Performance Evaluation of the San Dieguito Wetlands Restoration Project

Annual Review Workshop for SONGS Wetland Mitigation

May 6, 2025

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

- Good morning, I'm excited to talk to you about the performance of the San Dieguito Wetlands Restoration Project.
- This presentation reports the results of the thirteenth year of performance monitoring, and our evaluation of project progress towards meeting the performance standards required for successful mitigation.

Two types of standards used to assess wetland performance

Standard	Sampling location	To earn mitigation credit	Evaluation method
Absolute	**Restored wetland**	**All absolute standards must be met each year**	**Based on the current year**
Relative	Restored and reference wetlands	Proportion of relative standards met at restored wetland must equal or exceed the lowest performing reference wetland	Based on 4-year running average

- First, there are absolute standards, which are evaluated only in the restored San Dieguito Wetlands.
- All absolute standards must be met each year to receive mitigation credit.
- The evaluation of each absolute standard is based on the value for the current year.
- I'm now going to walk through the results for each of the five absolute standards, beginning with tidal prism.

Tidal prism shall be maintained

Tidal prism	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024

Standard met

Standard not met

- The tidal prism is the volume of water exchanged in an estuary between the low and high tide levels, and it is a metric of tidal flushing, inundation of marsh habitat, and inlet stability.
- The tidal prism standard specifies that the tidal prism of San Dieguito Wetland shall be maintained.
- The tidal prism standard has been met every year since monitoring began, as indicated by the green boxes.

No major topographic degradation

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Tidal prism													
Topography													

Standard met

Standard not met

- The topography standard requires that the wetland not undergo major topographic degradation, such as excessive erosion or sedimentation.
- This standard has also been met since monitoring began.

Plant reproduction at least once every 3 years

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Tidal prism													
Topography													
Plant reproduction													

Standard met

Standard not met

- The plant reproduction standard requires that seven common salt marsh plant species demonstrate reproduction at least once in three years.
- This standard has also been met every year since monitoring began.

Exotic species do not impair functions

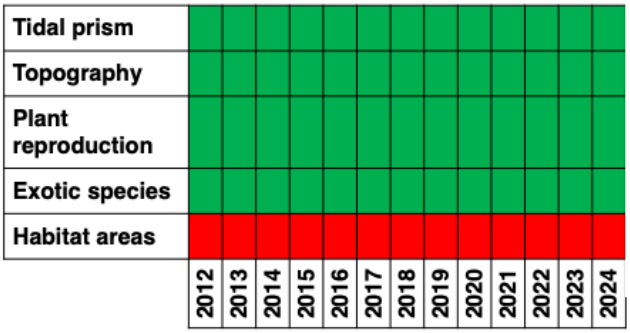
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Tidal prism													
Topography													
Plant reproduction													
Exotic species													

Standard met

Standard not met

- The exotic species standard requires that the important functions of the wetland shall not be impaired by exotic species that can have negative impacts on wetland functioning, for example by altering food webs or physical habitat structure.
- This standard has also been met since monitoring began.

Habitat areas shall not vary by more than 10% from acreages outlined in restoration plan



Planned acres

Salt marsh: 92.6 acres
Mudflat: 24.9 acres
Subtidal: 32.0 acres

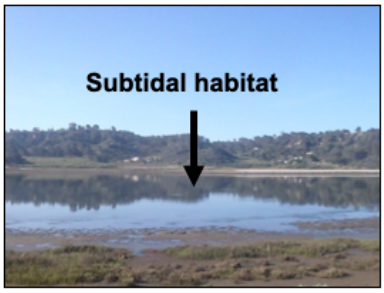
Standard met

Standard not met

- The habitat areas standard specifies that wetland habitat areas shall not vary by more than 10% from the planned habitat acreages outlined in the Final Restoration Plan, as shown here by the acreages of salt marsh, mudflat, and subtidal habitat on right.
- This standard is designed to preserve the mix of habitats provided in the Final Restoration Plan and guard against large scale conversions of one habitat type to another, for example of vegetated marsh to mudflat or vice versa.
- This standard has yet to be met, so we will examine this standard in more detail.

Subtidal habitat classification at San Dieguito Wetlands (SDW)

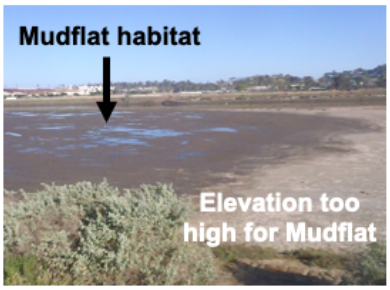
Habitat	Elevation (ft, NGVD)	Necessary characteristics
Subtidal	< -0.9	Continuously submerged



- I'll begin by providing an overview of the criteria used to classify each habitat type, beginning with subtidal habitat.
- Habitat is classified as subtidal if it is continuously submerged and at elevations less than -0.9 ft NGVD.

Mudflat habitat classification at San Dieguito Wetlands (SDW)

Habitat	Elevation (ft, NGVD)	Necessary characteristics
Subtidal	< -0.9	Continuously submerged
Mudflat	-0.9 to 3.5	Intertidal, < 5% vegetation cover



- Habitat is classified as Mudflat if it is intertidal and ≤3.5' NGVD with <5% cover of vegetation. In the photo on the right, this unvegetated intertidal area on the left would be classified as mudflat, but this unvegetated area on the right would not because the elevation is too high to be considered mudflat.

Salt marsh habitat classification at San Dieguito Wetlands (SDW)

Habitat	Elevation (ft, NGVD)	Necessary characteristics
Subtidal	< -0.9	Continuously submerged
Mudflat	-0.9 to 3.5	Intertidal, < 5% vegetation cover
Salt marsh	-0.9 to 4.5	Intertidal, ≥ 30% vegetation cover

- Habitat is classified as Salt Marsh if the area is intertidal and ≤ 4.5' NGVD and also has at least 30% cover of vegetation, which is evaluated with aerial imagery.

"Other" habitat classification at San Dieguito Wetlands (SDW)

Habitat	Elevation (ft, NGVD)	Necessary characteristics
Subtidal	< -0.9	Continuously submerged
Mudflat	-0.9 to 3.5	Intertidal, < 5% vegetation cover
Salt marsh	-0.9 to 4.5	Intertidal, ≥ 30% vegetation cover
*Other**	*-0.9 to 4.5*	*Intertidal, < 30% vegetation cover*

**not a planned habitat*

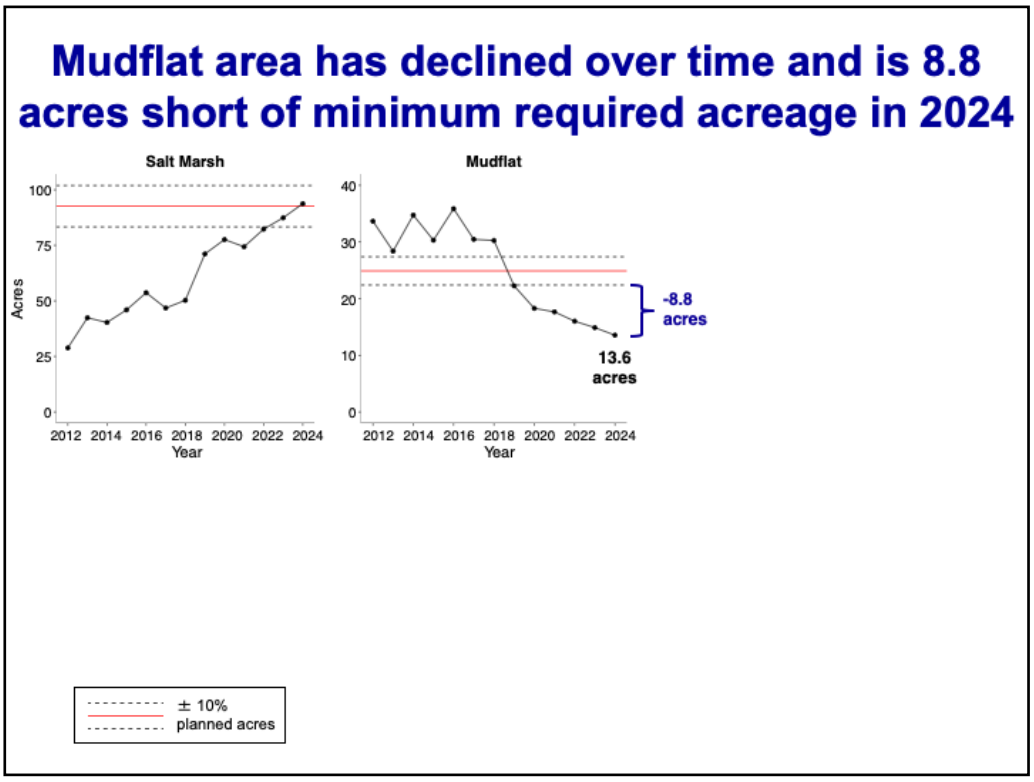
- Lastly, there is "Other" habitat, which is not a planned habitat type and is not included in the Final Restoration Plan. This category was defined after monitoring began, and includes areas that are intertidal and ≤4.5' NGVD with less than 30% cover of vegetation.
- For example in this photo on the right, this area is too sparsely vegetated to be assessed as salt marsh, but has too much vegetation and is too high in elevation to be considered mudflat.

