Benefits for Project Monitoring and Decision-Making: The WRMP and the SBSPRP

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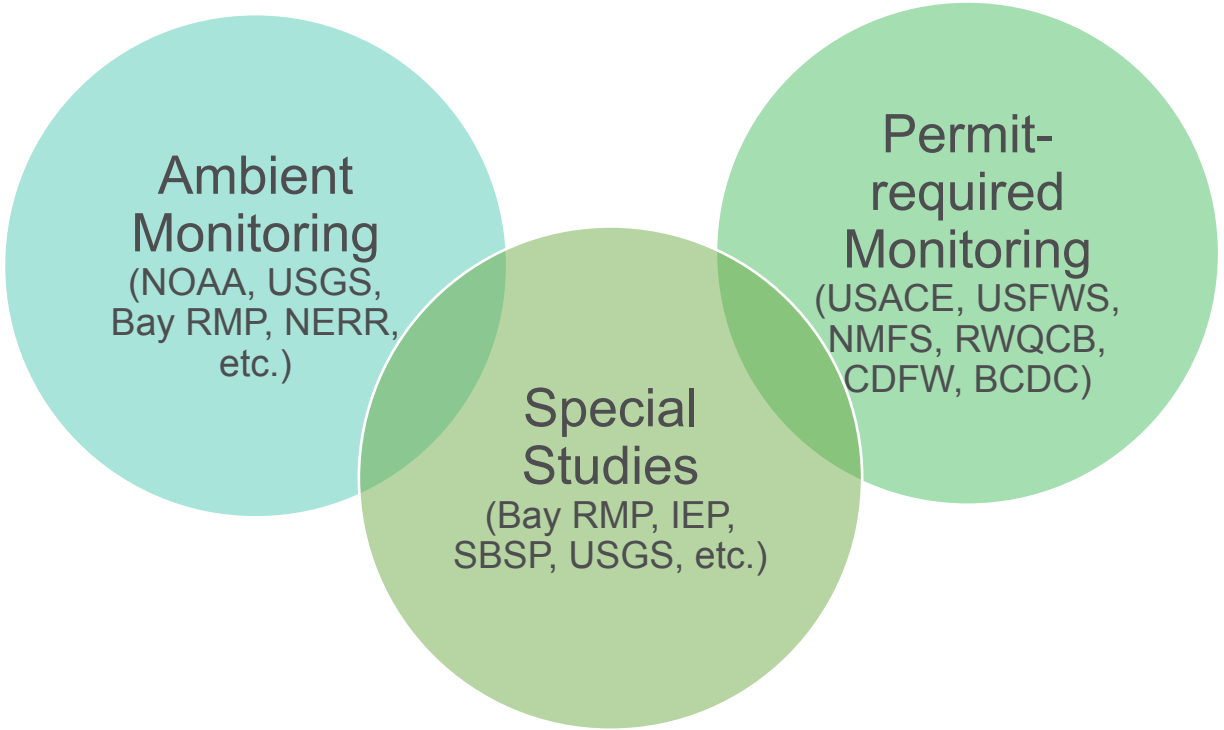
Photo: Shira Bezalel

Existing Monitoring of SFE Tidal Wetlands and Restoration Projects



- Different indicators
- Different SOPs
- Not coordinated across space and time
- Data not always translated into **information**
- Expensive

Wetlands Regional Monitoring Program

The WRMP delivers coordinated regional monitoring of San Francisco Bay's wetlands to:

- Inform science-based decision-making for wetland restoration and adaptive management
- Increase the cost-effectiveness of permit-driven monitoring associated with wetland restoration projects

Co-managed by the San Francisco Estuary Partnership and San Francisco Estuary Institute

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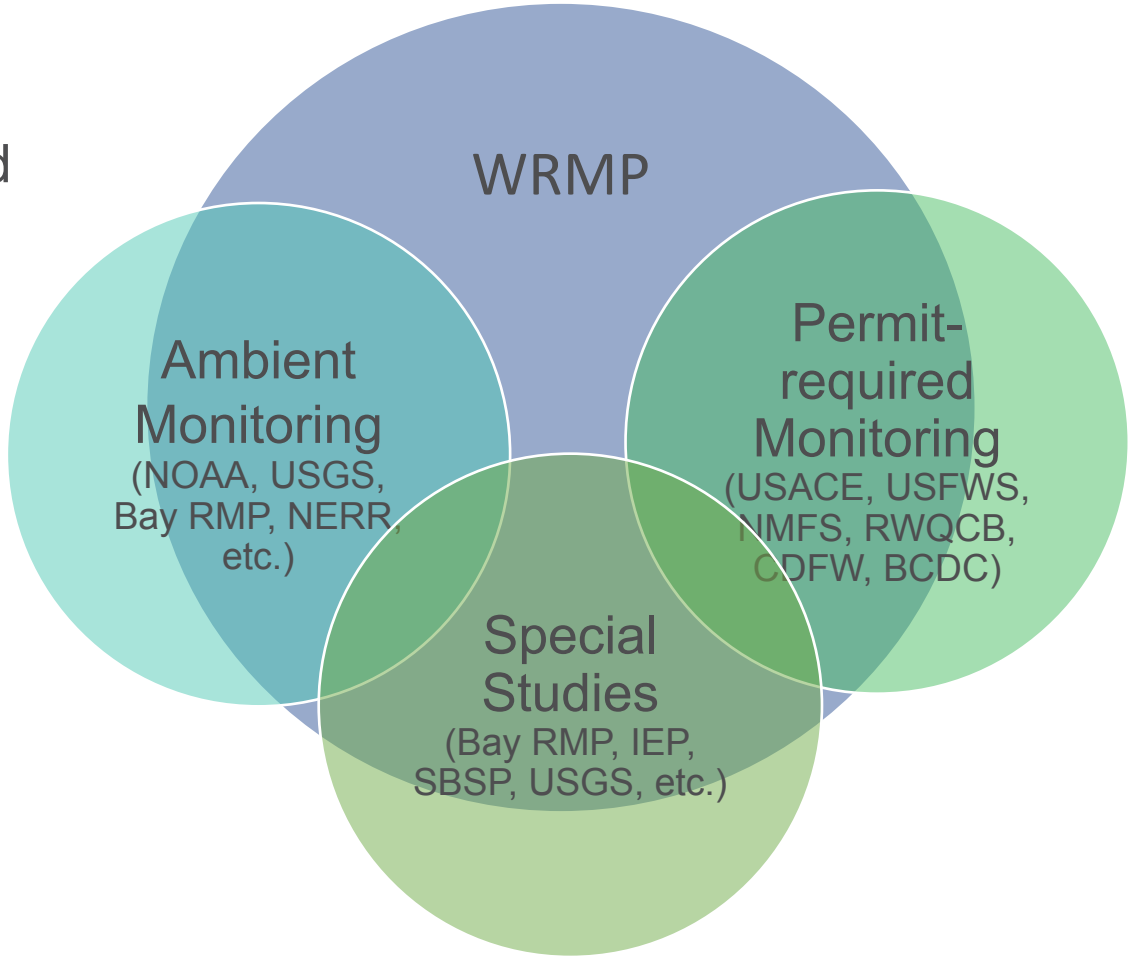
WRMP Vision

- Consistent indicators and SOPs
- Coordinated across space and time
- Central data management
- Data translated into **information for end users**
- Cheaper and more cost-effective



WRMP Timeline

Lead Time and Ramp Up

Current - Implementation

2016-2019	2019-2022	2022-2025
Program Development • Program Administration • Governance • Science Framework • Outreach	**Program Development** • Program Administration • Governance • Science Implementation • Data Management • Outreach	**Program Development and Implementation** • Program Administration • Operationalize Monitoring Site Network • Align Performance Measures and WRMP Indicators • Regulatory Coordination • CBO Engagement • Outreach and Training
Funding: USEPA and in-kind		**Funding: USEPA, SFBRA, in-kind, other**

Program Partners

TAC Workgroups

- Geospatial
- Hydrogeomorphology
- Vegetation
- Fish & Fish Habitat
- People & Wetlands

SAN FRANCISCO ESTUARY PARTNERSHIP

SFEI San Francisco Estuary Institute


WHAT?
WHERE?
WHO?
WHEN?
WHY?
HOW?

WRMP Guiding Questions

1. Where are the region's tidal wetlands and wetland projects, and what net landscape changes in area and condition are occurring?
2. How are external drivers, such as accelerated sea level rise, development pressure, and changes in runoff and sediment supply, impacting tidal wetlands?
3. How do policies, programs, and projects to protect and restore tidal marshes affect the distribution, abundance, and health of plants and animals?
4. What new information do we need to better understand regional lessons from tidal wetland restoration projects in the future?
5. How do policies, programs, and projects to protect and restore tidal wetlands benefit and/or impact public health, safety, and recreation?

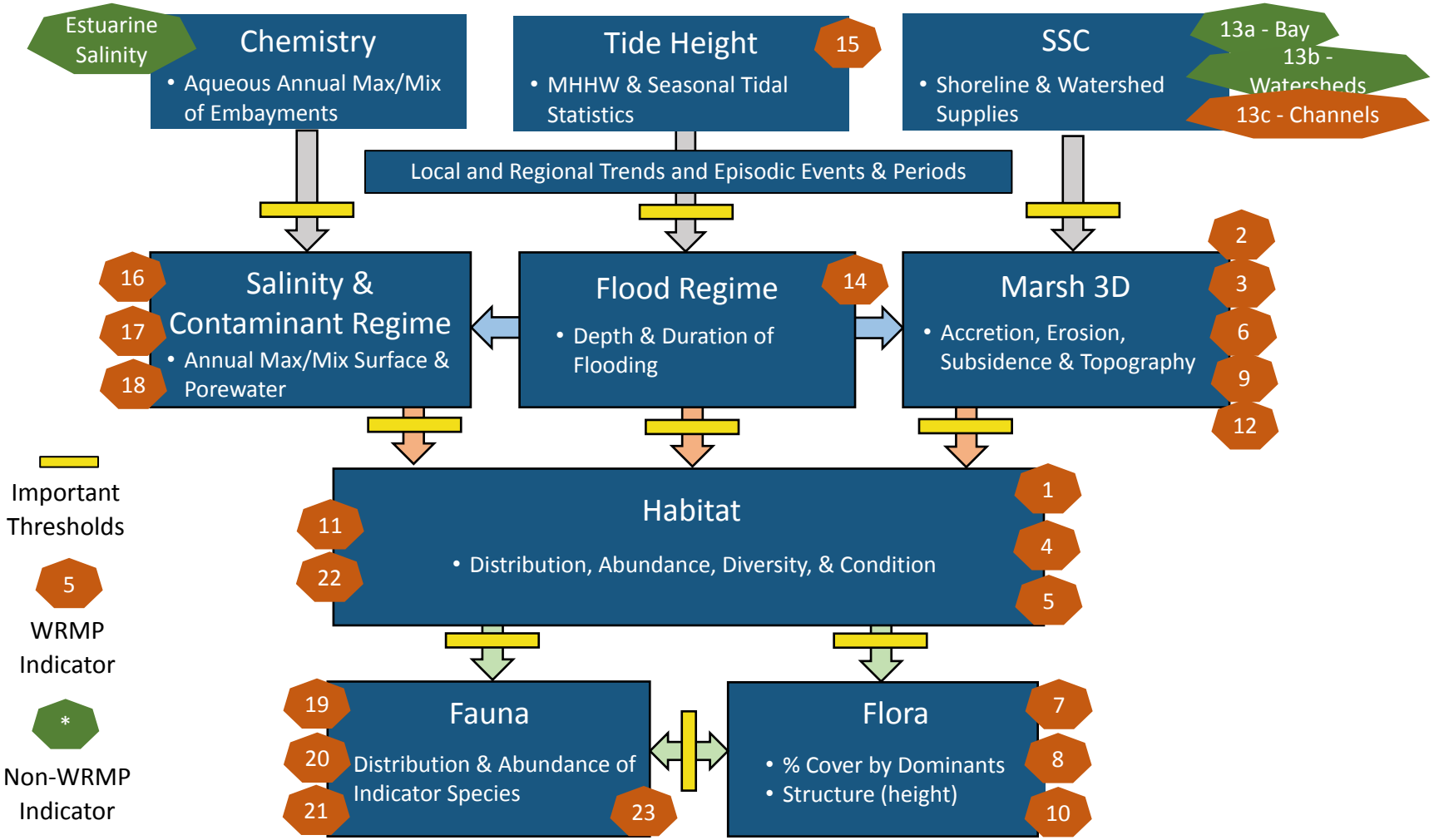
WRMP Science Framework

Master Matrix: Translates management questions into monitoring questions, indicators, and metrics

