Salinas River Lagoon Fish Distribution Study

Summary of Recent Tidewater Goby Surveys

Submitted To:
Monterey County Water Resource Agency

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November 2018

Table of Contents

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, 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; 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). The tidewater goby, as a species, 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 large surf, they often drain rapidly. This is followed by an influx of ocean water with the tidal cycle, which drastically changes the salinity and temperature of the habitat. 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 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).

This review of past collection information and the 2018 fish distribution survey was designed to provide insight about 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, it was anticipated that distributional information may help to better understand potential colonization pathways (e.g. via the Old Salinas River to Elkhorn Slough) of tidewater gobies. 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 resilience to disturbance (Hellmair and Kinziger 2014). Lastly, non-lethal tissue samples were collected for future genetic analysis, which may provide information on the source population of recolonization and pathways connecting the tidewater goby metapopulation.

This detailed information about tidewater goby densities and distributions within the lagoon is an important consideration given the upcoming 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 (artificial breaching) as well as other operations. Distribution surveys were designed to help inform the permit application process and provide information on population resilience to natural and artificial 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 (Hellmair and Kinziger 2014). Information about population persistence and demographic information (length/age frequencies), are based in part on data collected in the lagoon by HES from 2011-2014, and by Brenton Spies, a PhD candidate at University of California, Los Angeles from 2014-2017. In addition, FISHBIO sampled numerous locations

throughout the lagoon environment on October 13, 2018, to build upon the data previously collected by HES and Mr. Spies. Results from all of these efforts are presented 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-ft X 8-ft; ¼ inch mesh size) were used to sample fish in areas with deeper water or along obstructed banks. In these locations, the seine was set 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-ft X 6-ft; ¼ inch mesh size) was used for sampling and the seine 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 ft wide; ⅛ inch mesh size; B. Spies, pers. comm.). B. 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 using a two-person crew on October 13, 2018, utilized a 10 x 4 ft. beach seine (⅛ inch mesh). Numerous locations were sampled throughout the lagoon, distributed from the sandbar to upstream of the Highway 1 Bridge, as well as in the Old Salinas River (OSR) directly behind the slidegate. Sampling sites were accessed on foot from the Salinas National Wildlife Refuge, and sampling began at the OSR slidegate. Sampling proceeded around the western perimeter of the lagoon (near the breach site) and the southern shoreline at locations spaced approximately 200 meters (600 feet) apart, until water depth and dense emergent/riparian vegetation prevented sampling by beach seine. No particular habitat type was targeted or favored for sampling; rather, equidistant sampling locations were chosen to obtain an adequate overview of the spatial distribution of gobies within the lagoon. At each sampling location, two to three seine hauls were conducted. All fish captured during each survey, regardless of method, were identified to species and all tidewater goby were enumerated.

The month of October is during the period with the highest abundance for tidewater goby in general, and as such, it was expected that this would be the period with the highest detection

probability. All targeted sampling for tidewater goby was conducted following protocols developed by the United States Fish and Wildlife Service (USFWS 2005 Appendix F).

During the survey on October 13, 2018, all captured tidewater gobies were measured to the nearest millimeter (total length; TL), permitting an evaluation of 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).

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 captured and measured during the October 2018 sampling event, 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

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

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; as a consequence, this report foregoes analysis of fish densities, and focuses on the temporal and spatial distribution of tidewater goby in the Salinas River Lagoon.

Results

Lagoon Steelhead Monitoring Surveys (HES)

Tidewater goby (n = 2) were detected during routine lagoon monitoring in October 2013 (but not 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, 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 2013-2104 is displayed in Figure 1.

Metapopulation studies (Brenton Spies, UCLA)

Brenton Spies has conducted multiple surveys in the Salinas River Lagoon and nearby locations since 2014, and shared his collection information with FISHBIO for consideration in drafting the Habitat Conservation Plan.

He surveyed the Salinas River Lagoon and/or the Old Salinas River multiple times since 2014, and was able to document and collect tidewater gobies during each visit. As his main objective was to obtain specimen samples of tidewater goby, 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 1.

His field notes and more detailed accounts are provided in Appendix A.