Habitat areas standard not met in 2024

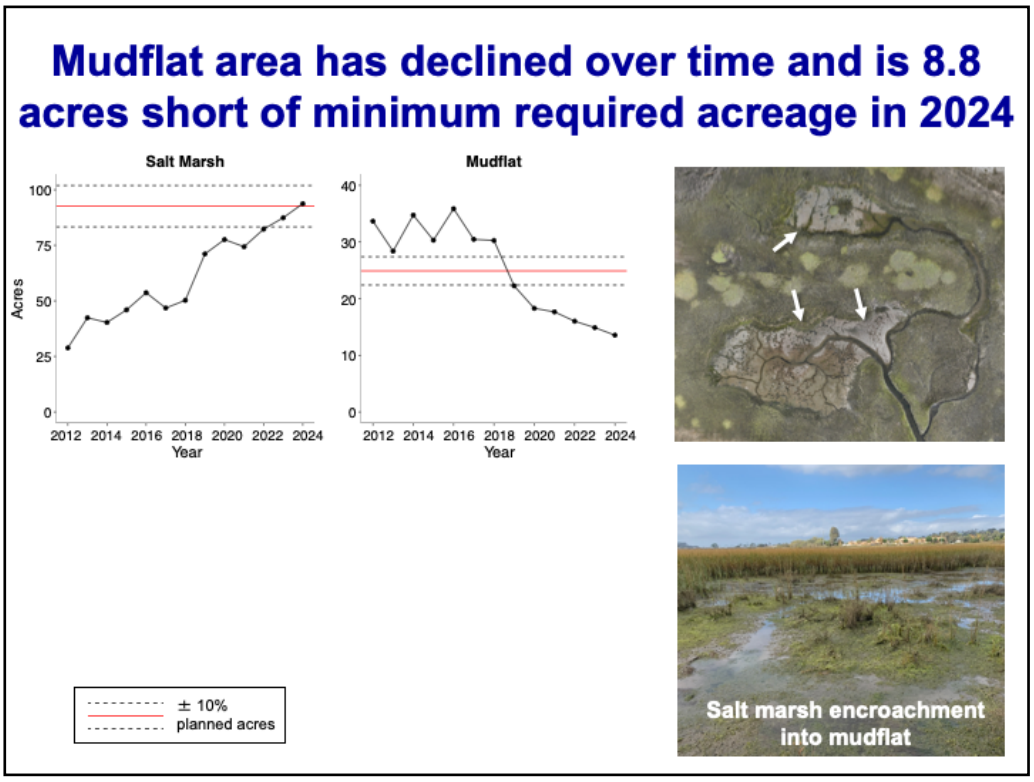
Habitat	Elevation (ft, NGVD)	Necessary characteristics	Planned acres	± 10% planned acres	2024 acres
Subtidal	< -0.9	Continuously submerged	32	28.8 – 35.2	**31.2**
Mudflat	-0.9 to 3.5	Intertidal, < 5% vegetation cover	24.9	22.4 – 27.4	**13.6**
Salt marsh	-0.9 to 4.5	Intertidal, ≥ 30% vegetation cover	92.6	83.3 –101.9	**93.8**
*Other**	*-0.9 to 4.5*	*Intertidal, < 30% vegetation cover*	*0*	*NA*	*11.3*
		Total	149.5		

**not a planned habitat*

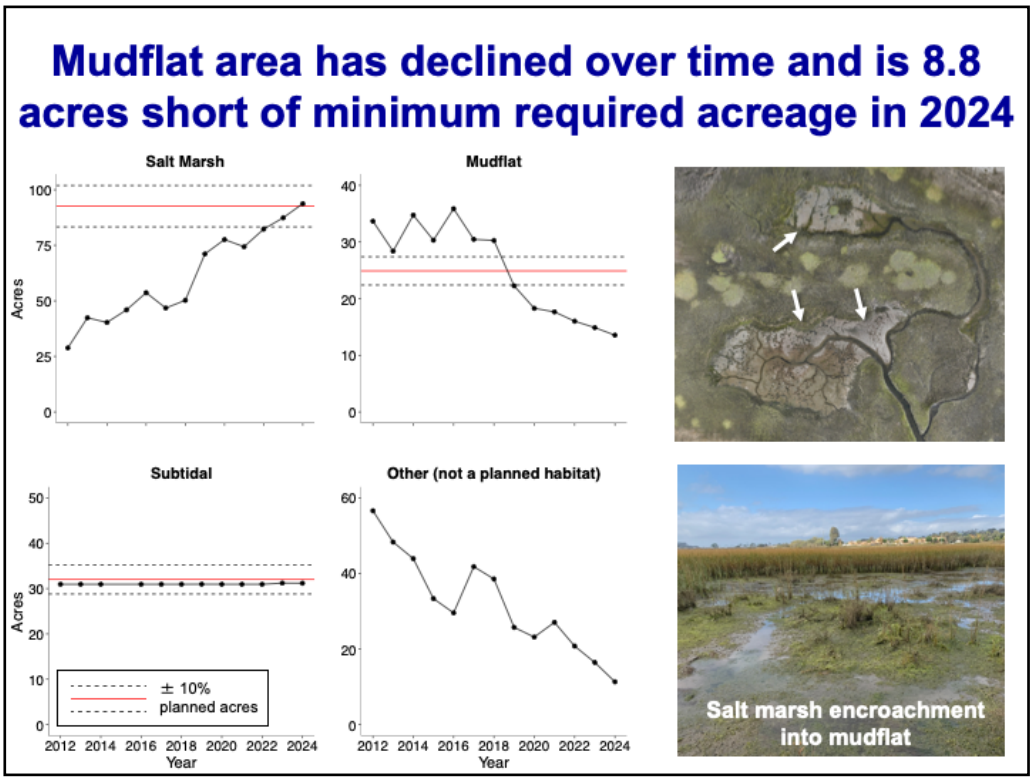
- We now show the results for 2024 that indicate why the habitat areas standard was not met in 2024. This table shows the planned acres, the range of acres that are within 10% of those planned values and the acres measured in 2024.
- Subtidal and salt marsh habitat were within 10% of the planned acreages in 2024, but the area of mudflat was less than 10% of the minimum required acreage of 22.4 acres at 13.6 acres.



- Looking at the trend in habitat areas over time, we see that salt marsh acreage has continued to increase over time and now exceeds the planned acreage of this habitat type.
- Natural colonization of marsh plants, in combination with the success of SCE's planting program, have contributed to this increase in salt marsh area in recent years.
- In contrast, the area of mudflat has been decreasing over time, particularly in the last 5 years, and is currently 8.8 acres lower than the minimum required area of 22.4 acres.



- Loss of mudflat habitat has been driven by salt marsh encroachment into these habitats.
- The arrows in the aerial image of the mudflat at the top of the slide shows areas at the edge of the salt marsh expansion front where you can see the expansion of Spartina clones (which are these green circles) into designed mudflat areas.
- Salt marsh encroachment operates in a positive feedback where established vegetation drives additional sediment accretion, which facilitates further mudflat conversion to salt marsh.



- The area of subtidal habitat has been consistent over time, and it is promising to also see a decline in Other habitat over time.
- At this point in the project, most of the Other habitat is at higher elevations that can only convert to salt marsh, not to mudflat.

Two types of standards used to assess wetland performance

Standard	Sampling location	To earn mitigation credit	Evaluation method
Absolute	Restored wetland	All absolute standards must be met each year	Based on the current year
Relative	**Restored and reference wetlands**	**Proportion of relative standards met at restored wetland must equal or exceed the lowest performing reference wetland**	**Based on 4-year running average**

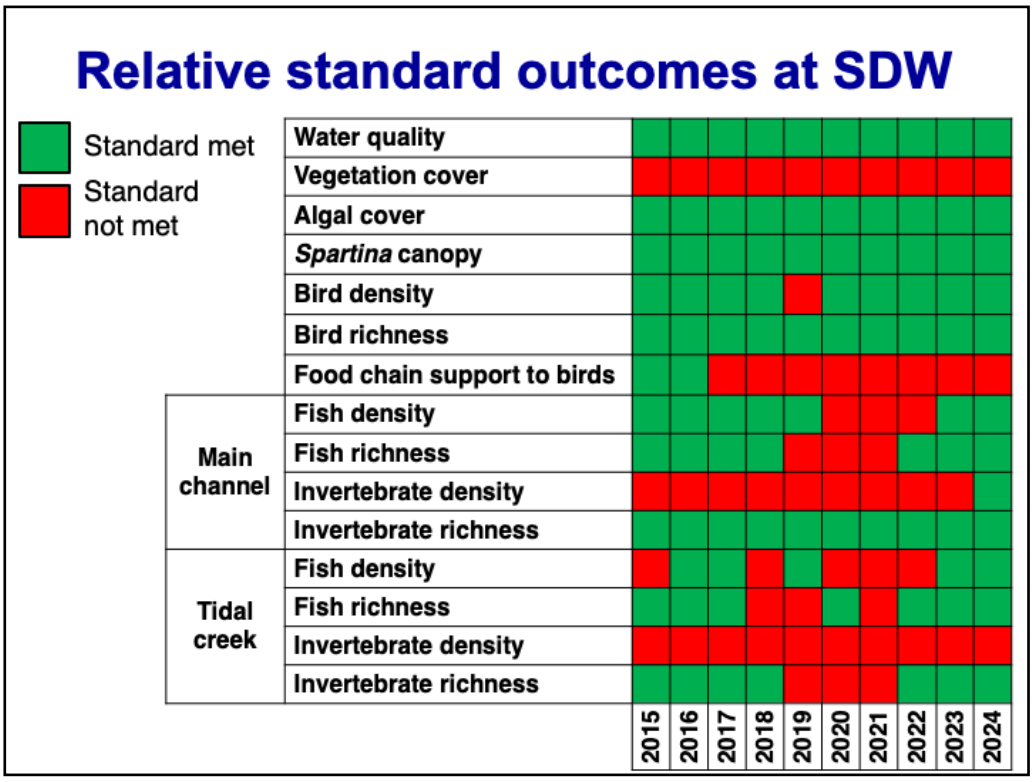
- Moving on from the absolute standards, we now focus on the relative standards, which compare the restored wetlands to natural reference sites.
- To earn mitigation credit for a given year, the proportion of relative standards met at the restored wetland must equal or exceed the lowest performing reference wetland.
- Evaluation of each relative standard is based on a four-year running average to account for natural fluctuations over time.

- We measure the restored wetland relative to reference wetlands because the goal is for the restored wetland to be similar to reference wetland.
- Here, similar means that the 4-year running average for a relative standard at SDW is equal to or exceeds the lowest performing reference wetland.
- For standards where only one year of data is available for LPL, 2024 data was used for all wetlands. Where a full year of data was not available for LPL in 2024, we excluded this site from evaluation and used the 4-year running average for the remaining wetlands.
- San Dieguito Wetlands is considered similar to reference wetlands if the proportion of relative standards met at SDW equals or exceeds the lowest performing reference wetland.

