Salinas River Lagoon Fish Distribution Study

2022 Summary of Tidewater Goby Surveys

Submitted To:
Monterey County Water Resource Agency

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July 2022

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This work is funded in part by a Cooperative Endangered Species Conservation Fund Non-Traditional Section 6 Grant (Agreement No. Q2140404) to the Monterey County Water Resources Agency to support the development of the Salinas River Habitat Conservation Plan

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 U.S. Endangered Species Act in 1994.

Until their discovery during routine fish monitoring surveys in the Salinas River Lagoon (hereafter "the 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, Hagar Environmental Services [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 to the north; 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 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), to 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. 2016).

When estuaries breach, typically during periods of high rainfall and heavy 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, 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 in tidewater goby populations at any given time. 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.

However, not all tidewater goby populations are characterized by a diversity of sizes and ages. Instead, some populations found along the northern California coast are composed entirely of similar-sized individuals, indicating that their reproductive period is restricted to a particular time of year. This demographic variation is often mirrored in a population's genetic diversity so that populations with a diversity of fish sizes and ages tend to also have higher genetic diversity, while those composed of similar-sized individuals tend to be more genetically similar. Furthermore, the lack of size and age diversity within populations of low genetic diversity appears to increase their vulnerability to environmental disturbance. In such populations, reproduction is mostly limited to a short window of time, and a spike in salinity during or shortly after this period (when the population consists exclusively of small, less tolerant individuals) can lead to extirpation. In contrast, the continuous presence of adults with broader physiological tolerance makes it more likely for goby populations with diverse age demographics to persist through such events (Hellmair and Kinziger 2014).

A review of past collection information, supplemented by fish distribution surveys carried out since 2018, is intended to provide insight into the suitability of the Salinas River Lagoon as tidewater goby habitat, population dynamics following re-colonization after more than six decades, and the distribution of tidewater goby within the lagoon. In addition, distributional information may help to better understand potential colonization pathways of tidewater gobies (e.g., via the Old Salinas River to Elkhorn Slough). Furthermore, the length frequency distribution of captured tidewater goby was used to provide insights regarding reproductive patterns (seasonal or continuous), which may provide an indication of the population's resilience to disturbance (Hellmair and Kinziger 2014). This detailed information about tidewater goby densities and distributions within the lagoon is an important consideration 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 NMFS and the U.S. Fish and Wildlife Service for lagoon management (facilitated breaching) as well as other operations. Prior to completion of the HCP, a Low Effect HCP is being developed in the meantime to permit lagoon management. Distribution surveys are designed to help inform the permit application process and provide information on population resilience to unassisted and facilitated breaching events. Arguably, high densities of tidewater goby in areas distant from the sandbar are indicative of lower population-susceptibility to drastic environmental fluctuation induced by breaching. Information about population persistence and demographic information (length/age frequencies) are based in part on data collected in the lagoon by HES from 2010-2014, and by Brenton Spies (doctoral student at the University of California, Los Angeles from 2014-2017). In addition, FISHBIO has sampled numerous locations throughout the lagoon environment between 2018 and 2022.

Results from all of these efforts are summarized below.

Methods

Field Methods

This report summarizes tidewater goby survey data collected in the lagoon using three different methods. The first method, used by HES during routine lagoon monitoring surveys for steelhead, captured fish using large beach seines and bag seines at eight locations throughout the lagoon. Large beach seines (150 feet X 8 feet; ¼ inch mesh size) were used to sample fish in areas with deeper water or along obstructed banks. In these locations, the seine was deployed from a small boat and hauled across the channel to the opposite bank. Where the water was shallow enough to maneuver the seine or where there were few underwater obstructions, a smaller bag seine (100 feet X 6 feet; ¼ inch mesh size) was used for sampling, and this seine was hauled fully onto the open sand borders of the lagoon. This method is effective for capturing multiple size classes of bottom-oriented, mid-water, and near-shore species (HES 2014). Captured fish were identified by species, enumerated, measured or estimated for fork length, and external condition was noted. A detailed description of the methods used for routine lagoon monitoring can be found in HES 2014.

The second method, used by Brenton Spies, consisted of collection surveys intended to target tidewater goby with a small, handheld A-frame seine (4 feet wide; ⅛ inch mesh size; B. Spies, pers. comm.). Spies' investigations were designed to collect a small number of specimens from a large number of locations (coast-wide), rather than to evaluate the densities and distributions of tidewater goby and other species within particular habitats. As a consequence, he could not provide detailed records on the exact number of gobies captured, their lengths, or the number of individuals belonging to other species. He generally sampled areas where he expected to find tidewater gobies, rather than conducting broader distribution surveys, and discontinued sampling upon reaching his collection target of five individuals.

Finally, surveys conducted by FISHBIO used a two-person crew with a 10 x 4-foot beach seine (⅛ inch mesh). Numerous locations were sampled throughout the lagoon, distributed from the sandbar to the Highway 1 Bridge, as well as in the Old Salinas River (OSR) directly behind the slidegate (Figure 1). 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 (Figure 2). 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 Appendix F).

Measurements of tidewater gobies were used to evaluate the reproductive period of the species in the Salinas River Lagoon. As growth in fishes is more or less 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 (location "G", located directly under the southbound Highway 1 bridge, not pictured).

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 mm (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 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 past 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, using seine hauls of comparable lengths, and can thus be used as an indicator of relative fish densities. Of note, capture numbers in individual seine hauls are generally low, so that the observed variation typically ranges between 0 and 1.

Results

Locations throughout the Salinas River Lagoon where tidewater gobies were documented since confirmation of re-colonization of this habitat are summarized by year in Figure 3. All pre-2022 survey efforts that documented tidewater goby in the lagoon, as well as targeted goby surveys (including those that did not result in detection) are summarized in the appendices to this report.

During the spring survey on May 9, 2022, tidewater goby were found at two of the sampled locations. Both individuals showed coloration indicative of recent spawning activity (Figure 4) and were captured just south of the sandbar separating the lagoon from the ocean. Overall, the fish community was dominated by marine and euryhaline species (those with a broad salinity tolerance), including Pacific staghorn sculpin, Pacific herring, topsmelt, threespine stickleback and prickly sculpin. Additionally, two hitch were captured in the Old Salinas River.

Similar to the previous surveys, estimation of index densities is not biologically meaningful due to low capture numbers. It is expected that the low observed numbers of tidewater goby are attributable to the timing of the survey, coinciding with the reproductive period of the species. Mature individuals may be in burrows guarding eggs and/or may have decreased in abundance due to post-spawn mortality. It is expected that larval and juvenile tidewater goby increased in abundance in the weeks following the survey, although their detection may be difficult due to extremely high abundance of Mysis shrimp in the lagoon, which have a similar appearance to larval tidewater goby.

