2019

Annual Report of the Status of Condition A: Wetland Mitigation

SAN ONOFRE NUCLEAR GENERATING STATION (SONGS) MITIGATION PROGRAM

Marine Science Institute

UCSB

2019

Annual Report of the Status of Condition A: Wetland Mitigation

SAN ONOFRE NUCLEAR GENERATING STATION (SONGS) MITIGATION PROGRAM

Submitted to the California Coastal Commission
October 2020

By Mark Page, Stephen Schroeter and Daniel Reed
Marine Science Institute, University of California Santa Barbara

Contributors
David Huang, Andres Deza, Emily Blair, Morgan Tusa, Justin Hoesterey, Russell Johnston, Denise Weisman, Lindsey Chamberlain, Carly Haack, Isaac Scott
Marine Science Institute, University of California Santa Barbara

Science Advisory Panel
Richard Ambrose, University of California Los Angeles
Peter Raimondi, University of California Santa Cruz
Russell Schmitt, University of California Santa Barbara

Coastal Commission Staff
Kate Huckelbridge
Laurie Koteen

Table of Contents

1.0 Executive Summary

Condition A of the San Onofre Nuclear Generating Station's (SONGS) coastal development permit (CDP) requires Southern California Edison (SCE) and its partners to construct or substantially restore a minimum of 150 acres of tidal wetlands, excluding buffer zone and transition, as partial mitigation for the projected reductions in populations of adult fish throughout the Southern California Bight due to operations of the power plant. San Dieguito Lagoon, located in northern San Diego County was chosen as the wetland mitigation site. Construction of the San Dieguito Wetlands Restoration Project began in September 2006 and was completed in September 2011. The success of the San Dieguito Wetlands Restoration Project in satisfying the mitigation requirements is based on its ability to meet the physical and biological performance standards provided in the SONGS coastal development permit. Annual monitoring is required to determine whether the restoration project has met these standards. Monitoring also tracks ecosystem development and identifies opportunities for adaptive management. The monitoring is overseen by the California Coastal Commission (CCC) and is done independently of SCE. This report summarizes the eighth year of post-construction monitoring done in 2019.

Two types of standards are used to evaluate the performance of the restoration project. Absolute standards are measured only in San Dieguito Wetlands and must be met every year to receive mitigation credit. Relative standards are measured in San Dieguito Wetlands against natural wetlands in the region that serve as reference sites. San Dieguito Wetlands must be similar to the reference wetlands to satisfy the relative performance standard requirement.

In the eighth year of performance monitoring, the restored wetland is providing habitat for an array of invertebrates, fish, and birds, and wetland plants. This includes the provision of nursery habitat for juvenile California Halibut and nesting and foraging habitat for the endangered Ridgway's Rail and Belding's Savannah Sparrow. Although the wetland is providing resource value it has not met the performance criteria required for successful mitigation as discussed below.

San Dieguito Wetlands met the absolute performance standards for tidal prism, topography, plant reproductive success (as seed production) and exotic species in 2019. San Dieguito Wetlands did not satisfy the success criteria for the habitat areas standard. The habitat areas standard requires the acreage of wetland habitats be within ±10% of planned areas. To be assessed as salt marsh habitat, cover of vegetation must be at least 30% as evaluated within 10 m x 10 m grids that cover the entire wetland. Habitat assessed as salt marsh in San Dieguito Wetlands increased by approximately 23 acres from 2018 to 2019, but the wetland is still 12 acres below the minimum number of required acres of this habitat, and has yet to meet the absolute standard for habitat areas.

San Dieguito Wetlands passed seven relative performance standards, including those pertaining to water quality, bird species richness, fish density in main channel and tidal creek habitat, invertebrate species richness in main channel habitat, algal cover, and *Spartina* canopy architecture. The eight relative standards San Dieguito Wetlands failed to pass included those pertaining to the densities of birds, food chain support (bird feeding), invertebrate density in main channel and tidal creek habitat, invertebrate species richness in tidal creeks, fish species richness in main channel and tidal creek habitat or the standard for cover of vegetation.

The relative standard pertaining to vegetation cover is high in the reference wetlands, Mugu Lagoon, Carpinteria Salt Marsh, and Tijuana Estuary, where coverage can exceed 85%. A goal of the restoration project is to not only achieve the required acreage of salt marsh habitat, but also the high cover of vegetation found in the reference wetlands. The monitoring data from 2012 to 2018 reveals that the overall trend of increase in cover in the higher cover classes similar to those found in the reference wetlands had been very shallow with only ~18 acres of 85% cover as of 2018. However, there was an appreciable increase in the acres of >85% cover to ~30 acres in 2019, which is encouraging for meeting the relative standard for vegetation cover in the foreseeable future. Concerning is the deficit in shorebirds in San Dieguito Wetlands relative to the reference sites, and there remains a paucity of polychaete and oligochaete worms in the restored site relative to the reference sites. The underperformance of these groups contributed to the failure of San Dieguito Wetlands to meet the relative standards for bird and macroinvertebrate densities in 2019.

To facilitate plant development and address the failure of San Dieguito Wetlands to pass the absolute standard for habitat areas and the relative standard for vegetation cover, SCE has undertaken a planting program within three areas of module W4/W16. An experiment designed to evaluate the effect of the container size of nursery grown plants and plant clustering on the development of cover was embedded in the larger planting effort to inform SCE's planting program. Results of this experiment indicated that plants grown in gallon containers in the nursery survived and grew much better after planting than those grown in smaller containers known as rosepots. Clustering of plants in groups of three during planting had no effect on plant performance. As a result of this experiment, SCE has only used plants grown in gallon containers and planted as singletons in their planting program moving forward. Experiments started in 2020 are currently underway to evaluate the effect of irrigation, decompaction, soil amendments, planting, and seeding on the development of plant cover.

The success of the San Dieguito Wetlands in meeting the mitigation requirement for a given year is based on its ability to meet the physical and biological performance standards provided in the SONGS permit. The San Dieguito Wetlands Restoration Project did not satisfy the absolute standard requirement, meeting only four of the five absolute standards. The restored wetland did not meet the success criteria for the relative standards, which require that at least the same proportion of relative standards be met in the San Dieguito Wetlands as are met in the worst performing reference wetland. In 2019, 46.6% of the relative standards were met in the San

Dieguito Wetlands compared with 100% of standards met by all of the reference wetlands.

In order to receive mitigation credit for a given year, the wetland restoration project must meet all of the absolute standards and at least the same proportion of relative standards as the worst performing reference wetland. So far, the San Dieguito Wetlands has yet to meet the absolute standard for habitat areas and failed to meet the relative standard requirement except in 2013. Although the San Dieguito Wetlands is providing habitat for wetland plants and animals, it has not yet satisfied the performance success criteria provided in the SONGS permit and has not yet received mitigation credit.

In examining the overall progress of San Dieguito Wetlands towards compliance with the requirements of the SONGS permit, the cover of salt marsh vegetation is on a promising trajectory to meet the performance criteria for salt marsh habitat in the near term. More concerning is the underperformance of some relative standards pertaining to biological communities and how this relates to the 10-year milestone related to project compliance. There is a requirement that the absolute and relative performance standards must be met by 10 years after the initiation of Fully Implemented Monitoring. Furthermore, three consecutive years of compliance must occur by 12 years or remediation may be required at the discretion of the Executive Director. While the mechanisms behind the underperformance of vegetation appear fairly obvious (high soil salinities, poor drainage), the mechanism behind the underperformance of other biological standards are less obvious. UCSB scientists are examining existing data and collecting additional data to explore possible reasons behind the underperformance of some biological standards in San Dieguito Wetlands. This work will initially focus on macro-invertebrates, where preliminary data suggest likely mechanisms that might explain low densities in tidal creek and main channel habitat.

On-going activities and future plans moving forward include continued performance monitoring in 2020 as required by the SONGS permit, monitoring the planting program and experiments for vegetation, and further analysis of existing data, and the collection of additional data to assist in the determination of mechanisms underlying the under-performance of those relative standards not met in 2019.

2.0 Introduction

2.1. Purpose of Report

This report focuses on Condition A of the San Onofre Nuclear Generating Station's (SONGS) coastal development permit (6-81-330-A), which pertains to mitigation for SONGS impacts to fish populations in the Southern California Bight. Southern California Edison (SCE) and the California Coastal Commission (CCC) have clear and distinct roles in the implementation of Condition A. Under the condition, SCE is required to construct or substantially restore a minimum of 150 acres of tidal wetlands, excluding the buffer zone and transition habitat. The CCC is to provide scientific oversight and monitoring of the wetland mitigation project that is independent of SCE. This report presents the results from the CCC's monitoring of the SONGS wetland mitigation project (hereafter referred to as the San Dieguito Wetlands) during 2019 (the eighth year following completion of construction of the wetland) and summarizes the status of the project's progress towards compliance with Condition A of the SONGS permit.

2.2. Background

SONGS Operations: In 1974, the California Coastal Zone Conservation Commission issued a permit (No. 6-81-330-A, formerly 183-73) to SCE for Units 2 and 3 of the San Onofre Nuclear Generating Station (SONGS). SONGS is located on the coast in north San Diego County. Construction of SONGS Units 2 and 3 was completed in 1981. Operation of Units 2 and 3 began in 1982 and 1983, respectively. The SONGS Unit 2 and 3 reactors are cooled by a single pass seawater system and have separate intake lines, each 18 feet in diameter that are located in about 30 feet of water offshore of the power plant. The volume of water taken in each day by these two intake lines when Units 2 and 3 were fully operational was about 2.4 billion gallons.

The water taken in was heated to approximately 19°F above ambient in the plant and then discharged through an extensive diffuser system designed to dissipate the heat. The discharge pipe for Unit 2 terminates 8,500 feet offshore, while the discharge pipe for Unit 3 terminates 6,150 feet offshore. The last 2,500 feet of the discharge pipes for Units 2 and 3 consist of a multi-port diffuser that rapidly mixes the cooling water with the surrounding water. The heated cooling water and turbulence kills fish eggs, larvae and small immature fish taken into the plant, the mortality of which was responsible for a substantial impact on adult nearshore fish populations in southern California. To cool the discharge water, the diffusers drew in ambient seawater at a rate about ten times the discharge flow and mixed it with the discharge water. The surrounding water was swept up along with sediments and organisms and transported offshore at various distances. Mixing caused by the diffuser system resulted in the formation of a turbid plume in the vicinity of the San Onofre kelp forest, which is located adjacent to the two diffuser lines. These discharge effects were responsible for a substantial impact on kelp forest habitat down coast of the diffusers.

Units 2 and 3 of SONGS are not currently producing power. Unit 2 was shut down in early January 2012 for routine refueling and replacement of the reactor vessel head.

On January 31, 2012, Unit 3 suffered a small radioactive leak largely inside the containment shell, with a release to the environment below allowable limits, and the reactor was shut down per standard procedure. On investigation, both units were found to show premature wear in 15,000 places on over 3,000 tubes in the replacement steam generators that were installed in 2010 and 2011. A decision to shut down the reactors was made on June 7, 2013 and a certification of permanent cessation of power operations was issued on July 22, 2013. The operating license was modified to "possession" only and SCE is no longer authorized to operate or place fuel in the reactors. Since the shutdown, the flow in each unit has been reduced to about 42 million gallons per day or roughly 3% of the normal operating flow. In March 2019, the Commission determined that the magnitude of the reduction in discharge makes it unlikely that this level of flow contributes to significant adverse ecological impacts and based on this determination they defined the end of the operating life of SONGS as the end of 2013, and set the full operating life of SONGS at 32 years.

<u>SONGS Impacts</u>: A condition of the SONGS Coastal Development permit required study of the impacts of the operation of Units 2 and 3 on the marine environment offshore from the San Onofre power plant, and mitigation of any adverse impacts. The impact assessment studies found that the SONGS cooling water system for Units 2 and 3 had major adverse impacts to living marine resources, which included:

- Projected reductions in populations of adult fish throughout the Southern California Bight based on losses of fish eggs, larvae, and immature fish entrained by the cooling water intakes and killed inside the power plant.
- Measured reductions in local populations of adult fishes caused by the mortality of fish impinged against the cooling water screens inside the power plant.
- A substantial reduction in the size of the giant kelp forest and its associated community adjacent to the SONGS diffusers.

<u>Mitigation Requirements</u>: As a result of the impact studies, the CCC added new conditions in 1991 requiring SCE and its partners to mitigate the adverse impacts of the power plant on the marine environment. These measures include: (1) create or substantially restore at least 150 acres of southern California wetlands as out-of-kind mitigation for the losses of immature fish (Condition A), (2) install fish barrier devices at the power plant to reduce the losses of adult fish impinged and killed in the plant (Condition B), and (3) construct a 300-acre kelp reef as in-kind mitigation for the loss of giant kelp forest habitat (Condition C). The 1991 conditions also required SCE to provide the funds necessary for CCC to contract marine scientists to perform technical oversight and independent monitoring of the mitigation projects (Condition D). In 1993, the CCC added a requirement for SCE to partially fund construction of an experimental white sea bass hatchery. Due to the experimental nature of the hatchery, the CCC did not assign mitigation credit to its operation.

In April 1997, the Commission revised Condition A to allow the permittee to meet its 150-acre wetland acreage requirement by receiving up to 35 acres enhancement credit for the permittee's permanent maintenance of an open inlet that will produce continuous tidal flushing at San Dieguito Lagoon. The CCC also confirmed in April 1997 its previous finding that independent monitoring and technical oversight was required in Condition D to ensure full mitigation under the permit. Condition D requires SCE and its partners to fund scientific and support staff retained by the CCC to oversee the site assessments, project design and implementation, and monitoring activities for the mitigation projects. Scientific expertise is provided to the CCC by a small technical oversight team hired under contract. The technical oversight team members include three Research Biologists from UC Santa Barbara: Steve Schroeter, Ph.D., marine ecologist, Mark Page, Ph.D., wetlands ecologist (half time), and Dan Reed, Ph.D., kelp forest ecologist (half-time). In addition, a science advisory panel advises the CCC on the design, implementation, monitoring, and remediation of the mitigation projects. Current science advisory panel members include Richard Ambrose, Ph.D., Professor, UCLA, Peter Raimondi, Ph.D., Professor, UC Santa Cruz, and Russell Schmitt, Ph.D., Professor, UC Santa Barbara. In addition to the science advisors, the contract program staff is aided by a team of field assistants hired under a contract with the University of California, Santa Barbara to collect and assemble the monitoring data. Independent consultants and contractors also assist the contract program's staff when expertise for specific tasks is needed. The CCC's permanent staff also spends a portion of their time on this program, but their costs are paid by the CCC and are not included in the SONGS budget.

3.0 Project Description

The CCC decided that the goal of out-of-kind compensation for adverse effects on fish populations in the Southern California Bight due to SONGS operations will most likely be met if the wetland mitigation project: (1) is located near SONGS, but outside its influence to ensure that the compensation for lost resources will occur locally rather than at a distant location (Fig. 3.0.1), (2) creates or substantially restores 150 acres of wetlands, and (3) performs for a period of time equal to the operating life of SONGS Units 2 & 3, including the decommissioning period to the extent that there are continuing discharges.

Figure 3.0.1. Locations of SONGS, the impact site (red triangle), San Dieguito Lagoon (green square), site of the San Dieguito Wetlands Restoration Project, and three wetlands used as reference sites to evaluate the performance of the restoration project: Carpinteria Salt Marsh, Mugu Lagoon, and Tijuana Estuary (white circles).

The restoration project included excavation and grading to create intertidal salt marsh, mudflat, and subtidal basin habitats (Fig. 3.0.2). In addition, four Least Tern nesting sites were constructed, which were not part of the SONGS mitigation requirement. Disposal sites to the northeast and southeast of the project site received most of the over 2 million cubic yards of material excavated during construction of the wetland.

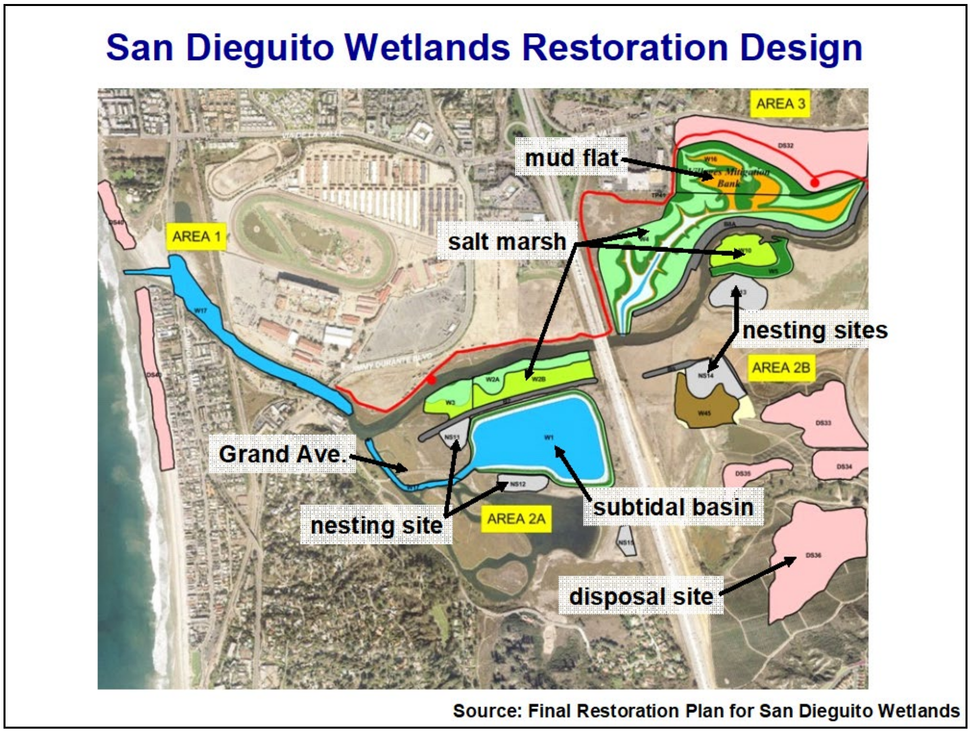


Figure 3.0.2. The design plan view of the restoration project that was approved by the CCC. The project included the creation of tidal salt marsh, indicated by shades of green, mudflat, indicated by the light brown and light gray, and subtidal basin, indicated by blue. In addition, four nesting sites, shown in gray, were constructed, which were not part of the SONGS mitigation requirement. The areas in pink are disposal sites. Dark gray linear features are berms along the effective flow area of the San Dieguito River. The yellow boxes that indicate Areas 1, 2a, 2b, and 3 pertain to the staging of construction activities.

Construction began in September with most excavation and grading completed by the end of 2008 (Fig. 3.0.3, 3.0.4a,b). Construction of the large subtidal and intertidal basin (44 acres) in Area 2A west of Interstate 5 commenced in December 2006 and was completed with the opening to tidal exchange in January 2008. Construction of wetland habitat commenced in other areas within the restoration site in April 2007. This included modules on the east side of Interstate 5, both north (Area 3) and south (Area 2B) of the San Dieguito River that were graded to create high and middle salt marsh and intertidal mud flat habitat. Excavation and grading, including the construction of tidal creek networks, was completed in Area 3 (modules W4/16) and these areas were opened to tidal exchange in December 2008. Grading of modules W2/3 in Area 2A was completed in November 2010 (Figs. 3.0.2, 3.0.3).

Timeline

Start date	September 2006
Project Task	**Completion Date**
Construction:	
All modules	November 2010
Additional wetland (Grand Ave)	February 2011
Re-grading of W2/W3	March 2014
Planting:	2008, 2009, 2011, 2016-2019
Inlet dredging:	September 2011 Nov/Dec 2015, 2017, 2019
Performance monitoring	January 2012 to present (8 years)

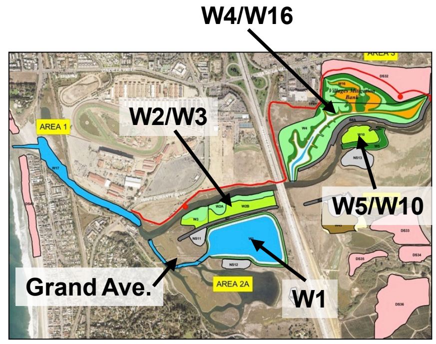


Figure 3.0.3. Timeline for the San Dieguito Wetlands Restoration Project.

This area was re-graded again in March 2014 to lower the elevation of the marsh plain and improve drainage to facilitate the development of marsh vegetation. The construction of additional wetland acreage ("Grand Avenue") was completed in February 2011.

Following excavation and grading, portions of the restoration project were planted with salt marsh plants. Planting of selected species (largely pickleweed) in high marsh habitat occurred in 2009. Test planting of cordgrass occurred in 2009. The largest planting of cordgrass throughout the restoration was done in November 2011 following initial post-construction inlet channel dredging, which was completed in September 2011. Some additional planting at high marsh tidal elevations occurred in 2016, 2017, and 2018 with planting at higher and lower elevations in 2019 (see Section 7.0).

Material excavated from the construction site was deposited in upland disposal sites within the project area (Fig. 3.0.4b). Berms designed to constrain storm runoff were completed in February 2009 along the boundary of the effective flow area of the San Dieguito River (Fig. 3.0.4b). Maintenance dredging of the inlet was conducted in November-December 2015, 2017 and 2019. Performance monitoring began in January 2012, following the initial dredging in September 2011.

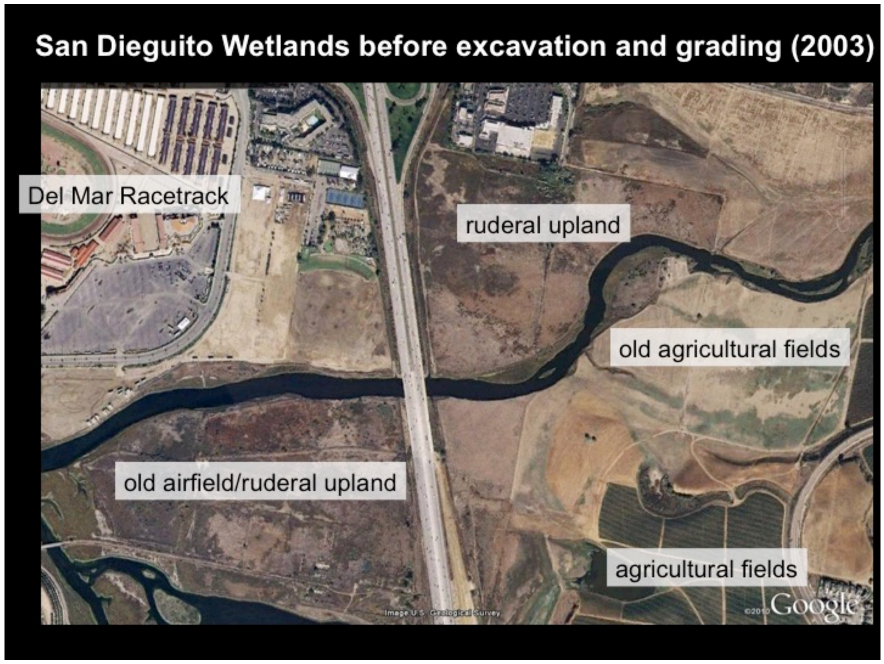


Figure 3.0.4a. Satellite view of the project site in 2003 before excavation and grading. Highlighted are the San Dieguito River and adjoining ruderal upland, including the site of an old WWII dirigible airfield, old agricultural fields, and visible at the bottom of the image, a portion of the Fish and Game Basin constructed in 1978.

Figure 3.0.4b. During construction, the ruderal areas, old agricultural fields, and the WWII airfield were excavated and graded to create the planned intertidal and subtidal wetland habitats of the restoration project visible in this image taken in 2016.

Following construction, annual monitoring independent of SCE is required to evaluate the physical and biological performance standards provided in the SONGS coastal development permit. Monitoring also tracks ecosystem development and identifies adaptive management opportunities pertaining to the physical and biological functioning of the wetland. Scientists from UCSB with advice from the Science Advisory Panel (SAP) conduct the independent monitoring.

Figure 3.0.5. Examples of biological resources supported by the San Dieguito Wetlands.

In the eighth year of monitoring, the restored wetland is providing habitat for an array of invertebrates, fish, and birds, and wetland plants. This includes the provision of nursery habitat for juvenile California Halibut, and habitat for the endangered Ridgway’s Rail and Belding’s Savannah Sparrow, as well for rare visitors such as the Eurasian Widgeon (Fig. 3.0.5). Although the wetland is providing resource value it has not yet met the performance criteria required for successful mitigation, discussed in Section 5.0 that reviews the results from performance monitoring in 2019.

4.0 Methods of Project Evaluation

4.1. Monitoring Plan

Condition A of the SONGS permit requires that monitoring of the wetland restoration be done to ensure compliance of mitigation measures over the full operating life of SONGS Units 2 and 3, which encompasses past and future years of operation of SONGS units 2 and 3 as well as the decommissioning period to the extent there are continuing circulating pump discharges. This monitoring measures compliance of the mitigation project with the performance standards specified in the SONGS permit. In accordance with Condition D (Administrative Structure) of the permit, contract scientists retained by the Executive Director developed the Monitoring Plan to guide the monitoring work and oversee the monitoring studies outlined in the plan. The SONGS permit provides a general description of the performance standards and monitoring required for the wetland mitigation project. The Monitoring Plan includes detailed descriptions of each performance standard and the methods that will be used to determine whether they have been met.

A draft Monitoring Plan for the SONGS Wetland Mitigation Program was reviewed by State and Federal agencies and SCE in May 2005. A revised Monitoring Plan was part of the coastal development permit (No. 6-04-88) for the wetland restoration project considered and approved by the Commission on October 12, 2005. The Monitoring Plan was subsequently updated in June and October 2011, July 2014, 2016, August 2017, and August 2018, and will continue to be updated as more information becomes available pertaining to the logistics of sampling and methods of evaluating the performance standards.

