Salt Marsh Vegetation & Biological Standards
Status Update

May 2, 2022
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 and a review of some of the data that we are collecting to understand and address the reasons for this underperformance.

Salt Marsh Vegetation & Biological Standards
Status Update

Standards that have consistently underperformed 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 10 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 10 years.
- The standard for invertebrate density in tidal creek has never been met.

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Other standards that have underperformed in San Dieguito Wetlands:

- Fish density, richness (MC,TC) Not consistently met in last 4 years
  None met in 2021
- Food chain support (density of feeding birds) Not met in last 5 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.
- Not consistently met over the past 4 years
- None of those standards were met in 2021
- And food chain support, in terms of the density of feeding birds, has not been met in the past 5 years.

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- Fish density, richness (MC,TC) Not consistently met in last 4 years
  None met in 2021
- Food chain support (density of feeding birds) Not met in last 5 years

- For todays presentation, we will discuss the current status of vegetation and the results of two experiments undertaken to evaluate factors that could improve the success of the SCE planting program.
- We will also present some analyses and observations pertaining to possible factors 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

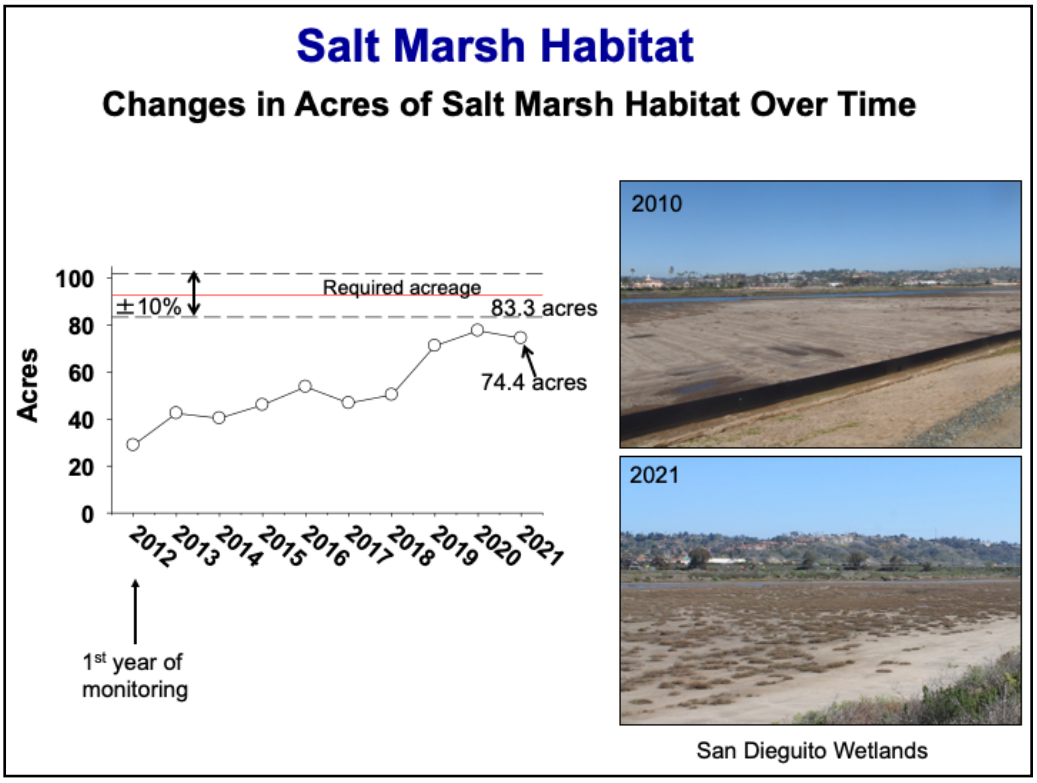
Absolute Standard: Habitat Areas

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

Relative Standard: Vegetation

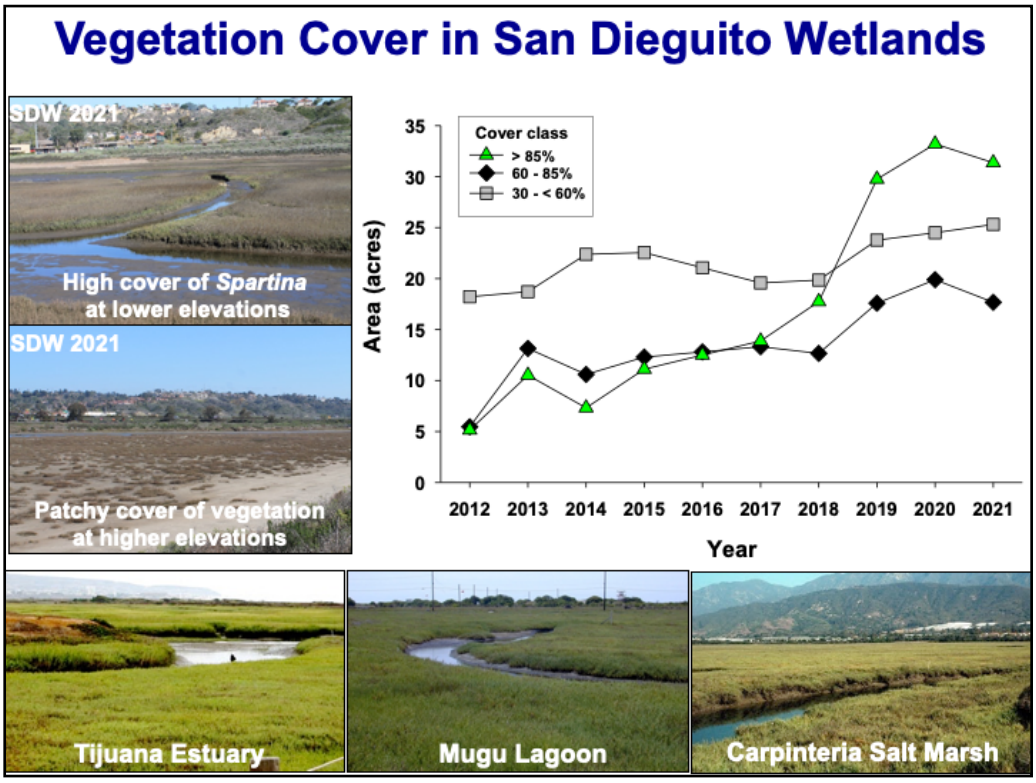
The proportion of total vegetation cover in the marsh shall be similar to those proportions found in the reference sites.

- 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 classified 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 Kat in the Performance talk.
- The second standard that pertains to the cover of vegetation is the Vegetation standard.
- This standard requires that the proportion of total vegetation cover in the marsh shall be similar to those proportions found in the reference sites.
- In practice, this standard is only evaluated in habitat that has been classified as salt marsh, at least 30% cover.

