Salt Marsh Vegetation & Biological Standards
Status Update

May 4, 2021
SONGS Mitigation Monitoring Project
Marine Science Institute, University of California Santa Barbara

- This presentation concerns the status of standards that have consistently underperformed in San Dieguito Wetlands.

Salt Marsh Vegetation & Biological Standards
Status Update

Standards that have consistently underperformed over multiple years in San Dieguito Wetlands:

	Status
• Salt marsh vegetation	
– Habitat areas	Standard has yet to be met
– Vegetation cover	Standard has yet to be met
• Biological standards	
– Invertebrate density (MC)	Standard met once in 9 years
– Invertebrate density (TC)	Standard has yet to be met

- Standards that have consistently underperformed over multiple years in San Dieguito Wetlands include two that depend on the development of salt marsh vegetation.
- First, is the habitat areas standard, which as an absolute standard, must be met every year,
- This is the only absolute standard that has yet to be met.
- The second standard is the relative standard for vegetation cover, which also has not yet been met.
- Because of the importance of vegetation development to meeting these two standards, discussion and adaptive management activities to increase vegetation cover over the past several years has been a focus of efforts by ourselves and SCE.
- Among the standards that pertain to biological communities, which have consistently underperformed are those related to the densities of invertebrates in main channel and tidal creek habitats.
- The standard for invertebrate density in main channel has only been met once over the past 9 years.
- The standard for invertebrate density in tidal creek has never been met.

Salt Marsh Vegetation & Biological Standards
Status Update

Standards that have consistently underperformed over multiple years in San Dieguito Wetlands:

	Status
• Salt marsh vegetation	
– Habitat areas	Standard has yet to be met
– Vegetation cover	Standard has yet to be met
• Biological standards	
– Invertebrate density (MC)	Standard met once in 9 years
– Invertebrate density (TC)	Standard has yet to be met

Other standards that have underperformed in San Dieguito Wetlands:

• Fish density, richness (MC,TC)	Standards not met in 2020
• Food chain support (bird feeding)	Not met in last 4 years

- A second group of standards have underperformed more recently.
- These include the relative standards for fish density and richness in main channel and tidal creek habitats.
- None of these standards were met in 2020, and not consistently met over the past 3 years
- And food chain support, in terms of bird feeding activity, has not been met in the past 4 years.

Salt Marsh Vegetation & Biological Standards
Status Update

Standards that have consistently underperformed over multiple years in San Dieguito Wetlands:

	Status
• Salt marsh vegetation	
– Habitat areas	Standard has yet to be met
– Vegetation cover	Standard has yet to be met
• Biological standards	
– Invertebrate density (MC)	Standard met once in 9 years
– Invertebrate density (TC)	Standard has yet to be met

Other standards that have underperformed in San Dieguito Wetlands:

- Fish density, richness (MC,TC) Standards not met in 2020
- Food chain support (bird feeding) Not met in last 4 years

- For todays presentation, we will discuss the current status of vegetation and activities underway to facilitate vegetation development, and some analyses and observations pertaining to possible mechanisms that might be contributing to the low densities of invertebrates.
- Since invertebrates are important in food chain support to fish and birds, these mechanisms may also apply, at least in part, in explaining the underperformance of those standards.

