Salinas River Lagoon Fish Distribution Study

2023 Summary of Tidewater Goby Surveys

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Monterey County Water Resource Agency

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Executive Summary

The tidewater goby (*Eucyclogobius newberryi*) is a federally listed endangered species endemic to California (USFWS 1994). Tidewater goby are found in estuarine habitats that are relatively protected from the marine environment, occurring only in brackish lagoons along the California coast. Until their discovery during routine fish monitoring surveys in the Salinas River Lagoon in 2013, tidewater goby were last documented in the lagoon in 1951. Observations in 2013, and again in 2014, likely represented a natural recolonization event for the species from nearby Bennett Slough or Moro Cojo Slough (HES 2014). Periodic fish distribution monitoring since 2018, supplemented by review of past collection information, is intended to provide insight about the suitability of the Salinas River Lagoon as tidewater goby habitat, population dynamics following recolonization after more than six decades, and the distribution of tidewater goby within the lagoon.

Similar to preceding years, tidewater goby were found at most sampled locations during the May and October 2023 surveys. Numbers of tidewater goby captured with each seine haul during the 2023 survey ranged from 0 to 17 in May, and from 0 to 21 in October.

In May, tidewater gobies captured during the survey measured from 33 mm to 52 mm in total length. In October, tidewater goby across a broad range of lengths were documented in the lagoon, ranging from 14 mm to 54 mm. These size ranges correspond to estimated individual ages ranging from 195 to 397 days and 48 to 423 days, respectively, confirming a broad and prolonged (presumably year-round) reproductive period.

These findings are encouraging, suggesting that tidewater goby, which typically struggle to persist in habitats that remain connected to the ocean for prolonged periods of time, were able to successfully survive, grow and reproduce in the lagoon in 2023. Notably, the Salinas River Lagoon was connected to the marine environment for the majority of the year following a facilitated breaching on January 3, 2023, and remained under tidal influence until September 21, 2023.

During both surveys, diversity of fish species captured was low. Other species included Pacific staghorn sculpin, threespine stickleback, mosquitofish, speckled sanddab, topsmelt, silverside, prickly sculpin, hitch, fathead minnow, and arrow goby.

Tidewater goby continue to be widely distributed throughout the lower lagoon, similar to the past several years. Prolonged time period(s) of lagoon closure likely benefit the tidewater goby population in the Salinas River lagoon by providing stable environmental conditions, as the species is rarely found in areas with strong tidal fluctuations or current. However, the population has persisted in the lagoon despite the wet 2016/2017 and 2022/2023 winters, when the Salinas River Lagoon breached and remained connected to the marine environment for extended periods of time, likely through a favorable combination of suitable environmental conditions and accessible refuge areas.

Background

The tidewater goby (*Eucyclogobius newberryi*) is a federally listed endangered species endemic to California (USFWS 1994). Tidewater goby are found in estuarine habitats that are relatively protected from the marine environment, occurring only in brackish lagoons along the California coast from San Diego to Crescent City. The number of tidewater goby populations greatly declined during the late 20th century, likely due to heavy coastal development, and the species was listed as Endangered under the Endangered Species Act in 1994.

Until their discovery during routine fish monitoring surveys in the Salinas River Lagoon (lagoon) in 2013, tidewater goby were last documented in the lagoon in 1951. Prior surveys for tidewater goby in 1991, 1992, 2004, and 2010-2012 failed to document the species in the lagoon (USFWS 2013, HES 2012, HES 2013). Presumably, tidewater goby were extirpated from the lagoon due to levee construction and channelization (USFWS 2013). Observations in 2013, and again in 2014, likely represented a natural recolonization event for the species from nearby Bennett Slough or Moro Cojo Slough (approximately 11.3 km; HES 2014). Between 2013 and 2014, the tidewater goby population appeared to increase in abundance, and in 2014, tidewater goby were the second most abundant species sampled in the lagoon (only three species were detected; HES 2015). Routine fish monitoring surveys were not conducted by Monterey County Water Resources Agency (MCWRA) or its contractors from 2015 - 2017.

Tidewater goby habitats are typically separated from the Pacific Ocean by sandbars for most of the year, which effectively isolate populations and prevent fish from moving amongst existing populations or colonizing new habitats. Because migration between populations is rare, substantial genetic differences have developed among tidewater goby populations (e.g., McCraney et al. 2010). As a species, the tidewater goby is thought to persist as a metapopulation, wherein individual subpopulations in relatively isolated habitats frequently experience extirpation (localized extinctions). If habitat remains or again becomes suitable, it may be recolonized during comparatively brief periods of connectivity (Lafferty et al. 1999a, Lafferty et al. 1999b). In the metapopulation model, sub-populations survive and/or remain viable through continual exchange of individuals or recolonizations after extirpations. Extinction and recolonization rates are higher in the southern portion of the species' range (Lafferty et al. 1999a, Lafferty et al. 1999b), whereas sub-populations are more stable along California's North Coast (Kinziger et al. 2015).

When estuaries breach, typically during periods of high rainfall and large surf, they often drain rapidly. This is followed by an influx of ocean water over subsequent tidal cycles, which can drastically change the salinity and temperature of the lagoon. Adult tidewater gobies have a broad tolerance for environmental changes to cope with such dramatic fluctuations. While these fish typically inhabit brackish waters with salinities less than 12 parts per thousand (ppt), they have been documented in the wild at salinities greater than that of seawater (up to 42 ppt; Swift et al. 1989). However, juvenile gobies appear less resilient to such breaching events and suffer high rates of mortality when exposed to increases in salinity (Hellmair & Kinziger 2014).