Salinity concentrations (measured with a YSI ProSolo Digital Water Quality Meter) were moderate (Table 2) and slightly lower than salinities observed during the previous year.

Tidewater gobies captured during the May 2022 field survey measured 40 mm and 45 mm in length, corresponding to estimated ages of 261 and 314 days (hatch dates of June 29 and August 21, 2021), respectively.

Notably, the turbidity in the lagoon during May 2022 sampling was high, which may partially explain the apparent absence of widgeon grass (*Ruppia maritima*; either not visible or insufficient sunlight penetration to facilitate aquatic plant growth). *Ruppia* is generally associated with tidewater goby occupancy and considered an indicator of suitable tidewater goby habitat.

More detailed collection records from the 2022 distribution surveys are available in Appendix E.

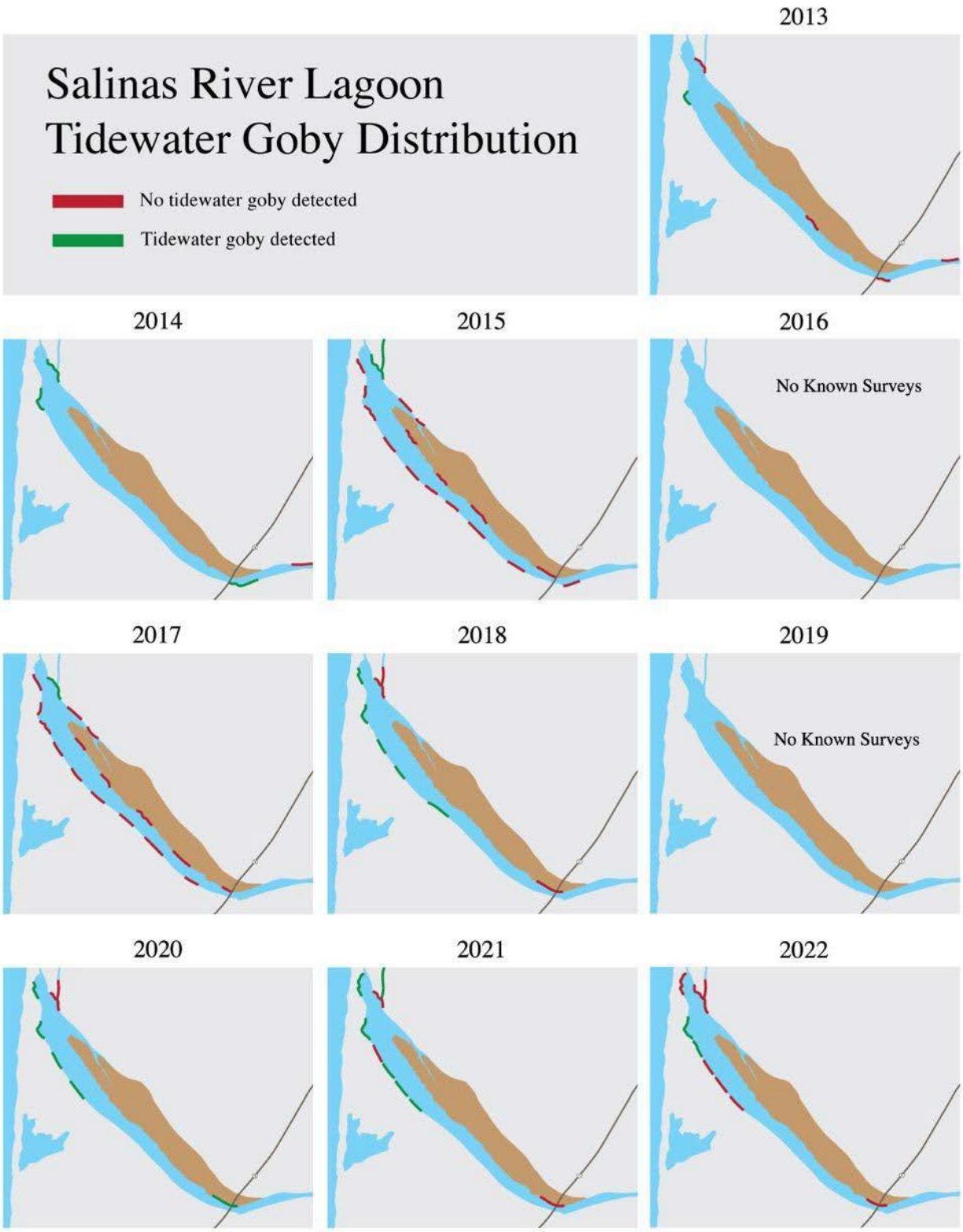

Figure 3. Summary of post-recolonization detection records of tidewater gobies in the Salinas River Lagoon, illustrating presence (green) and non-detection (red). Note: Methods and effort are not standardized. Data from 2015-2017 was collected by Brenton Spies (UCLA Graduate Student) as part of a range-wide distribution study and was shared with MCWRA.

Figure 4. Tidewater goby collected in the Salinas River lagoon, adjacent to the Salinas NWR, on May 9, 2022.

Table 1. Summary of sampling locations in the Salinas River Lagoon, May 9, 2022.

Location	Surface Temperature (ºC)	Surface Salinity (ppt)	TWG Catch	Other species	Comment
36.749704; -121.801128 (A)	18.7	11.02	0	Staghorn sculpin; Prickly sculpin; Threespine stickleback	Ruppia absent
36.750070; -121.801114 (B)	18.3	11.02	0	Threespine stickleback; Staghorn sculpin; Hitch	Ruppia absent
36.750506; -121.803841 (C)	17.8	10.64	0	Staghorn sculpin; Threespine stickleback	Ruppia absent
36.747189; -121.803235 (D)	15.9	10.61	1	Pacific herring; Topsmelt; Threespine stickleback; Staghorn sculpin	Ruppia absent
36.742671; -121.799886 (E)	17.0	10.59	0	Staghorn sculpin; Threespine stickleback	Ruppia absent
36.739192; -121.795568 (F)	17.2	10.38	0	Staghorn sculpin; Threespine stickleback	Ruppia absent
36.731993; -121.783053 (G)	16.4	8.01	0	Staghorn sculpin; Threespine stickleback	Ruppia absent
36.746134; -121.802480 (H)	16.7	10.61	1	Staghorn sculpin; Topsmelt; Threespine stickleback	Ruppia absent
36.741381; -121.798735 (I)	16.3	10.63	0	Threespine stickleback; Staghorn sculpin; Prickly sculpin	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 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. Continued persistence in the lagoon and the Old Salinas River (although not verified in 2018 or 2020) are testament to the broad environmental tolerances of tidewater goby, as they are able to 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 a single population.

