2022

Annual Report of the Status of Condition A: Wetland Mitigation

San Onofre Nuclear Generating Station (SONGS) Mitigation Program

https://marinemitigation.msi.ucsb.edu/

msi Marine Science Institute

UCSB

2022

Annual Report of the Status of Condition A: Wetland Mitigation

SAN ONOFRE NUCLEAR GENERATING STATION (SONGS) MITIGATION PROGRAM

Submitted to the California Coastal Commission
July 2023

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

Contributors
David Huang, Andres Deza, Justin Hoesterey, Denise Weisman, Emily Blair, Lindsey Chamberlain, Russell Johnston, Lee Harrison and Morgan Tusa
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
Alexis Barrera
Kate Huckelbridge

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 CDP. Annual monitoring is required to determine whether the restoration project has met these standards. The monitoring is overseen by the California Coastal Commission (CCC) and is done independently of SCE. This report summarizes results from the eleventh year of performance monitoring completed in 2022.

There are five absolute performance standards. Absolute standards are measured only in San Dieguito Wetlands and must be met every year for SCE to receive mitigation credit. San Dieguito Wetlands met the absolute standards for tidal prism, topography, plant reproductive success (measured by seed production) and exotic species in 2022. San Dieguito Wetlands has not yet met the habitat areas standard due to insufficient acreages for salt marsh and mudflat habitats. Habitat assessed as salt marsh in San Dieguito Wetlands increased from 74.4 acres in 2021 to 82.3 acres in 2022. As of 2022, the wetland is 1 acre below the minimum number of required acres (83.3 acres) for this habitat. The trajectory of increase in salt marsh over time is promising and it is anticipated that the minimum required acres of this habitat may be achieved in the near future. Since 2020, habitat assessed as mudflat in San Dieguito Wetlands has been below the minimum required acres (22.4 acres). In 2022, mudflat area decreased to 16.0 acres, or 6.4 acres below the minimum number of required acres. To investigate potential drivers of mudflat loss, in 2022, we conducted elevation surveys with a Real Time Kinematic (RTK) global positioning system within areas planned as mudflat. We found that some areas planned as mudflat are currently above 1.3' NGVD, which is the upper elevation limit of planned mudflat, and are being colonized by vegetation. These results suggest that sediment accretion within mudflat areas has occurred and that remaining mudflat is vulnerable to accretion and salt marsh encroachment.

There are 15 relative performance standards. Relative standards are measured in San Dieguito Wetlands and evaluated 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. San Dieguito Wetlands passed nine performance standards that pertain to water quality, bird density and species richness, fish and invertebrate species richness in main channel and tidal creek habitats, algal cover, and *Spartina* canopy architecture. San Dieguito Wetlands failed to pass the remaining six relative standards that pertain to fish and

invertebrate density in main channel and tidal creek habitats, cover of vegetation, and food chain support (density of feeding birds).

Vegetation cover is high in the three reference wetlands, Mugu Lagoon, Carpinteria Salt Marsh, and Tijuana Estuary. 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 (typically > 85%) found in the reference wetlands. There was a promising increase in the acres of > 85% cover at San Dieguito Wetlands from 31.4 acres in 2021 to 36.4 acres in 2022.

Of concern, is the continued deficit in invertebrate density in main channel and tidal creek habitats and, more recently, the underperformance of fish density and richness in main channel and tidal creek habitats, as well as food chain support in San Dieguito Wetlands relative to the reference wetlands. The underperformance of these standards contributed to the failure of San Dieguito Wetlands to meet the relative standard requirement for 2022.

SCE has undertaken a planting program to facilitate vegetation development and address the failure of the restoration site to pass the absolute standard for habitat areas and the relative standard for vegetation cover. To date, SCE's Planting Program has planted 227,731 plants (2018 – December 2022). Two experiments were embedded within the larger planting effort in 2020 to inform SCE's planting program. The findings of these experiments were published in the peer-reviewed literature in June 2023 (Beheshti et al., 2023). We will continue to monitor the overall progress of the planting program to evaluate whether the desired goal of increasing vegetation cover is achieved.

The standards for fish density in main channel and tidal creek habitats have been met intermittently over time, and the standards for invertebrate density have yet to be met in main channel and tidal creek habitats. One possible hypothesis for the low densities of fish and invertebrates in tidal creeks in San Dieguito Wetlands is that tidal creek elevations are higher (shallower, less frequently inundated) than in the reference wetlands and that fish and invertebrate density varies inversely with elevation. Across all wetlands, we found a trend of decreasing invertebrate density with increasing tidal elevation in tidal creek habitats. However, elevation does not explain invertebrate density differences in main channel habitat, because station elevations are similar among the wetlands. Sediment properties were also similar among main channel and tidal creek habitats, suggesting that other mechanisms, such as larval supply, could influence invertebrate colonization in San Dieguito Wetlands.

To compare fish and invertebrate densities *within* San Dieguito Wetlands in areas where creek morphology differs, in Fall 2022 we surveyed lower elevation creeks adjacent to the San Dieguito Wetlands Project Area (the 22nd Agricultural District Restoration; Figure 7.3.4.2). We also measured fish and invertebrate densities in lower elevation supplemental tidal creeks not currently sampled during performance monitoring within the San Dieguito Wetlands Project Area (W4 supplemental creeks; Figure 7.3.4.2). We found that fish and invertebrate density and species richness were greater in lower elevation supplemental creeks (22nd Agricultural District and W4 supplemental creeks) relative to the higher elevation tidal creeks currently monitored for performance.

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 in the SONGS permit. The San Dieguito Wetlands Restoration Project did not satisfy the absolute performance standard requirement, meeting four of the five absolute standards. The restored wetland also 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 2022, 60.0% of the relative standards were met in the San Dieguito Wetlands compared with 73% of standards met in the worst performing reference wetland (Tijuana Estuary).

To receive mitigation credit for a given year, the wetland restoration project must meet all 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 or the relative standard requirement. Consequently, San Dieguito Wetlands has not yet satisfied the performance success criteria provided in the SONGS permit and has not yet received mitigation credit.

Although the proportion of relative standards met in San Dieguito Wetlands declined from 2016-2021, in 2022, the proportion of relative standards met in San Dieguito Wetlands increased from 40% in 2021 to 60% in 2022. There is language in the SONGS permit that pertains to the responsibility of the permittee to meet the performance standards and the prescription of remedial measures should the standards not be met. On-going activities and future plans include continued performance monitoring in 2023 as required by the SONGS permit (CCC 1997), monitoring SCE’s adaptive management program for vegetation, further analysis of existing data, additional analyses of newly acquired elevation data (i.e., RTK transect surveys, Digital Elevation Model) and the collection of additional data to assist in the determination of mechanisms underlying the under-performance of those relative standards not met in 2022.

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, CCC 1997), 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 2022 (the eleventh 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 (CCC 1997).

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.

SONGS Impacts: 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.

Mitigation Requirements: 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 five Research Biologists from University of California, Santa Barbara: Steve Schroeter, Ph.D., marine/wetlands ecologist (part-time), Kathryn Beheshti, Ph.D., marine/wetlands ecologist (full-time), Rachel Smith, Ph.D., marine/wetlands ecologist (full-time), Mark Page, Ph.D., wetlands ecologist (half-time), and Dan Reed, Ph.D., kelp forest ecologist (half-time). Drs. Beheshti and Smith were hired and started in January and August 2022, respectively. 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 (determined to be 32 years).

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.

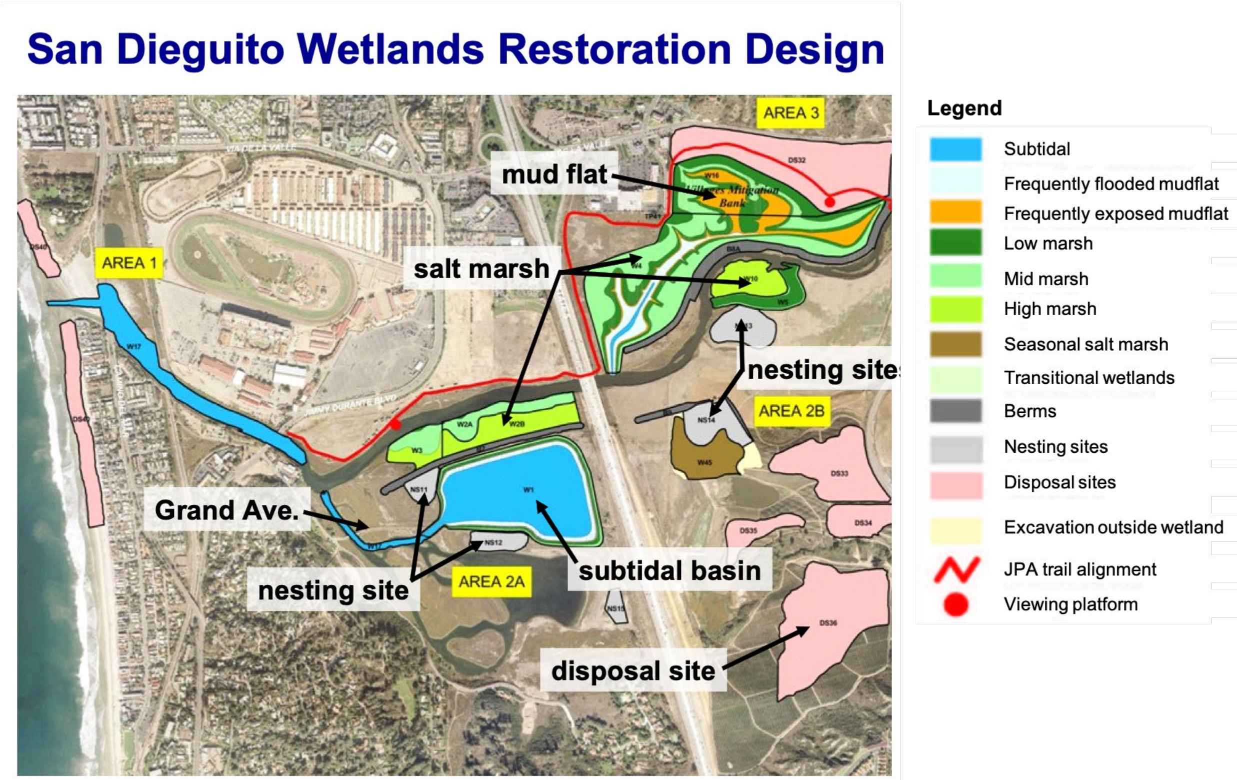


Figure 3.0.2. The design plan view of the restoration project that was approved by the CCC. The project included the creation of tidal salt marsh, indicated by shades of green, mudflat, indicated by the light brown and light blue, and subtidal basin, indicated by blue. In addition, four nesting sites were constructed, shown in gray, and 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. Source: Final Restoration Plan for San Dieguito Wetlands

Construction began in September 2006 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 construction 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 mudflat 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).

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.

Timeline

Construction 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, 2016-2022
Inlet dredging:	September 2011 Nov/Dec 2015, 2017, 2019, 2022
Performance monitoring	January 2012 to present (11 years)

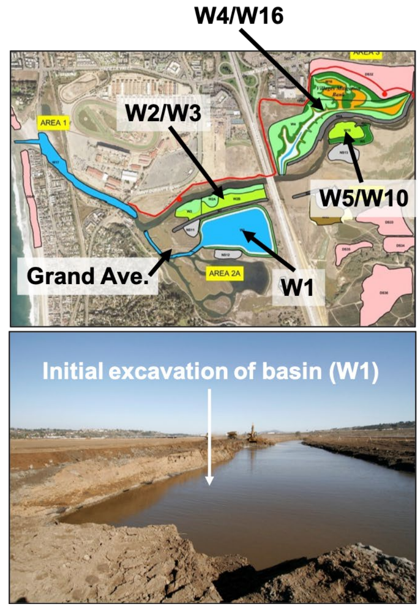


Figure 3.0.3. Timeline for the San Dieguito Wetlands Restoration Project.

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 2008. 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 (Table 3.0.1) at high marsh tidal elevations occurred from 2016 - 2018 with planting at higher and lower elevations from 2019 through 2022 (see Section 7.0).

Year	# of Plants
2018	24,220
2019	38,240
2020	20,922
2021	97,856
2022	47,493
Total	**227,731**

Table 3.0.1. The number of plantings by year (2018-2022) as part of SCE's Planting Program.

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. Maintenance dredging of the inlet was conducted in November-December 2015, 2017, 2019, and 2022. Performance monitoring began in January 2012, following the initial dredging of the inlet in September 2011.

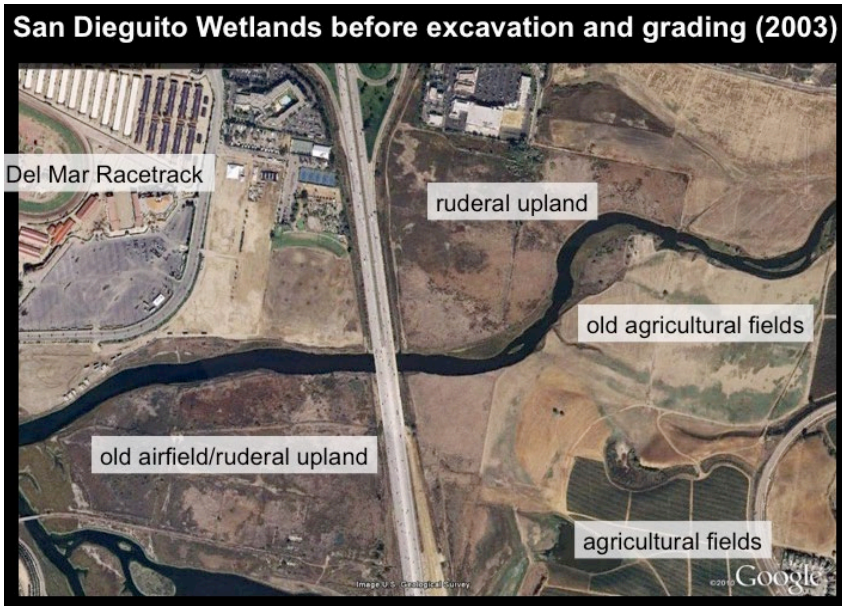


Figure 3.0.4a. Satellite view of the project site in 2003 before excavation and grading, including ruderal upland areas, an old WWII dirigible airfield, old agricultural fields, and visible at the bottom of the image, a portion of the Fish and Game Basin constructed in 1978. Image Source: Google Earth; U.S. Geological Survey.

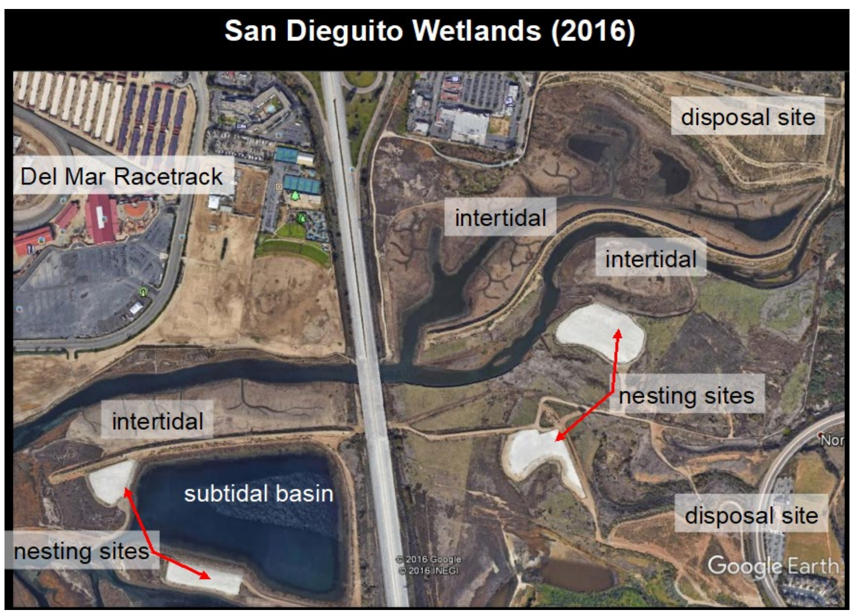


Figure 3.0.4b. During construction, the ruderal areas, old agricultural fields, and the WWII airfield were excavated and graded to create the planned intertidal and subtidal wetland habitats of the restoration project visible in this 2016 image. Image Source: Google Earth; NEGI.

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.

In the eleventh year of performance monitoring, the restored wetland continues to provide habitat for an array of invertebrates, fish, birds, and wetland plants (Fig. 3.0.5), including threatened and endangered species such as the Ridgway's Rail and Belding's Savannah Sparrow. Although the wetland is providing resource value, it has not yet met the performance criteria required for successful mitigation, as discussed in Section 5.0, which reviews the results from performance monitoring in 2022.

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

4.0 Methods of Project Evaluation

4.1. Monitoring Plan

Condition A of the SONGS permit (CCC 1997) 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 in 2019, the CCC determined to be 32 years. This monitoring measures compliance of the mitigation project with the performance standards specified in the SONGS permit (CCC 1997). In accordance with Condition D (Administrative Structure) of the permit, contract scientists retained by the CCC Executive Director developed the Monitoring Plan to guide the monitoring work and oversee the associated studies outlined in the plan. The SONGS permit (CCC 1997) 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 are 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 and was considered and approved by the Commission on October 12, 2005. The Monitoring Plan was subsequently updated in June and October 2011, July 2014, July 2016, August 2017, August 2018, June 2021, and May 2022 (Page et al. 2022) as more information became 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 (CCC 1997) 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 (CCC 1997) 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: 1) absolute standards that are evaluated only in the San Dieguito Wetlands, and 2) 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., dissolved 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 (i.e., for Topography, Exotic Species). All absolute standards must be met in a given year 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. 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 (CCC 1997) 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., 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 Point 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 (CCC 1997) 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 is similar to the reference wetlands requires that the mean value for the performance variable at San Dieguito Wetlands not be significantly worse than the mean value for the worst 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 lowest 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 rationale for determining similarity are provided in the Monitoring Plan for the SONGS Wetland Mitigation Project (Page et al. 2022).

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 process treats each reference wetland as the mitigation wetland and uses 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 (CCC 1997) 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 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 eleventh year of monitoring. More detailed methods can be found in the Monitoring Plan for the SONGS Wetland Mitigation Project (Page et al. 2022).

5.1. Absolute Performance Standards

5.1.1. Tidal Prism

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

Approach: 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 5.1.2, 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.

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 across spring and neap tidal cycles 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.

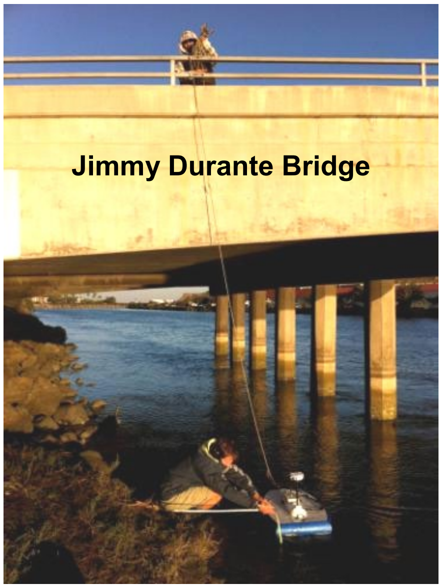


Figure 5.1.1.1. Measurements of tidal flows are taken at Jimmy Durante Bridge (0.9 km from the inlet) using a portable Acoustic Doppler Profiler/discharge measurement system (yellow circle) that is towed back and forth (indicated by the yellow arrow) across the width of the channel by monitoring staff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

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 2020 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.

Results: The regression fit to the adjusted tidal prism measurements for 2022 falls between the dashed green lines, indicating that the tidal prism at the San Dieguito Wetlands was maintained in 2022 (Fig. 5.1.1.2). Therefore, San Dieguito Wetlands met this standard for 2022.

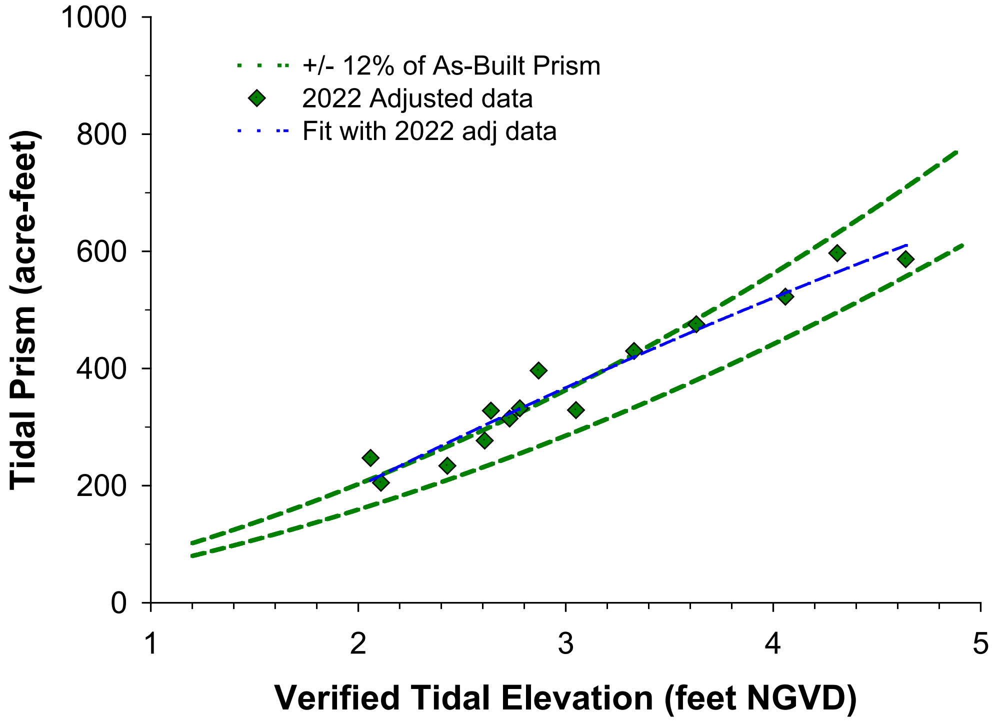


Figure 5.1.1.2. The regression fit to the tidal prism measurements taken January-December 2022 (blue dashed line) must fall within the two dashed green lines, which represent 88% and 112% of the as-built prism, for the tidal prism to be maintained. Tidal prism measurements for 2022 were adjusted for the excavation of additional wetland by the 22nd Agricultural District adjacent to the Grand Avenue Bridge.