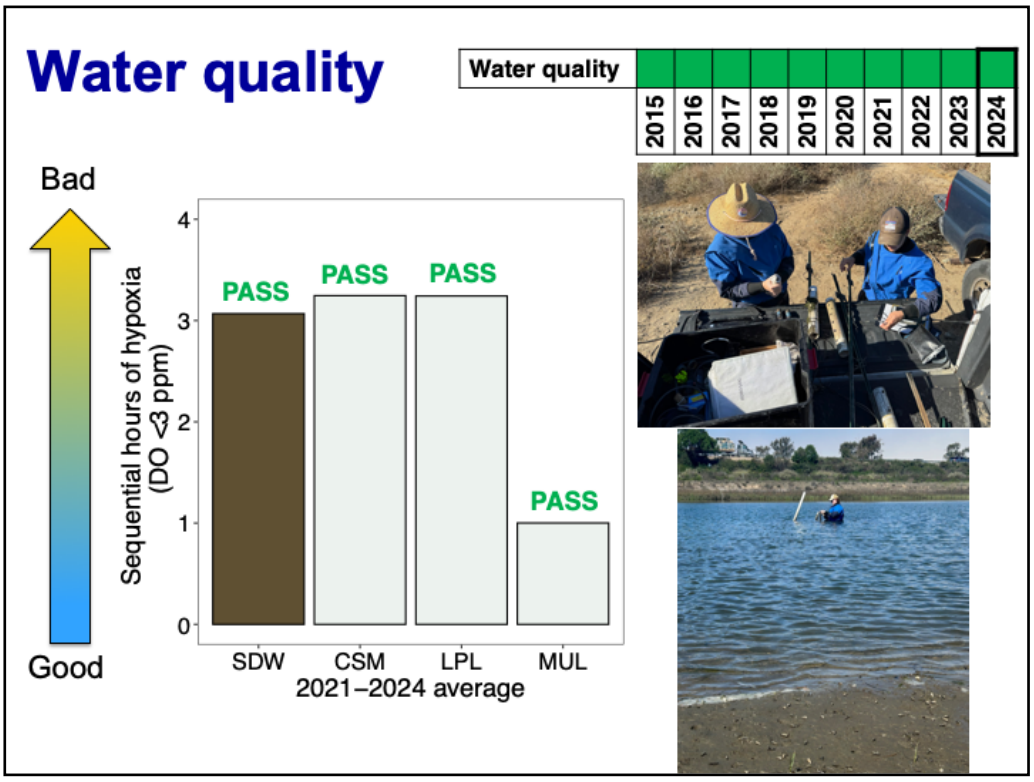
Relative standards

	Water quality
	Vegetation cover
	Algal cover
	Spartina canopy
	Bird density
	Bird richness
	Food chain support to birds
Main channel	Fish density
	Fish richness
	Invertebrate density
	Invertebrate richness
Tidal creek	Fish density
	Fish richness
	Invertebrate density
	Invertebrate richness

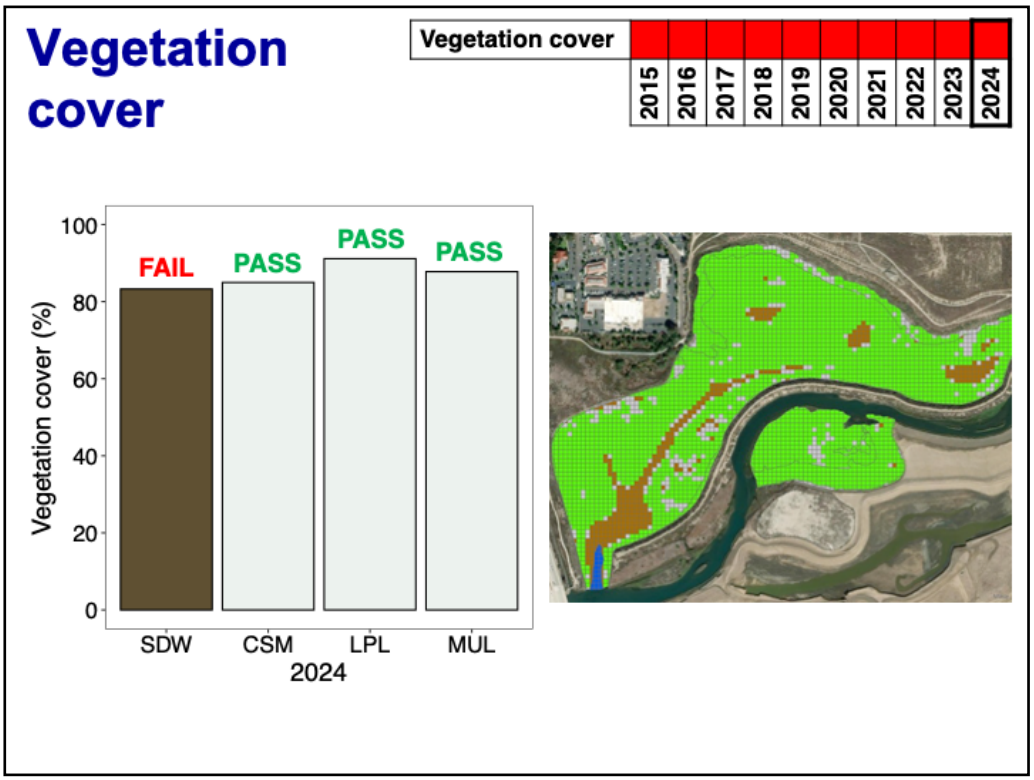
- Here is the list of the 15 relative performance standards used to evaluate the success of the San Dieguito Wetlands Restoration Project. These include standards related to water quality, vegetation and algal cover, birds, fish and invertebrates. We evaluate fish and invertebrate density and richness in both main channel and tidal creek habitats. Here, richness refers to the number of species.



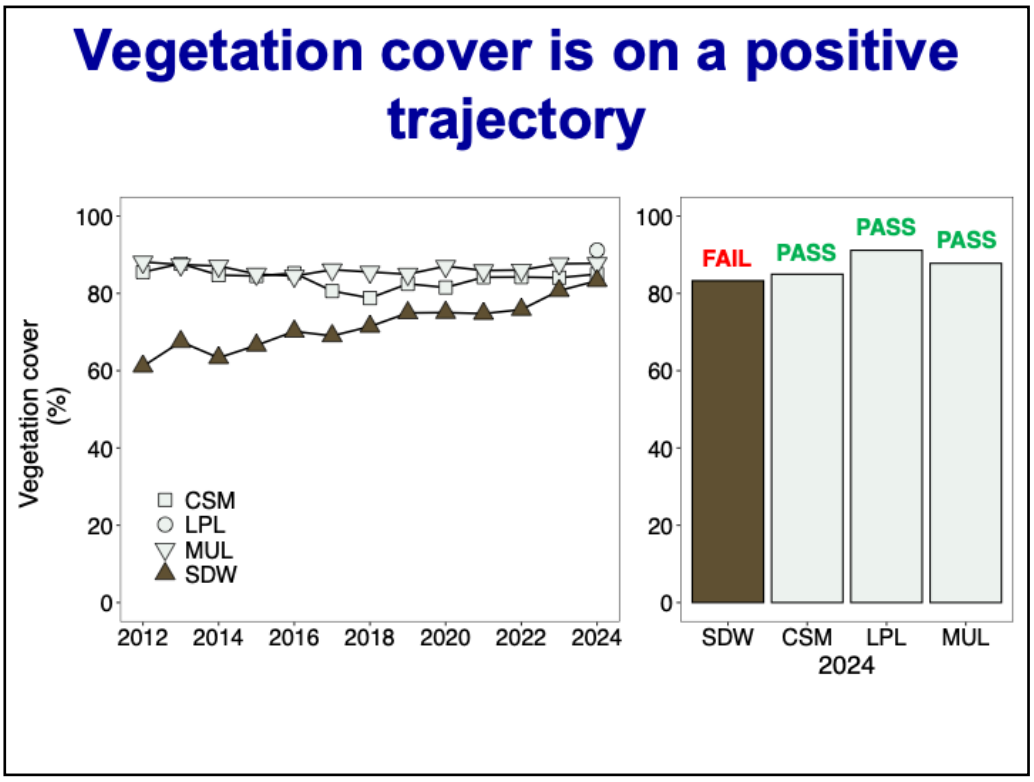
- This table gives an overview of the outcomes for the relative standards at SDW over the last 10 years.
- Some standards are consistently met, whereas other standards have never been met or have been intermittently met over time. That said, there has been a general improvement across all standards over time.
- We will now focus on the results of the relative standards for 2024, beginning with water quality.