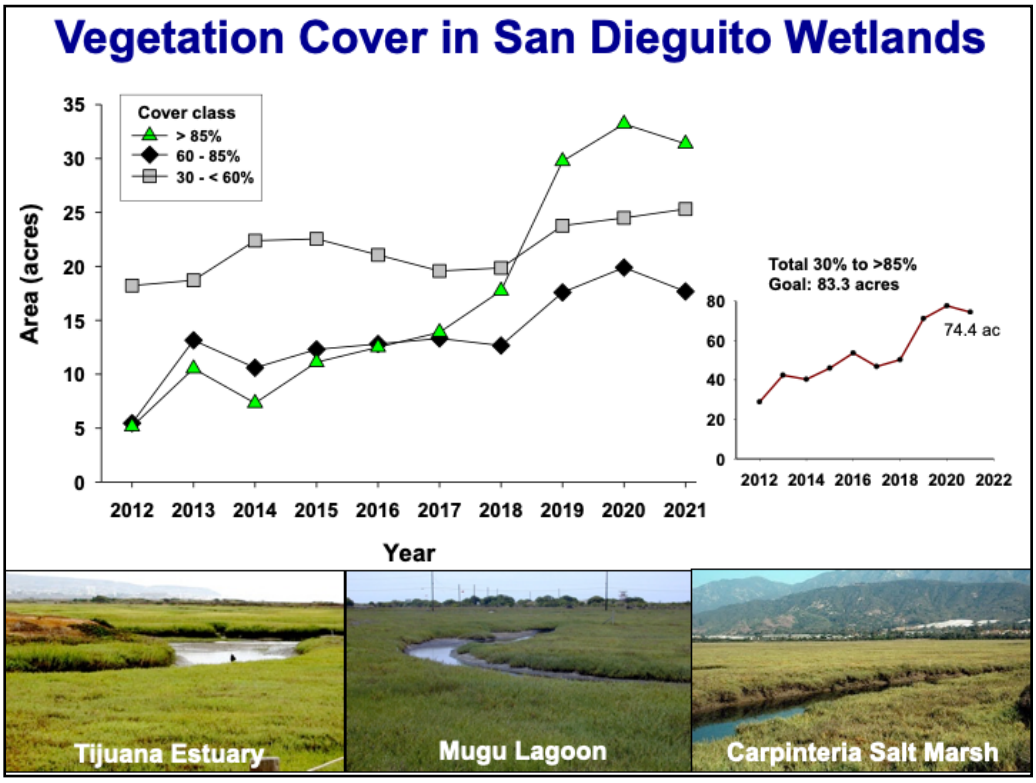


- This slide reviews the change in area (acres) of salt marsh habitat over time.
- The planned acres of salt marsh habitat is shown by the red line, with +/- 10% of that value indicated by the dashed line.
- Although progress has been made in vegetation development, the wetland remains about 9 acres short of the minimum required number of acres of salt marsh habitat, at least 30% cover.
- There was an appreciable increase in the acreage of salt marsh habitat from 2018-to 2020, likely facilitated by the higher levels of rainfall during 2018 relative to the previous years, but then a slowing in 2020 and a small decline (a little over 3 ac) from 2020 to 2021, perhaps a result of the low rainfall we've received over the past couple of years.

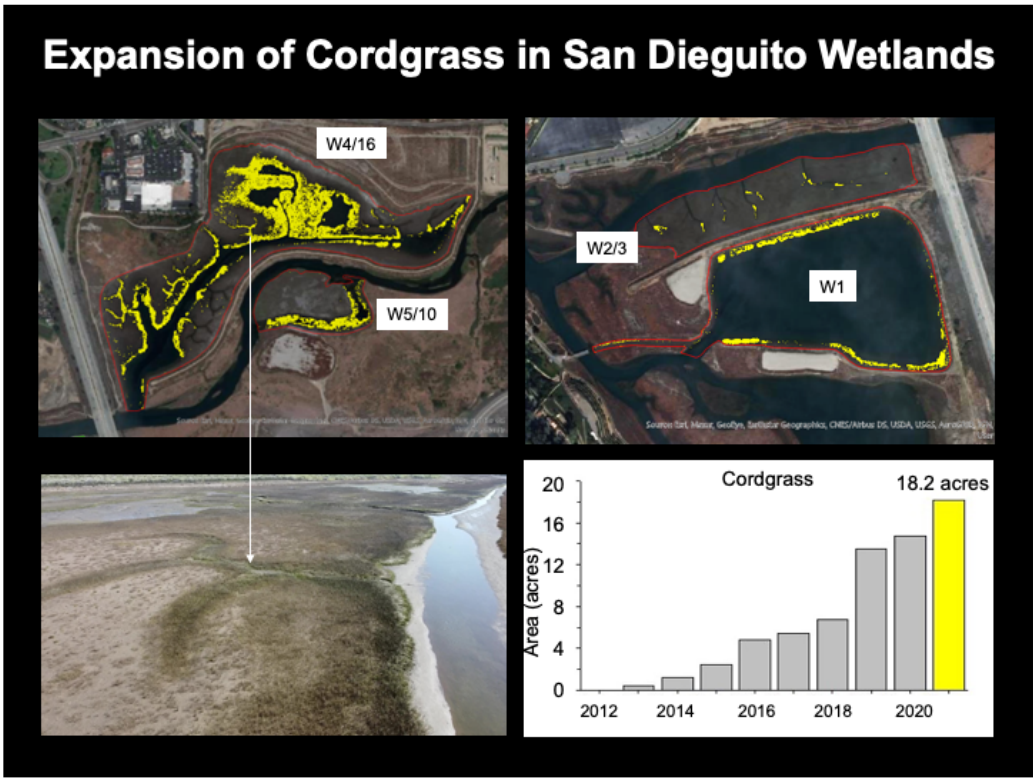
- One goal of the restoration project is to achieve not only a minimum of 83.3 acres of salt marsh habitat, but a high cover of vegetation similar to the reference wetlands shown along the bottom of the slide.
- The photos on left show the high cover of Spartina found throughout lower marsh plain elevations in SDW, but that cover of vegetation, which consists largely pickleweed Salicornia, at higher elevations, is more patchy.



- Taking a look at trend of overall increase in vegetation cover, the figure on the right shows changes in vegetation cover over time for cover classes of vegetation of >85%, 60-85%, and 30-60% through 2021.
- There was an appreciable increase in the acres of >85% cover to around 30 acres in 2019, and that increased to close to 35 acres in 2020, but declined slightly in 2021.
- Acres in 60 – 85% cover class also declined
- The cover of 30-60% has changed little over the past couple of years.
- This likely reflects a slowing of growth of vegetation out of cover classes of <30% and into the 30-60% cover class, and of the 30-60% growing into the 85% class.



- The inset on the right of this slide shows again the overall increase in areas of at least 30% cover through 2021.



- 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 and W2/3 on the west side of the freeway.
- There was an increase of 4-5 acres from 2020 to 2021.
- Cordgrass has expanded into shallow areas of some of the tidal creeks in modules on both sides of the freeway, which we will touch on again further in the presentation.

Studies to Inform Adaptive Management

Salt Marsh Vegetation

- IDAPS experiment: Test the effects of **I**rrigation, **D**ecompaction, **A**mendments, **P**lanting, and **S**eeding on increasing the cover of vegetation at higher elevations. Only *Arthrocnemum* planted.

Plants in quadrat

De-compacting

Adding amendment

Experimental quadrats

- To address the shortfall in acres of salt marsh habitat, and to increase the cover of salt marsh vegetation, SCE is conducting a vigorous planting program, which Setal Prabhu will talk about in the presentation following this one.
- Two experiments were embedded within the planting program in 2020.
- The goal of the first experiment, which we call the IDAPS experiment was to test the effect of several variables to increase plant cover in sparsely vegetated areas at higher elevations.
- These variables were 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), which is typically found at higher tidal elevations.

Studies to Inform Adaptive Management

Salt Marsh Vegetation

- IDAPS experiment: Test the effects of **I**rrigation, **D**ecompaction, **A**mendments, **P**lanting, and **S**eeding on increasing the cover of vegetation at higher elevations. Only *Arthrocnemum* planted.
- Fill-in experiment: Test the effects of planting versus seeding on filling in gaps in plant cover at lower tidal elevations. No soil treatments or irrigation. *Arthrocnemum, Frankenia, Salicornia* planted.