Conceptual Models: Explain correlative and causative relationships between tidal wetland indicators based on observations, models, and related science

Monitoring Plan: Framework for cost-effective monitoring and data synthesis across sites and subregions

Data Management Strategy: Facilitates integrated analysis of data from existing monitoring programs/projects and the WRMP


Estuarine Salinity
Chemistry
• Aqueous Annual Max/Mix of Embayments
Tide Height
15
• MHHW & Seasonal Tidal Statistics
SSC
• Shoreline & Watershed Supplies
13a - Bay
13b - Watersheds
13c - Channels
Local and Regional Trends and Episodic Events & Periods
16
17
18
Salinity & Contaminant Regime
• Annual Max/Mix Surface & Porewater
Flood Regime
14
• Depth & Duration of Flooding
Marsh 3D
• Accretion, Erosion, Subsidence & Topography
2
3
6
9
12
Habitat
• Distribution, Abundance, Diversity, & Condition
11
22
1
4
5
19
20
21
Fauna
Distribution & Abundance of Indicator Species
23
Flora
• % Cover by Dominants
• Structure (height)
7
8
10
Important Thresholds
5
WRMP Indicator
*
Non-WRMP Indicator

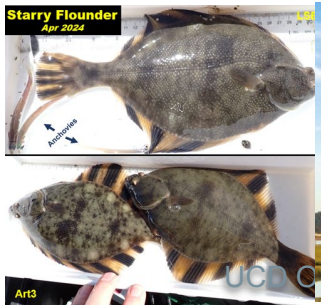
Workgroups and SOPs

Established WG and SOPs:

- Fish and Fish Habitat*
- Vegetation*
- Hydrogeomorphic*
- Geospatial*
- People and Wetlands

Additional WGs:

- Bird (2024)
- Mammal (2025)



* = Approved SOP

WRMP Science Framework

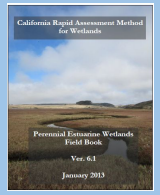
- Guiding Questions
- Management Questions
- Monitoring Questions/Priority Actions
- Metrics
- Protocols

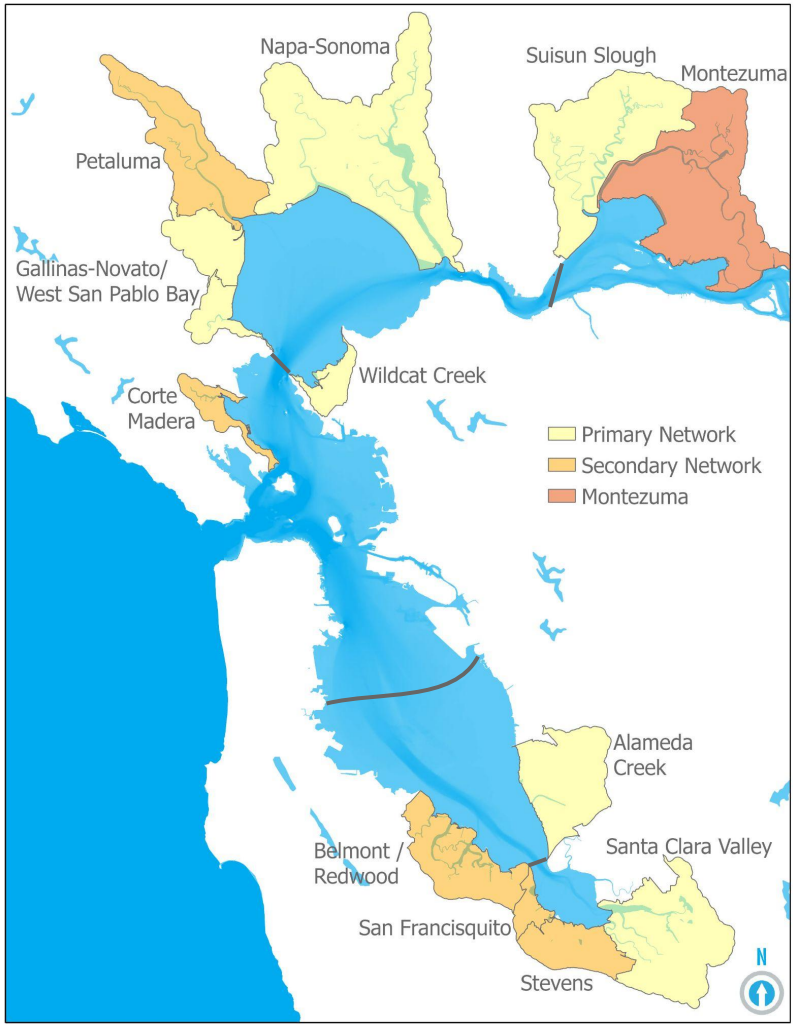
How do policies, programs, & projects to protect & restore tidal marshes affect the distribution, abundance, & health of plants & animals?

How are fish & wildlife **habitats** changing?

What is the distribution & abundance of tidal wetlands?