4.2. Performance Standards

Performance standards specified in Condition A of the SONGS permit are used to evaluate the success of the San Dieguito Wetlands Restoration Project in meeting the intended out-of-kind compensation for impacts to fish populations in the Southern California Bight due to SONGS operations. Monitoring independent of the permittee is done in accordance with Condition D of the SONGS permit to: (1) determine whether the performance standards established for Condition A are met, (2) determine, if necessary, the reasons why any performance standard has not been met, and (3) develop recommendations for appropriate remedial measures that may be required. The performance standards that are used to measure the success of the wetland restoration project fall into two categories: absolute standards that are evaluated only in the San Dieguito Wetlands, and relative standards, which require that the value of a given performance variable be similar to that measured in reference wetlands in the region. The performance standards include long-term physical standards pertaining to topography (i.e., erosion, sedimentation), water quality (i.e., oxygen concentration), tidal prism (which affects tidal flushing), and habitat areas, and biological performance standards pertaining to biological communities (i.e., fish, invertebrates, and birds), cover of salt marsh vegetation, *Spartina* canopy architecture, reproductive success of marsh plants, food chain support provided to birds, and exotic species.

The evaluation of each absolute performance standard in any given year is assessed by 1) a comparison of the value obtained from monitoring to a fixed value (i.e., for Habitat Areas, Tidal Prism, Plant Reproduction) or to other performance monitoring data and or using best professional judgement (i.e., for Topography, Exotic Species). All absolute standards must be met in a given year in order for that year to receive mitigation credit and count towards compliance with Condition A.

The evaluation of each relative performance standard is based on a four-year running average calculated from data collected at the San Dieguito Wetlands and the reference wetlands for that year and the previous three years, similar in approach to that is used to evaluate the success of the Wheeler North Artificial Reef. Use of a short-term (4-year) running average accounts for natural variation over time that could affect the performance of the restoration site relative to the reference wetlands. For example, invertebrate, fish, and bird populations can vary in their species numbers and abundance from year to year and given this variation it is likely that the reference wetlands (much like the San Dieguito Wetlands) would not consistently meet all the relative standards in a given year.

4.3. Reference Wetlands

The SONGS permit specifies that successful achievement of the relative performance standards will be measured in comparison to reference wetlands. Ideally, the biological assemblages in a successfully restored wetland should vary in a manner similar to those in the natural wetlands used for reference. Temporal variability, especially of the sort associated with weather (e.g., air temperature, rainfall) or oceanographic conditions (e.g., swell height, water temperature, sea level) can be accounted for by sampling the restored and natural reference wetlands concurrently. Concurrent monitoring of the restored and natural wetlands will help ensure that regional changes in weather and oceanographic conditions affecting the restored wetland will be reflected in the performance standards, since the reference wetlands should be subjected to similar conditions.

The permit requires that the wetlands chosen for reference be relatively undisturbed, natural tidal wetlands within the Southern California Bight. Relatively undisturbed wetlands have minimal human disturbance to habitats (e.g., trampling of vegetation, boating, fishing). Natural tidal wetlands appropriate as reference sites are not constructed or substantially restored, are continuously open to the ocean, and receive regular tidal inundation. The Southern California Bight extends from Pt Conception to the US/Mexico border. After evaluating 46 wetlands within the Southern California Bight, three wetlands, Tijuana River Estuary, Mugu Lagoon, and Carpinteria Salt Marsh were chosen as reference wetlands that best met the criteria of undisturbed, natural tidal wetlands within the Southern California Bight.

4.4. Determination of Similarity

A requirement of the SONGS permit is that the response variables used to assess the relative performance standards of the San Dieguito Wetlands Restoration Project (hereafter referred to as “relative performance variables”) be “similar” to those of the reference wetlands. Evaluating whether a particular relative performance variable at the San Dieguito Wetlands Restoration Project requires that the mean value for the performance variable at San Dieguito Wetlands not be significantly worse than the mean value for the worse performing of the three reference wetlands. A one sample, one tailed statistical test is used to evaluate all such comparisons. Significance is determined using an approach that utilizes both a formal probability value and an effect size. Generally, this is done by means of a t-test except in the case of the performance standards pertaining to vegetation and algae. For these standards, only the mean values are compared because the values are wetland wide censuses made using aerial imagery and thus there is no variability around a mean value. The performance for a particular relative performance variable at San Dieguito Wetlands is considered to be worse than the lower of the three reference wetlands if the p-value for the comparison is less than or equal to the proportional effect size (i.e., the proportional difference between San Dieguito Wetlands and the lowest performing reference wetland). The only exception to this rule is when the p-value and the proportional effect size are both greater than 0.5 in which case assessment for the period is considered inconclusive and additional studies will be done. As an example, if the proportional effect size for a given performance variable was 0.25 (i.e., the mean value at San Dieguito Wetlands was 75% of the mean value at the worst of the three reference wetlands), then a t-test yielding a p-value ≤ 0.25 would indicate the San Dieguito Wetlands Restoration did not meet the performance standard, whereas p-values > 0.25 would indicate that it did meet the performance standard. More details concerning the approach and the rational for determining similarity are provided in the Monitoring Plan for the SONGS Wetland Mitigation Project (Page et al. 2018, http://marinemitigation.msi.ucsb.edu/documents/wetland/ucsb_mm_reports/wetland_mitigation_monitoring_plan_updated_august2018.pdf.)

The rationale for using the mean value of the worst performing of the reference wetlands is that the reference wetlands are considered to be acceptable standards of comparison for the San Dieguito Wetlands. Hence, if the San Dieguito Wetlands Restoration is performing at least as well as one of the reference wetlands, then it should be judged successful. The scaling of the p-value (α) to the effect size recognizes sampling error when estimating mean values and balances the probability of falsely concluding that the San Dieguito Wetlands Restoration is not similar to the reference wetlands when it is (Type I error) with the probability of falsely concluding that the San Dieguito Wetlands Restoration is similar to the reference wetlands when it is not (Type II error).

To ensure that the San Dieguito Wetlands are not held to a higher standard than the reference wetlands, the above procedure is also applied to the three reference wetlands (Tijuana Estuary, Mugu Lagoon, and Carpinteria Salt Marsh) to evaluate whether they would have met the relative performance standards. This is done by treating each reference wetland as the mitigation wetland and using the other wetlands as the three reference wetlands. The San Dieguito Wetlands are considered similar to the reference wetlands if the proportion of relative standards met by the San Dieguito Wetlands is equal to or greater than the proportion of relative standards met by any of the reference wetlands. The above approach ensures that the assessment of similarity is consistent with the SONGS permit requirement that the performance standards be met without the unreasonable requirement that the San Dieguito Wetlands outperform the reference wetlands (Tijuana Estuary, Mugu Lagoon, and Carpinteria Salt Marsh) for every performance standard. Importantly, this approach deals realistically with the inherent variability of nature in a manner that best serves the interests of both the public and SCE.

5.0 Performance Assessment of the San Dieguito Wetlands Restoration Project

Listed below are the performance standards that are used to evaluate whether the San Dieguito Wetlands Restoration meets the goals and objectives of the wetland mitigation set forth in Condition A of the SONGS coastal development permit, the methods used to evaluate each performance standard, and the results from the eighth year of monitoring. More detailed methods can be found in the Monitoring Plan for the SONGS Wetland Mitigation Project (http://marinemitigation.msi.ucsb.edu/documents/wetland/ucsb_mm_reports/wetland_mitigation_monitoring_plan_updated_august2018.pdf).

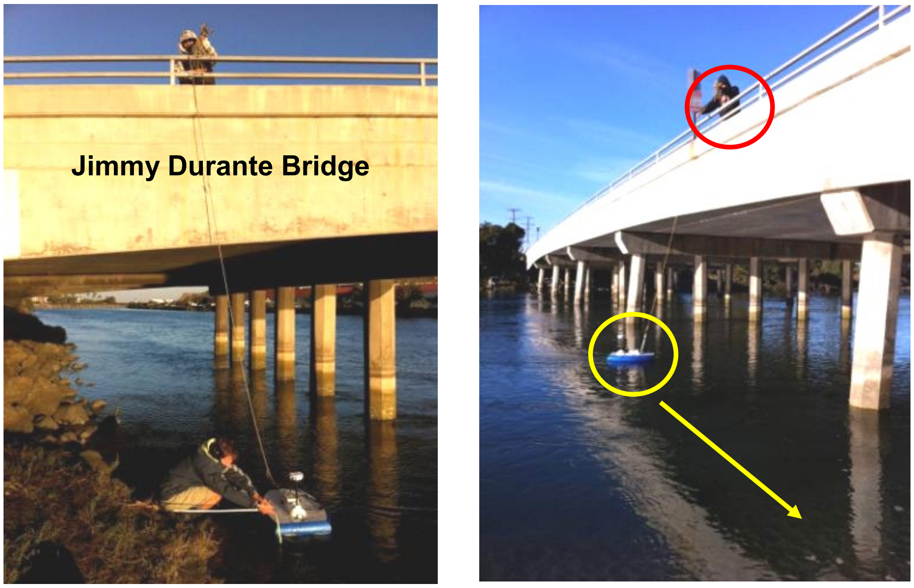
5.1. Absolute Performance Standards

5.1.1. Tidal Prism

THE DESIGNED TIDAL PRISM SHALL BE MAINTAINED, AND TIDAL FLUSHING SHALL NOT BE INTERRUPTED.

<u>Approach</u>: The tidal prism standard, as an absolute standard, is applied only to the San Dieguito Wetlands restoration. The tidal prism is the amount of water that flows into and out of an estuary with the flood and ebb of the tide, excluding any contribution from freshwater inflows (Hume 2005). Numerical modeling suggested that after restoration, the tidal prism in the wetland would increase. However, predictions of tidal prism from this modeling were likely to differ from actual values for the as-built wetland since they did not include the effects of friction, which could contribute to a smaller than predicted tidal prism and are not based on the actual as-built topography. Therefore, the tidal prism of the restored wetland was measured on completion of construction in July 2012 and used as the standard of comparison to detect changes in this performance variable during subsequent monitoring.

Since tidal prism can influence the area of wetland habitat inundated by the tides, the tidal prism standard is evaluated, in part, using criteria set forth in the habitat areas standard, which provide that the areas of the different habitats (subtidal, intertidal mudflat, vegetated salt marsh) shall not vary by more than 10% from the areas in the Final Restoration Plan. The planned tidal volume-elevation relationship indicated that a decrease in tidal prism of greater than 12% could result in a reduction in the area of tidally inundated planned salt marsh habitat (1.3 to 4.5’ NGVD) of greater than 10%. Since the area of planned intertidal salt marsh habitat may not differ by more than 10% from the as-built area (see Section 5.1.1.2, Habitat Areas), the tidal prism cannot be less than 88% of the as-built prism to ensure no more than 10% of planned salt marsh habitat remains exposed during a 4.5’ tide. However, since a larger than planned tidal prism could potentially increase erosion within the restored wetland, the prism shall also not be larger than 112% of the as-built prism.



River Surveyor--Acoustic Doppler Current Profiler (ADCP)

Figure 5.1.1.1. Measurements of tidal flows are taken at Jimmy Durante Bridge (0.9 km from the inlet) using a portable Acoustic Doppler Profiler/discharge measurement system (yellow circle) that is towed back and forth across the width of the channel by monitoring staff (red circle) every 15 minutes during an incoming tide.

Tidal prism is calculated by cumulating values of tidal flow volumes measured over an entire incoming (flood) tide for a range of maximum high tides using a portable Acoustic Doppler Current Profiler (ADCP) system (SonTek River Surveyor, Fig. 5.1.1.1). The performance standard is met if the regression line fit through the prism measurements taken during the monitoring year falls within 12% of the as-built prism value. The 22nd Agricultural District completed the final phase of a restoration project within a parcel adjacent to the Grand Avenue Bridge in 2017. Excavation completed as part of this restoration project added approximately 45 acre-feet to the as-built tidal prism. Tidal prism measurements for 2019 were adjusted downward to take into consideration the increase in prism resulting from the 22nd Agricultural District restoration project, and then evaluated against the as-built prism measured in 2012.

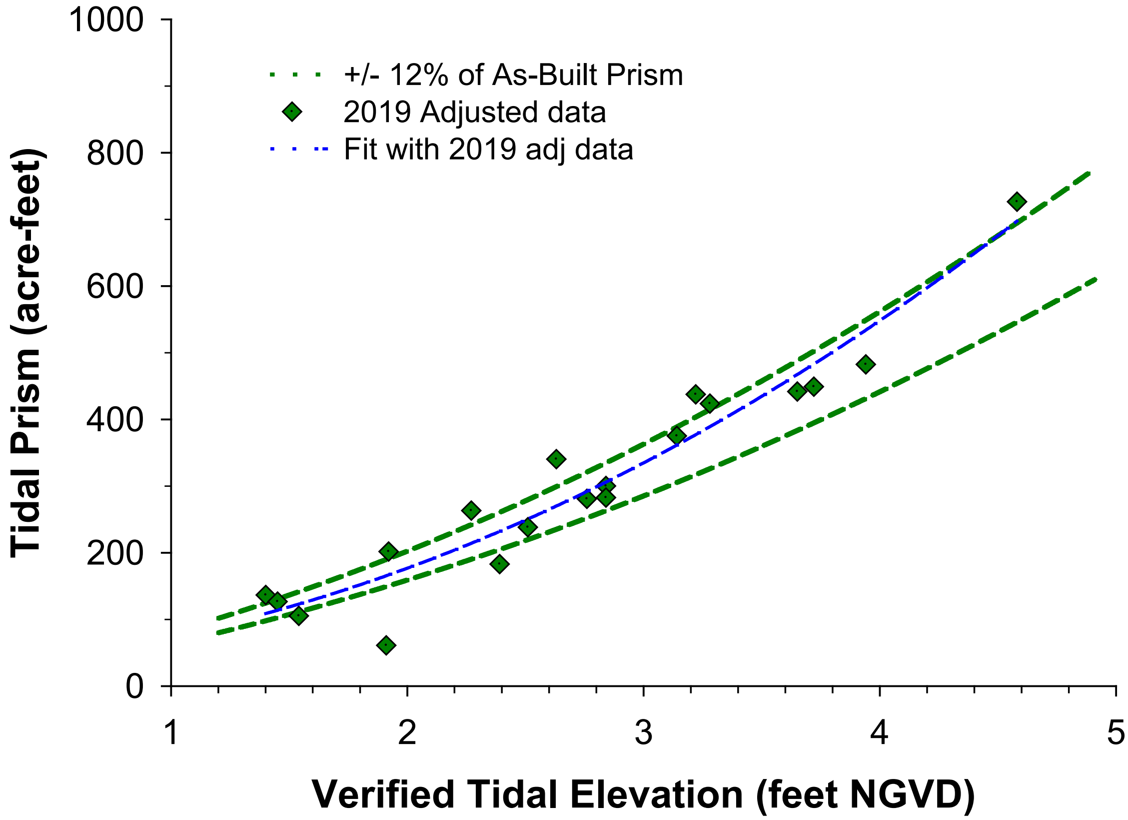


Figure 5.1.1.2. The regression fit to the tidal prism measurements taken January-December 2019 (blue dashed line) must fall within the two dashed green lines, which represent 88% and 112% of the as-built prism, for the tidal prism to be maintained. Tidal prism measurements for 2019 were adjusted for the excavation of additional wetland by the 22nd Agricultural District adjacent to the Grand Avenue Bridge.

Results: The regression fit to the adjusted tidal prism measurements for 2019 falls between the dashed green lines, indicating that the tidal prism at the San Dieguito Wetlands was maintained in 2019 (Fig. 5.1.1.2). Therefore, this performance standard is met for 2019.

5.1.2. Habitat area

THE AREAS OF DIFFERENT HABITATS SHALL NOT VARY BY MORE THAN 10% FROM THE AREAS INDICATED IN THE FINAL RESTORATION PLAN.

Approach: The habitat areas standard, as an absolute standard, is applied only to the San Dieguito Wetlands restoration. This performance standard is designed to preserve the mix of habitats specified in the Final Restoration Plan (SCE 2005) and to guard against large scale conversions of one habitat type to another, for example of vegetated marsh to mudflat. The Final Restoration Plan indicates that subtidal habitat will occur at elevations of < -0.9’ NGVD, intertidal mudflat will occur from -0.9 to 1.3’ NGVD, and intertidal salt marsh will extend from 1.3 to 4.5’ NGVD and specifies acreages of the different habitats (Fig. 5.1.2.1). While this is useful for planning the acreages and distributions of the proposed habitats, salt marsh and mudflat habitats may not be constrained by these elevation boundaries. As a result, areas of the three habitats are assessed using criteria based on inundation, elevation, and cover of vegetation. Subtidal habitat is defined as continuously submerged. Mudflat habitat is defined as intertidal, occurring lower than 3.5’ NGVD to provide for frequent tidal inundation, and as sparsely vegetated (< 5% cover of vegetation) since mudflats are by definition unvegetated (Fig. 5.1.2.2).

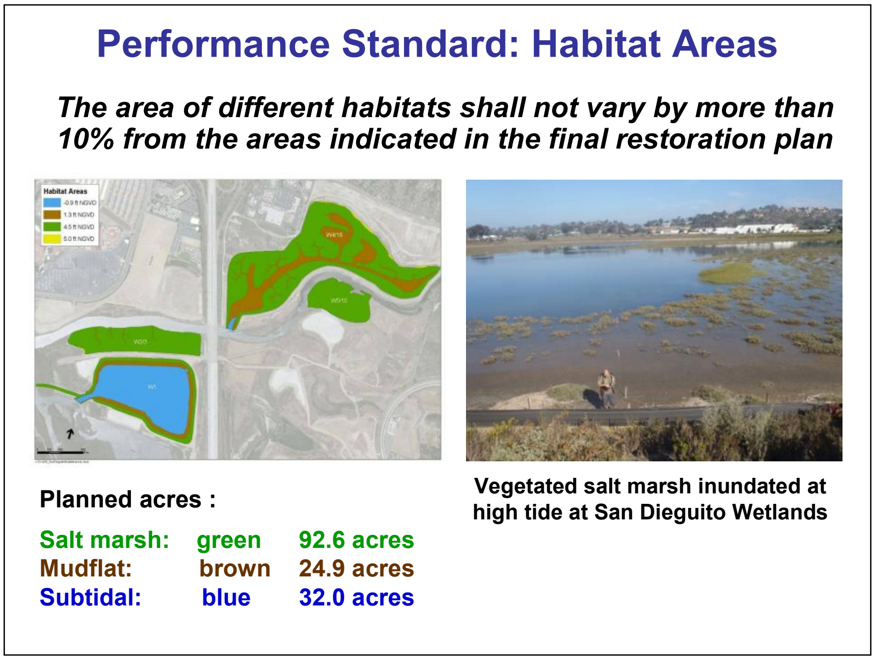


Figure 5.1.2.1. Panel on the left shows areas of planned salt marsh (green), mudflat (brown), and subtidal (blue) habitats as provided in the Final Plan for the restoration project. The photo on the right shows marsh vegetation inundated during a high tide.

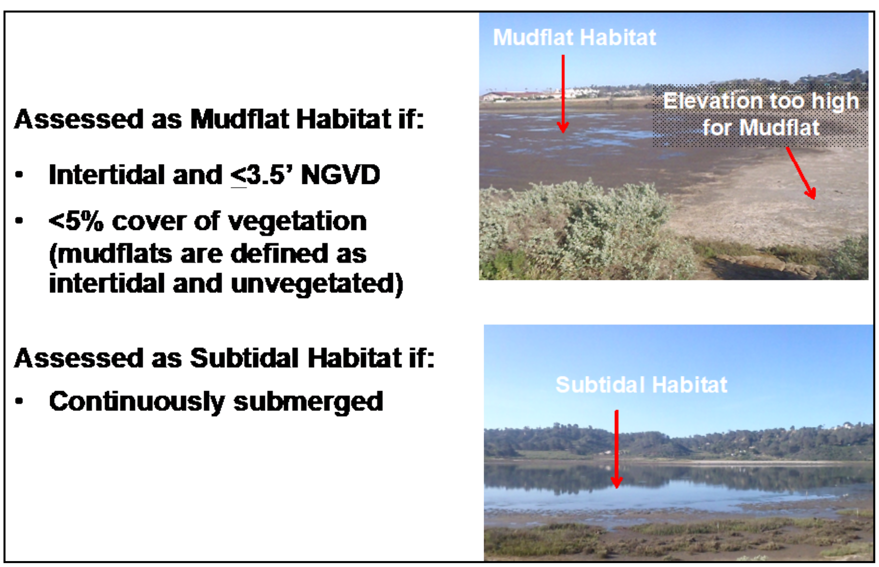


Figure 5.1.2.2. Criteria used to classify areas of the restoration project as mudflat and subtidal habitat.

The upper elevation limit for mudflat was based on the observation of surface salt deposits above this level in some areas of San Dieguito Wetlands indicating infrequent tidal inundation. The upper elevational boundary of subtidal habitat is determined using continuously recording data loggers that measure water level height. Salt marsh habitat is defined as intertidal, occurring at or below 4.5' NGVD, the upper elevation limit of tidally influenced habitat for this project, and as vegetated by at least 30% cover of salt marsh plants (Figs. 5.1.2.3, 5.1.2.4). This minimal cover of vegetation will provide perches and bare space for foraging of the State listed endangered Belding's Savannah Sparrow and other species. Areas that do not meet the criteria for subtidal, mudflat, and salt marsh habitat are designated as "other", not a planned habitat. Elevation contours at 3.5' and 4.5' NGVD are determined using a Real Time Kinematic (RTK) global positioning system (GPS) with a vertical and horizontal accuracy of a few centimeters (typically < 3 cm). Habitats are assessed within 10 m x 10 m plots that cover the entire wetland and superimposed on multispectral aerial images of the restoration site taken annually in late spring to early summer. The acreages of subtidal, mudflat, and salt marsh habitats are computed with the aid of ArcMap and ArcGIS software and compared to the planned acreages in the Final Plan to determine whether they are within 10% of planned values.

a)

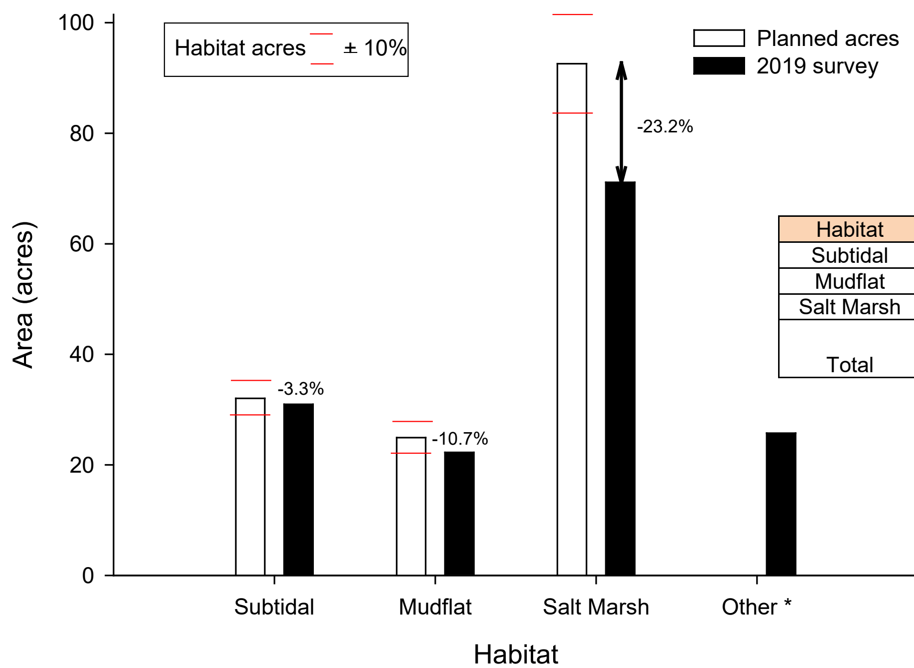
Salt Marsh Habitat at San Dieguito Wetlands

b)

Example of "Other"

Figure 5.1.2.3. Examples of an area assessed as a) salt marsh habitat, where cover of salt marsh vegetation was ≥ 30%, and b) an area assessed as "Other", not a planned habitat that is too high in elevation to be assessed as mudflat and too sparsely vegetated to be assessed as salt marsh.

<u>Results</u>: The solid bars in Figure 5.1.2.4 indicate the acreages determined in our 2019 survey. While the area of subtidal habitat was within 10% of the planned acreage in 2019, the area of mudflat was slightly less than 10% (-10.7%), and there was a deficit in salt marsh habitat (of ~12 acres), which was also not within ± 10% of the planned acreages. Salt marsh acreage in 2019 was about 71 acres, 12 acres below the lower 10% limit of the designed acreage. As a result, the San Dieguito Wetlands did not meet the performance standard for Habitat Areas in 2019.



Habitat	Planned	± 10	2019
Subtidal	32.0	28.8-35.2	31.0
Mudflat	24.9	22.4–27.4	22.3
Salt Marsh	92.6	83.3–101.9	71.1
Total	149.5	134.5–164.5	124.4

Figure 5.1.2.4. Comparison of the areas of subtidal, mudflat, and salt marsh habitat in the Final Restoration Plan to the 2019 survey. Areas assessed as “Other” were not assessed as one of the planned habitats provided in the Final Restoration Plan and not included in the total acres of habitat created.

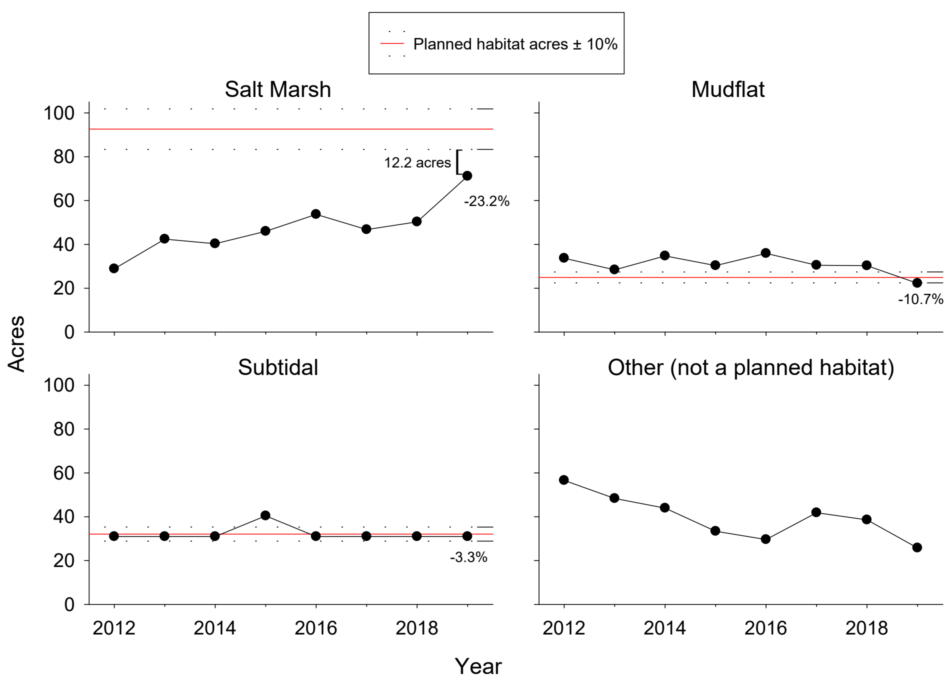


Figure 5.1.2.5. Comparison of the areas of salt marsh, mudflat, and subtidal habitat determined in the 2012 through 2019 surveys to the planned areas in the Final Restoration Plan (solid red line, black dashed lines ±10%). Also shown is the change in acres of “other”, not a planned habitat.

