Salinas Lagoon Seining Report

Spring 2022

Submitted To:
Monterey County
Water Resources Agency

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Executive Summary

In fulfillment of the objective of determining the presence and spatial distribution of steelhead in the lower Salinas River to help inform the development of the Salinas River Habitat Conservation Plan (HCP), FISHBIO conducted fish community and water quality sampling of the lower Salinas River and Lagoon on May 9-10, 2022. This sampling event occurred 82 days after the sandbar had reformed at the lagoon mouth following a period of 51 days of connectivity with the ocean from December 27, 2021, through February 16, 2022. Water quality data collected during the seine sampling indicated brackish conditions resulting from the recent connectivity with the ocean. This high salinity was reflected in the composition of the fish community in the lower river, which was dominated by marine and euryhaline species. The predominant species detected in the seine catch were juvenile Pacific herring (*Clupea pallasii*) and Pacific staghorn sculpin (*Leptocottus armatus*). We hypothesize that these marine-origin species came to dominate the system during the period of connectivity with the ocean, and that their abundance is likely to decrease as the system transitions to a freshwater state. In total, 10 species of fish were captured during the sampling event, and four of these were represented only by single individuals. No new species records for the system were observed, as all captured species had been captured in the lower river in previous sampling events between 2002 and present.

No steelhead (*Oncorhynchus mykiss*) were observed during the May 2022 seine sampling event. However, water quality data indicate that abiotic factors were not limiting for rearing juvenile steelhead, as temperatures and dissolved oxygen levels remained within a suitable range for the species. To increase our ability to detect potentially very rare juvenile *O. mykiss*, we employed environmental DNA (eDNA) sample analysis. This is the first time this methodology has been employed in the standard lagoon monitoring. In total, three samples were collected at each of four sites ranging from the furthest upstream site to the lagoon slidegate. Multiple samples were collected at each location in order to maximize the likelihood of detection and to achieve replication in the event of a positive detection. Analysis of collected samples resulted in no detections of *O. mykiss* DNA. Although this is not definitive evidence that no *O. mykiss* are present in the lower river, the absence of their DNA in any of the collected samples combined with their absence in the seine catch lends further support to the hypothesis that they are either not present or present only in very low numbers.

A single adult (three- to four-year-old) striped bass (*Morone saxatilis*) was captured at the upstream-most sample site. Although CPUE for striped bass was quite low, additional individuals were observed at many of the sampling location. However, their large size and strong swimming ability allowed them to evade capture by the beach seine. We hypothesize that these apparently abundant striped bass may have significant impacts on imperiled native *O. mykiss* utilizing the lagoon habitat and suggest targeted sampling and diet analysis as a potential future effort to obtain more data on potential impacts.

Background

Monterey County Water Resources Agency (MCWRA) has played a leading role in monitoring and managing the Salinas Lagoon since 1996, when the organization adopted the Salinas River Lagoon Management and Enforcement Plan (MEP) that was developed by the multi-stakeholder Salinas River Task Force. Since that time, the recommended measures included in the MEP have primarily been implemented by MCWRA and its contractors, and the U.S. Fish and Wildlife Service (USFWS). The Salinas River Lagoon project area described in the MEP includes the lower portion of the river from the seasonally present sandbar separating the river from Monterey Bay to approximately two miles upstream.

Beginning in 2002, MCWRA implemented a Lagoon Monitoring Program, and this program was updated in 2010 to incorporate the recommendations of the National Marine Fisheries Service (NMFS) draft Biological Opinion for sandbar management (NMFS 2009). These changes were intended to mitigate potentially negative effects on lagoon-rearing steelhead (*Oncorhynchus mykiss*) belonging to the federally Threatened South-Central California Coast Distinct Population Segment (SCCC DPS; USFWS 1997). One component of this draft Biological Opinion was a requirement for sampling the fish community in the lower river in the spring and summer, in addition to the fall samples that MCWRA had been collecting in previous years. In subsequent years, samples were collected by Hagar Environmental Science (HES) in the spring, summer, and fall of 2011, 2012, and 2013, and spring of 2014. Since the withdrawal of the draft Biological Opinion in February 2019, fish community and water quality sampling has been conducted to support development of the Salinas River HCP, and resumed in the fall of 2020, with surveys conducted by FISHBIO. Sampling was conducted in October of 2020 and April of 2021, but was not performed in the fall of 2021. Sampling was most recently performed in May of 2022. In total, Salinas Lagoon seine sampling has been conducted 22 times since sampling began in 2002 (six spring events, four summer events, and 12 fall events: Table 1).

Table 1. Temporal coverage of Salinas Lagoon sampling events from 2002 to 2022.

Year	Spring	Summer	Fall
2002	-	-	October
2003	-	-	October
2004	-	-	October
2005	-	-	October
2006	-	-	October
2007	-	-	-
2008	-	-	October
2009	-	-	October
2010	-	August	October
2011	May	August	October
2012	April	July	October
2013	April	July	October
2014	April	-	-
2015	-	-	-
2016	-	-	-
2017	-	-	-
2018	-	-	-
2019	-	-	-
2020*	-	-	October
2021*	April	-	-
2022*	May	-	TBD

*Sampling conducted by FISHBIO

The fish community composition in the lagoon is largely dependent on freshwater inflow from the Salinas River that affects water quality and habitat conditions. The early winter of 2021 was wetter than average (Table 2), with 154% of normal precipitation (6.11 inches) as measured in Salinas and 150% of normal precipitation (5.37 inches) as measured in King City falling in the first quarter of the 2022 water year (September through December, 2021; MCWRA 2022). A significant proportion of this precipitation came in the form of a storm event at the end of December, which necessitated facilitated lagoon breaching on December 27, 2021. However, conditions were considerably drier in the spring, with the report for the second quarter (January through March 2022) indicating only 11% of average rainfall (0.76 inches) in Salinas and 17% of average rainfall (1.15 inches) in King City (Table 2; MCWRA 2022a).

Table 2. Summary of precipitation as a percentage of average by water year quarter. Precipitation accumulation measured at the Salinas Airport and in King City.

