

Salinas Index Reach Monitoring Surveys

October 2023

Permit No.: SCP: S-183400003-20036-001; 4(d) APPS# 26762



Submitted To:
Monterey County Water Resources Agency

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December 2023

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This work is funded in part by a Cooperative Endangered Species Conservation Fund Non-Traditional Section 6 Grant (Agreement No. Q2140403) to the Monterey County Water Resources Agency to support the development of the Salinas River Operations Habitat Conservation Plan.

Executive Summary

Index reach monitoring has been conducted intermittently since 2010 to document the distribution and abundance of rainbow trout/steelhead (*Oncorhynchus mykiss*) in the Arroyo Seco, Nacimiento, and San Antonio Rivers. These surveys were included in the draft Biological Opinion for the Salinas River Diversion Facility (NMFS 2007) as a means of assessing the over-summer population abundance and distribution of *O. mykiss* as well as the overall fish community.

On October 26 and 27, 2023, FISHBIO staff conducted index reach monitoring using backpack electrofishing at 10 sites across three rivers. These included two sites in the San Antonio River, three sites in the Nacimiento River, and five sites in the Arroyo Seco River (Figure 1). Fish were captured in all sample locations, and a total of 15 different species were captured across all sites. Fifteen *O. mykiss* were captured in total, all of them in the Arroyo Seco River, where they were observed at each sampling location. All captured *O. mykiss* were implanted with passive integrated transponder (PIT) tags.

A total of six invasive species – smallmouth bass (*Micropterus dolomieu*), spotted bass (*Micropterus punctulatus*), common carp (*Cyprinus carpio*), western mosquitofish (*Gambusia affinis*), green sunfish (*Lepomis cyanellus*), and bluegill sunfish (*Lepomis macrochirus*) – were among the captured fish. Invasive species were observed in all three watersheds, but were most abundant in the Nacimiento, where high flows this spring may have washed several species downstream from the reservoir. Notably, the San Antonio sites that were sampled in 2023 were further downstream in the river than locations sampled in previous years, and the species composition was slightly different than previous surveys. As such, caution is warranted in making direct comparisons between San Antonio index reach monitoring data from previous years with data from this year.

The observation of a relatively abundant *O. mykiss* population in the Arroyo Seco River is encouraging and somewhat expected given past survey results and the historically wet year that occurred in 2023. Observations of *O. mykiss* in downstream reaches (i.e., downstream of the Arroyo Seco Road bridge) indicates that river conditions have remained favorable throughout most of the wetted stream. In addition, the presence of multiple age classes as well as young-of-year individuals confirms that suitable habitat conditions for successful spawning occurred in 2023.

During this sampling effort, the protocol of multiple-pass depletion sampling was modified in an effort to improve efficiency, increase sampled habitat, and maximize the capture and PIT tagging of *O. mykiss*. Instead, field crews conducted extended transects, thereby increasing total sampling effort at each site. Further, they focused on sampling in likely *O. mykiss* habitat only (i.e., riffles and runs, heads of pools). This was intended to increase the likelihood of encountering *O. mykiss* at all surveyed locations.

Introduction

Index reach monitoring has been conducted annually since 2010 during the late summer and early fall to document the distribution and abundance of *O. mykiss* at several sites in the Arroyo Seco, San Antonio, and Nacimiento Rivers. Despite missing some survey years due to drought or budget considerations, this is one of the longest-running fisheries datasets for the Salinas Basin. Index reach monitoring attempts to achieve an understanding of juvenile *O. mykiss* distribution and abundance in response to varying environmental conditions. In addition, the monitoring provides an opportunity to implant captured *O. mykiss* with PIT tags in preparation for future monitoring efforts.

Surveys have primarily been conducted with backpack electrofishing, which allows for sampling in a variety of habitats. However, permit constraints and habitat conditions have prevented electrofishing in some years, and multi-pass dive counts have been used as an alternative. Due to unknown detection probabilities and differences in methodology, it is difficult to assess absolute abundance through time. However, both methods have been crafted to allow for relative comparisons of population trends, especially between years when electrofishing was used as the primary method for index reach monitoring. Most recently, index reach monitoring was conducted in October 2022 using electrofishing. Prior to that, surveys were conducted in 2021 (dive counts), 2018 (electrofishing), 2017 (dive counts), 2014 (dive counts), and 2010-2013 (electrofishing).

Electrofishing and snorkel surveys at index reach sites have revealed that *O. mykiss* can persist in the mainstems of the Nacimiento and Arroyo Seco Rivers throughout the summer in most years. Previous findings suggest a low density of *O. mykiss* in the Nacimiento River and a higher but variable abundance of *O. mykiss* in the Arroyo Seco from year to year, which generally decreases in a downstream direction. Of note is the presence of *O. mykiss* of various sizes (young-of-year up to > 300 mm FL) in the Arroyo Seco in 2017, suggesting that conditions permitted successful reproduction of *O. mykiss* even during years of severe drought.

These surveys are especially useful in light of the Habitat Conservation Plan (HCP) that is being developed for water operations in the basin. As part of the HCP, fish passage analyses are being conducted for the Nacimiento and San Antonio rivers to evaluate the feasibility of facilitating fish passage around the dams on both rivers. Index reach monitoring can provide baseline estimates of *O. mykiss* habitat use downstream of the dams in each river. In addition, surveys provide an opportunity for tagging and recapturing individuals with PIT tags, which may be an important component of the monitoring for the HCP. Surveys this year were designed in part to evaluate the potential for tagging large numbers of juvenile *O. mykiss* in the Arroyo Seco, which would likely be a critical component of any future PIT tag monitoring program. As such, the relative densities of captured *O. mykiss* in 2023 will serve as a useful data point for the design of future monitoring programs.

This summary report is intended to provide an overview of the sampling methodology and survey results. Details of previous surveys can be found in the relevant annual fisheries reports produced by the Monterey County Water Resources Agency and are referenced as appropriate.

Methods

Field Surveys

Surveys were conducted at a total of 10 sites: 2 sites in the San Antonio River, 3 sites in the Nacimiento River, and 5 sites in the Arroyo Seco River (Figure 1). Some of these sites have been surveyed repeatedly since 2010, allowing for comparisons of fish community composition, fish community size structure, and relative densities of various species. Although sampling reaches were extended this year, care was taken to ensure that previously sampled index reach monitoring sites were included within these larger reaches. In addition, many sites were added this year or shifted in location in an effort to maximize potential catch of *O. mykiss*. Notably, sampling in the Arroyo Seco was hindered this year by road conditions that rendered the historical upstream sampling locations inaccessible. As such, sampling began at the Arroyo Seco Road bridge, and continued in an upstream direction throughout all suitable *O. mykiss* habitat for approximately 1 mile, until upstream travel became impossible due to a deep pool with steep bedrock sides (Figure 1).