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 (e.g., 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). Although these criteria are 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).

Performance Standard: Habitat Areas

The area of different habitats shall not vary by more than 10% from the areas indicated in the final restoration plan

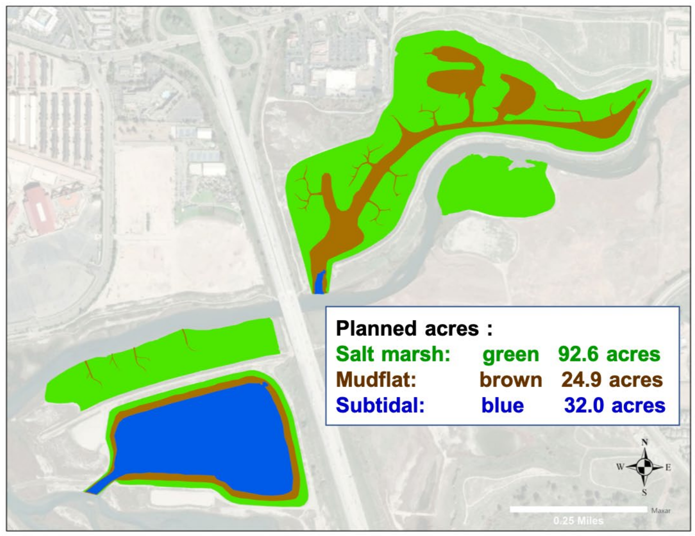


Figure 5.1.2.1. Areas of planned salt marsh (green), mudflat (brown), and subtidal (blue) habitats as provided in the Final Plan for the restoration project.

Assessment of Subtidal & Mudflat Habitat

Classified as Subtidal Habitat if:

- Continuously submerged

Classified as Mudflat Habitat if:

- Intertidal and ≤3.5' NGVD
- <5% cover of vegetation (mudflats are defined as intertidal and unvegetated)

Figure 5.1.2.2. Criteria used to classify areas of the restoration project as subtidal and mudflat 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 elevation 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, with at least 30% cover of salt marsh vegetation (Figs. 5.1.2.3). This minimal cover of vegetation will provide perches and bare space for foraging by 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" which is 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 grid plots that cover the entire wetland and are 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.

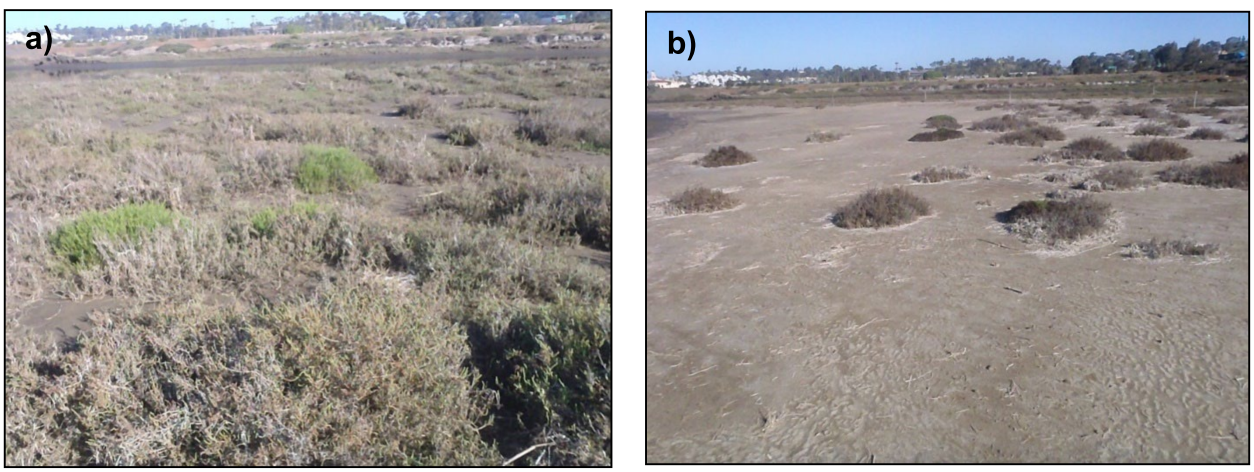
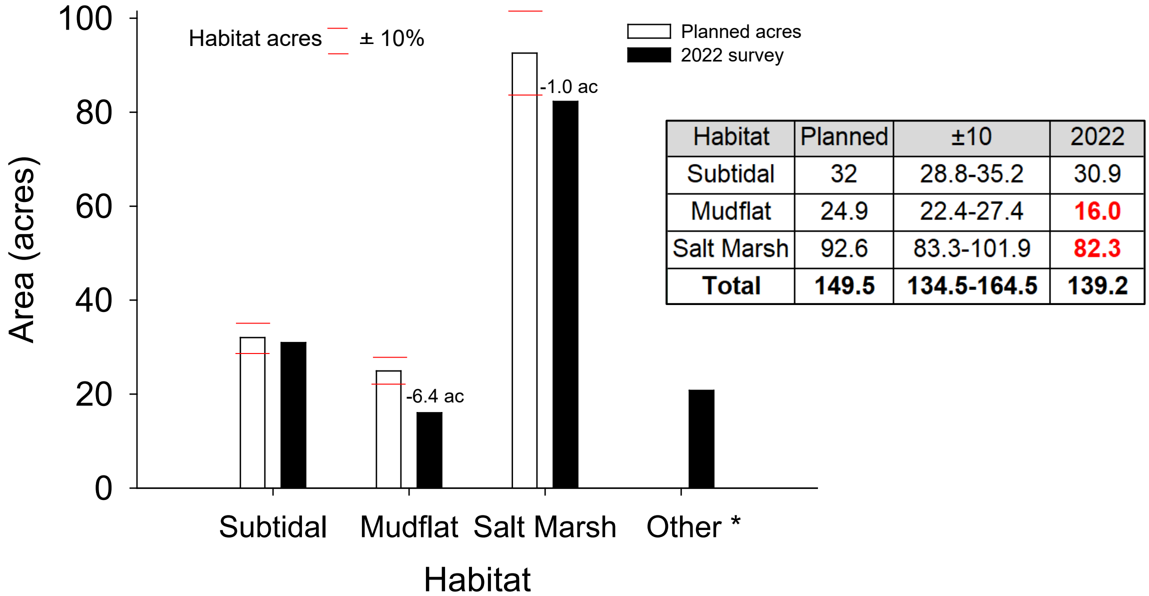


Figure 5.1.2.3. Examples of an area assessed as a) salt marsh habitat, where cover of salt marsh vegetation was ≥ 30%, and b) an area assessed as "other", not a planned habitat that is too high in elevation to be assessed as mudflat and too sparsely vegetated to be assessed as salt marsh.

<u>Results</u>: The solid bars in Figure 5.1.2.4 indicate the acreages determined in the 2022 survey. Although the area of subtidal habitat was within ± 10% of the planned acreage in 2022, the area of mudflat at 16.0 acres, was 6.4 acres below the lower 10% limit of designed acreage and less than 10% of the planned acreage. Salt marsh habitat at 82.3 acres was also less than 10% of the planned acreage and 1.0 acre below the lower 10% limit of designed acreage. As a result, San Dieguito Wetlands did not meet the standard for habitat areas in 2022.



Habitat	Planned	±10	2022
Subtidal	32	28.8-35.2	30.9
Mudflat	24.9	22.4-27.4	**16.0**
Salt Marsh	92.6	83.3-101.9	**82.3**
Total	**149.5**	**134.5-164.5**	**139.2**

Figure 5.1.2.4. Comparison of the areas of subtidal, mudflat, and salt marsh habitat in the Final Restoration Plan to the 2022 survey. Areas assessed as “other” (*) were not assessed as one of the planned habitats provided in the Final Restoration Plan and are not included in the total acres of 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 an encouraging increase from 2018 to 2022, perhaps facilitated by the rainfall of 2018. There has also been an encouraging general decline in “other” since monitoring began. One recent development that may lead to failure to meet the habitat areas standard is the decrease in mudflat such that the acres of mudflat are now below 10% of the planned acres. This decline is due in part to the encroachment of salt marsh into areas that are planned mudflat.

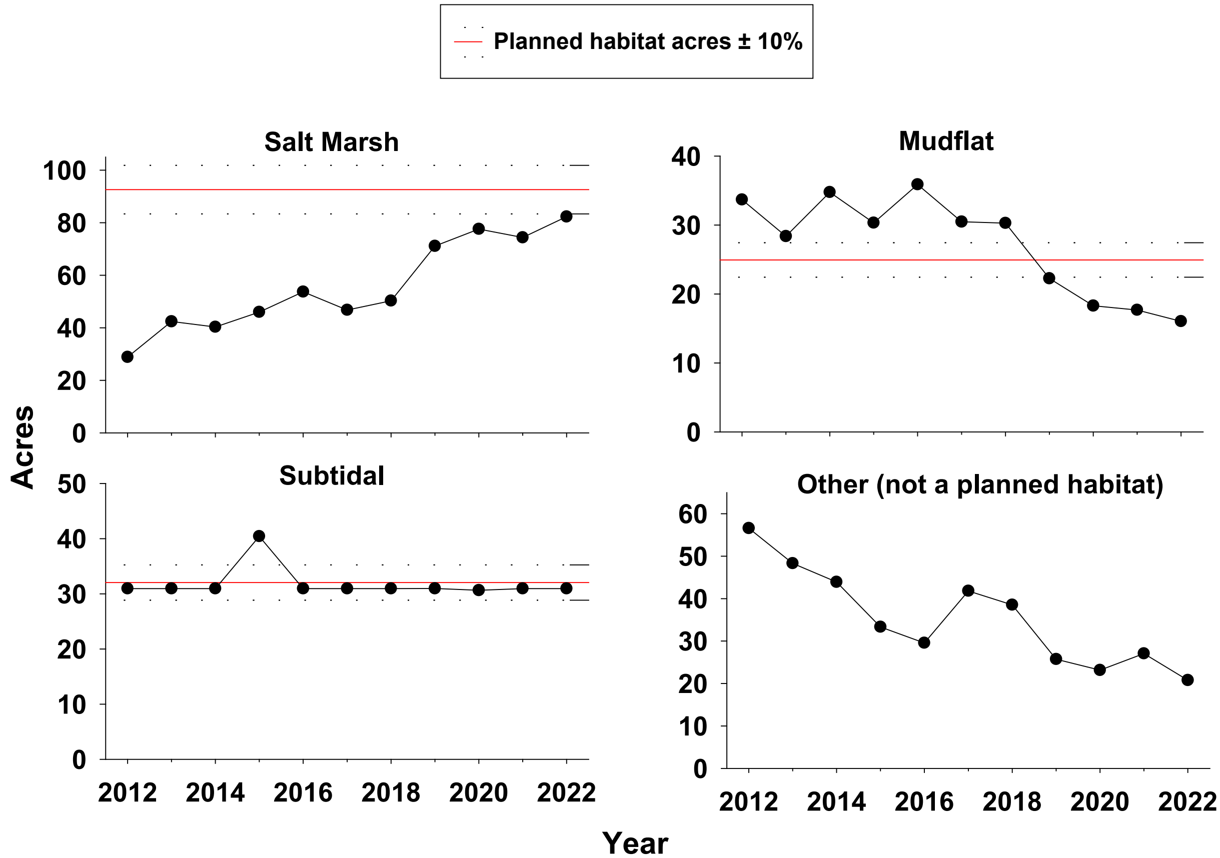


Figure 5.1.2.5. Comparison of the areas of salt marsh, mudflat, and subtidal habitat from 2012 through 2022 to the planned areas in the Final Restoration Plan (solid red line, black dashed lines ±10%). Also shown is the change in acres of “other”, which is not a planned habitat.

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 and thus, San Dieguito met this standard in 2022.

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 seeds are produced for seven common species found in the mid to high salt marsh: Parish's Glasswort (*Arthrocnemum subterminale*), Pickleweed (*Salicornia virginica = Salicornia 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 2019 through 2022, which is consistent with the permit requirements (Fig 5.1.4.1). Since all seven species produced seed within three years, San Dieguito Wetlands met the standard for reproductive success in 2022.

Plant	2019	2020	2021	2022
Parish's Glasswort	yes	yes	yes	yes
Saltgrass	yes	yes	yes	yes
Alkali Heath	yes	yes	yes	yes
Marsh Jaumea	yes	yes	yes	yes
Spiny Rush	yes	yes	yes	yes
California Sea Lavender	yes	yes	yes	yes
Pickleweed	yes	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.

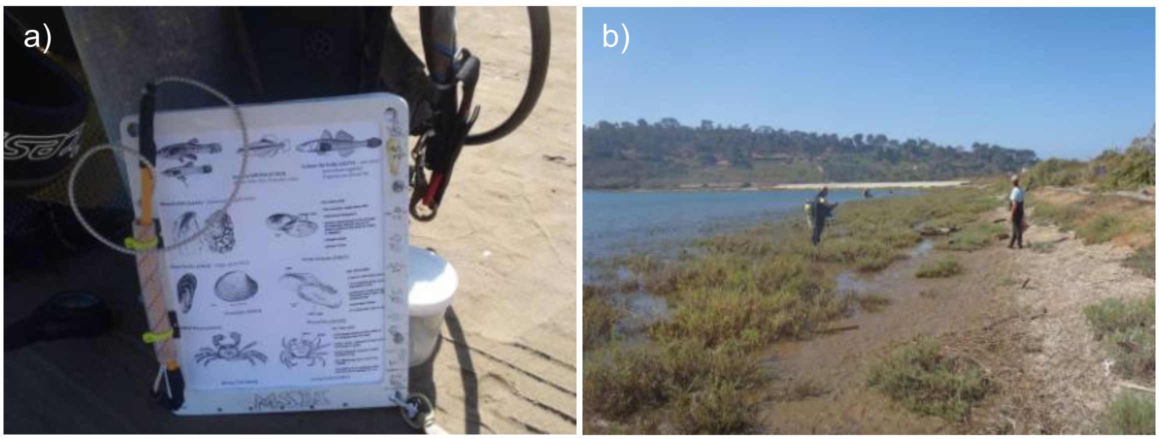


Figure 5.1.5.1. a) Exotic species targeted during the special survey and b) divers preparing to enter the basin (W1) to conduct the special survey.

In addition, a special survey looking for exotic species is conducted that covers as much of the wetland as possible. This survey focuses on plants and non-cryptic macro-invertebrates in intertidal and subtidal habitats (Fig. 5.1.5.1). Appropriate entities (CDFW, NOAA NMFS) will be formally notified if specific species of concern (e.g. *Caluerpa* spp.) are detected.

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 2022. *Limonium ramosissimum* was observed along the high marsh of W1 and all individuals were hand-pulled from the ~100 m of affected shoreline. Individuals were rather small and at relatively low densities. There was no evidence that *L. ramosissimum* affected important wetland functions in 2022, but we will continue to closely monitor the wetland for this persistent invasive in 2023. Notably, the Yellowfin Goby (an Asian species first encountered in Southern California in 1977 in Los Angeles Harbor and in San Diego a few years later) was the seventh most abundant fish as determined from our fish sampling in 2018. In 2022, no Yellowfin Goby were observed in any of the monitored wetlands.

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.

1. **Water Quality**
2. **Bird Density**
3. **Bird Species Richness**
4. **Fish Density – Main Channel (MC)**
5. **Fish Species Richness – MC**
6. **Fish Density – Tidal Creek (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. Note: Fish density and species richness and invertebrate species richness were not evaluated in 2012.

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, 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 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.

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 2022, and the four-year running average, which is used to evaluate the standard. In 2022, the four-year running average for sequential hours of hypoxia at San Dieguito was lower than the lowest performing reference wetland (Tijuana Estuary). Thus, San Dieguito Wetlands met the water quality standard in 2022.

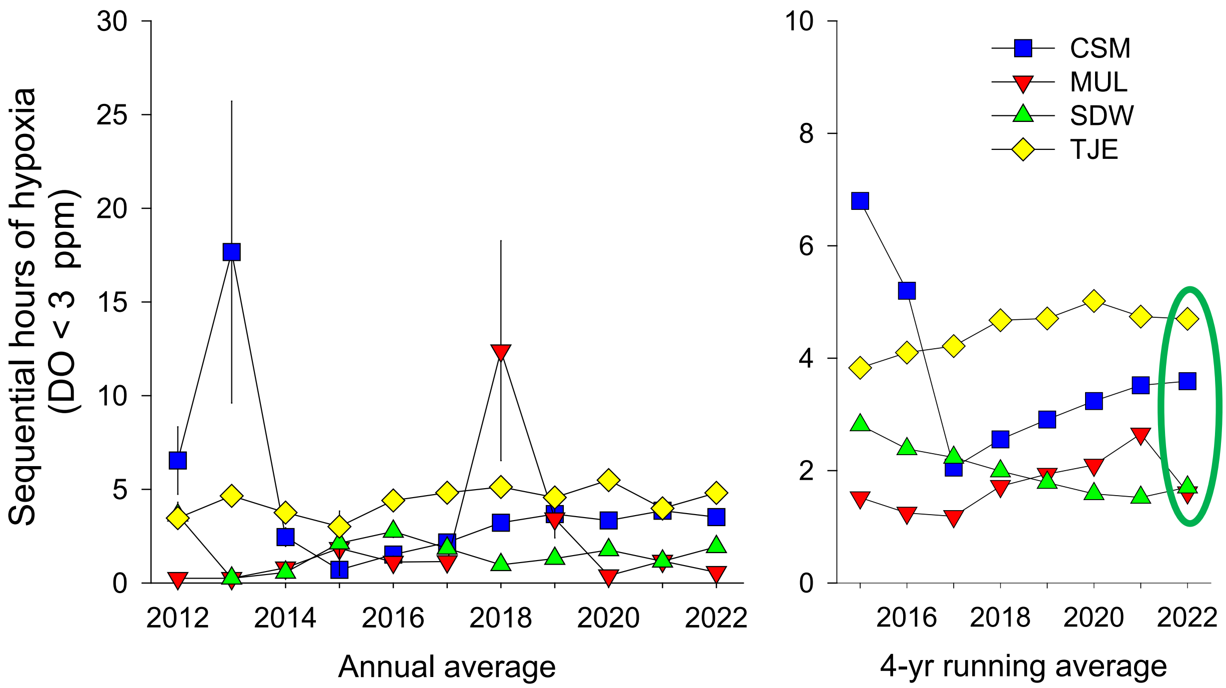


Figure 5.2.1.1. Comparison of annual mean sequential hours of hypoxia (left) and the 4-year running average used to evaluate the standard (right) between San Dieguito Wetlands and the reference wetlands. Mean length in hours of continuous hypoxia ([O_2] < 3 mg/l (ppm) in the San Dieguito Wetlands compared 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 indicates standard was met.

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 was 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.

Spartina has encroached into some tidal creeks, preventing the effective sampling of fish and macro-invertebrates. In these cases, sampling locations were either moved further up the tidal creek to avoid the *Spartina* (see W4-TC2, W4-TC4, W4-TC6, Figure 5.2.2.1; teal diamonds), as was the case in 2022, or the creek was abandoned, as was done in 2019 in W4-TC5. Figure 5.2.2.1 indicates which sampling enclosures were deemed unsuitable for sampling due to *Spartina* encroachment (red circles) in 2022.