Figure 5.1.2.5 shows the trend over time in acres of the salt marsh, mudflat, and subtidal habitat categories and the "other" category, which is not a planned habitat. There has been a slow but general increase in salt marsh habitat since 2012, and a more pronounced increase from 2018 to 2019, which is encouraging. Also encouraging is the decrease in Other in 2019, which reflects the filling in of vegetation, particularly at lower elevations. One trend to keep an eye on is the decrease in mudflat such that the acres of mudflat are now slightly below 10% of the planned acres. This is due in part to the encroachment of *Spartina* in the low marsh into areas that are planned mudflat.

5.1.3. Topography

THE WETLAND SHALL NOT UNDERGO MAJOR TOPOGRAPHIC DEGRADATION (SUCH AS EXCESSIVE EROSION OR SEDIMENTATION).

Approach: The intent of the Topography Standard is to ensure that the expected functions of the wetland are not affected by excessive erosion or sedimentation. Topographic changes resulting from excessive erosion or sedimentation could impede tidal flow within the wetland, altering tidal prism and the areas of planned wetland habitat. Erosion or sedimentation within the restored wetland may result from high volumes of storm run-off, littoral movement of sand that blocks the inlet channel, slumping of banks or berms, or other causes.

Survey data and field observations are used to determine whether the topography standard is met. Visual surveys are done throughout the restored wetland to identify any sign of substantial erosion or sediment deposition that could impede tidal flow. Additional surveys are done following storm events when bank erosion, channel scour and sediment deposition are likely to occur. Constructed berms and associated structures (e.g. culverts, weirs) are a special topographical feature of the restored wetland. These features are visually inspected during the surveys.

Results: Survey data and field observations indicated that the expected functions of the San Dieguito Wetlands were not affected by excessive erosion or sedimentation in 2019 and therefore this performance standard is currently met.

5.1.4. Reproductive success

CERTAIN PLANT SPECIES, AS SPECIFIED IN THE WORK PROGRAM, SHALL HAVE DEMONSTRATED REPRODUCTION (I.E. SEED SET) AT LEAST ONCE IN THREE YEARS.

Approach: The reproductive success of salt marsh plants is evaluated by measuring whether seed are produced for seven common species found in the mid to high salt marsh: Parish's Glasswort (*Arthrocnemum subterminale*), Pickleweed (*Salicornia virginica = Sarcocornia pacifica*), Alkali Heath (*Frankenia salina*), Spiny Rush (*Juncus acutus*), Marsh Jaumea (*Jaumea carnosa*), California Sea Lavender (*Limonium californicum*), and Salt Grass (*Distichlis spicata*). These are the most common species found within the restoration site. The seven common species are inspected for the presence of seeds at 10 sampling stations per plant species distributed throughout the wetland in summer-fall when seed set is greatest. Seed set is identified from a subsample of mature flowers of each species.

Results: All seven species produced seed in 2017 through 2019, which is consistent with the permit requirements (Fig 5.1.4.1). Since all seven species produced seed within three years, the standard for Reproductive Success is met for 2019.

Plant	2017	2018	2019
Parish's Glasswort	yes	yes	yes
Saltgrass	yes	yes	yes
Alkali Heath	yes	yes	yes
Marsh Jaumea	yes	yes	yes
Spiny Rush	yes	yes	yes
California Sea Lavender	yes	yes	yes
Pickleweed	yes	yes	yes

Figure 5.1.4.1. Plant species evaluated for seed set. A "yes" indicates the species produced seed for that year.

5.1.5. Exotics

THE IMPORTANT FUNCTIONS OF THE WETLAND SHALL NOT BE IMPAIRED BY EXOTIC SPECIES.

Approach: Exotic species can cause compositional and functional changes in estuarine ecosystems. Such changes can occur, for example, through the alteration of food webs or the physical structure of habitats (e.g., burrowing activities that affect the stability of tidal channel banks, Talley et al. 2001). Monitoring data collected for fish, invertebrates, birds, and vegetation are used to assess the prevalence of exotic species.

a) b)

Figure 5.1.5.1. a) Exotic species targeted during the special survey and b) divers preparing to enter the basin (W1) to conduct the special survey.

In addition, a special survey looking for exotic species is conducted that covers as much of the wetland as possible. This special survey focuses on plants and non-cryptic macro invertebrates in intertidal and subtidal habitats (Fig. 5.1.5.1).

Results: Densities of exotic species were very low and there was no evidence that exotic species impaired the important functions of San Dieguito Wetlands in 2019. Notably, the Yellowfin Goby, an exotic species that was the fifth most abundant fish as determined from our fish sampling in 2013 has not been abundant the last six years.

5.2. Relative Performance Standards

There are 15 relative performance standards (Fig. 5.2.1). Standard 1, Water Quality is a physical standard, standards 2-14 are biological standards pertaining to birds, fish, invertebrates, and plants, and standard 15 pertains to food chain support provided by the restored wetland to birds.

Relative Performance Standards

1. **Water Quality**
2. **Bird Density**
3. **Bird Species Richness**
4. **Fish Density – MC**
5. **Fish Species Richness – MC**
6. **Fish Density – TC**
7. **Fish Species Richness – TC**
8. **Invertebrate Density – MC**
9. **Invertebrate Species Richness – MC**
10. **Invertebrate Density – TC**
11. **Invertebrate Species Richness –TC**
12. **Vegetation Cover**
13. **Algal Cover**
14. **Spartina Canopy Architecture**
15. **Food Chain Support**

MC=Main Channel, TC=Tidal Creek

Figure 5.2.1. Relative performance standards used to evaluate the success of the San Dieguito Wetlands Restoration Project.

1. WATER QUALITY VARIABLES [TO BE SPECIFIED] SHALL BE SIMILAR TO REFERENCE WETLANDS.

Approach: Because of its documented importance to wetland health, the concentration of dissolved oxygen (DO) is used to evaluate water quality within the restored wetland. Dissolved oxygen concentration can change rapidly with inlet closure resulting in adverse effects on estuarine biota. However, dissolved oxygen also varies with location, the tidal cycle and time of day (it is generally higher during the day due to oxygen provided by photosynthesis, and lower during the night due to respiration). Measurements of dissolved oxygen are therefore made using a continuously recording environmental data logger (e.g., HOBO Dissolved Oxygen Datalogger U26-001) deployed in comparable channel locations at the restored and reference wetlands to characterize representative values of dissolved oxygen concentrations within the wetlands. Data are recorded every 15 minutes and downloaded every 2-3 weeks after which the logger is re-calibrated.

Dissolved oxygen concentration (DO) below 3 ppm (=3 mg/l) is considered hypoxic and sustained concentrations below this value may be detrimental to estuarine biota (Ecological Society of America, 2012). Therefore, one approach to assessing dissolved oxygen is to assess the length of time continuously spent below this concentration. The water quality standard is evaluated by comparing the mean length in hours of continuous hypoxia between San Dieguito Wetlands and the reference wetlands. If the mean number of consecutive hours with DO < 3 ppm is significantly higher in the San

Dieguito Wetlands than in the reference wetland with the highest value, then San Dieguito Wetlands fails to meet the standard.

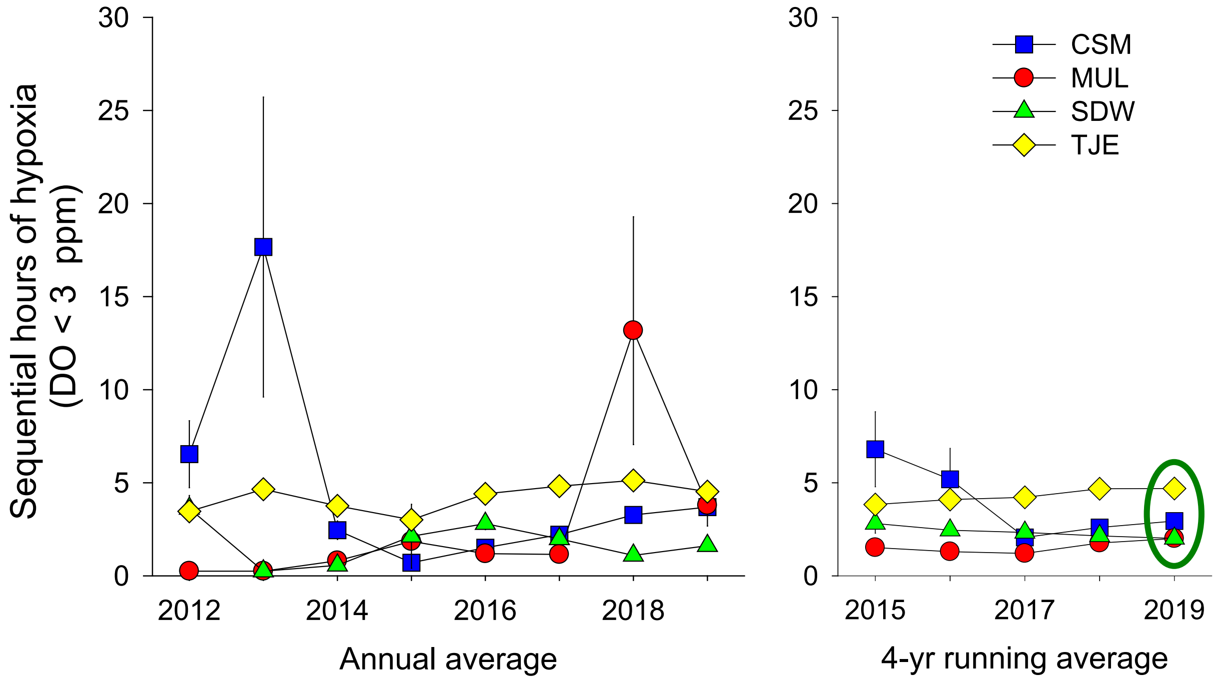


Figure 5.2.1.1. Mean length in hours of continuous hypoxia ([O_2] < 3 ppm in the San Dieguito Wetlands compared with the three reference wetlands. Abbreviations used in this and subsequent figures: CSM=Carpinteria Salt Marsh, MUL=Mugu Lagoon, SDW=San Dieguito Wetlands, and TJE=Tijuana Estuary. Mean values ±1SE are shown in this and subsequent figures. Green ellipse indicate standard was met.

Results: Figure 5.2.1.1 shows the mean number of hours of continuous hypoxia at the San Dieguito Wetlands compared with the three reference wetlands annually from 2012 through 2019 and the four-year running average, which is used to evaluate the standard. Again, this standard is evaluated by comparing values in San Dieguito Wetlands to the reference wetland with the highest value of sequential hours of hypoxia. For the four-year running average, the value for sequential hours of hypoxia at San Dieguito was lower than the reference wetland with the highest value (Tijuana Estuary) and therefore San Dieguito Wetlands met the Water Quality standard in 2019.

5.2.2. *General sampling design for fish and macro-invertebrates.*

San Dieguito Wetlands and the three reference wetlands are sampled in the late summer-fall. Six tidal creeks and six sections of the main channel-basin habitat are sampled in each wetland (Fig. 5.2.2.1). Because tidal creeks and main channels differ in width, water depth, and hydrology, and are thus likely to support different assemblages of fish and macro-invertebrates, tidal creeks and main channels are assessed separately. A potential concern for the monitoring design was that basins of the type constructed in the San Dieguito Wetlands Restoration do not occur naturally in southern California wetlands, and thus cannot be compared to natural reference sites. However, data collected by Marine Ecological Consultants (1993) on fish abundance from different habitats at San Dieguito Lagoon prior to restoration found that fish assemblages were similar in basin and main channel habitats and thus it is biologically reasonable to treat the constructed basin as main channel habitat in post-construction monitoring. The six sampled creeks or sections of the main channel or basin habitat (in the case of San Dieguito) are treated as replicates in subsequent analysis.

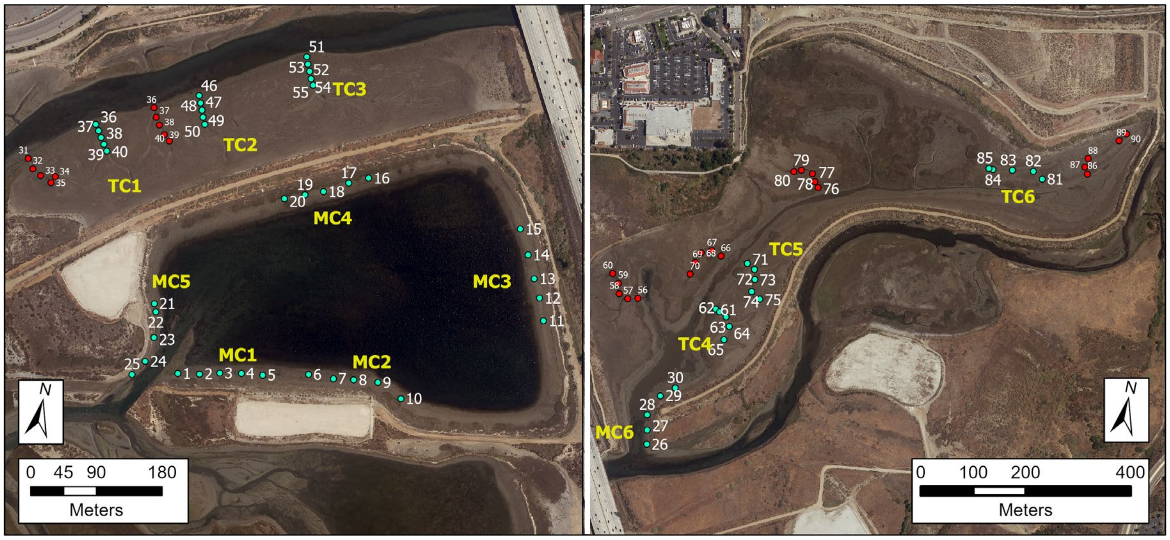


Figure 5.2.2.1. Location of tidal creeks (TC) and sections of main channel and basin (MC) sampled for fish and macro-invertebrates in San Dieguito Wetlands. Blue dots indicate stations sampled for macro-invertebrates within each TC and MC replicate in 2019. Some tidal creek stations that were sampled 2012-2018 (red dots) were moved to the nearest creek because of encroachment of *Spartina* into sampling areas in 2019.

5.2.3. Fish

WITHIN 4 YEARS OF CONSTRUCTION, THE TOTAL DENSITIES AND NUMBER OF SPECIES OF FISH SHALL BE SIMILAR TO THE DENSITIES AND NUMBER OF SPECIES IN SIMILAR HABITATS IN THE REFERENCE WETLANDS.

Approach: Data on the density and numbers of species of fish are collected using 0.43 m^2 circular enclosure traps and larger beach seines (generally 1000 m^2). Enclosure traps are used to sample gobies, which are small, numerically abundant fishes that are poorly sampled by other methods (Steele et al 2006a). Beach seines in combination with blocking nets are used to sample larger more mobile fishes (Steele et al 2006b). Fish captured by both methods are identified and counted in the field and returned to the water alive.

The total number of fish is standardized to 1 m^2 for each enclosure or beach seine sample. The averages for enclosures and beach seines are averaged to produce a combined estimate of total density (average number per 1 m^2) for each tidal creek or main channel-basin replicate. Species richness is determined as the number of unique species for each tidal creek or main channel replicate in enclosure trap and seine sampling per 1 m^2 (species density). These replicate values for density and species richness are used to calculate the means and standard errors used to evaluate similarity in total density and species richness of fish in tidal creeks and main channel-basin habitats between the restored and reference wetlands in a given year. Ridgway's Rail (formerly the Light-footed Clapper Rail) nesting in Tijuana Estuary prevented sampling using seines in 2012 so that year is not included in the running average calculation of fish density and richness.

Results: Fish density increased dramatically from 2013 to 2015 in Carpinteria Salt Marsh in both main channel and tidal creek habitats (Fig. 5.2.3.1). This increase was due to the recruitment of large numbers of gobies in this wetland. For the 4-year running averages, fish density in main channel habitat in San Dieguito Wetlands was not significantly lower than Mugu Lagoon, the lowest performing reference wetland for this standard in 2019 (Fig 5.2.3.1). Similarly, the 4-year running average of fish density in tidal creek habitat in San Dieguito Wetlands was not significantly lower than Mugu Lagoon in 2019 (Fig 5.2.3.1). Therefore, the standard for fish density in both main channel and tidal creek habitat was met in 2019.

A relative standard that was met in 2018, but not met in 2019 is fish species richness in main channel habitat. The annual values show that richness declined from 2016 to 2017 in San Dieguito Wetlands and has remained below the reference sites. The 4-year running average in San Dieguito Wetlands is not similar to the lowest performing reference site and as a result this standard was not met for 2019 (Fig. 5.2.3.2).

There has been a general decline in the running average for fish species richness in tidal creeks, whereas averages in the reference wetlands have remained relatively constant. As was the case for fish species richness in main channels, the 4-year running average of fish species richness in tidal creeks was lowest in San Dieguito Wetlands in 2019 and as a result this standard was not met in 2019.

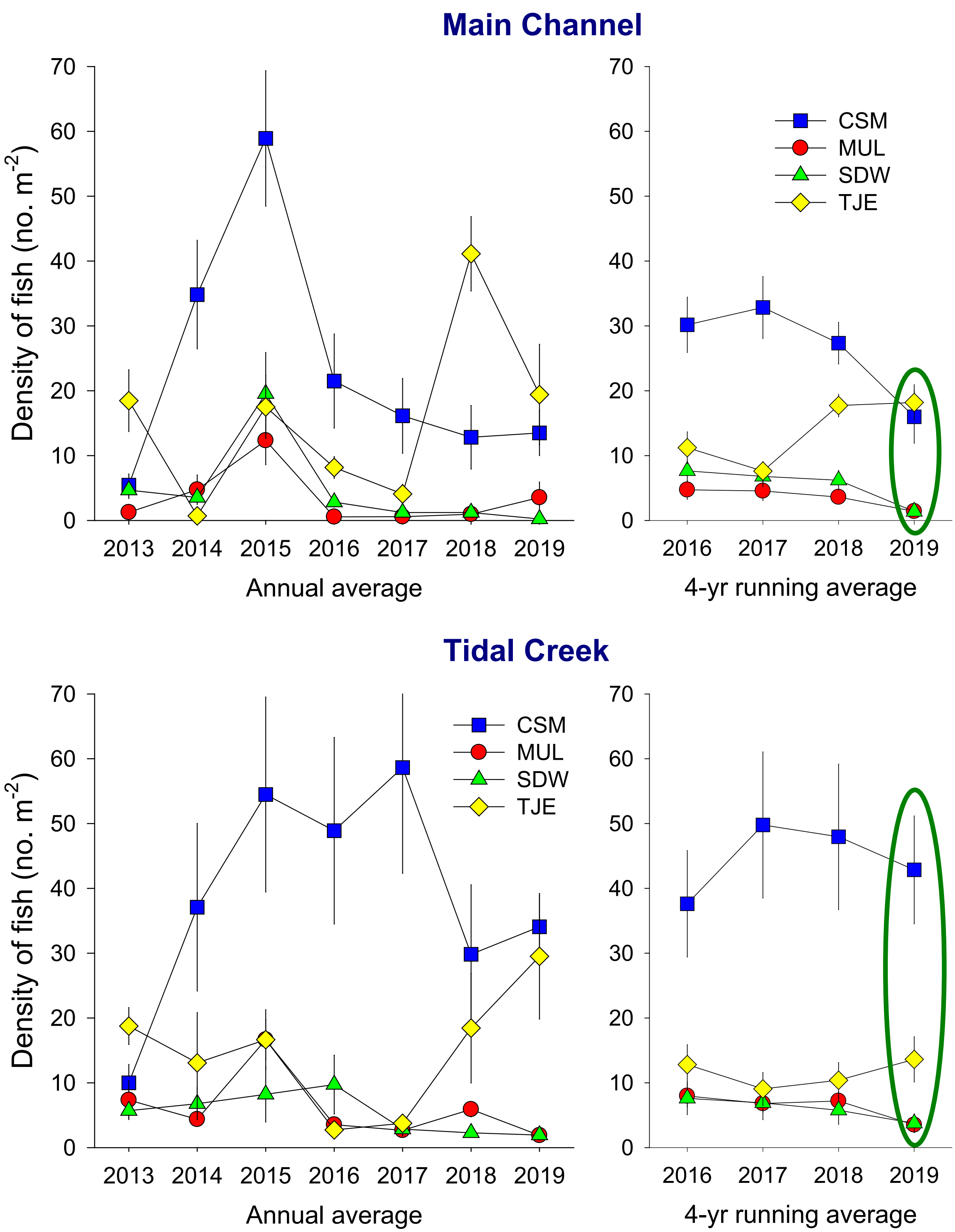


Figure 5.2.3.1. Comparison of annual fish density (left) and the 4-year running average used to evaluate the standard (right) between San Dieguito Wetlands and the reference wetlands in main channel and tidal creek habitats. Section of main channel-basin or individual tidal creek is the unit of replication (n = 6 in each habitat type). Green ellipses indicate standard was met.

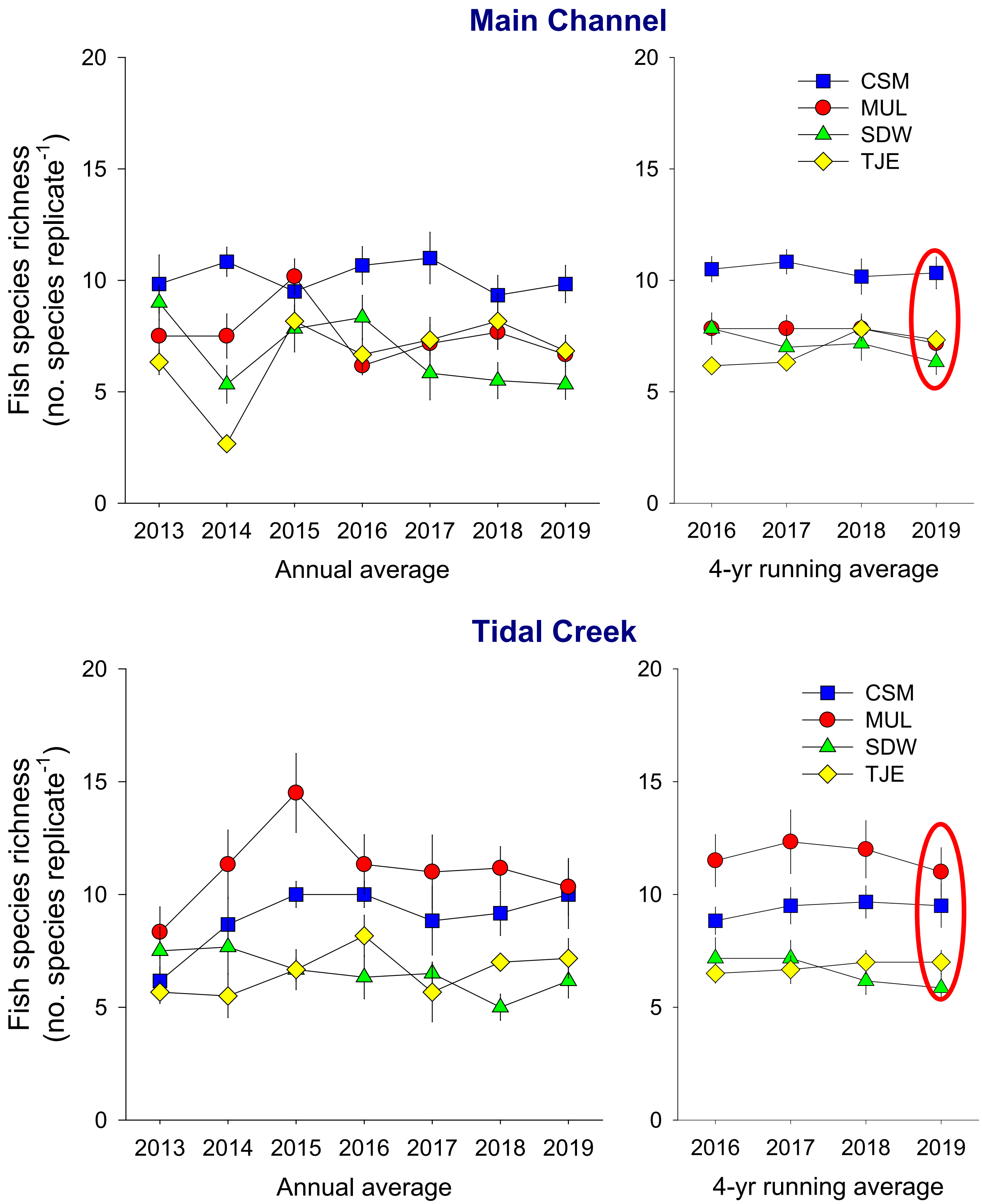


Figure 5.2.3.2. Comparison of annual fish species richness (left) and the running average used to evaluate the standard (right) between San Dieguito Wetlands and the reference wetlands for main channel and tidal creek habitats. Section of main channel-basin or individual tidal creek is the unit of replication (n=6 in each habitat type). Red ellipses indicate standard was not met.