One adaptation that appears to safeguard populations against this natural stressor is the tidewater goby's ability to reproduce across a range of conditions and throughout the year - unlike most fish species - with an increase in spawning activity during summer months (Goldberg 1977; Swift et

al. 1989). As a result, a large range of individual ages and sizes can often be observed concurrently in a given tidewater goby population. This reproductive strategy is thought to balance the risk of high juvenile mortality by maximizing reproductive output: some reproduction can occur during all times of the year (ensuring the continual presence of salinity-tolerant adults), while peak spawning activity is observed during summer, when the chance of estuary breaching (and high juvenile mortality) is lowest (Hellmair & Kinziger 2014).

A review of past collection information, supplemented by periodic fish distribution surveys carried out since 2018, is intended to provide insight about the suitability of the Salinas River Lagoon as tidewater goby habitat, population dynamics following recolonization after more than six decades, and the distribution of tidewater goby within the lagoon. This information about tidewater goby densities and distributions within the lagoon is important for future lagoon management and the ongoing process of creating a Habitat Conservation Plan (HCP) for the Salinas River and Lagoon. As part of the HCP, long-term permits are expected to be issued by the National Marine Fisheries Service and the U.S. Fish and Wildlife Service for water level management in the lagoon (Old Salinas River outflow and facilitated breaching) as well as other operations. Distribution surveys were designed to inform the permit application process and provide information on population resilience to natural and facilitated breaching events.

The temporal changes in distribution of tidewater goby, based on numerous surveys by FISHBIO and other entities, are summarized herein. Details on specific tidewater goby surveys can be found in a comprehensive summary report, prepared on behalf of MCWRA (FISHBIO 2022). This report relies on and incorporates the results of historic collections but focuses on the tidewater goby distributional survey conducted on May 9, 2023, and October 17, 2023. These latest surveys provided a rare opportunity to monitor the status of tidewater goby in the Salinas River lagoon following an unusually wet winter, which resulted in a prolonged period of connectivity to the marine environment. Typically, tidewater goby struggle to persist in habitats that remain connected to the ocean for prolonged periods of time (the Salinas River Lagoon was connected to the marine environment by facilitated breaching on January 3, 2023, and remained under tidal influence until September 21, 2023). However, the species was able to survive, grow and successfully reproduce in the lagoon during this time, as evidenced by widespread habitat occupancy and presence of a broad range of individual sizes during both surveys.

Methods

Field Methods

Tidewater goby collection surveys conducted by FISHBIO used a two-person crew with a 10 x 4 ft. beach seine (⅛ inch mesh). Numerous locations were sampled throughout the lagoon, distributed from near the sandbar/breach location to the Highway 1 Bridge, as well as in the Old Salinas River (OSR) directly behind the slidegate (Figure 1). No habitat type was initially targeted or favored for sampling when sites were selected in 2018; rather, approximately equidistant sampling locations were chosen to obtain an adequate overview of the spatial distribution of gobies within the lagoon. During subsequent sampling events, initially selected locations were revisited. Areas for sampling by beach seine were generally limited by water depth as most sites along the southern shore of the lagoon quickly become too deep for effective seining. In addition, nesting of

federally-listed snowy plover has periodically resulted in access limitations at some sampling locations (i.e., Site C, near the mouth of the lagoon) during the spring.

All targeted sampling for tidewater goby was conducted following protocols developed by the U.S. Fish and Wildlife Service (USFWS 2005 Appendix F). At each sampling location, one to two seine hauls were conducted (Figure 2), depending on the available area that could be sampled efficiently (multiple seine hauls are only possible where sufficient area with adequate depth was available for sampling, the areas sampled by sequential seine hauls did not overlap). After each seine haul, all captured fish are transferred from the seine to an aerated, temporary holding bucket. Once all fish are removed from the seine, they are identified to species level, enumerated and measured.

Following identification and measurement, all sampled fish, including tidewater goby, are released at the site of capture.

Measurements of tidewater gobies were used to evaluate the reproductive period of the species in the Salinas River Lagoon. As growth in fishes is generally continuous and indefinite, differences in size – or range in individual sizes encountered in a population at a particular point in time – can be used as an approximation of the temporal extent of their reproductive period, particularly in small, short-lived species such as the tidewater goby (Hellmair & Kinziger 2014).

Figure 1. Aerial image indicating collection locations of tidewater goby surveys conducted by FISHBIO and referenced in this report. Of note, Sites A and B are located on the lagoon and OSR-side of the slidegate, respectively. Site C (breach location) could not be sampled in May 2023 due to access restrictions (nesting snowy plovers) but was sampled in October 2023.

Figure 2. Using a two-person, small-mesh beach seine to sample tidewater goby in the Salinas River lagoon.

Data Analysis

Von Bertalanffy growth parameters (L_∞, k and t_0) estimated for a northern California population of tidewater goby (Big Lagoon, Humboldt Co.; Hellmair & Kinziger 2014) were used to derive approximate daily ages for tidewater goby, according to the following formula:

$$L_t = L_\infty * (1 - e^{-k*(t-t_0)}),$$

where L_t is the length at time of capture, L_∞ is 94.18 (the theoretical maximum size for the species), k is 0.67, t_0 is -0.11 and t is the age, in years.

This can be rearranged as

$$t_{days} = \left(\frac{ln\ ln\ \left(1 - \frac{L_t}{L_\infty}\right)}{-k} + t_0 \right) * 365$$

to estimate the daily age of an individual tidewater goby of a known total length (TL) L_t. For example, a fish measuring 33 mm (TL) is estimated to be 195 days old.