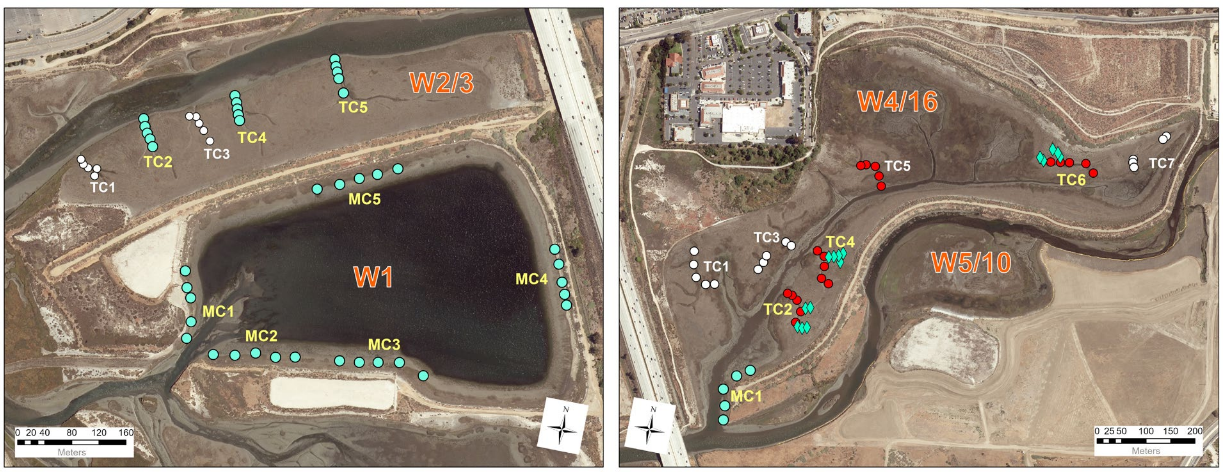


Figure 5.2.2.1. Location of tidal creeks (TC) and sections of main channel and basin (MC) sampled for fish and macro-invertebrates in San Dieguito Wetlands in modules W1, W2/3, and W4/16. Teal circles indicate stations that are currently sampled for macro-invertebrates within each TC and MC replicate in 2022. Teal diamonds indicate stations that were moved upstream for sampling in 2022 due to *Spartina* encroachment. Red circles indicate tidal creek stations formerly sampled that are now unsuitable for sampling because of the encroachment of *Spartina*. White circles indicate tidal creeks that are not sampled.

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.

<u>Approach</u>: Data on the density and numbers of species of fish are collected using 0.43 m^2 circular enclosure traps and larger beach seines (2 m x 7.6 m). 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 and 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 estimates of fish density for each of the six tidal creek and main channel-basin replicates are calculated by standardizing to number per 1 m^2, the number of fish caught by both enclosure traps and seines, then adding these values together across all stations within each tidal creek and main channel replicate. Species richness is calculated for each of the six tidal creek and main channel-basin replicates using the number of unique species sampled by both methods (beach seines and enclosure traps) across all stations within each tidal creek and main channel replicate.

The six replicate values for density and species richness for each tidal creek and main channel replicate are used to calculate the means and standard errors used to evaluate similarity in total density and species richness of fish in the two habitats between the restored and reference wetlands in a given year. Ridgway's 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) and smaller peaks in fish density were evident in the other wetlands in main channel habitat, including San Dieguito. For the 4-year running average in 2022, fish density in main channel habitat in San Dieguito Wetlands was significantly lower than Mugu Lagoon, the lowest performing reference wetland for this standard in 2022 (Fig 5.2.3.1). Similarly, the running average of fish density in tidal creek habitat in San Dieguito Wetlands was significantly lower than Mugu Lagoon in 2022 (Fig 5.2.3.1). The running average of fish density in both main channel and tidal creek habitat in San Dieguito Wetlands has declined over the past 4 years and San Dieguito did not meet these standards in 2022.

Fish species richness in main channel habitats declined in San Dieguito Wetlands from 2016 to 2020 but increased in 2021 and 2022 to levels similar to or exceeding the reference wetlands. Fish species richness in San Dieguito Wetland exceeded values at the reference wetlands in 2022. Given this increase, the 4-year running average for 2022 for fish species richness in main channel habitats at San Dieguito Wetlands was greater than the lowest performing reference, Tijuana Estuary. Thus, San Dieguito met the standard for fish species richness in main channel habitats in 2022 (Fig. 5.2.3.2).

There has been a general decline in the running average for fish species richness in tidal creeks at all wetlands from 2018 through 2022. Although fish species richness increased at all wetlands in 2021, this metric declined in all wetlands in 2022 relative to 2021. From 2019-2022, fish species richness in tidal creek habitats has been similar at both San Dieguito Wetlands and Tijuana Estuary, showing comparable declines in 2020 from 2019 levels, increases in 2021, and then a decline in 2022, though the decline in 2022 was less pronounced at San Dieguito Wetlands. In 2022, the 4-year running average for San Dieguito Wetlands for fish species richness in tidal creeks was similar to the lowest performing reference site, Tijuana Estuary. Thus, San Dieguito met the standard for fish species richness in tidal creek habitats in 2022. (Fig. 5.2.3.2).

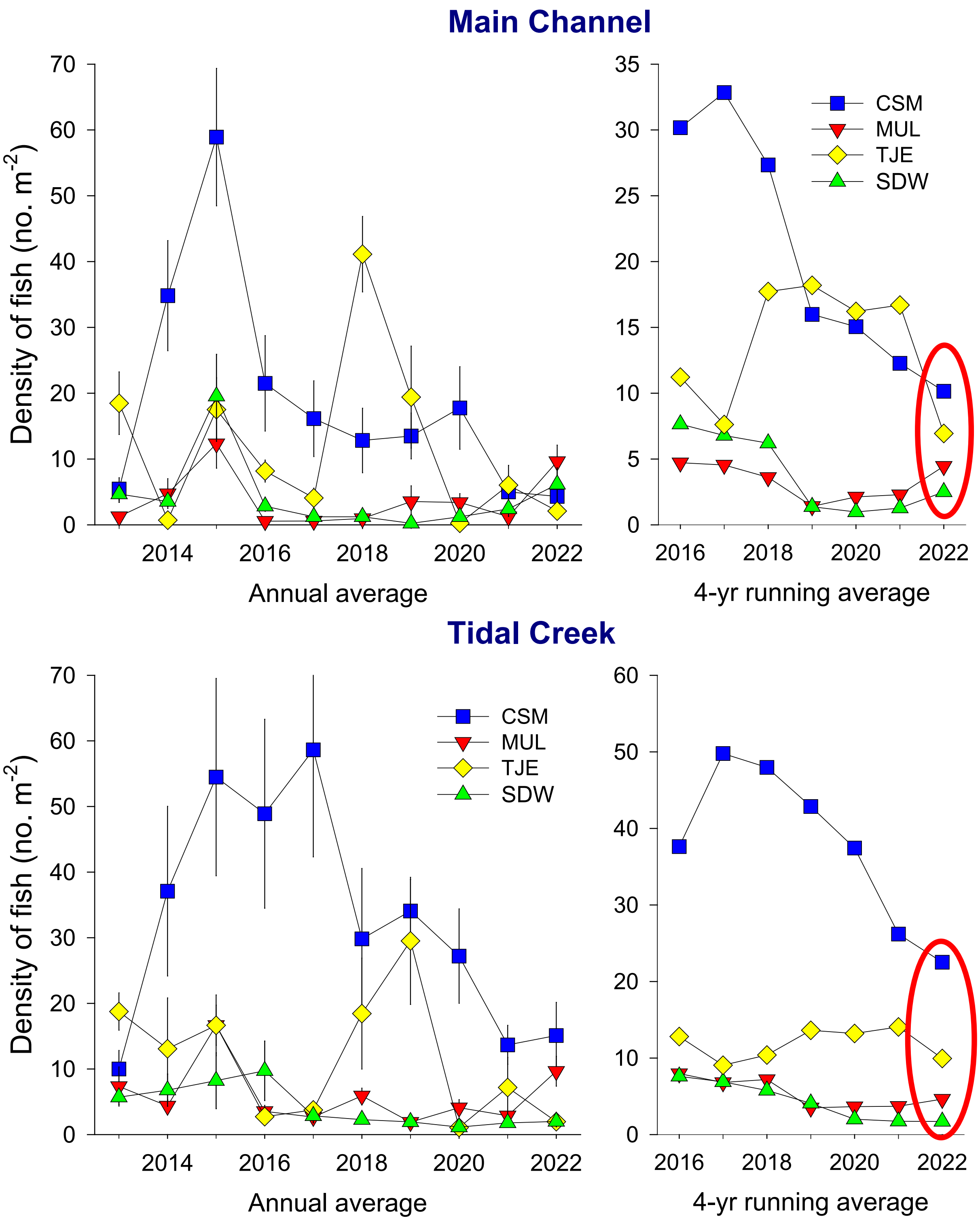


Figure 5.2.3.1. Comparison of annual fish density (left) and the 4-year running average used to evaluate the standard (right) between San Dieguito Wetlands and the reference wetlands in main channel (top) and tidal creek (bottom) habitats. Section of main channel-basin or individual tidal creek is the unit of replication (n = 6 in each habitat type). Red ellipses indicate standard was not met for 2022.

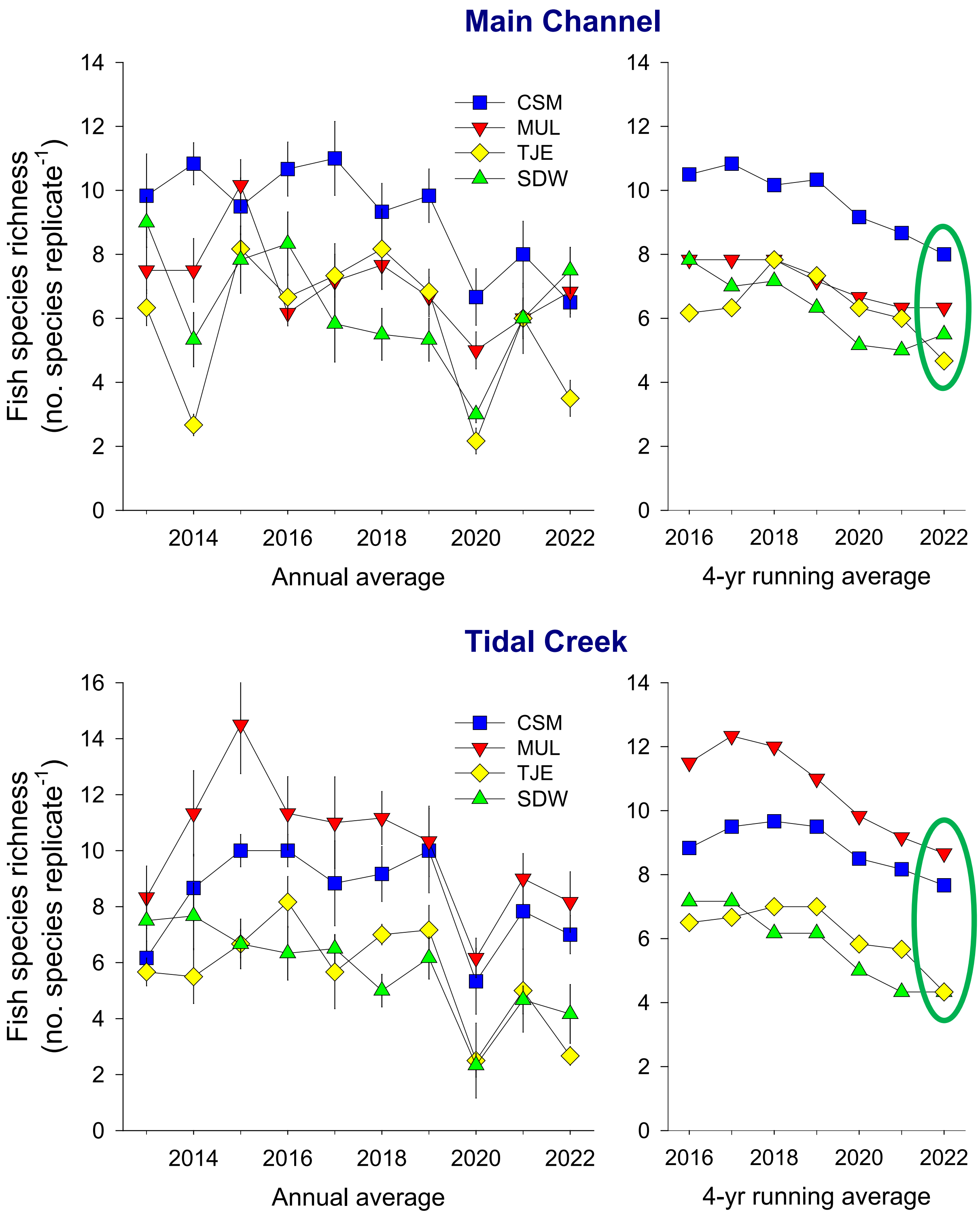


Figure 5.2.3.2. Comparison of annual fish species richness (left) and the 4-year running average used to evaluate the standard (right) between San Dieguito Wetlands and the reference wetlands for main channel (top) and tidal creek (bottom) habitats. Section of main channel-basin or individual tidal creek is the unit of replication (n = 6 in each habitat type). Green ellipses indicate standard was met for 2022.

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 three 25 cm x 25 cm quadrats spaced uniformly (low, mid, high) at each station (n=5) 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 ft 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 Clams and Bay 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 0.5 mm 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).

Densities 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. 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, means and standard errors are calculated from these replicate values.

Results: From 2012 to 2022, the annual and running average density of macro-invertebrates has generally been highest in main channel and tidal creek habitats in Mugu Lagoon and Carpinteria Salt Marsh (Fig. 5.2.4.1). The 4-year running average density of macro-invertebrates in main channel and tidal creek habitat of San Dieguito Wetlands has been consistently lower than the density in the lowest performing reference wetland, which has been Tijuana Estuary. This pattern also held in 2022, as the running average for macro-invertebrate densities in San Dieguito Wetlands remained well below the lowest performing reference site. Thus, San Dieguito Wetlands did not meet the standards for macro-invertebrate density in main channel and tidal creek habitats in 2022 (Fig. 5.2.4.1).

The annual and running average for macro-invertebrate species richness in main channel and tidal creek habitat has been highest in Mugu Lagoon and Carpinteria Salt Marsh. In 2022, the 4-year running average of macro-invertebrate species richness in the main channels of San Dieguito Wetlands was above Tijuana Estuary, the lowest performing reference wetland. Thus, San Dieguito Wetlands met the standard for macro-invertebrate species richness in main channel habitat in 2022 (Fig. 5.2.4.2).

The standard for macro-invertebrate species richness in tidal creek habitat was last met in 2018, but there has been a general decline in richness at San Dieguito Wetlands and the running average was below the lowest performing reference site, Tijuana Estuary, from 2019-2021(Fig. 5.2.4.2). Over the last four years, macro-invertebrate richness in tidal creeks has varied at both San Dieguito Wetland and Tijuana estuary, with greater richness at Tijuana Estuary in 2019 and 2021 and greater richness at San Dieguito in 2020. In 2022, the running average at San Dieguito Wetlands was similar to the lowest performing reference wetland (Tijuana Estuary). Thus, San Dieguito Wetlands met the standard for macro-invertebrate species richness in tidal creek habitat in 2022.

In previous annual reports (2012-2020), invertebrate density in main channel habitats in 2012 was shown as having “passed”, yet this result was driven by a greater abundance of nematodes at San Dieguito relative to the lowest performing wetland, Tijuana Estuary. Nematodes were *not* counted after 2012 because 1) the field methods used to sample invertebrates were inappropriate for roundworm sampling and 2) the permit (CDP 6-81-330) was specific about sampling macro-invertebrates (see Section 5.2.4), not meiofauna (i.e., nematodes, copepods). The relevant figures and text have been revised to include this correction.

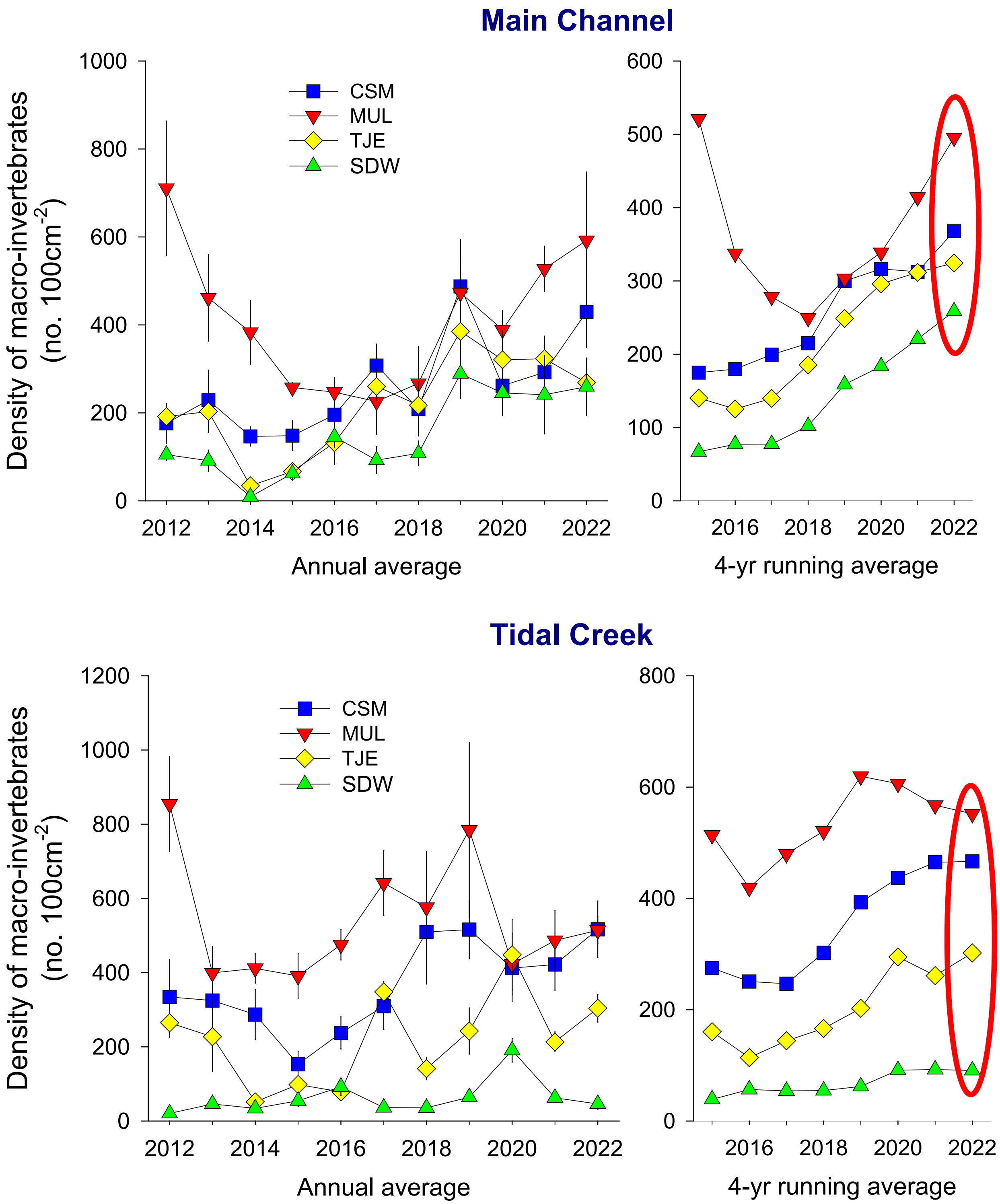


Figure 5.2.4.1. Comparison of macro-invertebrate density between San Dieguito Wetlands and the reference wetlands for main channel (top) and tidal creek (bottom) habitats. Section of main channel-basin or individual tidal creek is the unit of replication. Red ellipses indicate that the standard was not met for 2022.

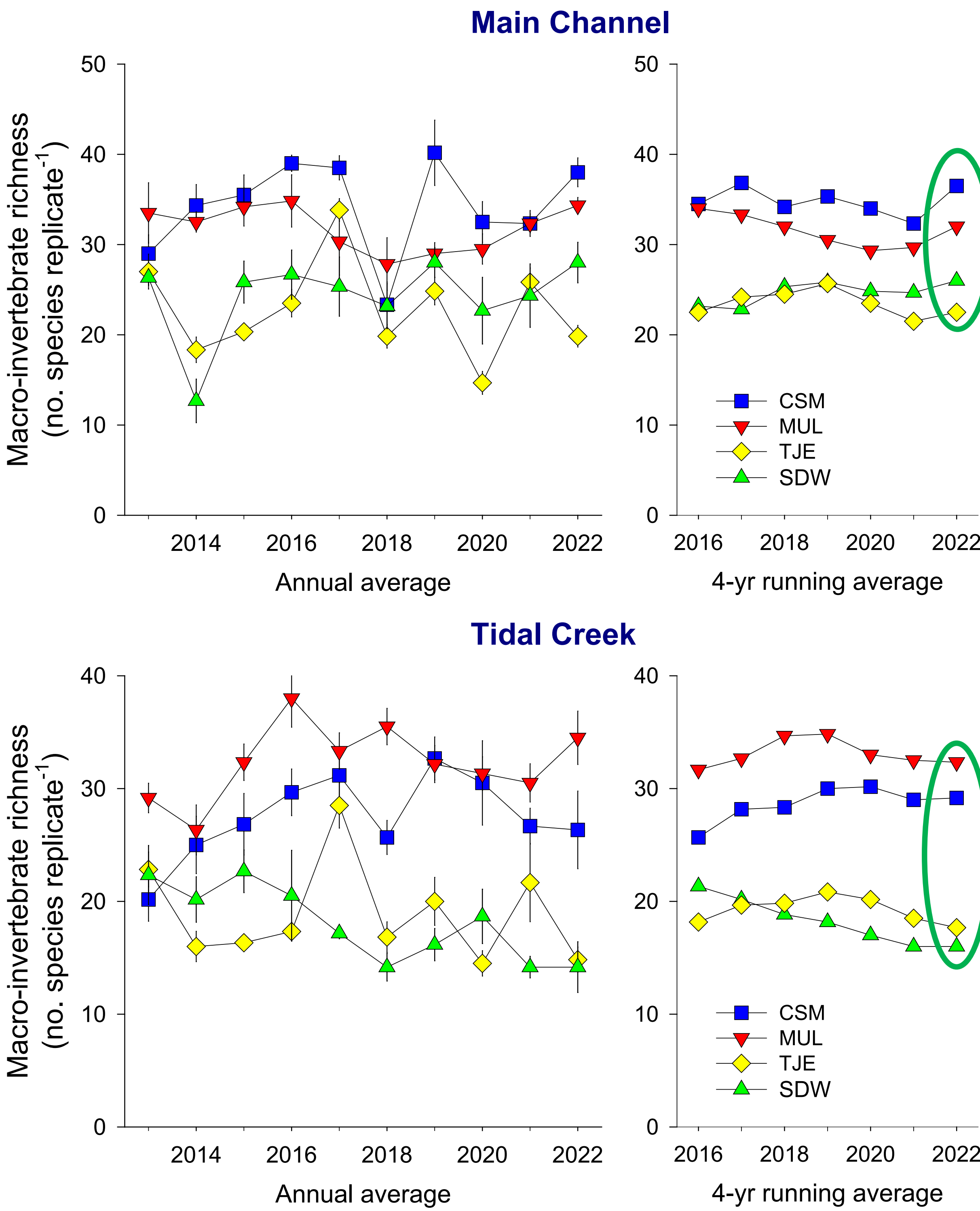


Figure 5.2.4.2. Comparison of macro-invertebrate species richness between San Dieguito Wetlands and the reference wetlands for main channel (top) and tidal creek (bottom) habitats. Section of main channel-basin or individual tidal creek is the unit of replication. Note: complete sampling was not conducted for invertebrate richness in 2012. Green ellipses indicate the standard was met for 2022.