The seasonally harsh environmental conditions in the Salinas River Lagoon, particularly during the summer months when little or no freshwater enters the lagoon, may be partially responsible for maintaining the tidewater goby population in the lagoon by limiting invasion or permanent colonization by other species that may compete with or predate tidewater goby. Ambient salinity levels throughout much of the year likely limit the ability of exotic 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). Similarly, bluegill sunfish (*Lepomis macrochirus*) have been found at salinities of up to 5 ppt in the San Francisco Estuary, but salinities greater than 12 ppt are considered lethal to this species (Moyle 2002). Green sunfish (*Lepomis cyanellus*) likely have a lower salinity tolerance and appear to avoid salinities in excess of 2 ppt. Inland silverside (*Menidia beryllina)*, in contrast, have a rather high salinity tolerance, and can survive at salinities approaching that of seawater (Moyle 2002). While silverside can be seasonally very abundant, it is unclear if this species competed with tidewater goby for habitat or prey resources. During the time of the 2020 survey, salinities were remarkably low throughout the sampled habitat, never exceeding 1 ppt in sampled areas, even at the locations closest to the berm at the breach site. Also, some species such as hitch, inland silverside, and threadfin shad were documented in larger numbers than in previous years, or for the first time (such as fathead minnow in the Old Salinas River). In 2021 and 2022, salinities were higher, but moderate, ranging from approximately 8 ppt to 15 ppt, with the salinities gradually decreasing in an upstream direction.

Several large fish, presumably striped bass (*Morone saxatilis*), are generally observed at the surface during the surveys, likely feeding on abundant silverside, shad, or herring, depending on the species most abundant at the time. The presence of abundant, midwater forage fish likely deflects predation pressure by introduced piscivores away from tidewater goby, yet not much is known regarding the interaction between gobies and nonnative, small-bodied fishes that may share

and compete for similar resources. In the lower estuary, marine fishes likely compete with and/or prey upon tidewater gobies when salinities are sufficiently high for their persistence. At times, 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. Both species have a salinity tolerance of 0-55 ppt (based on laboratory trials), yet tidewater gobies appear to prefer salinities below 15 ppt, whereas arrow gobies prefer salinities greater than 15 ppt (Capelli 1997, as cited in Dawson et al. 2002). Yellowfin goby (*Acanthogobius flavimannus*) has been consistently documented in the Salinas River lagoon in recent years and may prey upon and/or compete with tidewater goby. Other marine/estuarine fishes, such as topsmelt (*Atherinops affinis*), staghorn sculpin (*Leptocottus armatus*), starry flounder (*Platichthys stellatus*) or surfperches (Embiotocidae) may occasionally prey upon tidewater goby yet are not known to have detrimental impacts on tidewater goby populations.

Tidewater goby, when present, often show a close association with widgeon grass, which was widespread and common throughout the lagoon during the October 2018 and 2020 sampling events. The abundance of widgeon grass appeared to taper off towards the Highway 1 bridge crossing but was still present in the immediate vicinity of the bridge. In 2021 and 2022, *Ruppia* appeared less abundant, but may have been obscured by high turbidity.

In general, the repeated surveys documented in this report suggest that tidewater gobies distribute broadly throughout the lagoon, although the surveys did not identify any specific areas of high densities or large concentrations of tidewater gobies. Previously, tidewater gobies appeared concentrated in the vicinity of the slidegate connecting the lagoon to the Old Salinas River, perhaps because localized conditions there were more favorable for the species (B. Spies, pers. comm.). Despite only being found in low densities during the surveys documented in this report, overall results suggest that the species can be abundant at times. It should be noted that tidewater goby populations can vary drastically in abundance from year to year – from thousands to millions – depending on whether conditions are favorable during their peak reproductive season in the summer, when the likelihood of natural breaching is lowest (Hellmair et al. 2011).

The length range of captured tidewater gobies documented in recent years (21 mm and 30 mm in 2020 and 2021, respectively) suggest a reproductive period spanning several months and, as a consequence, a moderate level of resilience to environmental disturbance. A prolonged and diverse reproductive period appears to provide a natural safeguard against stochastic events, such as breaching, that may impact larval and juvenile individuals. The modest number of tidewater goby observed in 2022 may be explained by the timing of the survey, which coincided with the expected peak reproductive period of the species. Mature individuals may be in burrows guarding eggs and/or may have decreased in abundance due to post-spawn mortality. It is expected that larval and juvenile tidewater goby will increase in abundance in the subsequent weeks. An additional survey during fall, when tidewater goby abundance is usually highest, would provide a better understanding of the reproductive period of the species in the Salinas lagoon, as spawning is expected to continue into the spring and summer months.

The prolonged time period(s) when the lagoon remained closed to the ocean during the recent years likely benefited the tidewater goby population by providing stable environmental conditions,

as the species is rarely found in areas with strong tidal fluctuations or current. Despite the wet 2016/2017 winter, when the Salinas River Lagoon breached and remained connected to the marine environment for an extended period of time, tidewater goby persisted in the lagoon. In recent years, the duration of connectivity to the ocean were shorter, but still lasted multiple weeks. Changes in salinity resulting from breaching or gradual shifts of particular isoclines throughout the year likely result in a spatial redistribution of tidewater goby to the most favorable environmental conditions found along the salinity gradient. This pattern is evidenced by shifting occupancy patterns throughout the periodic surveys summarized herein. However, as the species is very small, these fishes are weak swimmers, and abrupt changes in water level and salinity should be minimized if possible. As such, operation of the slidegate connecting the Salinas River Lagoon to the Old Salinas River may have served well to provide perennial habitat for the species, a colonization pathway to the Salinas River Lagoon, and by maintaining ambient salinity levels suitable for tidewater goby persistence, while limiting permanent establishment of closely related species (arrow goby) that may outcompete the tidewater goby at higher salinities.