Water Year	Quarter	Salinas Precipitation (in)	% of Average Precipitation	King City Precipitation (in)	% of Average Precipitation
2019-2020	4th (July-Sep 2020)	0.20	10	0.17	18
2020-2021	1st (Oct-Dec 2020)	3.91	24	3.72	30
2020-2021	2nd (Jan-Mar 2021)	7.35	65	7.03	88
2020-2021	3rd (Apr-Jun 2021)	5.75	46	7.33	62
2020-2021	4th (July-Sep 2021)	0.04	20	0.01	6
2021-2022	1st (Sep-Dec 2021)	6.11	154	5.37	150
2021-2022	2nd (Jan-Mar 2022)	0.76	11	1.15	17

MCWRA can partially regulate the water level in the lagoon via releases to the Old Salinas River through the lagoon outlet slidegate. However, once the lagoon stage exceeds approximately six feet, MCWRA conducts facilitated breaching to prevent flooding of crop fields and residences adjacent to the lower river (USFWS 2007). In December of 2021, the sand bar at the Salinas Lagoon remained closed until the lagoon reached a stage of 6.3 feet and over-topped the channel that was excavated by MCWRA crews on December 27, 2021. Following the facilitated breach, the lagoon remained open for approximately 51 days until the sand bar barrier was restored by diminishing river discharge and wave action on February 16, 2022 (Figure 1).

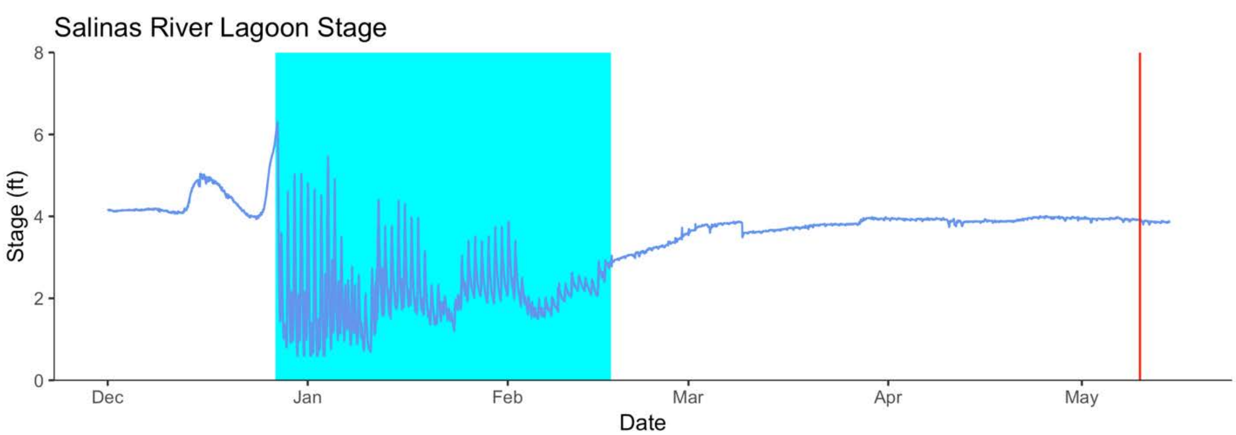

Figure 1. Water level (in feet) of the Salinas River lagoon from December 1, 2021, through May 15, 2022. The highlighted portion of the plot indicates the period when the sand bar was breached, and the river was connected to Monterey Bay (December 27, 2021, through February 16, 2022). The vertical red line indicates the date of spring seine sampling.

Figure 2. The downstream-most arm of the lagoon adjacent to the breach site (formerly three distinct sample sites) was sampled with a single seine haul due to its very narrow configuration in May of 2022.

Methodology

Fish Community Sampling

Salinas Lagoon sampling is intended to assist in determining the presence and spatial distribution of steelhead in the lower Salinas River and Lagoon. The purpose of these sampling efforts is to capture any juvenile SCCC DPS steelhead that may be rearing in the lagoon. Objectives include evaluating presence or absence, condition, relative abundance (i.e., catch per unit effort; CPUE), and distribution of juvenile steelhead in the Salinas Lagoon.

The downstream end of the Salinas lagoon is characterized by open, sandy, gradual beaches that are particularly suitable for beach seining. However, the highly mobile nature of the substrate in the lower lagoon, combined with high flows and tidal action, make this portion of the river a very dynamic area. The period of connectivity with the ocean this winter and early spring led to significant changes in the configuration of the lagoon, with a significant narrowing of the downstream-most arm (i.e., the breach site and its surrounding area) compared to past years. This physical change required an adjustment to some of the sampling locations, which deviated slightly from the sites established in the previous two years of surveys. Instead of collecting three distinct seine hauls around the perimeter of the breach site (sites 1–3; Figure 2, Figure 3), a single seine haul covering virtually the entire width of the lower lagoon was conducted. However, samples were also collected adjacent to the Old Salinas River slidegate and along the beach immediately opposite the slidegate (Station 5; Figure 3), as they had been in previous years.

FISHBIO field crews attempted to conduct sampling at each of the established upstream sampling locations, but ultimately found that one of these sites could not be sampled due to the presence of large woody debris that could not be moved (Station 8; Figure 3). Instead, a seine sample was collected approximately 0.25 miles upstream underneath the Highway 1 Bridge (Figure 3). In total, 10 seine hauls were conducted across 10 sites (Stations 1+2+3 combined, 4, 5, 6, 7, Highway 1 Bridge, 9, 10, 11, 12; Figure 3).

Fish community sampling was conducted using a 100-foot beach seine with 1/4-inch mesh. At each sampling site, the seine was set in a semi-circle a short distance from shore. Crew members then pulled the seine onto shore, while ensuring the float line stayed above the surface and keeping the lead line as close to the substrate as possible. At sites where water depths precluded wading, an inflatable raft was used to deploy the seine. These protocols and the dimensions of the net mean that the maximum area that could be sampled by each seine haul was approximately 3,520 ft^2 (~327 m^2), although the true value was less than this due to the presence of obstacles and variations in wind direction that shifted the net.