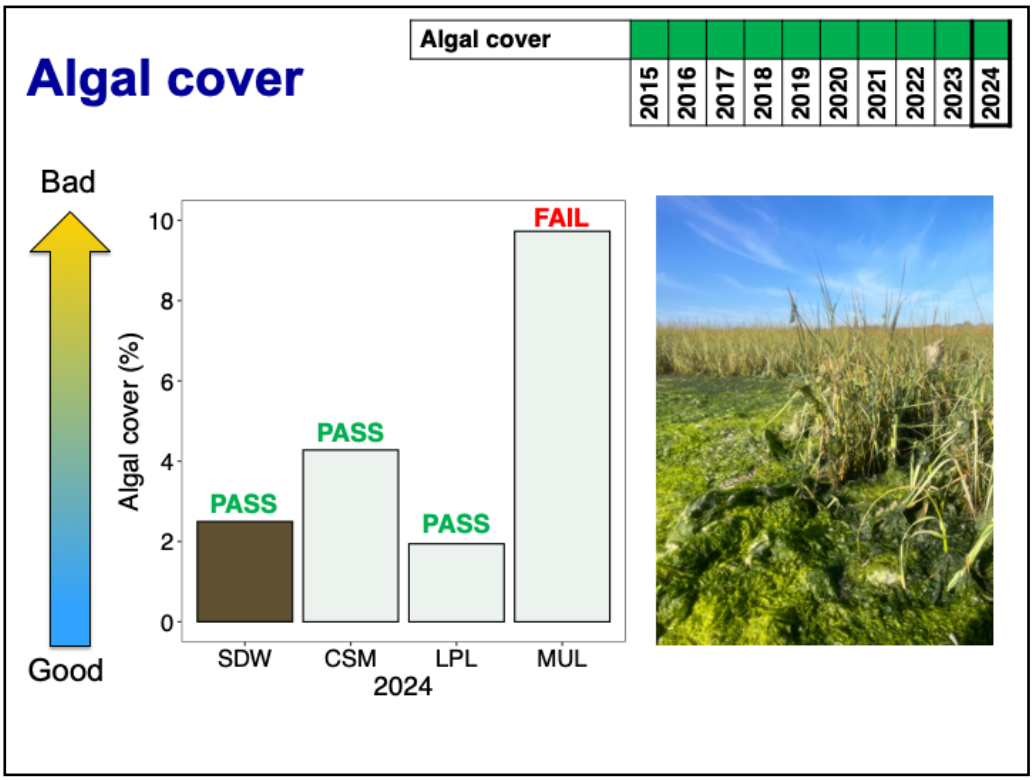
- We measure water quality with continuous water loggers, as shown on the right, and we compare the mean sequential hours of hypoxia, where dissolved oxygen levels are below 3 ppm. Thus, for this standard, lower values are more desirable, as shown by the arrow on the left. In this and the following figures, the results for San Dieguito are shown in brown, and the results for the reference sites will be shown in light green.
- The table in the upper right hand corner indicates that San Dieguito has consistently met this standard for the last 10 years. This pattern continued in 2024, and all wetlands, including SDW passed the water quality standard in 2024.



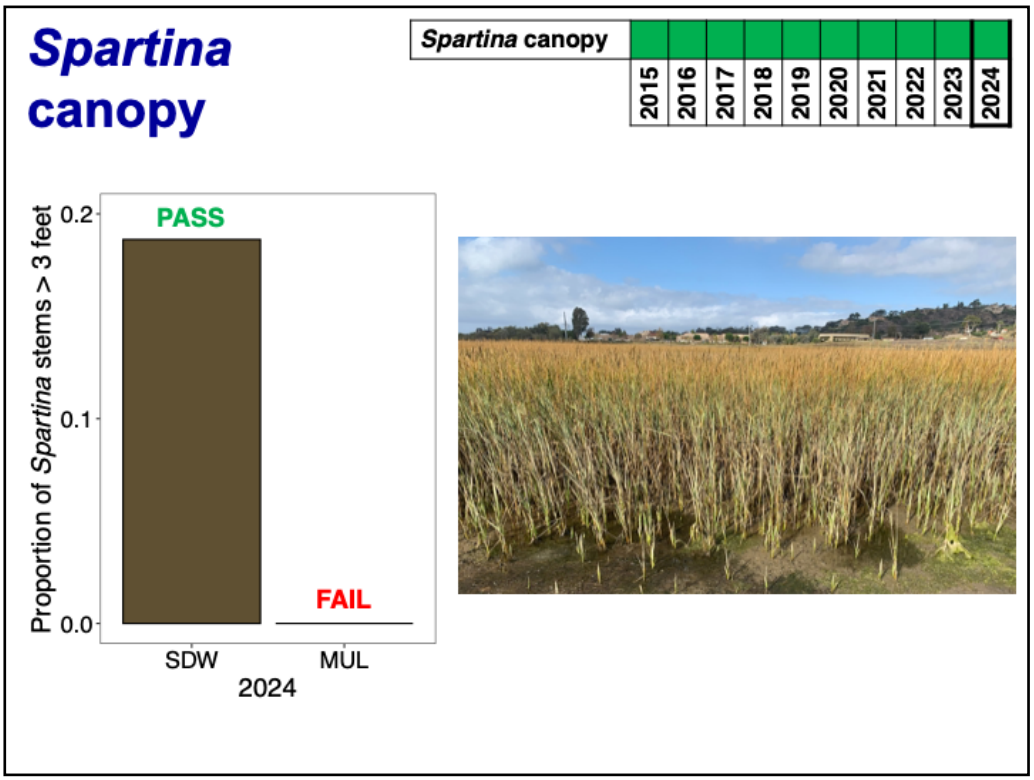
- We now move on to vegetation cover. The vegetation cover standard uses aerial imagery (as shown on the right) to assess the percent cover of salt marsh that is greater than 30%.
- This standard has not yet been met, and SDW failed this standard in 2024. To better understand this underperformance, we can examine the annual time series for vegetation cover.



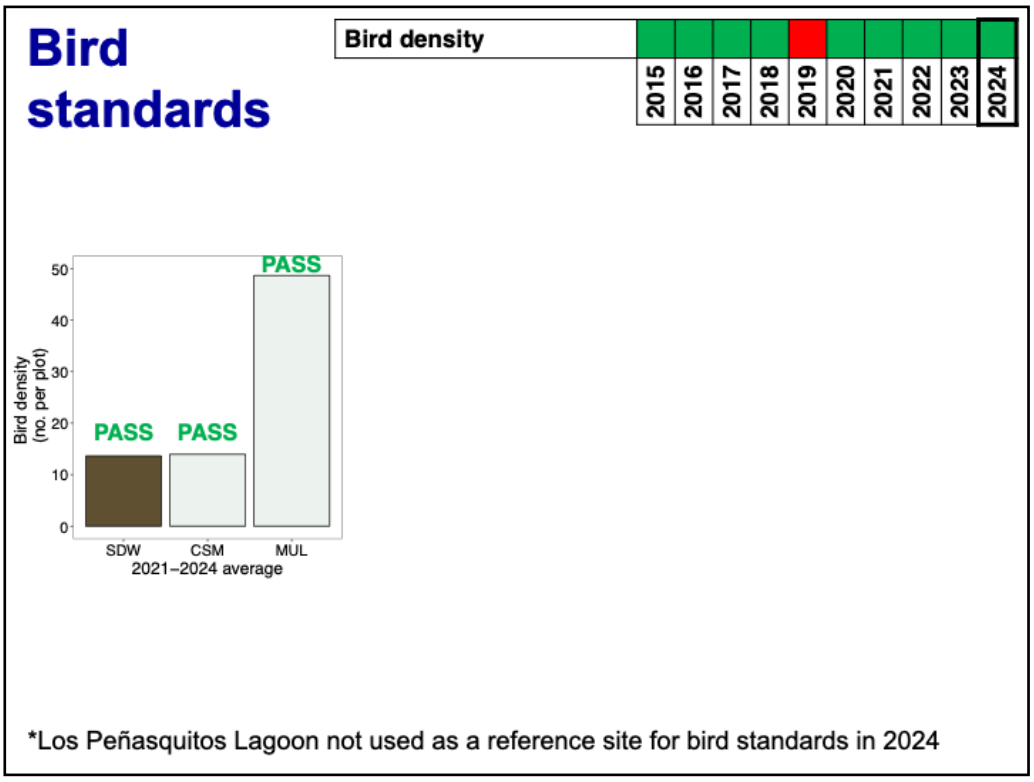
- Vegetation cover has generally increased over time. Over the last two years, there has been a substantial increase in vegetation cover at San Dieguito, and it is now just below the annual value for Carpinteria Salt Marsh.
- Vegetation cover at SDW is on a promising trajectory. This increasing trend has been consistent over time and will likely intercept the values for the reference wetlands soon.



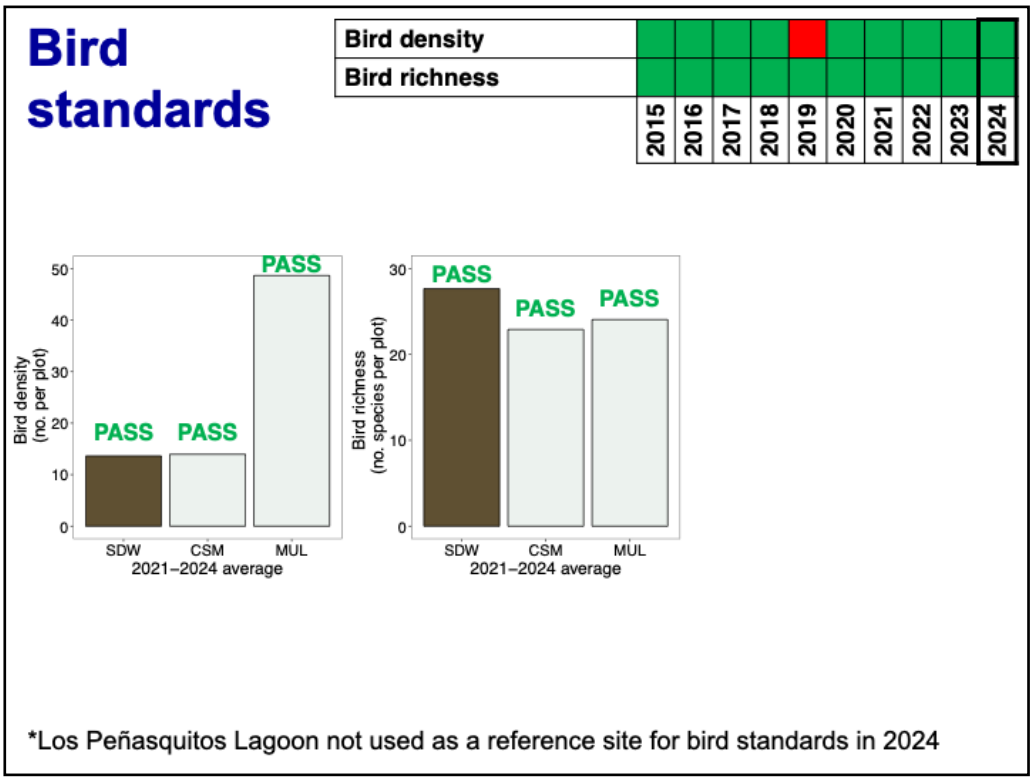
- We now examine the results for algal cover. The algal cover standard uses aerial imagery to assess the percent algal cover. Excessive algal growth can can affect wetland structure and function through effects on vegetation, invertebrates, bird feeding, and water quality. Thus, higher values of algal cover are less desirable, as shown by the arrow on the left.
- San Dieguito has consistently met this standard for the last 10 years. This pattern continued in 2024, and SDW passed this standard in 2024, as algal cover was lower than at the lowest performing reference wetland, Mugu Lagoon, which had high algal cover.



