mean ± SE). "Other" category includes Percidae, Atherinopsidae, Gobiidae, Clupeidae, and Poeciliidae. "NA" for standard error when only one sample site within a reach.

CPUE per Reach:	1A	1B	2	3	4	5
Centrarchidae *Lepomis/Pomoxis*	0.000±0.000	0.033±0.015	0.000±N/A	0.000±N/A	0.072±0.072	0.007±0.007
Centrarchidae *Micropterus*	0.024±0.017	0.011±0.011	0.000±N/A	0.000±N/A	0.024±0.024	0.009±0.006
Catostomidae	0.074±0.034	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Nonnative Cyprinidae	0.000±0.000	0.000±0.000	0.000±N/A	0.000±N/A	2.745±2.729	8.542±4.428
Other	0.074±0.043	0.025±0.019	0.000±N/A	0.000±N/A	1.284±0.880	2.195±1.486
Native Cyprinidae	0.005±0.005	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Ictaluridae	0.000±0.000	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Cottidae	0.000±0.000	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Gasterosteidae	4.540±2.848	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Petromyzontidae	0.000±0.000	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Salmonidae	0.000±0.000	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000

Table B11.—March/April 2014 seining catch-per-unit-effort (mean ± SE). "Other" category includes Percidae, Atherinopsidae, Gobiidae, Clupeidae, and Poeciliidae. "NA" for standard error when only one sample site within a reach.

CPUE per Reach:	1A	1B	2	3	4	5
Centrarchidae *Lepomis/Pomoxis*	0.000±0.000	0.424±0.367	0.000±N/A	0.000±N/A	0.264±0.172	0.027±0.018
Centrarchidae *Micropterus*	0.005±0.005	0.045±0.045	0.000±N/A	0.000±N/A	0.014±0.014	0.027±0.018
Catostomidae	3.740±2.292	7.488±5.907	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Nonnative Cyprinidae	0.000±0.000	0.000±0.000	0.000±N/A	0.000±N/A	4.480±2.608	8.218±4.215
Other	0.483±0.337	0.798±0.401	0.000±N/A	0.000±N/A	4.014±2.740	6.856±2.447
Native Cyprinidae	0.003±0.003	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Ictaluridae	0.000±0.000	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Cottidae	0.113±0.074	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Gasterosteidae	0.872±0.482	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Petromyzontidae	0.000±0.000	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Salmonidae	0.000±0.000	0.022±0.022	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000

Table B12.—June 2014 seining catch-per-unit-effort (mean ± SE). "Other" category includes Percidae, Atherinopsidae, Gobiidae, Clupeidae, and Poeciliidae. "NA" for standard error when only one sample site within a reach.

CPUE per Reach:	1A	1B	2	3	4	5
Centrarchidae *Lepomis/Pomoxis*	0.000±0.000	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.043±0.043
Centrarchidae *Micropterus*	0.021±0.017	0.057±0.057	0.000±N/A	0.000±N/A	0.025±0.025	0.016±0.016
Catostomidae	1.606±0.993	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Nonnative Cyprinidae	0.000±0.000	0.000±0.000	0.000±N/A	0.000±N/A	0.202±0.202	2.241±1.285
Other	0.000±0.000	0.000±0.000	0.000±N/A	0.000±N/A	26.629±17.375	38.876±31.982
Native Cyprinidae	0.000±0.000	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Ictaluridae	0.000±0.000	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Cottidae	0.006±0.006	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Gasterosteidae	1.651±0.805	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Petromyzontidae	0.000±0.000	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000
Salmonidae	0.000±0.000	0.000±0.000	0.000±N/A	0.000±N/A	0.000±0.000	0.000±0.000

Table B13.—October/November 2013 trammel netting catch-per-unit-effort (mean ± SE), by Restoration Reach. "Other" category includes Percidae, Atherinopsidae, Gobiidae, Clupeidae, and Poeciliidae.