Once the seine was pulled onto shore, crews quickly processed captured fish by placing specimens to be measured in aerated recovery buckets and counting extremely abundant species before releasing them. Once all fish were removed from the net, crews recorded fork and total length data on at least 30 individuals of each captured species (with the exception of threespine stickleback; *Gasterosteus aculeatus*), before plus-counting any remaining individuals. Because of a recent striped bass (*Morone saxatilis*) mark-recapture study in the Salinas lagoon, captured striped bass were first scanned for passive integrated transponder (PIT) tags using an Oregon RFID handheld PIT tag reader before implanting untagged individuals with a 13 mm tag and recording the identification number on the datasheet. Crews then verified the tag number by scanning it once more and sealed the injection site with tissue glue prior to releasing the individual. The same protocol would have been applied to any captured *O. mykiss*, but none were encountered.

Water Quality Sampling

After fish processing was completed, crews collected water quality data using a YSI water quality sampling meter in the sampled area. Staff used the YSI to measure temperature (˚C), specific conductivity (µS/cm at 25˚C), conductivity (µS/cm), salinity (parts per thousand; ppt), and dissolved oxygen (mg/L) at the surface.

Data Analysis

Data collected during this sampling effort was added to a database of compiled HES and FISHBIO data, and analyzed for CPUE. Because raw data was not available for HES surveys and their CPUE was calculated as individuals per 10 seine hauls, all data was first standardized to individuals captured per seine haul, to account for differences in effort between the two surveys and to ensure comparability with FISHBIO survey data. Cumulative and species-specific CPUE was then calculated for each sampling event. Data collected during FISHBIO surveys was also analyzed for species diversity at each sampling location within the lagoon using the Shannon-Weiner Diversity Index.

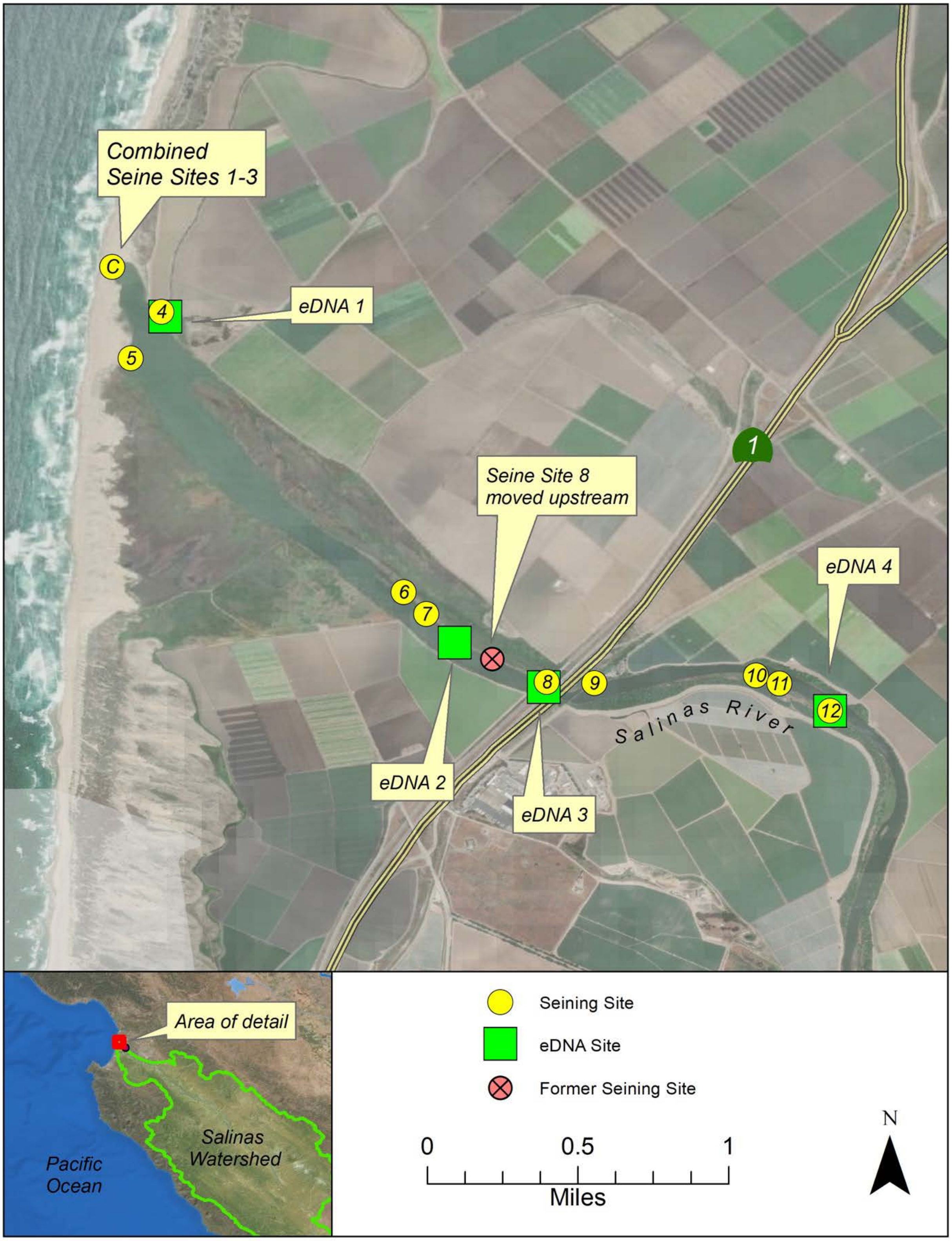

Figure 3. Stations sampled by FISHBIO in May 2022.

Results

Fish Community Sampling

A total of 1,400 fish representing 10 different species were captured in May 2022 (Table 3). Total CPUE was 14 percent higher than in April 2021 and was the highest of any spring sampling event to date (Table 3). CPUE from past summer and fall sampling events is also presented in the Appendix for comparison (Tables A1 and A2). All species captured in the May 2022 sampling event have been observed in the system before, and no *O. mykiss* were captured in the seine samples.

Table 3. Cumulative and species-specific catch per unit effort (CPUE) across the six spring sampling events from 2011–2022. Note that CPUE is calculated using a single seine haul as the base unit of effort. Non-native species are indicated by bolded common and scientific names.