5.2.4. Macro-invertebrates

WITHIN 4 YEARS OF CONSTRUCTION, THE TOTAL DENSITIES AND NUMBER OF SPECIES OF MACRO-INVERTEBRATES SHALL BE SIMILAR TO THE DENSITIES AND NUMBER OF SPECIES IN SIMILAR HABITATS IN THE REFERENCE WETLANDS.

Approach: Three methods are used to sample macro-invertebrates. First, epifauna (e.g., California Horn Snail, *Cerithidea californica*) are sampled by counting individuals within two sets of 3-25 x 25 cm quadrats spaced uniformly (low, mid, high) at each station on the unvegetated banks of tidal creeks and sections of main channel-basin between the lower limit of vegetation (or, if unvegetated, an elevation of ~1.3' NGVD) and the thalweg for tidal creeks or, in main channel, a water depth of approximately 50 to 80 cm, which accommodates deployment of the enclosure traps. Second, deep living larger infauna (i.e., animals that live well beneath the sediment surface such as the Jackknife Clam and Ghost Shrimp) are sampled adjacent to the quadrats using a 10 cm diameter (large) core pushed into the sediment to a maximum depth of 50 cm. The contents of the 10 cm core are sieved through a 3-mm mesh screen in the field. Animals retained by the 3-mm mesh are identified and counted in the field and returned to the habitat. Third, smaller infaunal invertebrates (primarily worms) are sampled using a 3.5-cm diameter (small) core pushed into the sediment to a depth of 6 cm. The small core samples are taken adjacent to the large core samples and are preserved on site in 10% buffered formalin. The samples are returned to the laboratory where they are screened through a 0.5mm mesh. Specimens are identified and counted under the microscope and archived in ethanol. Invertebrates are identified to the lowest practical taxon for smaller specimens (e.g., polychaetes, oligochaetes, amphipods) and to species for larger specimens (e.g., bivalves, decapod crustaceans).

Density of macro-invertebrates sampled using each method are standardized to number per 100 cm^2 and then combined to obtain a density value for each of the 5 stations within a tidal creek or section of main channel-basin. These station values are then averaged for each tidal creek or section of main channel-basin, which are the units of replication giving 6 replicate estimates of macroinvertebrate density in each habitat per wetland. Species richness of macro-invertebrates is evaluated by recording the number of unique species per tidal creek or section of main channel-basin obtained using all sampling methods, including any invertebrate species noted in the enclosure traps and beach seines used to sample fish. Species richness is assessed as the mean number of species per replicate main channel or tidal creek using the 6 replicate tidal creeks and sections of main channel-basin for each wetland in a year. These replicate values are used to calculate the means and standard errors used to evaluate similarity in total density and species richness of macro-invertebrates in tidal creeks and sections of channel-basin between the restored and reference wetlands in a given year.

Results: The annual density and running average of density of macro-invertebrates has generally been highest in main channel and tidal creek habitat in Mugu Lagoon and Carpinteria Salt Marsh from 2012 to 2019 (Fig. 5.2.4.1). The 4-year running average of density of macro-invertebrates in the main channels and tidal creeks of San Dieguito Wetlands has been consistently lower than the lowest performing reference wetland, which has been Tijuana Estuary. In 2019, the running average for San Dieguito

Wetlands has continued to be well below the lowest performing reference site and thus the standards for macro-invertebrate density in main channel and tidal creek habitats are currently not met (Fig. 5.2.4.1).

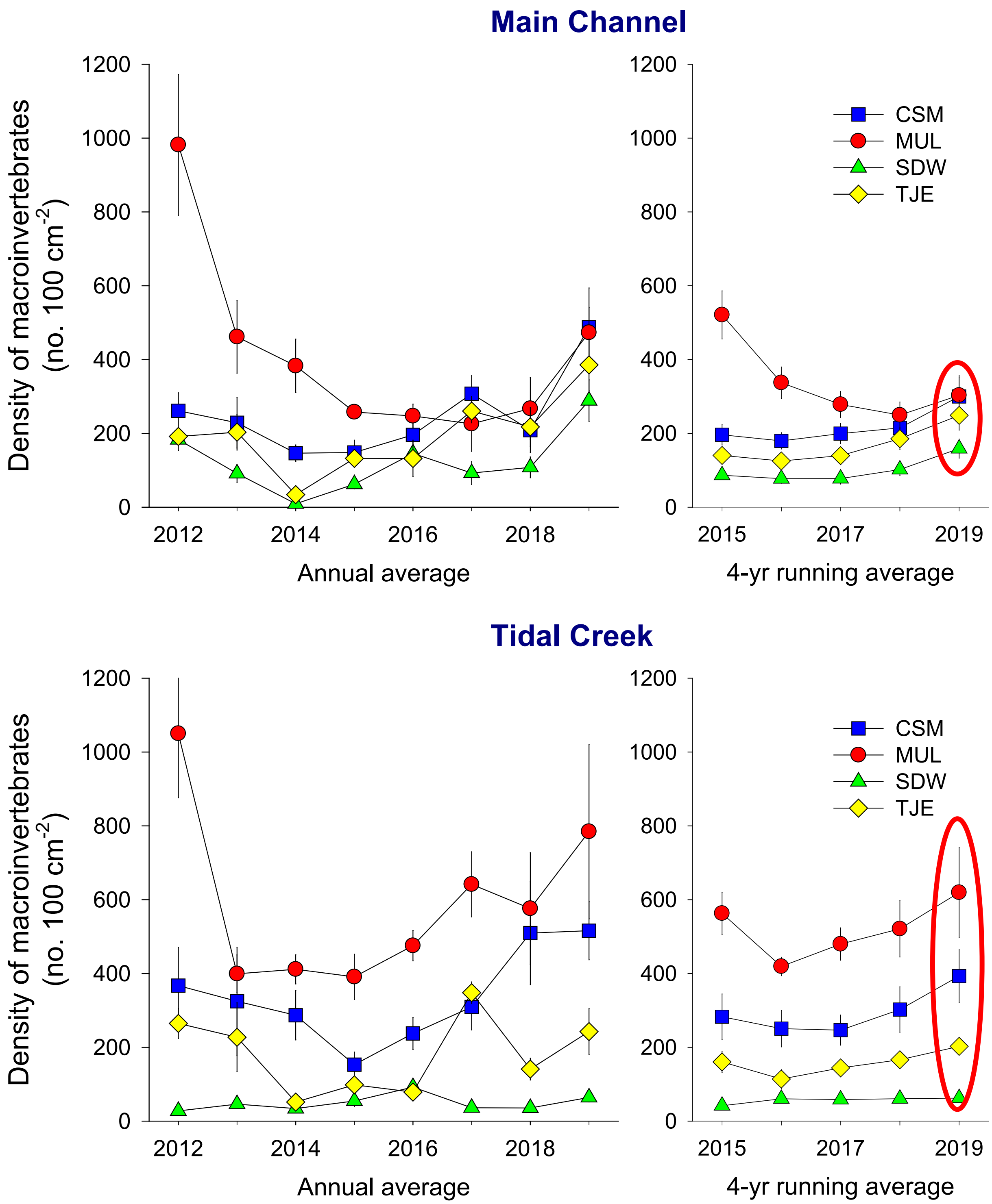


Figure 5.2.4.1. Comparison of macro-invertebrate density between San Dieguito Wetlands and the reference wetlands for main channel and tidal creek habitats. Section of main channel-basin or individual tidal creek is the unit of replication. Red ellipses indicate standard not met.

The annual mean and running average for species richness in main channel and tidal creek habitat has been highest in Mugu Lagoon and Carpinteria Salt Marsh. In 2019, the 4-year running average of species richness of macro-invertebrates in the main channels of San Dieguito Wetlands was similar to Tijuana Estuary, the lowest performing reference wetland. Therefore, the performance standard for macro-invertebrate species richness in main channel habitat of San Dieguito Wetlands is currently met (Fig. 5.2.4.2). Unique invertebrates recorded during fish sampling using seines are included in determining invertebrate richness. Seine sampling was not conducted in 2012 due to Ridgway's Rail nesting and as a result richness is not included for that year.

The standard for species richness of macro-invertebrates in tidal creek habitat was met in 2018, but there has been a general decline in richness and the running average is now below the lowest performing reference site, Tijuana Estuary, in 2019 (Fig. 5.2.4.2). As a result, this standard is not currently met. Interestingly, during the period of decline in richness of macro-invertebrate in the tidal creeks of San Dieguito Wetlands, there has been a trend of increase in richness in the reference wetlands (Fig. 5.2.4.2).

Main Channel

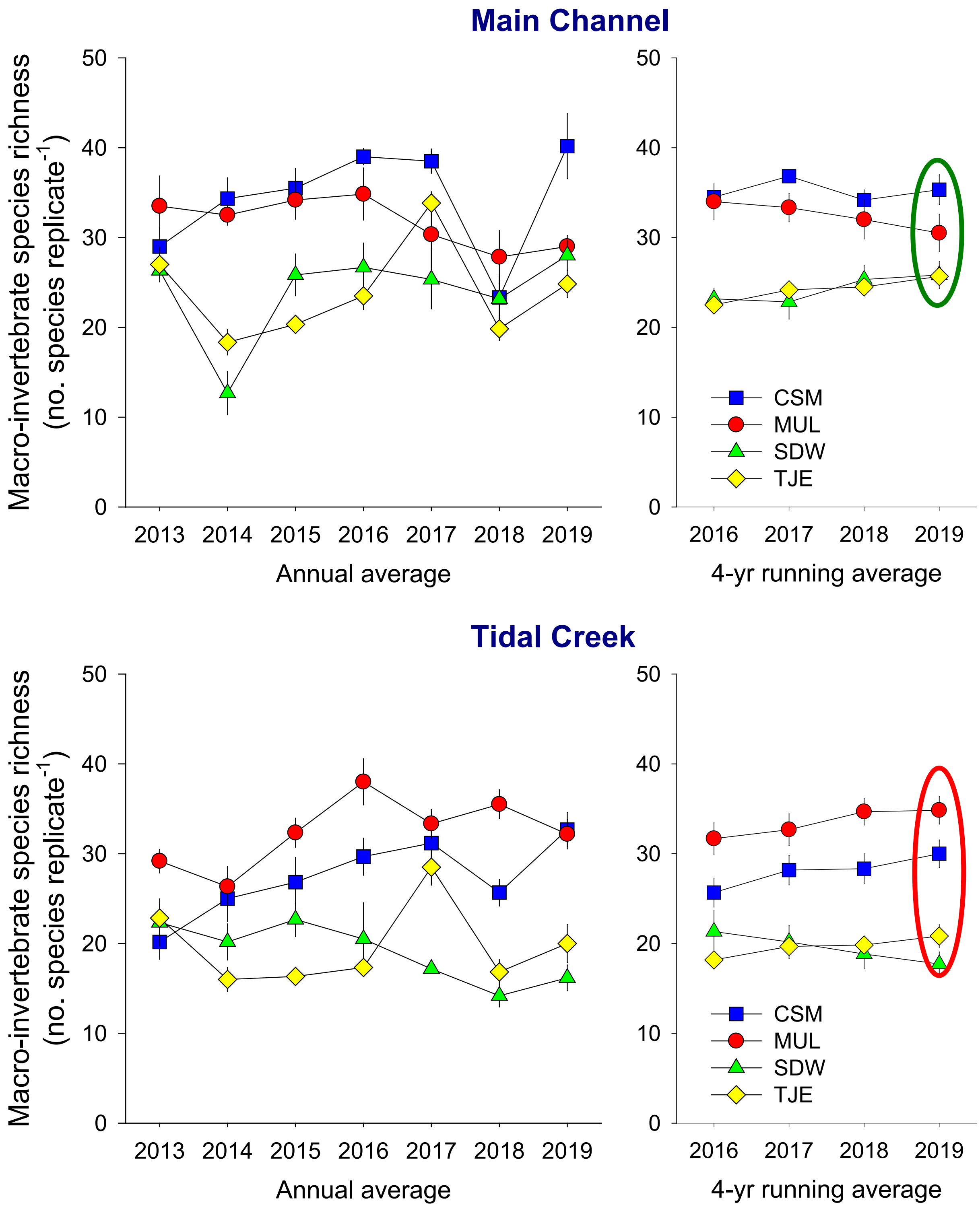


Figure 5.2.4.2. Comparison of macro-invertebrate species richness between San Dieguito Wetlands and the reference wetlands for main channel and tidal creek habitats. Section of main channel-basin or individual tidal creek is the unit of replication. Complete sampling was not conducted for invertebrate richness in 2012. Green ellipse indicates standard was met. Red ellipse indicates standard was not met.

5.2.5. Birds

WITHIN 4 YEARS OF CONSTRUCTION, THE TOTAL DENSITIES AND NUMBER OF SPECIES OF BIRDS SHALL BE SIMILAR TO THE DENSITIES AND NUMBER OF SPECIES IN SIMILAR HABITATS IN THE REFERENCE WETLANDS.

Approach: Birds are sampled by walking within clear viewing distance (using binoculars or a spotting scope) of 20 replicate rectangular plots of 100 x 150 m spread throughout the wetlands (Fig. 5.2.5.1, plots for San Dieguito Wetlands) and visually identifying and counting all birds sighted within each plot. The time spent identifying and counting birds within each plot is five minutes to standardize sampling effort. Bird sampling is conducted during the same period of the tide cycle (falling and low tide) to reduce the potential effects of this variable on bird abundance. Birds overflying the plots are counted if they are within approximately 30 m above the plot. All wetlands are sampled within a few days of one another to reduce the potential effects of weather, and other factors that might vary among wetlands over time on bird density and species richness.

Figure 5.2.5.1. Distribution of the 20-100 x 150 m bird sampling plots in the San Dieguito Wetlands.

Bird assemblages in coastal wetlands of southern California exhibit strong seasonal variations in species richness and density that are driven by the movement of migratory birds. Sampling observations are made during three periods: winter (January, February), spring (April, May), and fall (October, November) that have high bird densities and distinctive species composition. Six sampling surveys are made in each wetland during each seasonal period with three surveys taken within each of the two months of each period.

The total density and number of species (species density) of birds within each of the 20 plots are averaged across the 18 survey dates to provide a mean value for these response variables for each plot, providing 20 mean values per wetland. Yearly mean total densities and mean species density of birds within each wetland are computed using the 18-survey averages for each of the 20 plots as replicates for each wetland and these values are used for evaluating similarity between the restored and reference wetlands.

Results: Mugu Lagoon had the highest bird density in 2012 through 2019 and the highest 4-year running average for bird density over the same time period. There has been a general decline in the 4-year running average of bird density in San Dieguito Wetlands (Fig. 5.2.5.2). In 2018, this standard was met, but in 2019, the running average has fallen below Carpinteria Salt Marsh, the lowest performing reference wetland, and thus is no longer similar to the reference wetlands. As a result, the standard for bird density in San Dieguito Wetlands is currently not met.

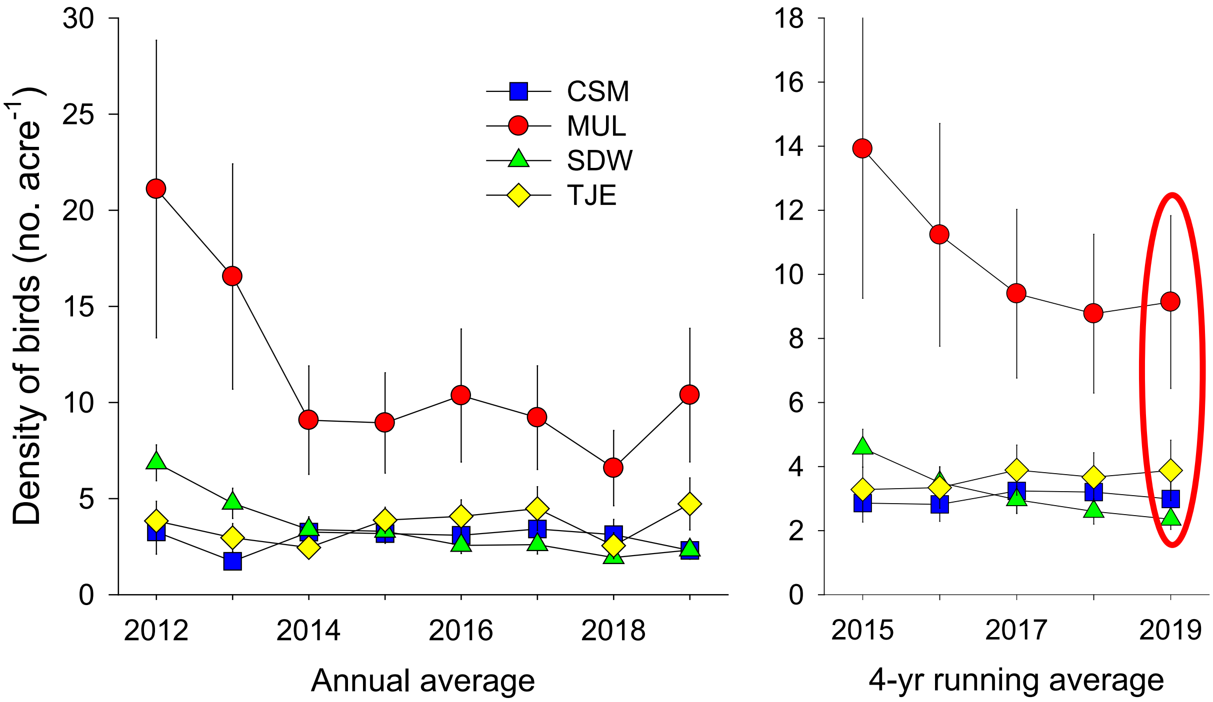


Figure 5.2.5.2. Comparison of bird total density between San Dieguito Wetlands and Tijuana Estuary, Mugu Lagoon, and Carpinteria Salt Marsh. Red ellipse indicates standard was not met. Note change in scale in y-axis.

The 4-year running average of bird species richness remained highest in Mugu Lagoon and Tijuana Estuary in 2019. There has been a general decrease in the 4-year running average for bird species richness in San Dieguito Wetlands relative to the reference wetlands. The 4-year running average for bird species richness in the reference wetlands has remained relatively constant during this period. Although, species richness has declined in San Dieguito Wetlands relative to the reference wetlands, this value was similar to Carpinteria Salt Marsh, the lowest performing reference wetland in 2019 (Figure 5.2.5.3). Therefore, the standard for bird species richness in San Dieguito Wetlands is currently met.

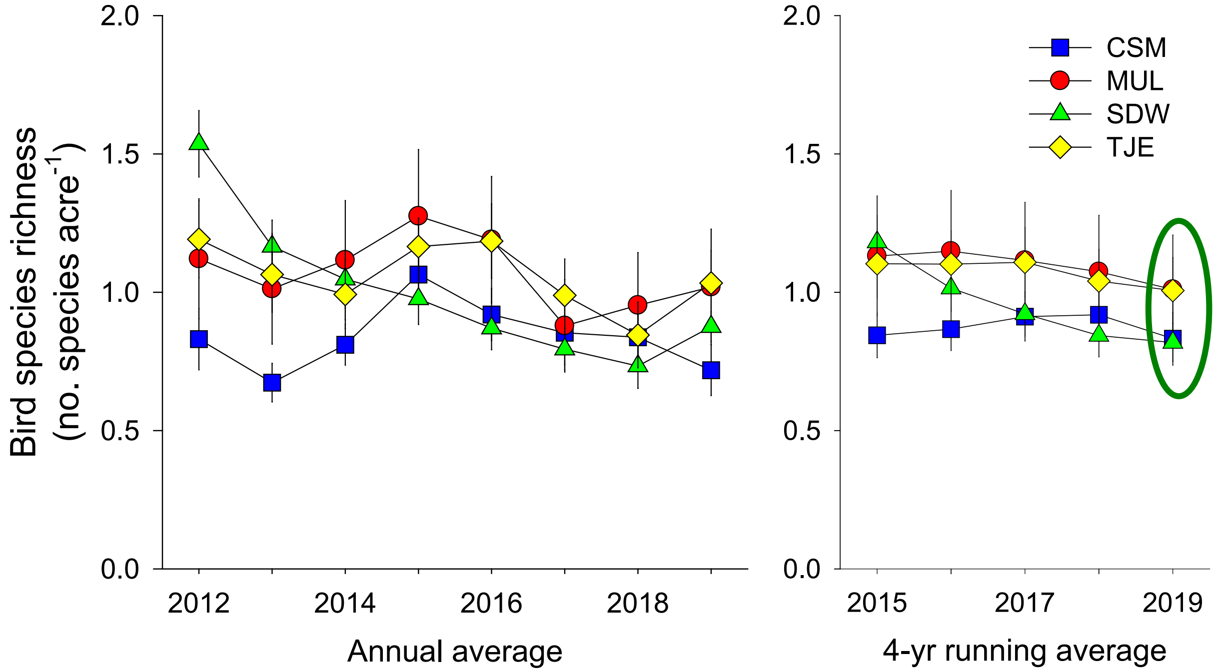


Figure 5.2.5.3. Comparison of bird species richness between San Dieguito Wetlands and the three reference wetlands. Green ellipse indicates standard was met.

5.2.6. Vegetation

THE PROPORTION OF TOTAL VEGETATION COVER AND OPEN SPACE IN THE MARSH SHALL BE SIMILAR TO THOSE PROPORTIONS FOUND IN THE REFERENCES SITES.

Figure 5.2.6.1. View of San Dieguito Wetlands modules W5 & W10 taken in March 2016 showing cordgrass (in center) and mudflat below it.

Approach: The percent cover of salt marsh vegetation and open space is evaluated in the restored and reference wetlands in 10 m x 10 m plots forming grids that entirely cover salt marsh habitat as defined above (see Habitat Areas). Estimates of the percent cover of salt marsh vegetation in San Dieguito Wetlands and the reference wetlands are made using aerial imagery taken in the late spring or summer. Mean percent cover of vegetation in salt marsh habitat (at least 30% cover) in the restored and reference wetlands is computed using the 10 m x 10 m plots as replicates. Since percent cover of vegetation is evaluated for the entire salt marsh habitat in each wetland, comparisons are made only using mean values. This performance standard is met if the average percent cover of vegetation within the restored wetland is not lower than that in the reference wetlands.

Results: Salt marsh vegetation is colonizing San Dieguito Wetlands and has increased slowly in distribution and cover (Fig. 5.2.6.1, see Section 7.0). However, the annual and 4-year running average of percent cover of vegetation in salt marsh habitat remains lower than in any of the reference wetlands (Fig. 5.2.6.2). The cover of vegetation in San Dieguito Wetlands, although on a promising trajectory of increase, is not yet similar to the reference wetlands and consequently the performance standard for cover of vegetation was not met in 2019. A planting program and experiments underway to improve the performance of wetland vegetation is described in Section 7.0.

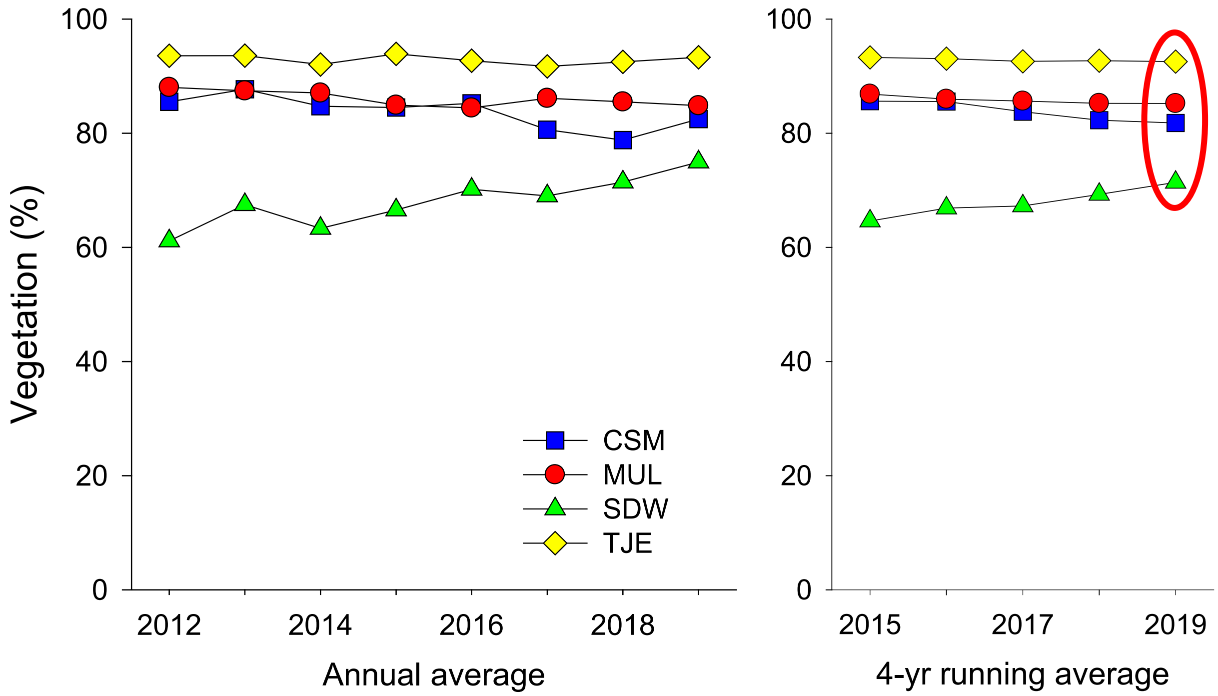


Figure 5.2.6.2. Comparison of the percent cover of salt marsh vegetation between San Dieguito Wetlands and the reference wetlands. Percent cover is evaluated in areas assessed as salt marsh habitat (at least 30% cover of vegetation). Red ellipse indicates standard was not met.

5.2.7. Algae

THE PERCENT COVER OF ALGAE SHALL BE SIMILAR TO THE PERCENT COVER FOUND IN THE REFERENCE SITES.

Approach: This performance standard is designed to monitor the development of unusually dense mats of filamentous green macroalgae in the restoration site. Thick mats of macroalgae have the potential to interfere with wetland structure and function by smothering benthic invertebrates and inhibiting bird feeding (Everett 1991). Macroalgal mats can also be deposited on the salt marsh during high tides, adversely affecting salt marsh vegetation, and can lower dissolved oxygen concentration during decomposition. Estimates of the cover of macroalgae are made from the aerial images taken to monitor the cover of salt marsh vegetation. Since excessive macroalgal growth can be detrimental, the percent cover of macroalgae in the restored wetland must be lower than the reference wetland with the highest cover of macroalgae. Since the entire wetland is censused, comparisons of the average percent cover of algae among wetlands are made only using mean values.