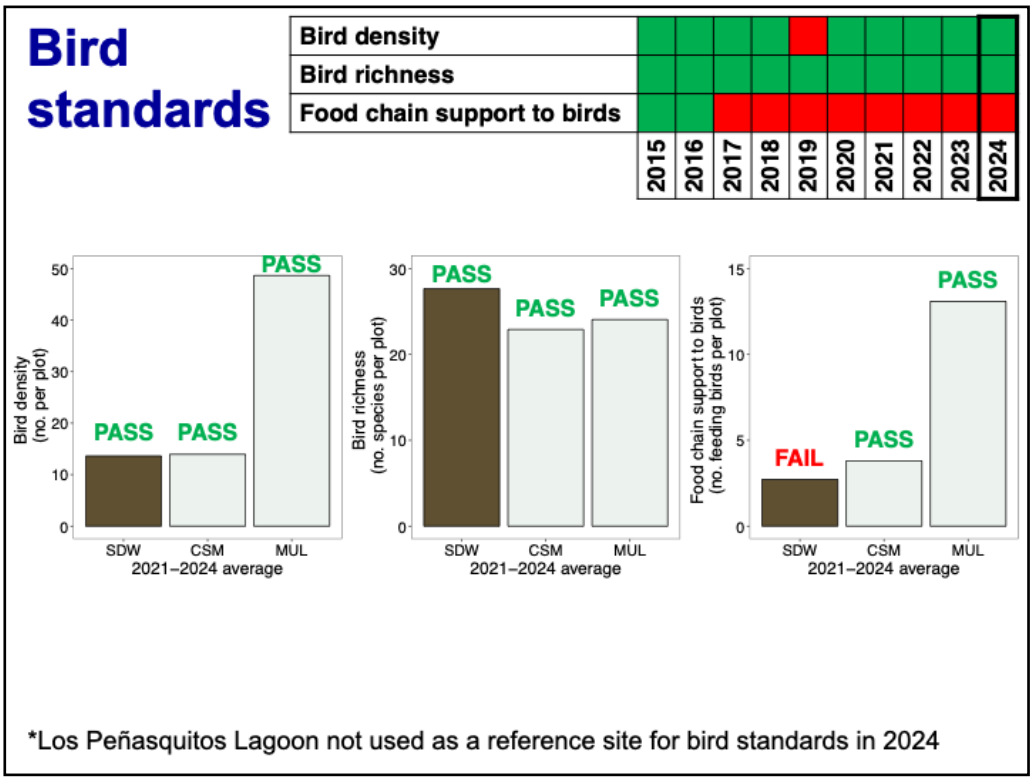
- We now move onto Spartina canopy architecture. This standard is meant to assess the capacity for Spartina to provide habitat for Ridgway's Rail and other bird species by measuring the proportion of Spartina stems greater than 3 feet.
- San Dieguito has consistently met this standard for the last 10 years. This pattern continued in 2024, and SDW passed this standard in 2024, as Spartina canopy was greater than at the lowest performing reference wetland, Mugu Lagoon.



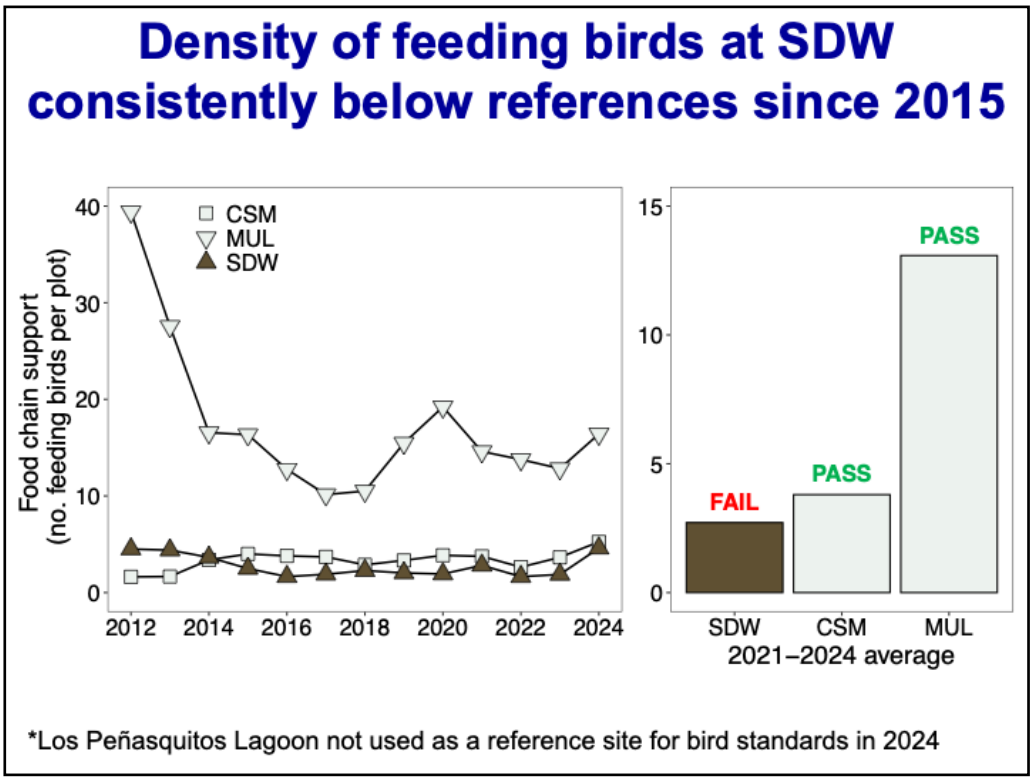
- We now move onto the bird standards, beginning with bird density. We did not include Los Penasquitos lagoon as a reference site for the bird standards in 2024 because we did not have a full year of bird data collected for this lagoon. Therefore, we exclude this lagoon and used the 4-year running average for the remaining three wetlands.
- Bird density has been consistently met at San Dieguito for the last 10 years, aside from in 2019. This pattern continued in 2024, and SDW passed this standard in 2024, with a comparable bird density to Carpinteria Salt Marsh. Bird densities were substantially higher at Mugu Lagoon.



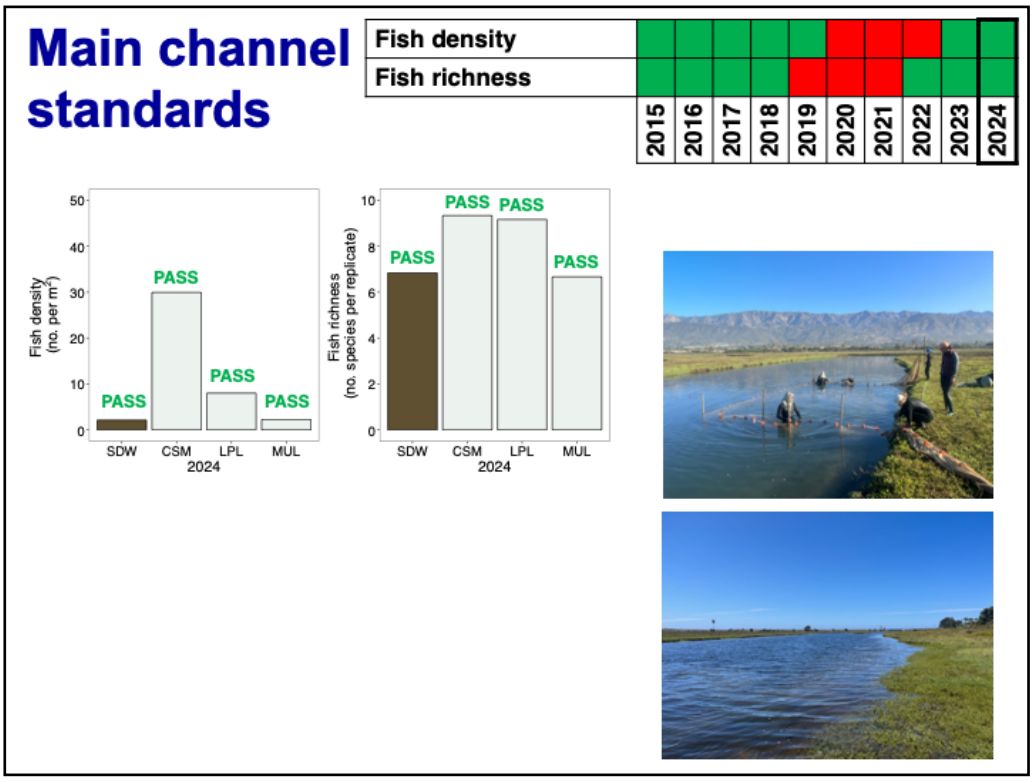
- Moving on to bird richness, this is another standard that has been consistently met at San Dieguito over time. As in prior years, San Dieguito passed this standard in 2024 with the highest value for bird richness relative to the other wetlands.