		Date	**May 2011**	**April 2012**	**April 2013**	**April 2014**	**April 2021**	**May 2022**
		Total Seine Hauls	16	17	14	8	12	10
Family	**Common Name**	**Scientific Name**						
Petromyzontidae	Pacific lamprey	*Petromyzon tridentata*	0	0.10	0	0	0	0
Clupeidae	Pacific herring	*Clupea pallasii*	0	2.90	89.80	0	104.42	67.80
	Threadfin shad	***Dorosoma petenense***	0	0.10	0	0	0	0
Cyprinidae	**Common carp**	***Cyprinus carpio***	0	0.20	0	0	0	0
	Hitch	*Lavinia exilicauda*	8.30	11.80	6.50	0	0.08	0.10
	Sacramento blackfish	*Orthodon microlepidotus*	0.10	0.90	0	0	0	0
	Sacramento pikeminnow	*Ptychocheilus grandis*	0	0.10	0	0	0	0
Catostomidae	Sacramento sucker	*Catostomus occidentalis*	2.30	1.10	0.20	0	0	0
Osmeridae	Topsmelt	*Atherinops affinis*	0	0	0	0	1.08	2.30
	Steelhead	*Oncorhynchus mykiss*	0.1	0.1	0	0	0	0
Poeciliidae	**Western mosquitofish**	***Gambusia affinis***	0	0	0	0	0.08	0.70
Atherinidae	**Inland silverside**	***Menidia beryllina***	0	0	0	0	0.58	0
Cottidae	Pacific staghorn sculpin	*Leptocottus armatus*	5.30	0	15.9	0	15.5	18.8
	Prickly sculpin	*Cottus asper*	0.20	0.8	0	1.3	0.67	1.50
Gasterosteidae	Threespine stickleback	*Gasterosteus aculeatus*	0	6.60	1.90	10.40	0.25	48.5
Embiotocidae	Shiner surfperch	*Cymatogaster aggregata*	0.20	0.20	0	0	0	0
Moronidae	**Striped bass**	***Morone saxatilis***	0.30	2.40	0.60	0	0.08	0.10
Gobiidae	Tidewater goby	*Eucyclogobius newberryi*	0	0	0	7.30	0	0
	Yellowfin goby	***Acanthogobius flavimanus***	0	0	0.10	0	0.17	0.10
Scianidae	White croaker	*Genyonemus lineatus*	0	0	0	0	0.08	0
Paralichthyidae	Speckled sanddab	*Citharichthys stigmaeus*	0	0	0	0	0.08	0.10
Pleuronectidae	Starry flounder	*Platichthys stellatus*	0.10	1.1	0	0	0	0
		Total CPUE	16.90	28.40	115	19	123.07	140
		Native Species	8	11	5	3	8	7
		Non-native Species	1	3	2	0	4	3
		Total Number of Species	9	14	7	3	12	10

Shannon Wiener Diversity Index (H') values were calculated for each of the sampling stations. This diversity index is a quantitative measurement that takes both species richness and abundance into account, and serves as a statistical representation of biodiversity. The index ranges from 0 (no diversity) to 5 (extremely high diversity), but H' values typically range from 1.5 to 3.5 (Gaines 1999). Shannon-Weiner Diversity ranged from 0.34 to 1.18 across the 10 sampling locations (Table 4), with the highest values occurring at the furthest upstream stations. This increase in diversity at upstream locations is likely driven by the lower salinity in these areas, which allowed for co-occurrence of both the euryhaline species that dominated the lower lagoon (e.g., Pacific herring and Pacific staghorn sculpin) and species with lower salinity tolerances (e.g., three-spined stickleback, hitch, western mosquitofish).

Table 4. Shannon-Weiner Diversity (H') values calculated for each sampling station.

Station	Shannon-Weiner Diversity (H')
Combined Stations 1–3	0.54
4	0.56
5	0.56
6	0.65
7	0.35
Adjusted Station 8 (Hwy 1 Bridge)	0.56
9	0.84
10	1.18
11	1.06
12	1.01

A single adult striped bass was captured at site 10 (Figure 4). Scanning indicated that this fish had not previously been implanted with a PIT tag, and therefore a 13-mm tag was injected into the individual prior to release. The fork length of this fish was 528 mm, suggesting it was three to four years old. This length also falls within the size range of the 237 striped bass that were tagged in the Salinas Lagoon by NMFS and Trout Unlimited between November 2019 and March 2020 (Tommy Williams, personal communication).

Although only a single striped bass was captured, this low CPUE does not reflect the species' true abundance in the system. During sampling, the field crew observed numerous large-bodied fish at many of the sample sites, which were presumed to be striped bass. The large size and strong swimming ability of these fish makes them difficult to capture with the beach seine, particularly in areas where debris is present and in areas where high winds make it difficult to quickly pull the net. The fact that striped bass have been caught in the past three seine sampling efforts conducted by FISHBIO despite the noted inefficiency of this gear for capturing this species is likely a testament to their abundance in the lagoon.

Figure 4. Striped bass captured in the May 2022 sampling. This individual did not possess an existing PIT tag, and therefore was tagged prior to release.

Environmental DNA

A total of 12 eDNA samples were collected during the sampling period (Table 5). Three samples were collected at each of four sites ranging from the Old Salinas River slidegate (Figure 5) to the upstream-most sample site (Station 12; Figure 3). Samples were collected in triplicate to increase the total volume of water sampled (and thereby increase *O. mykiss* eDNA detection probability), and to allow for replicability to improve confidence in the validity of results. Sample volumes were consistent among the three samples at each site, with 60 mL filtered per sample at the three upstream sites and 40 mL filtered per sample at the Old River slidegate site due to higher turbidity that more rapidly clogged the filter in that location. Samples were submitted to Jonah Ventures (Boulder, Colorado) for qPCR (laboratory methodology available in Appendix). The analysis did not detect *O. mykiss* DNA at any of the three sampled locations.

Table 5. Environmental DNA samples and detection results.

Date	Sample #	Volume (mL)	Location	*O. mykiss* DNA Detected?
5/9/22	1	40	Old River Slidegate	No
5/9/22	2	40	Old River Slidegate	No
5/9/22	3	40	Old River Slidegate	No
5/10/22	4	60	Station 6	No
5/10/22	5	60	Station 6	No
5/10/22	6	60	Station 6	No
5/10/22	7	60	Highway 1 Bridge	No
5/10/22	8	60	Highway 1 Bridge	No
5/10/22	9	60	Highway 1 Bridge	No
5/10/22	10	60	Station 12	No
5/10/22	11	60	Station 12	No
5/10/22	12	60	Station 12	No

Figure 5. Collecting an eDNA sample from the lagoon adjacent to the Old Salinas River slidegate.