At each site, sampling was concentrated on potential *O. mykiss* habitat (primarily riffles and some runs). A visual assessment of the instream and riparian habitat was conducted prior to beginning surveys at each site. This consisted of measuring the wetted width and length of the index reach using a digital rangefinder to allow for estimation of relative fish density within the reach. Note that calculation of absolute density was not possible as the reaches were not closed with block nets and fish were free to move in and out of the sampled area. However, total catch by area may still be used as a coarse comparison of fish abundance among the sampled reaches. Some reaches were relatively long because the pools and/or glides within these reaches were not sampled and were excluded from area calculations. Where possible, sites coincided with natural barriers such as cascades to limit fish movement out of the sampled reaches. Field crews also noted the occurrence of habitat features including algae, boulders, undercut banks, root wads, macrophytes, woody debris, overhanging vegetation, and artificial structures, and noted the primary substrates in the stream channel. In addition, field crews measured conductivity, temperature, and dissolved oxygen using a YSI water quality meter. More details on survey modifications are included below.

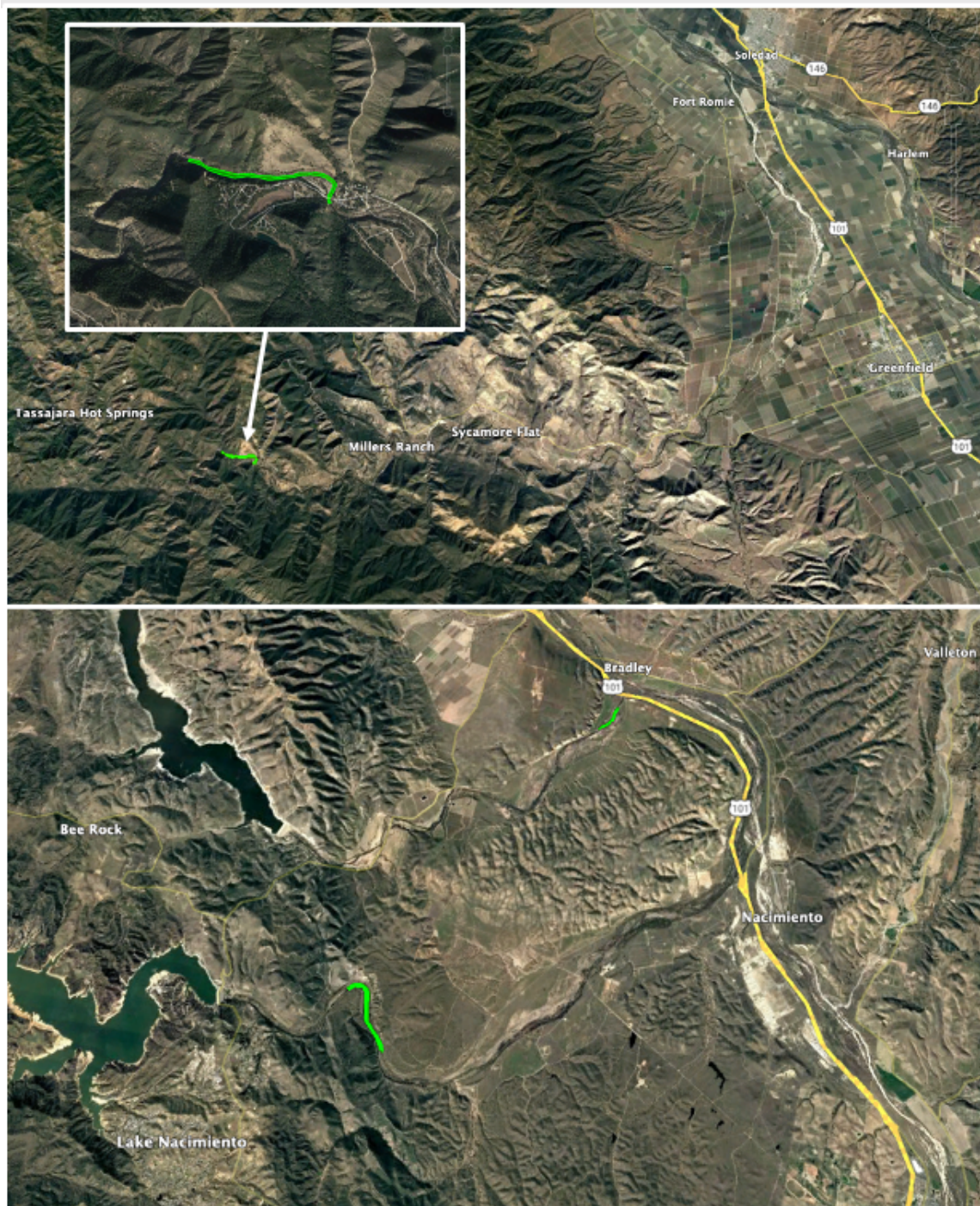


Figure 1. Map of survey reaches in the Arroyo Seco River (top) and Nacimiento and San Antonio Rivers (bottom).

Two Smith-Root LR24 Backpack Electrofishing Units were used at all sampling sites, using the quick set option to establish the initial power and waveform settings, which were verified with conductivity readings and cross referenced with the National Marine Fisheries Service (NMFS) Guidelines for Electrofishing Waters Containing Salmonids Listed under the Endangered Species

Act (NMFS 2000). Electrofishing proceeded in an upstream direction, and each operator was flanked by a netter. Captured fish were held in aerated live buckets and processed following the survey. During processing, fish were measured to total length, and fork length was also measured for all species possessing forked tails. The first 20 individuals of all captured species in each stream were measured, and any additional individuals belonging to those species were plus counted. All captured *O. mykiss* and individuals of other rare species were also weighed using a digital scale.

All captured *O. mykiss* were scanned for existing PIT tags using a handheld PIT tag reader (Oregon RFID), and once it was verified that they did not possess a tag they were anesthetized using Alka-Seltzer tablets dissolved in river water and implanted with a half-duplex PIT tag (Oregon RFID). Tissue glue was applied to the injection site, and the fish was allowed to recover in an aerated bucket prior to being released back into the river at the approximate location of its capture. PIT tags and the implantation syringe were cleaned with chlorhexidine solution between tagging of individuals.