Performance Standards Pertaining to Cover of Vegetation

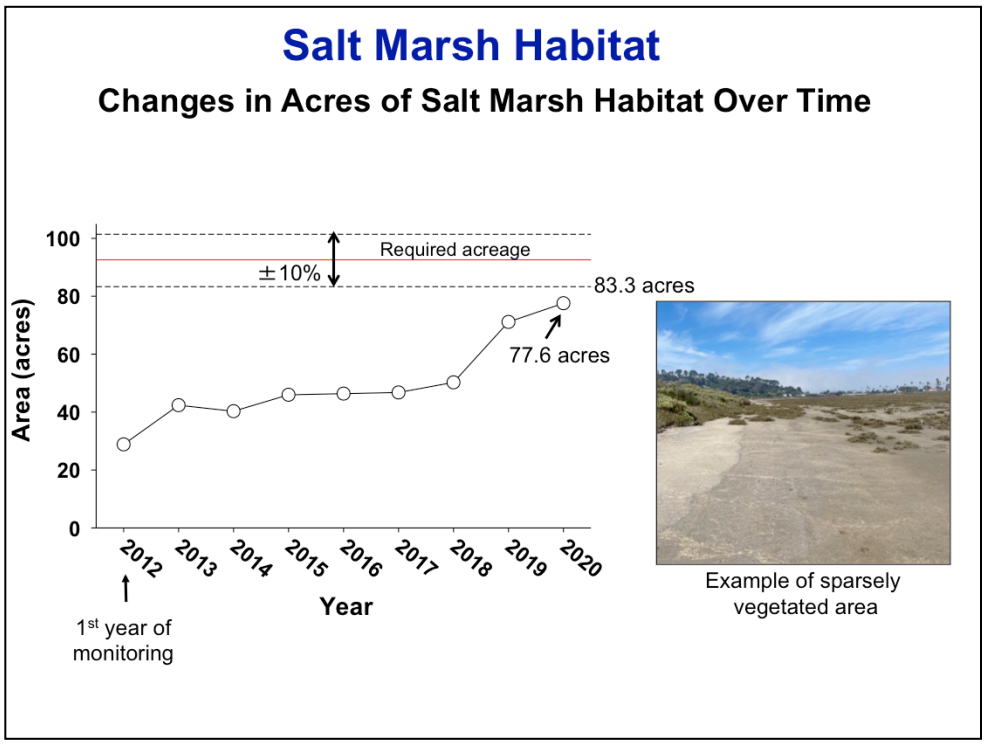
Absolute Standard: Habitat Areas

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

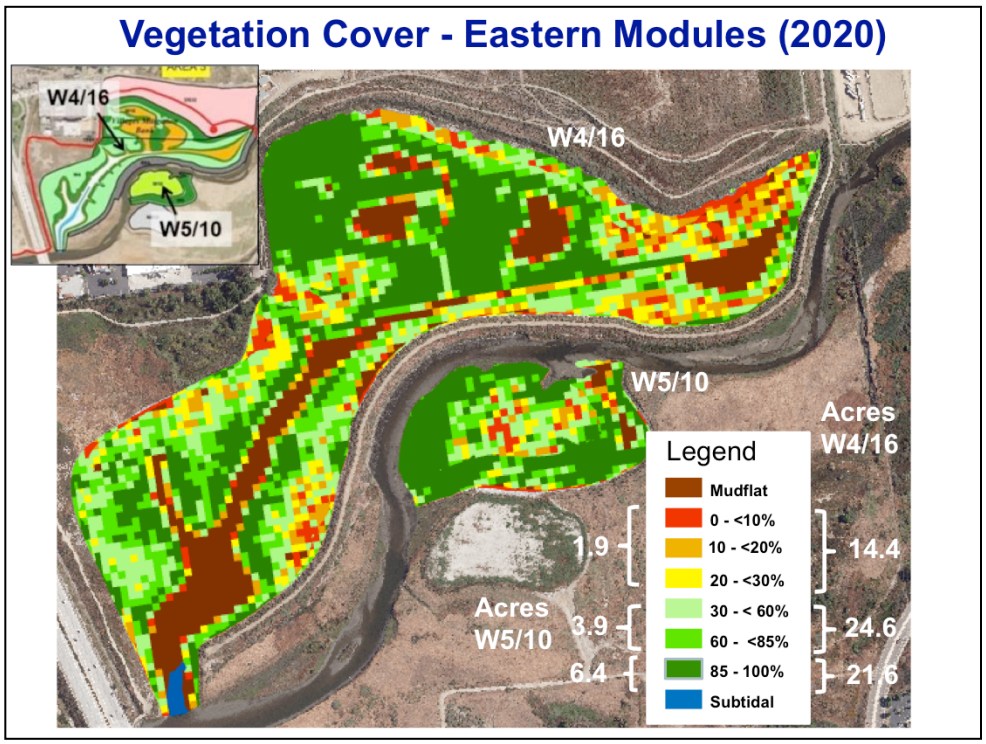
Relative Standard: Vegetation

The proportion of total vegetation cover in the marsh shall be similar to those proportions found in the reference sites.

- There are two standards that pertain to the cover of vegetation.
- The first is the Habitat Areas standard. This is an absolute standard that is evaluated only in San Dieguito Wetlands and specifies that the area of different habitats shall not vary more than 10% from the areas in the final restoration plan.
- To be assessed as salt marsh habitat the cover of vegetation must be at least 30% and this 30% is evaluated within 10 x 10 m grids covering the entire wetland as discussed by Steve in the Performance talk.
- The second standard that pertains to the cover of vegetation is the Vegetation standard.
- This is a relative standard and requires that the proportion of total vegetation cover in the marsh shall be similar to those proportions found in the reference sites.
- The project has relied on natural recruitment of vegetation and several planting efforts have been undertaken to facilitate vegetation development.

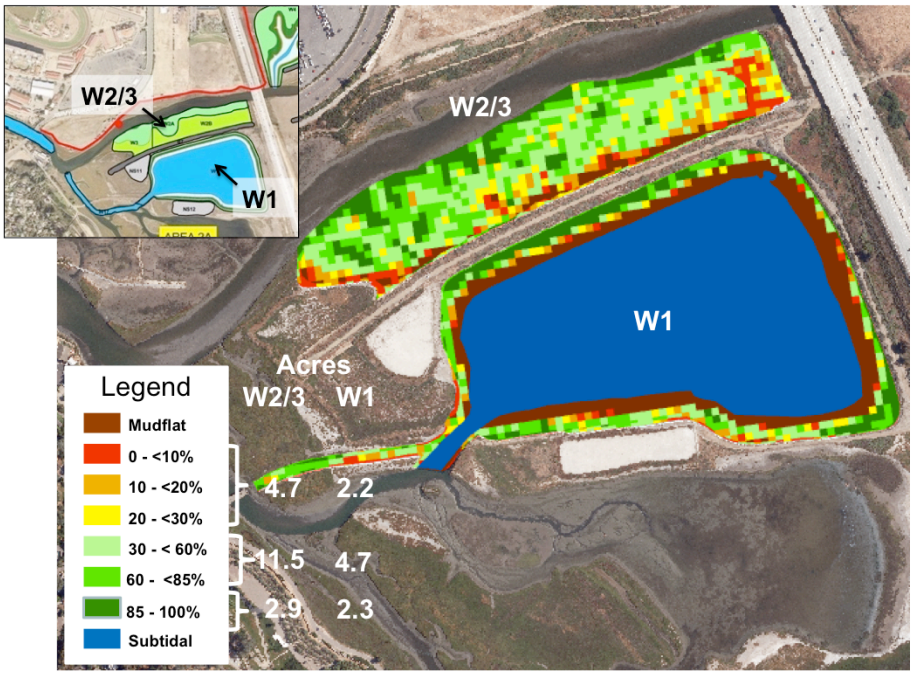


- In this figure we examine the change in area (acres) of salt marsh habitat over time.
- The planned acres of salt marsh habitat is shown by the red line, with +/-10% of that value indicated by the dashed line.
- Overall, after 9 years, vegetation is still underperforming although there was an appreciable increase in the acreage of salt marsh habitat over the past couple of years, likely facilitated by the higher levels of rainfall during 2018 relative to the previous years.
- San Dieguito is still 5 -6 acres short of the minimum number of required acres of salt marsh habitat, at least 30% cover although the trend moving forward in attaining this number of acres is promising.