Water Quality Sampling

Water quality sampling during the seining survey revealed that brackish conditions continue to persist following the lagoon connectivity with the ocean in early winter. Salinities ranged from 7.18 parts per thousand (ppt) at the sampling location farthest upstream (Station 12; Figure 3), to 11.82 ppt near the sandbar; Table 6). Dissolved oxygen concentrations were found to be extremely high (supersaturation), which may be attributable to active photosynthesis by microalgae. The presumed high abundance of suspended microalgae may be supported by high nutrient concentrations which are frequently documented through water chemistry monitoring by the Elkhorn Slough Foundation (results available at http://water.elkhornslough.org/), and likely also contributed to the high turbidity in the lagoon. As photosynthesis requires sunlight, oxygen concentrations are likely to decrease substantially overnight. Conditions encountered during field sampling were generally well within the environmental tolerances of the native fish species in the Salinas River basin, including steelhead and tidewater goby (*Eucyclogobius newberryi*).

Of note, sampling for tidewater goby with a small-mesh (⅛ inch) handheld beach seine on May 9 indicated an extremely high abundance of Mysid shrimp at most sampling locations throughout the lagoon. We suspect that high algal abundance currently supports the extreme abundance of these crustaceans. The shrimp, in turn, serve as a prey resource for fish in the lagoon. As such high concentrations of shrimp have not been observed during our previous surveys, we expect that they will not be sustained at their current level of abundance as their food base decreases and salinity concentrations become progressively lower over the spring and summer months.

Table 6. Summary of water quality parameters collected concurrently with beach seining on May 9 and 10, 2022.

Station	Temp (ºC)	Dissolved Oxygen (mg/l)	Oxygen Saturation (%)	Salinity (ppt)	Conductivity (µS/cm)
Combined Stations 1–3	17.8	11.56	128.9	11.82	17,788
4	18.8	9.63	108.9	11.82	17.788
5	16.8	8.17	83.0	11.82	17,788
6	16.5	18.34	197.7	8.11	13,740
7	15.3	12.15	139.8	7.75	13,200
Adjusted Station 8 (Hwy 1 Bridge)	17.1	19.81	224.1	7.57	13,085
9	20.5	19.83	231.0	8.01	13,903
10	19.4	20.32	229.7	7.87	13,675
11	20.5	22.64	246.5	7.65	13,331
12	19.3	22.61	242.5	7.18	12,798

Species Discussion

The sampling in May of 2022 is a snapshot of the fish community following a period of 82 days of lagoon closure after a period of 51 days of connectivity with Monterey Bay. Despite the extended period of closure, the fish community in the system continued to be dominated by marine and euryhaline species, particularly Pacific herring and Pacific staghorn sculpin. In the sections below, we provide a discussion of the changes in abundance of key species, and implications for lagoon use by rearing juvenile steelhead.

Striped Bass

As noted in previous reports, the results of a collaborative study by NMFS and Trout Unlimited suggest a very large population of striped bass resides in the lower Salinas River, and most of these fish appear to be between two and five years of age (Tommy Williams, personal communication). Between November 2019 and March 2020, the project implanted 237 individual striped bass with PIT tags. Another 527 untagged fish were captured by anglers participating in the study, although they may not all have been unique individuals. In total, only three tagged fish were recaptured by anglers, which has precluded accurate estimates of population abundance (the preliminary estimate was 31,053 individuals, with a 95% confidence interval of 15,527–124,210). As large-bodied fish with strong swimming abilities, it is likely that the 100-foot beach seine used in the Salinas Lagoon surveys is not particularly efficient at capturing striped bass. Despite this gear inefficiency, a single individual was captured in May 2022. This brings the total number of striped bass captured by FISHBIO surveys from October 2020 through May 2022 to six. Each of these captured striped bass has been found to be untagged, and FISHBIO field crews have implanted each with a unique PIT tag prior to releasing.

The apparent high density of striped bass in the lower Salinas River has important implications for the food web. As efficient predators, striped bass are known to be adept at prey-switching to whichever prey species becomes most abundant in a system (Nobriga and Feyrer 2008). It is possible that the striped bass population shifts their predatory focus from threadfin shad to Pacific herring as the fish community changes seasonally, but a lack of diet samples precludes testing this hypothesis. Striped bass are generally non-discriminating in the species they prey upon, and they can rapidly take advantage of new prey sources as they become available. These factors combined with the apparently very high abundance of this invasive predator in the Salinas Lagoon has potentially significant implications for juvenile steelhead that may utilize the lagoon habitat for rearing.

Pacific Herring

Large numbers of herring have been detected in previous sampling events (Table 3; Tables A1, A2), and as in previous years the vast majority appeared to be young-of-the-year fish. In May 2022, herring were broadly distributed across all sample sites and were captured in all seine hauls; however, they were most abundant in the lower lagoon. The seine haul performed adjacent to the breach site (combined Stations 1–3; Figure 3) captured 525 Pacific herring, whereas the seine haul further upstream at Station 7 (Figure 3) captured only three. The abundance of juvenile herring appears to be in line with the species' reproductive ecology in Central California, where their spawning is believed to peak in February or March (Bollens and Sanders 2004). This spawning leads to peak abundances of age-0 juvenile Pacific herring in the San Francisco Estuary between April and August (Fleming 1999). Spawning herring are known to congregate in dense schools in deep-water channels of bays, and then move inshore to subtidal and intertidal habitats in bays and estuaries (CDFW 2019). Data from this year's sampling and that of previous spring sampling events suggest that Pacific herring routinely move into the lower Salinas during the period of connectivity with the ocean in the late winter and early spring. In the most recent fall sampling (October 2020), no herring were observed, and they have only been sporadically detected in fall sampling events since 2002. This suggests that herring that enter the lower Salinas may not persist as salinity decreases over the summer and fall months. In recent years, it appears they may be supplanted by threadfin shad (*Dorosoma petenense*) moving downstream from the upper Salinas River watershed in the summer and fall (potentially from upstream reservoirs).