Results: The annual percent cover of macroalgae in San Dieguito Wetlands was lower than that in the reference wetland with the highest value (Mugu Lagoon) in 2012, 2013, and 2015 through 2019, but slightly higher than the reference wetland with the highest value (Carpinteria Salt Marsh) in 2014 (Fig. 5.2.7.1). The 4-year running average of macroalgal cover in San Dieguito Wetlands has been lower than the value in the reference wetland with the highest cover (Mugu Lagoon) from 2015 to the present and the relative standard for algae is therefore met for 2019 (Fig. 5.2.7.1).

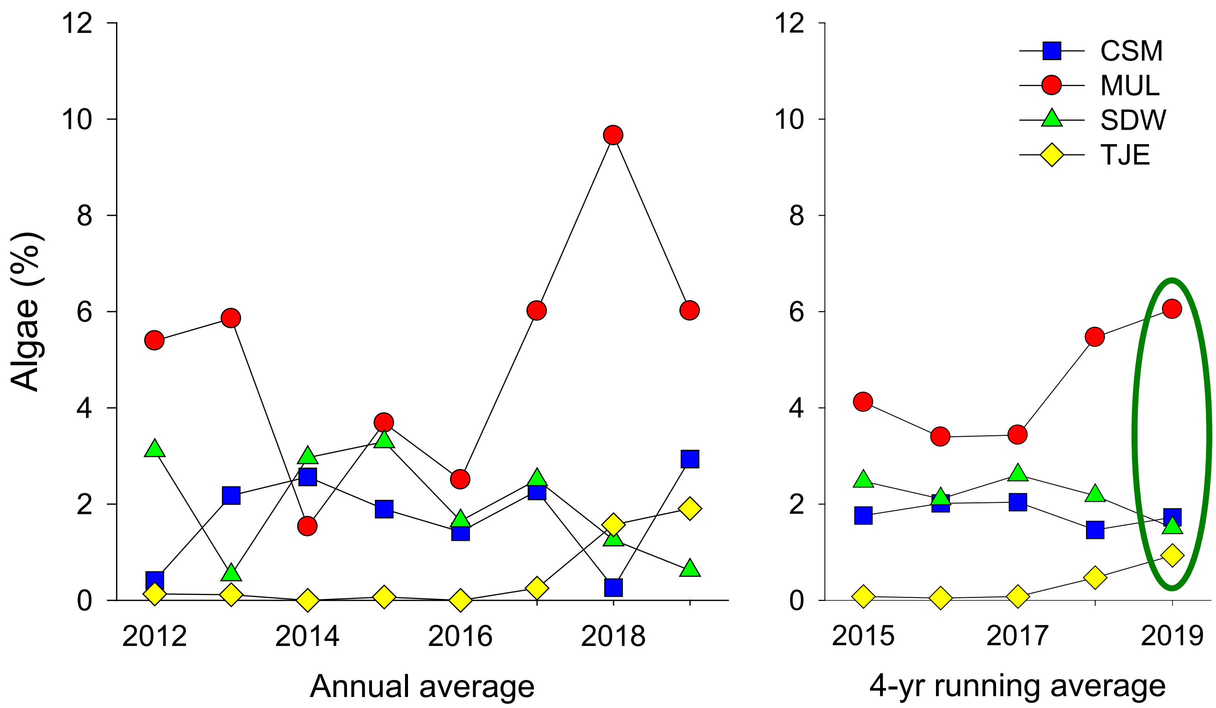


Figure 5.2.7.1. Comparison of percent cover of macroalgae between San Dieguito Wetlands and the reference wetlands. Green ellipse indicates standard was met.

5.2.8. *Spartina* canopy architecture

THE RESTORED WETLAND SHALL HAVE A CANOPY ARCHITECTURE THAT IS SIMILAR IN DISTRIBUTION TO THE REFERENCE SITES, WITH AN EQUIVALENT PROPORTION OF STEMS OVER 3 FEET TALL.

Approach: The canopy of *Spartina foliosa* provides habitat for the federally endangered Ridgway's Rail and other bird species. The number and height of stems of *S. foliosa* in the restored wetland and in Tijuana Estuary is assessed in four patches in each wetland. This standard is only evaluated relative to Tijuana Estuary because *Spartina* is absent in Carpinteria Salt Marsh and uncommon in Mugu Lagoon.

Spartina is sampled in replicate 0.1 m^2 circular quadrats placed over the cordgrass every 2 m along a 20 m long transect line extending parallel to the water line in each patch (Fig. 5.2.8.1) following methods developed by Zedler (1993) in Tijuana Estuary. From the sampling, the mean proportion of stems > 3 feet (91 cm) tall (excluding flowering stalks) is determined for each cordgrass patch. The mean proportion of stems >3 feet tall for each wetland is calculated using four sampled patches per wetland as replicates, and this value is compared between wetlands.

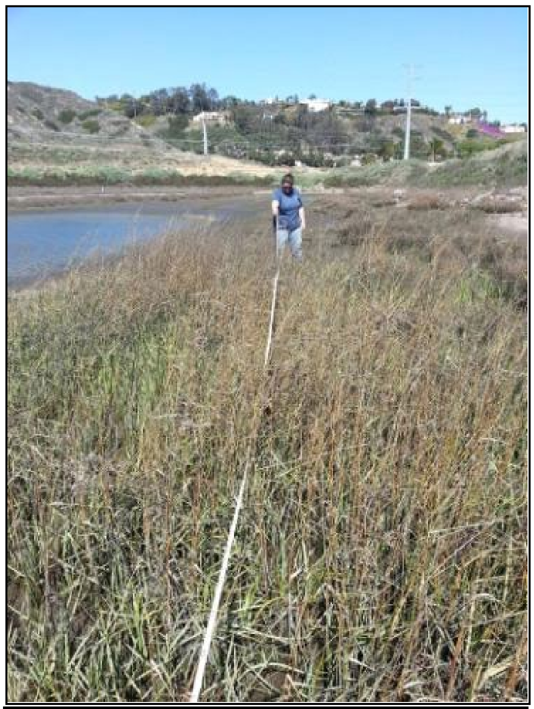


Figure 5.2.8.1. View of a sampling transect overlying a patch of cordgrass in module W4. Cordgrass is sampled in 0.1 m^2 quadrats placed every two meters along the 20 m long transect line. There are four transect lines per wetland.

Results: The annual mean proportion of stems >3 feet (or 91 cm) tall in San Dieguito Wetlands and Tijuana Estuary has been variable over time, including a drop in this value in San Dieguito Wetlands from 2014 to 2016 (Fig. 5.2.8.2). The decline in the height of stems in San Dieguito from 2014 to 2016 was possibly due to increased stress experienced by the plants associated with higher water levels in the wetland in 2014-2015 and the associated increase in tidal inundation of the plants. However, the average annual proportion of stems >3 feet tall has increased from 2017 to 2019 in San Dieguito Wetlands, whereas this value has remained variable in Tijuana Estuary. The 4-year running average dampens the annual variability and the mean proportion of stems > 3 feet has increased in San Dieguito Wetlands relative to Tijuana Estuary in 2018 and

2019. This value was similar between San Dieguito Wetlands and Tijuana Estuary in 2019 and the relative standard for *Spartina* canopy architecture is currently met.

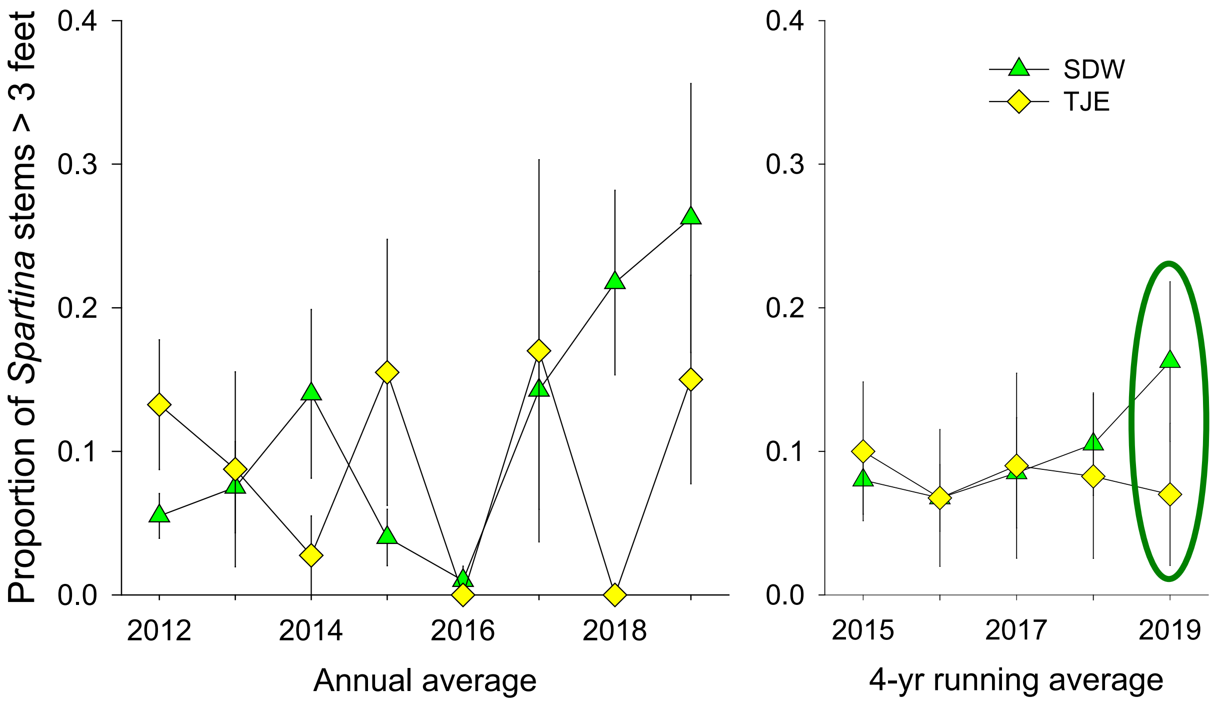


Figure 5.2.8.2, Comparison of the mean proportion of stems > 3 feet (91 cm) tall between San Dieguito Wetlands and Tijuana Estuary. Green ellipse indicates standard was met.

5.2.9. Food chain support

THE FOOD CHAIN SUPPORT PROVIDED TO BIRDS SHALL BE SIMILAR TO THAT PROVIDED BY THE REFERENCE SITES, AS DETERMINED BY FEEDING ACTIVITY OF THE BIRDS.

<u>Approach</u>: Food chain support (FCS) is one of the more important functions of coastal wetlands. Measurements of FCS provided to birds are conducted at the same time that birds are sampled to determine their density and species richness. This performance standard is evaluated using the density of birds feeding within selected plots. A bird is recorded as feeding if one feeding attempt is made over a five-minute time interval. Feeding observations are made on shorebirds found in all of the study wetlands (e.g., Willet, Marbled Godwit, Dowitcher). The density of feeding birds in each of the selected plots used in the analysis consists of the average across the 18 survey dates.

Because bird feeding is evaluated for shorebirds on mudflat, the sample size (number of plots) evaluated for bird feeding varies among wetlands depending on the number of plots that contain mudflat. To ensure that each wetland is weighted equally, the densities of feeding birds are averaged across sample dates for each plot containing mudflat in a given year, then is resampled with replacement 20 times (20 being the targeted sample size). This process is iterated 1000 times, and the mean for each iteration is calculated to produce a dataset of 1000 FCS values for each wetland for a given year.

The 4-year running median of the FCS values for each wetland is calculated using a 4-year mean of each iteration based on the current year and the previous three years producing 1000 values of the 4-year average of the FCS values for each wetland. The 4-year median and standard deviation of the FCS values for each wetland is calculated from the resampled distribution of these 1000 values. The four-year running median of the FCS value at San Dieguito Wetland must be similar to that at the lowest performing reference wetland (as per the methods described in Section 2.3) in order for the San Dieguito Wetland to meet this performance standard for any given year.

Results: The highest annual density of feeding birds occurred in Mugu Lagoon in 2012 through 2019 (Fig. 5.2.9.1). Although the 4-year running average of bird feeding activity has not been significantly lower at San Dieguito Wetlands compared with the lowest performing reference wetland 2015-2017, there has been a general decline in the density of feeding birds. This value was significantly lower than Carpinteria Salt Marsh, the lowest performing reference wetland in 2018 and remains lower than this reference site in 2019. Therefore, the relative standard for FCS was not met in 2019.

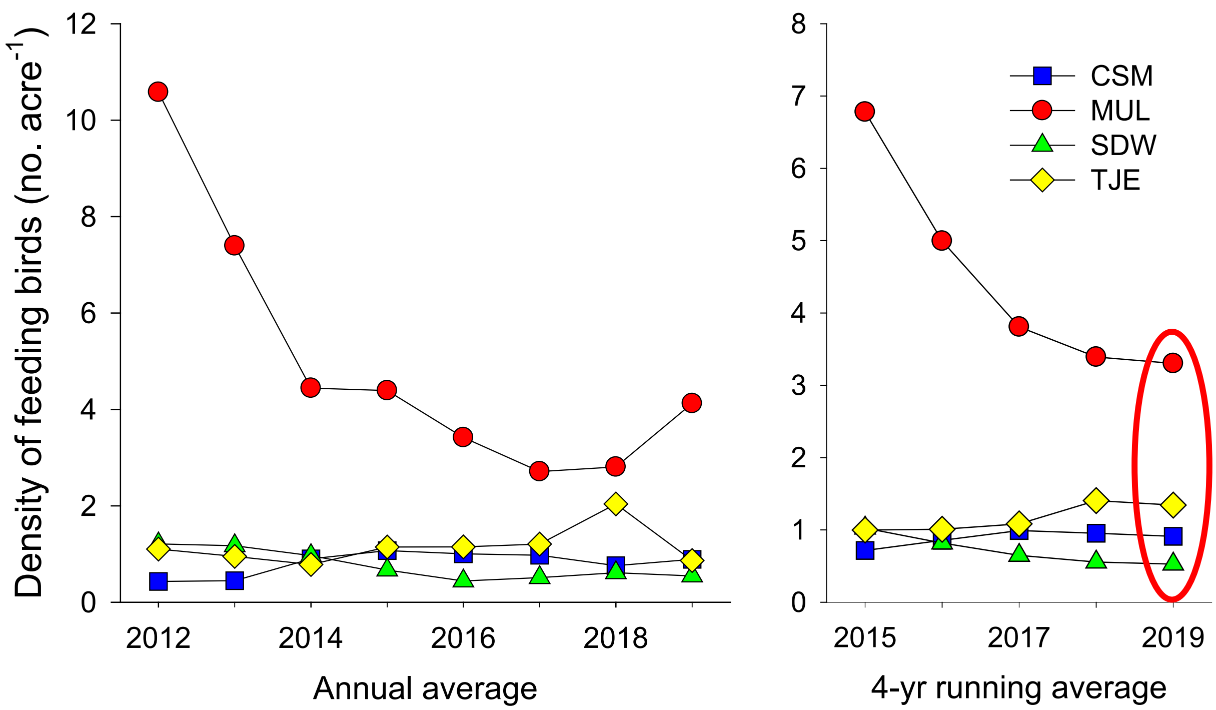


Figure 5.2.9.1. Comparison of the densities of feeding birds between San Dieguito Wetlands and the reference wetlands. Red ellipse indicates standard was not met. Note change in scale in y-axis.

6.0 Permit Compliance

6.1. Summary Assessment of the Absolute Performance Standards
In order for the San Dieguito Wetlands to receive mitigation credit for a given year, it must meet all of the absolute performance standards. The absolute standards are measured only in San Dieguito Wetlands and are assessed only for the current year.

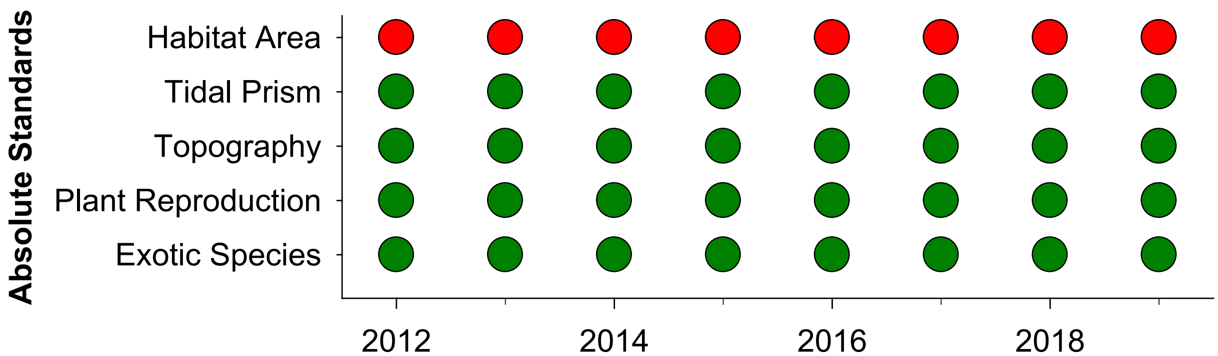


Figure 6.1.1. Summary of assessment of the Absolute Standards from 2012 through 2019. A green dot indicates that the San Dieguito Wetlands Restoration met the required criteria for a given absolute standard; a red dot indicates that it did not.

The San Dieguito Wetlands Restoration has met 4 of the 5 absolute standards from 2012 - 2019, but has consistently failed to meet the requirement of the habitat areas standard during this period (Fig. 6.1.1). Since the habitat areas standard was not met in 2019, and all absolute standards must be met in the current year to receive credit, the San Dieguito Wetlands did not receive mitigation credit for 2019.

6.2. Summary Assessment of the Relative Performance Standards
A requirement of the SONGS permit is that the response variables used to assess the relative performance standards of the San Dieguito Wetlands Restoration Project be “similar” to those of the reference wetlands (Section 4.4). To be considered similar to the reference wetlands, the mean value for each relative performance variable at San Dieguito Wetlands is compared to the mean value for that variable in the reference wetlands to determine whether the value for that variable is significantly worse in San Dieguito Wetlands than in the three reference wetlands (Section 4.4). The relative performance variables measured in San Dieguito Wetlands are compared to the reference wetlands using a 4-year running average. Then, these determinations for each performance variable are used in the assessment of the relative standards, which require that the proportion of relative standards met by the San Dieguito Wetlands be equal to or greater than the proportion of relative standards met by any of the reference wetlands. See Section 4.4 for details on the rationale and methodology of this approach.

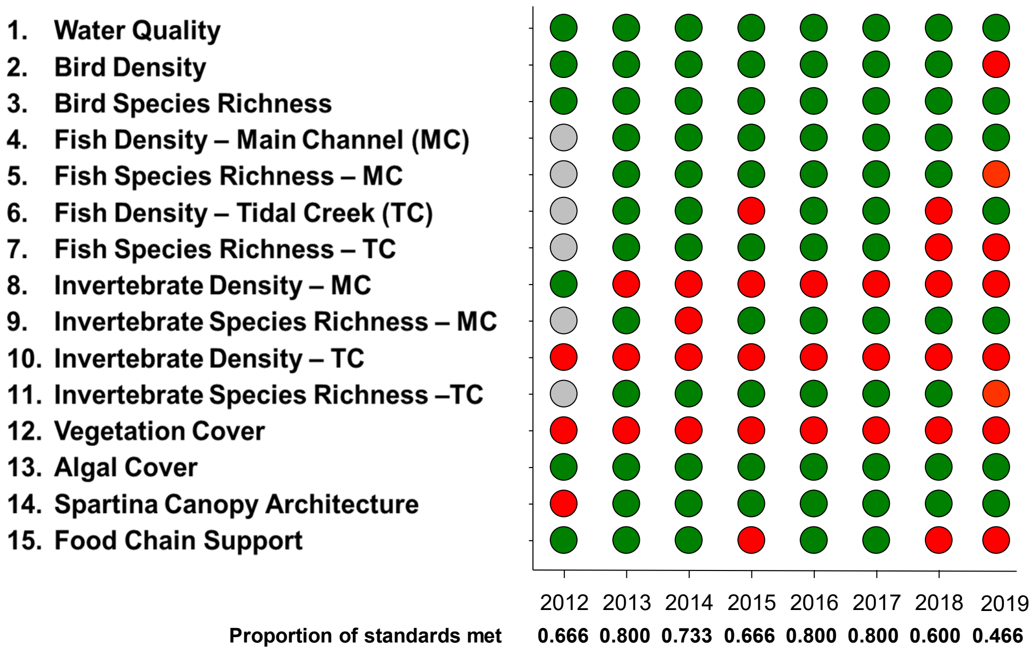


Figure 6.2.1. Summary of the assessment of the Relative Standards from 2012 through 2019. A green dot indicates that the San Dieguito Wetlands Restoration was similar to the reference wetlands for that standard in that year; a red dot indicates that it was not similar to the reference wetlands.

Figure 6.2.1 summarizes the annual assessment of the relative standards from 2012 through 2019 for San Dieguito Wetlands. The restoration project had consistently performed the same or better than the reference wetlands for standards pertaining to water quality, bird density and bird species richness, fish density and fish species richness in main channel habitat, invertebrate species richness in main channel, algal cover, and *Spartina* canopy architecture. However, the project has consistently failed to meet standards for invertebrate density in main channel and tidal creek habitat, and vegetation cover, and in 2019, failed to meet standards that had been met in 2018: bird density, fish species richness in main channel habitat and invertebrate species richness in tidal creeks.

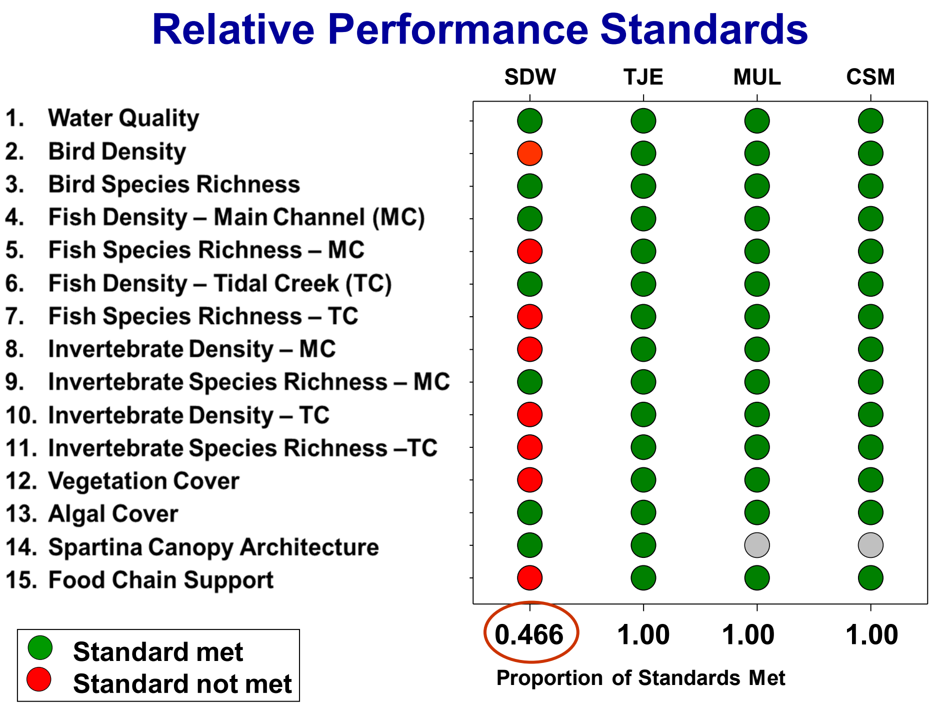


Figure 6.2.2. Summary evaluation of the Relative Standards for 2019. A green dot indicates that the value for the indicated response variable at a particular wetland is similar to the other wetlands. A red dot indicates that the indicated response variable was statistically worse or lower than the other wetlands. *Spartina* canopy architecture was only measured at San Dieguito Wetlands and the Tijuana Estuary.

Comparing the 4-year running averages used to evaluate the relative standards between San Dieguito Wetlands and the reference wetlands, Mugu Lagoon, Carpinteria Salt Marsh and Tijuana Estuary met a similar proportion (1.000) of the relative standards in 2019. San Dieguito Wetlands had a lower proportion of standards met (0.466) than all of the reference wetlands (Fig. 6.2.2). Therefore, San Dieguito Wetlands did not meet the relative standard requirement for 2019.

6.3 Project Compliance

In order to receive mitigation credit for a given year, the wetland restoration project must meet all of the absolute standards. To date, the San Dieguito Wetlands has met the absolute standards for tidal prism, topography, plant reproduction, and exotic species, but has yet to meet the habitat areas standard due to slow vegetation development (Fig. 6.3.1).

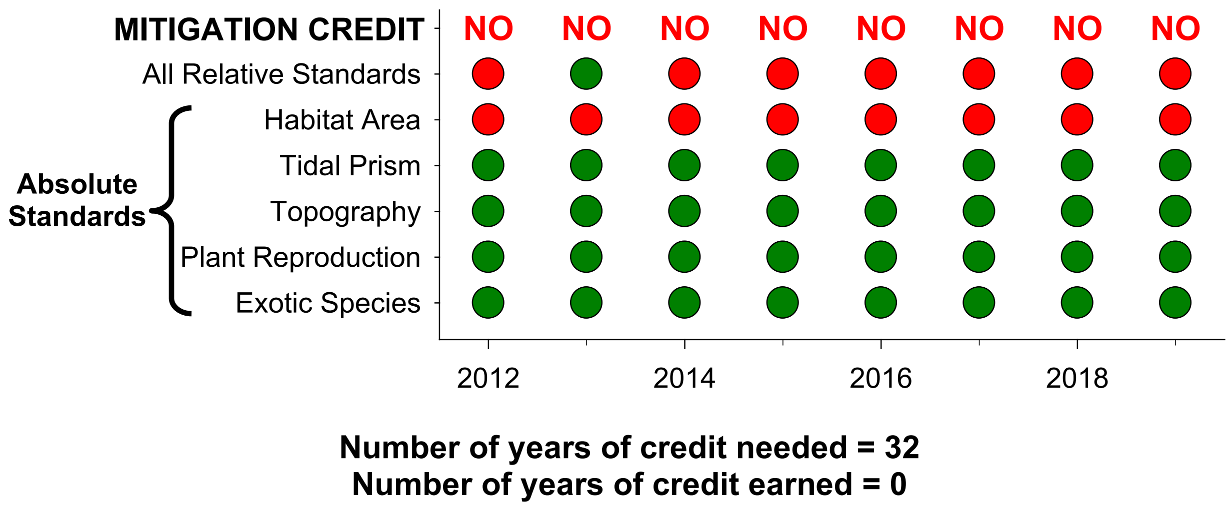


Figure 6.3.1. Status of compliance with the performance standards provided in the SONGS Permit. A green dot indicates standard was met, a red dot indicates a standard was not met.