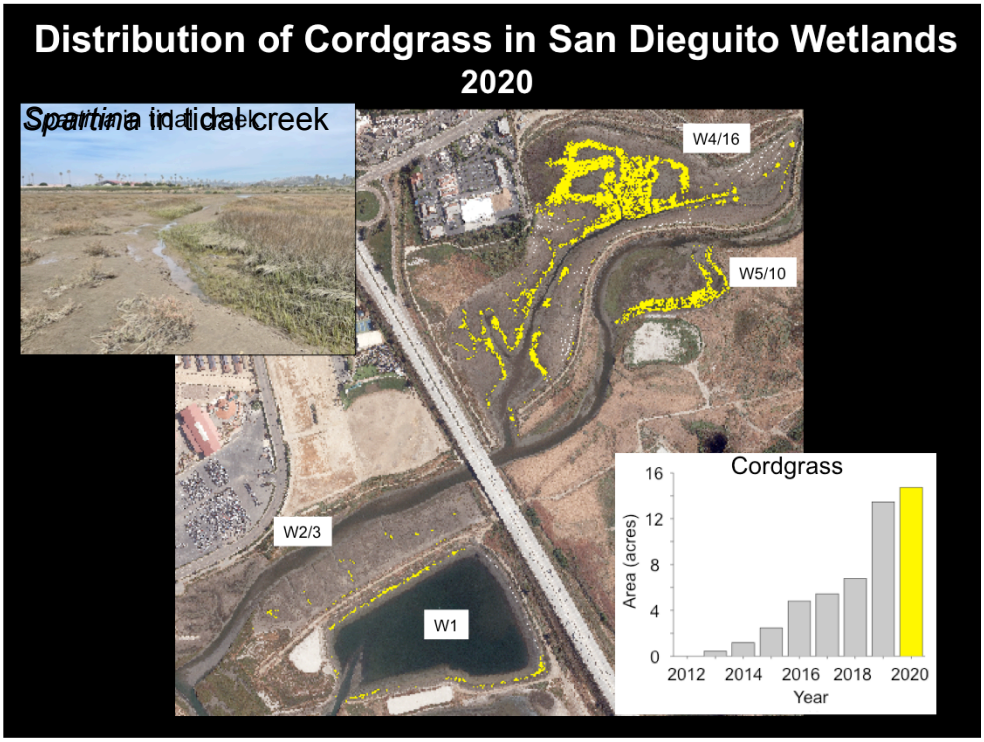


- We can use our monitoring data to help identify areas in the wetland where vegetation is underperforming.
- This slide shows the wetland modules on the east side of the freeway.
- The inset in the upper left corner is extracted from the Restoration Plan shows that most of these modules were planned vegetated salt marsh habitat, indicated as shades of green.
- The brown indicates planned mudflat.
- We have broken down vegetation cover determined using aerial imagery in 2020 into cover classes: warm colors represent cover classes <30% with red the lowest (0-10%)
- Areas that meet the Habitat Areas standard, that is with cover > or equal to 30% are indicated by shades of green, with darkest green showing areas that are 85% or greater cover.
- Also provided are the estimated acres for each cover class.
- As of 2020, areas of red and orange that might benefit from some form of intervention to achieve at least 30% plant cover, are located at the higher elevations and in the eastern portion of W4/16.
- Areas of orange and yellow, of low to intermediate plant cover might also benefit from planting not only to meet the habitat areas standard, but to increase cover towards the 85% or higher cover seen in the reference wetlands.

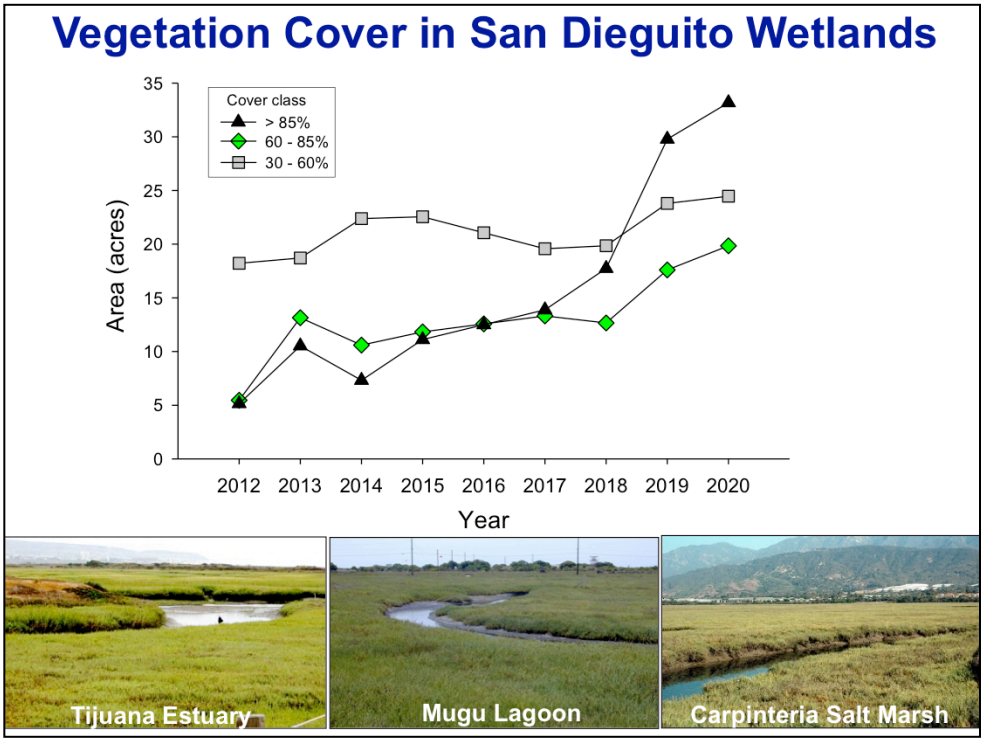
Vegetation Cover - Western Modules (2020)



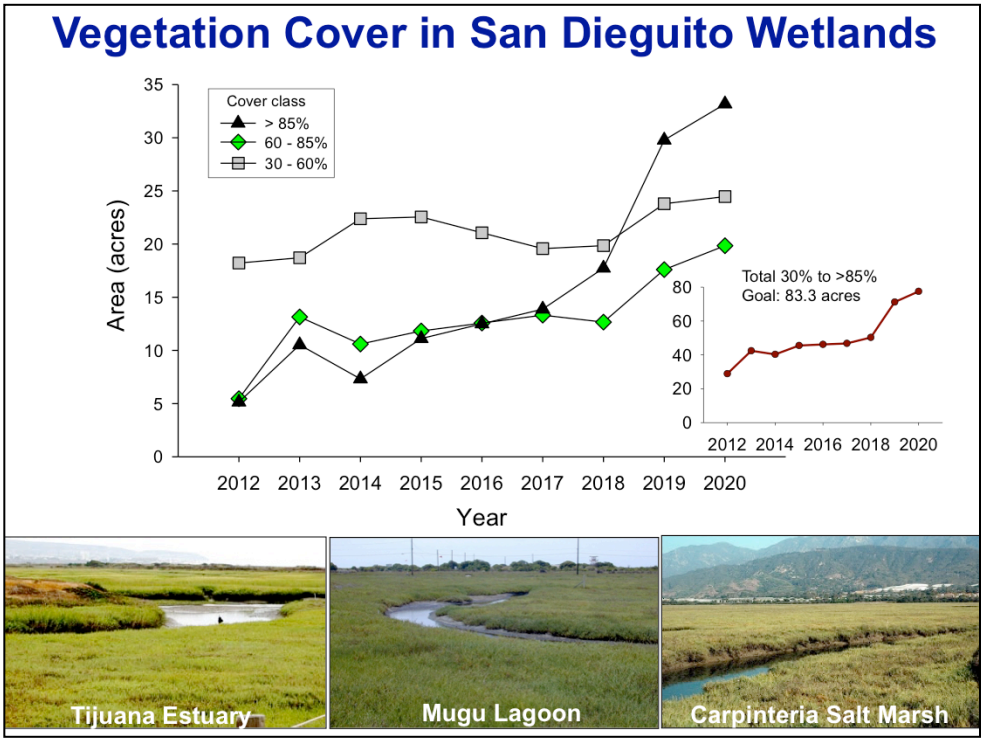
- Similarly, we can take a look at the modules on the west side of the freeway, that includes W2/3 and the basin, W1.
- The inset shows that modules W2/3 were planned vegetated salt marsh habitat.
- Module W1 is largely a subtidal basin bordered by mudflat and a strip of vegetated marsh.
- We can see that about 14 of 20 acres of W2/3 had achieved at least 30% cover in 2020 and that 5 acres of sparse vegetation remain, particularly at the higher elevations and eastern end.
- About 5 out of the 20 acres have achieved at least 85% cover in W2/3.