The environmental conditions most suitable for the two fish species of conservation concern in the Salinas River Lagoon – steelhead (*Oncorhynchus mykiss*) and tidewater goby - appear to be at odds with each other. While a closed sandbar/lagoon prevents steelhead from accessing (during their adult spawning migration) and leaving (during juvenile outmigration) the Salinas River basin, it also provides stable conditions for tidewater gobies to persist and reproduce. In the Salinas River lagoon, flooding of agricultural (and residential) lands bordering the lagoon can precede natural breaching, prompting MCWRA to facilitate breaching of the sandbar at the mouth of the Salinas River as required as part of its flood control activities. MCWRA is required to monitor changes in the estuary environment associated with the sandbar management activities and to operate the slidegate at the outlet to the Old Salinas River channel in order to meet the operational targets of the lagoon between December 1 and March 31.

In 2021, lagoon breaching was facilitated twice, once on January 29, and again on December 29. The effects of facilitated breaching on tidewater goby is a topic of concern in the ongoing creation of the Habitat Conservation Plan. Based on the survey record presented in this report, it can be concluded that tidewater goby have persisted in the lagoon throughout multiple periods of connectivity to the ocean following breaching events. The life history of the species requires infrequent connectivity to the marine environment for dispersal among populations and recolonization of populations that have been locally extirpated. However, as small/young tidewater goby have a reduced tolerance to stark environmental fluctuations brought on by breaching events, facilitated breaches (with a reduced magnitude of subsequent water level fluctuations) are thought to have a lower impact than large, more drastic unassisted breaching events. The conditions that necessitate facilitated breaching events are generally characterized by rapidly rising water levels in the lagoon (slower rises in water level can be buffered by outflow through the Old Salinas River). Small, bottom-oriented fish species such as tidewater goby, are not expected to redistribute onto the newly inundated margin habitat (and be potentially at risk of stranding in the event of a breach) in the short period of time between inundation and breaching. Pre-breach seining surveys to evaluate the composition of the fish community in areas subject to dewatering as a result of an impending breach have not documented tidewater goby. As a consequence, detrimental impacts to tidewater goby resulting from facilitated breaching are unlikely, as this action moderates the magnitude of environmental fluctuation expected from an unassisted breaching event. An

unassisted breach of the Salinas River lagoon would be preceded by a higher water level, resulting in a larger volume of water flowing from the lagoon after the initial breach, a larger scour channel across the sandbar, and likely prolonged connectivity to the marine environment. Regardless, deliberate breaching should be avoided, if possible, during the peak reproductive period of tidewater goby (spring and early summer).

Refugee habitats that may be mostly isolated from the surrounding aquatic habitats, such as off-channel ponds, or those that may become temporarily isolated during brief periods of low water levels in the lagoon, may serve as population safeguards in the event of environmental stochasticity in the Salinas River lagoon. Such habitats may exist at the confluence of Tembladero Slough and the Old Salinas River, or along the northern shoreline of the lagoon. However, the current status of tidewater goby occupancy or the environmental suitability of these habitats is unknown and should be evaluated in the near future for conservation planning.

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Appendix A - Lagoon Monitoring Surveys

Tidewater goby (n = 2) were detected during routine lagoon monitoring (conducted by Hagar Environmental Science) in October 2013, but were not detected during April or July of the same year. This observation of tidewater goby was the first record of the species in the lagoon since 1951. Both individuals were collected along the sandbar at the northwestern edge of the lagoon. During surveys conducted the following year (2014), the species was documented at three sites in April (n = 58). One of the individuals was captured at the mouth of the lagoon near the usual location of breaching, four of the individuals were captured along the sandbar at the northwestern edge of the lagoon, and 53 individuals were captured near the Highway 1 Bridge. No further sampling took place later in the year because of fish health concerns and overall ineffectiveness of seining operations due to excessive algal growth. An overview of detection locations in 2013-2014 is displayed in Figure 3.

Appendix B - Metapopulation Studies

Brenton Spies (UCLA) conducted multiple surveys in the Salinas River Lagoon and nearby locations between 2014 and 2017, and shared his collection data with FISHBIO for consideration in drafting the Habitat Conservation Plan.

Spies was able to document and collect tidewater gobies during each visit. As his main objective was to obtain specimen samples of tidewater goby for genetic analysis, rather than to evaluate the distribution of the species throughout the system, these surveys were not comprehensive and did not necessarily cover the entire geographic area of interest. In addition, his collection information does not detail the number or sizes of tidewater gobies that were observed during each survey. However, his records do provide valuable information on population persistence. His detection records have been incorporated into the occupancy overview in Figure 3.

Spies' field notes and more detailed accounts are provided below.

Old Salinas River, immediately south of road bridge (Monterey Dunes Way; 36º46'17.22" N, 121º47'24.21" W)

- November 14, 2014
  - Salinity (ppt): 11.97
  - Temperature (ºC): 16.9
  - Dissolved Oxygen (mg/l): 2.23 (24.9% saturation)

Tidewater gobies were abundant in the Old Salinas River, approximately 1.5 miles north of tidegate. Water quality appeared poor (highly eutrophic with brown surface film), with anoxic mud sediment. Emergent vegetation and ruppia (widgeon grass) were present. Threespine stickleback (*Gasterosteus aculeatus*) and mosquitofish (*Gambusia affinis*) were moderately abundant, yellowfin goby (*Acanthogobius flavimanus*) and prickly sculpin (*Cottus asper*) were present, but in low numbers.

- July 08, 2015
  - Salinity (ppt): 6.14
  - Temperature (ºC): 23.3
  - Dissolved Oxygen (mg/l): 7.12 (86.5% saturation)

Tidewater gobies were abundant under the bridge crossing, but several individuals were infected with microsporida fungus. The system appeared highly eutrophic (brown surface film present). Large amounts of organic and trash debris were present, the sediment was deep, soft anoxic mud. Emergent vegetation and ruppia were present. Threespine stickleback (*Gasterosteus aculeatus*) and mosquitofish (*Gambusia affinis*) were also abundant, yellowfin goby (*Acanthogobius flavimanus*) and prickly sculpin (*Cottus asper*) were present, but in low numbers.

Salinas River Lagoon (36º44'59.21"N, 121º48'4.00"W)

- July 07 and 08, 2015

- Salinity (ppt): 2.01
- Temperature (ºC): 22.7
- Dissolved Oxygen (mg/l): 12.79 (150.3% saturation)

The lagoon was closed at the time of sampling, but evidence of recent wave wash over the sandbar was noted. Approximately 40 seine hauls were performed throughout the system, spanning from the breach site up to the HWY 1 bridge. Tidewater gobies were only found in a small patch of ruppia (widgeon grass) approximately 600 meters from the mouth (north side), directly in front of the farmhouse. Ruppia and other aquatic vegetation was abundant in the lagoon. No tidewater gobies were found near slidegate or at the mouth/sandbar. Most gobies captured were larval or juveniles, confirming an actively reproducing population. No microsporidia infection was noted.