In order for the San Dieguito Wetlands to receive mitigation credit for a given year, it must also meet as many (as measured by the proportion of standards met) of the relative performance standards as the lowest performing reference wetland. The project has failed to meet the relative standard requirement in 7 out of 8 years (Fig. 6.3.1). While there are signs that the San Dieguito Wetlands Restoration Project is providing habitat for wetland plants and animals, it has not yet satisfied the performance success criteria provided in the SONGS permit and has not yet received mitigation credit.

7.0 Status of Salt Marsh Vegetation and Biological Communities

7.1. Salt Marsh Vegetation

The eighth year of monitoring of the San Dieguito Wetlands Restoration project was completed in 2019 and found that the project has yet to meet the performance standards required for successful mitigation. Failure to meet the performance standards is due, in part, to the slow rate of vegetation development, which affects the ability of the restored wetland to meet the standard for Habitat Areas. The Habitat Areas standard is an absolute standard that must be met every year for the project to receive mitigation credit. It requires that the area of different habitats (subtidal, mudflat, salt marsh) not vary by more than 10% from the areas in the final restoration plan. To be assessed as salt marsh habitat, the cover of vegetation must be at least 30% as evaluated within 10 m x 10 m grids covering the entire wetland (see Section 5.1.2).

A second standard pertaining to the cover of vegetation is the Vegetation standard. This is a relative standard that requires the proportion of total vegetation cover in the salt marsh be similar to those proportions found in the reference wetlands. Relative standards are assessed by comparing the performance variable of interest, in this case percent cover of vegetation in salt marsh habitat (i.e., cover at least 30%) between San Dieguito Wetlands and the reference wetlands (see Section 5.2.6). Vegetation cover is high in natural wetlands, typically >85% and a goal of the restoration project is to achieve not only the required acreage of salt marsh habitat, but also to attain a high cover of vegetation similar to the reference wetlands.

From 2012 to 2018, the slow trajectory of increase in the cover of salt marsh vegetation has been concerning. Large areas of the restoration project remained sparsely vegetated with cover less than the 30% minimum required to be assessed as salt marsh habitat. However, from 2018 to 2019, vegetation cover increased markedly, perhaps due to greater rainfall amounts during this period compared with previous years. Currently, San Dieguito Wetlands is 12.2 acres short of the required 83.3 acres of salt marsh habitat (at least 30% cover) compared the shortfall of 33 acres in 2018. The project has relied on the natural recruitment of vegetation and planting efforts to facilitate vegetation development. Past planting efforts in San Dieguito Wetlands have generally had poor outcomes except for cordgrass. This section reviews the current status of vegetation in the San Dieguito Wetlands restoration site and current planting efforts and experiments underway to facilitate vegetation establishment.

Current status of vegetation

In many areas of the restoration project, vegetation is becoming well established. These areas include, in particular, lower tidal elevations planned for cordgrass, *Spartina foliosa*. Figure 7.1.1 shows that cordgrass patches, indicated by the yellow color, are located primarily in modules W4/16 and W5 on the east side of the I5 freeway, with additional occurrence around the basin module W1 on the west side of the I5 freeway. Cordgrass has also colonized the upper reaches of some tidal creeks, including those in module W2/3. After a period of slow establishment following its last planting in 2011, cordgrass now occupies a total of about 13 acres, an increase of about 6 acres from 2018.

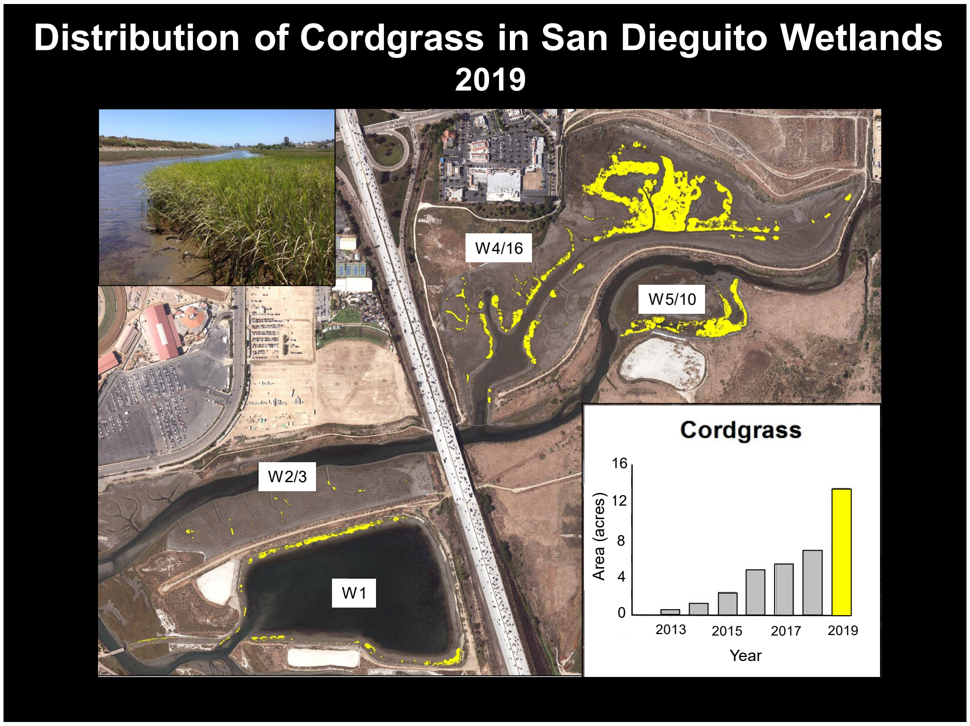


Figure 7.1.1. Distribution of cordgrass *Spartina foliosa* in San Dieguito Wetlands in 2019 (yellow) and increase in acres of cordgrass over time from 2012 to 2018 (gray).

However, vegetation is underperforming overall in the restoration site as shown in Figure 7.1.2. This figure shows the required acres of salt marsh habitat ±10% together with the trend in acres of salt marsh habitat over time. The minimum required acreage of salt marsh habitat is 83.3 acres (10% lower than the design acreage of 92.6 acres). The rate of increase in salt marsh habitat from 2012-2018 was slow and in 2018 the restoration project was still 33 acres short of the minimum required acreage. However, from 2018 to 2019, an additional 21 acres achieved the minimum of 30% to be assessed as salt marsh habitat. As a result, in 2019 San Dieguito Wetlands is approximately 12 acres short of the minimum required salt marsh acres and the trajectory of increase in salt marsh acreage is encouraging for meeting the Habitat Areas standard in the foreseeable future.

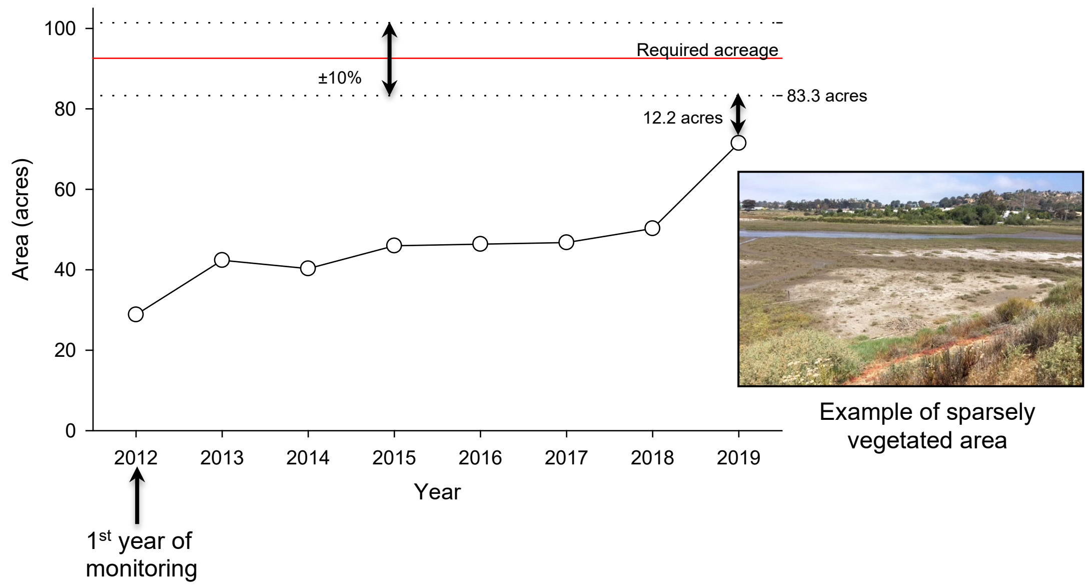


Figure 7.1.2. Change in acres of salt marsh habitat over time and the required acreage ±10% in San Dieguito Wetlands. San Dieguito Wetlands had a deficit of 12.2 acres of salt marsh habitat in 2019.

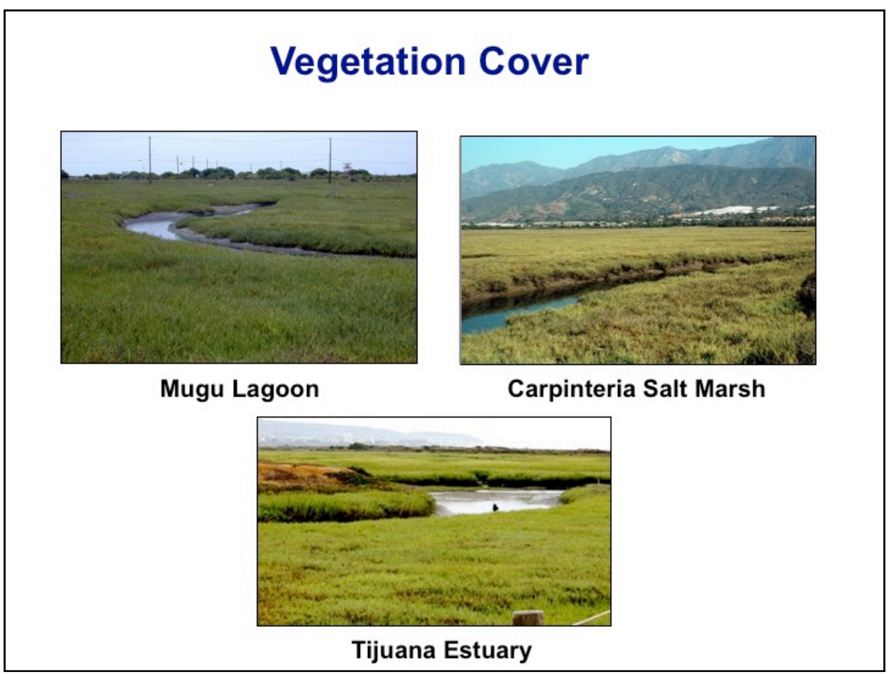


Figure 7.1.3. Photographs showing the high cover of vegetation in the reference sites, which is typical of southern California wetlands.

In addition to the absolute standard for habitat areas, the relative standard for vegetation cover requires that cover in San Dieguito Wetlands be similar to that of the reference wetlands. Vegetation cover is high in natural wetlands, typically >85%, as illustrated in Figure 7.1.3 for the reference wetlands, Mugu Lagoon, Carpinteria Salt Marsh, and Tijuana Estuary.

The goal of the restoration project is to achieve not only a minimum of 83.3 acres of salt marsh habitat, but also to attain a high cover of vegetation similar to the reference wetlands. Figure 7.1.4 shows the change in vegetation cover over time in San Dieguito Wetlands by cover classes. The monitoring data from 2012 to 2019 reveal that the overall rate of increase in cover in the higher cover classes has been very slow with only approximately 18 acres of 85% cover as of 2018 (Fig. 7.1.4). However, there was an appreciable increase in the acres of >85% cover to around 30 acres in 2019, which is encouraging. The acreage for the cover class of 30-60% is relatively flat because every year some of the vegetation in cover classes of <30%, or in the “other” category, grows into the 30-60% cover class, and some of the 60-85% grows into the >85% class.

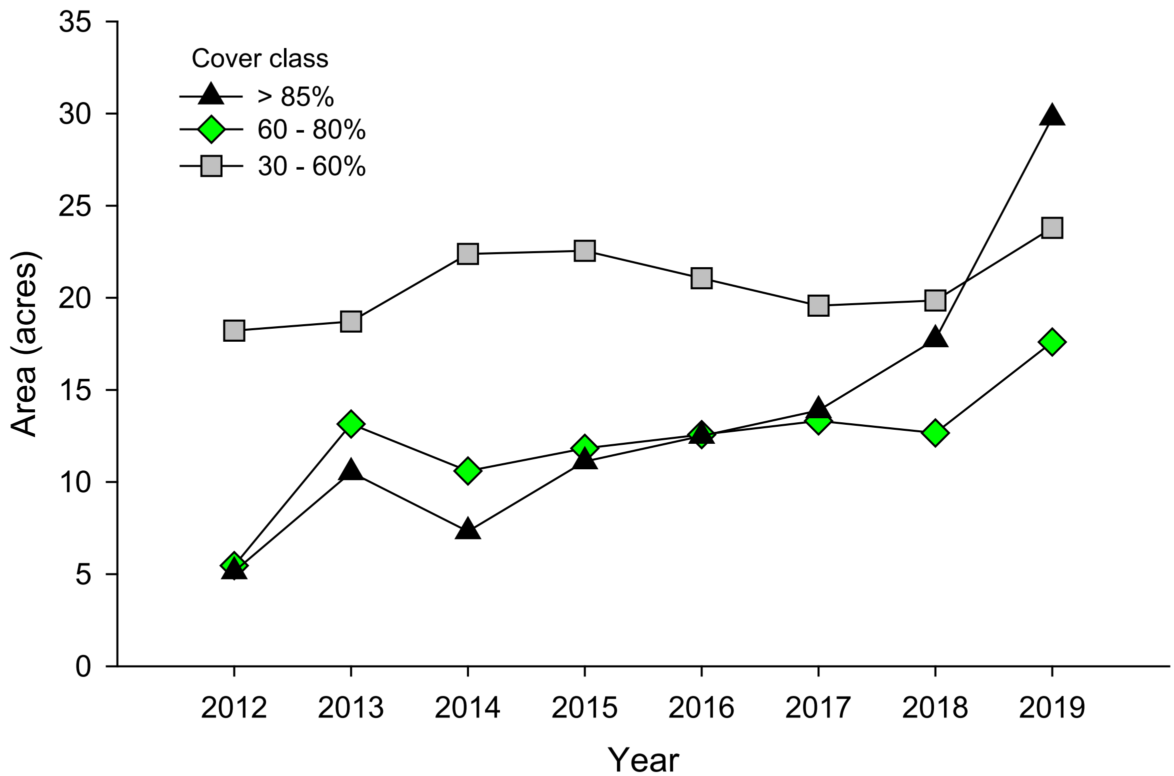


Figure 7.1.4. Change in acres of vegetation as a function of cover class over time.

Data collected to evaluate the performance standards for habitat areas and vegetation cover can be used to identify specific areas in the wetland where vegetation is underperforming and in need of intervention to facilitate plant establishment. Figure 7.1.5 shows vegetation cover in 2019 assessed within 10 m x 10 m grids using aerial imagery (Section 5.1.2) for the wetland modules on the east side of the freeway (W4/16, W5/10). The inset in this figure, extracted from the San Dieguito Wetlands Final Restoration Plan (2005), illustrates that most of these modules are planned vegetated salt marsh habitat (shades of green) together with some planned mudflat (brown). Vegetation cover in 2019 determined using aerial imagery is binned into cover classes with warm colors (red, orange, yellow) showing areas that were classified either as other (i.e. habitat with insufficient vegetation cover to be assessed salt marsh) or unplanned mudflat. Brown is planned mudflat. Areas of the restoration site that meet the Habitat Areas standard (i.e., cover ≥30%) are indicated by shades of green, with darkest green showing areas that are ≥85% cover. Also provided are the estimated acres of these cover classes. As of 2019, about 16 acres of “other” and unplanned mudflat (red, orange, and yellow) that might benefit from some form of intervention to facilitate plant development are located at the higher elevations and in the eastern portion of W4/16 and about 2 acres are located in modules W5/10.

Vegetation Cover - Eastern Modules (2019)

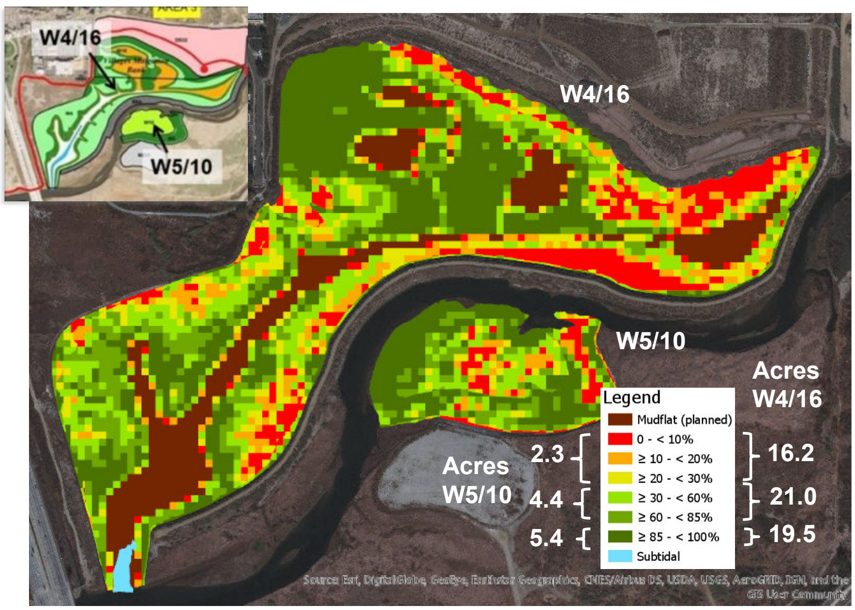


Figure 7.1.5. Cover of vegetation in the eastern modules of San Dieguito Wetlands in 2019 binned into cover classes, and the acres of each class by module. Inset in upper right shows planned habitats from the Final Restoration Plan.

Similarly, Figure 7.1.6 shows the modules on the west side of the freeway, which consists of W2/3 and the basin, W1. The inset shows that modules W2/3 are planned vegetated salt marsh habitat, whereas module W1 is a planned subtidal basin bordered by a narrow strip of mudflat and vegetated marsh.

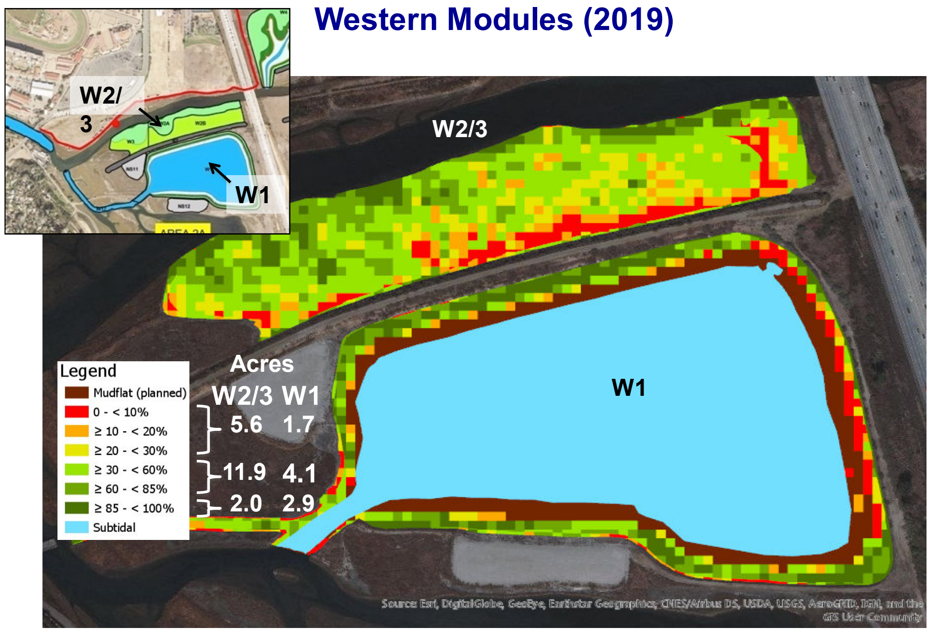


Figure 7.1.6. Cover of vegetation in the western modules of San Dieguito Wetlands in 2019 binned into cover classes. Inset in upper left shows planned habitats from the Final Restoration Plan.

Approximately 71% or 14 acres of module W2/3 was assessed as salt marsh habitat in 2019 with 5.6 acres of sparsely vegetated acres (< 30% cover) remaining primarily at higher elevations near the berm and eastern end of the module.

SCE's planting program

Despite the increase in cover of vegetation from 2018 to 2019, it is unlikely that the restoration project will meet the relative standard for vegetation even if the habitat areas standard is met in the foreseeable future. Results from performance monitoring have suggested that the low cover of vegetation in portions of the wetland is due largely to very high soil salinities found at higher tidal elevations, but other factors including other soil properties may also be important across the elevation gradient.

To facilitate plant development, SCE has undertaken a planting program. In 2017, SCE tilled some areas and installed irrigation lines in preparation for planting within three areas of W4/W16, indicated by the solid lines in Figure 7.1.7, which had a very low cover of vegetation. In March 2019, SCE planted 39,240 plants within these areas. In 2020, an additional 20,922 plants were planted throughout the restoration site (Fig. 7.1.8). In both years, Parish's glasswort, *Arthrocnemum subterminale*, comprised the vast majority (>70%) of planted plants, but other species including *Distchlis spicata*, *Frankenia salina*, and *Limonium californicum* were also planted.

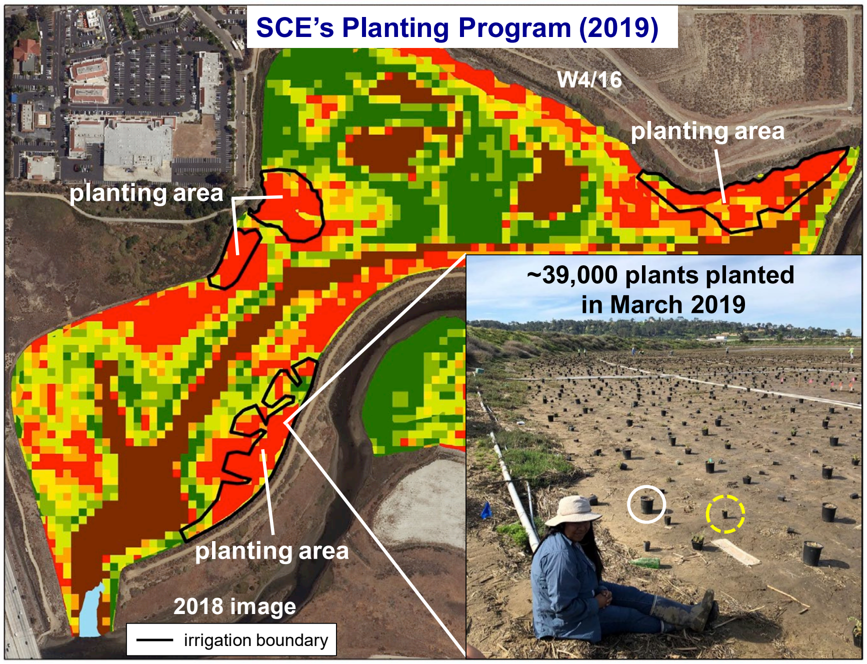


Figure 7.1.7. Location of SCE's planting program in 2019 within module W4/16. Approximately 39,000 plants were planted within the areas defined by black lines. These areas also receive irrigation. Plants were grown in two pot sizes in the nursery, gallon (white circle) and rosepot (yellow dashed circle).

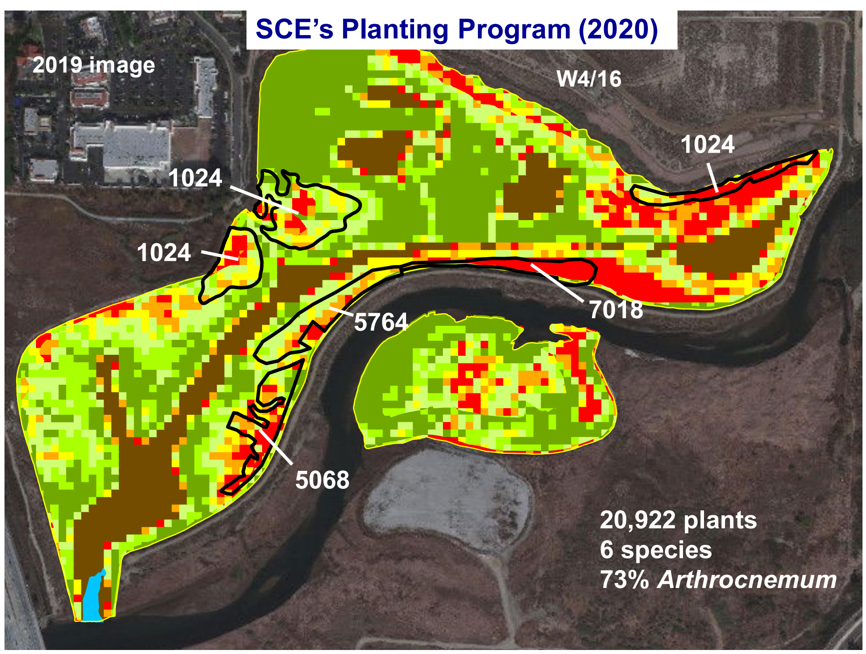


Figure 7.1.8. Location of SCE's current planting program within module W4/16. Approximately 21,000 plants were planted within the areas defined by black lines. These areas also receive irrigation.