- Cordgrass, *Spartina foliosa*, continues to expand in distribution throughout the lower elevation areas of the restoration project.
- The aerial image shows cordgrass patches, indicated by yellow color, in modules W4/16 and W5 on the east side of the freeway and around the basin module W1 on the west side of the freeway.
- There was an increase of about 6 acres in 2018 to 2019 compared with only 1.3 acres to 14.7 acres in 2020.
- Note that cordgrass has expanded into some of the tidal creek areas in modules on both sides of the freeway, which we will discuss further in the presentation.



- Taking a look at trend of increase in vegetation cover, this figure shows changes in vegetation cover over time for cover classes of vegetation of >85%, 60-85%, and 30-60% through 2020.
- One goal of the restoration project is to achieve not only a minimum of 83.3 acres of salt marsh habitat, but a high cover of vegetation similar to the reference wetlands shown on the slide.
- There was an appreciable increase in the acres of >85% cover to around 30 acres in 2019, and that has increased to close to 35 acres in 2020, although it looks like the rate of increase of the >85% cover class is slowing and more comparable to years prior to the rains of 2018.
- Cover in 60 – 85% cover class is increasing, which is encouraging
- The cover of 30-60% is increasing slowly as vegetation in cover classes of <30% grows into the 30-60% cover class, and some of the 30-60% grows into the 85% class.



- The inset on the right show the promising increase in areas of at least 30% cover through 2020.

Update on experiments to inform SCE planting program

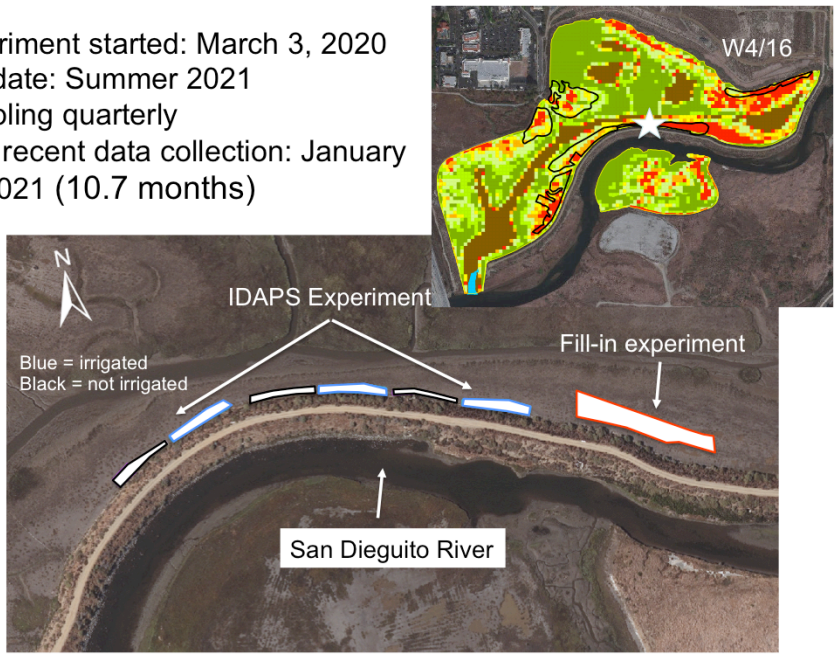
- IDAPS experiment: Test the effect of irrigation, decompaction, amendments, planting, and seeding on increasing the cover of vegetation. Only *Arthrocnemum* planted.
- Fill-in experiment: Test the effect of planting versus seeding on filling in gaps in plant cover at lower tidal elevations. No soil treatments or irrigation. *Arthrocnemum, Frankenia, Salicornia* planted.

De-compacting | Adding amendment | Experimental quadrats

- Setal Pradhu from SCE will speak about their planting program in the presentation following this one.
- Two experiments were embedded within the 2020 planting program.
- The goal of the first experiment, which we call the IDAPS experiment is to test the effect of several variables to increase plant cover in sparsely vegetated areas.
- These variables are irrigation, soil decompaction, and soil amendments, planting of potted plants, and seeding.
- Only one plant species was planted as part of this experiment, Arthrocnemum (Parish's glasswort).
- This experiment is being conducted at higher elevations.
- We call the second experiment, the Fill-in experiment.
- The goal of the Fill-in experiment is to test the effect of planting versus seeding on filling in gaps in plant cover at lower elevations.
- There are no soil treatments or irrigation in the Fill-in experiment.
- Three plant species Arthrocnemum, Frankenia, and Salicornia were planted and compared to a seeding only treatment.

Experiment locations & timetable

Experiment started: March 3, 2020
End date: Summer 2021
Sampling quarterly
Most recent data collection: January 19, 2021 (10.7 months)



- This slide shows the location, indicated by the star, and layout of the two experiments: IDAPS experiment at high elevation (4.25 – 3.5 feet NGVD) and the Fill-in experiment at lower elevation (< 3.5 feet NGVD) in Module W4 east of the I-5 freeway.
- Another Fill-in experiment on west side of freeway.
- The Fill-in experiment is being done at lower tidal elevations that already have approximately 10% cover of plants.
- These experiments were started in March 2020 and will be concluded this summer.
- We are sampling the percent cover, growth, and survival of plants in the experiment plots.