- Map of bayland habitats
- Map of special-status species habitats



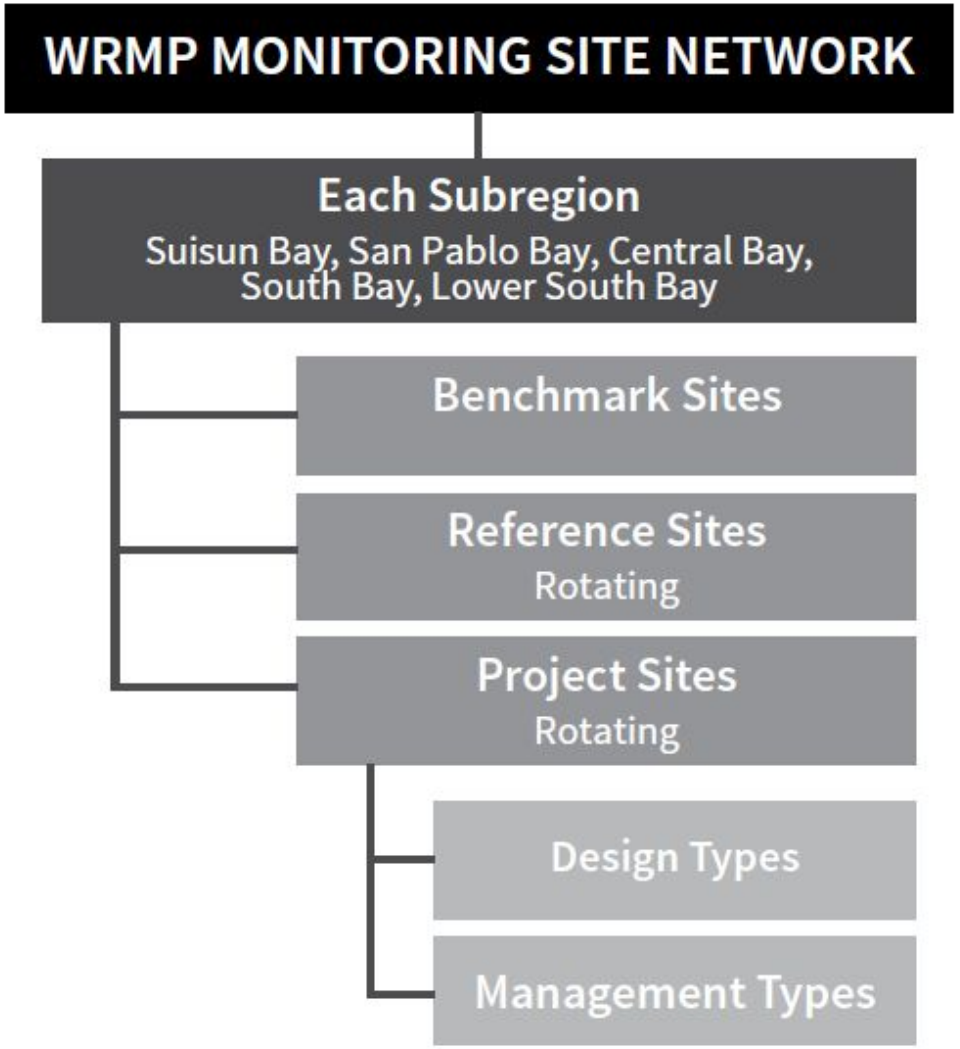


Priority Monitoring Site Networks

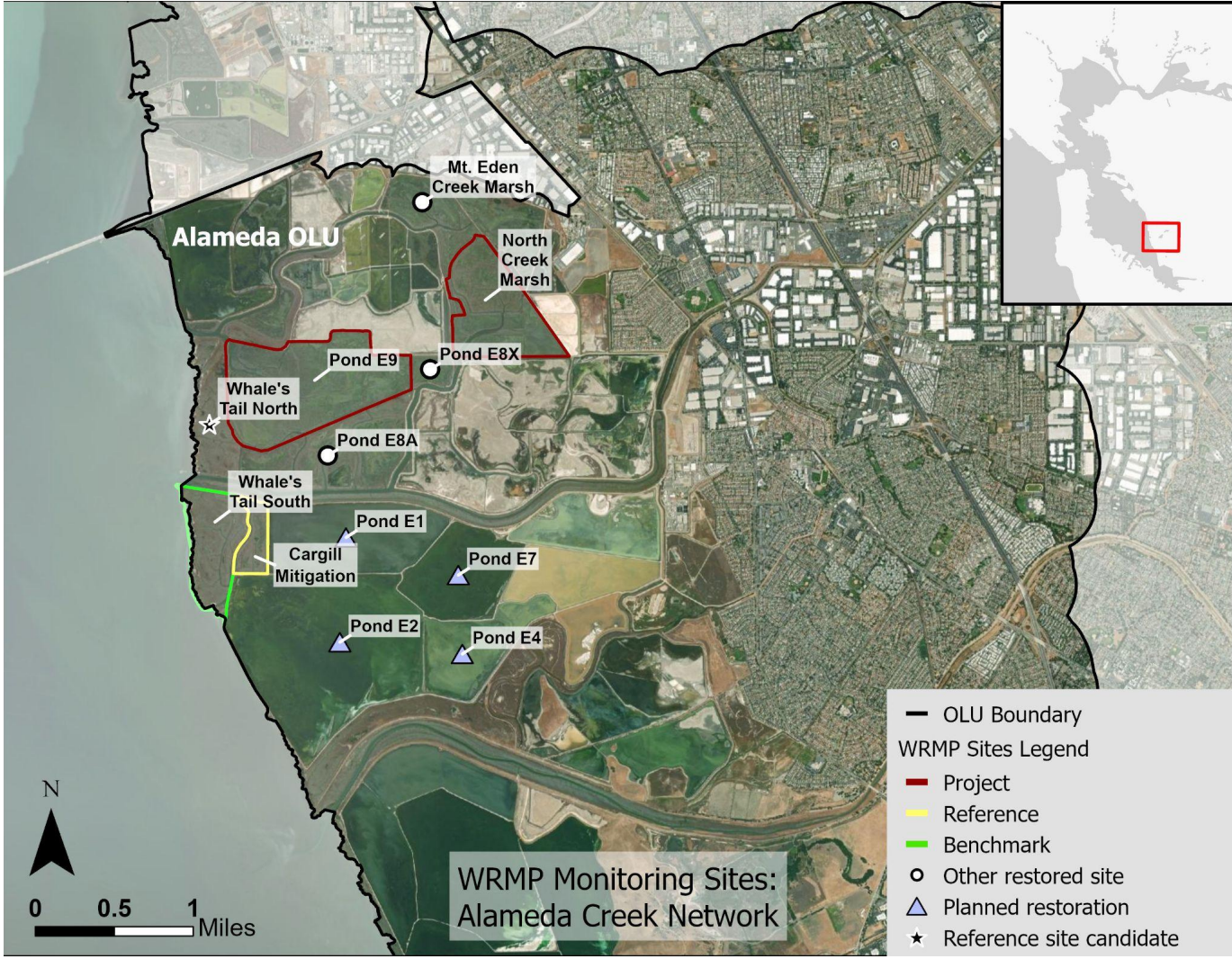
- Provide geographic coverage across the estuary
- Address WRMP Guiding Questions and near-term science priorities
- Leverage historical and existing wetland monitoring and projects
- Inform existing and planned tidal wetland restoration projects
- Support climate change planning in underserved communities

WRMP Monitoring Sites

- Benchmark sites: Represent mature, mostly ancient marshes
- Reference sites: Represent target conditions for restoration projects
- Project sites: Reflect a variety of design and management approaches



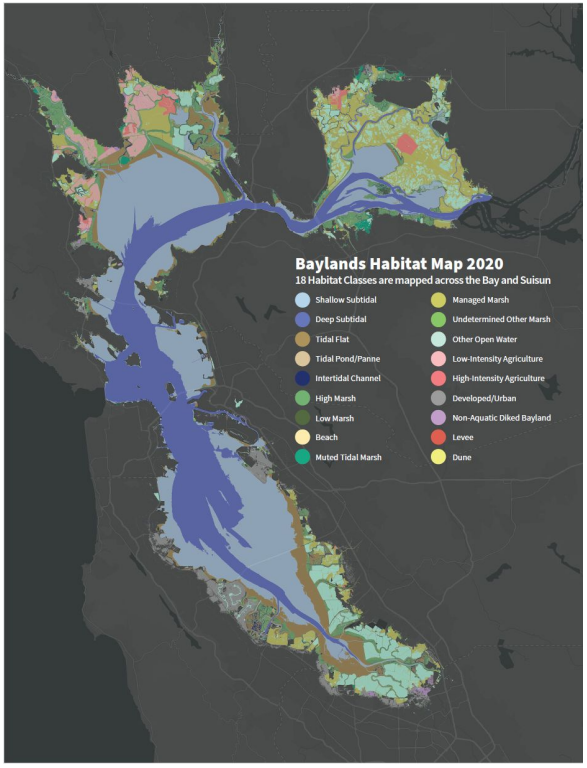
Example: Alameda Creek Network

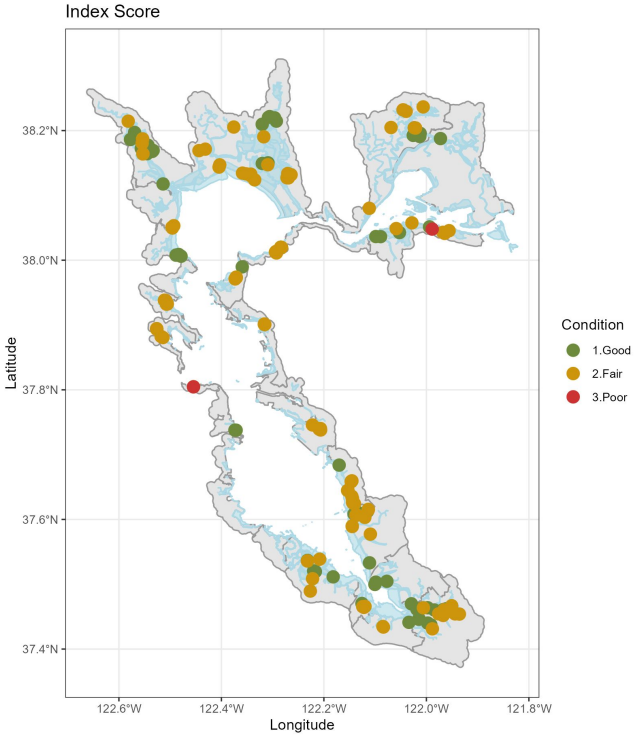


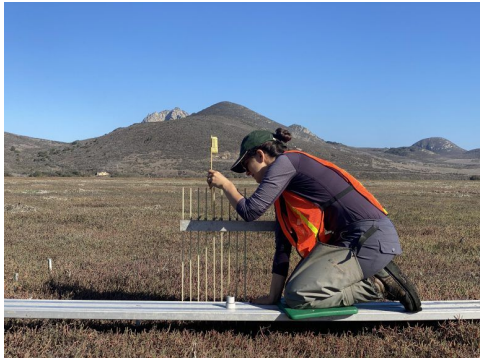

LEVEL
1
LANDSCAPE
ASSESSMENT

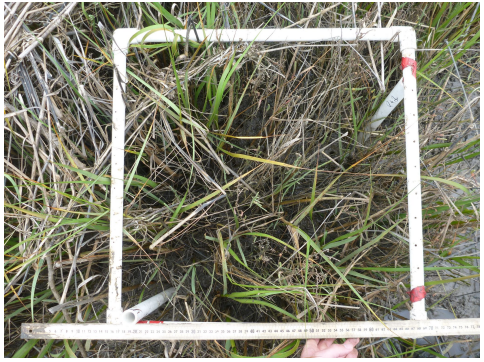

LEVEL
2
RAPID
ASSESSMENT

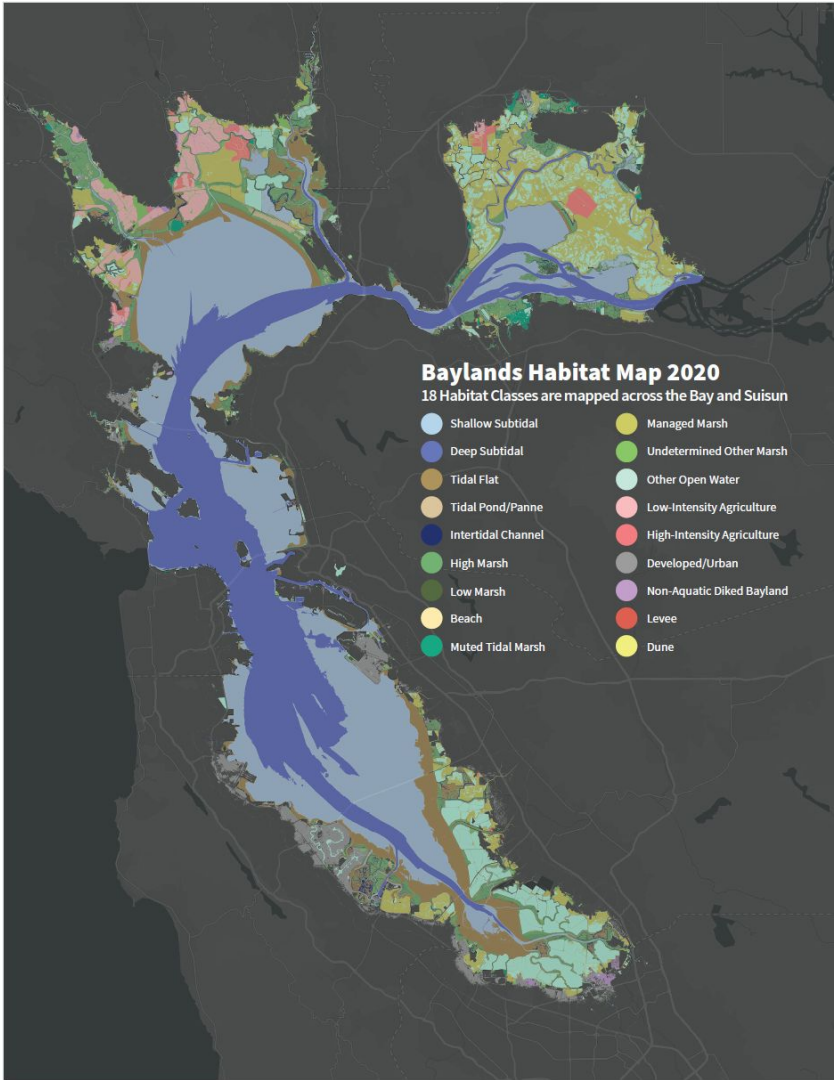

LEVEL
3
INTENSIVE
ASSESSMENT


Baylands Habitat Map 2020
18 Habitat Classes are mapped across the Bay and Suisun
Shallow Subtidal
Deep Subtidal
Tidal Flat
Tidal Pond/Panne
Intertidal Channel
High Marsh
Low Marsh
Beach
Muted Tidal Marsh
Managed Marsh
Undetermined Other Marsh
Other Open Water
Low-Intensity Agriculture
High-Intensity Agriculture
Developed/Urban
Non-Aquatic Diked Bayland
Levee
Dune


Index Score
38.2°N
38.0°N
37.8°N
37.6°N
37.4°N
Latitude
122.6°W
122.4°W
122.2°W
122.0°W
121.8°W
Longitude
Condition
1.Good
2.Fair
3.Poor