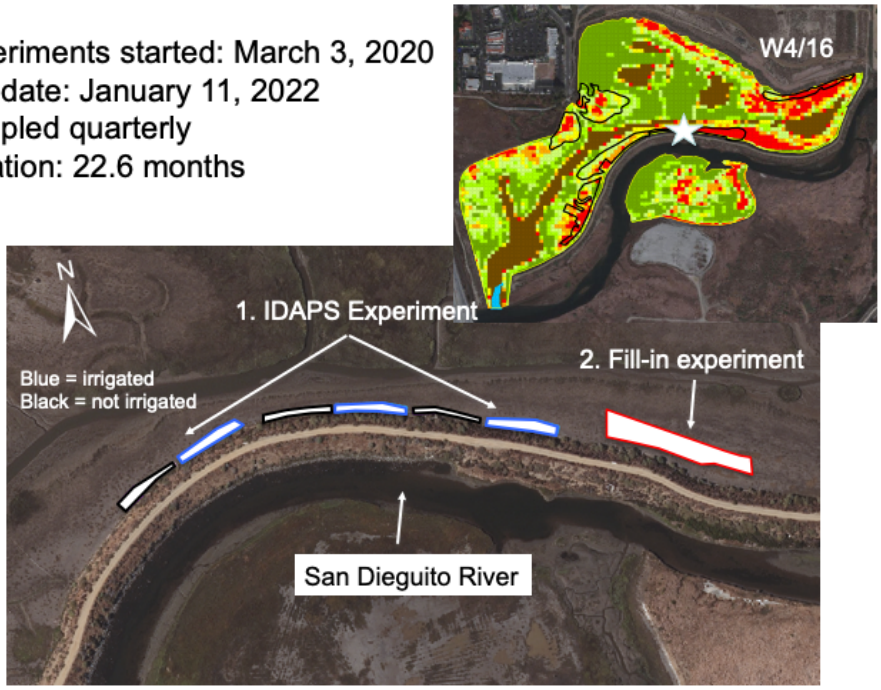
Plant species used in Fill-in experiment

Salicornia pacifica | *Frankenia salina* | *Arthrocnemum subterminale*

- We call the second experiment, the Fill-in experiment.
- The goal of the Fill-in experiment was to test the effect of planting and plant species versus seeding on filling in gaps in plant cover at lower elevations.
- There were no soil treatments or irrigation in the Fill-in experiment.
- Three plant species Salicornia, Frankenia, and Arthrocnemum, were planted and compared to a seed mix only treatment and an unmanipulated control.

Experiment locations & timetable

Experiments started: March 3, 2020
End date: January 11, 2022
Sampled quarterly
Duration: 22.6 months



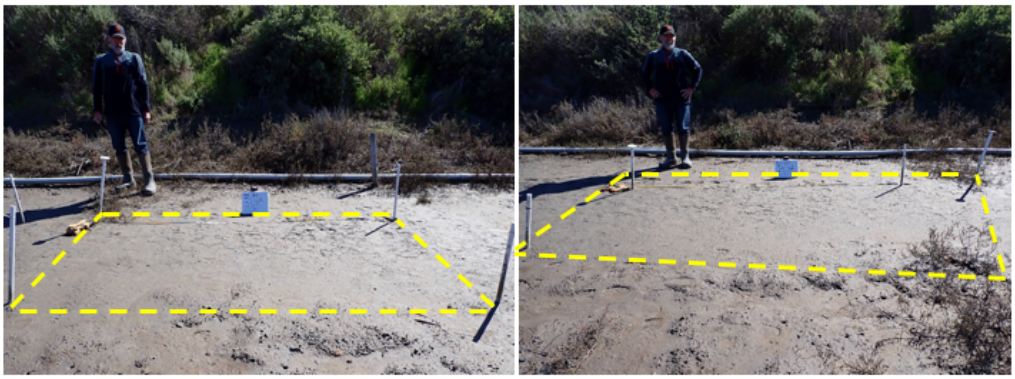
- This slide shows the location, indicated by the star, and layout of the two experiments: IDAPS experiment at high elevation (4.25 – 3.5 feet NGVD or 6.5 – 5.8 feet MLLW) and the Fill-in experiment at lower elevation (< 3.5 feet NGVD or 5.8 feet MLLW) in Module W4 east of the I-5 freeway.
- Another Fill-in experiment on west side of freeway in Module W2.
- The Fill-in experiment was done at lower tidal elevations that already have approximately 10% cover of plants.
- These experiments were started in March 2020 and concluded in mid January 2022.
- We collected data on the percent cover, growth, and survival of plants in the experiment plots.

Results

Seed mix treatments – No effect of seeding on plant cover
Difference in mean plant cover between seeded and control < 5% for both IDAPS and Fill-in experiments after 22 months

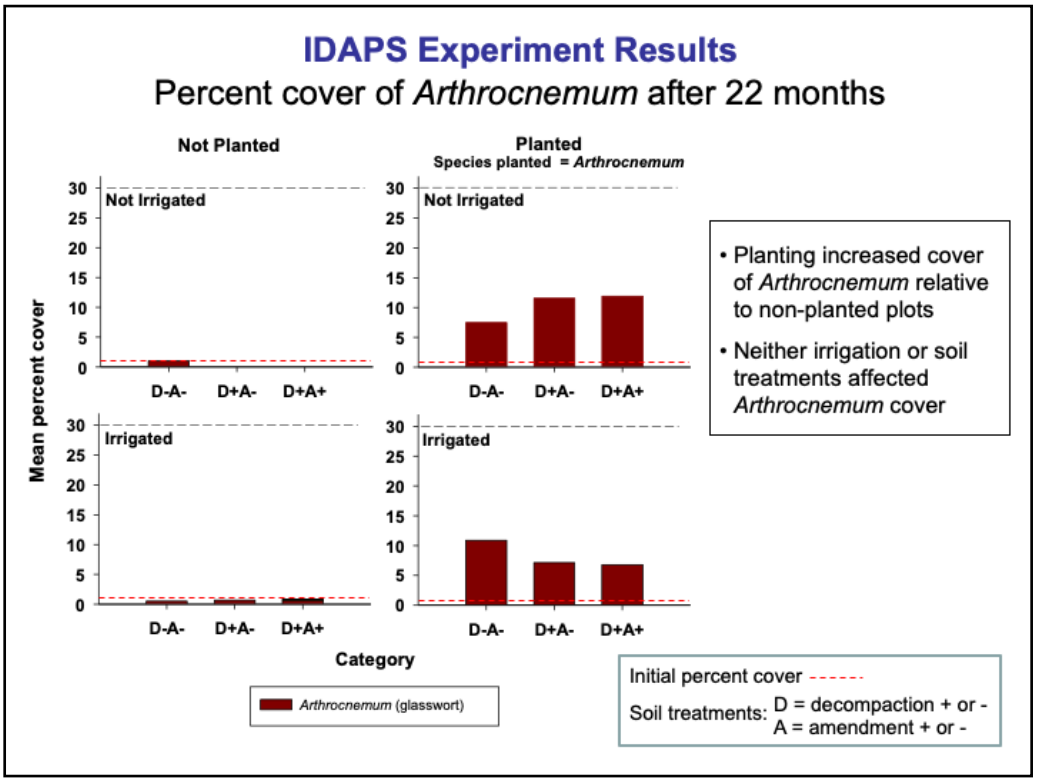
Seeded Plot (mid block) – No irrigation, planting or soil treatments