CPUE per Reach:	1A	1B	2	3	4	5
Centrarchidae *Lepomis/Pomoxis*	0.031±0.015	0.083±0.035	0.074±0.021	0.006±0.006	0.105±0.067	0.042±0.018
Centrarchidae *Micropterus*	0.005±0.003	0.021±0.011	0.015±0.009	0.015±0.009	0.000±0.000	0.005±0.005
Catostomidae	0.086±0.032	0.006±0.006	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000
Nonnative Cyprinidae	0.002±0.002	0.004±0.004	0.000±0.000	0.000±0.000	0.096±0.039	0.014±0.010
Other	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.661±0.655
Native Cyprinidae	0.021±0.009	0.000±0.000	0.000±0.000	0.031±0.023	0.043±0.033	0.005±0.005
Ictaluridae	0.000±0.000	0.014±0.009	0.055±0.026	0.457±0.380	0.152±0.052	0.577±0.242
Cottidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000
Gasterosteidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000
Petromyzontidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000
Mornoidae	0.003±0.003	0.000±0.000	0.008±0.006	0.000±0.000	0.000±0.000	0.009±0.009
Salmonidae	0.007±0.005	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000
Embiotocidae	0.000±0.000	0.000±0.000	0.000±0.000	0.006±0.006	0.000±0.000	0.000±0.000

Table B14.—January 2014 trammel netting catch-per-unit-effort (mean ± SE), by Restoration Reach. "Other" category includes Percidae, Atherinopsidae, Gobiidae, Clupeidae, and Poeciliidae.

CPUE per Reach:	1A	1B	2	3	4	5
Centrarchidae *Lepomis/Pomoxis*	0.014±0.008	0.040±0.040	0.073±0.051	0.145±0.033	0.037±0.019	0.099±0.028
Centrarchidae *Micropterus*	0.003±0.003	0.012±0.008	0.005±0.003	0.032±0.022	0.040±0.029	0.013±0.005
Catostomidae	0.046±0.020	0.004±0.004	0.002±0.002	0.000±0.000	0.000±0.000	0.002±0.002
Nonnative Cyprinidae	0.000±0.000	0.004±0.004	0.014±0.011	0.000±0.000	0.018±0.011	0.007±0.004
Other	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000
Native Cyprinidae	0.002±0.002	0.000±0.000	0.000±0.000	0.000±0.000	0.091±0.061	0.010±0.007
Ictaluridae	0.000±0.000	0.019±0.012	0.034±0.014	0.325±0.256	0.027±0.011	0.016±0.010
Cottidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000
Gasterosteidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000
Petromyzontidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000
Mornoidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000
Salmonidae	0.007±0.004	0.000±0.000	0.000±0.000	0.000±0.000	0.009±0.009	0.000±0.000
Embiotocidae	0.000±0.000	0.000±0.000	0.002±0.002	0.000±0.000	0.000±0.000	0.000±0.000

Table B15.—March/April 2014 trammel netting catch-per-unit-effort (mean ± SE), by Restoration Reach. "Other" category includes Percidae, Atherinopsidae, Gobiidae, Clupeidae, and Poeciliidae.

CPUE per Reach:	1A	1B	2	3	4	5
Centrarchidae *Lepomis/Pomoxis*	0.015±0.010	0.179±0.057	0.090±0.055	0.051±0.038	0.011±0.011	0.036±0.013
Centrarchidae *Micropterus*	0.010±0.007	0.049±0.016	0.004±0.004	0.027±0.027	0.050±0.019	0.018±0.006
Catostomidae	0.208±0.068	0.021±0.015	0.000±0.000	0.051±0.038	0.000±0.000	0.000±0.000
Nonnative Cyprinidae	0.000±0.000	0.014±0.010	0.016±0.012	0.051±0.038	0.080±0.028	0.070±0.024
Other	0.000±0.000	0.000±0.000	0.015±0.009	0.000±0.000	0.000±0.000	0.000±0.000
Native Cyprinidae	0.011±0.005	0.000±0.000	0.009±0.009	0.000±0.000	0.078±0.046	0.064±0.029
Ictaluridae	0.000±0.000	0.059±0.020	0.061±0.051	0.479±0.150	0.028±0.017	0.105±0.042
Cottidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000
Gasterosteidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000
Petromyzontidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000
Mornoidae	0.000±0.000	0.000±0.000	0.010±0.007	0.000±0.000	0.000±0.000	0.021±0.014
Salmonidae	0.005±0.003	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000
Embiotocidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000