During this sampling effort, the protocol of multiple-pass depletion sampling using block nets that was established by the former Biological Opinion (BO) was modified in an effort to improve efficiency and increase sampled habitat. The previous method of deploying block nets (which consumes extensive amounts of field time and likely leads to flushing fish out of the sample reach) and sampling until depletion is achieved, is time-consuming and offers robust data for only a limited sampling area. The purpose of these surveys is to compare indices of abundance over time and examine the longitudinal distribution of *O. mykiss* in each tributary. As such, extended transects increased the opportunity to capture juvenile *O. mykiss* in rivers where abundance is very low overall (e.g., Nacimiento) and provided more information on species distribution throughout the river. In addition, longer transects can increase our understanding of the overall fish community over a greater range. While depletion electrofishing offers the ability to develop estimates of absolute abundance in each site, the frequently very low numbers of captured *O. mykiss* precluded accurate abundance estimation using this method. As a more reliable alternative, relative abundance can still be evaluated by comparing catch-per-unit-effort (CPUE) between sites and within sites across years.

Data Analyses

Analyses were conducted in R statistical software (R Core Team 2017) and began with the calculation of Shannon-Weiner Diversity Index (H') values for each of the sample sites. This diversity index is a quantitative measurement that takes both species richness and abundance into account and serves as a statistical representation of biodiversity. Rarefied species richness values for each river were also calculated to account for differences in sample size among the various sites. Rarefaction randomly subsamples the total catch diversity at each site based on the minimum catch size and helps to correct for the fact that the diversity represented in catch tends to increase with increased sampling, thereby allowing for a more balanced comparison of species richness among the sample sites. Jaccard similarity values were then calculated for fish catch

among each river, and these values were used to create a hierarchical cluster. This process was performed to evaluate the similarity of fish communities in each river.

CPUE was also evaluated at each site, which allows for an assessment of relative fish abundance within each site despite differences in sampling effort. Because the sampling protocol only involved single pass electrofishing in each location, it was not possible to estimate absolute abundance of the species present in each site (meaning the true number of individuals), but CPUE provides a means of evaluating relative abundance, in that higher CPUE values in a given location would suggest a greater abundance of fish. Finally, average, minimum, and maximum total lengths of fish in each location were calculated for each site to allow for comparisons of size composition across sampled locations.

Results

Water Quality

Water quality assessments indicated suitable conditions for *O. mykiss* at all sites, with temperatures ranging from 10.9 to 16.9°C (51.6 to 62.4°F) and dissolved oxygen ranging from 9.81 to 11.77 mg/L (Table 1). Unlike past surveys, the San Antonio River was sampled further downstream in the watershed, thus excluding the previously sampled sites immediately below the dam that were characterized by continually poor water quality and intense sulfurous smells. Turbidity was only assessed visually, but water appeared generally more turbid in the Nacimiento River than the San Antonio River, perhaps due to the further downstream sampling location in the San Antonio. The Arroyo Seco was the least turbid of all three tributaries, as expected given the relatively undisturbed habitat in the basin and the absence of a dam. Emergent aquatic vegetation was very widespread in the San Antonio River and was also present in the Nacimiento.

Data on discharge during the surveys was obtained from the Nacimiento River below Nacimiento Dam near Bradley and Arroyo Seco near Greenfield gauges (USGS gauge numbers 11149400 and 11151870, respectively), as well as the San Antonio Reservoir release schedule. During surveys, Arroyo Seco discharge averaged approximately 14.6 cubic feet per second (cfs), Nacimiento River discharge averaged 62.1 cfs, and San Antonio discharge was approximately 10 cfs.

Table 1. Water quality metrics as measured at each index reach site.

Site	Survey Time	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	Discharge (CFS)*
Arroyo Seco 1	9:15	13.0	10.7	3.1	14.0
Arroyo Seco 2	11:00	–	–	–	14.6
Arroyo Seco 3	12:30	–	–	–	14.6
Arroyo Seco 4	14:00	–	–	–	15.3
Arroyo Seco 5	16:00	14.0	10.49	280.6	14.6

Nacimiento 1	8:30	10.9	9.81	174.2	76.9
Nacimiento 2	11:00	–	–	–	58.8
Nacimiento 3	12:30	13.3	10.6	183.2	50.7
San Antonio 1	14:30	16.5	11.77	294	10
San Antonio 2	15:30	16.9	10.92	375	10

*Discharge during the surveys was measured at the Nacimiento R BL Nacimiento Dam NR Bradley (USGS 11149400), and Arroyo Seco NR Greenfield (USGS 11151870) gauges and San Antonio Reservoir release schedule.

Fish Community

Species diversity was relatively similar across all sites, with a total of 15 species captured overall (n=7 in San Antonio, n=11 in Nacimiento, and n=8 in Arroyo Seco; Tables 2 and 3). The majority of fish captured were native, but there were more nonnative species present this year than in years past, including western mosquitofish, black bass (spotted and smallmouth), common carp, bluegill, and green sunfish. In each river, unique species were captured that were not observed in the other streams. Overall, both species richness and species diversity metrics were relatively low and reflect the minimal number of fish species present in each stream (Figures 2 and 3). The Nacimiento exhibited higher diversity than in previous surveys, a trend that was driven by the presence of several species that have not previously been observed in the watershed, including sunfish and black bass. Notably, the fish communities in the San Antonio and Arroyo Seco Rivers were more similar to each other than they were to the fish community in the Nacimiento, which is different than results in previous years where the Nacimiento and San Antonio have been the most closely related (Figure 4). CPUE was low overall but was generally higher in the Arroyo Seco and San Antonio rivers, the latter of which was driven by extremely abundant populations of hitch and Sacramento sucker (Figure 5). Fish captured in the Arroyo Seco were generally larger than fish captured in the other two streams, which were dominated by young of the year suckers and native minnows (Figure 6).

Table 2. Total counts of each species captured in each sample site and associated length ranges. Note that counts and lengths were not available for Arroyo Seco site 5, as that location was added in an effort to capture additional *O. mykiss* and other species were only recorded as observations. Further, lengths are not available for Arroyo Seco site 4, as non-trout species in that location were counted and not measured.