Other fish collected in the lagoon included threespine stickleback (*Gasterosteus aculeatus*) and mosquitofish (*Gambusia affinis*), both abundant. Topsmelt (*Atherinops affinis*) and prickly sculpin (*Cottus asper*) were moderately abundant and found mostly near the sandbar. One juvenile largemouth bass (*Micropterus salmoides*) was collected directly under the Hwy1 bridge.

- October 12, 2017
  - Salinity (ppt): 13 – 18, depending on exact location.
  - Temperature (ºC): NA
  - Dissolved Oxygen (mg/l): NA

The lagoon/sandbar was closed. Significant breaching in the recent past (likely from 2016/2017 winter rains) was evident, and recent wave wash over the sandbar was observed. Many arrow gobies (*Clevelandia ios*) were found throughout system. Tidewater gobies were present but in low abundance and only found directly in front of the slidegate connecting to the Old Salinas River (on the lagoon side). The slidegate was closed but appeared to be well maintained and used regularly. Gobies from Salinas River Lagoon and the Old Salinas River irrigation channel likely intermix and should be considered same population.

Tidewater gobies were captured in 5 of 20 seine hauls. All 5 seines with tidewater gobies were located in the slidegate outflow channel on the Salinas River side. Ruppia was present but not abundant. Large amounts trash and debris had collected by the slidegate where tidewater gobies were found. Threespine Stickleback (*Gasterosteus aculeatus*) and Mosquitofish (*Gambusia affinis*) were both abundant and collected concurrently with tidewater gobies. Prickly Sculpin (*Cottus asper*) were also collected with tidewater gobies but were not abundant throughout the system. Arrow gobies (*Clevelandia ios*) and topsmelt (*Atherinops affinis*) were both present and abundant throughout system, but not collected concurrently with tidewater gobies in individual seine hauls.

Appendix C – 2018 Tidewater Goby Distribution Survey

Summary

Multiple locations in the Salinas River Lagoon were sampled by seining with a handheld beach seine (10 ft long, 4 feet high, 1/8-inch mesh size) on October 13, 2018. One additional survey location ("G") is located on the north side of the lagoon, directly under the southbound Highway 1 bridge. Salinity concentrations (measured with a refractometer) were fairly consistent throughout the lagoon, ranging from 10 ppt in the vicinity of the Old Salinas River gate and the Old Salinas River, to 8 ppt near the Hwy 1 bridge. Tidewater gobies were found in locations with salinities of 9 ppt and 10 ppt, but not at the Hwy 1 bridge (8 ppt).

Tidewater gobies were found at each sampled location along the sandbar at/near the breach site and along the southwest shoreline of the lagoon to the point at which water depth precluded sampling (upstream from the wildlife refuge parking area). This finding contrasted with survey results from most previous years, when the distribution of tidewater goby appeared restricted to the lower lagoon (with exception of the year 2014, when the species was documented as far upstream as the Highway 1 bridge). Tidewater gobies were not found in the vicinity of the Old Salinas River slidegate.

Numbers of tidewater goby captured with each seine haul ranged from 0 (near Old Salinas River slidegate, Old Salinas River and Hwy 1 Bridge) to 3. At sampling sites where the species was detected, every seine haul captured at least one goby. Due to these low capture numbers, estimation of index densities is not biologically meaningful. Tidewater goby appeared widely distributed within the lagoon, suggesting that the species was abundant during this time.

Tidewater gobies captured this survey measured from 21 mm to 36 mm in total length, with a mean and median length of 31 mm. Using age-length relationships derived from a northern California population, these sizes correspond to ages between approximately 97 days and 222 days (mean/median 177 days). This corresponds to a reproductive period between early March and early July, centered around April 19.

Detailed collection records for each sampling site are provided below.

Location A (slidegate, lagoon side)

Three seine hauls were conducted in the lagoon adjacent to the slidegate. No tidewater gobies were found. Documented fish species included threadfin shad (*Dorosoma petenense;* n=7), threespine stickleback (*Gasterosteus aculeatus*; n =35), topsmelt (*Atherinops affinis*; n=4), and prickly sculpin (*Cottus asper*; n=4).

The salinity at this location was 10 ppt.

Location B (Old Salinas River, short distance from the slidegate)

One seine haul was conducted in the Old Salinas River, yielding threespine stickleback (*Gasterosteus aculeatus*; n =8), threadfin shad (*Dorosoma petenense;* n=32), and mosquitofish (*Gambusia affinis*; n=4). No tidewater gobies were found.

Some flow was evident from the lagoon into the Old Salinas River, visually estimated at 3-5 cfs. The salinity at this location was 10 ppt.

Location C (breach site)

Two seine hauls were conducted in the lagoon at the site of breaching and surf washover. Three tidewater gobies were captured (TL[mm]: 32, 35, 35) over sandy substrate. In addition, topsmelt (*Atherinops affinis*; n>50), threespine stickleback (*Gasterosteus aculeatus*; n=19) and prickly sculpin (*Cottus asper*; n=1) were documented at this location.

No aquatic vegetation was noted in the area, salinity was measured at 10 ppt.

Location D (southern end of beach berm)

One seine haul was conducted in this location, yielding threespine stickleback (*Gasterosteus aculeatus*; n =34), and one tidewater goby (TL: 26 mm). No other fish species were captured at this location.

The salinity at this location was 10 ppt.

Location E (southwest shore)

One seine haul was conducted at this location, just upstream of the last stand of bulrush (*Scirpus sp.*). Four tidewater gobies were captured at this location (TL [mm]: 33, 30, 32, 36). In addition, threespine stickleback (*Gasterosteus aculeatus*; n=47) and bluegill sunfish (*Lepomis macrochirus*; n=1; juvenile) were documented.

The salinity at this location was 10 ppt.

Location F (southwest shore)

Two seine hauls were conducted in the vicinity of the Salinas National Wildlife Refuge sign. Nine tidewater gobies were captured (TL[mm]: 21, 27, 28, 29, 30, 31, 31, 32, 36). In addition, topsmelt (*Atherinops affinis*; n=1), threespine stickleback (*Gasterosteus aculeatus*; n>150) and largemouth bass (*Micropterus salmoides*; n=1; 81 mm [FL]) were documented at this location.

Ruppia was noted in the area, salinity was measured at 9 ppt.

Location X (pond within the Salinas National Wildlife Refuge)

A visual survey and salinity measurement (> 95 ppt) ruled out the shallow pond (depth <20 cm) near the southern end of the Salinas River Wildlife Refuge as potential tidewater goby habitat.