Control (Unseeded) (mid block) - No irrigation, planting or soil treatments



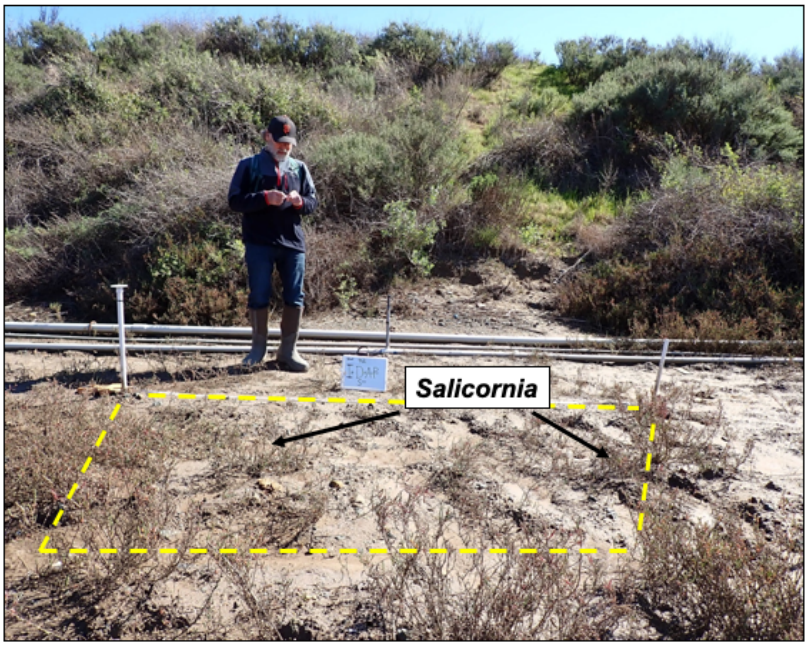
February 2022

- The next few slides summarize the results of the experiments.
- To summarize the results from the seed mix treatments – difference in mean plant cover between seeded and control plots was <5% and not statistically different for both the IDAPS and Fill-in experiments after 22 months.

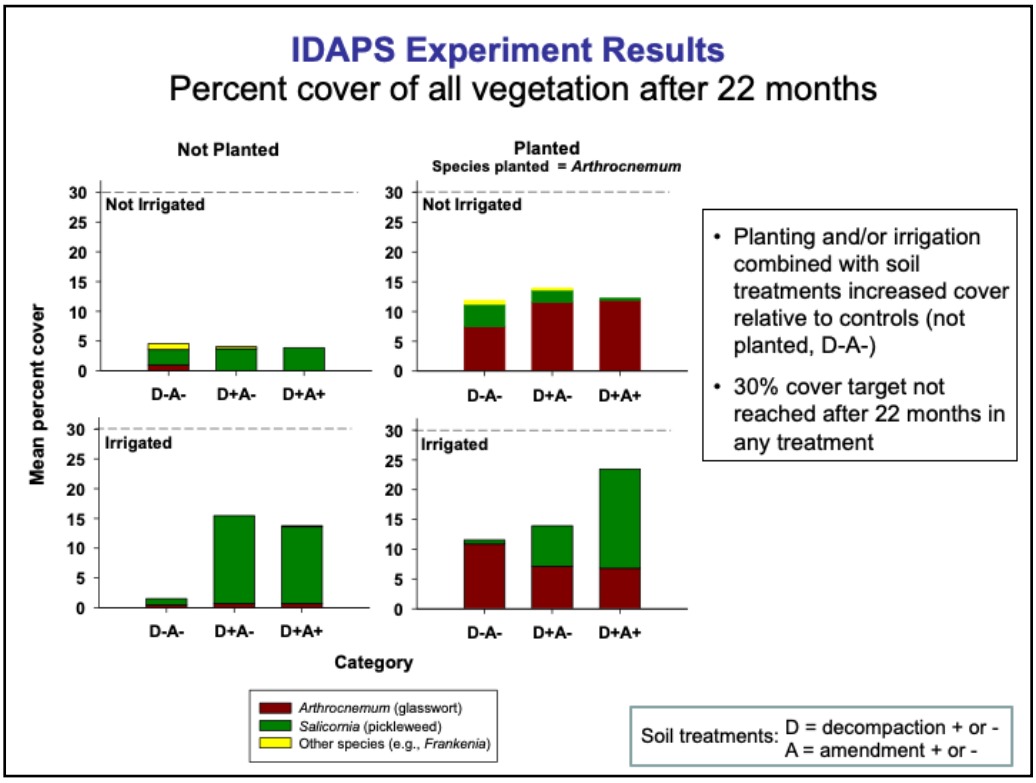


- This slide summarizes the results for the percent cover of Arthrocnemum after 22 months.
- The two panels on the left show the percent cover in unplanted treatments that were either not irrigated or irrigated in plots that were either not decompacted or amended (D-A-), decompacted, but not amended (D+A-), or decompacted and amended (D+A+).
- The two panels on the right show the percent cover in planted treatments that were not irrigated or irrigated in plots that received one of the three soil treatments.
- The black dashed line at 30% cover represents the target minimum cover required to be classified as salt marsh in performance monitoring
- We can see that planting, the panels on the right, increased cover of *Arthrocnemum* relative to non-planted plots, on the left, only up to about 10% or so.
- Looking at the right two panels, statistical analysis, the details of which are not presented here, also showed that neither irrigation or soil treatments affected the % cover of *Arthrocnemum*.

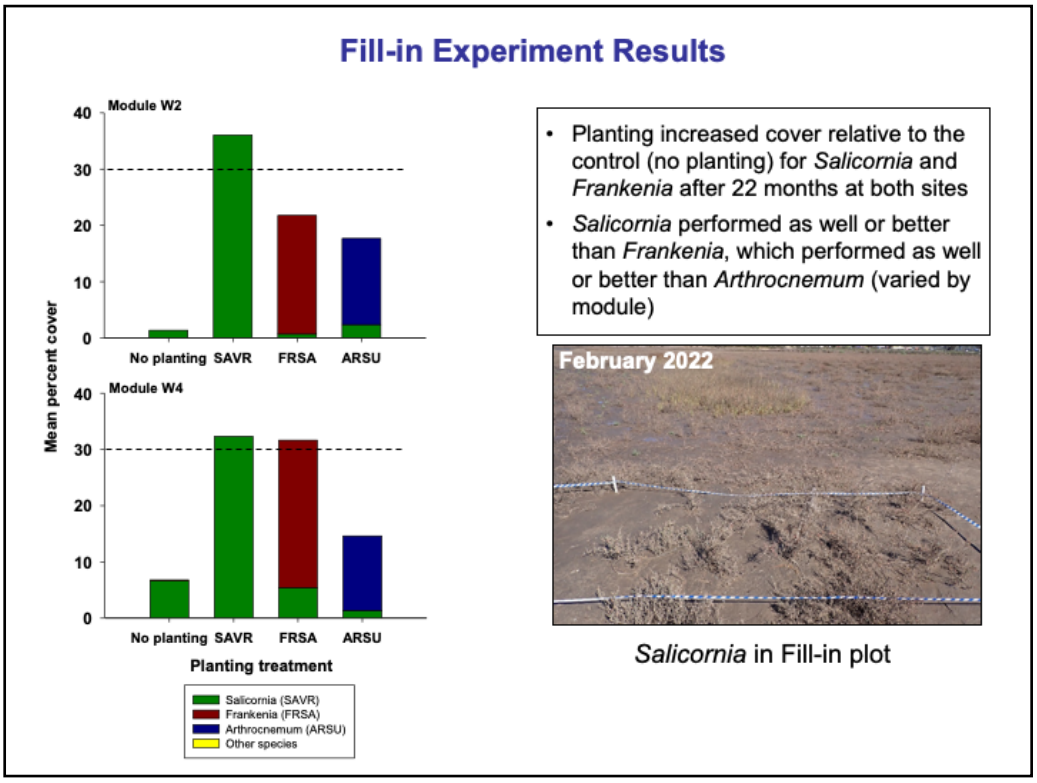
Salicornia recruited into some plots



- An unexpected result was the recruitment of pickleweed, Salicornia, into some experimental plots, as shown here.



- This slide shows the percent cover of all vegetation, planted Arthrocnemum, non-planted Salicornia together with a small contribution of other species, in experimental plots after 22 months.
- The panels are arranged in the same order as in the previous data slide.
- We can see that planting and/or irrigation combined with soil treatments increased cover relative to controls (not planted, D-A-) with a substantial contribution from the non-planted Salicornia, shown in green, in plots that had been irrigated and received the soil treatments.
- However, the bottom line is that the 30% cover target was not reached after 22 months in any treatment.