River	Site	Species	Count	Minimum Total Length (mm)	Maximum Total Length (mm)
Arroyo Seco	1	Hardhead	8	58	126
		<i>O. mykiss</i>	2	113	256
		Sacramento Pikeminnow	21	44	164
		Sacramento Sucker	56	43	119
		Speckled Dace	89	30	103
	2	<i>O. mykiss</i>	4	116	274
		Sacramento Pikeminnow	26	226	272
		Sacramento Sucker	9	186	186

	Spotted Bass	2	126	128
	Speckled Dace	83	-	-
	Hitch	2	-	-
	<i>O. mykiss</i>	4	103	268
	Sacramento Pikeminnow	27	-	-
3	Sacramento Sucker	18	-	-
	Smallmouth Bass	1	94	94
	Spotted Bass	1	-	-
	Speckled Dace	71	-	-
	<i>O. mykiss</i>	3	127	246
4	Sacramento Pikeminnow	21	-	-
	Sacramento Sucker	24	-	-
	Speckled Dace	63	-	-
	<i>O. mykiss</i>	2	108	116
5	Sacramento Pikeminnow	-	-	-
	Sacramento Sucker	-	-	-
	Speckled Dace	-	-	-
	Black Bass (<i>Micropterus</i> sp.)	1	84	84
	Bluegill Sunfish	1	93	93
	Green Sunfish	1	114	114
	Hitch	1	104	104
1	Hardhead	2	88	88
	Mosquitofish	1	35	35
	Prickly Sculpin	5	101	117
	Sacramento Pikeminnow	21	81	102
	Sacramento Sucker	11	82	125
	Three-spined Stickleback	81	24	56
Nacimiento	Hardhead	1	92	92
	Mosquitofish	4	27	37
	Prickly Sculpin	6	99	135
2	Sacramento Pikeminnow	21	85	138
	Sacramento Sucker	18	95	190
	Speckled Dace	1	64	64
	Three-spined Stickleback	9	-	-
	Bluegill Sunfish	1	79	79
	Hitch	3	76	120
3	Lamprey	1	145	145
	Prickly Sculpin	2	82	116
	Sacramento Pikeminnow	20	-	-

		Sacramento Sucker	32	-	-
		Spotted Bass	1	91	91
		Common Carp	4	72	139
		Hitch	206	65	151
		Mosquitofish	3	32	47
	1	Prickly Sculpin	2	66	78
		Sacramento Pikeminnow	38	60	106
		Sacramento Sucker	77	53	294
		Speckled Dace	3	55	62
San Antonio		Common Carp	1	144	144
		Hitch	56	153	153
		Mosquitofish	4	30	36
	2	Sacramento Pikeminnow	16	-	-
		Sacramento Sucker	48	-	-
		Speckled Dace	20	51	64
		Three-spined Stickleback	2	39	54

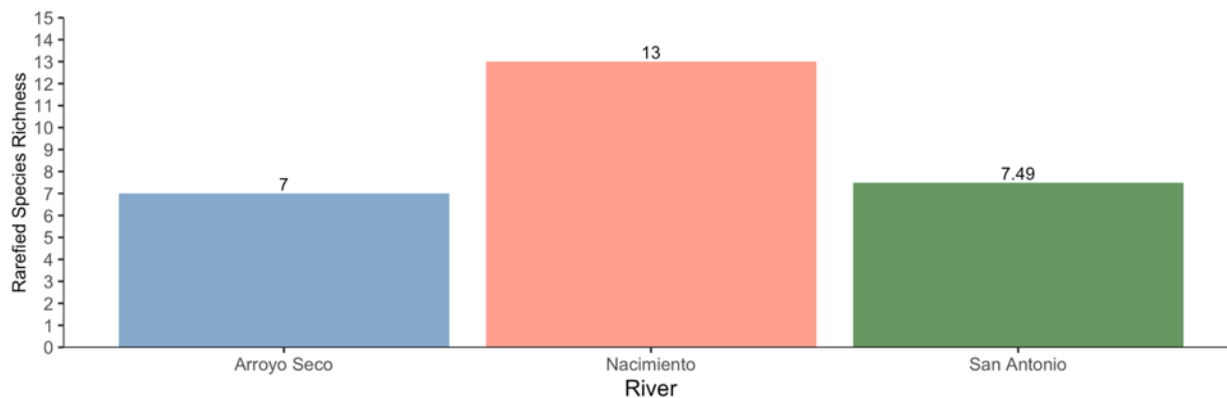


Figure 2. Rarefied species richness of combined sample sites in each river.

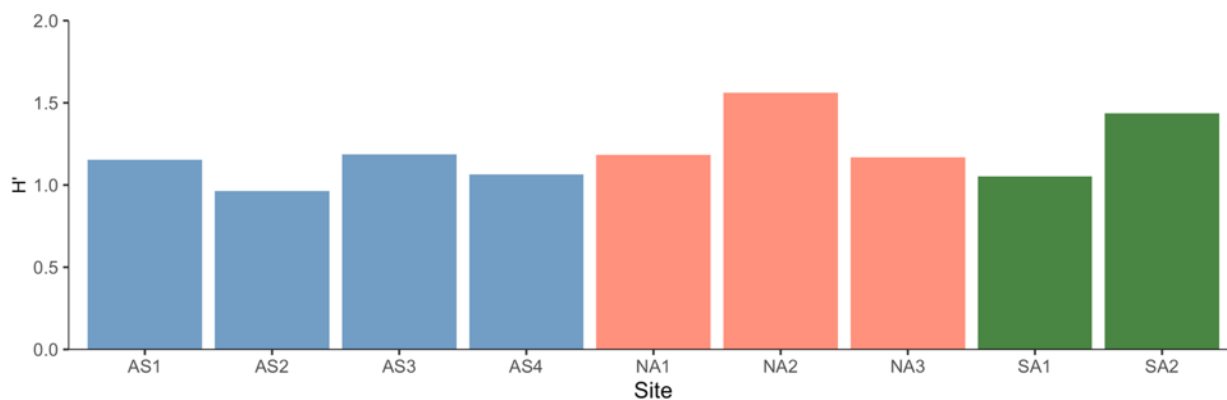


Figure 3. Shannon-Wiener Diversity Index (H') values of each sample site.