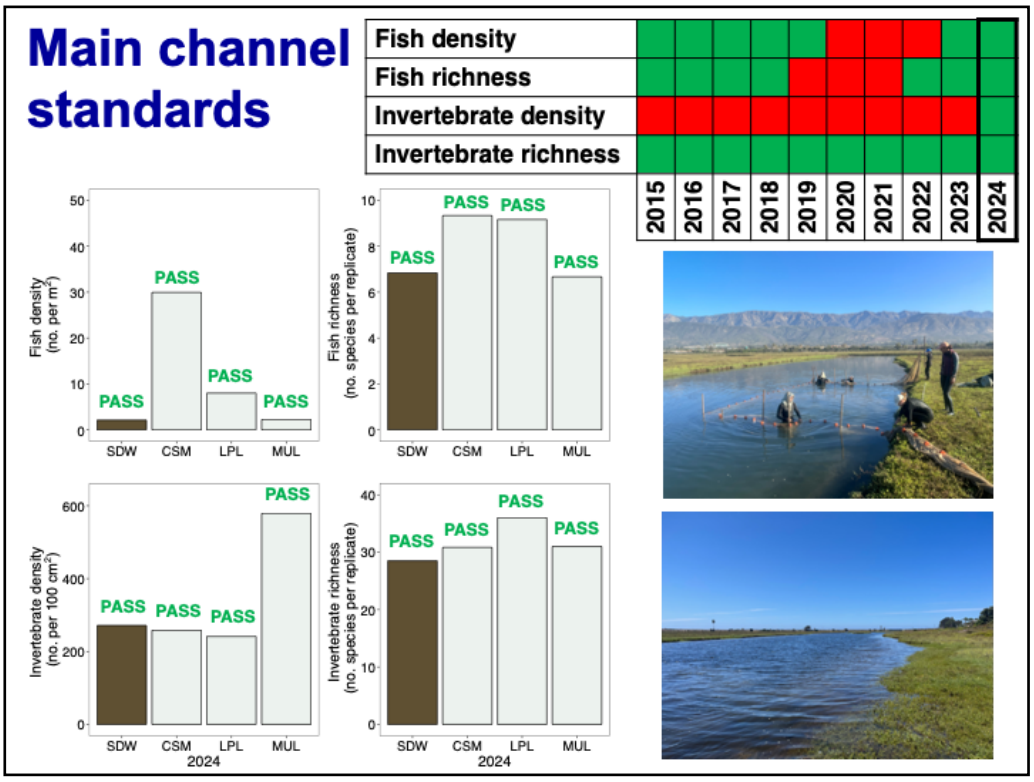
- Next, we move on to food chain support to birds. This standard has chronically underperformed at San Dieguito relative to the reference wetlands since 2017. This pattern continued in 2024, and food chain support was lowest at SDW in 2024.



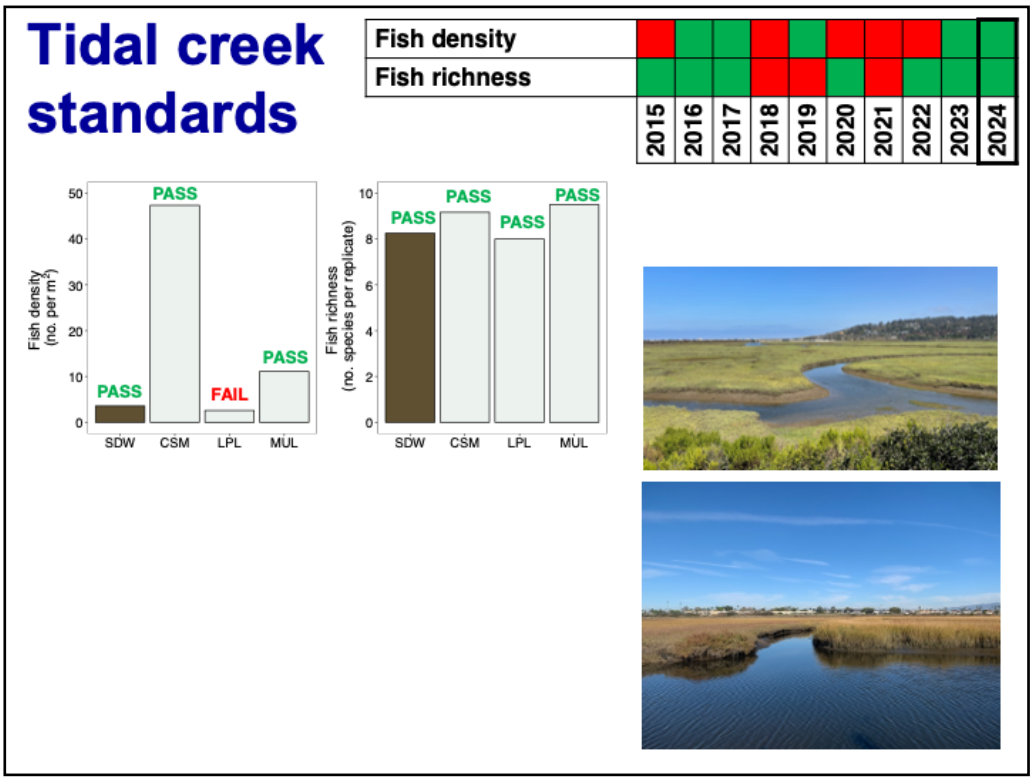
- To better understand this underperformance at San Dieguito, we will examine the full annual time series for food chain support to birds
- Across all years, food chain support to birds has been consistently highest at Mugu lagoon.
- At San Dieguito, the average density of feeding birds declined after 2014 and has remained just below Carpinteria Salt Marsh over time. Although there was a slight increase at San Dieguito in 2024, the 4-year running average at San Dieguito still remains below that of Carpinteria Salt Marsh in 2024.



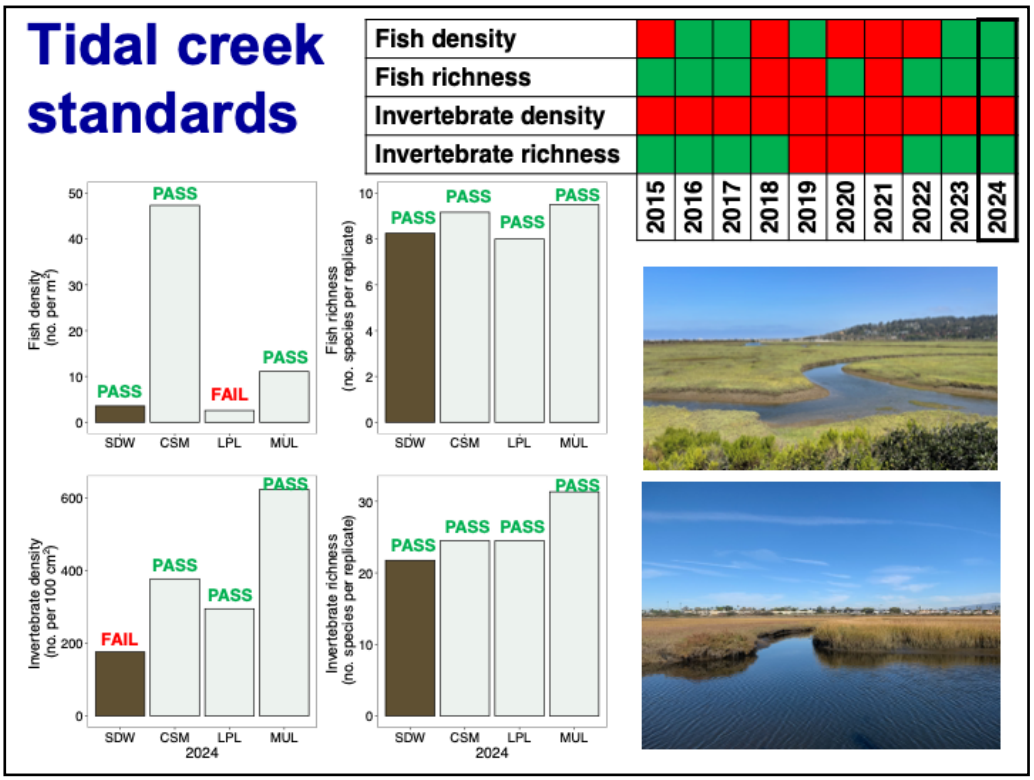
- We now move onto standards measured in main channel habitats, beginning with fish density and fish richness. These standards have been intermittently met over time, and San Dieguito has passed these standards over the past few years.
- In 2024, San Dieguito passed both fish standards in main channel habitats, and all wetlands passed these standards for this year.



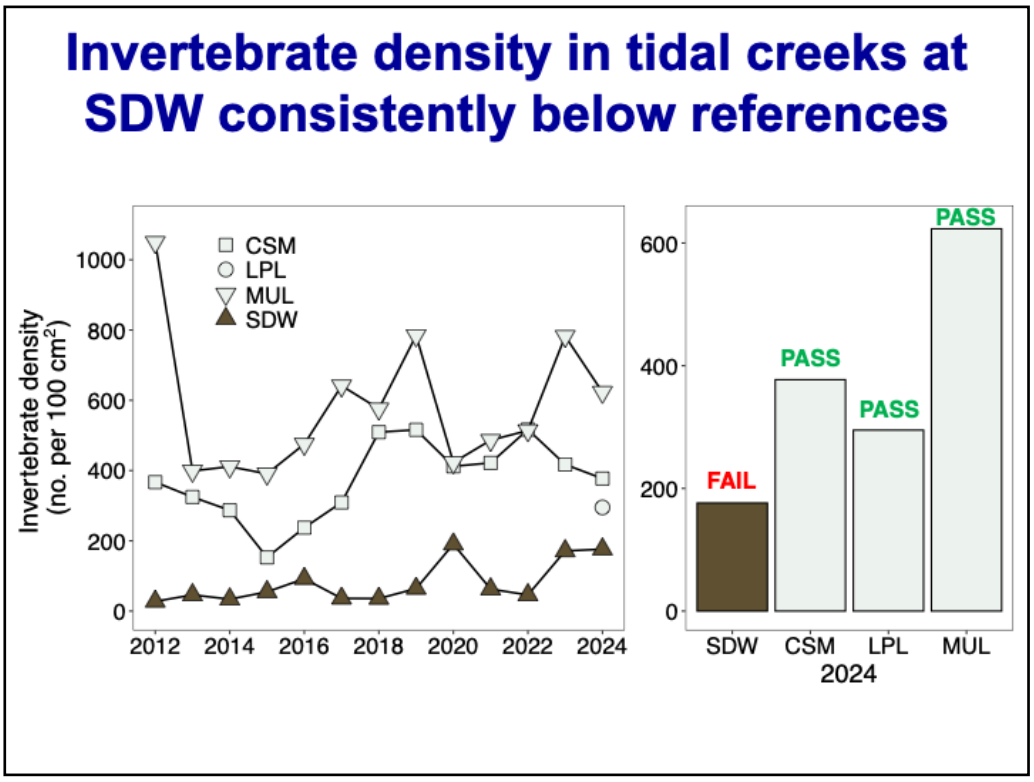
- We now examine invertebrate density and richness in main channel habitats.
- Invertebrate density in main channel habitats had not been met at San Dieguito wetland until this year, and this standard has been on a positive trajectory over the past few years.
- In contrast, invertebrate richness in main channel habitats has been consistently met at San Dieguito for the past 10 years.
- Thus, all wetlands passed the standards for both fish and invertebrate density and richness in main channel habitats in 2024.