Table B16.—June 2014 trammel netting catch-per-unit-effort (mean ± SE), by Restoration Reach. "Other" category includes Percidae, Atherinopsidae, Gobiidae, Clupeidae, and Poeciliidae. "NA" for standard error when only one sample site within a reach.

CPUE per Reach:	1A	1B	2	3	4	5
Centrarchidae *Lepomis/Pomoxis*	0.011±0.011	0.017±0.012	0.045±0.009	0.087±0.045	0.050±0.031	0.000±N/A
Centrarchidae *Micropterus*	0.000±0.000	0.014±0.014	0.013±0.005	0.052±0.052	0.100±0.041	0.088±N/A
Catostomidae	0.055±0.022	0.007±0.007	0.003±0.003	0.000±0.000	0.000±0.000	0.000±N/A
Nonnative Cyprinidae	0.000±0.000	0.013±0.009	0.031±0.021	0.052±0.052	0.024±0.014	0.088±N/A
Other	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A
Native Cyprinidae	0.005±0.005	0.000±0.000	0.006±0.006	0.000±0.000	0.011±0.011	0.000±N/A
Ictaluridae	0.000±0.000	0.004±0.004	0.040±0.019	0.035±0.024	0.119±0.040	0.059±N/A
Cottidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A
Gasterosteidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A
Petromyzontidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A
Mornoidae	0.000±0.000	0.000±0.000	0.006±0.004	0.000±0.000	0.000±0.000	0.000±N/A
Salmonidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A
Embiotocidae	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±0.000	0.000±N/A

APPENDIX C

Historical and current distribution of native species

Table C1.—Historical distributions and current detections during all Fish Assemblage Inventory and Monitoring Efforts, 2012–14. Species-specific historic presence based McBain and Trush 2002; individual species accounts further defined in the literature cited section of the same document.

Common Name:	Scientific Name:	Historical Presence* (by Reach):	Current Account:
White Sturgeon	*Acipenser transmontanus*	1–5	
Sacramento Sucker	*Catostomus occidentalis*	1–5	X
Sacramento Perch	*Archoplites interruptus*	1–5	
Prickly Sculpin	*Cottus asper*	1–5	X
Riffle Sculpin	*Cottus gulosus*	1–?	X
California Roach	*Lavinia symmetricus*	1–5	
Hardhead	*Mylopharodon conocephalus*	1–5	X
Hitch	*Lavinia exilicauda*	1–5	X
Sacramento Blackfish	*Orthodon microlepidotus*	1–5	X
Sacramento Pikeminnow	*Ptychocheilus grandis*	1–5	X
Speckled Dace	*Rhinichthys osculus*	1–5	
Sacramento Splittail	*Pogonichthys macrolepidotus*	1–5	X
Thicktail Chub	*Gila crassicauda*	1–5	
Tule Perch	*Hysterocarpus traskii*	1–5	X
Threespine Stickleback	*Gasterosteus aculeatus*	1–5	X
Kern Brook Lamprey	*Lampetra hubbsi*	1–5	X
Pacific Lamprey	*Lampetra tridentata*	1–5	X
Chinook Salmon	*Oncorhynchus tshawytscha*	1–5	X
Rainbow Trout/Steelhead	*Oncorhynchus mykiss*	1–5	X