Progress report – what we have learned

1. **No effect of seeding on plant cover**
   Plant cover low in Seeded (1-6%) and Control (1-6%) plots for both IDAPS and Fill-in experiments

- Although experients are on-going, we can provide a progress report – what we have learned so far.
- No effect of seeding on plant cover
- Plant cover low in Seeded (1-6%) and Control (1-6%) plots for both IDAPS and Fill-in experiments

Progress report – what we have learned

1. **Seeding treatments** – **No effect of seeding on plant cover**
   Plant cover low in Seeded (1-6%) and Control (1-6%) plots for both IDAPS and Fill-in experiments

2. **Planted treatments**
   a) IDAPS Experiment
      i. **No effect of the manipulations on plant cover or plant sizes** (i.e., soil amendments, decompaction, irrigation)
      ii. Plantings have not yet increased cover, which remains low in Planted (3-7%) and Control (1-6%) plots

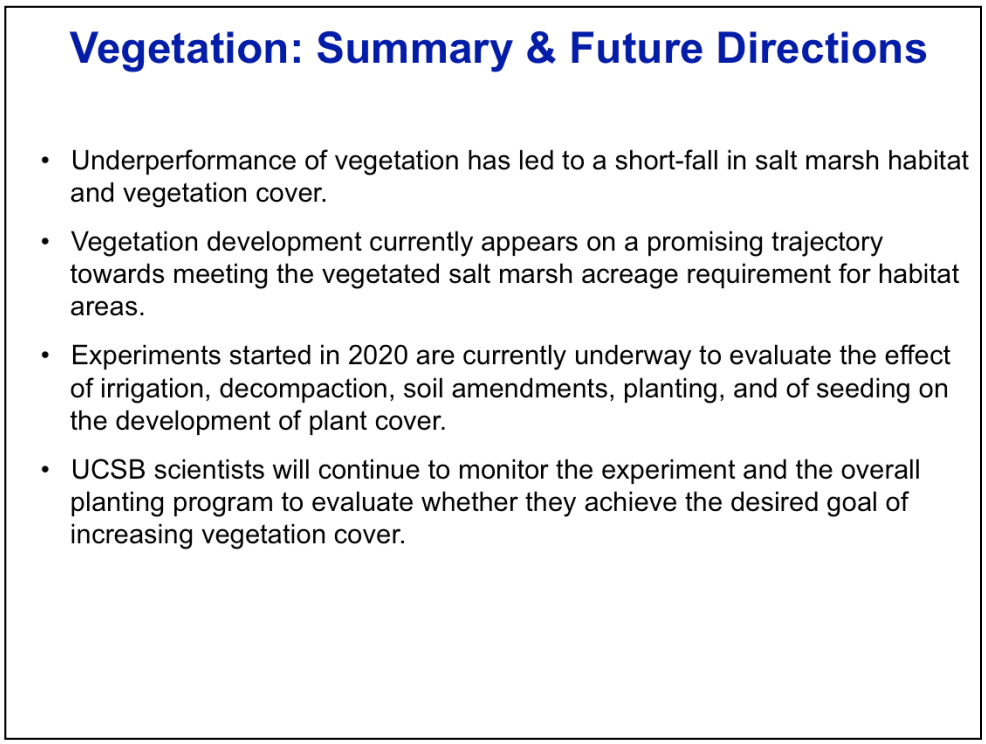
- Planted treatments
- IDAPS Experiment
- No effect of the manipulations on plant cover or plant sizes (i.e., soil amendments, decompaction, irrigation)
- Plantings have not yet increased cover, which remains low in Planted (3-7%) and Control (1-6%) plots

Progress report – what we have learned

1. **Seeding treatments – No effect of seeding on plant cover**
   Plant cover low in Seeded (1-6%) and Control (1-6%) plots for both IDAPS and Fill-in experiments

2. **Planted treatments**
   a) IDAPS Experiment
      i. **No effect of the manipulations on plant cover or plant sizes** (i.e., soil amendments, decompaction, irrigation)
      ii. Plantings have not yet increased cover, which remains low in Planted (3-7%) and Control (1-6%) plots
   b) Fill-in Experiment
      i. ***Arthrocnemum* not recommended for the goal of increasing plant cover compared with other species**
         - No difference for *Arthrocnemum* between Planted (6-7%) versus Control (1-6%) plots
         - Significantly higher % cover for *Frankenia* (14-22%) and *Salicornia* (26-28%) versus Control plots

- Turning to the Fill-in Experiment
- *Arthrocnemum* not recommended for the goal of increasing plant cover compared with other species
- No difference for *Arthrocnemum* between Planted (6-7%) versus Control (1-6%) plots
- However, the two other species, Frankenia and Salicornia, look more promising in increasing plant cover
- Significantly higher % cover for *Frankenia* (14-22%) and *Salicornia* (26-28%) versus Control plots



- To summarize the results for vegetation
- Underperformance of vegetation has led to a short-fall in the acres of salt marsh habitat and in vegetation cover.
- Vegetation development currently appears on a promising trajectory towards meeting the vegetated salt marsh acreage requirement for habitat areas.
- Experiments started in 2020 are currently underway to evaluate the effect of irrigation, decompaction, soil amendments, planting, and of seeding on the development of plant cover.
- UCSB scientists will continue to monitor the experiment and the overall planting program to evaluate whether they achieve the desired goal of increasing vegetation cover.

Performance Standards Pertaining to Invertebrates

Relative Standards:

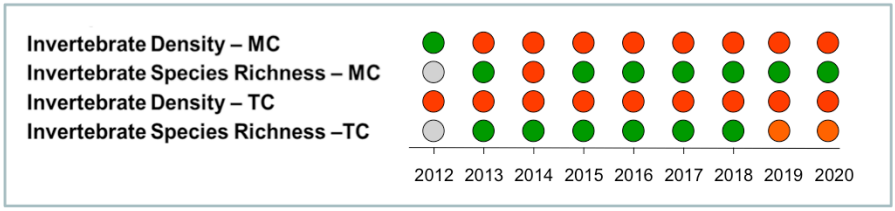
The total densities and number of species of macroinvertebrates shall be similar to the densities and number of species in similar habitats in the reference wetlands.

Evaluated separately for two habitats:

- Main channel
- Tidal creek

- Turning to the deficit in invertebrate densities.
- This slide shows the relative standards for invertebrates.