While density can often be useful in determining critical habitat or habitat preference of a species within a given environment, the methods to estimate density (individuals per unit sampled) must be comparable among sampling methods and events. A review of pre-2018 collection information of tidewater goby in the Salinas River Lagoon revealed that such comparable estimates of fish density cannot be derived. However, surveys since 2018 were conducted according to standardized protocol (area sampled by each seine haul was visually estimated) and can, thus, be used as an indicator of fish densities. Typically, locations suitable for seining are limited in accessible area, so that only a single seine haul can be performed. In addition, as the main objective of this monitoring effort is to repeatedly document the distribution of tidewater goby in the lagoon, once tidewater goby are detected at a site, no additional seine hauls are performed. This results in a limited ability to compare densities over time

Results

Locations throughout the Salinas River Lagoon where tidewater gobies were documented since confirmed recolonization of this habitat are summarized, by year, in Figure 3.

Similar to the preceding years, tidewater goby were found at most sampled locations during the May and October 2023 surveys. Numbers of tidewater goby captured with each seine haul during the 2023 survey ranged from 0 (along the southwestern shoreline) to 17 (in the OSR) in May, and from 0 to 21 (at location "I"; Figure 1) in October. At sampling sites where the species was detected, no subsequent seine hauls were performed following detection. Despite overall moderate capture numbers in individual seine hauls, tidewater goby continue to be widely distributed in the lagoon. Of note, tidewater goby were also captured during the complementary fish community surveys using a large beach seine with ¼ inch mesh on October 18. While clearly bycatch using this technique as these small-bodies fish can usually easily escape through mesh of this size, tidewater goby were documented about 1.2 km upstream of the Highway 1 Bridge (36.7311679, -121.77025).

In May, tidewater gobies captured during the survey measured from 33 mm to 52 mm in total length. Using the above-described age-length relationship, this corresponds to estimated individual ages ranging from 195 to 397 days, suggesting a prolonged reproductive period (202 days; Figure 4).

Overall, diversity of fish species captured during the May survey was low. Pacific staghorn sculpin, *Leptocottus armatus*, was the most abundant species sampled (n = 139) and was found at all sampled locations, with exception of the OSR. In addition, the survey documented threespine stickleback, *Gasterosteus aculeatus* (n = 8, with seven individuals captured in the OSR), mosquitofish *Gambusia affinis* (n = 18, with 17 individuals captured in the OSR), and one juvenile speckled sanddab, *Citharichthys stigmaeus* (Table 1).

In October, tidewater goby across a broad range of lengths were documented in the lagoon, ranging from 14 mm to 54 mm, corresponding to ages ranging from 48 to 423 days, confirming a broad and prolonged (presumably year-round) reproductive period (375 days; Figure 5).

Notably, during the October survey at location "I", the 16 captured gobies included multiple small individuals (as small as 14 mm TL), and it was observed that several of the smaller individuals were in the process of escaping through the mesh of the net. As a consequence, we conclude that the standardized net is not effective at reliably documenting tidewater gobies smaller than 15 mm. At the adjacent location ("F"), 21 gobies were captured and measured. Generally, the southern shoreline along the Salinas River National Wildlife Refuge (NWR), despite limited areas suitable for seining (due to water depth), appeared to host higher than average densities of tidewater goby of all sizes.

In October, fish catch was dominated by topsmelt (*Atherinops affinis*; n=162). Mosquitofish were abundant (too numerous to count) in the OSR, while threespine stickleback were too numerous to count in the OSR and at the Highway 1 bridge. Both species were found sporadically and in low numbers (n<2) elsewhere. Other species documented during the survey were rare and included

silverside (*Menidia beryllina*; n=43), Pacific staghorn sculpin (n=2), prickly sculpin (*Cottus asper*; n=1), hitch (*Lavinia exilicauda*; n=1), fathead minnow (*Pimephales promelas*; n=1), speckled sanddab (*Citharichthys stigmaeus*; n=1), and arrow goby (*Clevelandia ios*; n=1).

Tidewater goby are frequently associated with aquatic vegetation, particularly widgeon grass (*Ruppia* sp.), and the presence of Ruppia is considered a significant predictor of tidewater goby presence. However, at the time of the May survey, and like previous springtime surveys, widgeon grass was not yet present at the surveyed locations or readily detectable in the lagoon. This is likely attributable to the seasonal nature of vegetation growth in the lagoon, with vegetation coverage typically expected to increase throughout the late spring, summer, and early fall. During that time, tidewater goby are expected to be more densely concentrated in areas where widgeon grass is present or abundant, whereas they are likely more broadly distributed during the winter and spring. However, presumably due to the extended period of connectivity to the ocean in 2023, widgeon grass was not prevalent during the October survey, with the sole exception of small patches in the OSR. Despite the scarcity of this plant species, the tidewater goby population appeared robust. Although they were widely distributed throughout the lagoon, higher concentrations of tidewater goby were found along the southern shoreline in close proximity to partially inundated terrestrial vegetation.

Salinity concentrations (measured with a YSI ProSolo Digital Water Quality Meter) were moderate in May, ranging from only 0.15 ppt (in the OSR) to 3.55 ppt (at locations slightly south of the breach location; Table 1). In October, salinity ranged from 2.82 ppt at the Highway 1 bridge to 5.3 (at the breach location, site “C”; Tables 1 and 2). Importantly, the Salinas River Lagoon had remained open to the ocean following a facilitated breaching event on January 3, 2023, until September 21, 2023. Consequently, the lagoon has been subjected to seawater influx during tidal cycles, albeit buffered by freshwater inflow from the Salinas River. Environmental conditions are expected to fluctuate throughout the tidal cycles for as long as the lagoon remains connected to the marine environment. Daily fluctuations in environmental conditions are muted when the lagoon is closed, with the potential exception of dissolved oxygen, which can increase greatly during daytime hours as a consequence of algal and macrophyte photosynthesis.