Experiments to inform the planting program (2019, 2020)
SCE supported some small-scale experiments embedded within the larger planting program to inform this program moving forward. The overall goal of these experiments is to investigate factors that could facilitate the successful establishment and growth of planted plants, leading to an increase in plant cover that will bring the wetland into compliance with the SONGS permit. The specific plant species used in the experiments, number of replicates, configuration of the planting, and location of the experiments is constrained by the species and number of plants that were available, location of the irrigation system, and logistics of the planting process.

2019 Experiment
The specific questions addressed in this experiment were: 1) Does the size of the pot in which plants are grown in the nursery affect the survival and growth of these plants following planting in the field, and thus the development of vegetation cover? The motivation behind this question is that high soil porewater salinity is a stressor that adversely affects the growth and survival of planted plants. Monitoring has revealed that soil salinity decreases with depth in the soil. It follows that plants grown in larger pots may have deeper roots that have less exposure to higher salinities near the soil surface. In addition, plants grown in larger pots have more "potting soil" that can act as a soil amendment and facilitate plant growth and survival. 2) Does planting in clusters affect plant cover? The motivation behind this question is that the clustering of planted plants, rather than planting plants as singletons, better ameliorates physical stress and provides microhabitat conditions more favorable to plant survival and growth.
Plant responses to both container size and clustering reported here were evaluated at higher tidal elevations (4.0-4.5' NGVD) for *Arthrocnemum subterminale*. *Arthrocnemum* comprised the majority of plants planted in 2019 and 2020. At lower elevations (<3.5' NGVD), only the effect of clustering was evaluated for plants grown in rosepots, and only for *Salicornia virginica*.

Figure 7.1.9 shows the arrangement of the experimental plantings in rows with plants spaced about 2' apart along a transect line. Examples of two of the experimental variables are also shown. The two container sizes evaluated were rosepot (2.25" diameter x 3.25" deep) and one-gallon (6" diameter x 7" deep) containers. In the clustering experiment, plants are planted either as singletons or in groups of three. The experimental treatments were located in the three areas of the restoration site that are being planted by SCE and that currently have a sparse cover of vegetation (Fig. 7.1.10).

Container size

Clustering

Figure 7.1.9. Images showing the experimental layout, differences in size between rosepot and one-gallon containers, and three-plant clustering versus single plants.

Plant responses to the experimental treatments were evaluated over six months (see below).

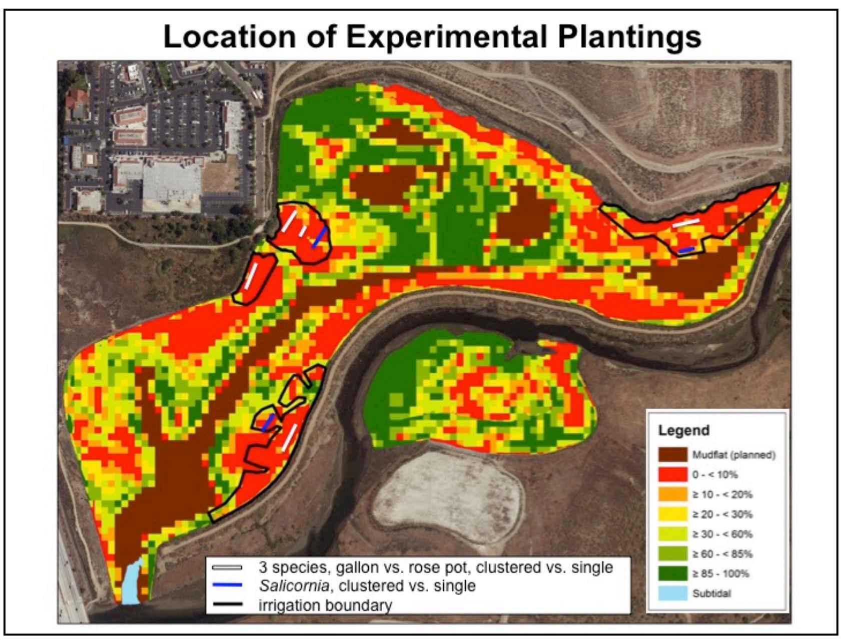


Figure 7.1.10. Location of the 2019 experimental treatments in the three areas of the restoration site that are being planted by SCE and that currently have a sparse cover of vegetation.

Results from the 2019 experiment can be summarized as follows (Fig. 7.1.11): 1) plants in gallon containers performed much better, attaining higher percent cover after six months, than plants in rosepots and 2) clustering of plants in groups of three had no obvious benefit on per capita plant cover. Results from the experiment were used to inform the planting program in 2020; only plants grown in gallon size containers were planted in the restoration site and plants were planted as singletons.

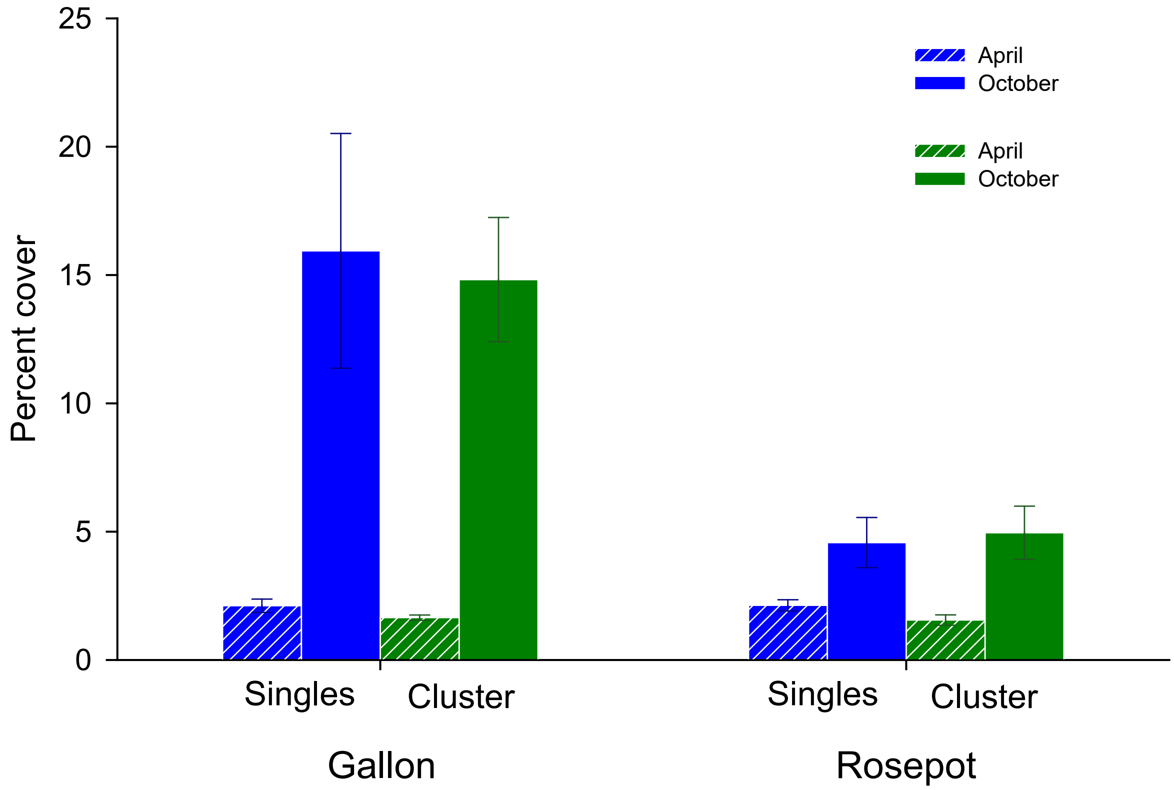


Figure 7.1.11. Change in percent cover of *Arthrocnemum subterminale* as a function of container size (gallon vs. rosepot) and clustering (singletons vs. cluster of three).

Two experiments are embedded within 2020 planting program (Figs. 7.1.12, 7.1.13). The goal of the first experiment is to test the effect of irrigation, soil decompaction, and soil amendments on the growth and survival of potted plants and of seeds. This experiment is being conducted at higher elevations where vegetation cover is less than approximately 10%. The goal of the second experiment is to test the effect of planting versus seeding on filling in gaps in plant cover at lower elevations where existing cover exceeds 10%, but insufficient to meet the habitat areas standard of at least 30% cover. No soil amendments or irrigation were applied in the second experiment.

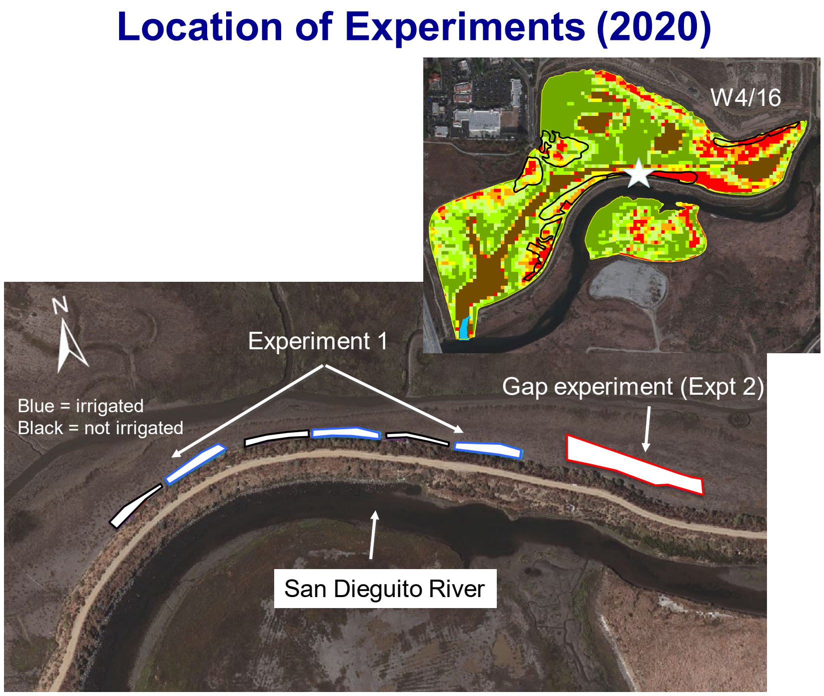


Figure 7.1.12. The location, indicated by the star, and layout of the two experiments undertaken in 2020: Experiment 1 at high elevation (4.25 – 3.5 feet NGVD) and the gap filling experiment at lower elevation (< 3.5 feet NGVD) in Module W4 east of the I-5 freeway. Another gap experiment is located on the west side of freeway in Module W2/3. The gap experiment is being done at lower tidal elevations that already have at least 10% cover of vegetation and without soil treatments or irrigation. These experiments are on-going.

Figure 7.1.13. Images showing a tractor de-compacting soil to a depth of approximately 1.5 feet, the manual addition of soil amendments (gypsum, soil conditioner), and the arrangement of experimental quadrats and plants within each quadrat.

Vegetation cover within the experimental quadrats, and overall SCE planting area, are being measured from images collected by drone quarterly for at least one year beginning in early March 2020. Vegetation cover is also assessed by sampling 100 uniform points quarterly within each quadrat, which will provide ground-truth data for the drone flights and detect any effects of seeding where sprouts would be hard to detect using aerial imagery.

Vegetation: Summary & Future Directions

- Underperformance of vegetation has led to a short-fall in salt marsh habitat and vegetation cover.
- It appears that favorable conditions, likely rainfall, led to a large increase in both vegetation acreage and cover.
- SCE is implementing a planting and irrigation program in portions of the wetland to facilitate vegetation development.
  - Approximately 60,000 plants planted in 2019-2020.
- An experiment completed in 2019 revealed that plants performed better in Gallon vs. Rosepots with no effect of plant clustering.
- Experiments started in 2020 are currently underway to evaluate the effect of irrigation, decompaction, soil amendments, planting, and of seeding on the development of plant cover.
- CCC contract scientists are monitoring the experiment and the overall planting program to evaluate whether they achieve the desired goal of increasing vegetation cover in a timely manner.

7.2. Status of Birds, Fish, and Macro-invertebrates

The success of San Dieguito Wetlands in supporting biological communities of birds, fish, and macro-invertebrates is evaluated under the relative standards by comparing the densities and numbers of species within these groups to the densities and numbers of species in the reference wetlands. Biological standards not met in San Dieguito Wetlands in 2019 included bird density and bird feeding (food chain support), invertebrate density in main channel and tidal creek habitat and species richness in tidal creeks, and fish species richness in main channel and tidal creek habitat.

The following sections review the status of birds, fish, and macro-invertebrates in San Dieguito Wetlands and prioritize plans to explore possible reasons for the underperformance of these groups.

7.2.1. Birds

During monitoring surveys in 2019, the two most abundant bird guilds in San Dieguito Wetlands were waterfowl (e.g., ducks, grebes, mergansers, coots) and shorebirds (e.g., willets, godwits, plovers, sandpipers, dowitchers) followed by lower densities of upland birds (e.g., sparrows, larks, flycatchers), wetland birds (e.g., rails, soras, egrets, herons), and seabirds (e.g., terns, seagulls, pelicans). Notably, the densities of shorebirds, overall the most abundant group in the reference wetlands, were the second most abundant group in San Dieguito Wetlands (Fig. 7.2.1.1).

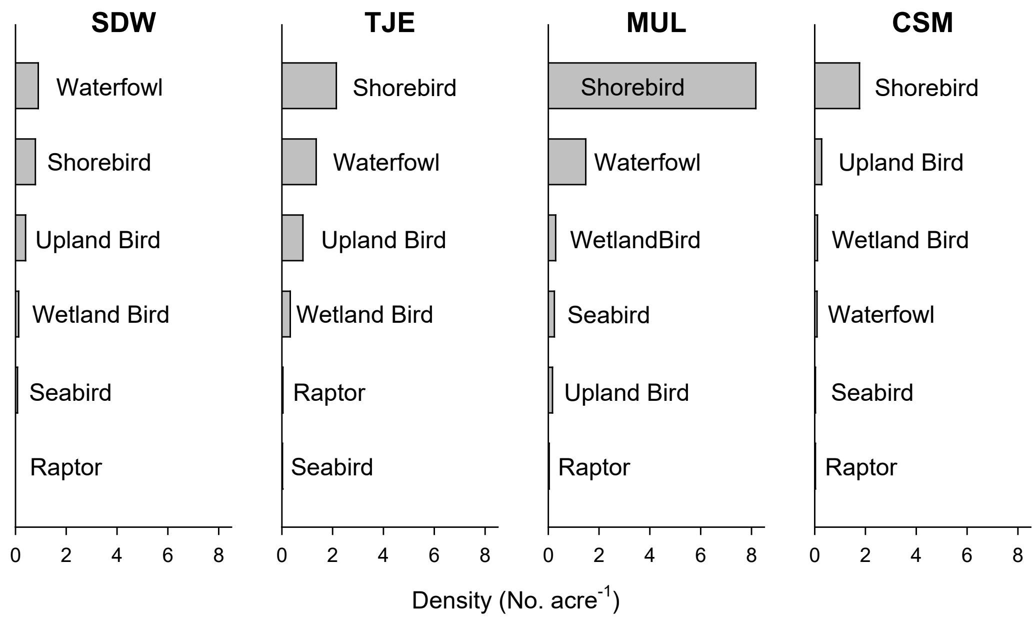


Figure 7.2.1.1. The six most abundant bird groups in San Dieguito Wetlands (SDW) and the reference wetlands, Tijuana Estuary (TJE), Mugu Lagoon (MUL), and Carpinteria Salt Marsh (CSM) in 2019.

Figure 7.2.1.2 shows densities of shorebirds and waterfowl in San Dieguito Wetlands and the reference wetlands over time. Densities of shorebirds have declined over the past eight years in San Dieguito Wetlands and Mugu Lagoon, but remain relatively constant in Carpinteria Salt Marsh and Tijuana Estuary. There is a deficit in shorebirds in San Dieguito Wetlands relative to the reference wetlands and thus it appears that there may be something about the restored wetland that is affecting shorebird abundance. There is currently no satisfactory explanation for the underperformance of bird density, or of bird feeding, a related relative standard that was also not met in 2019. Insufficient food resources (e.g., worms) is not a compelling explanation because invertebrate densities have been consistently low in San Dieguito Wetlands, while shorebird densities have declined over time.

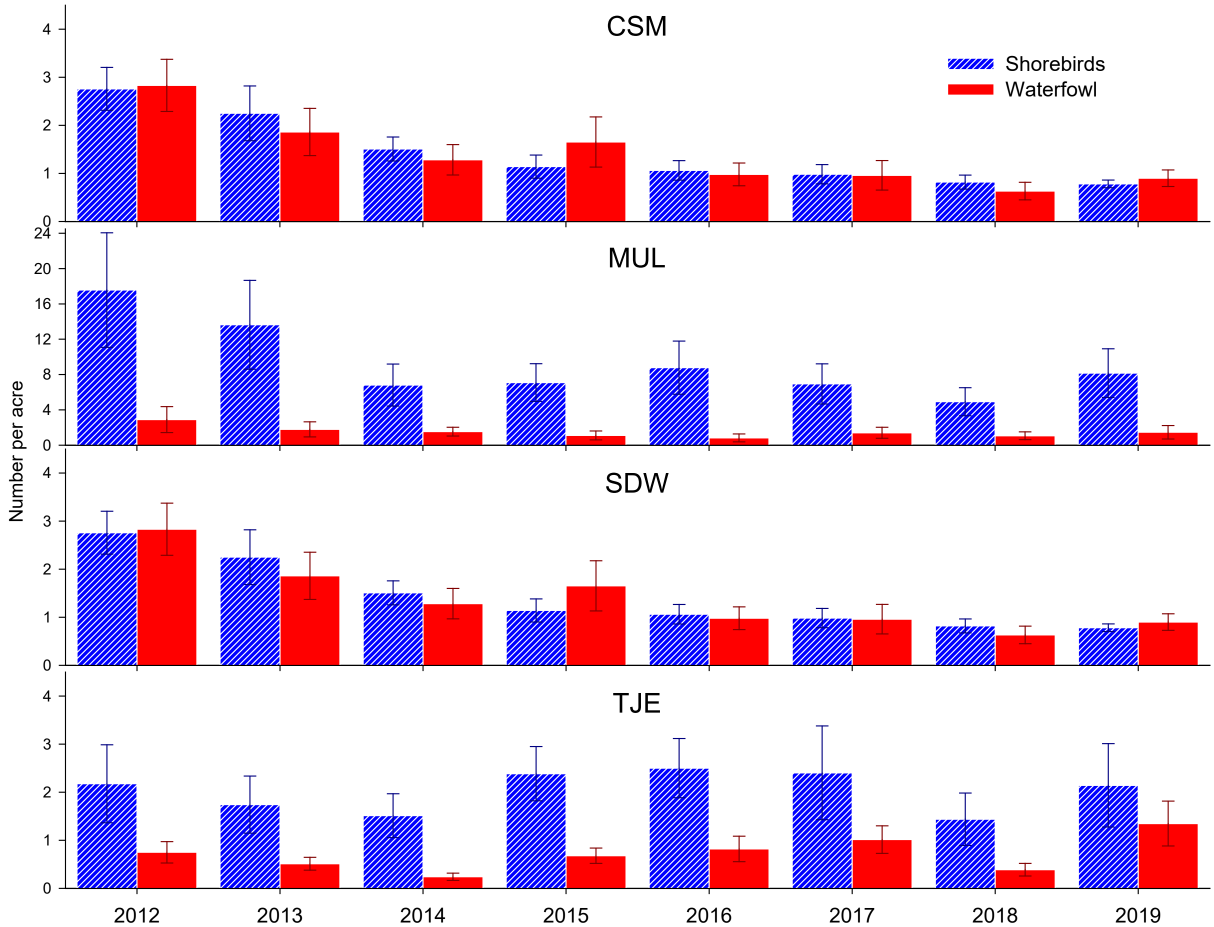


Figure 7.2.1.2. Densities of shorebirds and waterfowl in San Dieguito Wetlands and the reference wetlands, Tijuana Estuary (TJE), Mugu Lagoon (MUL), and Carpinteria Salt Marsh (CSM) in 2019. NOTE change in scale for y-axis at MUL.

7.2.2 Fish

During monitoring surveys in 2019, the top three fish groups in San Dieguito Wetlands were gobies (Arrow Goby, Shadow Goby), killifish and silversides (topsmelt, grunion) (Fig. 7.2.2.1). Gobies were most abundant in both main channel and tidal creek habitat in Carpinteria Salt Marsh and Tijuana Estuary, and in main channel in Mugu Lagoon, in contrast to the much lower abundances of this group in these habitats in San Dieguito Wetlands.

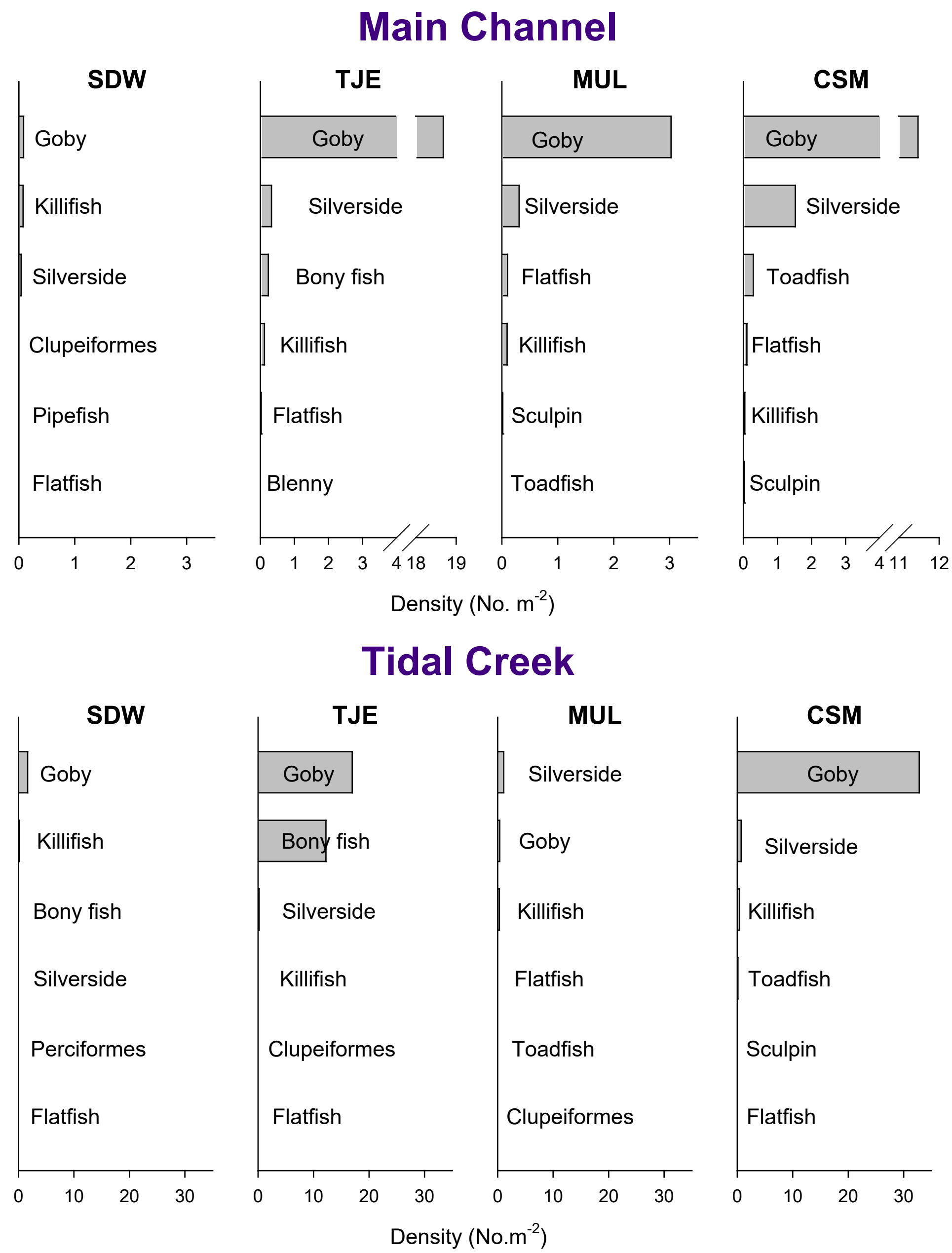


Figure 7.2.2.1. The six most abundant fish in SDW and the reference wetlands in main channel and tidal creek habitat in 2019. Note the differences among wetlands in the scale of the x-axis in main channel graphs to accommodate the wide disparity in the densities of gobies among sites.

One issue of potential concern that could affect fish abundance and species richness in San Dieguito Wetlands is the encroachment of cordgrass, *Spartina foliosa,* into tidal creek habitat. The colonization of tidal creeks by cordgrass suggests that these areas may be becoming shallower, perhaps due to slumping of the banks or sedimentation, allowing cordgrass to become established. This habitat change could be a possible mechanism that explains the paucity of gobies in San Dieguito Wetlands, at least in tidal creeks. However, there is no obvious explanation for the even lower goby densities in Mugu Lagoon tidal creeks, which lack cordgrass.

7.2.3. Macro-invertebrates

During surveys in 2019, the most abundant invertebrates in both main channel and tidal creek habitats in San Dieguito Wetlands and the reference wetlands were small worms in the class Polychaeta (Fig. 7.2.3.1). In main channel habitat, polychaete worms were followed in abundance by oligochaete worms in Mugu Lagoon and Tijuana Estuary and by snails and insects, respectively in San Dieguito Wetlands and Carpinteria Salt Marsh (Fig. 7.2.3.1a). In tidal creeks, polychaete worms were followed in abundance by snails in San Dieguito Wetlands and by oligochaetes in the reference wetlands (Fig. 7.2.3.1b).