Location G (HWY 1 Bridge)

Three seine hauls were conducted in the vicinity of the of the Highway 1 bridge crossing. No tidewater gobies were captured at this location. Threespine stickleback (*Gasterosteus aculeatus*; n>200), mosquitofish (*Gambusia affinis*; n=51), prickly sculpin (*Cottus asper*; n=9) and juvenile hitch (*Lavinia exilicauda*; n=21) were documented at this location.

Sparse ruppia was noted in the area, salinity was measured at 8 ppt.

Appendix D – 2020 Tidewater Goby Distribution Survey

Summary

Multiple locations in the Salinas River Lagoon were sampled by seining with a handheld beach seine (10 ft long, 4 feet high, 1/8-inch mesh size) on October 19, 2020. Locations sampled were identical to those sampled in 2018 (see Figure 1).

Tidewater gobies were found at most sampled locations, including the Hwy 1 Bridge, with exception of the immediate vicinity of the Old Salinas River slidegate and the Old Salinas River. These findings, similar to 2018, again contrasted with survey results from most previous years, when the distribution of tidewater goby appeared restricted to the lower lagoon.

Numbers of tidewater goby captured with each seine haul during the 2020 survey ranged from 0 (near Old Salinas River slidegate and Old Salinas River) to 3 (Location F; see Figure 1). At sample sites where the species was detected, no subsequent seine hauls were performed following detection. Similar to the previous surveys, estimation of index densities is not biologically meaningful due to low capture numbers. Despite low capture numbers in individual seine hauls, tidewater goby continued to be widely distributed within the lagoon, suggesting that the species remained abundant.

Salinity concentrations (measured with a YSI ProSolo Digital Water Quality Meter) were consistently low throughout all sampled locations, only varying between 0.39 ppt (near the breach site) and 0.60 ppt (at the Highway 1 bridge).

Tidewater gobies measured from 26 mm to 47 mm in length, with a mean length of 32.3 mm and a median length of 30 mm. Using age-length relationships derived from a northern California population, these sizes correspond to ages between approximately 136 days and 336 days (mean/median 169 days). This corresponds to a reproductive period between early November 2019 and early July 2020, centered around May 4.

Detailed collection records for each sampling site are provided below.

Location A (slidegate, lagoon side)

Two seine hauls were conducted in the lagoon adjacent to the slidegate. No tidewater gobies were found. Documented fish species included yellowfin goby (*Acanthogobius flavimanus*, n=3), threespine stickleback (*Gasterosteus aculeatus*; estimated at n=20 per seine haul), and inland silverside (*Menidia berrylina*; estimated at n=180 per seine haul).

The salinity at this location was 0.40 ppt, the water temperature was 18.9°C, dissolved oxygen concentration was 10.35 mg/l (111.6% saturation). *Ruppia* (widgeon grass) was present in high densities.

Location B (Old Salinas River, short distance from the slidegate)

One seine haul was conducted in the Old Salinas River. No tidewater gobies were found. The seine haul captured prickly sculpin (*Cottus asper*; n=1), threadfin shad (*Dorosoma petenense*; n=4), hitch (*Lavinia exilicauda*; n=1), fathead minnow (*Pimephales promelas*; n=53), and a large number of inland silverside (*Menidia berrylina*; estimated at n=330).

Some flow was evident from the lagoon into the Old Salinas River, visually estimated at 3-5 cfs. The salinity at this location was 0.40 ppt, the water temperature was 18.8°C, dissolved oxygen concentration was 11.15 mg/l (120.8% saturation). *Ruppia* was absent.

Location C (breach site)

Two seine hauls were conducted in the lagoon at the site of breaching (lowest elevation of sand berm). One tidewater goby was captured (TL = 26 mm) over sandy substrate. In addition, threespine stickleback (*Gasterosteus aculeatus*; n=21) and silverside (*Menidia berrylina*; estimated at n=900 combined) were documented at this location.

The salinity at this location was 0.40 ppt, the water temperature was 19.5°C, dissolved oxygen concentration was 9.62 mg/l (104.9 % saturation). *Ruppia* was present, but sparse.

Location D (southern end of beach berm)

Two seine hauls were conducted in this location, yielding one tidewater goby (TL = 29 mm), threespine stickleback (*Gasterosteus aculeatus*; n=28), mosquitofish (*Gambusia affinis*; n=2), hitch (*Lavinia exilicauda*; n=2) and silverside (*Menidia berrylina*; estimated at n=600 combined).

The salinity at this location was 0.40 ppt, the water temperature was 19.2°C, dissolved oxygen concentration was 14.22 mg/l (154.4 % saturation). *Ruppia* was present in low density.

Location E (southwest shore)

One seine haul was conducted at this location, just upstream of the last stand of bulrush (*Scirpus sp.*). One tidewater goby was captured at this location (TL [mm]: 33). In addition, hitch (*Lavinia exilicauda*; n=1), threespine stickleback (*Gasterosteus aculeatus*; estimated at n=50), and silverside (*Menidia berrylina*; n=120) were documented.

The salinity at this location was 0.39 ppt, the water temperature was 19.4°C, dissolved oxygen concentration was 13.48 mg/l (147.4 % saturation). *Ruppia* was present in medium density.

Location F (southwest shore)

One seine haul was conducted in the vicinity of the Salinas National Wildlife Refuge sign. Three tidewater gobies were captured (TL[mm]: 28, 30, 33). In addition, threespine stickleback (*Gasterosteus aculeatus*; n>150) and silverside (*Menidia berrylina*; n=133) were documented at this location.

The salinity at this location was 0.40 ppt, the water temperature was 18.5°C, dissolved oxygen concentration was 10.53 mg/l (112.7 % saturation). *Ruppia* was present in high density.

Location G (HWY 1 Bridge)

Two seine hauls were conducted in the vicinity of the Highway 1 bridge crossing. One tidewater goby was captured at this location (TL = 47 mm). Threespine stickleback (*Gasterosteus aculeatus*; n>200), mosquitofish (*Gambusia affinis*; n>200), prickly sculpin (*Cottus asper*; n=32), silverside (*Menidia berrylina*; n=5), juvenile green sunfish (*Lepomis cyanellus*; n=1), juvenile goldfish (*Carassius auratus*; n=1), and hitch (*Lavinia exilicauda*; n=1) were documented at this location.

Dense *ruppia* was noted in the area, salinity was measured at 0.6 ppt. The water temperature was 18.0°C, dissolved oxygen concentration was 5.11mg/l (55 % saturation). *Ruppia* was present in high density.