Underperformance of Invertebrates in San Dieguito Wetlands



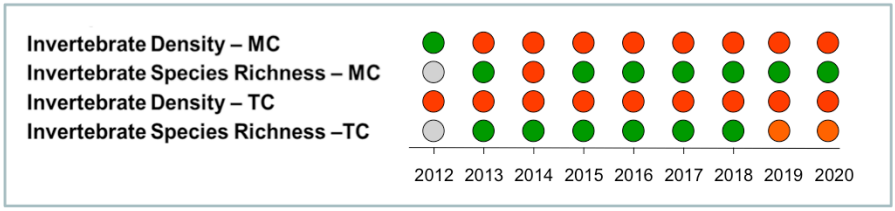
Standard met
Standard not met
No data

May be different mechanisms responsible for the underperformance of invertebrates in tidal creeks and main channels

Encroachment of *Spartina* into tidal creeks indicates elevation high enough in these areas to support low salt marsh vegetation

- To review, the standards for invertebrate density were only met the first year in main channel habitat and have never been met in tidal creek habitat.
- The standards for species richness, has been met for main channel habitat, and was until the last couple of years met in tidal creek habitat.
- There may be different explanations or mechanisms contributing to the underperformance of invertebrates in tidal creek and main channel habitats.
- As mentioned earlier, Spartina has encroached into portions of tidal creeks, indicating that creek elevations are high enough to support low marsh vegetation.

Underperformance of Invertebrates in San Dieguito Wetlands



Standard met
Standard not met
No data

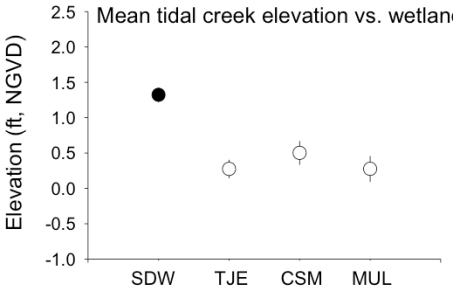
One possible hypothesis:

Invertebrate densities are lower at higher elevations and the tidal creek habitats are higher in SDW than the reference wetlands.

Encroachment of *Spartina* into tidal creeks indicates elevation high enough in these areas to support low salt marsh vegetation

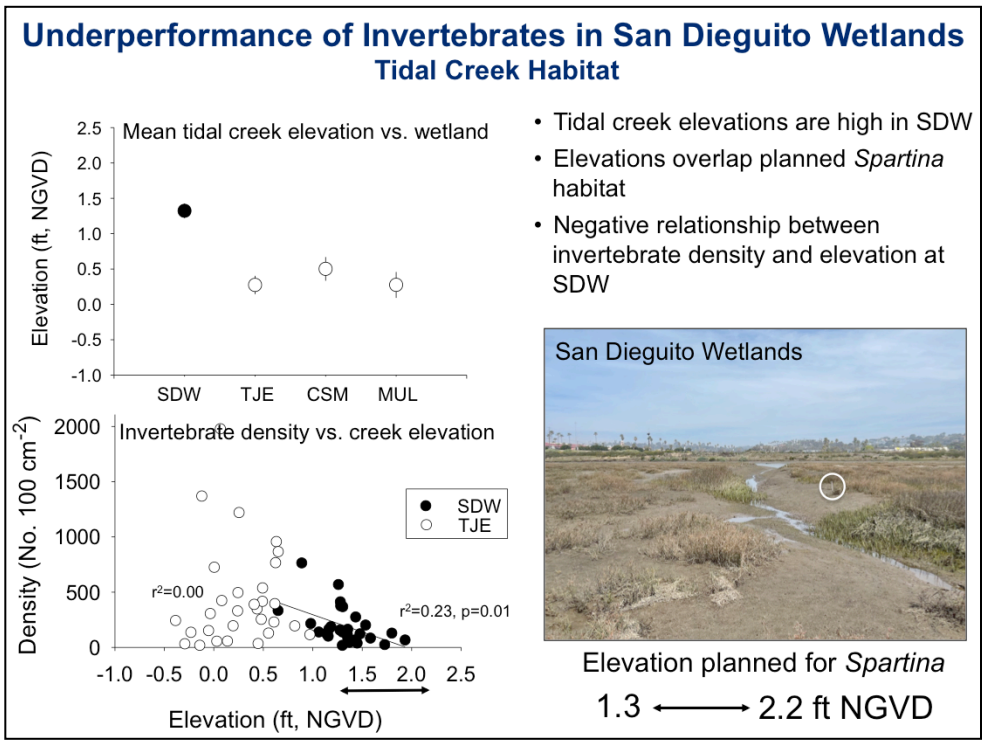
- One possible hypothesis for the low densities of invertebrates in tidal creeks is that the density of invertebrates varies inversely with elevation and that the elevations of this habitat are higher in San Dieguito Wetlands than the reference wetlands.

Underperformance of Invertebrates in San Dieguito Wetlands
Tidal Creek Habitat



- Tidal creek elevations are high in SDW

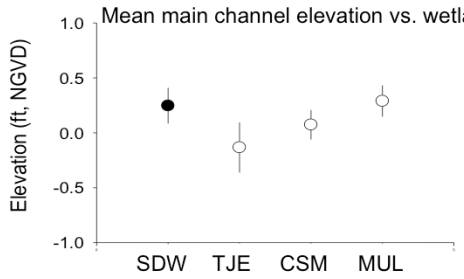
- We measured the elevation of all of our invertebrate sampling stations in SDW and the reference wetlands in 2020.
- In the figure in the top left, we have the elevation for each station, plus or minus 95% confidence intervals, on the y axis and wetland on the x-axis.
- We can see that the mean elevation of tidal creek stations in SDW is quite a bit higher, approximately a foot higher, than the reference wetlands, which are comparable.
- The white circle shows one of our sampling stations.



- We can take a look at the relationship between density of invertebrates at each station on the y axis and elevation on the x-axis shown in the figure on the bottom left.
- Data for SDW are represented using filled circles.
- Also included are data from TJE, the lowest performing reference wetland with open circles.
- We can see that SDW is not entirely depauperate, some stations in SDW have invertebrate densities comparable to stations in TJE, but there is a negative relationship between density and elevation at SDW
- Higher densities tend to be a lower elevations. (higher densities in old nicks)
- Tidal creek elevations at SDW overlap elevations that were planned low marsh to be vegetated by Spartina.
- These data support the hypothesis that the underperformance of invertebrates in SDW tidal creeks is related to the shallowness or higher elevation of the tidal creek habitat.