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, shows plots for San Dieguito Wetlands; see Wetland Monitoring Plan for reference site plot maps) 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 flying at or below 30 m from ground-level within the plot. To reduce the potential effects of weather and other factors that might vary among wetlands over time, all wetlands are sampled within a few days of one another.

Bird assemblages in coastal wetlands of southern California exhibit 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 number of birds within each of the 20 plots are averaged by plot across the 18 survey dates to provide a mean value of density for each plot and 20 mean values per wetland. Yearly mean total densities within each wetland are computed using the 20 plots as replicates for each wetland and these values are used for evaluating similarity in bird density between the restored and reference wetlands. Species richness is determined as the total number of unique bird species recorded in each of the 20 plots across the 18 survey dates for each wetland. These 20 replicate values for species richness are used to calculate the means and standard errors used to evaluate similarity in species richness of birds between the restored and reference wetlands in a given year.

Figure 5.2.5.1. Distribution of the 20-100 x 150 m bird sampling plots (shown by yellow boxes) in the San Dieguito Wetlands.

Results: Mugu Lagoon had the highest annual bird density from 2012 through 2022 and the highest 4-year running average for bird density over the same time period. There had been a general decline in the 4-year running average of bird density in San Dieguito Wetlands from 2012-2019, but the annual density value at San Dieguito Wetlands has been higher than Carpinteria Salt Marsh since 2020 (Fig. 5.2.5.2). In 2022, the running average at San Dieguito was similar to the lowest performing reference wetland (Carpinteria Salt Marsh). Thus, San Dieguito Wetlands met the standard for bird density in 2022.

Of the reference wetlands, Tijuana Estuary had the highest bird species richness from 2012 through 2022. This pattern is also reflected in the 4-year running average, which has been consistently highest at Tijuana Estuary (Figure. 5.2.5.3). There had been a general decrease in bird species richness in San Dieguito Wetlands from 2012-2018, followed by an increase from 2019-2022. In 2022, bird species richness was highest at San Dieguito Wetland and as a result, the 4-year running average for bird species richness in San Dieguito Wetlands was greater than the reference wetlands. Thus, San Dieguito Wetlands met the standard for bird species richness in 2022.

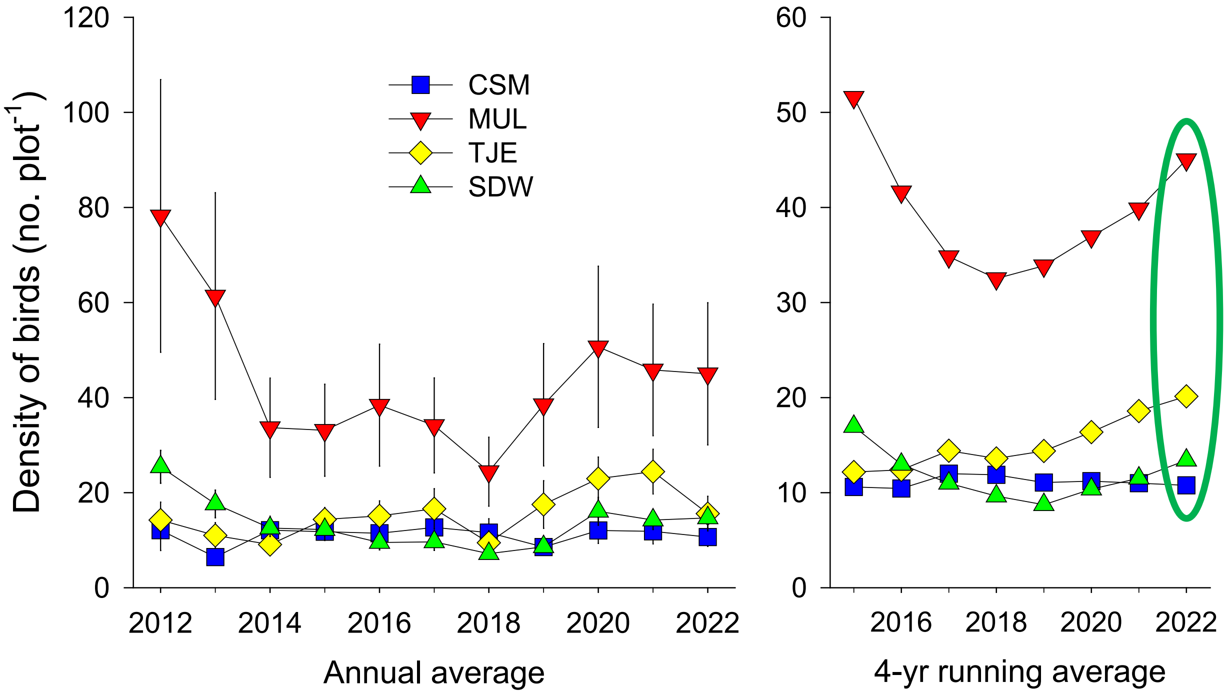


Figure 5.2.5.2. Comparison of bird density between San Dieguito Wetlands and Tijuana Estuary, Mugu Lagoon, and Carpinteria Salt Marsh. Green ellipse indicates standard was met for 2022.

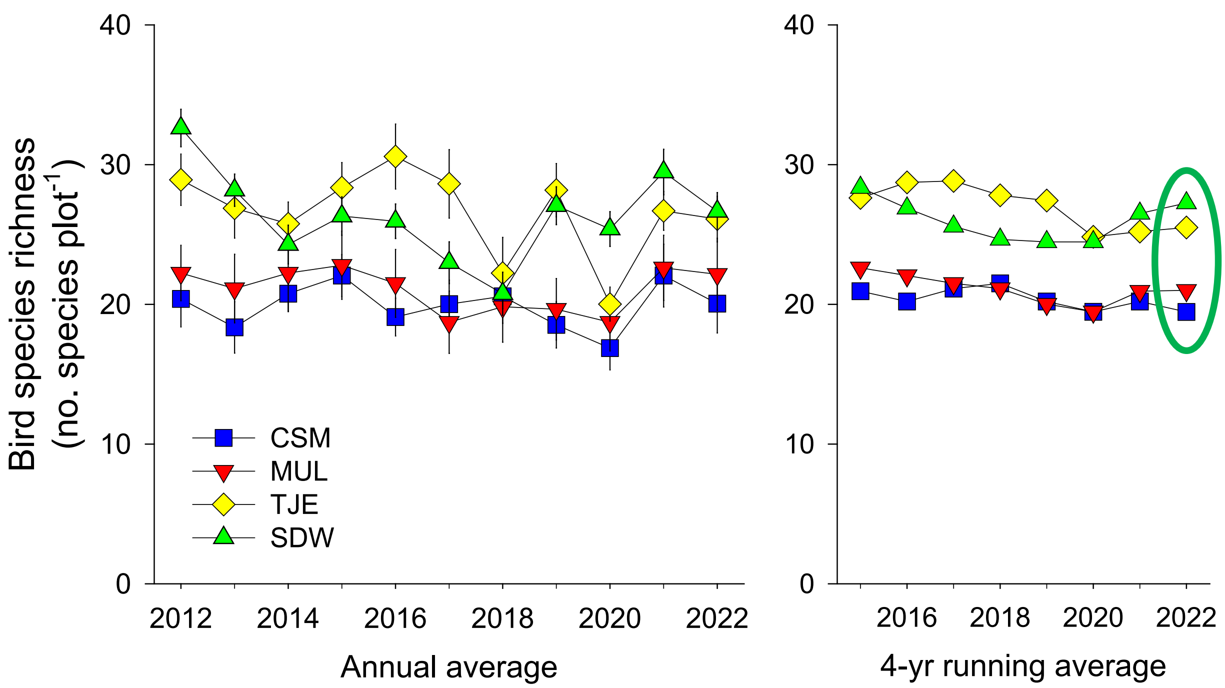


Figure 5.2.5.3. Comparison of bird species richness between San Dieguito Wetlands and the three reference wetlands. Green ellipse indicates standard was met for 2022.

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 REFERENCE SITES.

Figure 5.2.6.1. View of San Dieguito Wetlands modules W4 & W16 taken in 2020 showing extensive stands of cordgrass. Member of UCSB staff in foreground.

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 in each wetland (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 (habitat with 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 based on a census, (i.e., evaluated for all 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 in salt marsh habitat within the restored wetland is not lower than that in the reference wetland with the lowest percent cover of vegetation.

Results: Salt marsh vegetation in San Dieguito Wetlands has slowly increased in distribution and cover from 2012-2022 (Fig. 5.2.6.2, see Section 7.0). However, the annual and 4-year running average of percent cover of vegetation in salt marsh habitat remains lower than the reference wetlands (Fig. 5.2.6.2). The decrease in cover of vegetation in Carpinteria Salt Marsh in 2017-2018 was associated with the debris flow from the Thomas Fire. 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 standard for cover of vegetation was not met in 2022. The results from two long-term field experiments (2019-2022) aimed at evaluating the effectiveness of different forms of intervention on increasing vegetation cover at San Dieguito Wetlands were summarized briefly in prior annual reports (see Page et al. 2021; Beheshti et al.

2022) and are now reported in the peer-reviewed journal Restoration Ecology (Beheshti et al. 2023). These experiments helped inform an ongoing planting program aimed at increasing vegetation cover throughout the wetland, particularly in the persistently bare areas of the mid to high marsh.

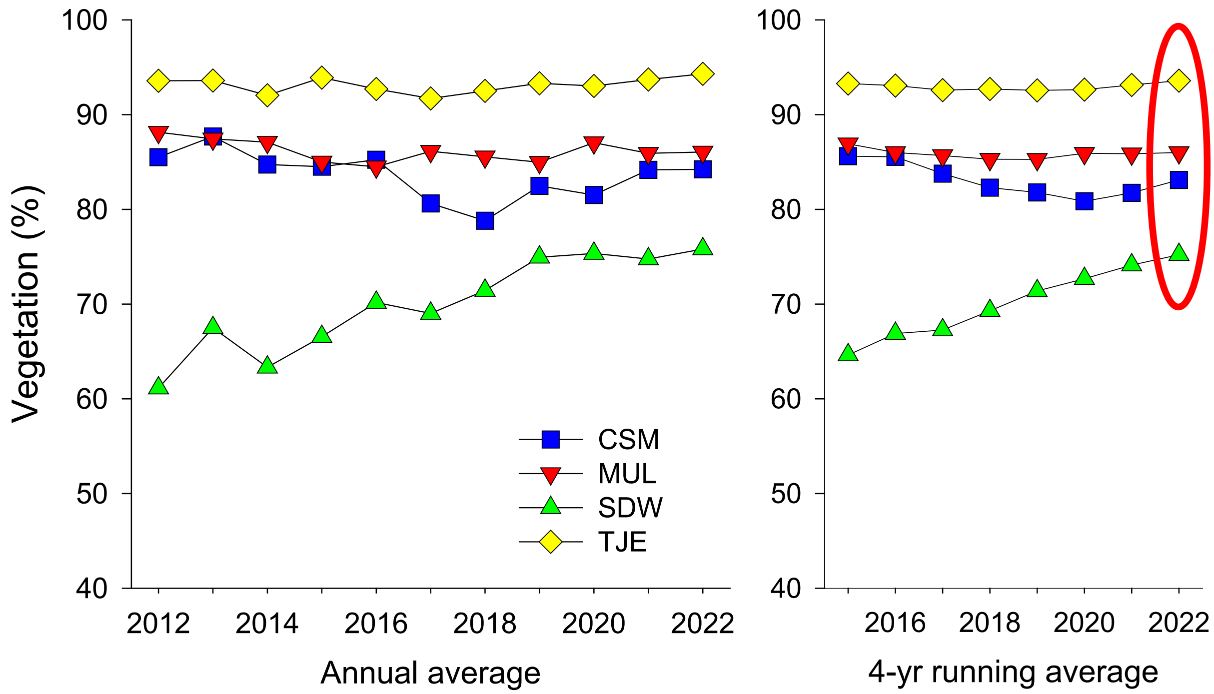


Figure 5.2.6.2. Comparison of the percent cover of salt marsh vegetation between San Dieguito Wetlands and the reference wetlands. Percent cover is evaluated in areas assessed as salt marsh habitat (at least 30% cover of vegetation). Red ellipse indicates standard was not met for 2022.

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 (Wasson et al. 2017), and can lower dissolved oxygen concentration during decomposition (Jeppesen et al. 2018). 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 2022, 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. Thus, San Dieguito Wetlands met the standard for algae in 2022 (Fig. 5.2.7.1).

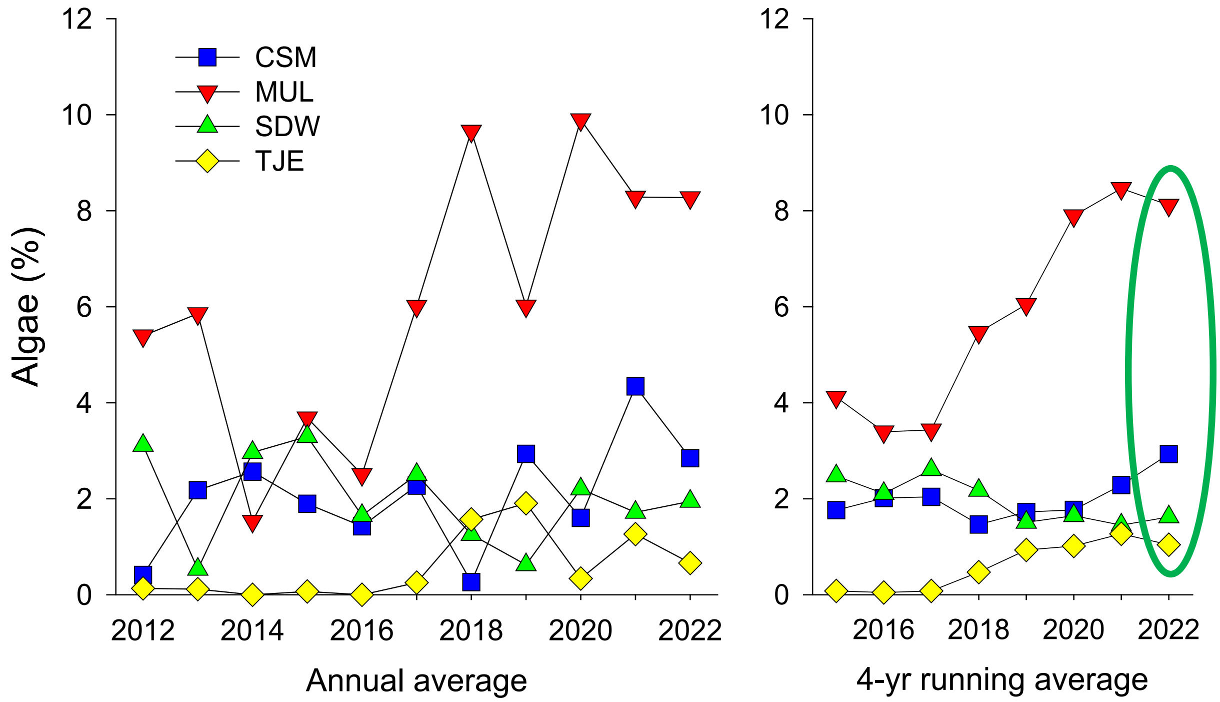


Figure 5.2.7.1. Comparison of percent cover of macroalgae between San Dieguito Wetlands and the reference wetlands. Green ellipse indicates standard was met for 2022.

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 at each site. 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 (*S. foliosa*) 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 2021 in San Dieguito Wetlands, whereas this value has been more variable in Tijuana Estuary. The mean proportion of stems > 3 feet tall declined at both San Dieguito Wetlands and Tijuana estuary in 2022 relative to 2021. The 4-year running average dampens the annual variability and in 2022, the mean proportion of stems > 3 feet was greater at San Dieguito Wetlands relative to Tijuana Estuary. Thus, San Dieguito Wetlands met the standard for *Spartina* canopy architecture in 2022.

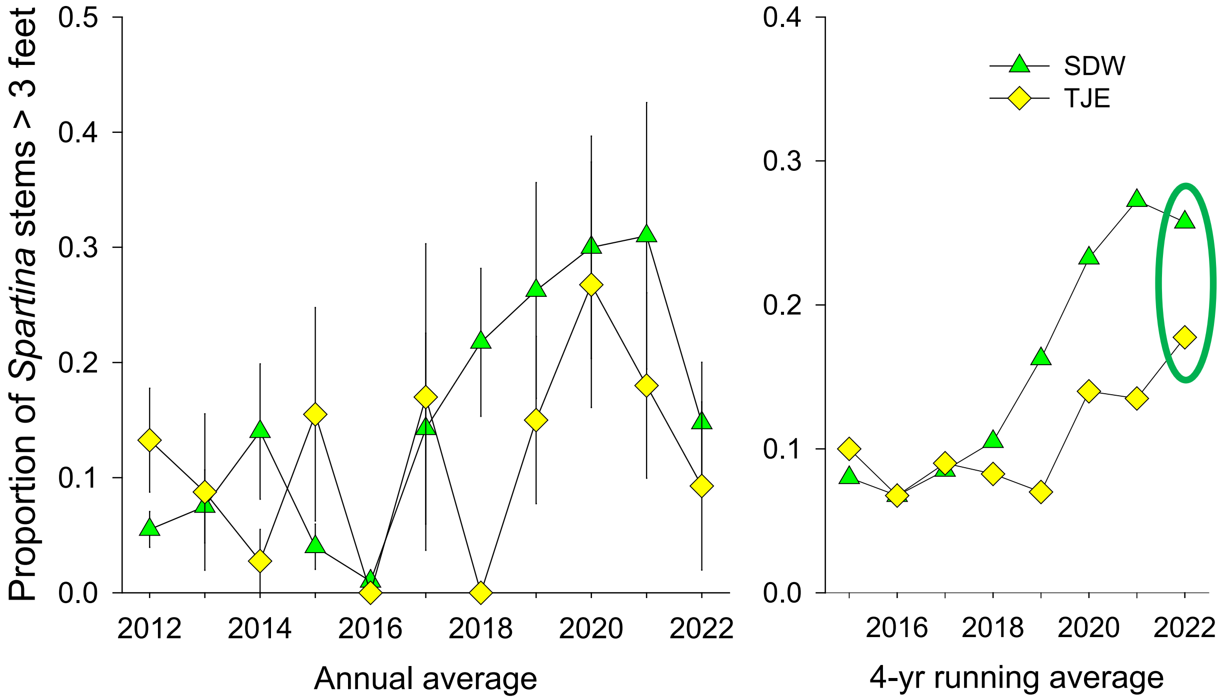


Figure 5.2.8.2, Comparison of the mean proportion of stems > 3 feet (91 cm) tall between San Dieguito Wetlands and Tijuana Estuary. Green ellipse indicates standard was met for 2022.

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.

Approach: 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).

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 and 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 in order for the San Dieguito Wetlands to meet this performance standard for any given year. The effect size for the FCS standard is the proportional difference between the median of the San Dieguito Wetlands and the reference wetland with the lowest FCS value. The p-value for the FCS standard is calculated as the percentile in the distribution of FCS values at San Dieguito Wetlands corresponding to the mean value of the lowest performing reference wetland (which was the Carpinteria Salt Marsh in 2022).

Results: The highest annual density of feeding birds occurred in Mugu Lagoon from 2012 through 2022 (Fig. 5.2.9.1). There was a general decline in the running average of the density of feeding birds at Mugu Lagoon through 2018, this trend reversed from 2019 to 2020 but densities dropped to near 2019 levels in 2021 and 2022. The running average of FCS in San Dieguito Wetlands was significantly lower than Carpinteria Salt Marsh, the lowest performing reference wetland from 2017-2022 and remains lower than this reference site in 2022. Thus, San Dieguito Wetlands did not meet the standard for FCS in 2022.