- This slide summarizes results of the Fill-in experiments that were conducted at lower elevations at two locations and without irrigation or the soil treatments.
- Three species were planted: Salicornia, Frankenia, and Arthrocnemum.
- Planting increased cover relative to the control (no planting) for *Salicornia* and *Frankenia* after 22 months at both sites with the 30% target obtained by Salicornia at both sites.
- *Salicornia* performed as well or better than *Frankenia*, which performed as well or better than *Arthrocnemum* (varied by module).

IDAPS and Fill-in experiments
Summary

- Seeding did not increase vegetation cover relative to controls at project elevations in either the IDAPS and Fill-in experiments
- In the IDAPS experiment, planting *Arthrocnemum* resulted in a small increase (7-10%) in cover relative to non-planted controls
- None of the IDAPS plots achieved 30% cover after 22 months
- Decompaction and irrigation encouraged the recruitment and growth of *Salicornia*
- In the Fill-in experiment, planting increased average cover of *Salicornia* and *Frankenia* at both sites (up to 34%) relative to the control (no planting)

- To summarize, seeding did not increase vegetation cover relative to controls at project elevations in either the IDAPS and Fill-in experiments
- In the IDAPS experiment, planting *Arthrocnemum* resulted in a small increase (7-10%) in cover relative to non-planted controls
- None of the IDAPS plots achieved 30% cover after 22 months
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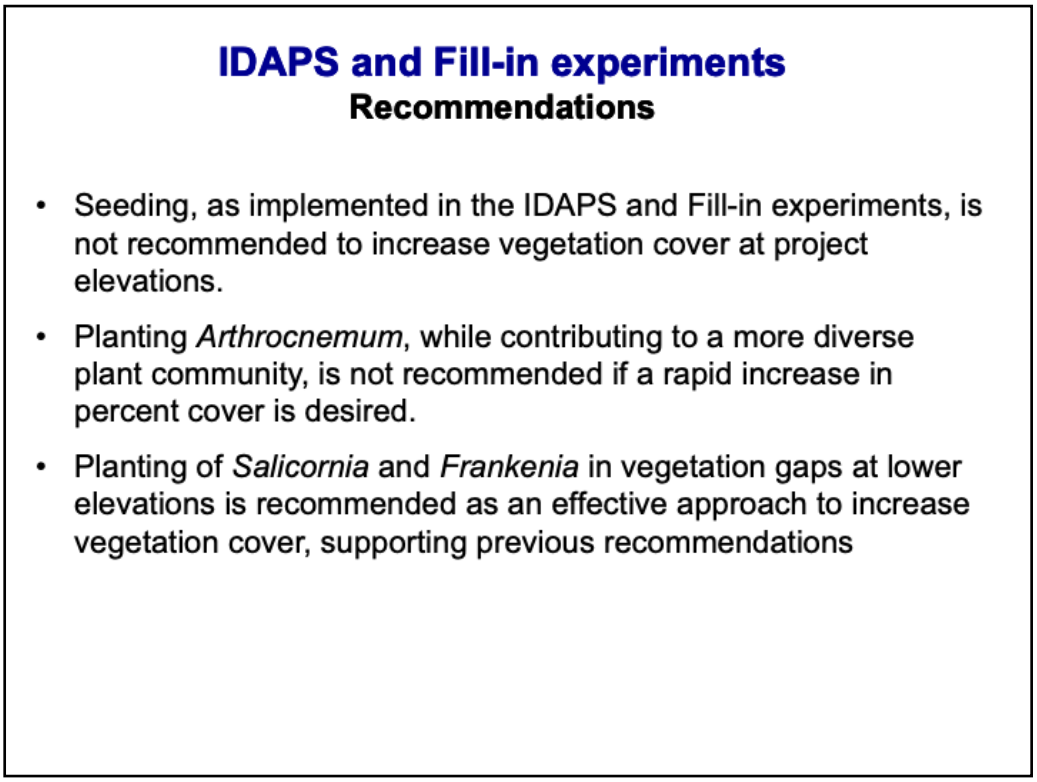


- To summarize, recommendations or lessons learned from the IDAPS and Fill-in experiments:
- Seeding, as implemented in the IDAPS and Fill-in experiments, is not recommended to increase vegetation cover at project elevations.
- Planting *Arthrocnemum*, while contributing to a more diverse plant community, is not recommended if a rapid increase in percent cover is desired.
- Planting of *Salicornia* and *Frankenia* in vegetation gaps at lower elevations is recommended as an effective approach to increase vegetation cover, supporting previous recommendations

Summary and recommendations to meet required area of salt marsh habitat and relative standard for vegetation cover – high vs lower elevations

- **Absolute standard for Habitat Areas**

  Requirement: A minimum of 83.3 acres of salt marsh habitat (at least 30% cover of marsh vegetation) in San Dieguito Wetlands

  Current deficit: 9 acres of salt marsh habitat

  Recommendation: Plant in vegetation gaps at lower elevations to increase cover to at least 30% (~20 acres of "Other" available lower)

- **Relative standard for Vegetation Cover**

  Requirement: Salt marsh cover in San Dieguito Wetlands must be similar to the lowest performing reference wetland (~85% cover)

  Current percent cover: 74% (4 year running average)

  Recommendation: ~20 acres of "Other" available lower, therefore fill-in planting is also recommended at lower elevations to achieve at least 85% cover.

- This slide provides recommendations to meet required area of salt marsh habitat and the relative standard for vegetation cover by elevation.
- Absolute standard for Habitat Areas
- Requirement: A minimum of 83.3 acres of salt marsh habitat (at least 30% cover of marsh vegetation) in San Dieguito Wetlands
- Current deficit: 9 acres of salt marsh habitat
- Recommendation: Plant in vegetation gaps at lower elevations to increase cover to at least 30%

- Relative standard for Vegetation Cover
- Requirement: Salt marsh cover in San Dieguito Wetlands must be similar to the lowest performing reference wetland (~85% cover)
- Current percent cover: 74% (4 year running average)
- Recommendation: There are ~20 acres of "Other" available lower. Therefore successful fill-in planting lower will not only eliminate the deficit in salt marsh habitat but is also recommended to achieve the desired ~85% cover in salt marsh habitat.

Performance Standards Pertaining to Invertebrates

Relative Standards:

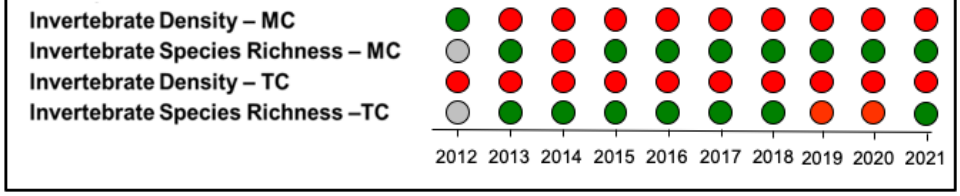
The total densities and number of species of macroinvertebrates shall be similar to the densities and number of species in similar habitats in the reference wetlands.

Evaluated separately for two habitats:

- Main channel
- Tidal creek

- Turning to the underperformance of invertebrates in SDW.
- This slide reviews the relative standards for invertebrates.