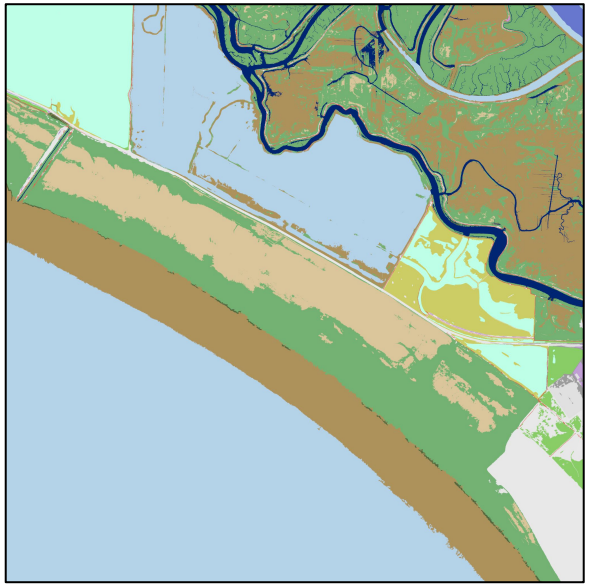


2020 Baylands Habitat Map

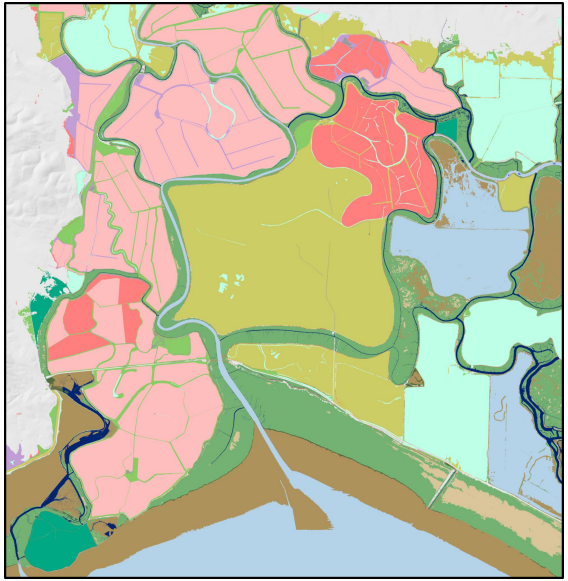
- Reflects bayland habitats as of 2020
- First high resolution baylands habitat map since 2009
- Created by the WRMP using automated, consistent & repeatable methods
- Uses Object Based Image Analysis, high resolution aerial imagery, LiDAR elevation data, tidal data, & other metrics to classify habitats
- Employs a standardized habitat classification scheme
- Map will be updated every 3-5 years
- Methods can be applied outside of the Bay

Importance of Mapping and Continued Monitoring

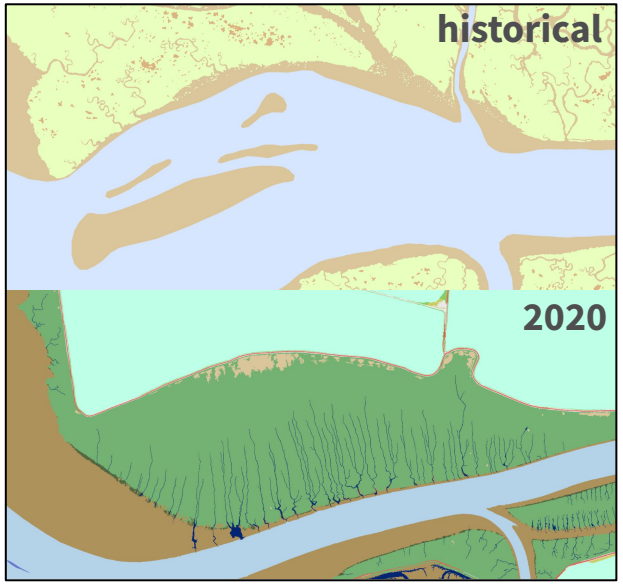
Highlighting expected changes and the need for regular, consistent mapping