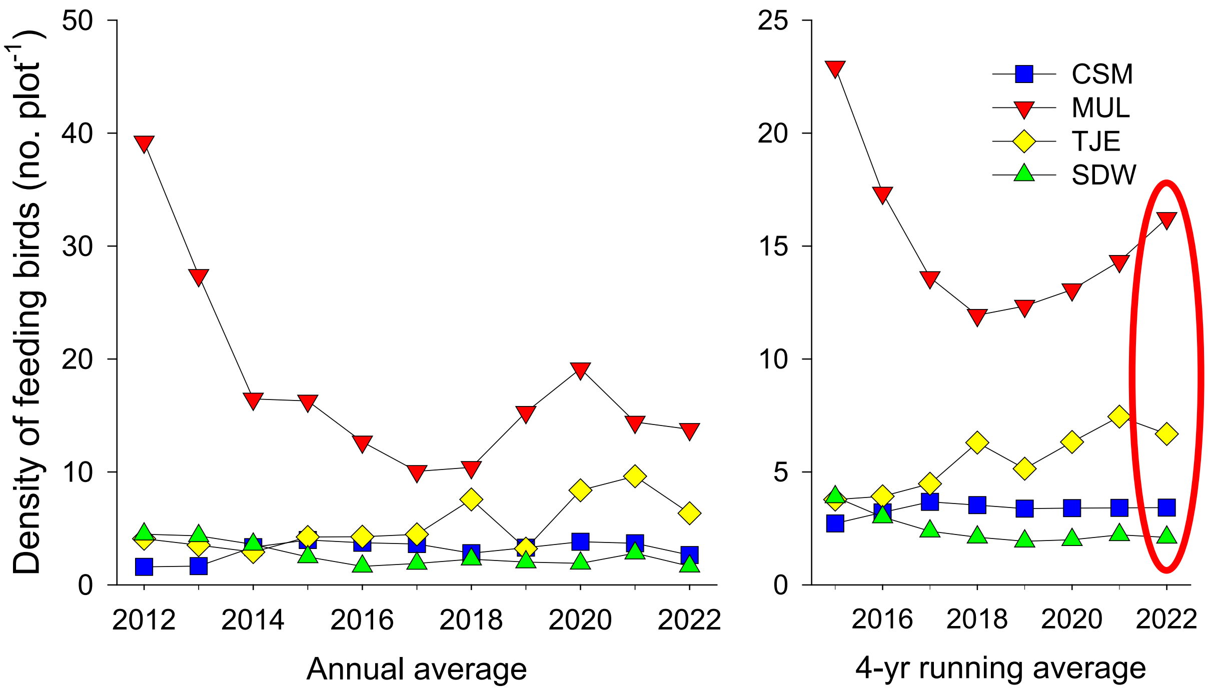


Figure 5.2.9.1. Comparison of the densities of feeding birds between San Dieguito Wetlands and the reference wetlands. Red ellipse indicates the standard was not met in 2022.

6.0 Permit Compliance

6.1. Summary Assessment of the Absolute Performance Standards

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.

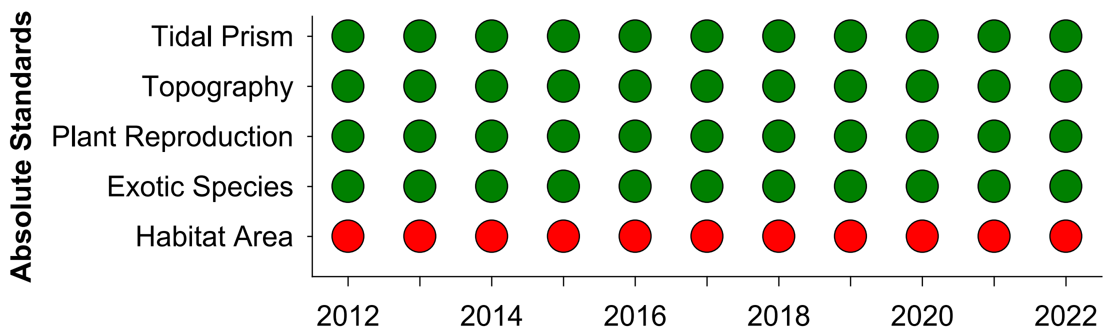


Figure 6.1.1. Summary of assessment of the absolute standards from 2012 through 2022. A green dot indicates that the San Dieguito Wetlands Restoration met the required criteria for a given absolute standard; a red dot indicates that it did not.

The San Dieguito Wetlands Restoration has met 4 of the 5 absolute standards from 2012–2022, 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 2022, and all absolute standards must be met in the current year to receive credit, the San Dieguito Wetlands did not receive mitigation credit for 2022.

6.2. Summary Assessment of the Relative Performance Standards

A requirement of the SONGS permit (CCC 1997) 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 the lowest performing wetland. See Section 4.4 for details on the rationale and methodology of this approach. Figure 6.2.1 summarizes the annual assessment of the relative standards from 2012 through 2022 for San Dieguito Wetlands. Only nine standards were evaluated in 2012 (Figure 6.2.1). From 2013 to 2022, all fifteen relative standards were evaluated. The project met 9 of 15 standards in 2022.

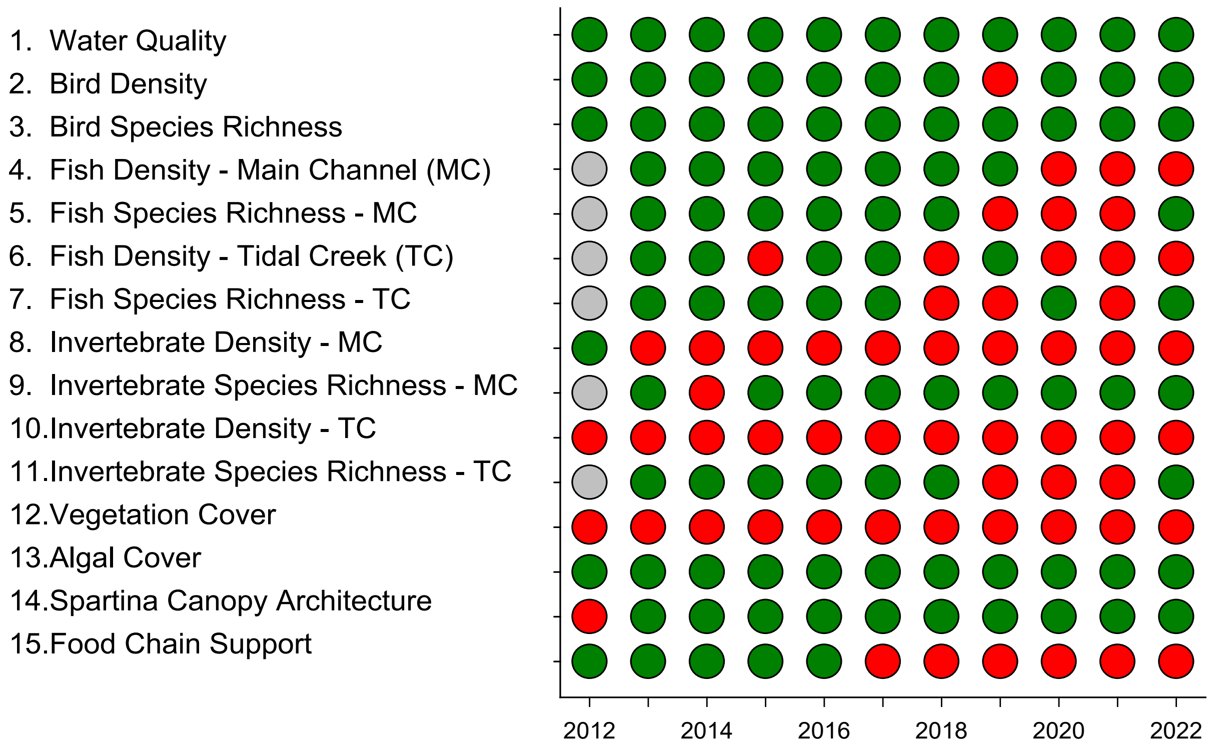


Figure 6.2.1. Summary of the assessment of the Relative Standards from 2012 through 2022. A green dot indicates that the San Dieguito Wetlands Restoration was similar to the reference wetlands for that standard in that year; a red dot indicates that it was not similar to the reference wetlands.

Comparing the proportion of relative standards met among wetlands, Tijuana Estuary was the worst performing reference wetland (0.73) in 2022. San Dieguito Wetlands had a lower proportion of standards met (0.60) than Tijuana Estuary in 2022 (Fig. 6.2.2).

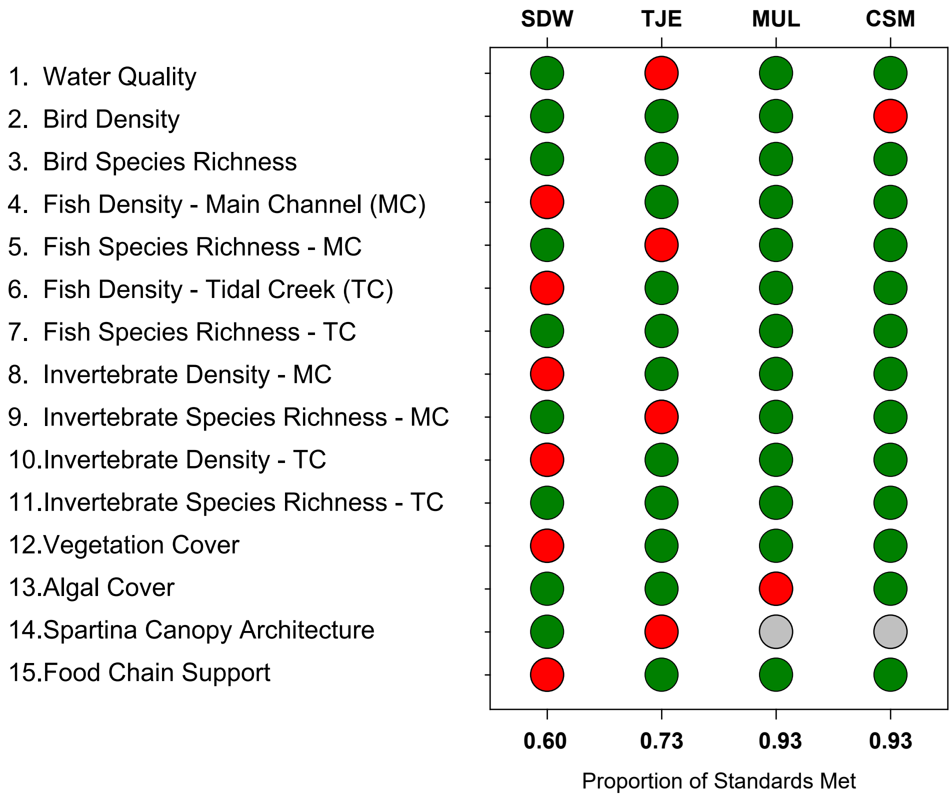


Figure 6.2.2. Summary evaluation of the Relative Standards for 2022. A green dot indicates that the value for the indicated response variable at a particular wetland is similar to the other wetlands. A red dot indicates that the indicated response variable was statistically worse or lower than the other wetlands. *Spartina* canopy architecture was only measured at San Dieguito Wetlands and the Tijuana Estuary (grey dots).

6.3. Project Compliance

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).

For the San Dieguito Wetlands to receive mitigation credit for a given year, it must also meet as many of the relative performance standards (as measured by the proportion of standards met) as the lowest performing reference wetland. The project has failed to meet the relative standard requirement in 10 out of 11 years (Fig. 6.3.1). Although 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 (CCC 1997) and has not yet received mitigation credit.

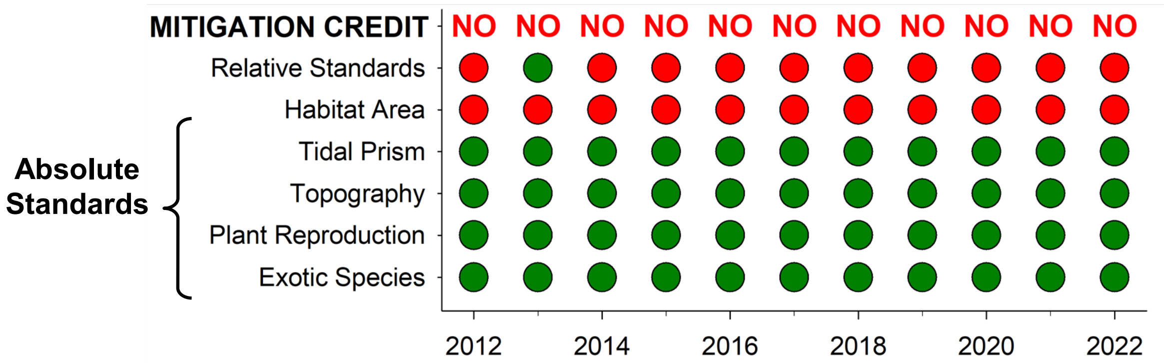


Figure 6.3.1. Status of compliance of San Dieguito Wetlands with the performance standards provided in the SONGS Permit. A green dot indicates that standard was met, a red dot indicates that a standard was not met.

7.0 Status of Salt Marsh Vegetation and Biological Communities

7.1. Overview

Multiple standards have consistently underperformed or been intermittently met in San Dieguito Wetlands over the past eight years (Fig. 7.1.1). Two of these standards depend on the development of salt marsh vegetation. The first of these is the absolute standard pertaining to habitat areas, which, as an absolute standard, must be met each year for the restoration project to receive mitigation credit for that year. Habitat areas is the only absolute standard that has yet to be met. The second is the relative standard pertaining to the cover of salt marsh vegetation, which has also not yet been met. Vegetation development is needed for these two standards to be met. Discussion and adaptive management activities to increase vegetation cover has been a focus of efforts by UCSB scientists, CCC staff, and SCE over the past several years. Initially, our priority was to understand the factors inhibiting salt marsh plants from establishing at the restoration site. More recently our concern has shifted, as the area of salt marsh approaches the required acreage minimum (83.3 acres) and mudflat continues (2019-2022) to decline well below its required acreage minimum (22.4 acres, Figure 5.1.2.5). As of 2022, we are optimistic that San Dieguito Wetlands will reach the 83.3 acre minimum for salt marsh, but doubtful that we will gain back the acres of mudflat lost over the past four years by 2023. Consequently, we expect San Dieguito Wetlands will not meet the habitat areas standard again in 2023, given present trends.

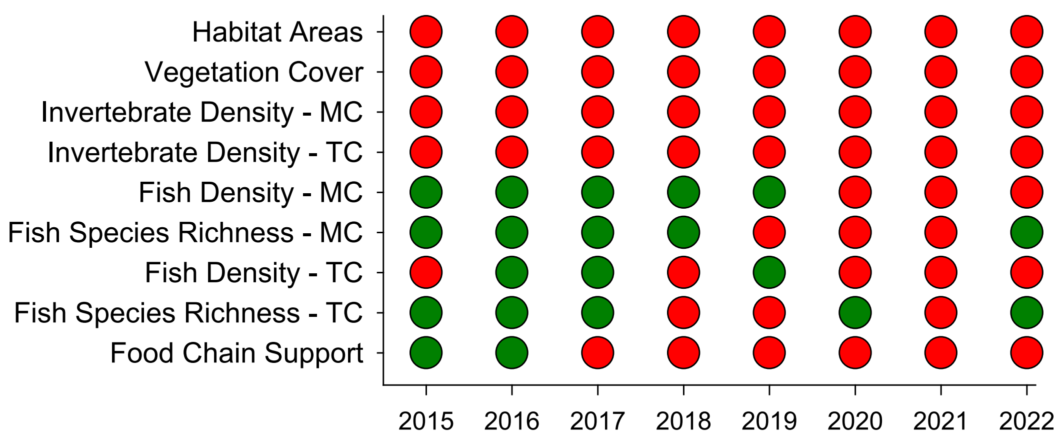


Figure 7.1.1. Summary of performance standards that have underperformed in San Dieguito Wetlands from 2015-2022. Monitoring began in 2012 and 2015 was the first year we had a four-year running average (shown above).

Among the other standards that have underperformed are the relative standards pertaining to the densities of invertebrates in main channel-basin and tidal creek habitats. The standards for invertebrate density in main channel and tidal creek habitats have never been met. Note: In 2012, the standard for invertebrate density in main channel habitats was met due to the inclusion of roundworms in the analyses. Roundworms were later discarded from future analyses as they are not effectively sampled with our protocols. Subsequent reports reflect this change in credit for the standard (Beheshti et al. 2022). More recently, the relative standards for fish density and richness in main channel and tidal creek habitats have underperformed. These standards have not been consistently met in the last 4 years and the standards for fish density in main channel or tidal creek habitats were not met in 2022. In addition, food chain support, evaluated as the density of feeding birds, has not been met in the past 6 years.

The sections below discuss the current status of vegetation in San Dieguito Wetlands, activities underway to facilitate vegetation development, and some analyses and observations pertaining to factors that might be contributing to the low densities of invertebrates and fishes. Since invertebrates are important in food chain support to fish and birds, these factors may also apply, at least in part, in explaining the underperformance of those standards.

7.2. Salt Marsh Vegetation

7.2.1 Current status of vegetation

In many areas of the restoration project, vegetation is well established. Cordgrass, *Spartina foliosa*, continues to expand in distribution throughout the restoration project. Figure 7.2.1 shows extensive stands of cordgrass throughout the wetland. In 2022, cordgrass continued to colonize many of the constructed tidal creeks used for performance monitoring. After a period of slow establishment following its most recent planting in 2011, cordgrass now occupies over 18 acres of San Dieguito Wetlands.

Figure 7.2.1. Cordgrass (*Spartina foliosa*) throughout San Dieguito Wetland. Cordgrass has been expanding a) along and within constructed tidal creeks and b) the marsh plain, and c) encroaching into planned mudflat habitat.

Although progress has been made in vegetation development, the wetland remains about 1 acre short of the minimum required acres of salt marsh habitat (Figure 7.2.2.). Following an appreciable increase in the acreage of salt marsh habitat from 2018-2019, likely facilitated by the higher levels of rainfall during 2018 relative to the previous years, salt marsh acreage made minor gains, perhaps a result of the low rainfall in the years that followed. Yet, from 2021-2022, the wetland gained over 8 acres of salt marsh habitat.

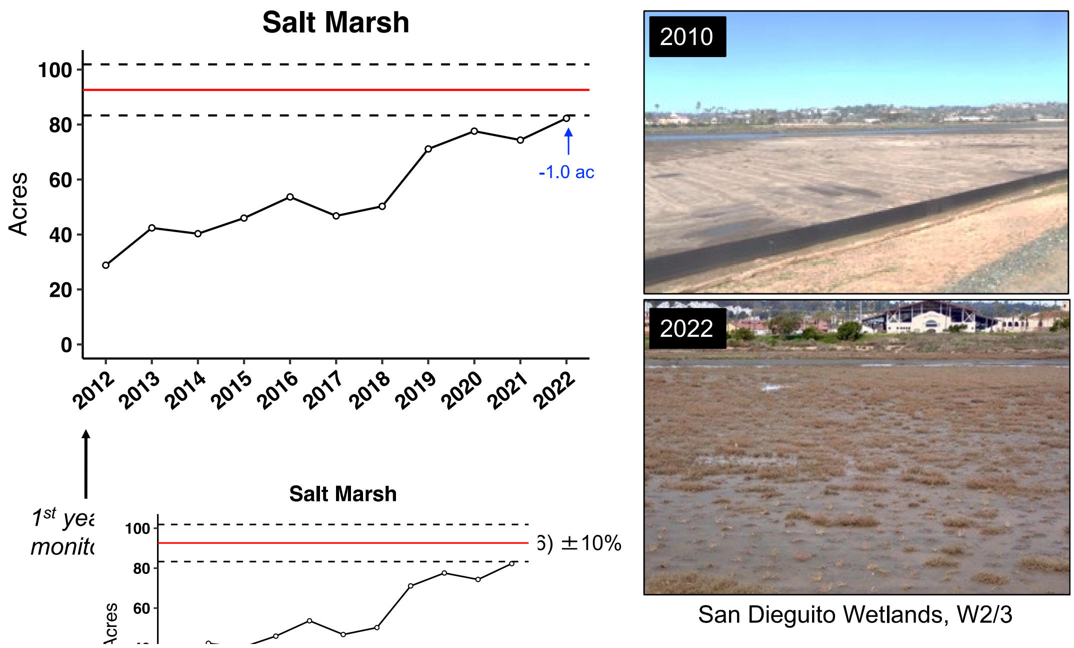


Figure 7.2.2. Change in acres of salt marsh habitat over time and the required acreage ±10% in San Dieguito Wetlands. San Dieguito Wetlands had a deficit of 1 acre of salt marsh habitat in 2022 relative to the minimum required acreage of salt marsh habitat of 83.3 acres.