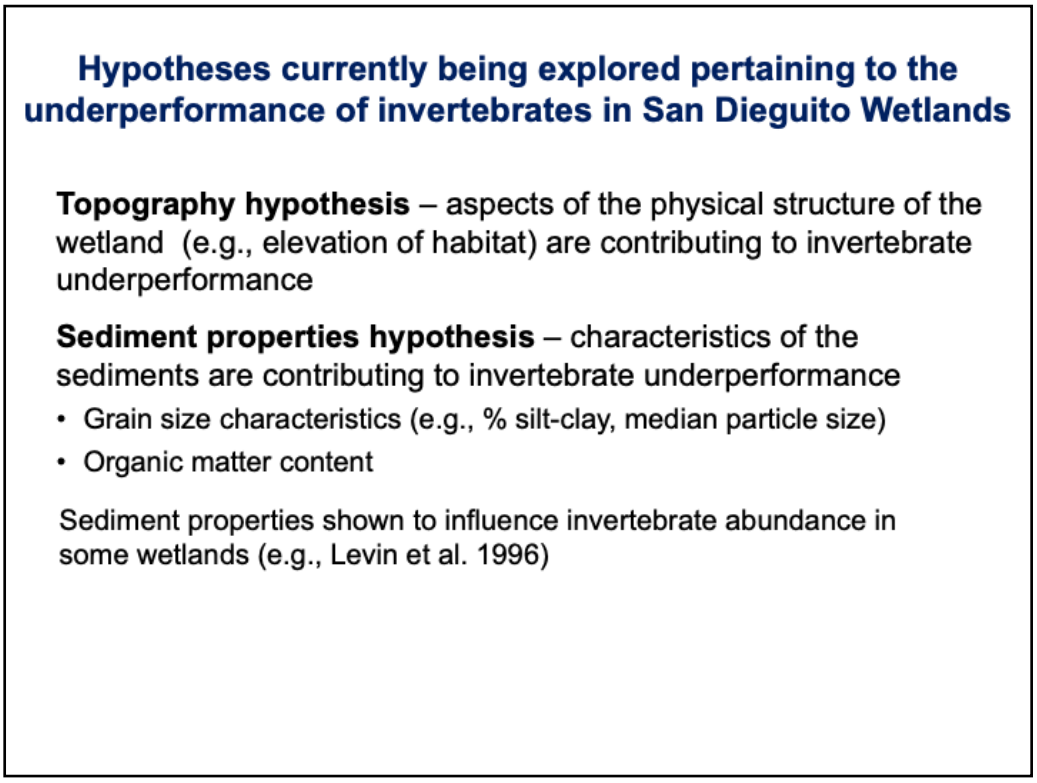
Underperformance of Invertebrates in San Dieguito Wetlands



Standard met
Standard not met
No data

Examples of sampled invertebrates retained on a 1.0 mm mesh sieve

- 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 in main channel and tidal creek habitat have been more consistently met although the standard was not met in tidal creek habitat in 2019 and 2020.
- Most of the invertebrates that are sampled consist of small infauna, particularly different types of worms, illustrated in the images on the right.
- There may be different and more than one explanation or mechanism contributing to the underperformance of invertebrate density in tidal creek and main channel habitats.



- Two hypotheses are currently being evaluated pertaining to the underperformance in density of invertebrates in SDW relative to the reference sites.
- The topography hypothesis proposes that an aspect or aspects of the physical structure of SDW is contributing to the deficit of invertebrates.
- As mentioned earlier, Spartina has encroached into bottoms of tidal creeks in some locations, suggesting that tidal creeks are more shallow than the reference sites and this could affect invertebrate abundance in this habitat.
- The second hypothesis that we are currently exploring concerns sediment properties.
- Sediment properties, for example % silt-clay or the amount of organic matter has been shown to influence invertebrate distribution and abundance at some wetlands.
- We have observed that sediments at some main channel sites in SDW, for example, appear sandy but we lacked information on how grain size or organic matter content might vary among our study wetlands and habitats.

Hypotheses currently being explored pertaining to the underperformance of invertebrates in San Dieguito Wetlands

Topography hypothesis – aspects of the physical structure of the wetland (e.g., elevation of habitat) are contributing to invertebrate underperformance

Sediment properties hypothesis– characteristics of the sediments are contributing to invertebrate underperformance

- Grain size characteristics (e.g., median particle size)
- Organic matter content

Approach:

- Analyze data on invertebrate density collected during annual performance monitoring in 2020 and 2021
- Collect and analyze additional data pertaining to elevation and sediment properties

- Our approach evaluating these two possibilities is to use data on invertebrate density collected during annual performance monitoring in 2020 and 2021 together with ancillary data on sample elevation of the collected samples.
- During performance monitoring in 2021, we also collected sediment samples from a subset of our sampling locations and had these samples analyzed for grain size characteristics and percent organic matter.

Hypotheses currently being explored pertaining to the underperformance of invertebrates in San Dieguito Wetlands

Topography hypothesis – aspects of the physical structure of the wetland (e.g., elevation of habitat) are contributing to invertebrate underperformance

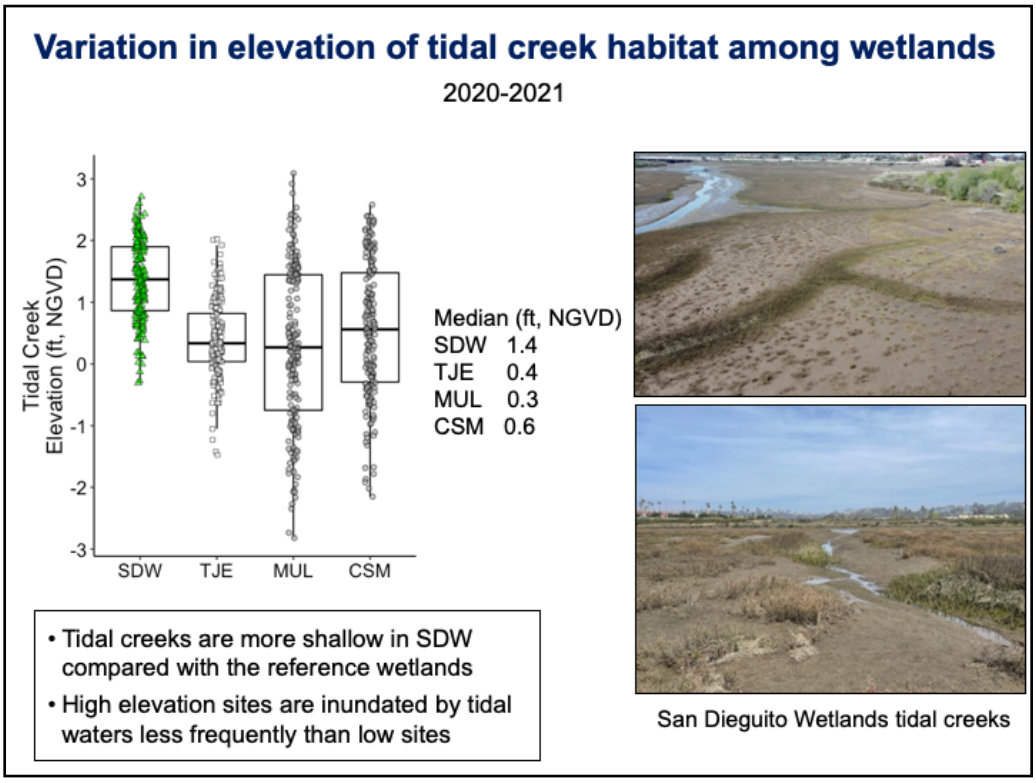
Sediment properties hypothesis – characteristics of the sediments are contributing to invertebrate underperformance

- Grain size characteristics (e.g., median particle size)
- Organic matter content

Approach:

- Analyze data on invertebrate density and species richness collected during annual performance monitoring in 2020 and 2021
- Collect and analyze additional data pertaining to elevation and sediment properties

- Today, we will present some data on the relationship invertebrate densities and elevation.
- We recently received the results of the sediment analysis and these data are currently being analyzed.