Panne expansion & erosion in Hwy 37 strip marsh

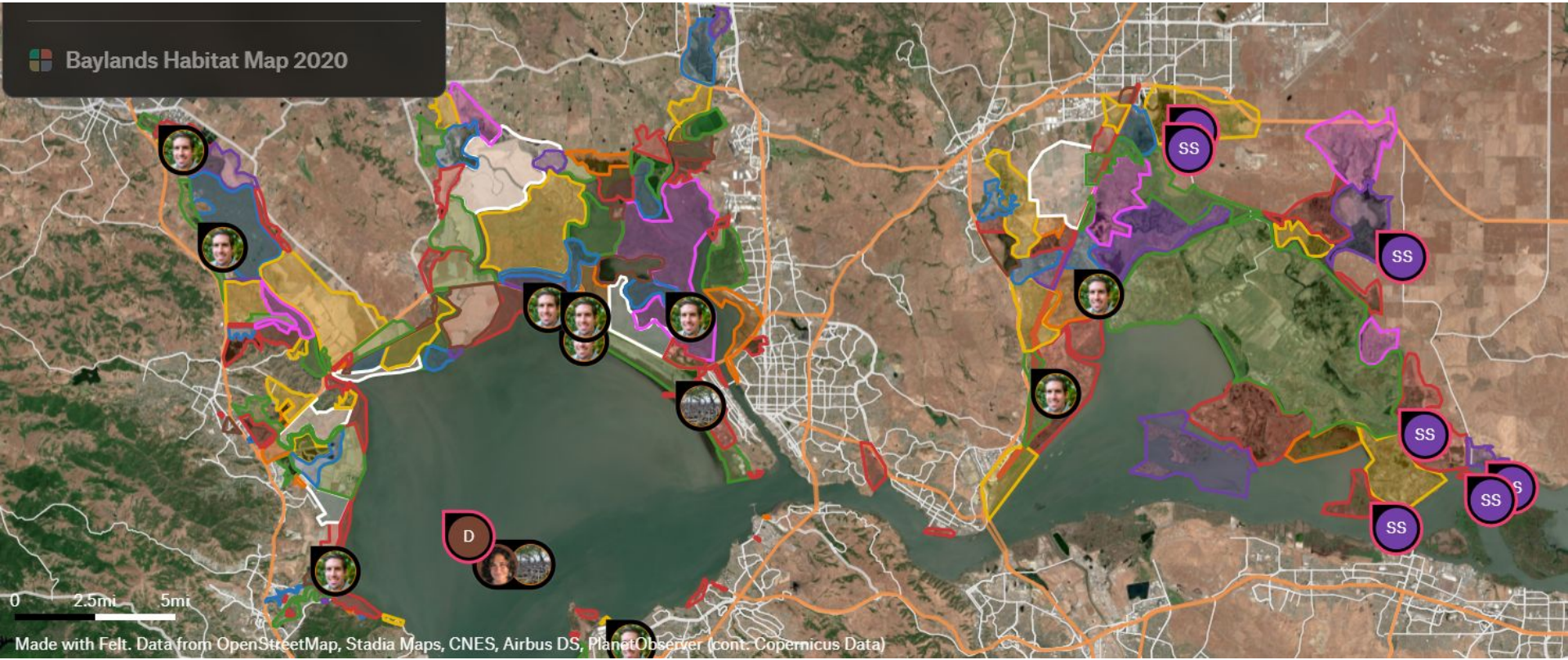


Restoration progress in Sonoma Creek Baylands

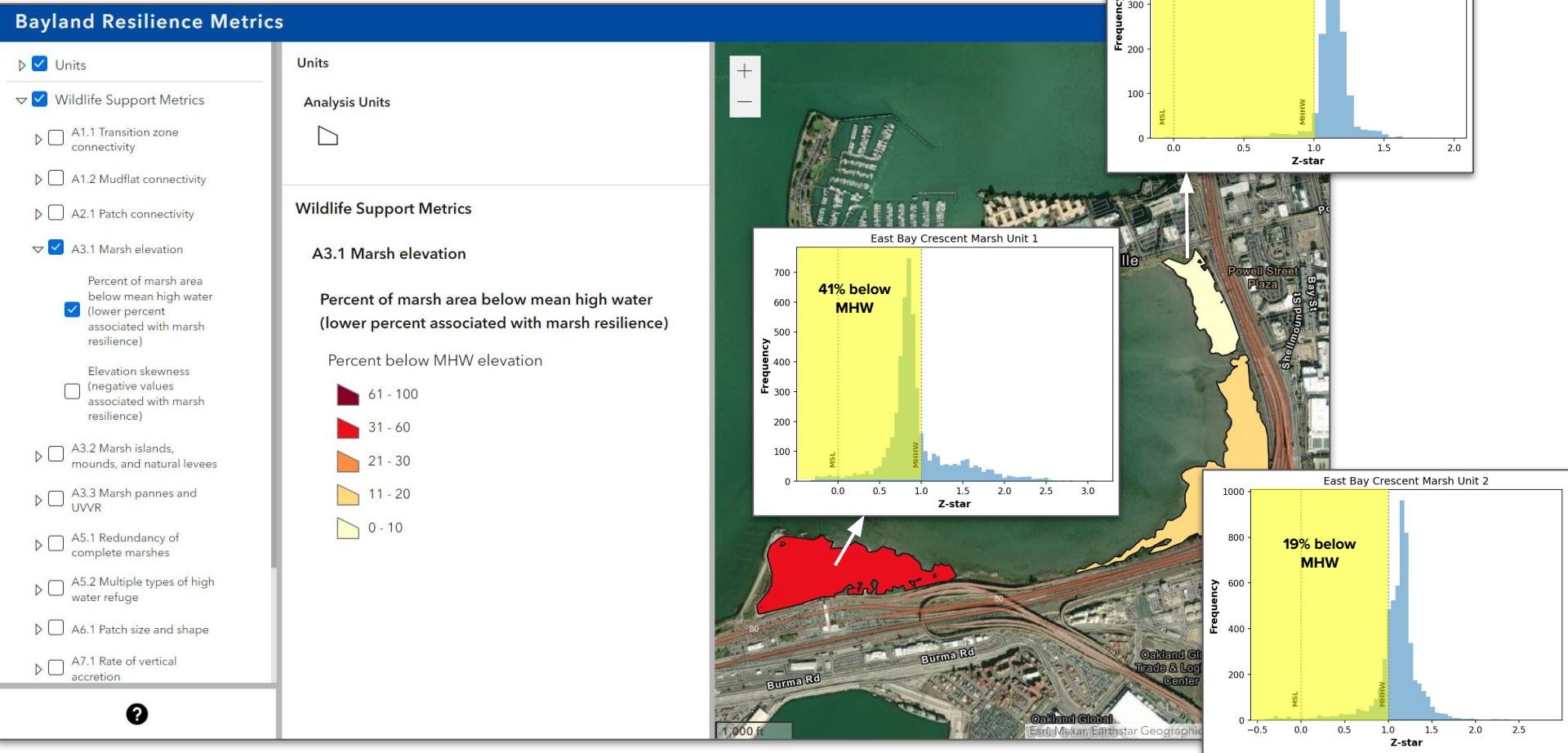


Wetland expansion at Calaveras Point

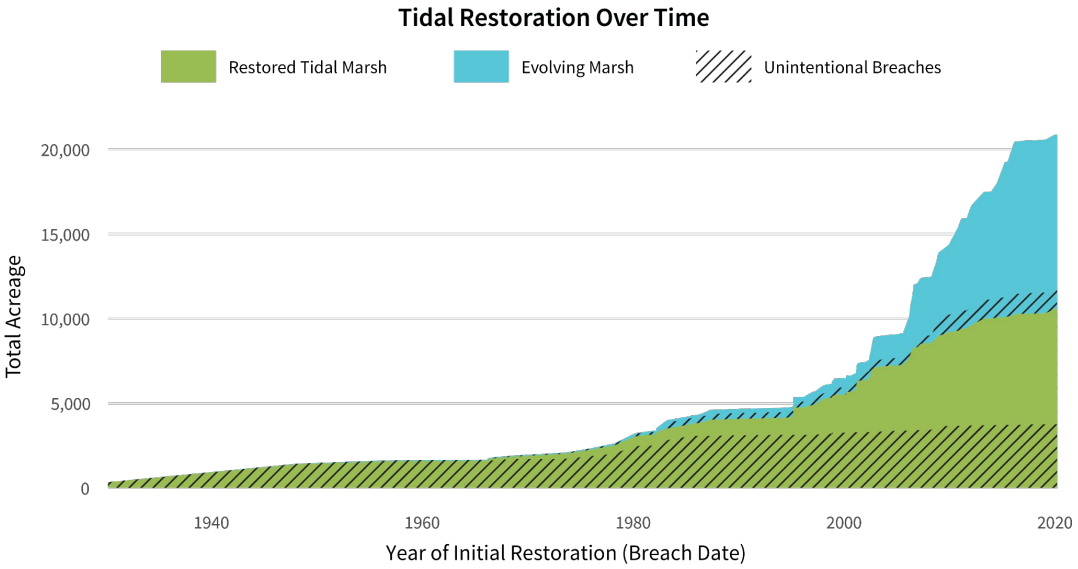
Wetland Management Units

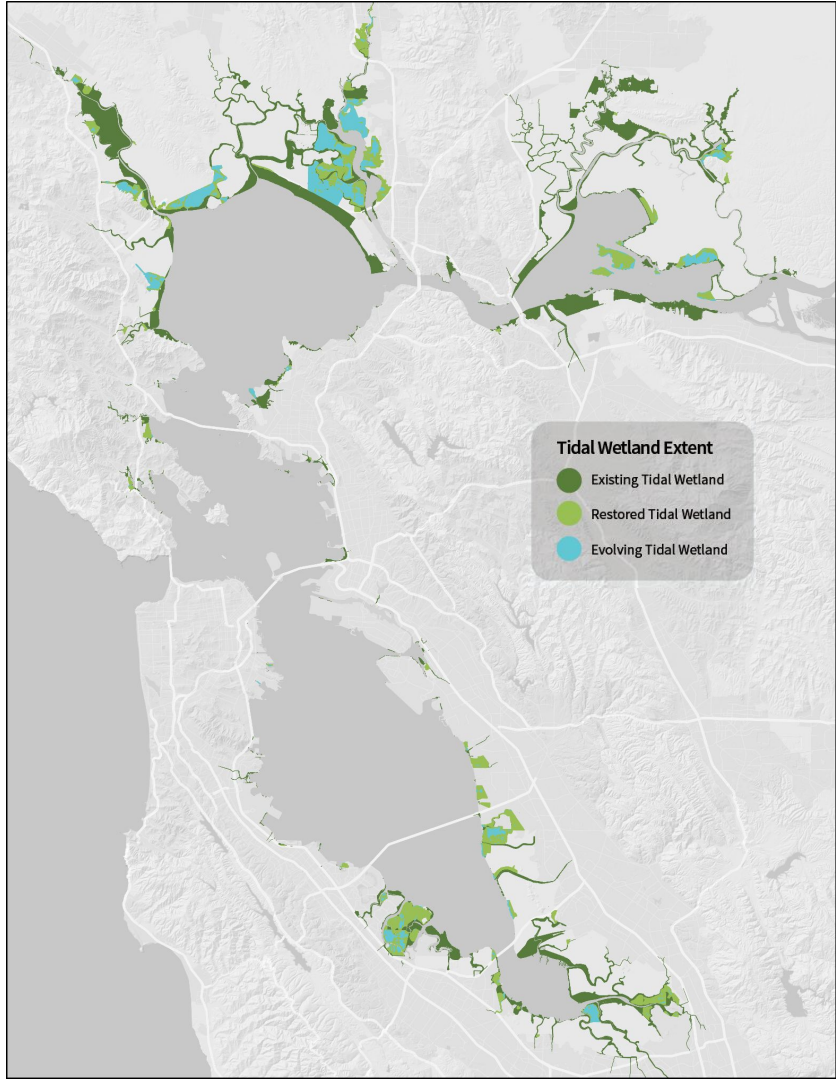


Landscape Resilience Metrics



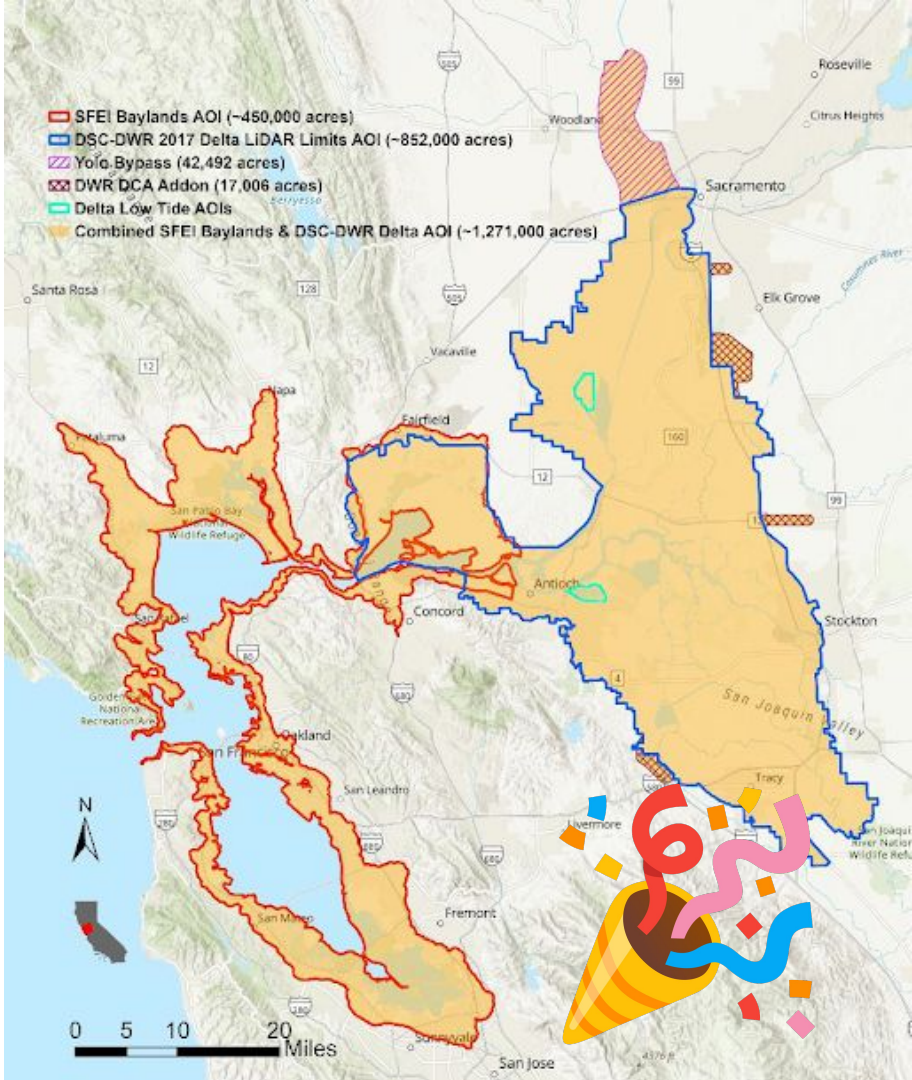
Wetlands Increasing Over Time





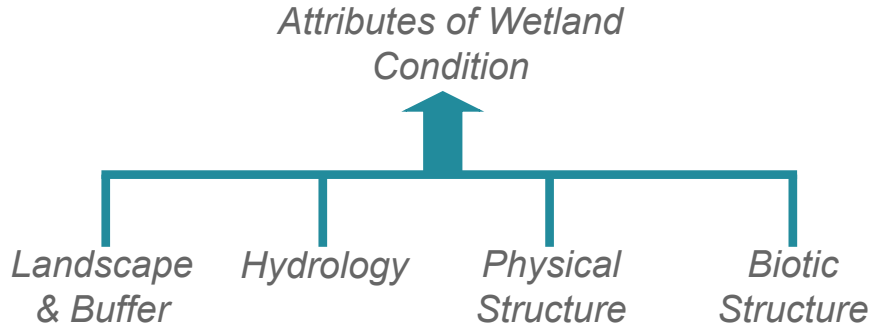
Coming Soon: New LiDAR Data!

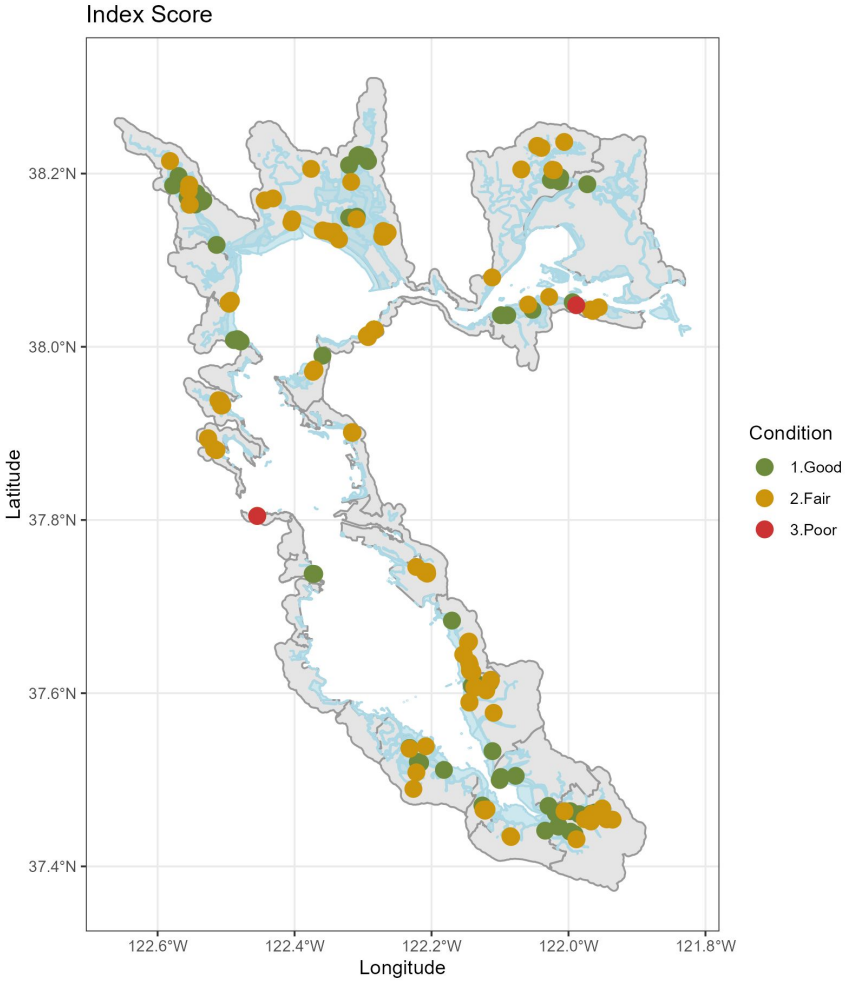
- First estuary-wide LiDAR since 2010/2011
- Planned for summer 2025
- Low-tide (below MSL) collection
- Freely available to all program partners, restoration projects, and the general public
- Will support a 2025 update to the Baylands Habitat Map