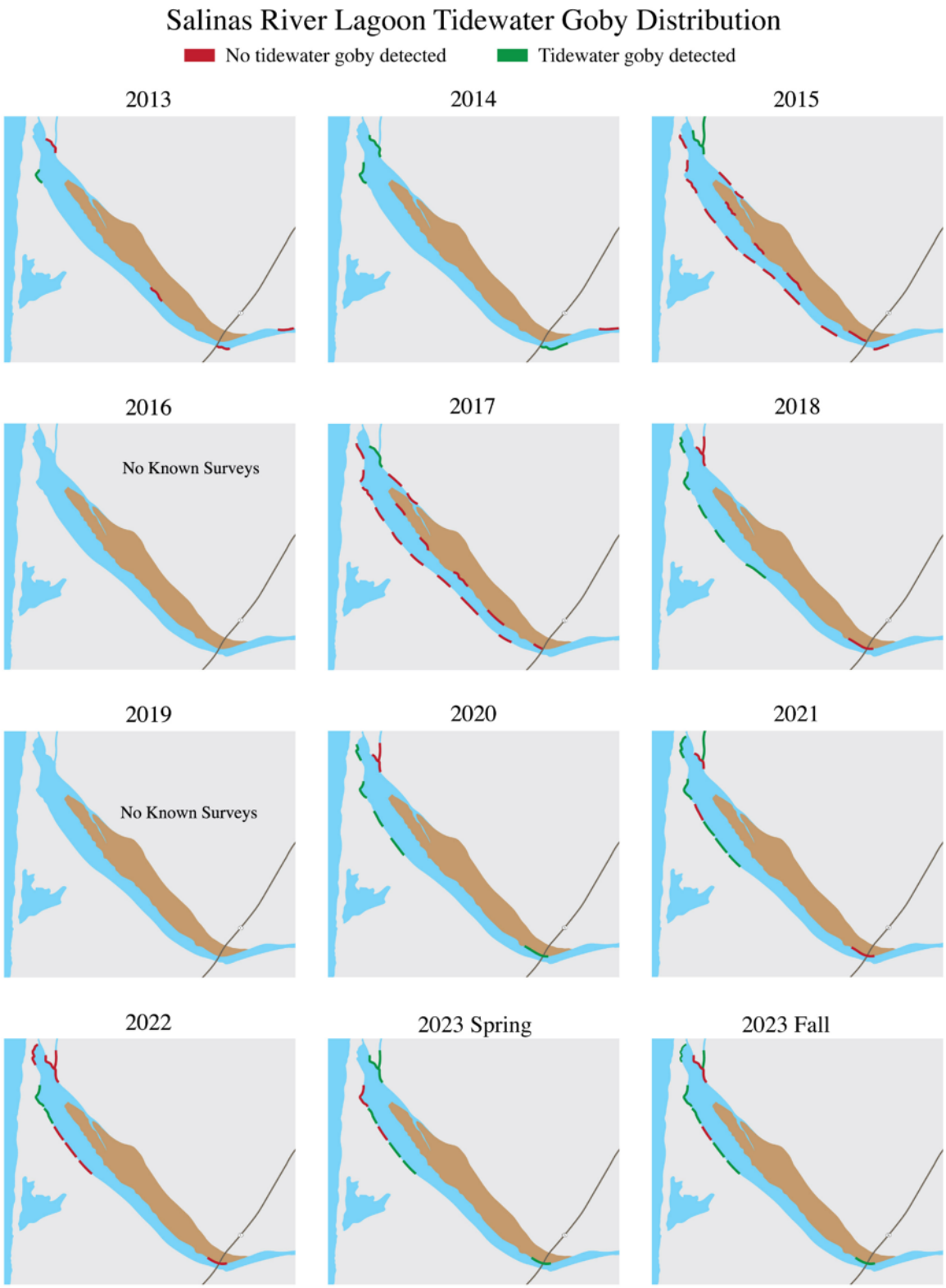

Figure 3. Summary of post-recolonization detection records of tidewater gobies in the Salinas River Lagoon, illustrating presence (green) and non-detection (red). Note: Methods and effort are not standardized.