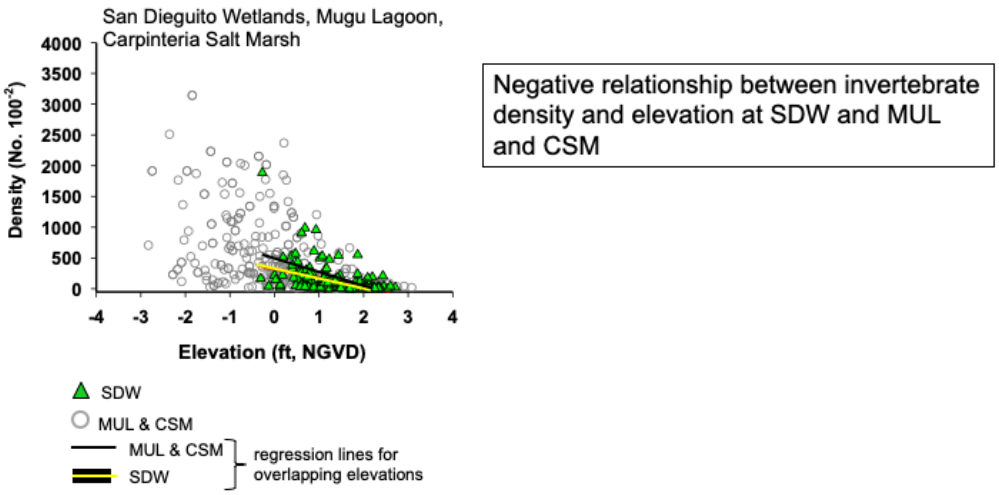


- Last year we reported that the elevations of the tidal creeks in SDW are higher than in the reference wetlands.
- In the figure on the left, we include data collected in 2021 and provide more detail on where the differences occur.
- Each point represents an elevation measurement taken at the location of each of the cores that we take to sample small infaunal invertebrates.
- The darker horizontal bars are median elevations, the boxes enclose 50% of the data, and the vertical lines encompass the range of values.
- You will notice that the median elevation in SDW is about 0.8 ft higher than the reference wetlands but that sample elevations also extend lower, ~1-2' at the reference sites than SDW.

- In terms of inundation frequency, the lowest coring site at SDW covered approximately 80% of the time compared with lower elevations at the reference wetlands that are covered 100% of the time.
- The higher elevations, which are comparable across sites, except TJE is lower, covered 5 - 10% of the time.

Relationship between invertebrate density and the elevation of tidal creek habitat

2020-2021

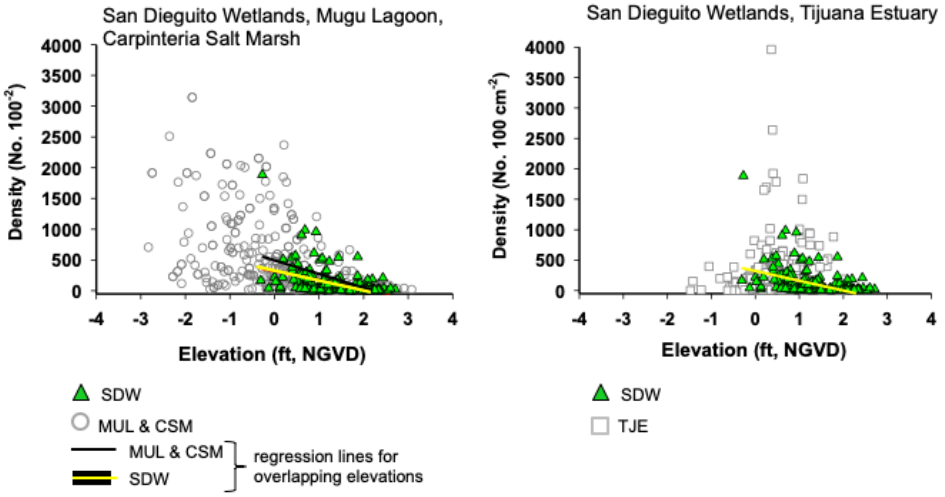


Negative relationship between invertebrate density and elevation at SDW and MUL and CSM

- Taking a look at the relationship between invertebrate density and elevation, this figure shows invertebrate density as #/100 cm2 on the y axis and elevation on the x axis for reference wetlands MUL and CSM, as the gray circles and SDW as the green triangles.
- You will notice, as illustrated in the earlier slide, that the elevations for MUL and CSM extend lower than those at SDW, which has few points below 0 ft NGVD.
- The data for MUL and CSM were not statistically different and the regression line for these sites, the black line, uses the combined data.
- There was a significant negative relationship between density and elevation for MUL and CSM and SDW.

Relationship between invertebrate density and the elevation of tidal creek habitat

2020-2021

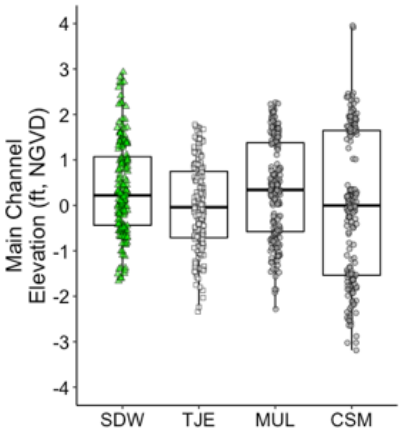


No relationship between invertebrate density and elevation at TJE

- This slide includes the data for TJE, shown on the right.
- There was no relationship between invertebrate density and elevation in this wetland.
- TJE differs from MUL and CSM in that there are few tidal creek sample points below -1 foot in TJE.

Relationship between invertebrate density and the elevation of main channel habitat

2020-2021



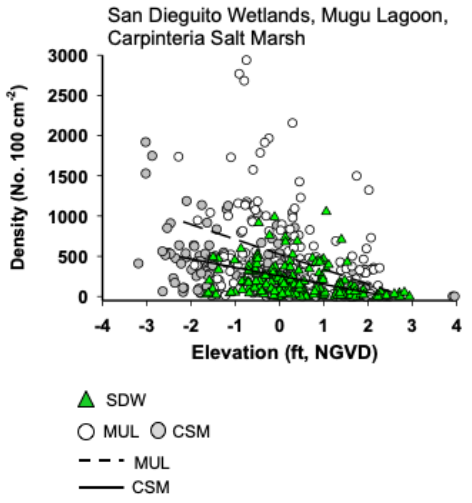
Median (ft, NGVD)
SDW 0.2
TJE -0.1
MUL 0.4
CSM -0.1

Main channel elevations in SDW are within the range of the reference sites

- Taking a look at main channel habitat, the figure on the left shows elevation data for the sampled sections in this habitat.
- Median main channel elevations of SDW are within the range of the reference sites.

Relationship between invertebrate density and the elevation of main channel habitat

2020-2021

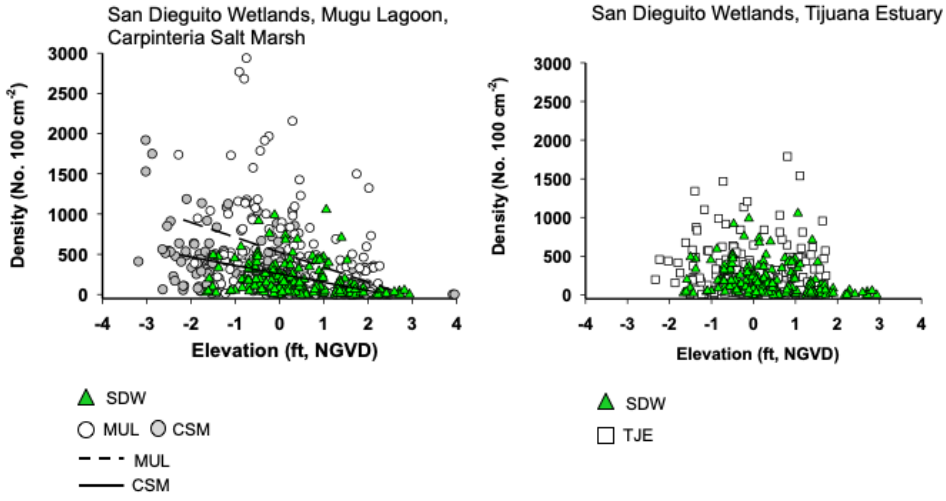


- No relationship between density and elevation at SDW
- There is a negative and significantly different relationship between density and elevation at MUL and CSM

- This figure shows the relationship between density and elevation in main channel habitat in SDW and MUL and CSM
- As reported last year, there was no relationship between elevation and invertebrate density in main channels at SDW.
- There was a negative relationship between density and elevation for MUL and CSM and the relationship differed between these two wetlands.