CRAM

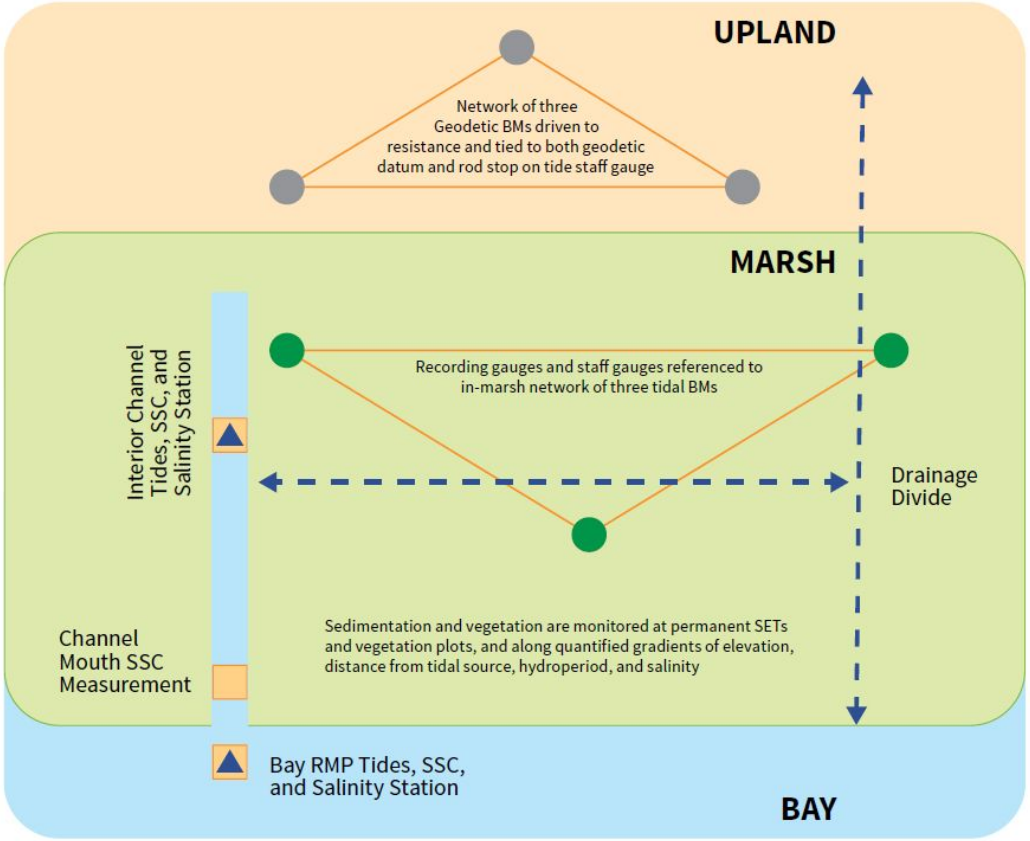
- California Rapid Assessment Method (CRAM) for Perennial Estuarine Wetlands
- Rapid field assessment of tidal marsh conditions across space and time





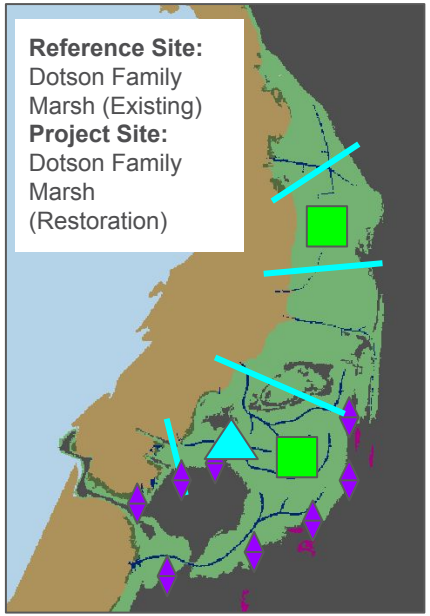
Site-Specific Monitoring

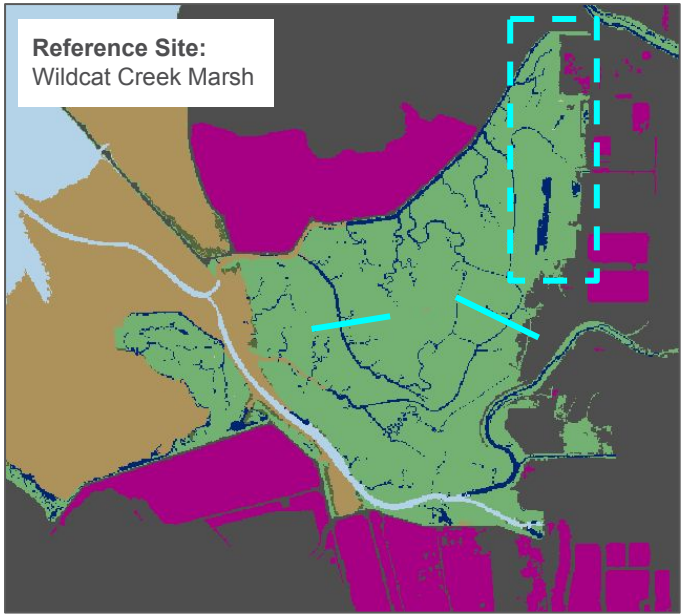
- Elevation and vegetation transects
- Surface Elevation Tables (SETs)
- Frequency, duration, and depth of tidal inundation
- Salinity/SSC in tidal marsh channels
- Photo-documentation

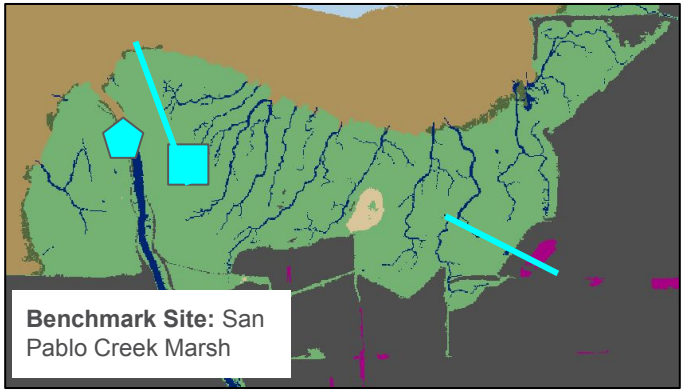


Potential Site-Scale Monitoring Example: Wildcat Network

- Proposed new long-term water level - salinity - SSC station
- Proposed new short-term water level station
- Existing SET-MH
- Proposed new SET-MH
- Proposed new elevation-vegetation transect
- Existing photopoint station
- *Future monitoring to support planned ecotone levee?*







not to scale; locations are for illustrative purposes only

Image: Shira Bezalel

People & Wetlands

Indicators for monitoring human interactions with wetlands and people involved in:

- Decision-making about restoration projects
- Visitation
- Stewardship and education events/programs

Products that evaluate the equitable distribution of:

- Restoration projects and their benefits to people
- Wetland wave attenuation benefits

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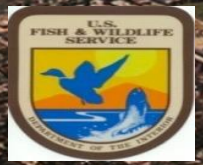
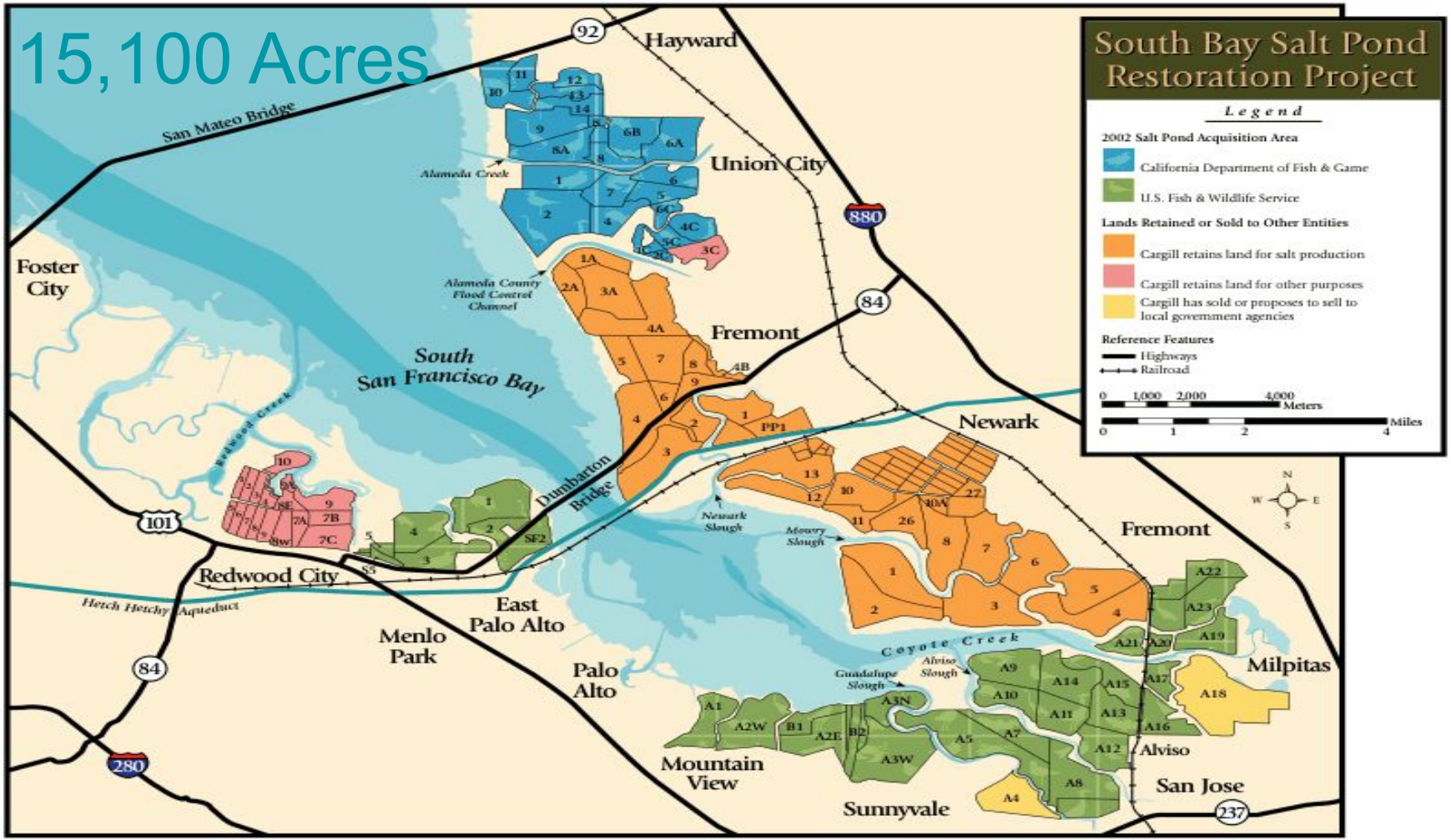
Photo: Sarah Pearce

South Bay Salt Pond Restoration Project

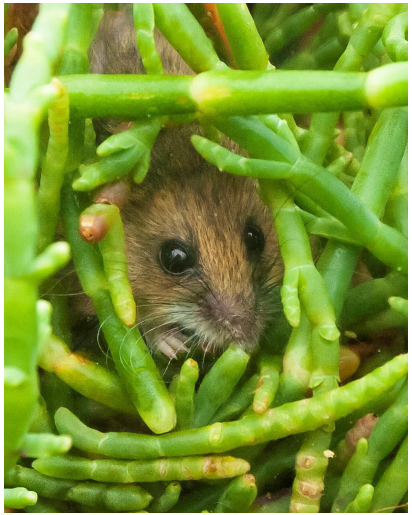
SBSP Restoration Project

- Acquisition of 15,100 acres from Cargill
- Program Initiated in 2003
- Program Planning 2003-2007
- Restoration began in 2007
- Over 20+ years later…….2025