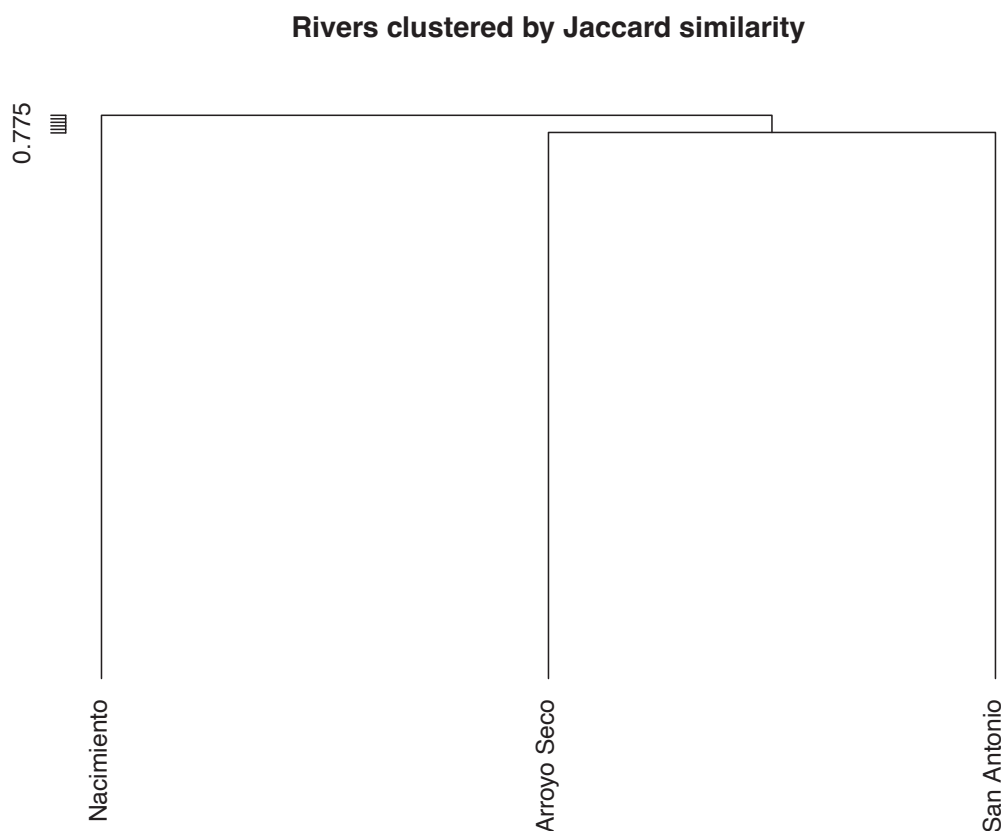


Figure 4. Fish catch across the sites in each of the three rivers clustered by Jaccard similarity.

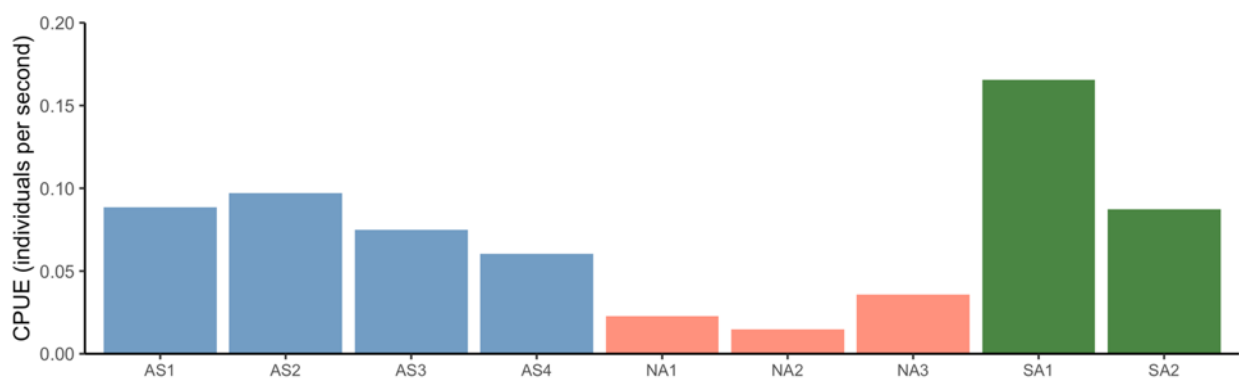


Figure 5. CPUE in terms of individuals captured per second of electrofishing effort. Note that Arroyo Seco site 5 is excluded as non-trout species were not counted or processed in that location.

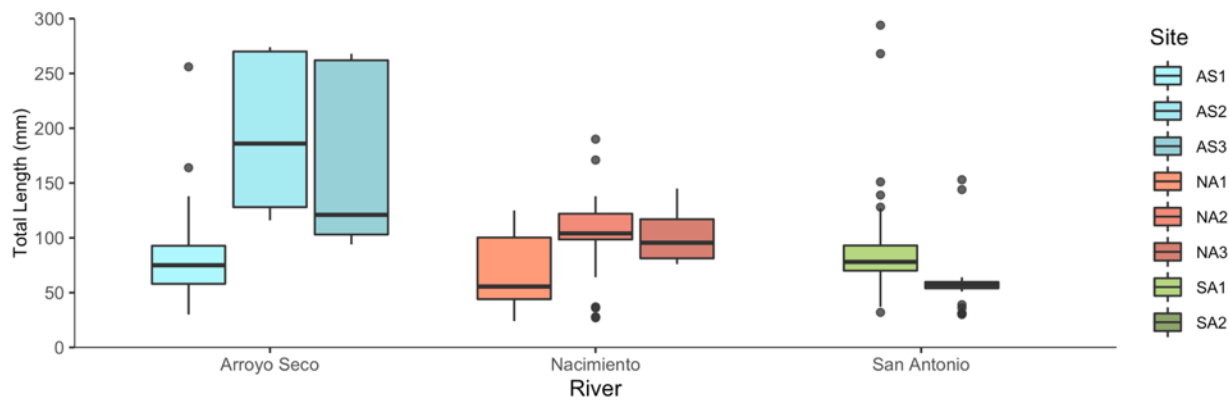


Figure 6. Length composition of fish captured in each of the sample sites. Note that sites 4 and 5 in the Arroyo Seco are excluded as non-trout species captured in those locations were not measured.