Pacific Staghorn Sculpin

During the May 2022 sampling, Pacific staghorn sculpin CPUE was the highest observed since August of 2010. This species is frequently found in the lower reaches of coastal streams and can spend their whole lives in estuaries (Moyle 2002), but their presence in the Salinas Lagoon has fluctuated markedly since 2002, with relatively low but persistent catch rates punctuated by periodic increases in abundance (e.g., summer of 2010; spring of 2013, 2021, and 2022). In May 2022, Pacific staghorn sculpin were the second most abundant species captured (after Pacific herring). Fluctuations in the abundance of Pacific staghorn sculpin likely coincide with the timing of lagoon breaching as well as water quality conditions in the lagoon, as the species is known to migrate with tides and seasonal fluctuations in salinity. Spawning occurs from October to April, with a peak in January and February in areas with stable salinity. Due to the small size of individuals captured during the May sampling event, most individuals were likely young-of-the-year fish that were born sometime in the fall or winter of 2021.

Conclusions

The Salinas Lagoon is a dynamic system that is marked by sudden, dramatic shifts in depth, discharge, and water quality, and associated shifts in the composition of the aquatic community. Historically, this system had an extensive floodplain that would be seasonally inundated, and estimates suggest that the area of open water in the lagoon may have been approximately 340 acres in 1910 (NMFS 2007). This expansive wetland likely provided rearing habitat for juvenile steelhead throughout the year. Disconnection of this former wetland habitat, changes in the hydrograph, habitat alterations, and nonnative species introductions have reduced the suitability of the Salinas Lagoon for rearing steelhead.

Juvenile steelhead have rarely been detected in the lagoon, appearing in only five of the past 22 surveys that have occurred between 2002 and 2022 (Table 3; Tables A1, A2). They were last detected during the seining effort in October 2013, and they have not been captured in any of the seining efforts conducted by FISHBIO since 2020. When the species has been detected in the lagoon, the CPUE has never exceeded 0.1 individuals per seine haul. The incorporation of eDNA sampling into the standard lagoon sampling protocol this spring provides further evidence that steelhead are either not present or very rare in the lower river. Repeated inclusion of eDNA methodology in future lagoon sampling is worthwhile given its potential informational value. Although negative detections do not provide conclusive evidence of steelhead absence, they do strengthen confidence that the species is rare at most. On the other hand, a positive eDNA detection would definitively demonstrate steelhead presence even if traditional seine sampling failed to detect them.

Water quality data suggest that abiotic factors such as dissolved oxygen and water temperature have remained within a range suitable for rearing juvenile steelhead, and as such, are likely not responsible for the absence of the species from the lower river. Biotic factors, however, may be playing a more significant role in reducing juvenile steelhead lagoon use. Today, striped bass are the most abundant anadromous species in the river, and likely serve as the most significant remaining connection between the marine and freshwater food webs. Striped bass have been shown to be important predators of juvenile steelhead in other systems in California (Michel et al. 2018), and may occur at very high densities (e.g., 1,227 individuals per river kilometer; Michel et al. 2018). There are still no accurate estimates of the total striped bass population in the Salinas, but their apparent density in the lower section of the river suggests that their population is quite large. This abundance combined with the species' ability to rapidly adapt to new prey sources as they become available (Nobriga and Feyrer 2008) may play a role in limiting use of the lagoon by rearing juvenile steelhead. However, striped bass may focus their predation on the abundant forage fish species (e.g., Pacific herring, threadfin shad) that have been frequently detected in lagoon surveys, and this may limit their impact on any juvenile steelhead utilizing the lagoon as rearing habitat. Further investigation into the ecology and dynamics of the Salinas striped bass population – including studies on their natal origin, their movement, their dietary composition, and their abundance across seasons and years – are warranted in order to investigate their impacts on steelhead and to better comprehend their potential influence on steelhead recovery actions.

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Appendix

Table A1. Cumulative and species-specific catch per unit effort (CPUE) across the four summer sampling events ranging from August 2008 to July 2013. Note that CPUE is calculated using a single seine haul as the base unit of effort. Non-native species are indicated by bolded common and scientific names.

		Date	**Aug 2010**	**Aug 2011**	**July 2012**	**July 2013**
		Total Seine Hauls	7	9	13	13
Family	**Common Name**	**Scientific Name**				
Clupeidae	Pacific herring	*Clupea pallasii*	35.70	0	0	0.80
	Pacific sardine	*Sardinops sagax*	0.10	0	0	0
Cyprinidae	**Common carp**	***Cyprinus carpio***	0.10	0	0	0.60
	Hitch	*Lavinia exilicauda*	134.10	4.10	16.20	4.50
	Sacramento blackfish	*Orthodon microlepidotus*	33.60	0	0.10	0.10
	Unidentified cyprinid	*Cyprinidae*	0.10	0	0	0
Catostomidae	Sacramento sucker	*Catostomus occidentalis*	45.90	0	2.60	1.10
Osmeridae	Topsmelt	*Atherinops affinis*	15.10	0	0	0
Salmonidae	Steelhead	*Oncorhynchus mykiss*	0	0.10	0	0
Poeciliidae	**Western mosquitofish**	***Gambusia affinis***	0	0.40	1.50	0.20
Cottidae	Pacific staghorn sculpin	*Leptocottus armatus*	33.30	0.60	0.90	0.80
	Prickly sculpin	*Cottus asper*	5.40	0.40	20	5.10
	Unidentified sculpin	*Cottidae*	0.30	0	0	0
Gasterosteidae	Threespine stickleback	*Gasterosteus aculeatus*	347.60	3.40	5.10	21.20
Embiotocidae	Shiner surfperch	*Cymatogaster aggregata*	13.40	0	0	0
Moronidae	**Striped bass**	***Morone saxatilis***	0.40	0	2.40	3.60
Centrarchidae	**Largemouth bass**	***Micropterus salmoides***	0	0	0	0.10
Gobiidae	**Yellowfin goby**	***Acanthogobius flavimanus***	0	0	0	4.60
	Unidentified goby	*Gobiidae*	0.50	0	0	0
Sebastidae	Unidentified rockfish	*Sebastes spp.*	0.20	0	0	0
Pleuronectidae	Starry flounder	*Platichthys stellatus*	0.90	0.10	0.10	0.10
		Total CPUE	666.70	9.10	30.90	42.80
		Native Species	15	6	7	8
		Non-native Species	2	1	2	5
		Total Number of Species	17	7	9	13

Table A2. Cumulative and species-specific catch per unit effort (CPUE) across the 12 fall sampling events ranging from October 2002 to October 2020. Note that CPUE is calculated using a single seine haul as the base unit of effort. Non-native species are indicated by bolded common and scientific names.