Appendix E – 2021 Tidewater Goby Distribution Survey

Summary

During the spring survey on April 12, 2021, tidewater goby were found at most sampled locations, with exception of the Highway 1 Bridge, the lagoon side of the slidegate, and one of the sampled locations adjacent to the NWR (Table 1; Figure 3). Locations sampled were identical to those sampled in 2018 and 2020 (see Figure 1), as well as two additional locations (herein termed "H" and "I"), located between "D" and "E", and "E" and "F", respectively.

Numbers of tidewater goby captured with each seine haul during the 2021 survey ranged from 0 (near Old Salinas River slidegate) to 14 (in the Old Salinas River). At sampling sites where the species was detected, no subsequent seine hauls were performed following detection. Similar to the previous surveys, estimation of index densities is not biologically meaningful due to low capture numbers. Despite low capture numbers in individual seine hauls, tidewater goby continued to be widely distributed. Salinity concentrations (measured with a YSI ProSolo Digital Water Quality Meter) were moderately high (Table 1), as compared to earlier surveys (e.g., in 2020, when salinities ranged from only 0.39 ppt near the breach site to 0.60 ppt at the Highway 1 bridge).

Tidewater gobies captured during the April 2021 field survey measured from 16 mm to 46 mm in length, with a mean length of 34.1 mm, suggesting ages ranging from 61 to 325 days (mean 206) and prolonged reproductive period. According to this method, the youngest goby hatched on February 10, 2021, and the oldest on May 22 the previous year.

Detailed collection records for each sampling site are provided below.

Location A (slidegate, lagoon side)

One seine haul was conducted in the lagoon adjacent to the slidegate. No tidewater gobies were found. Documented fish species included staghorn sculpin (*Leptocottus armatus*; n = 16), prickly sculpin (*Cottus asper*; n=2) and Pacific herring (*Clupea pallasii*; n=126).

The salinity at this location was 14.60 ppt, the water temperature was 15.6°C, dissolved oxygen concentration was 6.64 mg/l. *Ruppia* (widgeon grass) was absent.

Location B (Old Salinas River, just downstream from the slidegate)

One seine haul was conducted in the Old Salinas River. A total of 14 tidewater gobies were found, ranging in size from 34 to 46 mm. The seine haul also captured threespine stickleback (*Gasterosteus aculeatus*; 98), staghorn sculpin (*Leptocottus armatus*; n = 8), prickly sculpin (*Cottus asper*; n=18), Pacific herring (*Clupea pallasii*; n=26), and silverside (*Menidia berrylina*; n=15).

Some flow was evident from the lagoon into the Old Salinas River, visually estimated at 2 cfs (gauge height on lagoon side: 4 ft) The salinity at this location was 14.21 ppt, the water temperature was 15.5°C, dissolved oxygen concentration was 5.30 mg/l. *Ruppia* was absent.

Location C (breach site)

One seine haul was conducted in the lagoon at the breach site. One tidewater goby was captured TL = 22 mm). In addition, staghorn sculpin (*Leptocottus armatus*; n = 38), Pacific herring (*Clupea pallasii*; n=144), and silverside (*Menidia berrylina*; n=19) were captured.

The salinity at this location was 15.03 ppt, the water temperature was 15.4°C, dissolved oxygen concentration was 8.24 mg/l. *Ruppia* was absent.

Location D (southern end of beach berm)

One seine haul was conducted in the lagoon at the breach site. One tidewater goby was captured (TL = 31 mm). Pacific herring (*Clupea pallasii*; n=6), staghorn sculpin (*Leptocottus armatus*; n=101), and silverside (*Menidia berrylina*; too numerous to count) were also documented.

The salinity at this location was 14.97 ppt, the water temperature was 15.4°C, dissolved oxygen concentration was 5.97 mg/l. *Ruppia* was absent.

Location E (southwest shore)

One seine haul was conducted at this location. One tidewater goby (TL = 20 mm), Pacific herring (*Clupea pallasii*; n=21), and staghorn sculpin (*Leptocottus armatus*; n=30) were captured at this location.

The salinity at this location was 14.62 ppt, the water temperature was 15.6°C, dissolved oxygen concentration was 5.10 mg/l. *Ruppia* was absent.

Location F (southwest shore)

One seine haul was conducted in the vicinity of the Salinas National Wildlife Refuge sign, resulting in the capture of three tidewater goby (TL = 31, 54, 45). Pacific herring (*Clupea pallasii*; too numerous to count), staghorn sculpin (*Leptocottus armatus*; n=15), and silverside (*Menidia berrylina*; too numerous to count) were also documented.

The salinity at this location was 13.18 ppt, the water temperature was 17.2°C, dissolved oxygen concentration was 11.14 mg/l. *Ruppia* was absent.

Location G (HWY 1 Bridge)

One seine haul was conducted in the vicinity of the of the Highway 1 bridge crossing. Pacific herring (*Clupea pallasii*; n = 170) and staghorn sculpin (*Leptocottus armatus*; n=74) were the only species captured at this location.

Salinity was measured at 9.32 ppt. The water temperature was 16.5°C, dissolved oxygen concentration was 10.40 mg/l. *Ruppia* was absent.

Location H (southwest shore)

Located between collection locations "D" and "E", one seine haul was conducted here. Pacific staghorn sculpin (*Leptocottus armatus*; n=20), Pacific herring (*Clupea pallasii*; too numerous to count), and silverside (*Menidia berrylina*; too numerous to count) were documented.

The salinity at this location was 15.00 ppt, the water temperature was 15.5°C, dissolved oxygen concentration was 5.88 mg/l. *Ruppia* was absent.

Location I (southwest shore)

Located between collection locations "E" and "F", a single seine haul was conducted here. Five tidewater goby (TL = 16, 18, 18, 20, 27) were captured. In addition, Pacific staghorn sculpin (*Leptocottus armatus*; n=16), Pacific herring (*Clupea pallasii*; n=17), and silverside (*Menidia berrylina*; n=14) were documented.

The salinity at this location was 14.53 ppt, the water temperature was 16.2°C, dissolved oxygen concentration was 5.32 mg/l. *Ruppia* was absent.

Table E1. Summary of sampling locations in the Salinas River Lagoon, April 12, 2021.