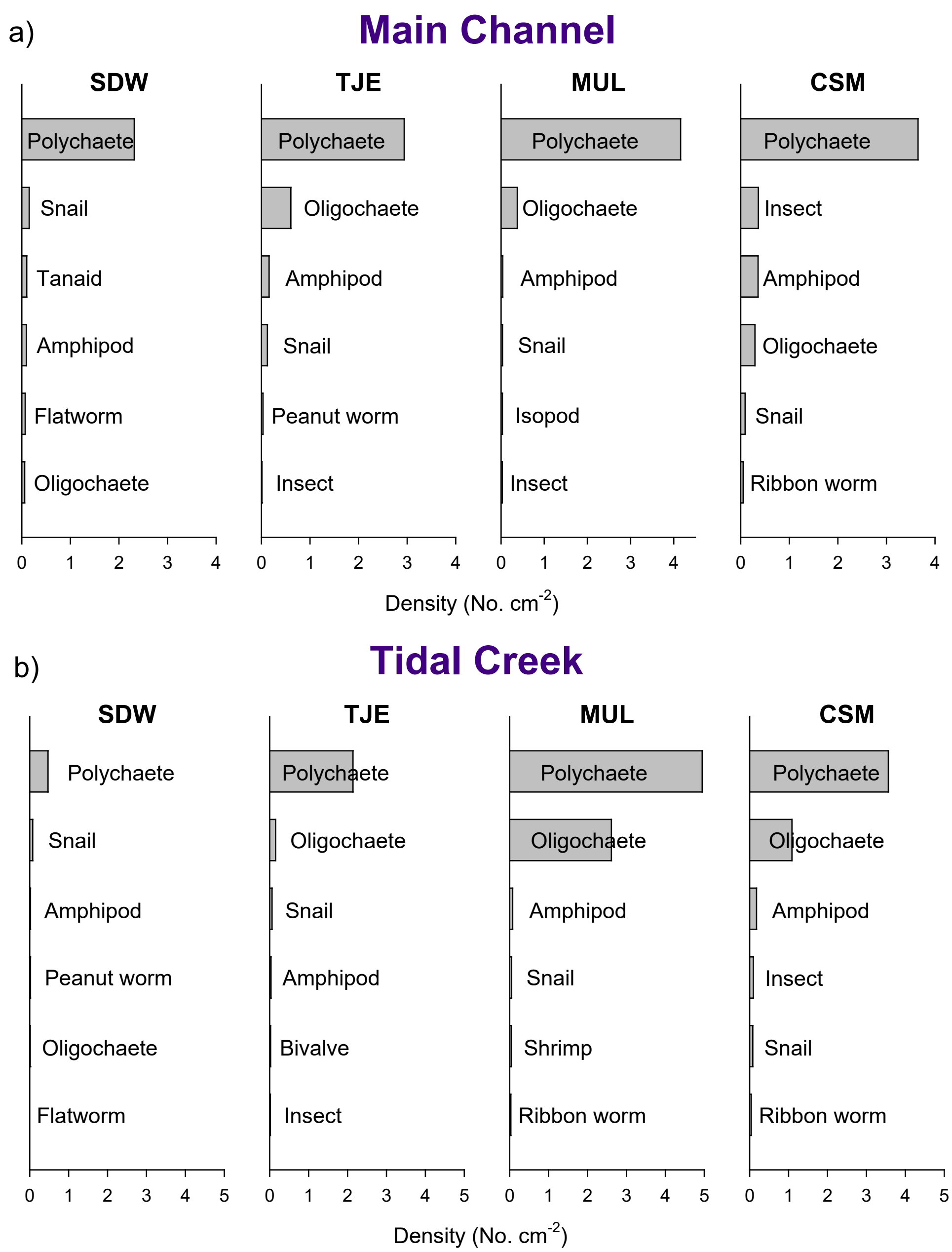


Figure 7.2.3.1. The six most abundant invertebrate taxa in a) main channel and b) tidal creek habitat in the restored wetland (SDW) and reference wetlands (TJE, MUL, CSM) in 2019. Note the paucity of polychaete worms in SDW tidal creek habitat, in particular, compared with the reference wetlands.

Overall, densities of both polychaete and oligochaete worms were lower in San Dieguito Wetlands compared with the reference wetlands (Fig. 7.2.3.1), contributing to the failure of San Dieguito Wetlands to meet the relative standard for invertebrate density in both main channel and tidal creek habitats in 2019 (see Section 5.2.4 Macro-invertebrates).

Furthermore, the densities of invertebrates in main channel and tidal creek habitat have remained low and relatively unchanged over the past eight years (Figs. 7.2.3.2, 7.2.3.3, 7.2.3.4, 7.2.3.5). This pattern is concerning because one would expect an increase over time in the abundance of this group, which attains high densities in the reference wetlands, and it appears that there may be some, as yet unknown, physical or biological factor that is contributing to the low abundance of worms in San Dieguito Wetlands.

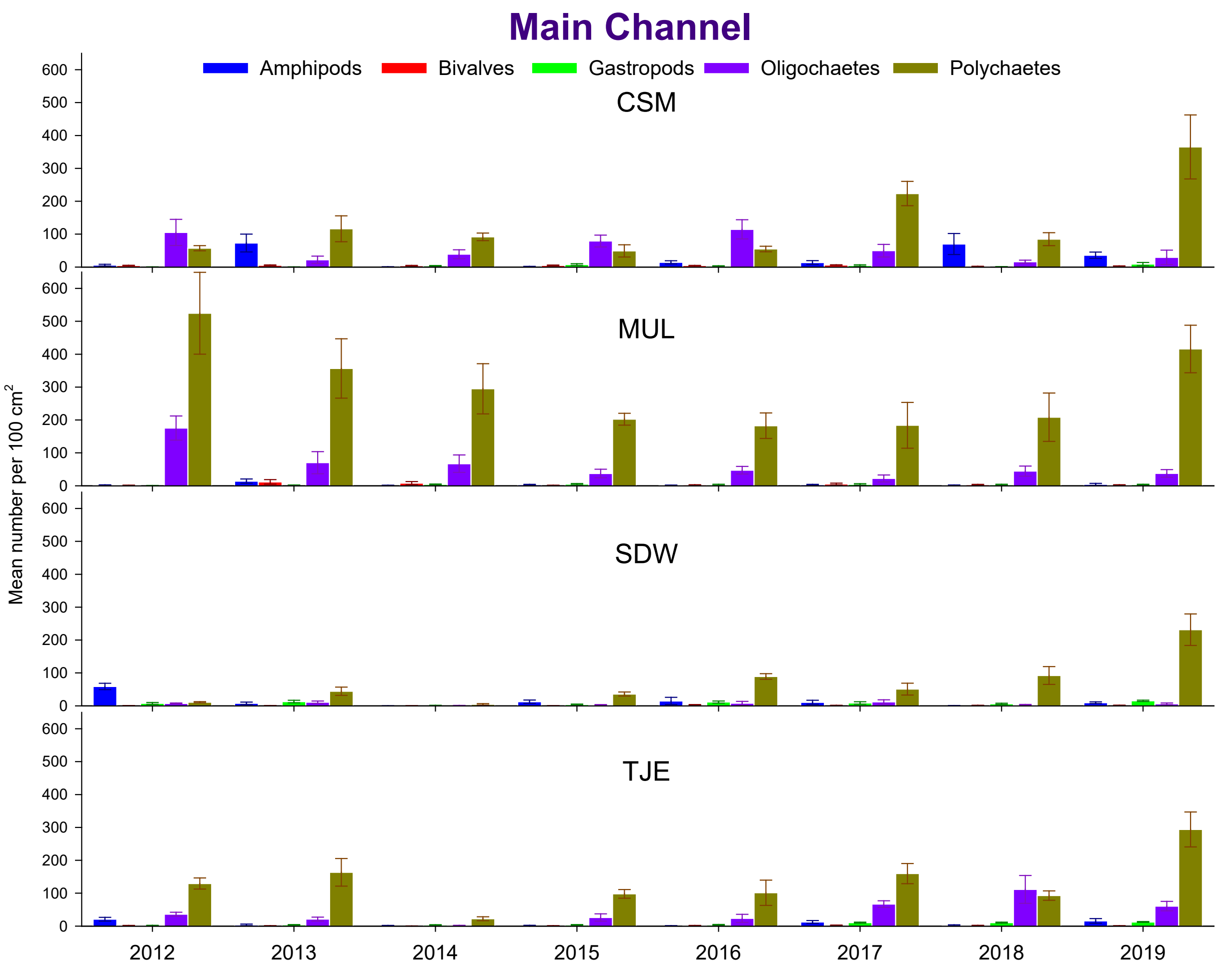


Figure 7.3.2.2. Densities of the most abundant invertebrate groups over time in main channel habitat in SDW and the reference wetlands (CSM, MUL, TJE). Densities of these groups in main channel habitat have remained low and relatively constant over the past eight years of monitoring in SDW except for polychaete worms, which increased in abundance in all wetlands in 2019.

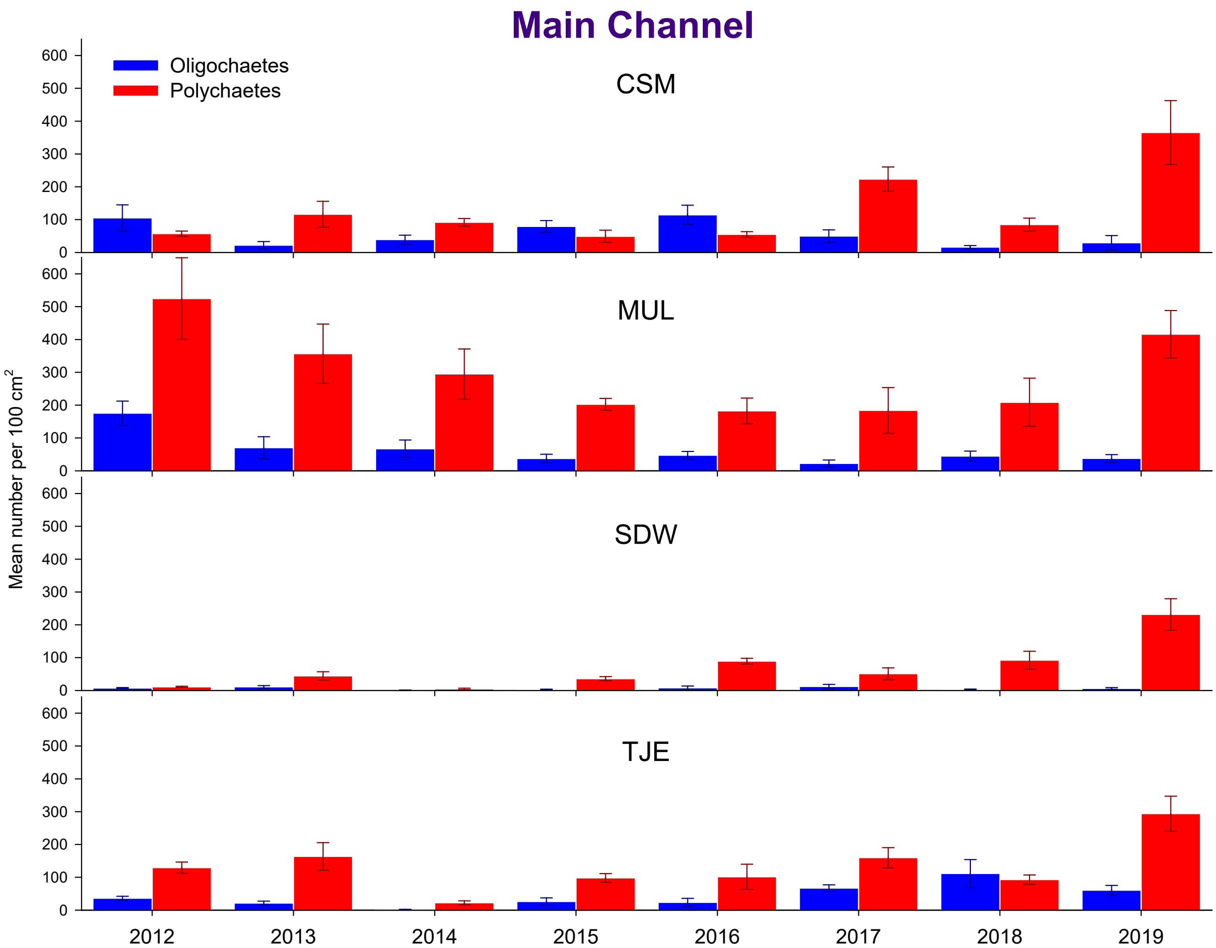


Figure 7.3.2.3. Densities of polychaete and oligochaete worms over time in main channel habitat in SDW and the reference wetlands (CSM, MUL, TJE). Densities of these worm groups in SDW main channel have remained low, although polychaete worms increased in all wetlands from 2018 to 2019.

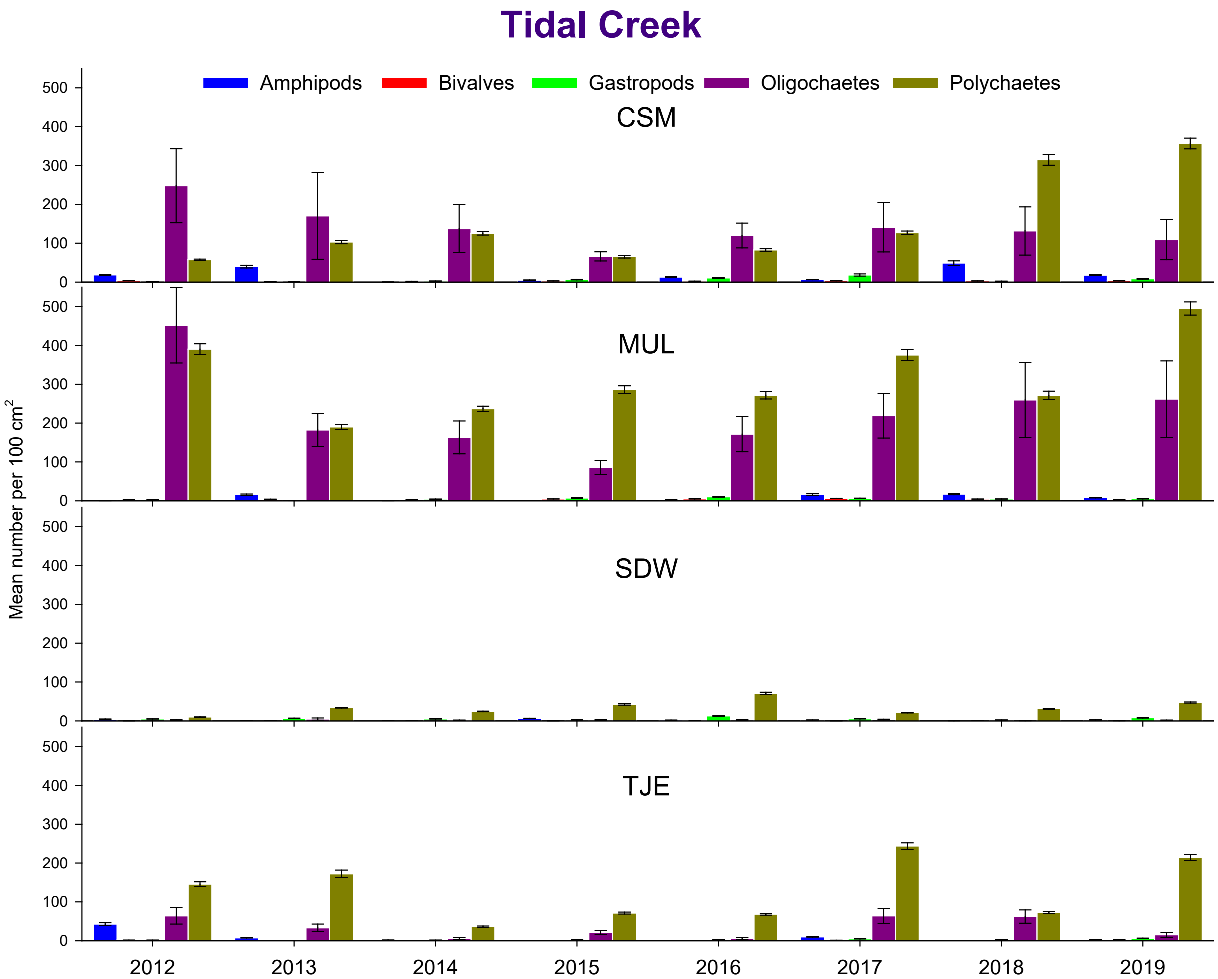


Figure 7.3.2.4. Densities of the most abundant invertebrate groups over time in tidal creek habitat in SDW and the reference wetlands (CSM, MUL, TJE). Densities of these groups in SDW tidal creeks have remained low and relatively constant over the past eight years of monitoring in SDW compared with the reference wetlands.

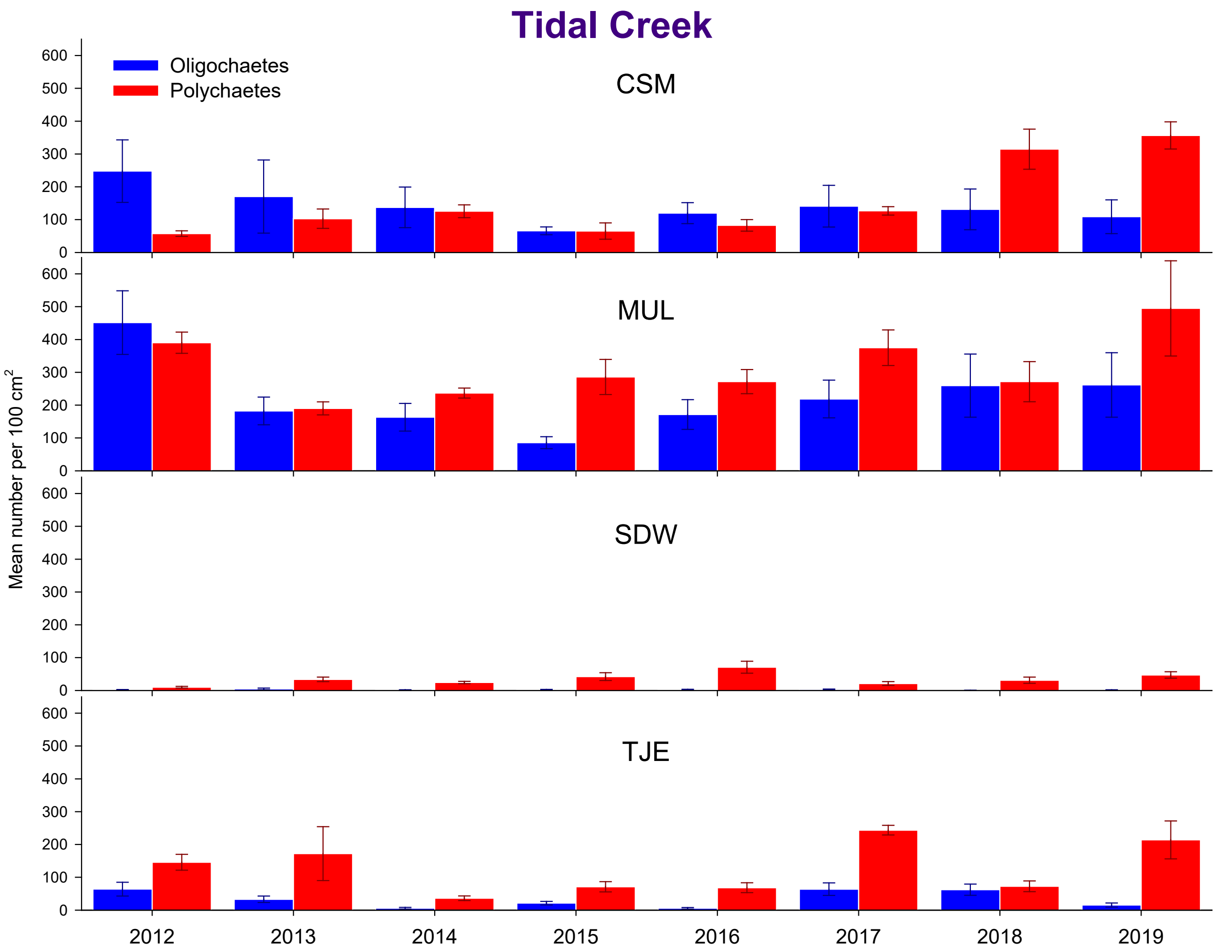


Figure 7.3.2.5. Abundance of polychaete and oligochaete worms over time in tidal creek habitat in SDW and the reference wetlands (CSM, MUL, TJE). Densities of these worm groups in SDW tidal creeks have remained low and relatively constant over the past eight years of monitoring in SDW compared with the reference wetlands.

While the mechanisms responsible for the underperformance of vegetation appears obvious (i.e., highly saline soils, infrequent tidal inundation and poor drainage), the mechanisms responsible for the underperformance of invertebrates in San Dieguito Wetlands are not obvious. UCSB scientists have begun exploring possible mechanisms contributing to the deficit of invertebrates by looking at patterns in the abundance of various groups in the monitoring data. This work is ongoing, but initially there does not appear to be a particular invertebrate feeding guild, for example, that is underrepresented in San Dieguito Wetlands compared with the reference wetlands that could suggest an obvious reason behind the deficit in invertebrates in San Dieguito Wetlands. A deficit in oligochate worms, which are deposit feeders, could suggest low particulate organic matter content in the sediments that provides food for these organisms. However, polychaete worms that include both deposit and suspension feeding taxa are also depressed in San Dieguito Wetlands.

Moving forward, UCSB scientists will prioritize examining existing data and collecting new data to explore possible mechanisms contributing to the deficit of invertebrates in

SDW. Work will focus primarily on one mechanism that preliminary data suggests could influence invertebrate density and is tractable: the effect of tidal elevation on invertebrate density. Preliminary data suggests that some monitoring locations in San Dieguito Wetlands may be at a higher tidal elevation than in the reference wetlands. If invertebrate density varies inversely with tidal elevation and the elevation of some tidal creeks/main channel stations are higher in San Dieguito Wetlands than in reference wetlands that might explain the low densities of invertebrates in San Dieguito Wetlands compared with reference sites. To further explore this possibility, data will be collected on tidal elevation at all sampling locations coincident with sampling in 2020, which will allow a comprehensive analysis of the relationship between invertebrate density and tidal elevation within and across wetlands.

A second possible mechanism to explain the underperformance of invertebrates in San Dieguito Wetlands may also be explored: the effect of physical properties of the sediments or pore water on invertebrate density. There are no comprehensive data that explore the relationship between sediment properties, such as grain size or organic matter content and the abundance of invertebrates between San Dieguito Wetlands and the reference wetlands. Core sediment samples will be taken in conjunction with invertebrate sampling during performance monitoring in 2020 and archived. These samples may be analyzed in the future for grain size and organic matter content should it be determined that such analyses may help to explain the low densities of invertebrates in San Dieguito Wetlands.

8.0 Progress Towards Compliance with the SONGS Permit

In examining the overall progress of San Dieguito Wetlands towards compliance with the requirements of the SONGS permit, the cover of salt marsh vegetation is on a promising trajectory and there is reason to be cautiously optimistic that San Dieguito Wetlands will meet the performance criteria for salt marsh habitat in the near term. UCSB scientists, CCC staff, and members of the SAP have put considerable effort into understanding the reasons behind the slow development of vegetation over the previous years, and SCE has engaged in activities to improve vegetation development, from regrading part of the wetland to increase tidal inundation and drainage of the marsh surface to an extensive and on-going planting program, and experiments to better understand factors that influence the growth and survival of nursery grown plants.

More concerning moving forward is the underperformance of relative standards relating to the densities of birds and bird feeding, invertebrate densities, and species richness of fish and how this relates to the 10-year milestone that pertains to project compliance. It is concerning that some of these standards that were met in 2018 were not met in 2019. There is a requirement that the absolute and relative performance standards must be met by 10 years after the initiation of Fully Implemented Monitoring ("Definition of Compliance in the Context of the SONGS Mitigation Projects", Monitoring Plan for the SONGS Wetland Mitigation Project). Furthermore, three consecutive years of compliance must occur by 12 years or remediation may be required at the discretion of the Executive Director. Given this deadline, there is an urgency to determine the reasons for the underperformance of these biological standards.

On-going activities and future plans moving forward include continued performance monitoring in 2020 as required by the SONGS permit, monitoring SCE's adaptive management program for vegetation, and further analysis of existing data, and the collection of additional data, if necessary, to assist in the determination of mechanisms underlying the under-performance of macro-invertebrate densities. Coastal Commission staff and SCE will be consulted regarding next steps to address the under-performance of vegetation cover and invertebrate densities to bring the project into compliance with the SONGS permit.

9.0 References

Ecological Society of America. 2012. http://www.esa.org/esa/wp-content/uploads/2012/12/hypoxia.pdf

Everett, R. A. 1991. Intertidal distribution of infauna in a central California lagoon: the role of seasonal blooms of macroalgae. Journal of Experimental Marine Biology and Ecology 150:223-247.

Hume, T. M. 2005. Tidal prism. In M. L. Schwartz (Ed.). Encyclopedia of Coastal Science. Springer, Dordrecht, The Netherlands.

MEC (Marine Analytical Systems, Inc.) 1993. San Dieguito Lagoon Restoration Project Biological Baseline Study, March 1992 - May 1993. Volume 1. Draft Technical Memorandum prepared for Southern California Edison.

Page, M., S. Schroeter, D. Reed. 2018. Monitoring Plan for the SONGS' Wetland Mitigation Project. Report to the California Coastal Commission. http://marinemitigation.msi.ucsb.edu/documents/wetland/ucsb_mm_reports/wetland_mitigation_monitoring_plan_updated_august2018.pdf

SCE (Southern California Edison Company). 2005. San Dieguito Wetlands Restoration Project: Final Restoration Plan. Submitted to the California Coastal Commission, November 2005.

Steele, M. A, S. C. Schroeter, and H. M. Page. 2006a. Sampling characteristics and biases of enclosure sampling fishes in estuaries. Estuaries and Coasts 29:630-638.

Steele, M. A, S. C. Schroeter, and H. M. Page. 2006a. Sampling characteristics and biases of enclosure sampling fishes in estuaries. Estuaries and Coasts 29:1172-1184.

Talley, T. S., J. A. Crooks, and L. A. Levin. 2001. Habitat utilization and alteration by the invasive burrowing isopod, *Sphaeroma quoyanum*, in California salt marshes. Marine Biology 138:561-573.

Zedler, J. B 1993. Canopy architecture of natural and planted cordgrass marshes – selecting habitat evaluation criteria. Ecological Applications 3:123-138.