O. mykiss

A total of 15 *O. mykiss* were collected, all of which were captured in the Arroyo Seco River. Catch patterns in each tributary were similar to previous surveys, with no *O. mykiss* captured in the San Antonio, zero or few *O. mykiss* captured in the Nacimiento, and numerous *O. mykiss* observed in the Arroyo Seco. The absence of *O. mykiss* in the Nacimiento confirms insights gained through previous rotary screw trap and index reach monitoring, namely that the abundance and/or production of *O. mykiss* in the Nacimiento is exceedingly low. Abundance and distribution of *O. mykiss* in the Arroyo Seco River matched patterns observed in previous years, with *O. mykiss* being present as far downstream as the Arroyo Seco Road bridge and generally increasing in an upstream direction. The capture of 15 *O. mykiss* in the Arroyo Seco river is lower than previous electrofishing surveys from 2010-2013, but higher than observations that occurred during previous dry years (i.e., 2013 and 2022; Table 3). However, sites did not directly overlap with previously sampled locations, and upstream sites that have historically harbored more *O. mykiss* were not accessible during this year’s sampling effort.

Table 3. Capture history of *O. mykiss* during all index reach monitoring surveys that used electrofishing as a primary sampling method.

Year	San Antonio	Nacimiento	Arroyo Seco Sites 1-3	Arroyo Seco Sites 4-5	Annual Total
2010	-	-	20	14	34
2011	-	0	27	35	62
2012	-	1	21	0	22
2013	-	0	13	0	13
2018	0	2	4	0	6
2022	0	1	7	1	9

2023	0	0	15	-	15
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- Indicates no electrofishing sampling occurred

Sizes of captured *O. mykiss* ranged from 95 to 274 mm corresponding to ages ranging from zero (young of the year) to age 1+, based on analyses of scales collected during surveys (Figure 7). As expected for this time of year, none of the captured *O. mykiss* showed physical signs of preparing for migration.



Figure 7. An age 1+ *O. mykiss* captured in the Arroyo Seco River.

Discussion

The results from the 2023 surveys confirm the general patterns of population abundance and distribution in the basin. Namely, the quality habitat and relatively abundant population of *O. mykiss* in the Arroyo Seco River, the scarce population of *O. mykiss* below the dam in the Nacimiento River, and the absence of an *O. mykiss* population below the dam in the San Antonio River. Although *O. mykiss* densities in the Arroyo Seco were only moderately abundant compared to previous surveys, sampled sites occurred in the lower portions of the watershed, and patterns from previous surveys suggest that occupancy and density is lower in the downstream sites. Patterns of occupancy, however, are dependent on environmental conditions, and surveys during years with below-average discharge (e.g., 2013, 2022) have revealed either zero or very few *O. mykiss* in downstream index reaches. In 2023, multiple *O. mykiss* were observed in these downstream reaches, suggesting that above average precipitation in 2023 created more favorable conditions for *O. mykiss* in the lower watershed. Of note is a persistent population of non-native black bass in the vicinity of the Arroyo Seco campground. Black bass are known predators of salmonids and although they were not exceedingly abundant in the sampling sites, they still may pose a threat to rearing and migrating *O. mykiss* in the watershed.

In the Nacimiento River, the absence of *O. mykiss* matches findings from previous surveys, where only four individual *O. mykiss* have been captured in over five years of electrofishing sampling effort (one in 2012, two in 2018, one in 2022). Visual surveys have documented additional *O. mykiss* in the Nacimiento, but always at very low densities. These patterns mirror what was observed with rotary screw trap monitoring and confirm that steelhead production in the Nacimiento remains poor, despite it possessing characteristics associated with productive trout habitat. It was hypothesized that the high flows in 2023 may have resulted in a more robust *O. mykiss* population in the river, however, it is possible that these discharges may have caused unfavorable spawning and rearing conditions this spring when they peaked as high as 6,900 cfs in March. The Nacimiento provides relatively complex habitat, including a variety of substrates (e.g., gravel, cobble, bedrock), riparian vegetation, large woody debris, and varying river reaches from riffles to pools. Given this habitat potential, there are currently efforts underway to improve understanding of the relationships between habitat availability and flow for various *O. mykiss* life stages. Results from this analysis could lead to improved steelhead production in the tailwater. It should be noted, however, that several fish captured in the Nacimiento over the last few years of surveys appeared to be emaciated, and wounds and parasites were noticed on numerous fish (Figure 8). This may suggest poor conditions and potentially high rates of predation in the stream. Fish condition in the Nacimiento appeared to be improved in 2023, potentially due to benefits from higher flows and cooler water temperatures throughout the year.



Figure 8. An emaciated pikeminnow with numerous parasites and a Sacramento sucker with a large wound, both captured during 2022 surveys.

Encouragingly, index reach monitoring data has consistently revealed a resilient population of *O. mykiss* in the basin despite changing environmental conditions including multiple consecutive dry years (Figure 9). For example, during previous dry year sampling in 2014, *O. mykiss* were not observed in the Arroyo Seco, and the survey reaches consisted of isolated pools with poor water conditions (i.e., water temperatures $>20^{\circ}\text{C}$ and dissolved oxygen levels <6.0 mg/L). Although no sampling was conducted in 2015–2016 due to low-flow conditions, surveys in 2017 revealed multiple *O. mykiss* ranging in size from less than 100 mm (visually estimated) to larger than 300 mm at four of the five sites surveyed. The presence of various age classes during the 2017 survey provides evidence of juvenile production during dry years from 2014 to 2016 and indicates that *O. mykiss* likely sought refuge further upstream in the watershed where conditions were

seemingly better for spawning and rearing. Similarly, although conditions were poor in 2022 and followed another three consecutive years of drought, *O. mykiss* were still captured at nearly all sampling locations in the Arroyo Seco and at one site in the Nacimiento, confirming the persistence of the population despite challenging conditions.

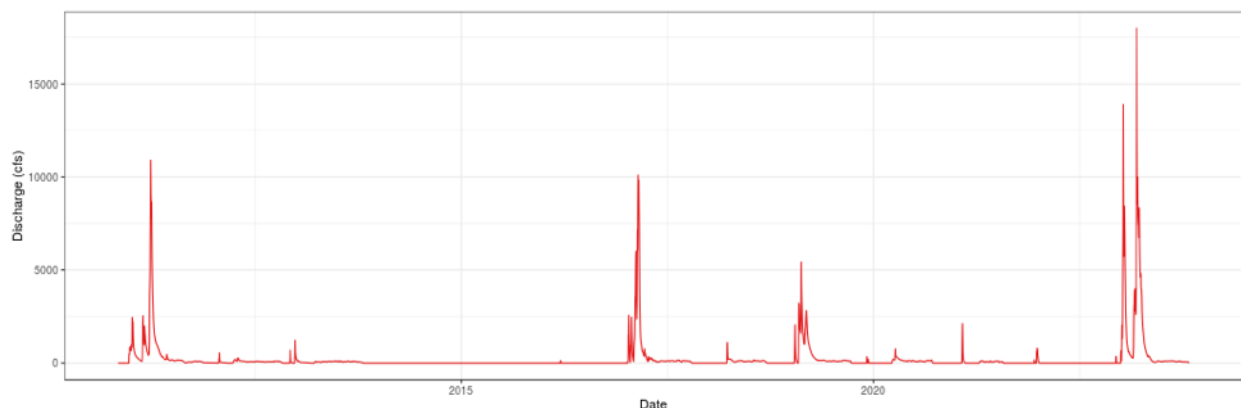


Figure 9. Annual discharge patterns in the Salinas River at Chualar from Nov. 2010 - Oct. 2023.