		Date	**Oct 2002**	**Oct 2003**	**Oct 2004**	**Oct 2005**	**Oct 2006**	**Oct 2008**	**Oct 2009**	**Oct 2010**	**Oct 2011**	**Oct 2012**	**Oct 2013**	**Oct 2020**
		Total Seine Hauls	9	17	5	17	9	8	12	12	16	17	12	8
Family	**Common Name**	**Scientific Name**												
Clupeidae	Pacific herring	*Clupea pallasii*	0.70	0	6.60	62.90	0.30	194.10	4.40	41.60	56.40	0	0.20	0
	Threadfin shad	***Dorosoma petenense***	0.20	4.80	27.80	0	0	12.90	0	0	0	0	5.10	29.88
Cyprinidae	**Common carp**	***Cyprinus carpio***	0.10	0.30	12.60	3.60	0	0	0.10	0	0	0	0.20	0
	Goldfish	***Carassius auratus***	0	0	0	0	0	0	0	0	0	0	0	0.13
	Hitch	*Lavinia exilicauda*	30.40	67.60	180	36.70	0.10	20.30	8.50	6.10	0.80	0	0.60	4.13
	Sacramento blackfish	*Orthodon microlepidotus*	0	3.20	1.40	18.10	0.10	0.60	0	30.30	0	0	0.10	0
	Sacramento pikeminnow	*Ptychocheilus grandis*	0	0.10	0	0	0	0	0	0	0	0	0	0
Catostomidae	Sacramento sucker	*Catostomus occidentalis*	3.80	13.80	90	18.10	0	0.10	0.10	3.10	0	0	0.10	0.25
Osmeridae	Topsmelt	*Atherinops affinis*	0	0	7	0	44.60	10.40	11.20	12.70	21.30	0	0	0
Salmonidae	Chinook salmon	*Oncorhynchus tshawytscha*	0.10	0	0	0	0	0	0	0	0	0	0	0
	Steelhead	*Oncorhynchus mykiss*	0	0	0	0	0	0	0	0	0.10	0	0.10	0
Poeciliidae	**Western mosquitofish**	***Gambusia affinis***	0	0.10	640	6.10	0	0	0	0.90	0	0.40	0.10	0
Atherinidae	**Inland silverside**	***Menidia beryllina***	0	0	0	0	0	0	0	0	0	0	0	0.38
Cottidae	Pacific staghorn sculpin	*Leptocottus armatus*	0.60	0.40	1	0.80	0	1.50	0.90	0.50	0.20	0.10	0.30	0.13
	Prickly sculpin	*Cottus asper*	0.10	0.40	5.40	0.10	0	0.30	0.20	1.90	0.40	0.40	0.50	1.13
	Unidentified sculpin	*Cottidae*	0	0	0	0	0	0	0	0	1.70	0	0	0
Gasterosteidae	Threespine stickleback	*Gasterosteus aculeatus*	54.3	47	59.8	16.9	0	8.5	6.8	31.7	0.1	3.5	37.5	1
Embiotocidae	Shiner surfperch	*Cymatogaster aggregata*	0	0	0	0	0	4.50	0.60	0	0.70	0	0	0
Moronidae	Striped bass	*Morone saxatilis*	0	0	0	0.40	0	0	0.10	0	0.70	0.20	0.70	0.50
Gobiidae	**Arrow goby**	***Clevelandia ios***	0	0	0	0	0	0	0	0.10	0	0	0	0
	Tidewater goby	*Eucyclogobius newberryi*	0	0	0	0	0	0	0	0	0	0	0.20	0
	Yellowfin goby	***Acanthogobius flavimanus***	0	0	0	0	0	0	0	0	0	0	0.30	11.38
Pleuronectidae	Starry flounder	*Platichthys stellatus*	0.10	0	0	0.90	0	0.50	0.70	0.10	0.20	0	0	0
		Total CPUE	90.40	137.70	212.60	164.60	45.10	253.70	33.70	129	82.60	4.60	46	48.91
		Native Species	8	7	8	9	4	10	10	9	11	4	10	5
		Non-Native Species	2	3	3	2	0	1	2	2	0	1	4	5
		Number of Species	10	10	11	11	4	11	12	11	11	5	14	10

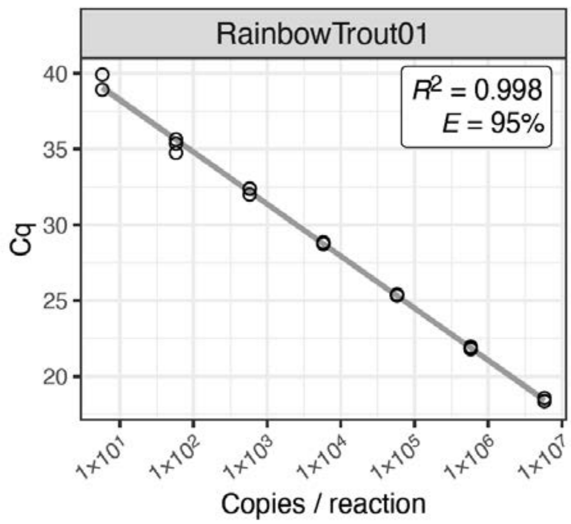
Environmental DNA qPCR Methods and Calibration Curves

The following pages provide details of the methods used for each qPCR assay and the associated standard curves. Each assay in each run is associated with a calibration curve based typically on a series of 7, 10-fold dilutions of a standard with a known concentration. The calibration curves show the relationship between the log10-transformed standard concentration and the number of PCR cycles at which the detection threshold was reached (Cq). A linear regression is applied to this relationship and the r2 intercept and slope extracted for further analyses.

- RunId = An internal identifier for the standard curve(s) used to calculate copy numbers in the submitted samples. Assays that share a RunId are multiplexed (i.e., multiple targets amplified in a single reaction).

- R2 = The coefficient of determination, or goodness of fit for the linear relationship (should be > 0.98).