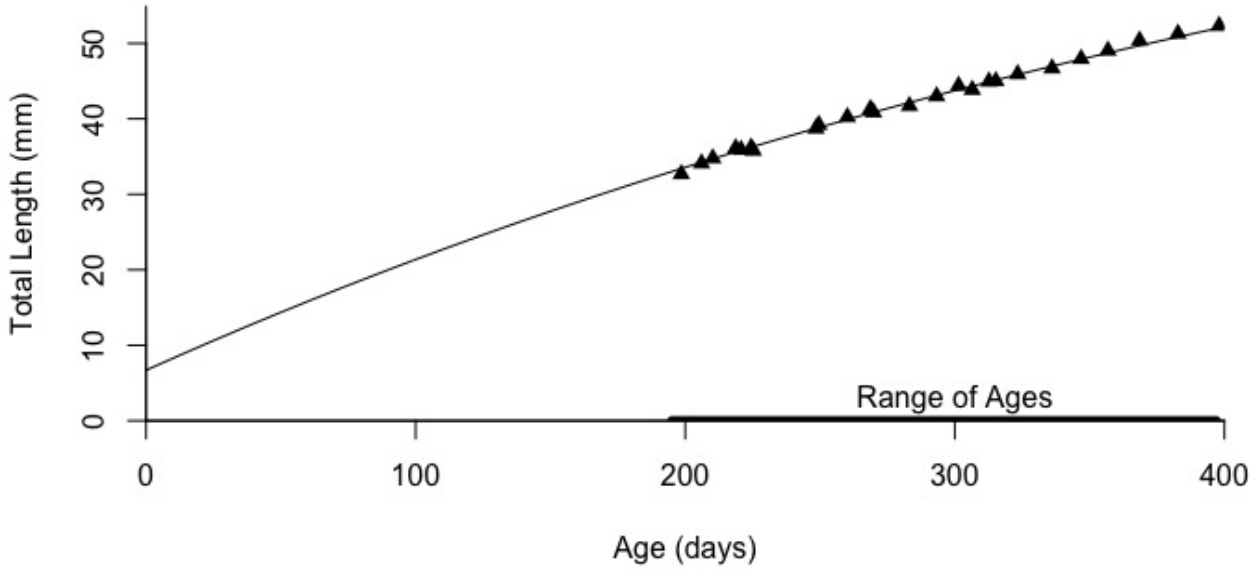

Figure 4. Total lengths (in millimeters [mm]) of tidewater goby (n = 25) captured during surveys conducted on May 9, 2023, and their estimated age, based on Von Bertalanffy growth parameters (Hellmair & Kinziger 2014).

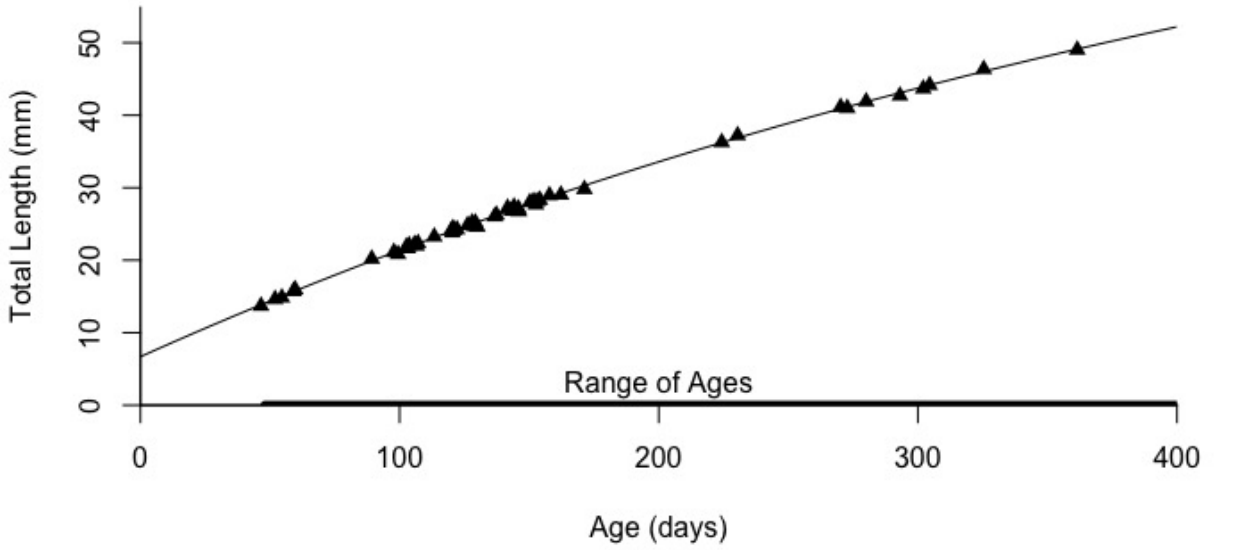

Figure 5. Total lengths (in millimeters [mm]) of tidewater goby (n = 54) captured during surveys conducted on October 17, 2023, and their estimated age, based on Von Bertalanffy growth parameters (Hellmair & Kinziger 2014).

Table 1. Summary of sampling locations, effort and catch in the Salinas River Lagoon, May 9, 2023.

Location	Coordinates	Surface Temperature (ºC)	Surface Salinity (ppt)	Area Sampled (sq ft)	TWG Catch	Other species (n)	Comment
(A)	36.749704; -121.801128	18.8	2.93	540	1	Pacific staghorn sculpin (2)	*Ruppia* absent
(B)	36.750070; -121.801114	20.7	0.15	500	17	Threespine stickleback (7), Mosquitofish (17)	*Ruppia* absent
(C)	36.750506; -121.803841	Not sampled due to access restrictions					
(D)	36.747189; -121.803235	18.7	3.55	1,500	0	Pacific staghorn sculpin (58)	*Ruppia* absent
(E)	36.742671; -121.799886	17.7	3.14	240	0	Pacific staghorn sculpin (7)	*Ruppia* absent
(F)	36.739192; -121.795568	16.7	2.76	600	2	Pacific staghorn sculpin (11)	*Ruppia* absent
(G)	36.731993; -121.783053	16.7	1.9	150	1	Pacific staghorn sculpin (2), Mosquitofish (1)	*Ruppia* absent
(H)	36.746134; -121.802480	18.5	3.55	720	1	Threespine stickleback (1), Pacific staghorn sculpin (8)	*Ruppia* absent
(I)	36.741381; -121.798735	17.4	2.86	960	3	Pacific staghorn sculpin (51), speckled sanddab (1)	*Ruppia* absent

Table 2. Summary of sampling locations, effort and catch in the Salinas River Lagoon, October 17, 2023.