Due to the absence of an approved BO for the Salinas Basin, surveys are no longer required as a regulatory action. As such, there is an opportunity to develop new methods for fisheries monitoring in the basin. As noted above, methods were altered this year to increase efficiency, provide additional opportunities to capture juvenile *O. mykiss* in rivers with low abundance, and increase understanding of *O. mykiss* occupancy over a greater range. In addition, this year's surveys were designed to provide information on the potential for capturing greater numbers of juvenile *O. mykiss* for tagging in the Arroyo Seco, which would likely be a component of any future monitoring program. Although sampling was somewhat hindered by the inability to access the upper watershed where fish densities are presumably higher, it still appears feasible to tag a sufficient number of *O. mykiss* in the Arroyo Seco watershed to facilitate a PIT tag mark-recapture program through index reach sampling paired with outmigration monitoring (i.e., rotary screw traps, incline plane traps). Given likely monitoring changes in the basin with the implementation of the HCP, we recommend an expanded index reach monitoring program throughout the summer months to provide expanded tagging opportunities for *O. mykiss* and improve understanding of their distribution throughout the watershed. Sampling sites could be chosen with a spatially stratified sampling scheme such as Generalized Random Tessellation Stratified (GRTS) sampling that covers both mainstem and tributary habitats in the Arroyo Seco Basin. This is especially important as understanding of steelhead habitat use in the various Arroyo Seco tributaries remains largely unknown. These expanded surveys could also be used to understand juvenile production on an annual basis, and the increase in tagged fish over time would provide information on growth, survival, migratory patterns, rate of anadromy, and production among the various tributaries.

Several findings from the index reach monitoring conducted to date are applicable to the development of the HCP in the Salinas Basin. One of the key considerations for maintaining steelhead populations in the basin is the ability to support populations in the Nacimiento and San

Antonio Rivers. Historically, these streams provided relatively abundant habitat for *O. mykiss* in their upper reaches, with steelhead migration to and from the ocean occurring opportunistically depending on annual flow conditions (NMFS 2007; Stillwater Sciences 2020). Following the construction of dams on both streams, this habitat has been cut off from the rest of the basin, and steelhead populations are now confined to the tailwaters below the dams. Given that passage around the dams seems potentially infeasible or impractical and may actually be detrimental to the population (Lusardi and Moyle 2017; Ohms et al. 2022), efforts should be made to improve habitats in the tailwaters to support spawning and rearing conditions for *O. mykiss* and potentially to increase the prevalence of the migratory phenotype (Eschenroeder et al. 2022). In the San Antonio River, a self-sustaining population of steelhead appears highly unlikely given current habitat conditions. However, in the Nacimiento River, habitat improvements could be made through targeted restoration and revised flow schedules. These sorts of improvements may offer comparable, or quite possibly superior population benefits compared to the labor-intensive approach of manually moving fish around the dams and are likely much more feasible to sustain in the long term.

The Arroyo Seco River clearly provides the vast majority of steelhead habitat in the basin and attempting to maintain connectivity of this tributary to the ocean during the main migratory periods should remain a focus. Overall, the monitoring and research that has taken place to date in the Arroyo Seco does not appear commensurate with the importance of the basin. Further understanding of barriers to migration, potential habitat, and *O. mykiss* distribution and patterns of habitat use among the upper mainstem and tributaries of the Arroyo Seco remains a data gap and should also be prioritized. A recent review of available data on the Arroyo Seco watershed found that estimates of potential steelhead habitat in the Arroyo Seco vary substantially, in large part due to the paucity of surveys that have been conducted in the watershed and the lack of empirical evidence about barriers, fish occupancy, and habitat quality (Lee et al. 2021). Many of the Arroyo Seco tributaries have not been surveyed, and targeted flow-passage thresholds have never been determined for known barriers in the mainstem, despite passage barriers being identified as one of the top stressors in the Arroyo Seco (NMFS 2007). Data on existing barriers and passage potential is needed to refine estimates of available habitat in the watershed. In particular, an examination of the bedrock chute at river mile 31 is a necessary first step to determine if steelhead passage is possible into the upper tributaries, or if upstream populations are comprised of resident populations of *O. mykiss* that may contribute anadromous offspring. Strategic monitoring of *O. mykiss* and their habitats in the Arroyo Seco and its tributaries is arguably the most immediately critical activity for ensuring the long-term persistence of Salinas steelhead, and for facilitating future population recovery efforts.

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Appendix A – Data Management Plan

This data management plan is designed to ensure that project data are collected using peer-approved methods, undergo a quality control and accuracy assessment process, include metadata that meet CDFW’s minimum standards.

The following documentation provides evidence of the methods and quality control procedures that were used to meet Grant Agreement requirements.