15,100 Acres
South Bay Salt Pond Restoration Project
Legend
2002 Salt Pond Acquisition Area
California Department of Fish & Game
U.S. Fish & Wildlife Service
Lands Retained or Sold to Other Entities
Cargill retains land for salt production
Cargill retains land for other purposes
Cargill has sold or proposes to sell to local government agencies
Reference Features
Highways
Railroad
0 1,000 2,000 4,000 Meters
0 1 2 4 Miles
N
W
E
S
Hayward
Union City
Fremont
Newark
Fremont
Milpitas
Alviso
San Jose
Sunnyvale
Mountain View
Palo Alto
Menlo Park
East Palo Alto
Redwood City
Foster City
San Mateo Bridge
Dumbarton Bridge
Alameda Creek
Alameda County Flood Control Channel
South San Francisco Bay
Redwood Creek
Newark Slough
Mowry Slough
Coyote Creek
Guadalupe Slough
Alviso Slough
Hetch Hetchy Aqueduct
92
880
84
101
280
237

Project Uncertainties



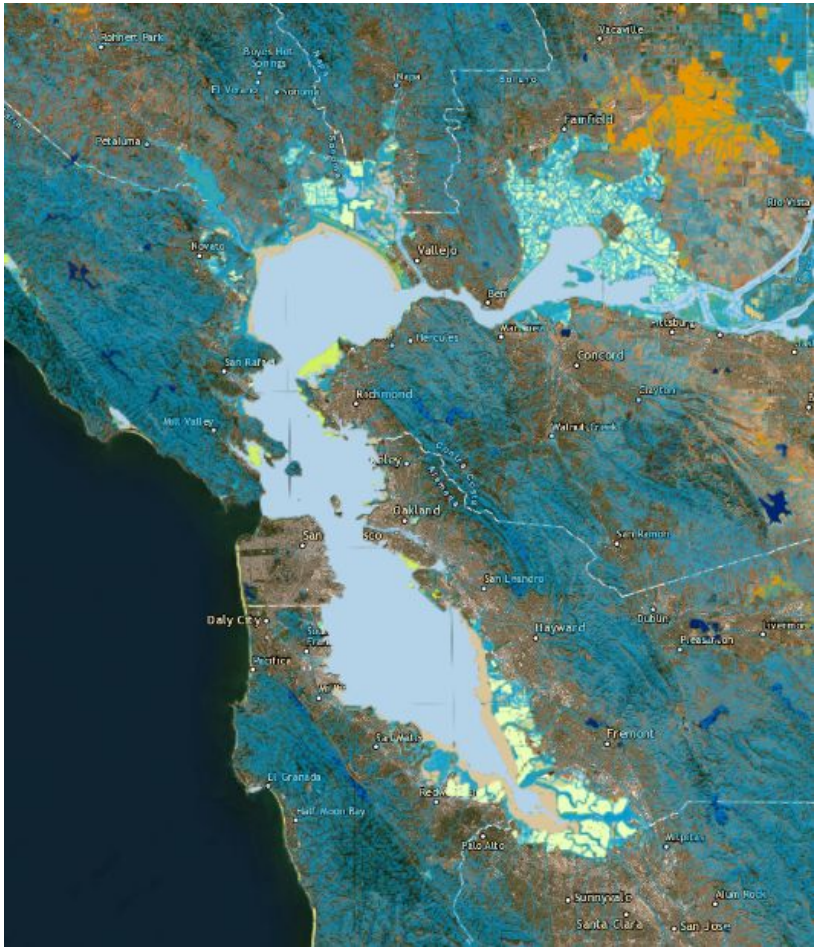
CATEGORY/ PO	RESTORATION TARGET	MONITORING PARAMETER (METHOD)	SPATIAL SCALE FOR MONITORING RESULTS	EXPECTED TIME FRAME FOR DECISION-MAKING	MANAGEMENT TRI
Sediment Dynamics Project Objective 1 (Preserve existing estuarine habitat areas)	No significant decrease in South Bay intertidal and subtidal habitats (south of San Bruno shoal), including restored pond mudflat, intertidal mudflat, subtidal shallow and subtidal channel areas.	▪ Area of restored mudflat. ▪ Area of outboard mudflat. ▪ Area of subtidal shallows and channel. Methods: Bathymetry and LiDAR surveys will be performed periodically, initially every 3–5 years and then less frequently if data suggest slower rates of	▪ Change in tidal mudflat and subtidal shallows expected to vary at the pond complex scales. Areas will be estimated and reported on the pond complex scale. ▪ Changes in South Bay need to be placed within system-wide (San Francisco Estuary) context to assess influence of external factors.	▪ Change in tidal mudflat & subtidal shallow: 10–20 years, assuming significant tidal habitat restoration continues beyond Phase 1. ▪ Subtidal channel change: 0–5 years.	▪ Outboard mudflat greater than the ran natural variability + observational variability/error.

AGEMENT TRIGGER	APPLIED STUDIES	POTENTIAL MANAGEMENT ACTION
ard mudflat decreases than the range of variability + ational lity/error.	▪ Will sediment movement into restored tidal areas significantly reduce habitat area and/or ecological functioning (such as plankton, benthic, fish or bird diversity or abundance) in the South Bay? ▪ Development of a 2- and 3-D South Bay tidal habitats evolution model.	▪ Convene study session to review and interpret findings to assess if observed changes are due to restoration actions or system-wide changes in the sediment budget (*e.g.*, effects of sea level rise). ▪ Study biological effects of loss of mudflat, subtidal shallows, and/or subtidal channel habitat. ▪ Adjust restoration phasing and design to reduce net loss of tidal mudflats. Potential actions include remove bayfront levees to increase wind fetch and sustain tidal mudflat, phase breaching to match demand and supply, and/or breach only high-elevation ponds

Adaptive Management

Monitoring Challenges

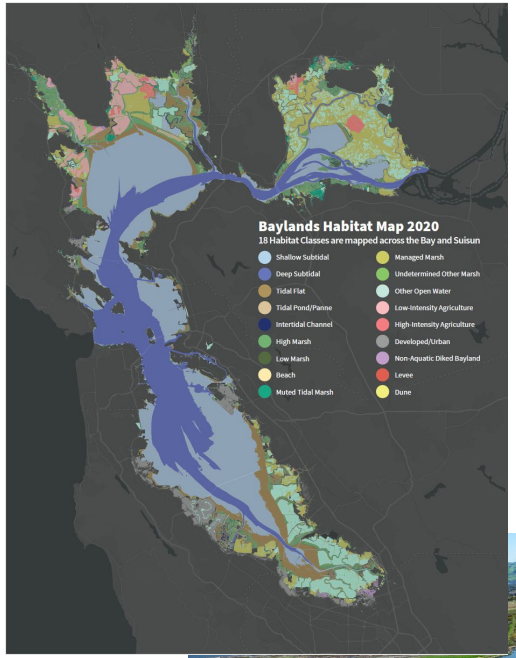
Habitat
Marsh
Establishment
Rails
SMHM
Waterbirds
Snowy Plover
Least terns
Harbor Seals
Public Access
Water Quality
Fish
Hydrology
Predators
…..and more



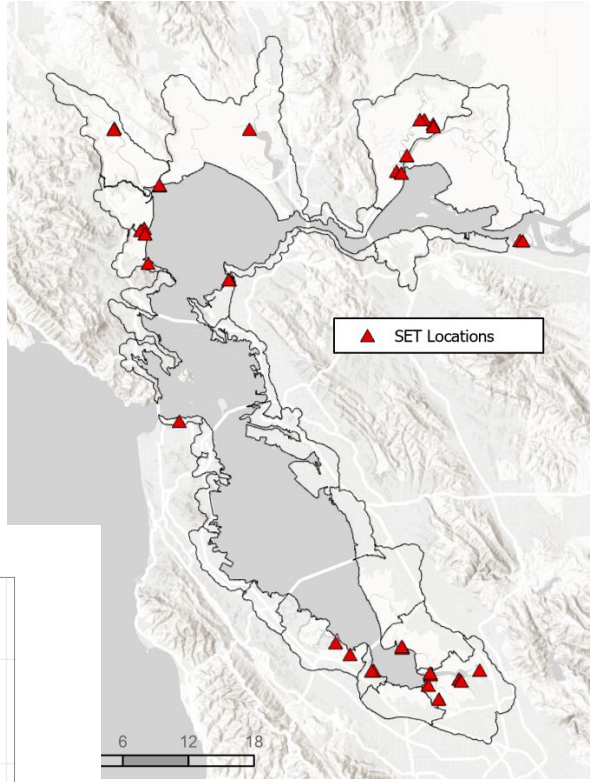
Benefits of Collaboration with WRMP

- Monitoring that overlaps or extends the SBSPRP monitoring
- Cost savings
- Helps answer AMP/permitting questions
- Broad spatial scale and context
- Collaboration with regional scientists through governance structures (TAC/SC)

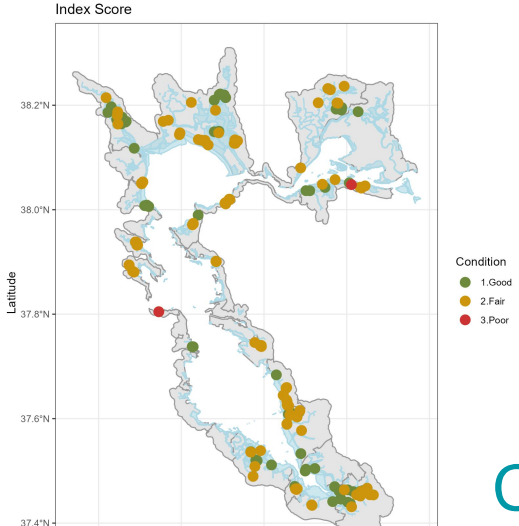
Habitat



Estuarine Fish



Vegetation



Sediment Dynamics

CRAM

Habitat Establishment

Tidal marsh habitat establishment (SBSPRP AMP)

- Vegetation acreage and density, species composition, acreage of mudflat, channels, ponds, transition area

Previous SBSP Mapping

South Bay Salt Pond Restoration Project
Restoring the Wild Heart of the South Bay

Habitat Evolution Mapping Project

South Bay Salt Pond Restoration Project

Final Report (2009-2011)

BRIAN FULFROST & ASSOCIATES

South Bay Salt Pond Restoration Project
Restoring the Wild Heart of the South Bay

Habitat Evolution Mapping Project

Decadal Update

(2019 & 2021)

Preliminary Results (2019)