Location	Coordinates	Surface Temperature (ºC)	Surface Salinity (ppt)	Area Sampled (sq ft)	TWG Catch	Other species (n)	Comment
(A)	36.749704; -121.801128	19.1	4.31	200	0	NA	*Ruppia* absent
(B)	36.750070; -121.801114	19.1	4.31	500	1	Threespine stickleback (TNTC), mosquitofish (TNTC), topsmelt (55), fathead minnow (1), Pacific staghorn sculpin (1), inland silverside (11)	*Ruppia* sparse
(C)	36.750506; -121.803841	18.8	5.30	1000	3	Speckled sanddab (1), arrow goby (1), inland silverside (1)	*Ruppia* absent
(D)	36.747189; -121.803235	19.1	4.70	1500	2	Topsmelt (105), inland silverside (5)	*Ruppia* absent
(E)	36.742671; -121.799886	19.7	3.95	350	0	Pacific staghorn sculpin (1), topsmelt (1), hitch (1)	*Ruppia* absent
(F)	36.739192; -121.795568	19.4	3.41	250	21	Inland silverside (26), threespine stickleback (1)	*Ruppia* absent
(G)	36.731993; -121.783053	19.4	2.82	200	8	Threespine stickleback (TNTC), topsmelt (1), prickly sculpin (1)	*Ruppia* absent
(H)	36.746134; -121.802480	19.3	4.10	800	3	-	*Ruppia* absent
(I)	36.741381; -121.798735	19.8	3.91	500	16	Threespine stickleback (1), mosquitofish (1)	*Ruppia* absent

Discussion

The tidewater goby population in the Salinas River Lagoon has most likely persisted since recolonization. As this species rarely lives longer than one year (Hellmair & Kinziger 2014), continuous presence of tidewater goby in the Salinas River Lagoon is a strong indication that the species can successfully reproduce in the Salinas River Lagoon over multiple generations. While the exact time period of recolonization is unknown, repeated collections since 2013 confirm that the lagoon provides suitable habitat for tidewater goby growth, survival, and reproduction. It seems likely that the initial recolonization (pre-2013 documentation) occurred via the Old Salinas River, as the species has been found consistently within the Elkhorn Slough/Moro Cojo Slough complex. However, no recent survey data for this area is available and a broader, regional survey of hydrologically connected brackish habitats in the region has not yet been conducted.

Continued persistence in the lagoon and the Old Salinas River (although not verified in 2019; Figure 3) is a testament to the broad environmental tolerances of tidewater goby, as they can withstand very low levels of dissolved oxygen (e.g., < 3 mg/l, November 2014) and a broad range of salinities (0 ppt to over 42 ppt; Swift et al. 1989), although juveniles appear susceptible to rapid salinity fluctuations (Hellmair & Kinziger 2014). Tidewater gobies from Salinas River Lagoon and the Old Salinas River likely intermix and should be considered the same population. During May of 2023, the largest concentration of tidewater goby was found in the OSR. During that time (and for most of the year in 2023), no outflow occurred from the lagoon through the OSR, and the resulting muted environmental fluctuation in the OSR likely benefited tidewater goby when the absence of flow from the lagoon provided stable and sheltered conditions. It appears likely that the OSR serves as an important refuge habitat for tidewater goby during periods of environmental stochasticity in the lagoon, such as breaching and subsequent tidal influence over extended periods of time. The slidegate connecting the Salinas River Lagoon to the Old Salinas River, generally used to manage or maintain water levels in the lagoon when a sandbar has formed, is closed when the lagoon is breached. The frequency of movement between the OSR and the lagoon (through the slidegate, in either direction) remains unknown, but appears likely when the gate is open. During the October survey, when discharge through the OSR had resumed following lagoon closure, only a single tidewater goby was captured in the OSR, where discharge was visually estimated at about 5 cfs (see Figure 6 for an image of discharge over the slidegate), resulting in visibly higher current velocities in the OSR than during past surveys. It is unknown if tidewater goby abundance was higher in areas further downstream in the OSR where current velocities are lower.

Although the species is rarely found in areas that are subject to current or prolonged tidal influence, tidewater goby clearly successfully persisted throughout the summer and early fall of 2023, as evidenced by a broad distribution, locally high abundances, and the presence of a large size (and age) range of individuals. Despite the prolonged connection to the ocean and exposure to tidal influence for nearly nine consecutive months, initial concerns regarding the persistence of tidewater goby in the lagoon under these conditions were unfounded. The species appears to reproduce continuously (Figure 5) in the lagoon, thus resulting in a broad range of age classes, expected to provide resilience to localized extirpation.

Based on the individual condition of tidewater goby observed during the May survey, reproduction appeared to be actively occurring during that period. Several specimens captured in the lagoon and

the OSR appeared gravid (containing eggs, prior to spawning), while others appeared spawned out and emaciated (Figure 7). Most sampled individuals showed coloration indicative of recent or ongoing spawning activity. It was expected that larval and juvenile tidewater goby would become abundant in the OSR and lagoon in subsequent months.

During the October survey, despite prolonged connectivity between the lagoon and the marine environment, tidewater goby continued to be widespread and locally abundant. Tidewater goby did not exhibit coloration indicative of active reproduction, but the range of documented sizes clearly indicated that reproductively mature individuals were present.

Figure 6. Discharge from the Salinas River Lagoon over the slidegate into the OSR on October 17, 2023.