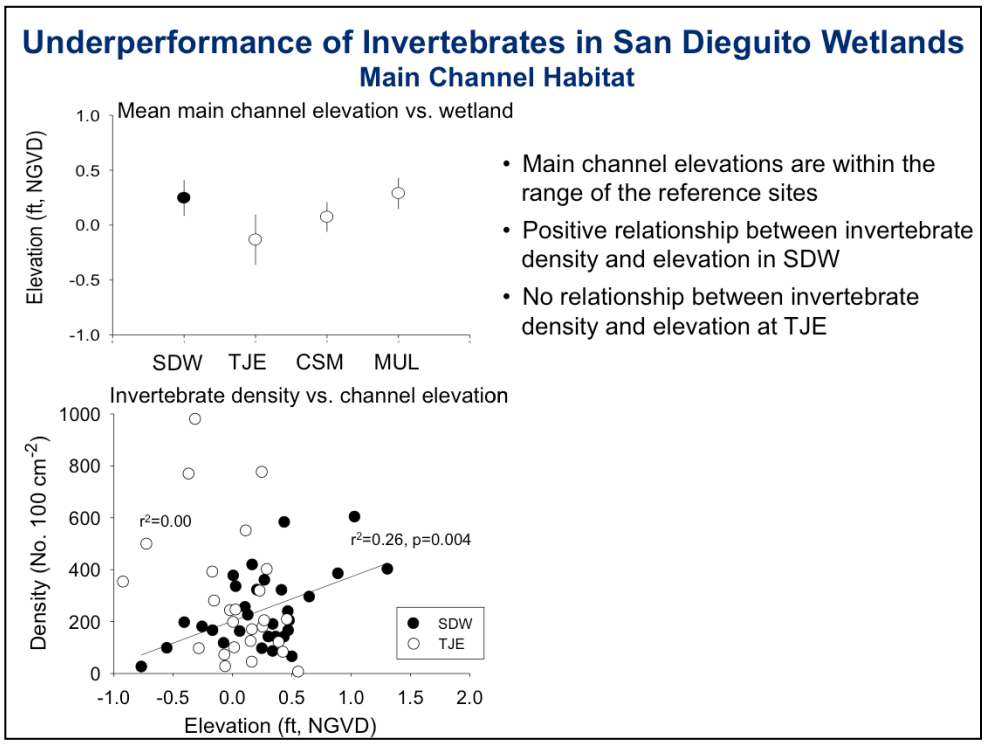
Underperformance of Invertebrates in San Dieguito Wetlands

Main Channel Habitat

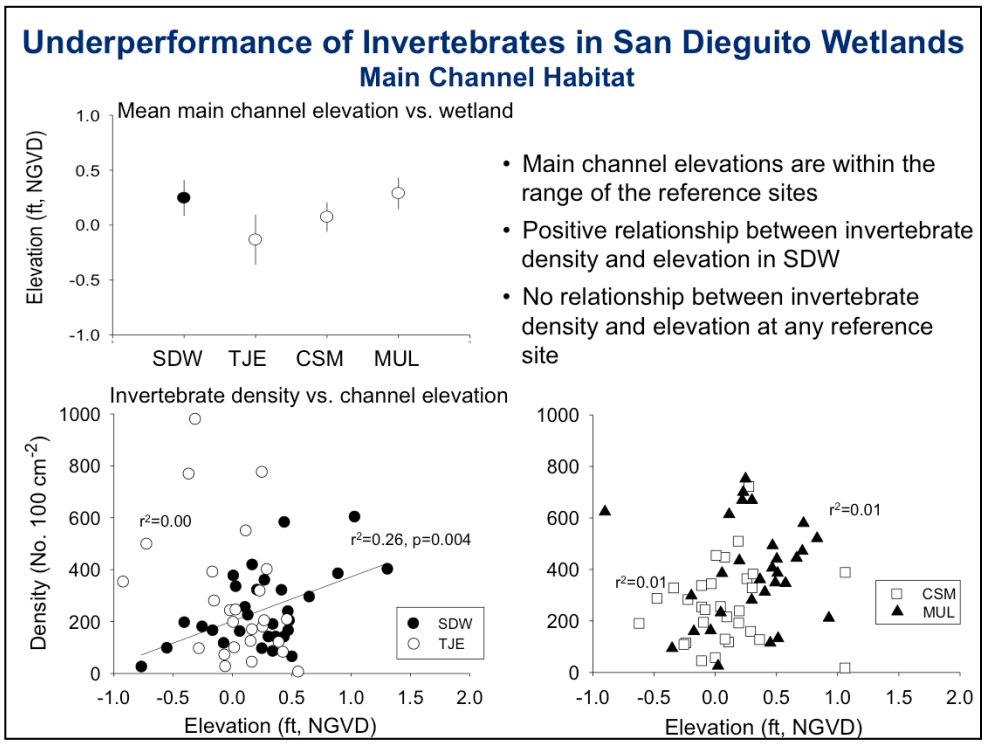


- Main channel elevations are within the range of the reference sites

- The situation is different for the main channel habitat.
- The top left figure compares mean elevations of these stations at SDW with those of the reference wetlands.
- The elevations in SDW are within the range of the reference wetlands, more comparable between SDW and CSM and MUL, stations at TJE lower.

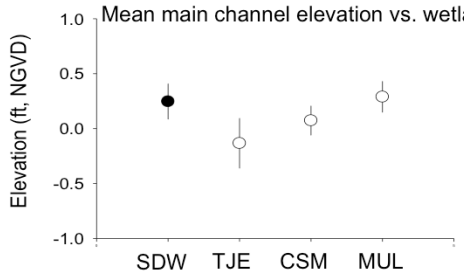


- Looking at the relationship between invertebrate density and elevation, in the lower left figure, the densities in SDW shown by filled circles, appear to be higher at higher elevations.
- The open circles are data from TJE, and show no relationship with elevation – elevations don't go as high as SDW.