Relationship between invertebrate density and the elevation of main channel habitat

2020-2021



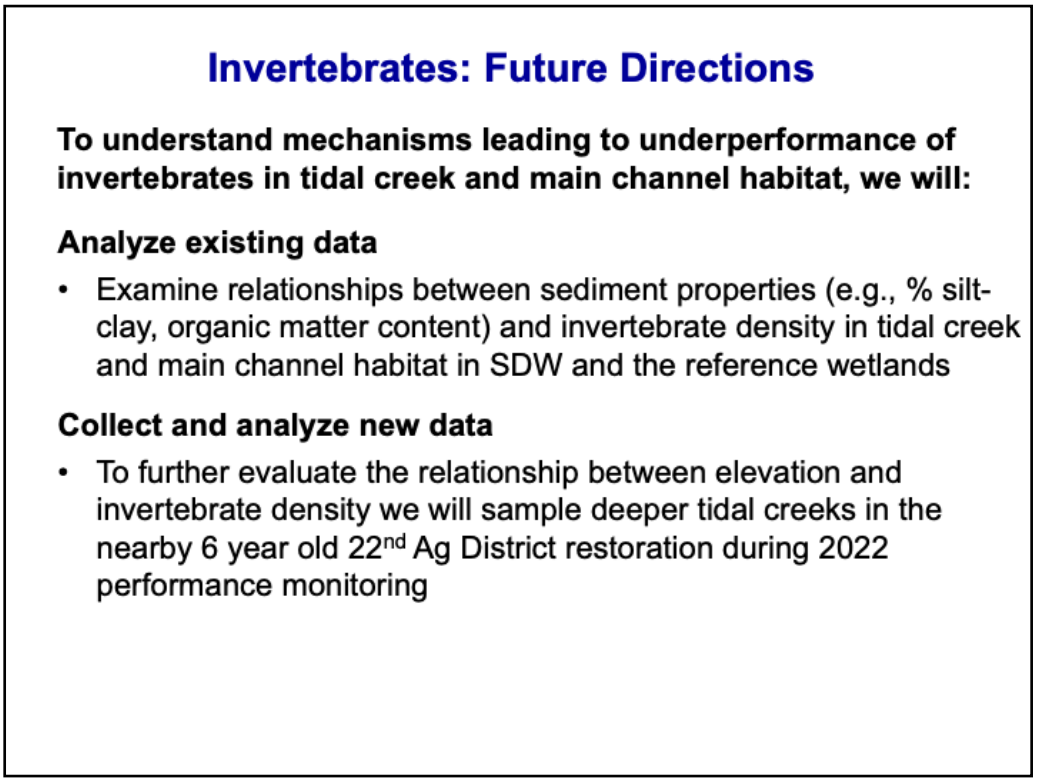
No relationship between invertebrate density and elevation at TJE

- Similar to the tidal creeks, there was no relationship between density and elevation in TJE main channel habitat.

Invertebrates: Summary

- Elevations of the tidal creeks in SDW do not extend as low as the reference wetlands
- Negative relationships between invertebrate density and elevation in SDW, MUL and CSM tidal creeks, and lack of relationship at TJE, suggest that higher elevations in SDW could explain, at least in part, lower densities of invertebrates at SDW in this habitat
- Main channel elevations are within the range of the reference sites
- Lack of relationship between invertebrate density and elevation in main channel habitat of SDW suggests other factors (e.g., sediment properties) influence invertebrate densities in this habitat

- To summarize, the elevations of the tidal creeks in SDW do not extend as low as the reference wetlands
- The negative relationships between invertebrate density and elevation in SDW, MUL and CSM tidal creeks, and lack of relationship at TJE, suggest that higher elevations in SDW could explain, at least in part, lower densities of invertebrates at SDW in this habitat
- Main channel elevations are within the range of the reference sites
- Lack of relationship between invertebrate density and elevation in main channel habitat of SDW suggests other factors (e.g., sediment properties) influence invertebrate densities in this habitat



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

Analyze existing data

- Examine relationships between sediment properties (e.g., % silt-clay, organic matter content) and invertebrate density in tidal creek and main channel habitat in SDW and the reference wetlands
- These samples were collected during last years performance monitoring and we have recently received the data from the lab that processed the sediment samples.

Collect and analyze new data

- To further evaluate the relationship between elevation and invertebrate density in tidal creeks, we will sample deeper tidal creeks in the nearby 6 year old 22nd Ag District restoration during 2022 performance monitoring.

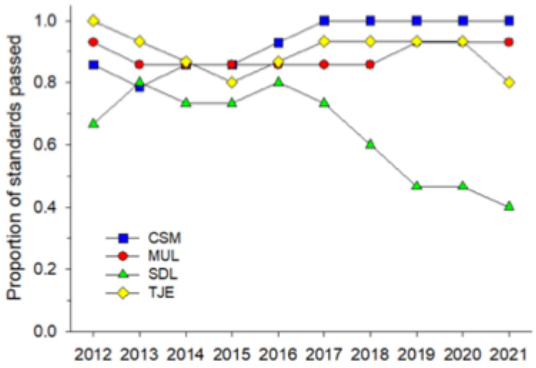
Evaluation of the Topography Hypothesis

Sample the deeper tidal creeks in the nearby 6-year old 22nd Ag District restoration to determine whether they have higher densities of invertebrates than the shallow San Dieguito Wetland tidal creeks

Expectation: Invertebrate densities will be higher in the Ag District than SDW creeks if elevation is contributing to the differences in invertebrate densities among wetlands.

- In this image, you can clearly see that the Ag District creeks, located just across the river channel from module W2/W3 are deeper, and filled with water in comparison to the empty SDW creeks on the other side of the river channel.
- The expectation is that invertebrate densities will be higher in Ag District creeks if elevation is contributing to the differences in invertebrate densities that we see among wetlands.
- Other locations in the reference wetlands that allow a similar comparison may also be sampled.
- The expectation is that invertebrate densities will be higher in the Ag District creeks than those in SDW if elevation is contributing to the differences in invertebrate densities among wetlands.

Underperformance of relative standards in San Dieguito Wetlands



Per the coastal development permit (CDP 6-81-330A), if the goals or standards are not achieved, the CCC Executive Director shall prescribe remedial measures to be implemented by the permittee, SCE.

We are beginning to evaluate potential remediation options, but must first focus on understanding the reasons why the wetland is not meeting certain performance standards.

- Conclude with this slide that summarizes the proportion of relative performance standards met over time.
- We are beginning to evaluate potential remediation options, but are presently focusing on understanding the reasons why the wetland is not meeting certain performance standards.

Agenda

Annual Public Workshop

San Onofre Nuclear Generating Station Wetland Mitigation Project

May 2, 2022

1:30 – 1:40	**Introduction and Overview – *Steve Schroeter, UCSB***
1:40 – 2:20	**Performance of the San Dieguito Wetlands Restoration Project – *Kat Beheshti, UCSB***
2:20 – 2:50	**Salt Marsh Vegetation and Biological Standards: Status Update – *Mark Page, UCSB***
2:50 – 3:00	**SCE planting program – *Setal Prabhu, SCE***
3:00 – ?	**General Discussion**

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