- (E) = The reaction efficiency, or how close to a doubling of product was achieved with each PCR cycle. For a 10-fold dilution, 100% efficiency is for ~3.3 cycles per 10-fold dilution. A range of values is acceptable here, but we try to keep efficiency between 85% - 110%



Forward primer: 5’ AGTCTCTCCCTGTATATCGTC 3

Reverse primer: 5’ AGTTTAGTTCATGAAGTTGCGTGAGTA 3

Probe: 5’ /56-FAM/CCAA+CAA+CT+CTTTA+AC+CATC/3IABkFQ/ 3

Primer/probe reference: Wilcox et al., 201

An amplicon from the NADH dehydrogenase, subunit 2 (ND2) was amplified via qPCR from genomic DNA samples using rainbow trout FWD and REV primers, and rainbow trout Probe. A standard curve was generated for each run to correspond to targeted region of the rainbow trout cytochrome b gene. Each qPCR reaction is run in triplicate and contains 8.0 uL of QuantaBio PerfeCTa qPCR ToughMix Low ROX (Catalog Number 97065-966), 500 nM of each primer, 300 nM of probe, 2.0 uL of gDNA, and 6.8 uL of Nuclease-free H2O for a total reaction volume of 20 uL. qPCR amplification was carried out on the Quantstudio 5 qPCR instrument with the following thermal profile conditions: 1 cycle of initial denaturation for 5 minutes at 95 C; followed by 50 cycles of 15 seconds at 95 C and 1 minute at 60 C.

Invasive Species Prevention Plan

All field gear used in the Salians 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 Lagoon 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.

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:** Michael Hellmair, Jack Eschenroeder, Erin Loury, Elizabeth Ramsay, Eva Salas
2. **When the data was collected:** May 9-10, 2022
3. **Where the data was collected:** Salinas River Lagoon
4. **How the data was collected (description of methods and protocols):** Sampling was conducted using a 100-foot beach seine with 1/4-inch mesh. At each sampling site, the seine was set in a semi-circle a short distance from shore. Crew members then pulled the seine onto shore, while ensuring the float line stayed above the surface and keeping the lead line as close to the substrate as possible. At sites where water depths precluded wading, an inflatable raft was used to deploy the seine. Once the seine was pulled onto shore, crews quickly processed captured fish by placing specimens to be measured in aerated recovery buckets and counting extremely abundant species before releasing them. Once all fish were removed from the net, crews recorded fork and total length data on at least 30 individuals of each captured species (with the exception of threespine stickleback; *Gasterosteus aculeatus*), before plus-counting any remaining individuals. After fish processing was completed, crews collected water quality data using a YSI water quality sampling meter in the sampled area. Staff used the YSI to measure temperature (˚C), specific conductivity (µS/cm at 25˚C), conductivity (µS/cm), salinity (parts per thousand; ppt), and dissolved oxygen (mg/L) at the surface. 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 Lagoon sampling is intended to assist in determining the presence and spatial distribution of steelhead in the lower Salinas River and Lagoon. The purpose of these sampling efforts is to capture any juvenile SCCC DPS steelhead that may be rearing in the lagoon. Objectives include evaluating presence or absence, condition, relative abundance (i.e., catch per unit effort; CPUE), and distribution of juvenile steelhead in the Salinas Lagoon.
6. **Definitions of variables, fields, codes, and abbreviations used in the data, including units of measure:** All species field codes are included on the following pages.
7. **The terms of any landowner access agreement(s), if applicable:** Landowner access was granted via personal communication to park a vehicle at the northern end of the Lagoon.
8. **References to any related Department permits or regulatory actions:** Relevant permits are included on the following pages
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
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

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
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
CFG**N**	Natural Origin
CFG**H**	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

MED	Medium
HVY	Heavy
Weather Code	**Description**
CLD	Cloudy
RAN	Rainy
CLR	Clear
NIT	Night

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

Relevant Department Permits

State of California – Department of Fish and Wildlife

SCIENTIFIC COLLECTING PERMIT, SPECIFIC USE – Permit

DFW 1379S (NEW 09/01/17)

Specific Use Permit Details:

Specific Use Permit ID: **S-183400003-20036-001**

Reference Title: **Salinas O. mykiss Lifecycle Monitoring Program**

Principal Investigator (PI):

Principal Investigator	PI Status	Approval Status	Conditions
SC-183400006: Andrea N Fuller	Active	Approved	

Geographic Location Details:

Taxonomic Group	Approved County	Approved Locations	Details	Approval Status	Conditions
Fisheries	Monterey	Salinas River	Beach seine surveys will be conducted at several point locations within the Salinas River Lagoon and upstream to the Salinas River Weir location (RM 3). The Salinas Weir will be operated at RM 3 and an RST may be operated (flow dependent) at RM 109.	Approved	

Method Details:

Taxonomic Group	Approved Methods	Details	Approval Status	Conditions
Fisheries	Seine, Beach	Lagoon Seining Surveys will occur one day during seasonal periods (Spring; Apr - May, summer; Jun - Aug, and fall; Oct). The CDFW regional biologist will be notified prior to sampling. Seine hauls will be conducted using a 1/8 inch mesh nylon seine. The seines used are nets suspended between poles with no purse or bunt, featuring a lead line at the bottom and a float line at the top (e.g., traditional beach seine). The seine will be set in a round haul fashion by fixing one end on the beach while the other end is deployed wading upstream and returning to shore in a half circle. Once the lead line approaches the shore, it will be withdrawn more than the cork line until fish are corralled in the bad and the lead line is on the beach. Fish captured in the bag of the seine will be kept submerged in the water until they are transferred to holding containers using dip nets. Each haul is expected to take approximately 5 minutes. Each seine site will have three hauls conducted by a team of at minimum three technicians. Fish from each haul will be separated by size class to avoid risk of predation and placed in aerated 5-gallon buckets prior to processing. Special status species will be given first priority during processing. As recommended by the Tidewater Goby (TWG) Survey Protocol (USFWS 2005) no measurements will be taken from TWG. They will be identified, enumerated, and released at the same point of capture. Any TWG exhibiting signs of physiological stress will be released immediately. Water temperature in the buckets will be kept within 2 degrees of the in-river water temperature. Seining may be conducted in water temperatures up to 70°F (21°C).	Approved	