Tidewater Goby Distribution Surveys (FISHBIO)

Tidewater gobies were found at each sampled location along the sandbar at/near the breach site and along the southwest shoreline of the lagoon until water depth precluded sampling (upstream from the wildlife refuge parking area). This finding contrasts 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). Contrary to expectations, tidewater gobies were not found in the vicinity of the OSR slidegate. During past surveys, the species was regularly found in this area, and in the OSR in the vicinity of the Monterey Dunes Way road crossing. Although this location was not sampled in October 2018 due to permit restrictions, high tidewater goby densities were also expected in this area (B. Spies, pers. comm.). Detailed collection records from the distribution surveys are available in Appendix B.

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 1.

Numbers of tidewater goby captured with each seine haul during the 2018 survey ranged from 0 (near OSR slidegate, OSR 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. However, despite low captured numbers in individual seine hauls, tidewater goby appear widely distributed within the lagoon, suggesting that the species was abundant during this time.

Salinity concentrations (measured with a refractometer) were fairly consistent throughout the lagoon, ranging from 10 ppt in in vicinity of the OSR gate and the OSR, 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 captured during the October 2018 field survey measured from 21 mm to 36 mm in 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; Figure 2). This corresponds to a reproductive period between early March and early July, centered around April 19.

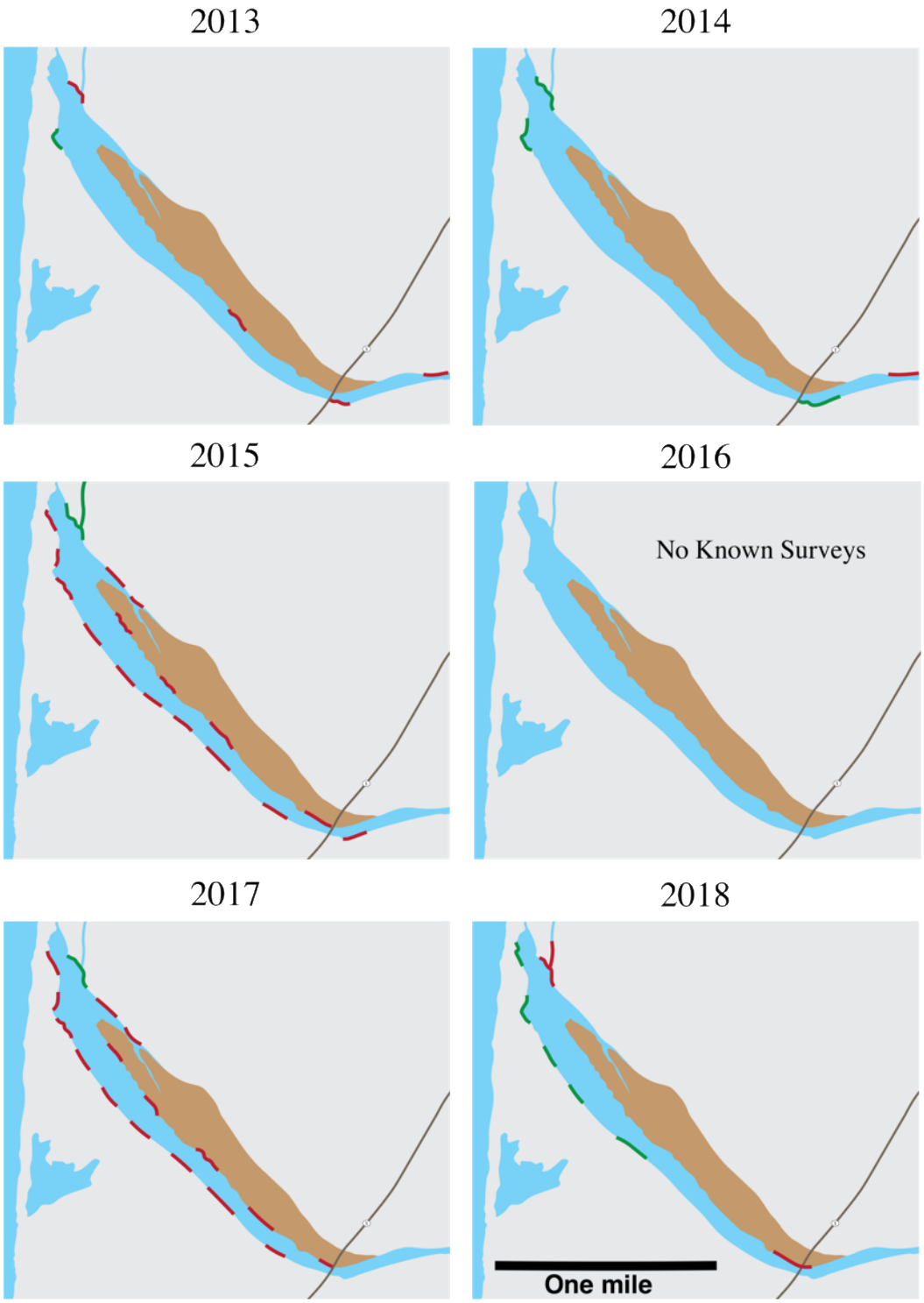

Figure 1. Summary of post-recolonization detection records of tidewater gobies in the Salinas River Lagoon, illustrating presence (green) and non-detection (red). Note: methods and effort are not standardized.

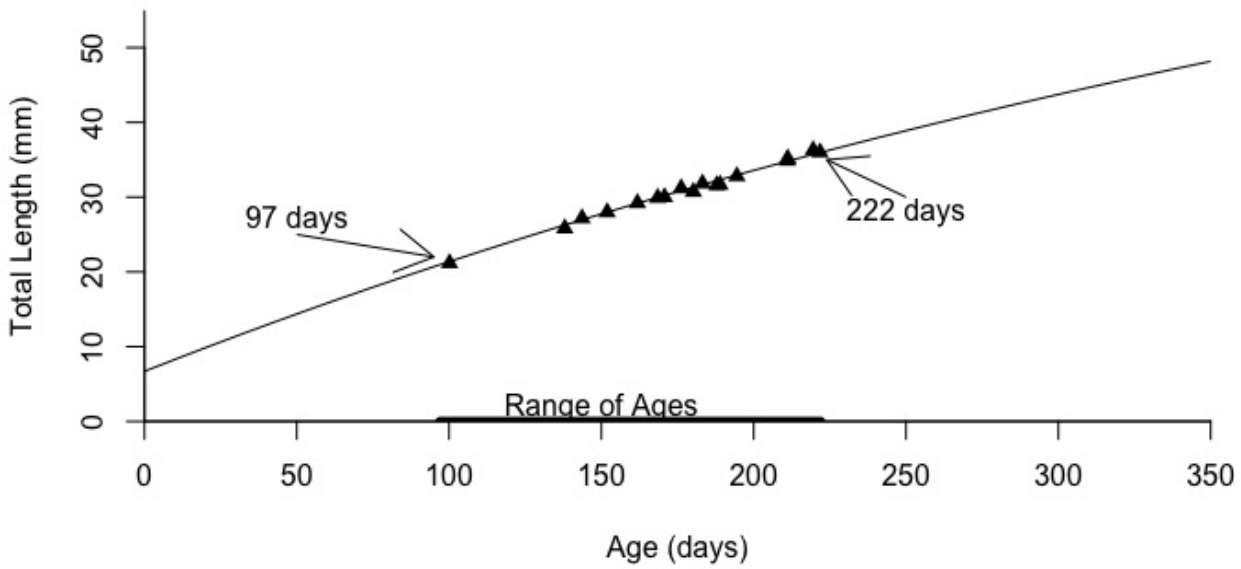

Figure 2. Total lengths (in millimeters [mm]) of tidewater goby (n = 17) captured during surveys conducted on October 13, 2018, and their estimated age, based on Von Bertalanffy growth parameters.

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 et al. 2014), continuous presence of tidewater goby in the Salinas River Lagoon (and the Old Salinas River) are 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 (although not verified in October 2018) in the Old Salinas River 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 et al. 2014). Tidewater gobies from Salinas River Lagoon and the Old Salinas River likely intermix and should be considered the same population.

It appears that the (seasonally) harsh environmental conditions in the Salinas River lagoon, particularly during the summer months when little or no freshwater enters the lagoon, are partially responsible for maintaining the tidewater goby population in the lagoon, including through limiting invasion or permanent colonization by other species. Exotic species, such as largemouth bass (*Micropterus salmoides*) and sunfishes (*Lepomis* spp.) are likely limited in their ability to use the lower estuary by ambient salinity levels. 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 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).