1. **Who collected the data:** Dana Lee, Ethan Switzer, Miguel Ibarra, Madisyn Pyorre
2. **When the data was collected:** October 2023
3. **Where the data was collected:** Arroyo Seco, Nacimiento, and San Antonio Rivers
4. **How the data was collected (description of methods and protocols):** Surveys conducted by FISHBIO used a two backpack electrofishers and a four person crew to net fish. Potential trout habitat was preferentially targeted or favored for sampling across multiple several hundred meter long reaches in each river. Sampling locations were chosen to coincide with previously sampled locations and were designed to obtain an adequate overview of the spatial distribution of *O. mykiss* within each watershed. At each sampling location electrofishing proceeded in an upstream direction. All fish captured during each survey were identified to species and enumerated, and a subset of each species were measured. All *O. mykiss* were measured and weighed and scanned for the presences of a PIT tag, and if none was found, implanted with a PIT tag. All data sheets collected in the field were scanned (with electronic copies stored on a server) before the data was entered into a database. Prior to data analyses, the database underwent QA/QC procedures including being checked against field datasheets by two separate individuals. All datasheets were also stored as hard copies at the FISHBIO office.
5. **The purposes for which the data was collected:** Salinas index reach monitoring is intended to assist in determining the presence and spatial distribution of *O. mykiss* in tributaries of the Salinas River. The purpose of these sampling efforts is to assess the over-summer condition of the potential steelhead population in the basin. Objectives include evaluating presence or absence, condition, relative abundance (i.e., catch per unit effort; CPUE), and distribution of *O. mykiss* in the watershed.
6. **Definitions of variables, fields, codes, and abbreviations used in the data, including units of measure:** All species field codes are included below.
7. **The terms of any landowner access agreement(s), if applicable:** Not Applicable
8. **References to any related Department permits or regulatory actions:** Not Applicable
9. **Peer review or statistical consultation documentation:** All reports were reviewed by multiple parties, including the Grant recipient, and will also be published online and therefore subject to external peer review.
10. **Data licensing and disclaimer language:** All data is the property of Monterey County Water Resources Agency and is subject to their data licensing and disclaimer requirements.

Abbreviation Codes

Common Name	Species Code
American Shad	AMS
Bass Unknown	BAS
Bigscale Logperch	LP
Black Bullhead	BKB
Black Crappie	BKS
Blue Catfish	BLC
Bluegill	BGS

Common Name	Species Code
Rainbow / Steelhead Trout	RBT
Red Shiner	RSN
Redear Sunfish	RES
Redeye Bass	REB
Riffle Sculpin	RFS
River Lamprey	RL
Sacramento Blackfish	SCB

Brook Trout	BKT
Brown Bullhead	BRB
Brown Trout	BT
California Roach	CAR
Catfish Unknown	CAT
Channel Catfish	CHC
Chinook Salmon	CHN
Common Carp	C
Delta Smelt	DSM
Fathead Minnow	FHM
Golden Shiner	GSN
Goldfish	GF
Green Sturgeon	GST
Green Sunfish	GSF
Hardhead	HH
Hitch	HCH
Inland Silverside	MSS
Kern Brook Lamprey	KBL
Kokanee Salmon	KOS
Lamprey Unknown	LAM
Largemouth Bass	LMB
No Catch	NONE
Pacific Lamprey	PL
Pacific Brook Lamprey	BL
Pacific Staghorn Sculpin	PSS
Prickly Sculpin	PRS
Pumpkinseed	PKS

Stanislaus River Station	Station Code
Caswell State Park	ST004X
Caswell State Park – North Trap	ST004N
Caswell State Park – South Trap	ST004S
Oakdale Recreation Area	ST040X
Stanislaus Weir	ST031X
Calaveras River Station	Station Code
Shelton Rd.	CR028X
Merced River Station	Station Code
Gallo Ranch	ME041X
Hatfield Park – North Trap	ME002N
Hatfield Park – South Trap	ME002S

Condition Code	Description
1	Good
2	Fair (partial cell block)
3	Poor (total cell block)
4	No sample taken

Debris Code	Description
LIT	Light
MED	Medium
HVY	Heavy

Weather Code	Description
CLD	Cloudy
RAN	Rainy
CLR	Clear
NIT	Night

Sacramento Perch	SP
Sacramento Squawfish	SASQ
Sacramento Sucker	SASU
Sculpin Unknown	SCP
Shimofuri Goby	SHM
Smallmouth Bass	SMB
Speckled Dace	SPD
Splittail	SPLT
Spotted Bass	SPTB
Striped Bass	STB
Sturgeon Unknown	STG
Sunfish Unknown	SNF
Threadfin Shad	TFS
Threespine Stickleback	TSS
Tule Perch	TP
Unknown (Unid Juvenile Fish)	UNID
Unknown Centrarchid	CENT
Wakasagi	WAG
Warmouth	W
Western Mosquitofish	MQK
White Catfish	WHC
White Sturgeon	WST
Yellow Bullhead	YEB
Yellowfin Goby	YFG

Tuolumne River Station	Station Code
Grayson	TU005X
Grayson – North Trap	TU005N
Grayson – South Trap	TU005S
Waterford	TU030X
Tuolumne Weir	TU024X
Arroyo Seco River	Station Code
Arroyo Seco River	AS012X
Nacimiento River	Station Code
Nacimiento River	NR001X
Salinas River	Station Code
Upper Salinas	SR109X
Salinas Weir	SR003X

Mark Codes	Description
CFGN	Natural Origin
CFGH	Hatchery Origin
CFG*	Caudal Fin Green
CFR*	Caudal Fin Red
CFO*	Caudal Fin Orange
CFP*	Caudal Fin Pink
CFB*	Caudal Fin Blue
AFG*	Anal Fin Green
AFB*	Anal Fin Blue
TCR**	Top Caudal Fin Red
BCR**	Bottom Caudal Fin Red
DCB**	Double Caudal Fin Red

(*) Always indicate stock origin (H or N)

(**) Indicate if mark is specific to location on fish (T or B or D)

Gear Status	Description
0	Set trap
3	Check and raise trap

Appendix B – Invasive Species Prevention Plan

All field gear used in the Salinas Lagoon was properly disinfected following California Department of Fish and Wildlife Aquatic Invasive Species Disinfection/Decontamination Protocols prior to the start of fieldwork.

A detailed list of the relevant disinfection procedures and preventative measures that were used to prevent the spread of aquatic invasive species in the Salinas Watershed is listed below.

If equipment is used on the project that was previously working in another stream, river, lake, pond, or wetland within 10 days of initiating work, we implement one of the following procedures to prevent the spread of New Zealand Mud Snails and other aquatic hitchhikers:

(1) Remove all mud and debris from equipment (waders, nets, watercraft, etc.) and keep the equipment dry for 10 days. OR

(2) Remove all mud and debris from Equipment (waders, nets, watercraft, etc.) and spray/soak equipment with either a 1:1 solution of Formula 409 Household Cleaner and water, or a solution of Sparquat 256 (5 ounces Sparquat per gallon of water). Treated equipment must be kept moist for at least 10 minutes. OR

(3) Remove all mud and debris from equipment (waders, nets, watercraft, etc.) and spray/soak equipment with water greater than 120 degrees F for at least 10 minutes. OR (4) Remove all mud and debris from equipment (waders, nets, watercraft, etc.) and freeze equipment below 0 degrees F for at least 48 hours.