- We now move onto standards measured in tidal creek habitats, beginning with fish density and fish richness. These standards have been intermittently met over time, and San Dieguito has passed these standards over the past few years.
- In 2024, San Dieguito passed both fish standards in tidal creek habitats. All wetlands passed these standards for fish richness in 2024, but Los Penasquito Lagoon failed the standard for fish density this year.

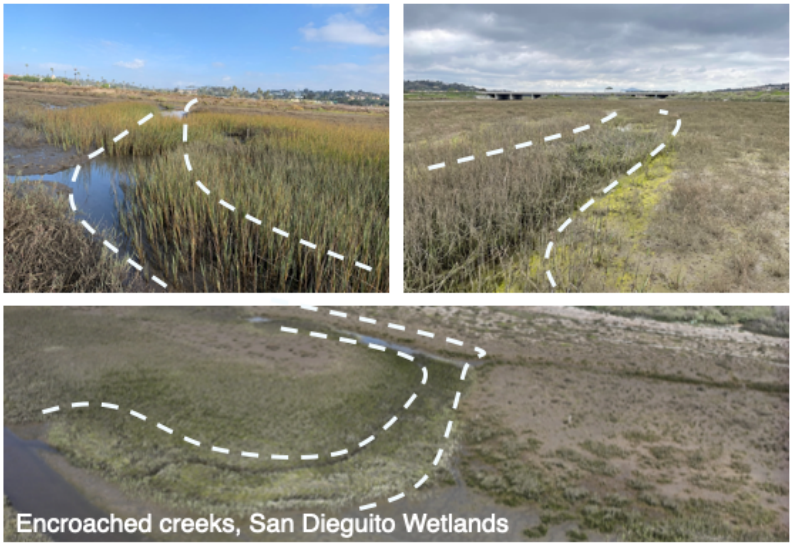


- We now examine invertebrate density and richness in tidal creek habitats.
- Invertebrate density in tidal creek habitats has never been met at San Dieguito wetland and SDW failed this standard in 2024
- In contrast, invertebrate richness in tidal creek habitats has recently been met at San Dieguito over the past few years, and this standard continued to be met in 2024.



- To better understand the underperformance of invertebrate density in tidal creeks at San Dieguito, we can examine the annual time series for this standard.
- The annual time series on the left indicates that invertebrate density at San Dieguito has remained well below the reference sites since the beginning of monitoring. There has been a slight improvement in these values over the last two years, but San Dieguito was still below the lowest performing reference site, Los Penasquitos Lagoon, in 2024.

Salt marsh encroachment into tidal creeks has required shifts in sampling locations



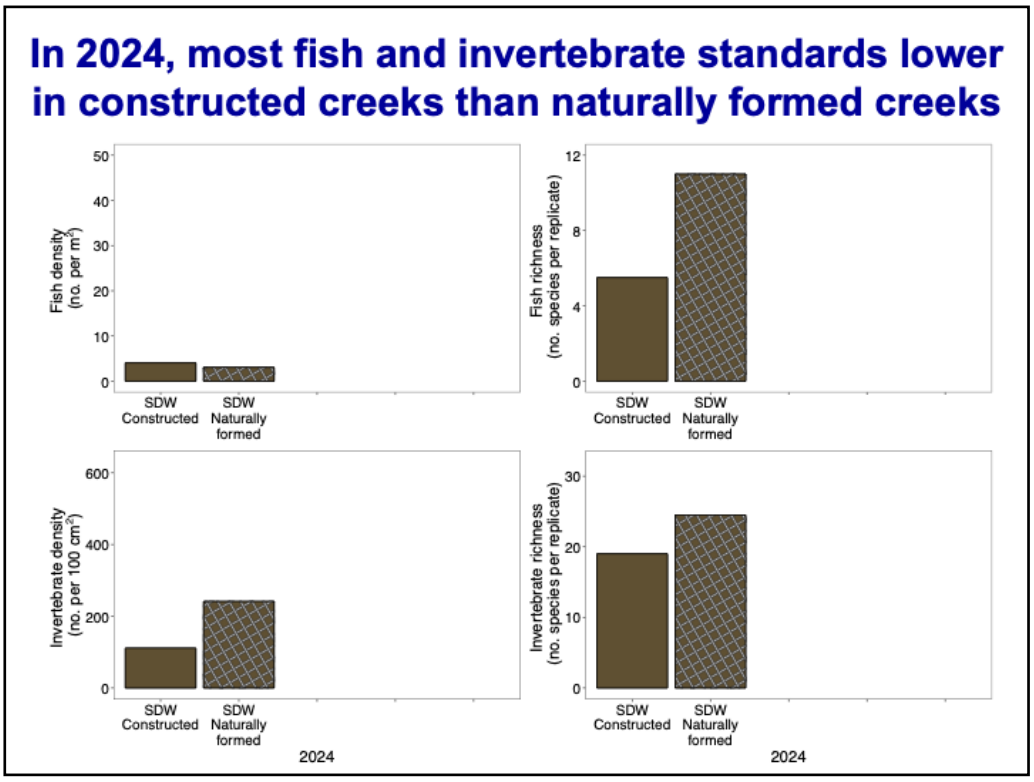
Sampling not possible in encroached creeks

- The results for fish and invertebrate density and richness in tidal creeks reflect the fact that salt marsh encroachment into tidal creeks at San Dieguito wetlands has required shifts in sampling locations over time, as sampling is not possible in encroached tidal creeks.

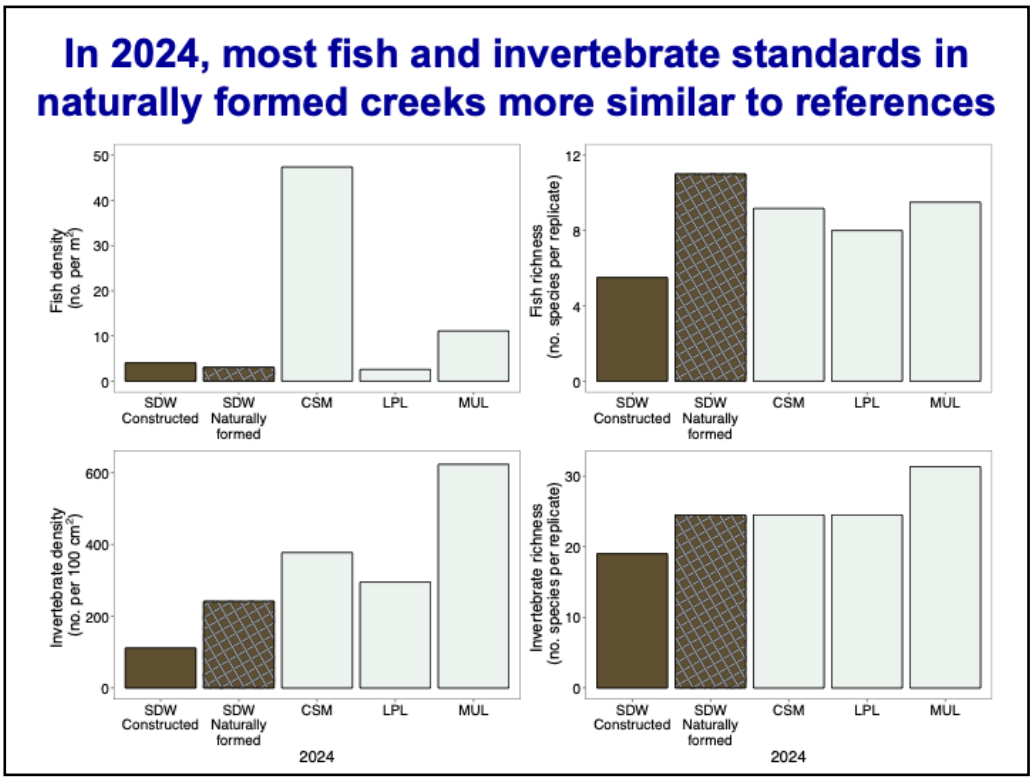
In 2024, only two constructed creeks were possible to sample