Overall, it appears that the (seasonally) harsh environmental conditions in the Salinas River Lagoon, particularly during the summer months when there is generally little or no freshwater flow entering the lagoon, are partially responsible for maintaining the tidewater goby population in the lagoon, including through limiting invasion or permanent colonization by other species. In contrast, the relatively high abundance of tidewater goby in the OSR documented during the May 2023 sampling event indicates that the OSR may serve as an important refuge habitat for tidewater goby during periods of environmental stochasticity in the lagoon, such as breaching and subsequent tidal influence over extended periods of time. The slidegate connecting the Salinas River Lagoon to the OSR, generally used to manage or maintain water levels in the lagoon when a sandbar has formed, is closed when the lagoon is breached. This creates a sheltered, low salinity environment where tidewater goby may persist in high abundances, serving as a potential source of tidewater goby movement into the lagoon environment and other (downstream) habitats. The frequency of movement between the OSR and the lagoon (through the slidegate, in either direction)

remains unknown, but appears likely when the gate is open, including for other species with greater swimming ability, such as steelhead.

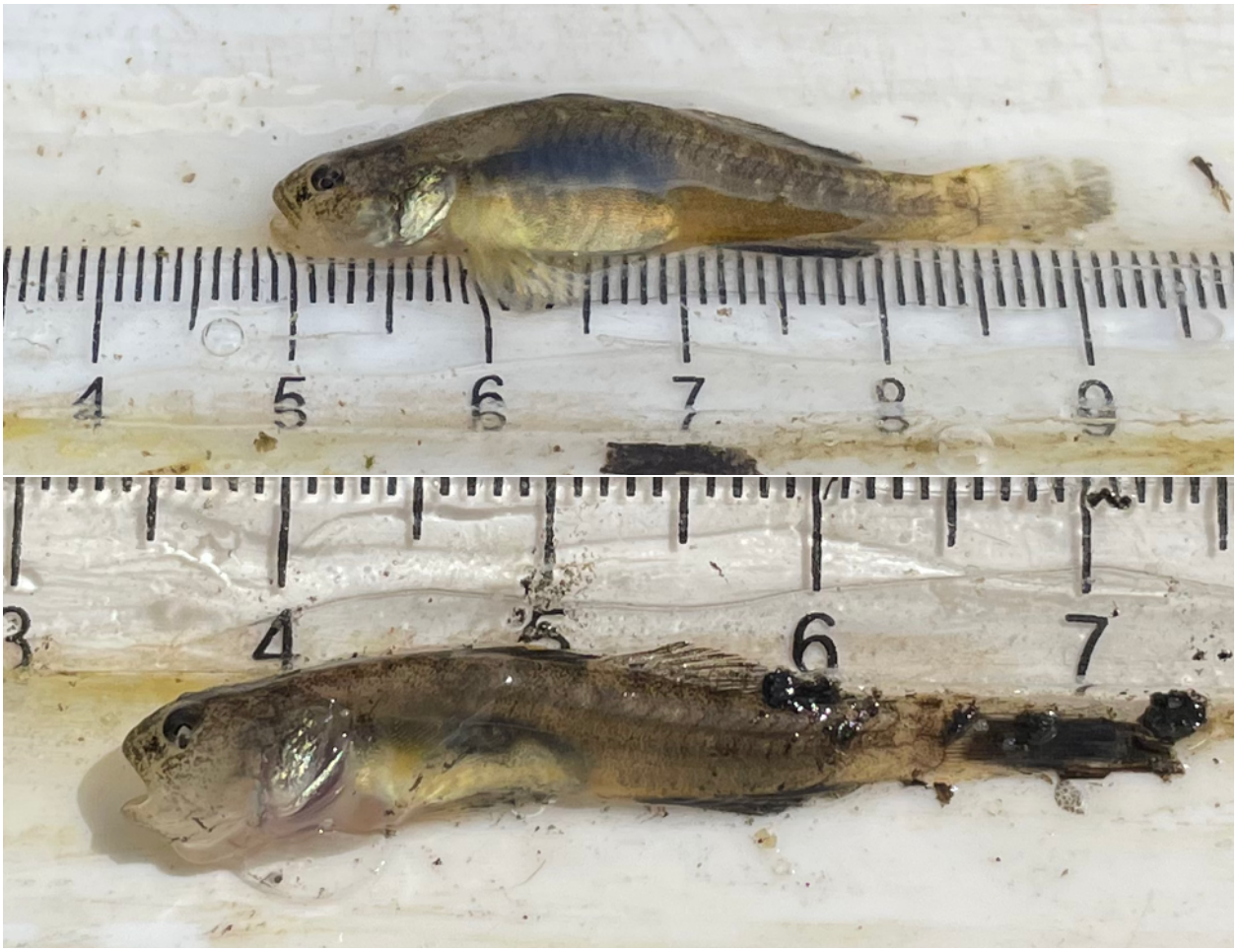

Figure 7. Tidewater goby collected in the Salinas River Lagoon, adjacent to the Salinas River NWR, on May 9, 2023, showing robust, presumably pre-spawn (top) and emaciated, presumably post-spawn (bottom) individuals.

Although widgeongrass (*Ruppia* sp.), which is often indicative of preferred tidewater goby habitat, was scarce in May and October, tidewater goby were instead associated with partially inundated terrestrial vegetation along the margins of the lagoon. It is unknown if *Ruppia* was absent in deeper areas of the lagoon, or simply not visible from the shoreline or shallow water due to the recent increase in water level (after the lagoon closure).