The goal of the restoration project is to achieve not only a minimum of 83.3 acres of salt marsh habitat, but also attain a high cover of vegetation similar to the reference wetlands (i.e., ≥ 85% cover). Figure 7.2.3 shows the change in vegetation cover over time in San Dieguito Wetlands by salt marsh (>30%) cover classes. The monitoring data from 2012 to 2022 reveal that the overall rate of increase in acreage for the highest cover class (>85%) has been fastest, having gained 35 acres over the 11-year period (Fig. 7.2.3). Whereas, salt marsh acreage with cover between 60-<85% and 30-<60% has gained 14 and 8 acres, respectively (Fig. 7.2.3).

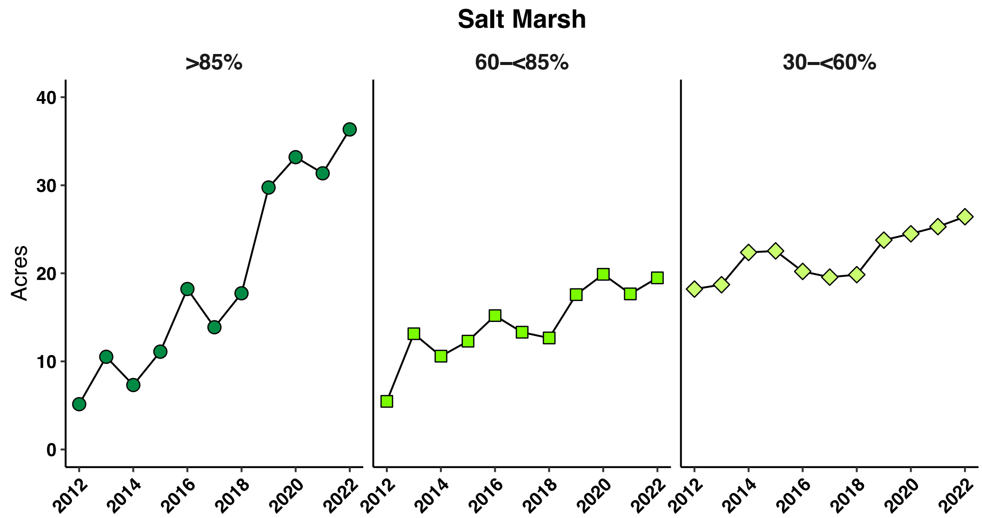
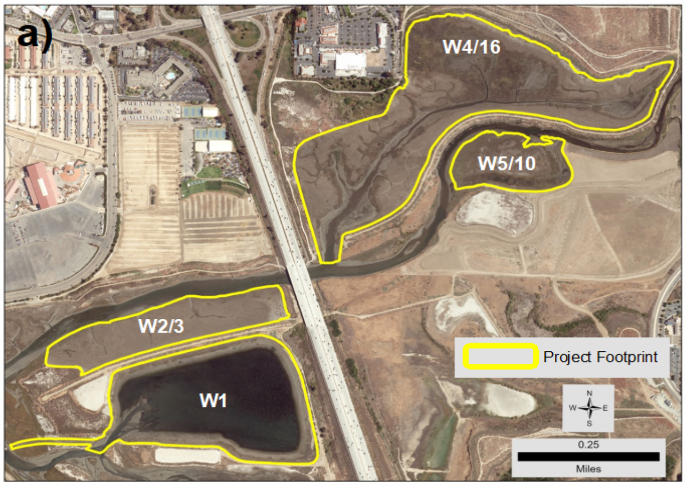


Figure 7.2.3. Change in acres of salt marsh vegetation as a function of salt marsh cover class over time from 2012–2022. View of the sparse (bottom left) and high (bottom right) cover of vegetation in San Dieguito.

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 (i.e., mid to high marsh) and in need of intervention to facilitate plant establishment. A recent publication reported on two large-scale field experiments conducted at the wetland to evaluate the effectiveness of different intervention strategies on increasing vegetation cover in the mid to high marsh (Beheshti et al. 2023).

Figure 7.2.4 shows vegetation cover in 2022 assessed within 10 m x 10 m grids using aerial imagery (see methods in Section 5.1.2) for the wetland modules on the west (W2/3, W1) and east side of the freeway (W4/16, W5/10). Vegetation cover in 2022, determined using aerial imagery, is binned into cover classes with warm colors (red, orange, yellow) showing areas that were classified as "other" (i.e., habitat with insufficient vegetation cover to be classified as salt marsh or too high in elevation to be classified as mudflat). Areas of the restoration site that meet the Habitat Areas standard (i.e., cover ≥ 30%) are indicated by shades of green, with the darkest green showing areas that are ≥ 85% cover. Also provided are the estimated acres of these cover classes wetland wide (Fig. 7.2.4a), and by module (Fig. 7.2.4b, c).



Wetland-wide (2022)

Grid Class	Cover Class	Acres
Other	0-<10%	4.5
	10-<20%	7.7
	20-<30%	8.6
Salt Marsh	30-<60%	26.4
	60-<85%	19.5
	>85%	36.3
Mudflat	Mudflat	16.0
Subtidal	Subtidal	30.9

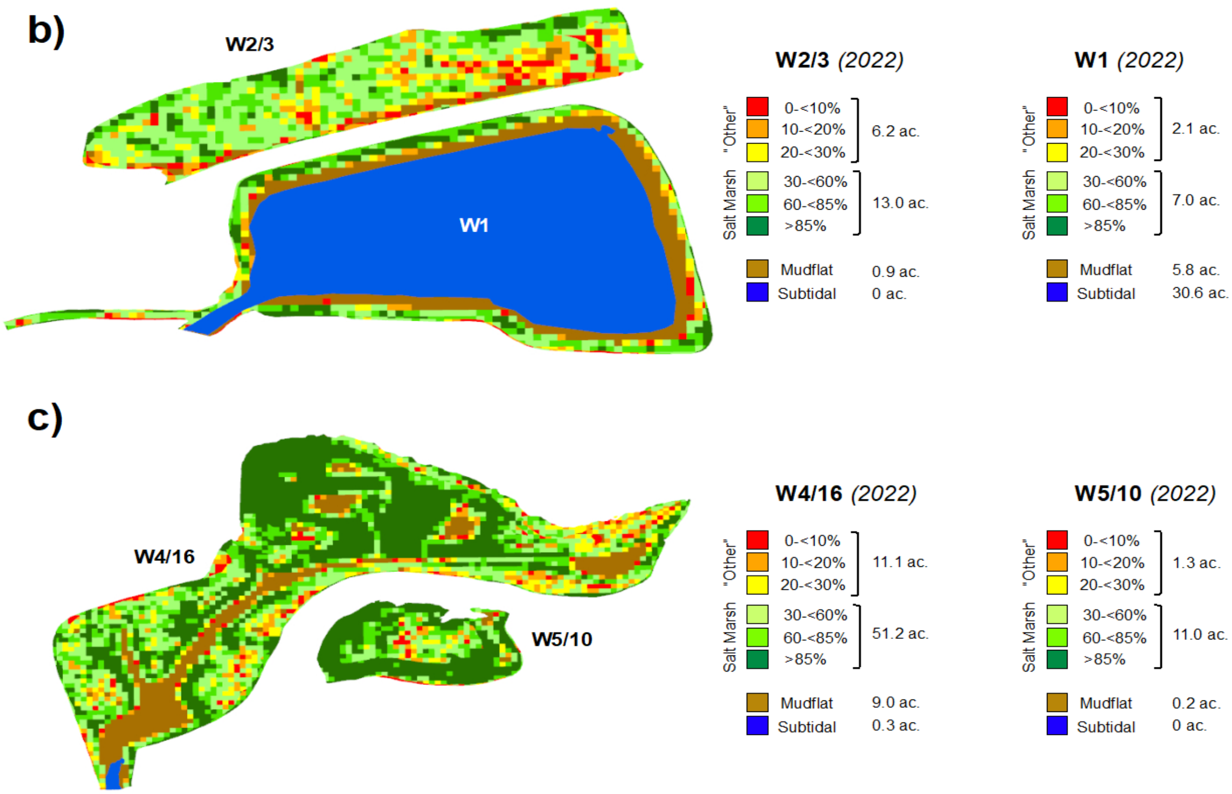


Figure 7.2.4. Acreages by cover class at San Dieguito Wetlands. a) 2022 wetland-wide acreages by cover class bin with labeled map of the wetland. b) Cover of vegetation in the western modules (W2/3 and W1) of San Dieguito Wetlands in 2022 binned into cover classes, and the acres of each habitat ("other", salt marsh, mudflat, subtidal) by module. c) Cover of vegetation in the eastern modules (W4/16 and W5/10) of San Dieguito Wetlands in 2022 binned into cover classes, and the acres of each habitat ("other", salt marsh, mudflat, subtidal) by module. In 2022, the total area of "other", salt marsh, mudflat, and subtidal was approximately 21, 82, 16 and 31 acres respectively.

7.2.2 Tracking habitat conversion

Since 2018, notable progress has been made in the development of vegetation at San Dieguito Wetlands. However, concurrent with the increase in salt marsh acreage (2018-2022), there has been a marked decrease in mudflat acreage (Fig. 5.1.2.5). During this period, salt marsh plants have encroached into planned mudflat habitat (Fig. 7.2.5) and as of 2022, the restoration project is 6.4 acres short of meeting the minimum required acres of mudflat habitat (Fig. 5.1.2.5). To evaluate how habitat within San Dieguito Wetlands that was designed to be mudflat (-0.9 - 1.3' NGVD) has evolved since monitoring began, the planned mudflat habitat within the project footprint area was isolated and aerial imagery classification of the three habitat types (mudflat, salt marsh, and other) was used to produce a time series (Fig. 7.2.5). From 2012 to 2022, 40% of planned mudflat habitat was converted to salt marsh. Over this 11-year period, there was a 9 acre increase in salt marsh and an over 6 acre loss of mudflat within the 26.6 acres of constructed planned mudflat (Fig. 7.2.6). Preliminary analyses of RTK surveys within the planned mudflat habitat suggest that some areas designed as mudflats have accreted sediment and now occur well above the as-built elevations and within the planned lower elevation limit of salt marsh (1.3' NGVD; Figure 7.2.7). As a result, salt marsh encroachment into planned mudflat habitat may continue in the coming years.

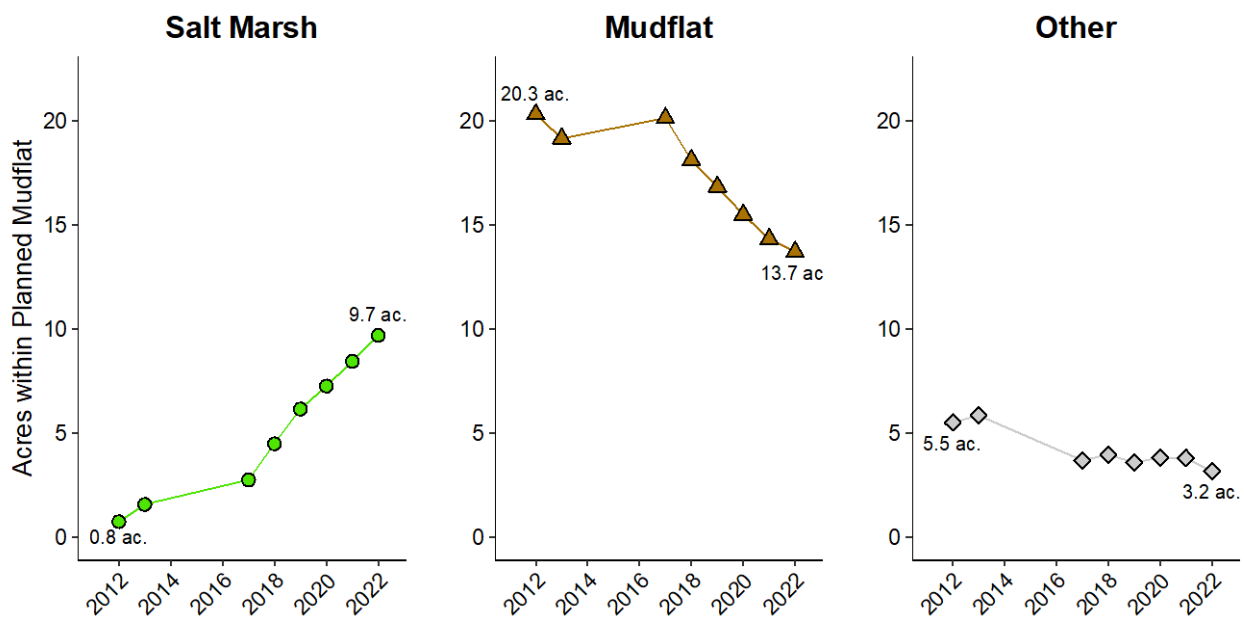


Figure 7.2.5. Time series of planned mudflat area by habitat type. Salt marsh habitat (green circles) within the planned mudflat area has increased since monitoring began in 2012, while habitat designated as mudflat (brown triangles) and other (grey diamonds) have declined.

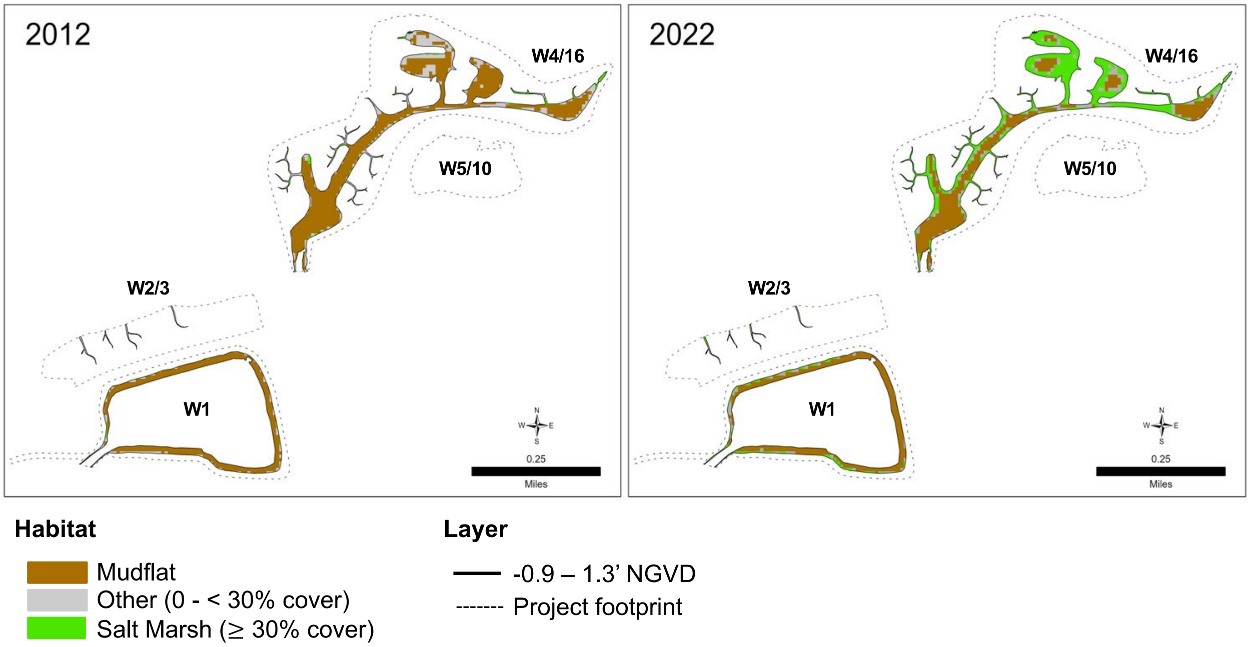


Figure 7.2.6. Planned mudflat maps from 2012 and 2022 color-coded by habitat type. In 2012, much of the planned mudflat habitat was mudflat (brown). By 2022, close to 50% of the planned mudflat habitat was vegetated and classified as salt marsh (green) or other (grey).

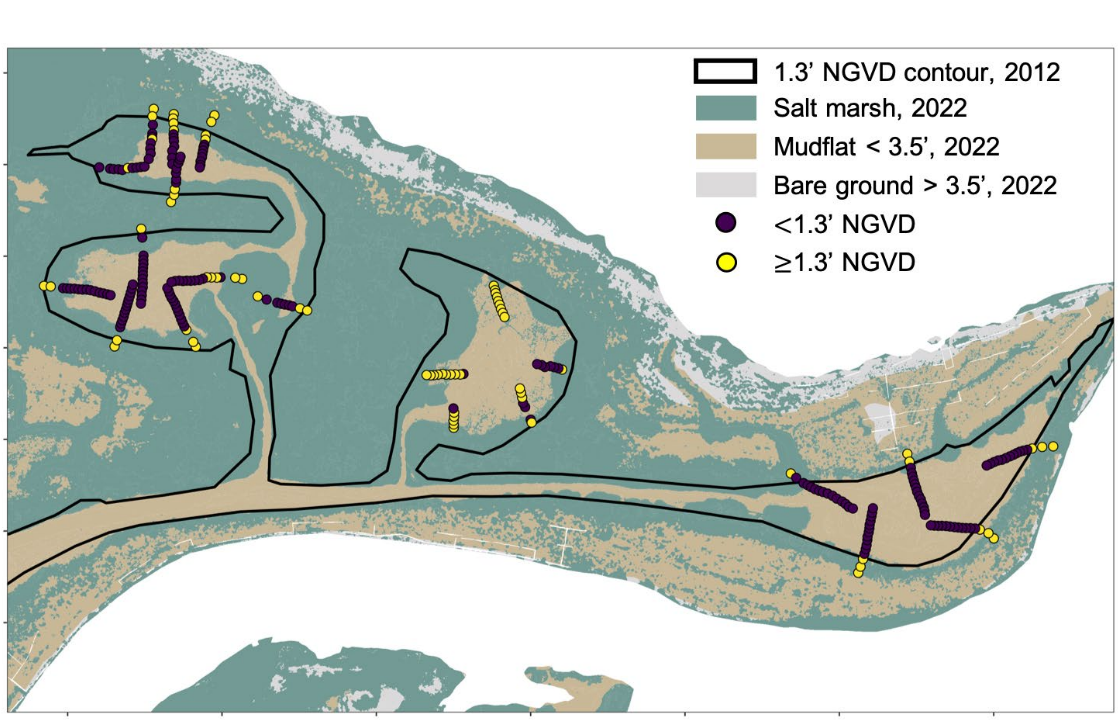


Figure 7.2.7. RTK elevation surveys within planned mudflat habitat (black line; 1.3' NGVD contour). Yellow dots indicate elevations greater than 1.3' NGVD; dark purple points indicate elevations less than 1.3' NGVD.

Within planned salt marsh habitat (1.3 - 4.5’ NGVD), the acreage of salt marsh has increased by 44.3 acres since 2012, with corresponding declines in habitat classified as mudflat (11.0 acre decline) or other (33.3 acre decline) (Fig. 7.2.8). The promising development of salt marsh habitat within the San Dieguito Wetlands is captured in Figure 7.2.9, which shows the patchiness of habitats in planned salt marsh habitat in 2012 compared with 2022.

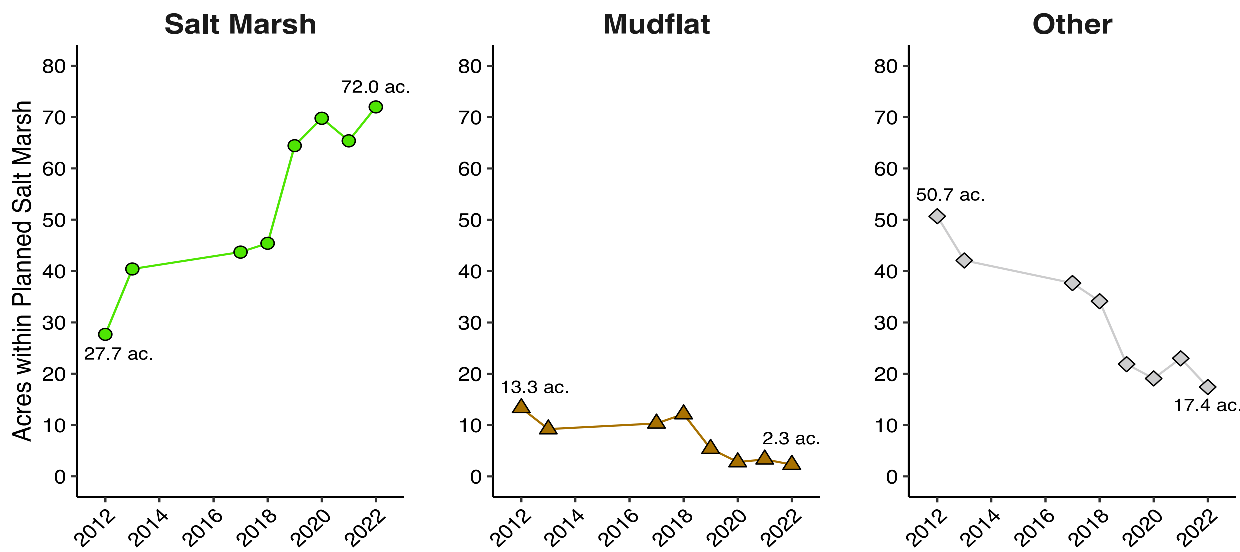


Figure 7.2.8. Time series of planned salt marsh area by habitat type. Salt marsh habitat (green circles) within the planned salt marsh area has increased since monitoring began in 2012, while habitat designated as mudflat (brown triangles) and other (grey diamonds) have declined.