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 lab trials), yet tidewater gobies appear to prefer salinities below 15 ppt, and arrow gobies those greater than 15 ppt (Capelli 1997, as cited in Dawson et al. 2002). 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 (*ruppia*), which was widespread and common throughout the lagoon during the October 2018 sampling event. The abundance of ruppia appeared to taper off towards the Highway 1 bridge crossing, but was still present in the immediate vicinity of the bridge. No tidewater gobies were found at this location, perhaps due to decreasing levels of salinity (8 ppt) and the species' ability for uninhibited movement to areas of preferable environmental conditions within the lagoon.

In general, the October survey revealed that tidewater gobies were widely distributed throughout the lagoon, although our survey did not identify any specific areas of high densities/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 October survey, overall results suggest that the species was abundant during this time. 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 (summer, when the likelihood of natural breaching is lowest; Hellmair et al. 2011).

The length range of captured tidewater gobies (15 mm) is greater than that found for some tidewater goby populations along the North Coast, which are at an elevated risk of extirpation due to their constrained reproductive period. A reproductive period approximately four months in duration – as estimated for the Salinas River Lagoon population of tidewater goby, suggests a medium level of resilience to environmental disturbance

The prolonged time period when the lagoon remained closed to the ocean during the recent drought likely benefitted 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 extended periods of time, tidewater goby persisted in

the lagoon. 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 lack of documentation of tidewater goby in front of the slidegate in October, despite being highly concentrated in this location during previous surveys (B. Spies, pers. comm.). However, as the species is very small, these fishes are weak swimmers, and abrupt changes in water level and salinity should be minimized if management action permits. 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 high enough to prevent distribution of exotic freshwater species to the lower lagoon while limiting permanent establishment of closely related species (arrow goby) that may outcompete the tidewater goby.

The environmental conditions most suitable for the two fish species of conservation concern in the Salinas River Lagoon – steelhead 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. Establishing connectivity to the marine environment during the primary migration period of steelhead is desirable, and in the Salinas River lagoon, flooding of agricultural (and residential) lands bordering the lagoon can precede natural breaching, prompting MCWRA to manually breach the sandbar at the mouth of the Salinas River as required as part of its flood control activities. Under the terms and conditions of the BO (NMFS 2009), the MCWRA is required to monitor changes in the estuary environment associated with the sandbar management activities and to operate the slide gate at the outlet to the Old Salinas River (OSR) channel in a manner that facilitates filling of the lagoon between December 1 and March 31. In order to maintain suitable conditions for both of these species, it would be prudent to initiate breaching events – if water levels warrant – as soon as possible to avoid overly drastic changes to the lagoon habitat (several small breaches are preferable to one large breaching event). In any case, artificial breaching of the lagoon during the primary reproductive period of tidewater goby (spring and summer) should be avoided.

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Appendix A - Metapopulation Studies

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 farm house. Ruppia and other aquatic vegetation was abundant in the lagoon. No tidewater gobies were found near tidegate 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 tidegate connecting to the Old Salinas River (on the lagoon side). The tidegate 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 tidegate outflow channel on the Salinas River proper side. Ruppia was present but not abundant. Large amounts trash and debris had collected by the tidegate 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 B - 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 October 13, 2018.

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.

Figure B1. Aerial image indicating collection locations for the October 13, 2018 survey.

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 (Figure 2). The salinity at this location was 10 ppt.

Figure B2. Old Salinas River, directly behind the slidegate, on October 13, 2018. Water was flowing in through the slidegate, visually estimated at 3-5 cfs.

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; Figure 3) were documented.
The salinity at this location was 10 ppt.

Figure B3. Juvenile bluegill sunfish (Lepomis macrochirus) and tidewater goby (Eucyclogobius newberryi) captured in the Salinas River Lagoon on October 13, 2018 (Location E; Figure 1).

Location F (southwest shore)

Two seine hauls were conducted in the vicinity of the Salinas National Wildlife Refuge sign (Figure 4). 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.

Figure B4. Aerial images indicating collection locations for the October 13, 2018 survey.

Figure B5. Juvenile largemouth bass captured in the Salinas River Lagoon on October 13, 2018.

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 (Figure 6). 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; Figure 7) were documented at this location.
Sparse ruppia was noted in the area, salinity was measured at 8 ppt.

Figure B6. Aerial images indicating collection locations for the October 13, 2018 survey.

Figure B7. Juvenile hitch, *Lavinia exilicauda*, captured in the vicinity of the Highway 1 bridge crossing on October 13, 2018.