It has been noted that arrow gobies (*Clevelandia ios*) can be found in large numbers in the Salinas River Lagoon, particularly while the sandbar is breached and for some time thereafter (B. Spies, pers. comm.). However, the species rarely co-occurs with tidewater gobies for extended periods of time, and no arrow goby was sampled in May 2023, despite prolonged connectivity to the marine environment. Both species have a salinity tolerance of 0-55 ppt (based on laboratory trials), yet tidewater gobies appear to prefer salinities below 15 ppt, and arrow gobies prefer those greater than 15 ppt (Capelli 1997, as cited in Dawson et al. 2002). A single arrow goby was documented

during the October survey (TL 49 mm), at the breach location (Figure 8). Due to the recent lagoon closure and low ambient salinity levels, the Salinas Lagoon does not appear to provide suitable habitat for continuous arrow goby occupancy.

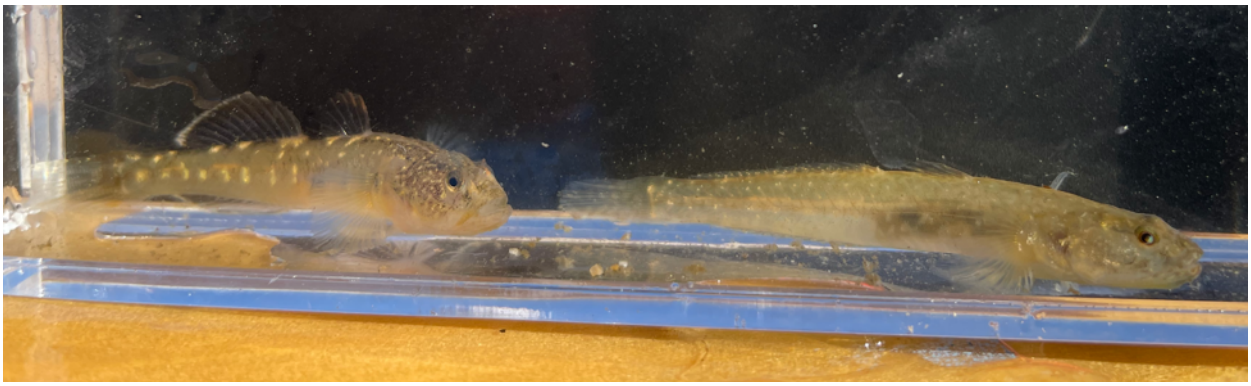

Figure 8. Tidewater goby (left) and arrow goby (right) captured at the same location ("C" in Figure 1) on 10/17/2023.

In the Salinas River Lagoon, ambient salinity levels likely limit the ability of predatory exotic freshwater species, such as largemouth bass (*Micropterus salmoides*) and sunfishes (*Lepomis* spp.), to use the lower estuary. While largemouth bass have been documented in salinity levels up to 16 ppt in their native range, they seem to generally avoid salinity levels above 5 ppt in California (Moyle 2002). Sunfishes likely have a lower salinity tolerance and largely avoid salinities greater than 2 ppt. Although recent fish community surveys, including the tidewater goby survey, rarely document the presence of these exotic freshwater species, their presence in the upper reaches of the lagoon is likely. The extent of interactions between tidewater goby and non-native freshwater species (in the upper lagoon, upstream of Hwy 1) is currently unknown, as targeted tidewater goby seining surveys have been limited to margin habitat in the lower lagoon that is sufficiently shallow for wading. Euryhaline exotic species such as striped bass, which are commonly documented in the Salinas River Lagoon and often found in the vicinity of locations where tidewater goby are periodically sampled, could exert predation pressure on the goby population in the lagoon. Given the abundance of other forage fish (such as smelt, silverside and herring), striped bass predation on tidewater goby is expected to be low. However, to our knowledge, the dietary composition of striped bass has not been evaluated in the lagoon. Small otter trawls have successfully evaluated the distribution of tidewater goby in deeper water (up to 16ft; Greg Goldsmith; pers. comm.) and may constitute a useful technique to determine the upstream limit of tidewater goby distribution in the Salinas River Lagoon in the future.

In summary, the species has continued to be widely distributed throughout the lower lagoon over the past several years (Figure 3). Prolonged time period(s) of lagoon closure likely benefit the tidewater goby population in the Salinas River lagoon by providing stable environmental conditions, as the species is rarely found in areas with strong tidal fluctuations or current. However, the population has persisted in the lagoon despite the wet 2016/2017 and 2022/2023 winters, when the Salinas River Lagoon breached and remained connected to the marine environment for extended periods of time, likely through a favorable combination of suitable environmental conditions and accessible refuge areas.

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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:** Michael Hellmair, Ethan Switzer, Miguel Ibarra, Marinn Browne
2. **When the data was collected:** May and October, 2023
3. **Where the data was collected:** Salinas River Lagoon
4. **How the data was collected (description of methods and protocols):** Surveys conducted by FISHBIO used a two-person crew with a 10 x 4-foot beach seine (⅛ inch mesh). No particular habitat type was preferentially targeted or favored for sampling; rather, approximately equidistant sampling locations were chosen to obtain an adequate overview of the spatial distribution of gobies within the lagoon. During subsequent sampling events, initially selected locations were revisited. At each sampling location, one to two seine hauls were conducted. All fish captured during each survey, regardless of method, were identified to species, and all tidewater goby were enumerated and measured. All targeted sampling for tidewater goby was conducted following protocols developed by the U.S. Fish and Wildlife Service (USFWS 2005). 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 tidewater goby in the lower Salinas River and Lagoon. The purpose of these sampling efforts is to capture any tidewater goby that may be inhabiting the lagoon. Objectives include evaluating presence or absence, condition, relative abundance (i.e., catch per unit effort; CPUE), and distribution of tidewater goby 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 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
Brook Trout	BKT
Brown Bullhead	BRB
Brown Trout	BT

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

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

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
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 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.