Location	Surface Temperature (ºC)	Surface Salinity (ppt)	TWG Catch	Other species	Comment
36.749704; -121.801128 (A)	15.6	14.60	0	Pacific herring; Staghorn sculpin; Prickly sculpin	Ruppia absent
36.750070; -121.801114 (B)	15.5	14.21	14	Threespine stickleback; Pacific herring; Staghorn sculpin; Prickly sculpin; Inland silverside	Ruppia absent
36.750506; -121.803841 (C)	15.4	15.03	1	Pacific herring; Staghorn sculpin; Inland silverside	Ruppia absent
36.747189; -121.803235 (D)	15.4	14.97	1	Pacific herring; Staghorn sculpin; Inland silverside	Ruppia absent
36.742671; -121.799886 (E)	15.6	14.62	1	Pacific herring; Staghorn sculpin	Ruppia absent
36.739192; -121.795568 (F)	17.2	13.18	3	Pacific herring; Staghorn sculpin; Inland silverside	Ruppia absent
36.731993; -121.783053 (G)	16.5	9.32	0	Pacific herring; Staghorn sculpin	Ruppia absent
36.746134; -121.802480 (H)	15.5	15.00	0	Pacific herring; Staghorn sculpin; Inland silverside	Ruppia absent
36.741381; -121.798735 (I)	16.2	14.53	5	Pacific herring; Staghorn sculpin; Inland silverside	Ruppia absent

Appendix F – 2022 Tidewater Goby Distribution Survey

Multiple locations in the Salinas River Lagoon were sampled by seining with a handheld beach seine (10 ft long, 4 feet high, 1/8-inch mesh size) on May 9, 2022. Locations sampled are identical to those sampled in 2021 (see Figure 1).

Location A (slidegate, lagoon side)

Two seine hauls were conducted in the lagoon adjacent to the slidegate. No tidewater gobies were found. Documented fish species included staghorn sculpin (*Leptocottus armatus*; n = 47), threespine stickleback (*Gasterosteus aculeatus*; n=1), and prickly sculpin (Cottus asper; n=1).

The salinity at this location was 11.02 ppt, the water temperature was 18.7°C, dissolved oxygen concentration was 10.46 mg/l (111.8 % saturation). *Ruppia* (widgeon grass) was absent.

Location B (Old Salinas River, just downstream from the slidegate)

One seine haul was conducted in the Old Salinas River. No tidewater gobies were found. The seine haul captured staghorn sculpin (*Leptocottus armatus*; n = 6), hitch (*Lavinia exilicauda*; n=2), and a large number of threespine stickleback (*Gasterosteus aculeatus*; too numerous to count). Many stickleback displayed spawning coloration.

Some flow was evident from the lagoon into the Old Salinas River. The salinity at this location was 11.02 ppt, the water temperature was 18.3°C, dissolved oxygen concentration was 10.34 mg/l (110.9 % saturation). *Ruppia* was absent.

Location C (breach site)

One seine haul was conducted in the lagoon at the site of breaching (lowest elevation of sand berm, at the far northern end or the lagoon). No tidewater goby were captured. A single threespine stickleback (*Gasterosteus aculeatus*) and six staghorn sculpin (*Leptocottus armatus*) were documented at this location, which was characterized by shallow water and sandy, otherwise featureless substrate. Notably, large numbers of mysid shrimp were captured.

The salinity at this location was 10.64 ppt, the water temperature was 17.8°C, dissolved oxygen concentration was 11.56 mg/l (128.9 % saturation). *Ruppia* was absent.

Location D (southern end of beach berm)

Two seine hauls were conducted in this location, yielding one tidewater goby (TL 45 mm), threespine stickleback (*Gasterosteus aculeatus*; n=6), Pacific herring (*Clupea pallasii*; n=4), staghorn sculpin (*Leptocottus armatus*; n=12), and one topsmelt (*Atherinops affinis*).

The salinity at this location was 10.61 ppt, the water temperature was 15.9°C, dissolved oxygen concentration was 7.72 mg/l (82.2 % saturation). *Ruppia* was absent.

Location E (southwest shore)

One seine haul was conducted at this location, just upstream of the last stand of bulrush (*Scirpus sp.*). Threespine stickleback (*Gasterosteus aculeatus*; n=6) and Pacific staghorn sculpin (*Leptocottus armatus*; n=9) were captured at this location.

The salinity at this location was 10.59 ppt, the water temperature was 17.0°C, dissolved oxygen concentration was 6.91 mg/l (75.5 % saturation). *Ruppia* was absent.

Location F (southwest shore)

One seine haul was conducted in the vicinity of the Salinas National Wildlife Refuge sign. Threespine stickleback (*Gasterosteus aculeatus*; n=4) and Pacific staghorn sculpin (*Leptocottus armatus*; n=4) were captured at this location.

The salinity at this location was 10.38 ppt, the water temperature was 17.2°C, dissolved oxygen concentration was 6.77 mg/l (75.0 % saturation). *Ruppia* was absent.

Location G (HWY 1 Bridge)

One seine haul was conducted in the vicinity of the of the Highway 1 bridge crossing. Threespine stickleback (*Gasterosteus aculeatus*; n=57) and Pacific staghorn sculpin (*Leptocottus armatus*; n=3) were the only two species captured at this location.

Salinity was measured at 8.01 ppt. The water temperature was 16.4°C, dissolved oxygen concentration was 14.36 mg/l (147 % saturation). *Ruppia* was absent.

Location H (southwest shore)

Located between collection locations “D” and “E”, one seine haul was conducted here. One tidewater goby (TL 40mm) was captured here, in addition to topsmelt (*Atherinops affinis*; n=1), Pacific staghorn sculpin (*Leptocottus armatus*; n=48), and threespine stickleback (*Gasterosteus aculeatus*; n=9).

The salinity at this location was 10.61 ppt, the water temperature was 16.7°C, dissolved oxygen concentration was 6.79 mg/l (74.2 % saturation). *Ruppia* was absent.

Location I (southwest shore)

Located between collection locations “E” and “F”, a single seine haul was conducted here. Pacific staghorn sculpin (*Leptocottus armatus*; n=21), threespine stickleback (*Gasterosteus aculeatus*; n=5) and one prickly sculpin (*Cottus asper*) were documented at this location.

The salinity at this location was 10.63 ppt, the water temperature was 16.3°C, dissolved oxygen concentration was 6.26 mg/l (68.3 % saturation). *Ruppia* was absent.

Appendix G – 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.

Appendix H – 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
2. **When the data was collected:** May 9, 2022
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

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

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

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

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

Debris Code	**Description**
LIT	Light
MED	Medium
HVY	Heavy

Weather Code	**Description**
CLD	Cloudy
RAN	Rainy
CLR	Clear
NIT	Night

Sacramento 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
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