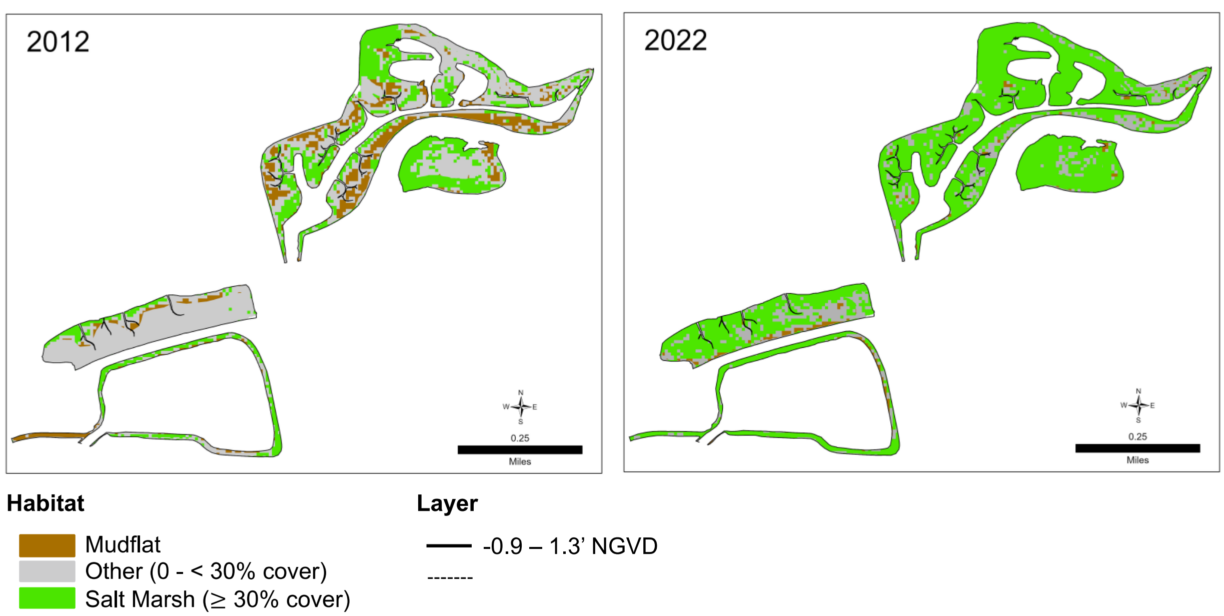


Figure 7.2.9. Planned salt marsh maps from 2012 and 2022 color-coded by habitat type. In 2012, there was relatively little salt marsh (green), with majority of the planned salt marsh habitat classified as mudflat (brown) or other (grey). By 2022, vegetation cover increased and majority of the planned salt marsh was classified as salt marsh.

7.2.3 Summary and future directions

- San Dieguito Wetlands has been steadily gaining salt marsh habitat since 2012.

- In more recent years, a portion of the increase in salt marsh acreage has come at the cost of planned mudflat habitat converting to salt marsh (40% of planned mudflat habitat is now classified as salt marsh).

- Elevation surveys show potential for further encroachment of salt marsh plants into planned mudflat habitat and provide evidence that salt marsh plants can persist and expand beyond the planned lower limit for salt marsh plants (1.3' NGVD) at San Dieguito Wetlands.

- Ground elevation surveys and the acquisition of a wetland-wide digital elevation model (DEM) in 2023 will facilitate a geomorphological analysis to understand sediment inputs, processes (accretion, erosion), and habitat evolution that will determine the areal extent and rate of habitat conversion over time.

- In 2023, sub-contractors working closely with the contract scientists will conduct geomorphological analyses to assess mudflat and tidal creek geomorphology within the wetland and predict their evolution over time.

7.3. Status of macro-invertebrates, fish, and food chain support

The success of San Dieguito Wetlands in supporting biological communities of macro-invertebrates and fish 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. The food chain support standard is evaluated by comparing the densities of feeding shorebirds between San Dieguito Wetlands and the reference wetlands. The following sections review the status of macro-invertebrates, fish, and food chain support in San Dieguito Wetlands and plans to explore reasons for the underperformance of these standards.

7.3.1 Underperformance of macro-invertebrates

To review, the standards for macro-invertebrate density have never been met in main channel or tidal creek habitats (Fig. 7.3.1.1). The standards for macro-invertebrate species richness have generally been met in tidal creek and main channel habitat, although the standard for richness in tidal creek habitat was not met from 2019–2021.

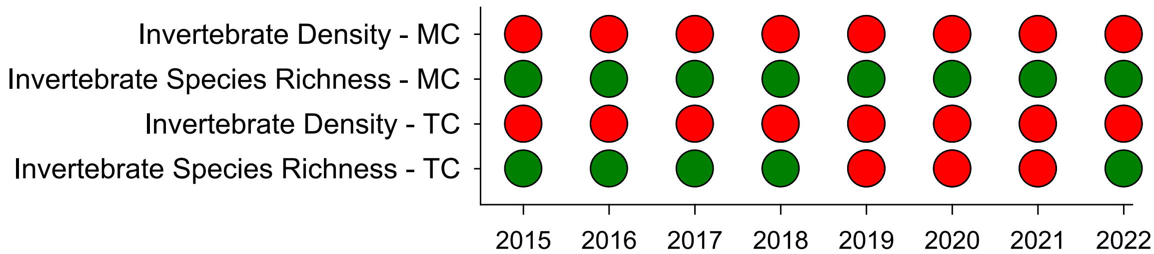


Figure 7.3.1.1 Performance of macro-invertebrate density and species richness in main channel and tidal creek habitat based on the 4-year running average from 2015 to 2022. A green dot indicates that standard was met, a red dot indicates that a standard was not met.

In 2022, the top five most abundant macro-invertebrates in main channel and tidal creek habitats in San Dieguito Wetlands and the reference wetlands were primarily small worms in the classes Polychaeta and Oligochaeta (Fig. 7.3.1.2.). In main channel habitat, polychaete worms were the most abundant taxon in San Dieguito Wetlands, Mugu Lagoon, and Carpinteria Salt Marsh, whereas oligochaete worms were the most abundant taxon in Tijuana Estuary. Noticeably, oligochaete worms were absent in the top five taxa in the main channel habitat in San Dieguito Wetlands, although oligochaete worms were present in the top five taxa in tidal creek habitats at all wetlands (Fig. 7.3.1.2.).

Across all years of monitoring, the densities of both polychaete and oligochaete worms have been lower in San Dieguito Wetlands compared with the reference wetlands (Fig. 7.3.1.2.), contributing to the failure of San Dieguito Wetlands to meet the relative standard for macro-invertebrate density in both main channel and tidal creek habitats in 2022.

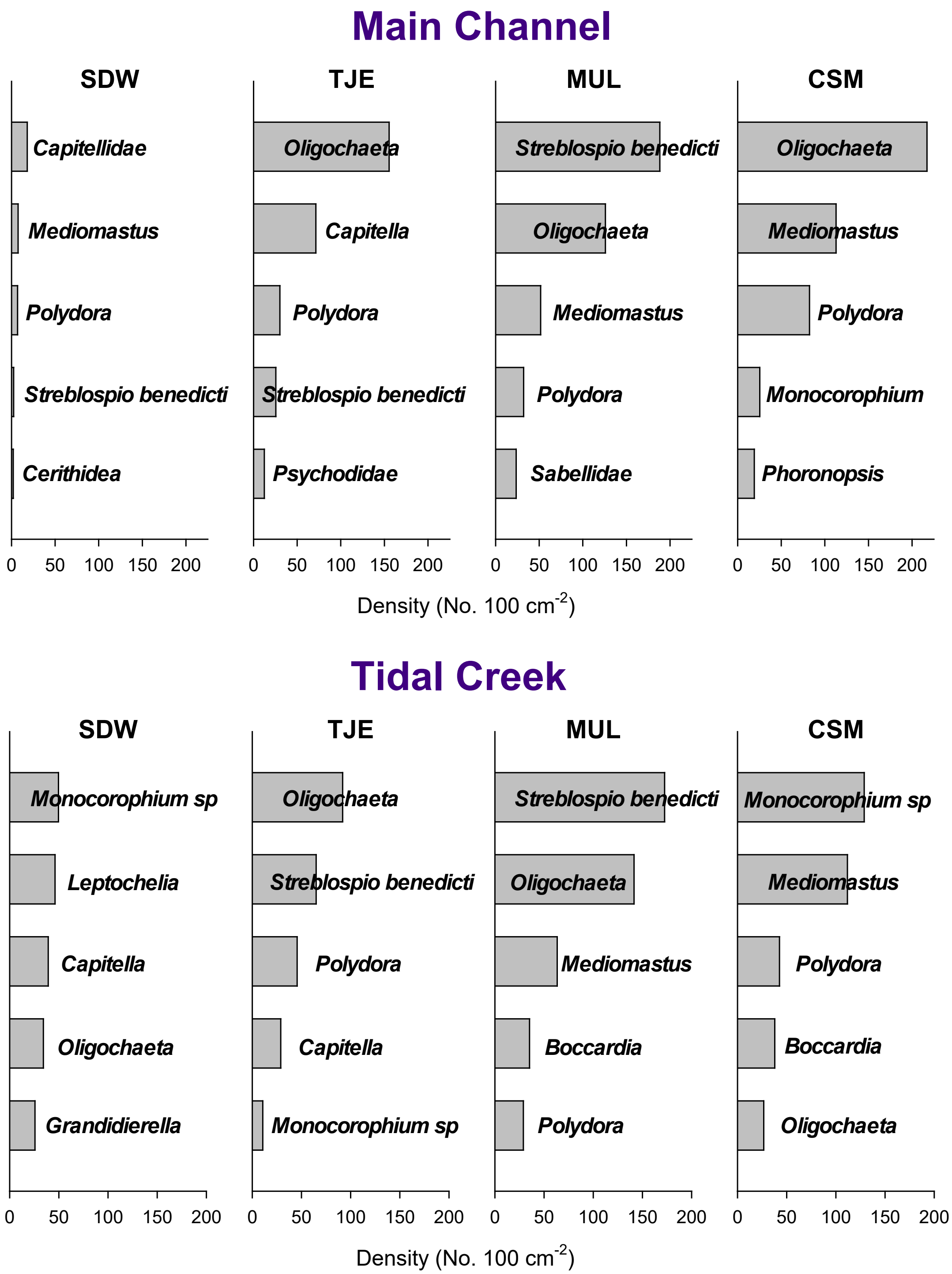


Figure 7.3.1.2. The top five most abundant macro-invertebrate taxa in main channel (top) and tidal creek (bottom) habitat in the restored wetland (San Dieguito Wetlands=SDW) and reference wetlands (Tijuana Estuary=TJE, Mugu Lagoon=MUL, Carpinteria Salt Marsh=CSM) in 2022.

7.3.2 Underperformance of fish and food chain support standards

To review, fish have met the relative standards more consistently than macro-invertebrates, but have failed the standard for density in tidal creeks and main channel the past three years (Fig. 7.3.2.1).

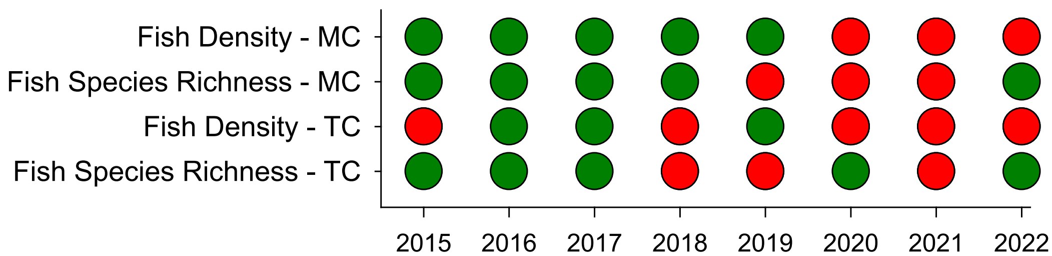


Figure 7.3.2.1 Performance of fish density and species richness in main channel and tidal creek habitat based on the 4-year running average from 2015 to 2022. A green dot indicates that standard was met, a red dot indicates that a standard was not met.

During monitoring surveys in 2022, variation in the densities of fish among wetlands were primarily driven by the abundance of three groups, gobies, topsmelt, and killifish (Fig. 7.3.2.2). In both main channel and tidal creek habitats, gobies were most abundant in San Dieguito Wetlands, Carpinteria Salt Marsh, and Tijuana Estuary, but killifish were most abundant in Mugu Lagoon.

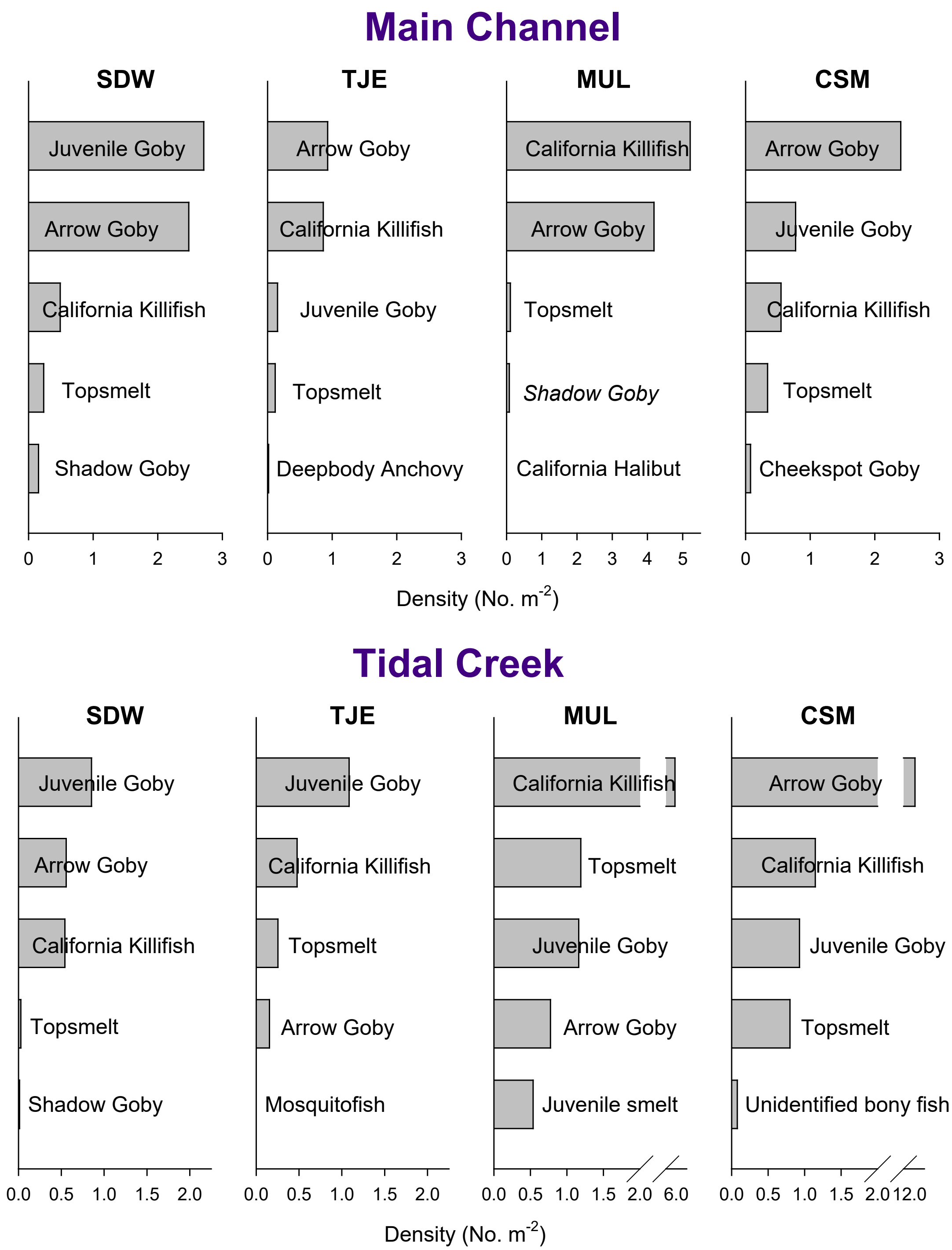


Figure 7.3.2.2. The five most abundant fish in San Dieguito Wetlands and the reference wetlands in main channel (top) and tidal creek (bottom) habitat in 2022. Note the differences among wetlands in the scale of the x-axis to accommodate the wide disparity in fish densities among sites.

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 some tidal creeks by cordgrass suggests that these areas were graded too high during construction, and may be becoming shallower, allowing cordgrass to become established. This habitat change could be a possible mechanism that explains the paucity of fish in San Dieguito Wetlands, at least in tidal creeks.

The relative standard for food chain support incorporates both the densities of shorebirds and their feeding activity. San Dieguito Wetlands has failed this standard the past six years (see Section 6.2). Although San Dieguito Wetlands passed the performance standard for overall bird density in 2022, the density of feeding shorebirds was lower in San Dieguito Wetlands than the reference wetlands (Fig. 7.3.2.3). There has generally been a deficit in shorebird density in San Dieguito Wetlands relative to the reference sites. Thus, the failure of San Dieguito Wetlands to pass the food chain support standard could be due, at least in part, to the low density of shorebirds, and there may be something about the restored wetland that is affecting shorebird abundance. In addition, a lower proportion of birds feeding in San Dieguito Wetlands relative to the reference wetlands could be due to insufficient food resources (e.g., worms). However, macro-invertebrate densities have been consistently low in San Dieguito Wetlands, including during periods when the wetland passed the standard for food chain support. Further analyses of existing data are required to identify the reasons for the underperformance of the food chain support standard in San Dieguito Wetlands.

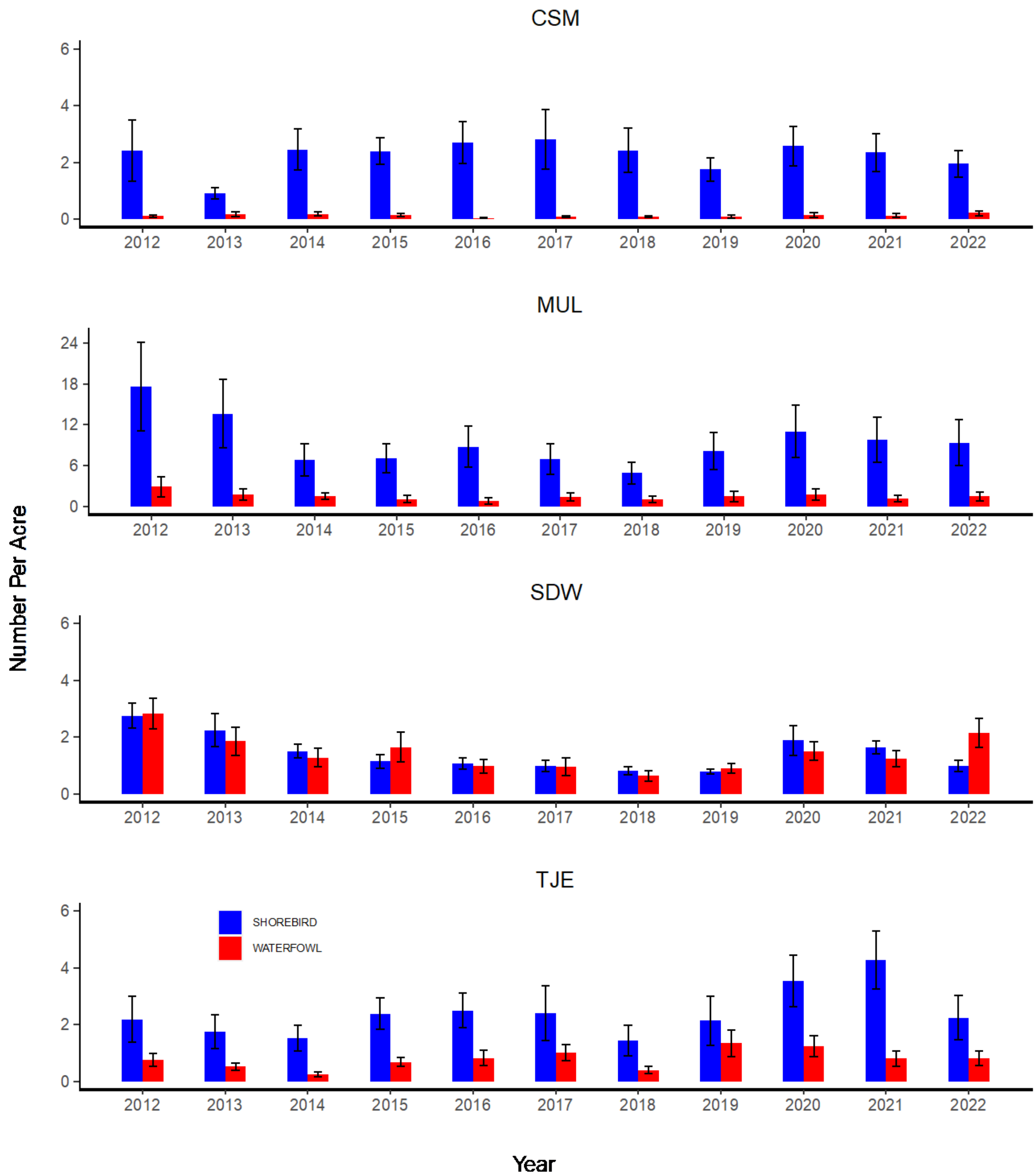


Figure 7.3.2.3. Densities of shorebirds and waterfowl in SDW and the reference wetlands over time. Note the differences among wetlands in the scale of the y-axis to accommodate the wide disparity in the densities of birds among sites.