Two "naturally-formed" creeks were also sampled and used to assess compliance

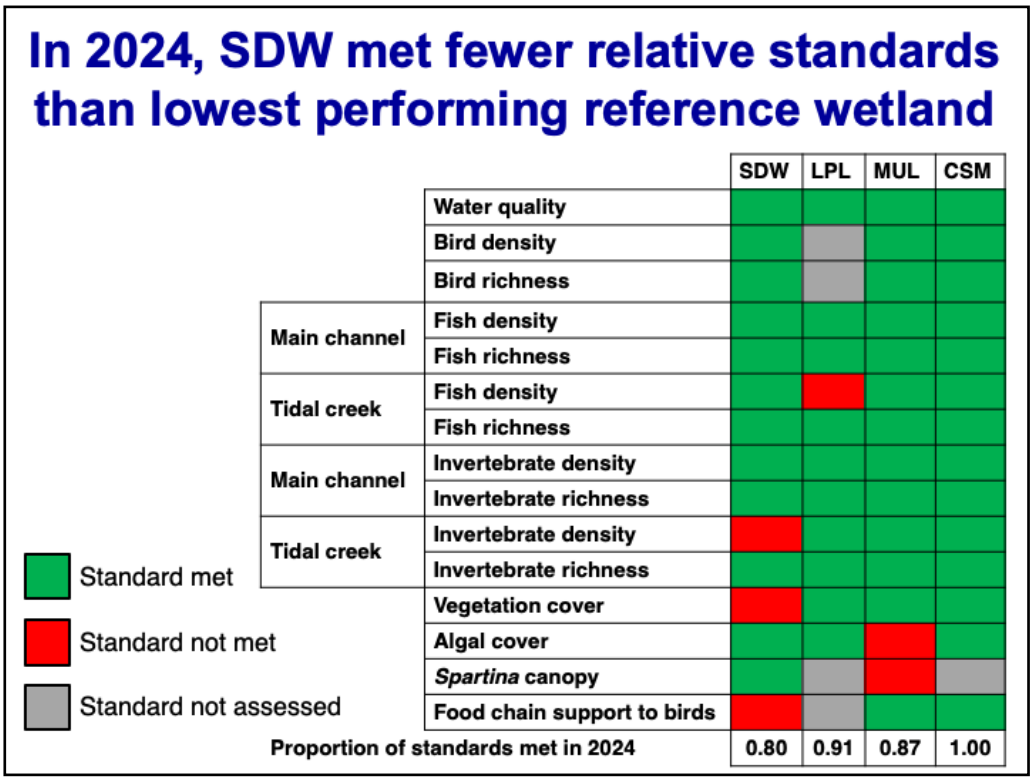
- To match the sample size of the reference sites, we aim to sample six constructed tidal creeks at San Dieguito Wetlands each year.
- However, due to Spartina encroachment, in 2024 it was only possible to sample two constructed tidal creeks, shown by the white circles on the west side of the restoration project.
- Over time, two "naturally formed" creeks have evolved from frequently exposed mudflat, as shown by the donut circles on the east side of the restoration project.
- In 2024, we also sampled these two naturally formed creeks and used them to assess compliance to have a more comparable sample size to the reference wetlands.



- If we compare the outcomes for fish and invertebrate density and richness for the constructed creeks at San Dieguito (shown in brown on the left) relative to those collected from the naturally formed creeks (shown with the hatched pattern on the right), we see that all fish and invertebrate standards except for fish density were lower in the constructed creeks relative to the naturally formed creeks.

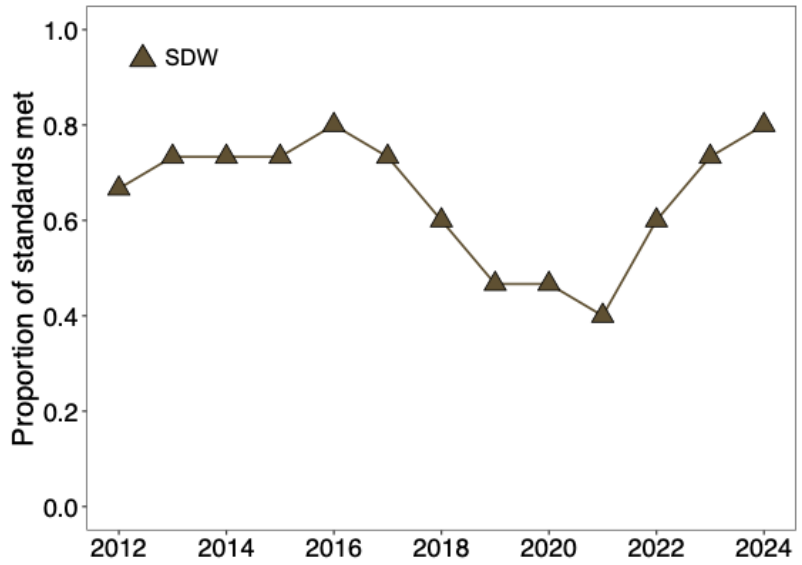


- If we compare the values collected from constructed and naturally formed tidal creeks at San Dieguito to the reference wetlands, it is clear that the values collected in the naturally formed creeks are more similar to those collected at the references.
- Thus, grouping constructed and naturally formed creeks together in assessing compliance may mask the contributions of constructed creeks, which were generally lower than the naturally formed creeks.
- In the third talk, Kat will go into more detail about the causes and consequences of tidal creek loss at San Dieguito Wetlands.

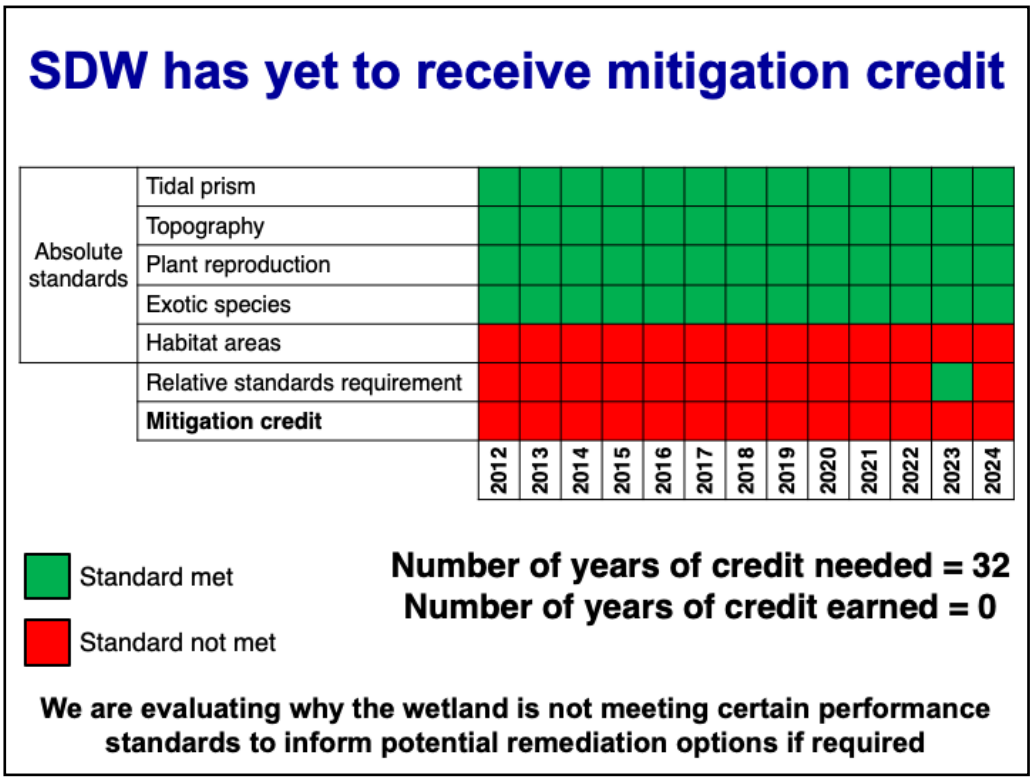


- This table summarizes the outcomes for each relative performance standard for each wetland for 2024.
- Green indicates that the standard was met, red indicates that the standard was not met, and gray indicates that the standard was not assessed.
- Carpinteria Salt Marsh did not fail any standards in 2024. Los Penasquitos Lagoon failed only one standard- fish density- meaning it met 91% of standards. Mugu Lagoon failed two standards – algal cover and Spartina canopy– meaning it met 87% of standards.
- San Dieguito Wetlands failed three standards, invertebrate density in tidal creeks, vegetation cover, and food chain support, meaning that it met 80% of standards and is the lowest performing wetland. Therefore, San Dieguito did not meet the relative standards requirement for 2024.

Proportion of relative standards met at SDW on upward trajectory



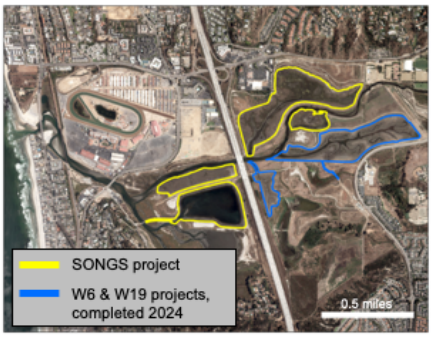
- There was a progressive decline in the the proportion of standards met at San Dieguito Wetlands beginning in 2017, but since 2022, we have seen an increase in the proportion of standards met, suggesting that the project is on an upward trajectory. This trend continued in 2024, even when Los Peñasquitos Lagoon replaced Tijuana Estuary as a reference site.



- However, San Dieguito Wetlands has yet to receive mitigation credit.
- To receive mitigation credit for a given year, the wetland restoration project must meet all of the Absolute Standards and as many of the Relative Standards as the lowest performing reference wetland.
- In terms of absolute standards, the San Dieguito Wetlands has yet to meet the Habitat Areas Absolute Standard due to the loss of mudflat.
- In 2024, San Dieguito Wetlands also failed to meet the relative standards requirement.
- We are evaluating why the wetland is not meeting certain performance standards to inform potential remediation options if required.

Anticipated changes for 2025 performance monitoring

- Additional restoration within San Dieguito Lagoon will require changes in evaluation of tidal prism standard
- Loss of tidal creeks will require changes in evaluation of fish and invertebrate relative standards



- We wanted to end by flagging some anticipated changes for 2025 performance monitoring. In 2024, the additional restoration of the W6 and W19 projects within the San Dieguito Lagoon, as shown in blue in this map, was completed. Opening these restored areas to tidal influence will require changes in the evaluation of tidal prism standard, and we are currently in the process of updating our evaluation approach.
- As highlighted earlier in the talk, the loss of tidal creeks will require changes in evaluation of fish and invertebrate relative standards, as we likely will not be able to sample any constructed tidal creeks in 2025.
- Kat will go into more detail about the causes and consequences of tidal creek loss in our next talk.

Agenda

Annual Public Workshop

San Onofre Nuclear Generating Station Wetland Mitigation Project

May 6, 2025

9:30 – 9:40	Introduction and Overview – Mark Page, UCSB
9:40 – 10:20	Performance of the San Dieguito Wetlands Restoration Project – Rachel Smith, UCSB
10:20 – 10:50	Causes and consequences of tidal creek loss at San Dieguito Wetlands– Kat Beheshti, UCSB
10:50 – 11:30	General Discussion

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