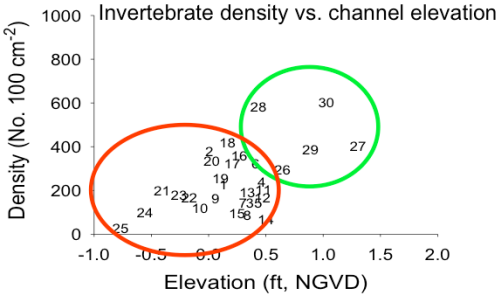


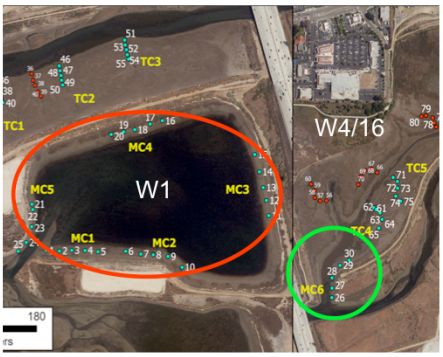
- The pattern of higher density at higher elevations, suggested for SDW, also not evident in CSM or MUL, shown in the bottom right figure – where station elevations are more comparable to SDW.

Underperformance of Invertebrates in San Dieguito Wetlands
Main Channel Habitat



Invertebrate densities higher at stations in entrance channel to W4/16 than basin (W1)

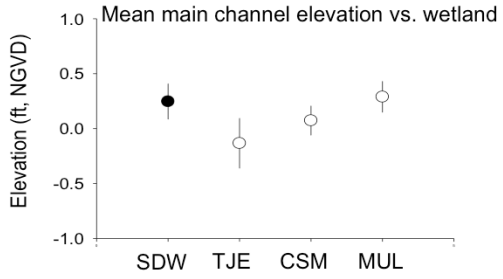




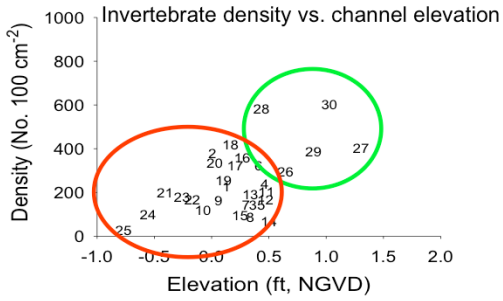
- Looking at the stations in SDW in more detail, we see that the stations with the highest densities are located in the entrance channel to module W4/16.
- Stations with lower densities tend to be located in the basin.

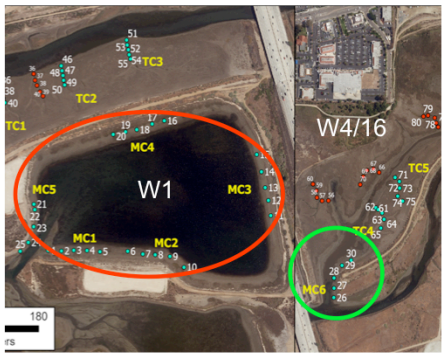
Underperformance of Invertebrates in San Dieguito Wetlands

Main Channel Habitat



Working hypothesis: sediments are coarser at basin stations, adversely affecting invertebrate densities





- Although the stations in the entrance channel are higher than the basin stations, our working hypothesis, based on observation in SDW, is that sediments are coarser at the basin stations, and that this is adversely affecting invertebrate densities at these stations.

Invertebrates: Future Directions

To understand mechanisms leading to underperformance of invertebrates in main channel and tidal creek habitat, we will:

Analyze existing data

- More detailed analysis of relationships between invertebrate density and elevation in main channel and tidal creek habitat

To understand mechanisms leading to underperformance of invertebrates in main channel and tidal creek habitat, we will:

- Continue to analyze existing data
- More detailed analysis of relationships between invertebrate density and elevation in main channel and tidal creek habitat

Invertebrates: Future Directions

To understand mechanisms leading to underperformance of invertebrates in main channel and tidal creek habitat, we will:

Analyze existing data

- More detailed analysis of relationships between invertebrate density and elevation in main channel and tidal creek habitat

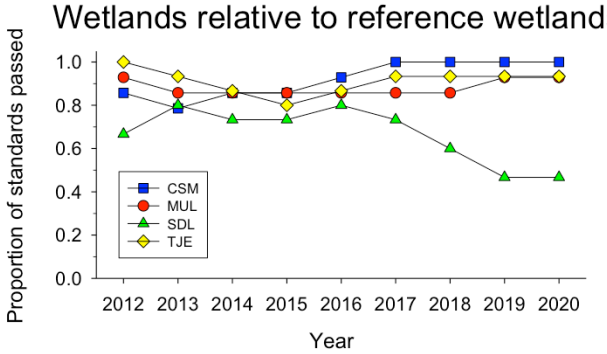
Collect new data

- Compare sediment properties (grain size, organic matter content) between stations in main channel and tidal creek habitat
- Propose a targeted experiment to compare colonization of invertebrates in sediments from basin and entrance channel (reciprocal transplant experiment)
- Control for any elevation effects in sampling and experiment

To understand mechanisms leading to underperformance of invertebrates in main channel and tidal creek habitat, we will:

- Collect new data
- Compare sediment properties (grain size, organic matter content) between stations in main channel and tidal creek habitat
- Propose a targeted experiment to compare colonization of invertebrates in sediments from basin and entrance channel (reciprocal transplant experiment)
- Control for any elevation effects in sampling and experiment

Progressive decline in proportion of standards met in San Dieguito Wetlands relative to reference wetlands



"Upon completion of construction of the wetland, monitoring shall be conducted to measure the success of the wetland in achieving stated restoration goals ..... and in achieving performance standards.... The permittee shall be fully responsible for any failure to meet these [restoration] goals and standards ... Upon determining that the goals or standards are not achieved, the Executive Director shall prescribe remedial measures, after consultation with the permittee, which shall be immediately implemented by the permittee with Commission staff direction." (SONGS Permit 1997)

The evaluation of potential remediation options will be an explicit task within the 2022-2023 work plan.

- To review the overall performance of the SDW with respect to the relative standards
- There has been a progressive decline in the proportion of standards met in San Dieguito Wetlands relative to the reference wetlands.
- 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.
- The evaluation of potential remediation options will be an explicit task within the 2022-2023 work plan.

Agenda

Annual Public Workshop

San Onofre Nuclear Generating Station Wetland Mitigation Project

May 4, 2021

1:30 – 1:40	**Introduction and Overview – *Mark Page, UCSB***
1:40 – 2:10	**Performance of the San Dieguito Wetlands Restoration Project – *Steve Schroeter, UCSB***
2:10 – 2:30	**Salt Marsh Vegetation and Biological Standards: Status Update – *Mark Page, UCSB***
2:30 – 2:45	**SCE planting program – Setal Prabhu, SCE**
2:45 – 3:15	**General Discussion**

For more information go to: http://marinemitigation.msi.ucsb.edu/