7.3.3 Explanations for the underperformance of macro-invertebrates and fish

Although the mechanisms responsible for the underperformance of vegetation appear obvious (i.e., highly saline soils, infrequent tidal inundation and poor drainage), the mechanisms responsible for the underperformance of macro-invertebrates and fish in

San Dieguito Wetlands are not. During 2021-22, UCSB scientists evaluated two hypotheses pertaining to the underperformance of macro-invertebrates and fish in San Dieguito Wetland tidal creeks relative to the reference sites.

The first hypothesis concerned sediment properties and pertains primarily to invertebrates. This hypothesis proposes that some characteristics of the sediments are contributing to invertebrate underperformance. Sediment properties (e.g., % silt-clay or the amount of organic matter) have been shown to influence invertebrate distribution and abundance at some wetlands (Levin et al. 1996). During performance monitoring, sediment samples were collected from a subset of the sampling locations and these samples were analyzed for grain size characteristics and percent organic matter. These analyses revealed that sediment properties in tidal creeks were similar across San Dieguito Wetlands and the reference wetlands, so the focus of the discussion below is on the second hypothesis.

The second hypothesis proposes that the physical structure of San Dieguito Wetlands is contributing to the deficit of macro-invertebrates relative to the reference wetlands. As discussed in Section 7.2, *Spartina* has encroached into the sides and bottoms of San Dieguito Wetland tidal creeks in some locations, suggesting that tidal creeks are at a higher elevation in San Dieguito Wetlands than the reference sites, which could affect macro-invertebrate and fish abundance.

UCSB scientists measured the elevation of the macro-invertebrate sampling stations in San Dieguito Wetlands and the reference wetlands in 2021-22. The mean thalweg elevation, the lowest elevation of the creek, in San Dieguito Wetlands is about 0.7 ft higher than the closest reference wetland, which is Tijuana Estuary, and 1.3 to 1.8 ft higher than Mugu Lagoon and Carpinteria Salt Marsh, the other two reference wetlands (Fig. 7.3.3.1). A consequence of these elevation differences is that the higher elevation creeks of San Dieguito Wetlands are inundated by tidal waters less frequently than lower elevation creeks of reference sites.

Examining macro-invertebrate density data across all elevations sampled in the tidal creeks reveals a trend of decreasing invertebrate density with increasing tidal elevation across all the wetlands (Fig. 7.3.3.2). The elevations for the reference wetlands extend lower than those at San Dieguito Wetlands, which has few points below 0 ft NGVD. The trend of decreasing macro-invertebrate density with increasing tidal elevation supports the hypothesis that the higher elevation of the tidal creeks in San Dieguito Wetlands could negatively influence macro-invertebrate density.

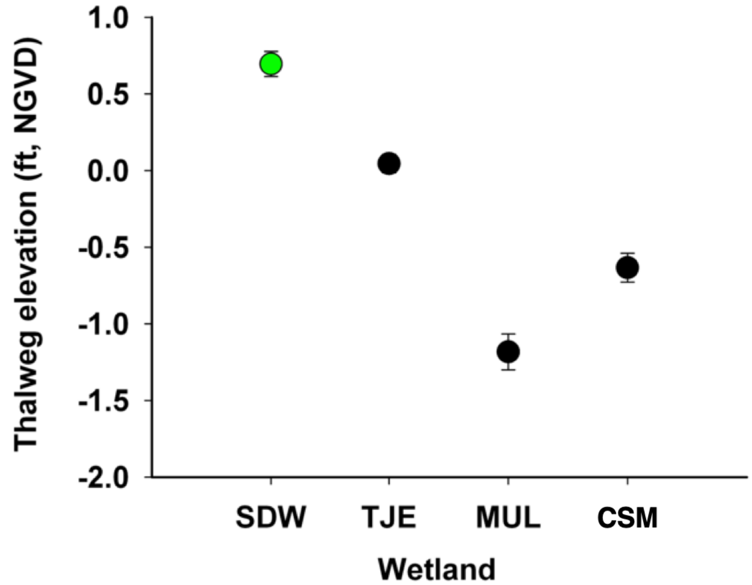


Figure 7.3.3.1. Thalweg elevation (ft, NGVD) at tidal creeks across all wetlands in 2021. Each point represents the mean elevation of the thalweg across all enclosure locations in the six tidal creeks monitored per wetland ± standard error. The mean thalweg elevation at San Dieguito (green point) is significantly higher than all of the reference wetlands (black points).

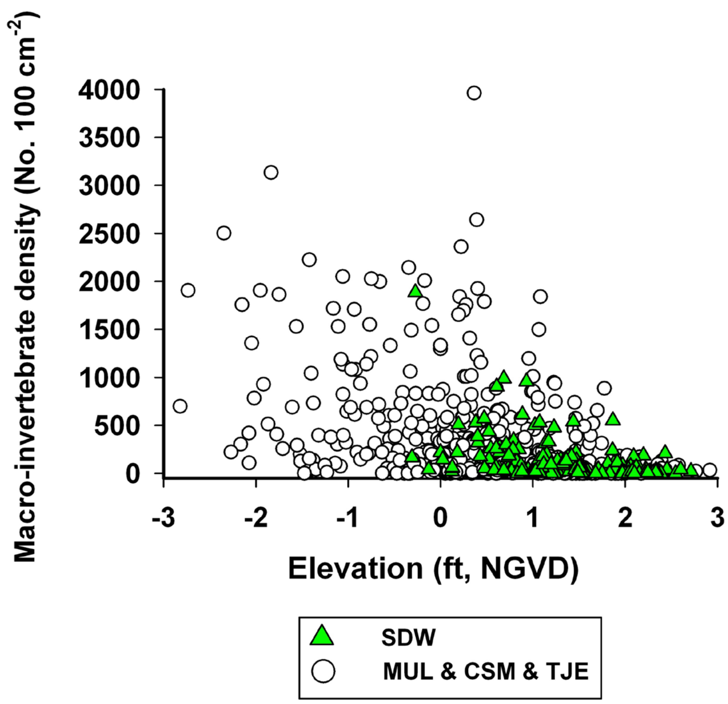


Figure 7.3.3.2. Relationship between macro-invertebrate density and elevation in tidal creek habitat in San Dieguito Wetlands (green triangles) compared to Mugu Lagoon, Carpinteria Salt Marsh, and Tijuana Estuary (unfilled circles) 2021-2022.

7.3.4 Evaluation of the topography hypothesis

To evaluate the topography hypothesis, macro-invertebrates and fish were sampled in the tidal creeks of the 7-year-old 22nd Agricultural District restoration located across the river channel from San Dieguito Wetlands modules W2/3 (i.e., the location of three of the six currently monitored creeks). Figure 7.3.4.1 illustrates that the 22nd Agricultural District creeks are filled with water at the same time in the tide cycle that the San Dieguito Wetlands creeks on the other side of the river channel (W2/3) are empty.

Figure 7.3.4.1. Image showing the lower elevation 22nd Agricultural District tidal creeks and the higher elevation creeks in San Dieguito Wetlands sampled during performance monitoring.

The expectation is that macro-invertebrate and fish densities would be higher in the 22nd Agricultural District creeks compared to those in San Dieguito Wetlands if the higher elevation of San Dieguito tidal creeks is contributing to the deficit in macro-invertebrates and fish.

Figure 7.3.4.2 shows in more detail the creeks that were sampled in W2/3 as part of performance monitoring in 2022, and the supplemental 22nd Agricultural District creeks that were sampled at the same time, together with the mean elevation of the thalweg, the lowest elevation, of the sampled creeks (top panel). The mean thalweg elevation of the 22nd Agricultural District creeks is more than 1.5 ft feet lower than those in W2/3. Two other lower elevation drainages that act as creeks entering mudflat areas in W4/16 on the east side of the freeway were also identified and sampled in 2022 (Fig. 7.3.4.2; bottom panel). The mean thalweg elevation of these supplemental sites is over 1.5 feet lower than the currently monitored creeks in W4/16.

The sampling data from the low elevation creeks were combined and compared to the creeks (n = 6) sampled during performance monitoring (Fig. 7.3.4.3). Mean density of macro-invertebrates was greater in the lower elevation creeks than in the creeks used for performance monitoring. Similarly, macro-invertebrate species richness was greater in the low elevation creeks than in the higher elevation creeks sampled for performance monitoring.

A similar pattern was observed for fish density and species richness. Fish density and richness was greater in the lower elevation supplemental creeks of the 22nd Ag District and W4/W16 than in the higher elevation creeks used for performance monitoring.

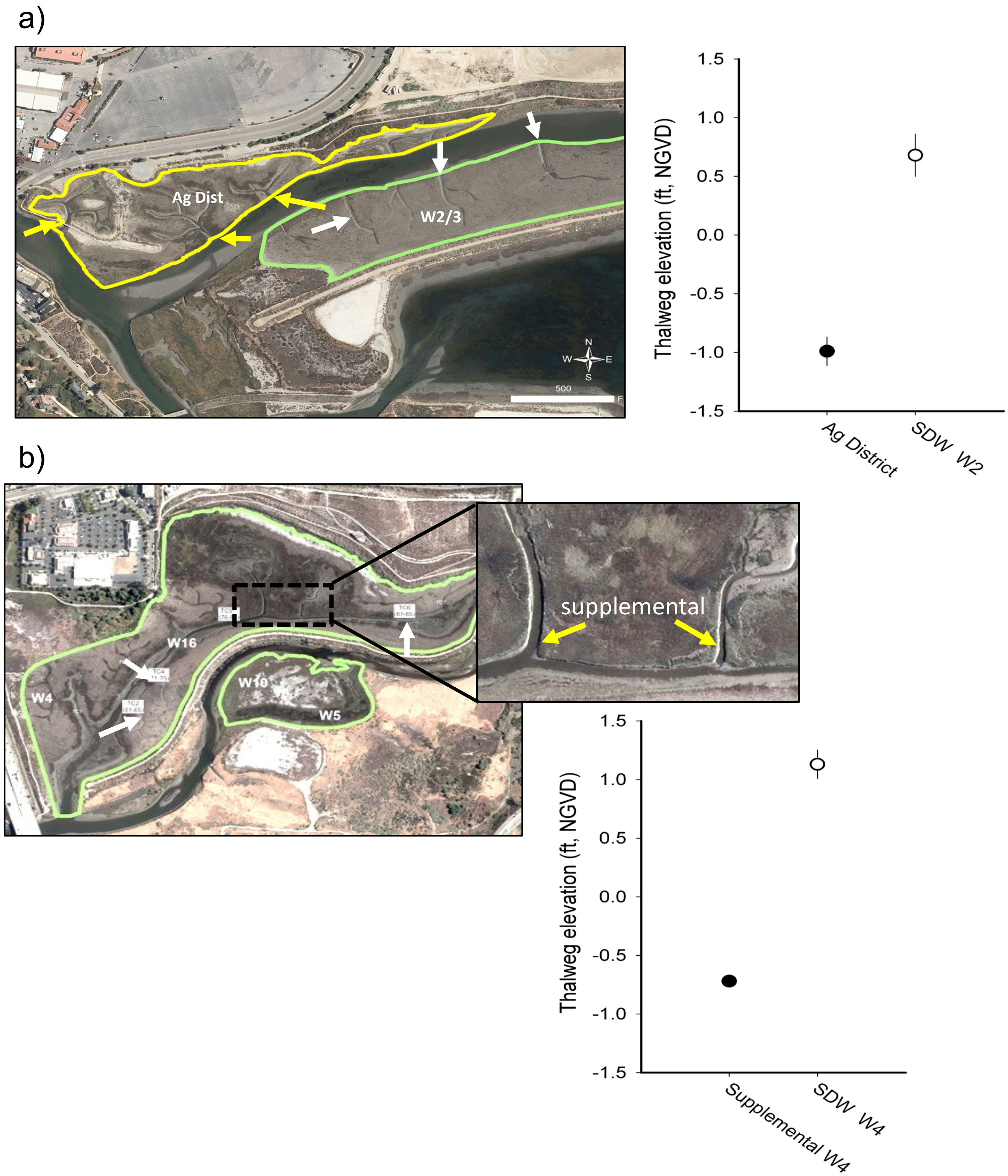


Figure 7.3.4.2. Top panel (a) shows the location of lower elevation 22nd Ag District tidal creeks (yellow arrows) and the higher elevation creeks sampled during performance monitoring in the W2/3 module in San Dieguito Wetlands (white arrows). Bottom panel (b) shows the location of the lower elevation Supplemental creeks in the W4/16 module (yellow arrows) and the higher elevation creeks sampled during performance monitoring in the W4/16 module in San Dieguito Wetlands (white arrows).

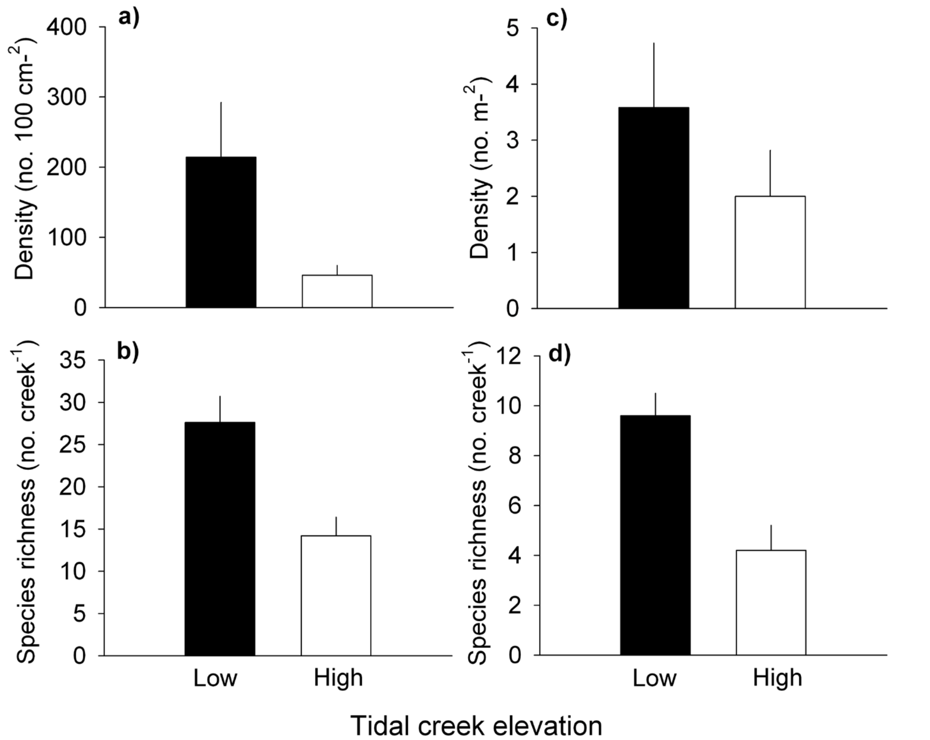


Figure 7.3.4.3. Comparison of the mean a) density of macro-invertebrates, b) species richness of macro-invertebrates, c) density of fish, and d) species richness of fish in lower to higher elevation tidal creeks. Data from low elevation creeks sampled in the 22nd Ag District and module W4/16 combined (n = 5) and compared to the higher elevation creeks sampled during performance monitoring (n = 6).

7.3.5 Summary and future directions

- The relative standards for macro-invertebrate and fish density and species richness in the tidal creeks of San Dieguito Wetlands have not been met consistently.
- The tidal creeks in San Dieguito Wetlands do not extend as low as tidal creeks in the reference wetlands.
- The high elevation of the constructed tidal creeks in San Dieguito Wetlands may impede the ability of the restoration site to consistently meet the relative standards for macro-invertebrates and fish.
- Measurements of wetland elevation are critical for identifying why San Dieguito Wetlands has not consistently met the relative standards for macro-invertebrates and fish.
- Ground elevation surveys and the acquisition of a wetland-wide digital elevation model (DEM) in 2023 will facilitate a geomorphological analysis to understand sediment inputs, processes (accretion, erosion) and habitat evolution that will determine the areal extent and rate of habitat conversion over time.

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 (CCC 1997), we are optimistic that San Dieguito Wetlands will meet the performance criteria for salt marsh habitat in 2023. UCSB scientists, CCC staff, and members of the SAP have put considerable effort into understanding the reasons behind the slow development of vegetation in San Dieguito Wetlands, and SCE has engaged in activities to improve vegetation development, from re-grading part of the wetland to increase tidal inundation and drainage of the marsh surface to an extensive and on-going planting program, and supporting experiments and ancillary monitoring to better understand factors that influence the growth and survival of nursery-grown plants (Beheshti et al. 2023).

However, the area of mudflat habitat has declined in recent years, contributing to the failure of San Dieguito Wetlands to meet the absolute standard for Habitat Areas. Some tidal creeks are also filling in with *Spartina*, suggesting that the creeks are at too high of an elevation, thus impeding the ability of the wetland to consistently meet the relative standards for macro-invertebrates and fish. Consequently, upcoming efforts will focus on understanding the drivers of loss of mudflat and underperformance of macro-invertebrates and fish in tidal creeks throughout San Dieguito Wetlands to inform any remediation should it be required.

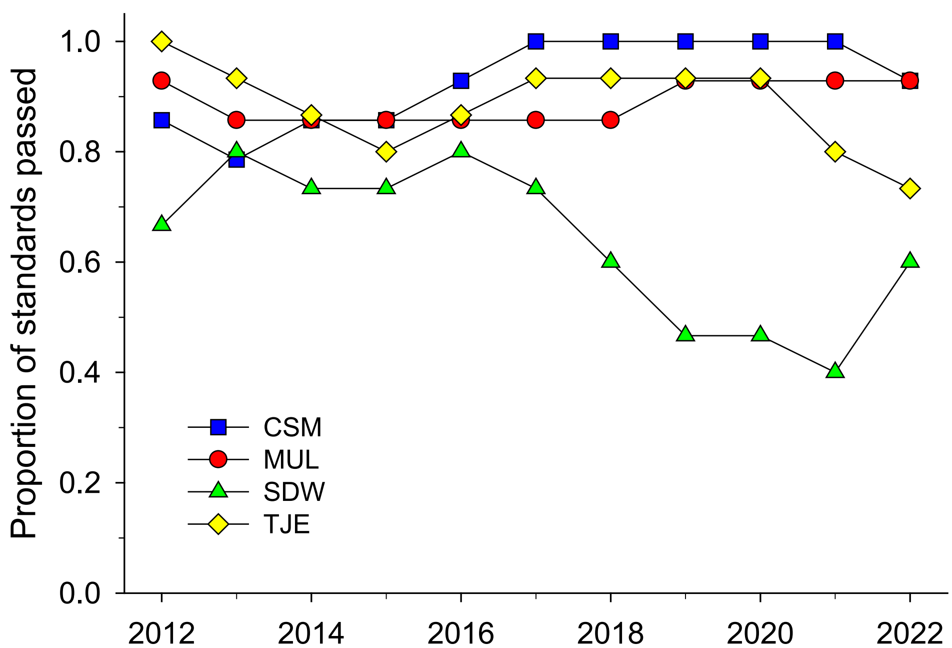


Figure 8.0.1. General decline in the proportion of standards met in San Dieguito Wetlands relative to the reference wetlands over time. Nine standards were evaluated in 2012 and all fifteen standards were evaluated from 2013-2022.

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 Coastal Commission's 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 2023 as required by the SONGS permit (CCC 1997), monitoring SCE's adaptive management program for vegetation, further analysis of existing data, additional analyses of newly acquired elevation data (i.e., RTK transect surveys, Digital Elevation Model) and the collection of additional data to assist in the determination of mechanisms underlying the under-performance of macro-invertebrates, fish, and food chain support. Coastal Commission staff and SCE will be consulted regarding next steps to address the persistent underperformance of a subset of the standards in San Dieguito Wetlands relative to the reference wetlands in order to bring the project into compliance with the SONGS permit (CCC 1997).

9.0 References

Beheshti, K.M., Schroeter, S.C., Deza, A.A., Reed, D.C., Smith, R.S. and Page, H.M. 2023. Large-scale field studies inform adaptive management of California wetland restoration. Restoration Ecology e13936.

CCC (California Coastal Commission). 1997. San Onofre Nuclear Generating Station (SONGS) Coastal Development Permit 6-81-330-A.

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.

Jeppesen, R., M. Rodriguez, J. Rinde, J. et al. 2018. Effects of Hypoxia on Fish Survival and Oyster Growth in a Highly Eutrophic Estuary. Estuaries and Coasts 41, 89–98.

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

Levin, L. A., D. Talley, and G. Thayer. 1996. Succession of macrobenthos in a created salt marsh. Marine Ecology Progress Series 141:67-82.

MEC (Marine Ecological Consultants, 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, and D. Reed. 2022. Monitoring Plan for the SONGS' Wetland Mitigation Project. Report to the California Coastal Commission.

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. 2006b. 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.

Wasson K., R. Jeppesen, C. Endris, D. Perry, A. Woolfolk, K. Beheshti, M. Rodriguez, R. Eby, E. Watson, F. Rahman, J. Haskins, and B.B. Hughes. 2017. Eutrophication decreases salt marsh resilience through proliferation of algal mats. Biological Conservation 212: 1-11.

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