May 21st, 2021

BRIAN FULFROST & ASSOCIATES

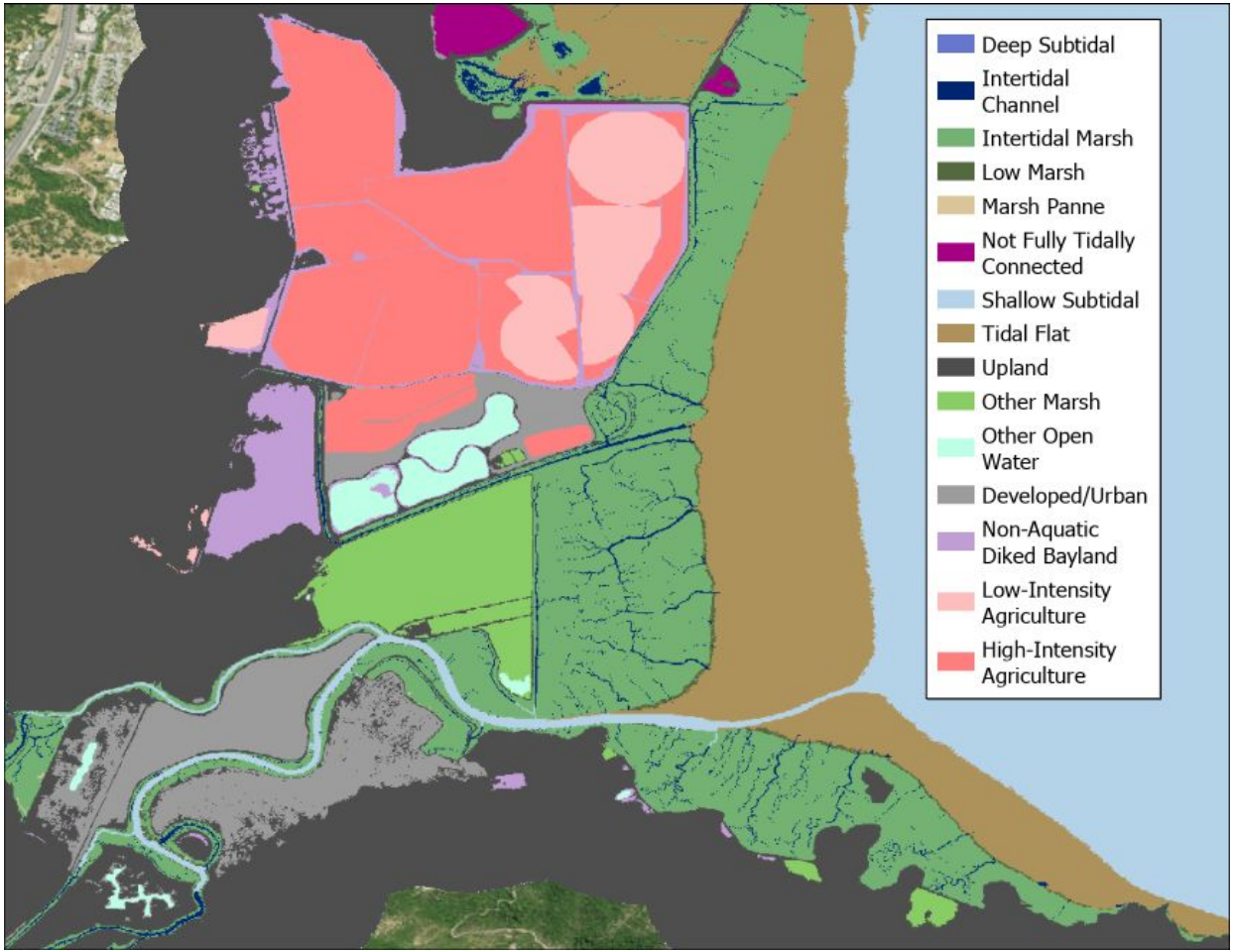
WRMP Management Question #1 and Science Priority #1

"Where are the region's tidal marsh ecosystems, including tidal marsh restoration projects, and what net changes in ecosystem area and condition are occurring?" and the following geospatial indicators:

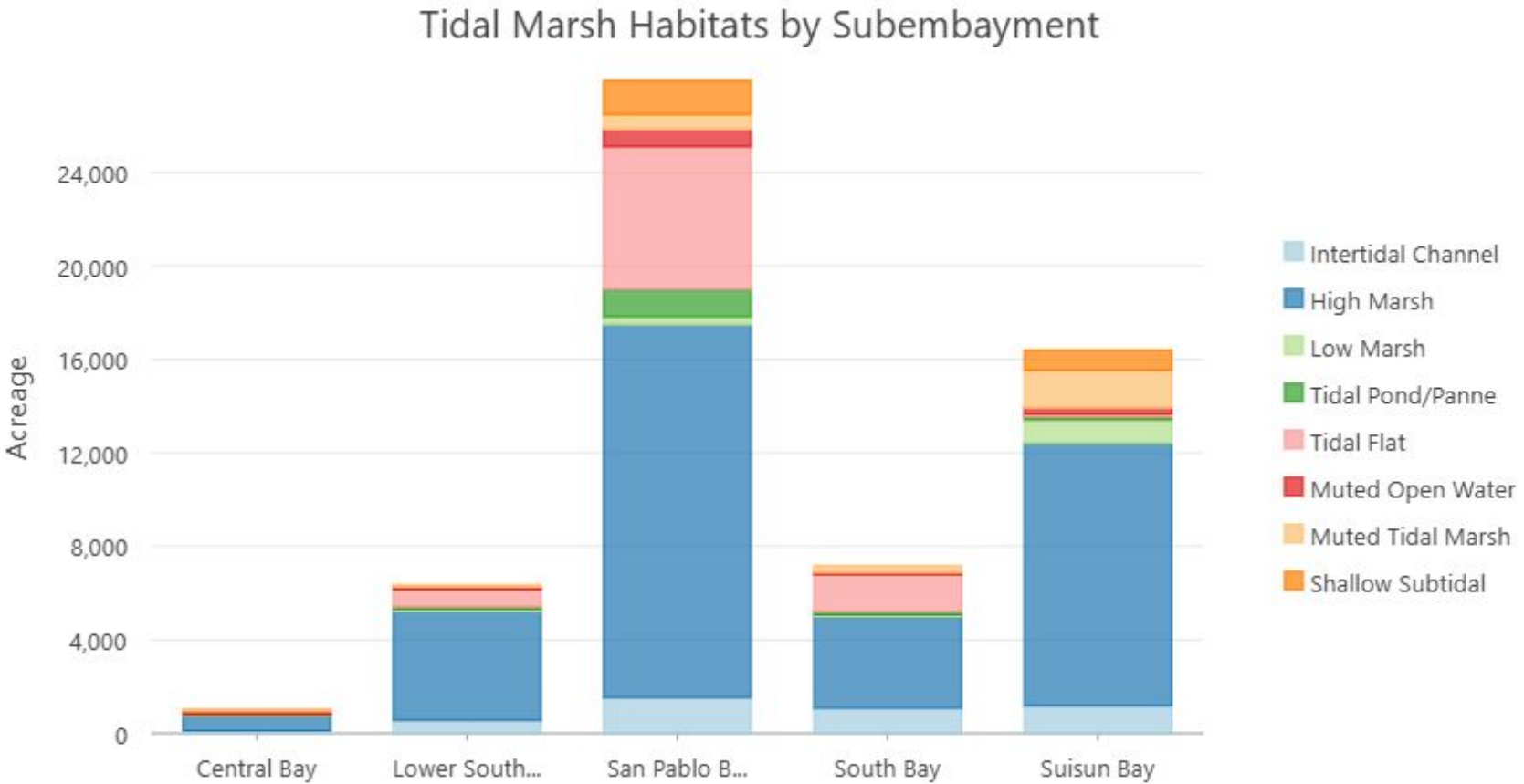
- **Indicator 1:** Map of **baylands habitat types** (e.g., **tidal marsh, tidal flats, diked bayland**) and their key landform features (e.g., l**evees, channels, pannes**), and related areas of permitted impacts, compensatory mitigation, and voluntary restoration projects.
- **Indicator 3:** Map of **estuarine-terrestrial transition zones and migration space.**

2020 Baylands Habitat Map

- Track restoration progress
- Marsh gain and loss
- Vegetation coverage
- Patch size and configuration
- Connectivity

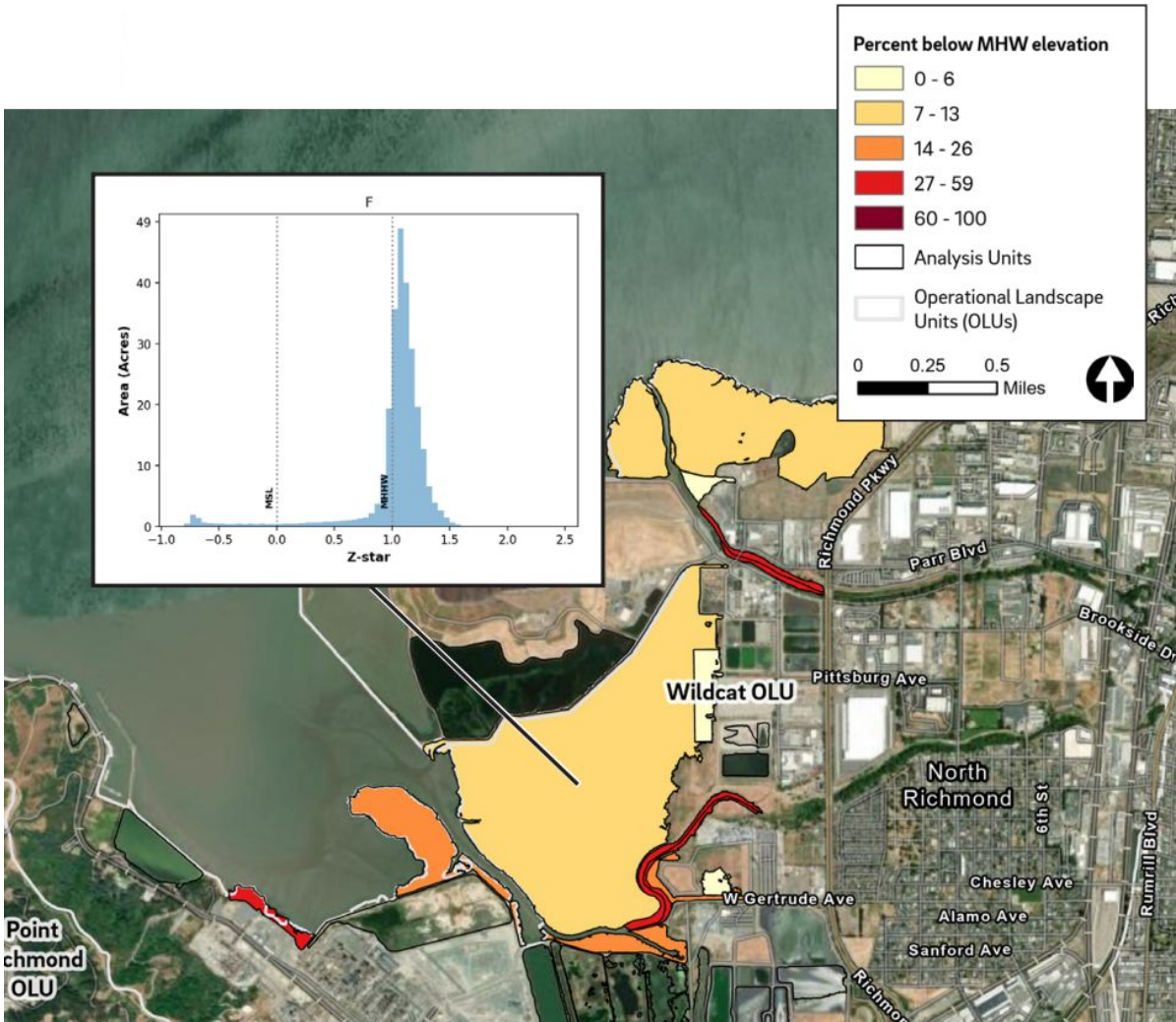


Tidal Marsh Extent (BHM 2020)



Elevation Capital

- Derived from BHM 2020 DEM & Tidal Datum Layers
  - Not Veg-Corrected*
  - NTDE (1983-2001)*
- Percent Below Mean High Water (MHW)

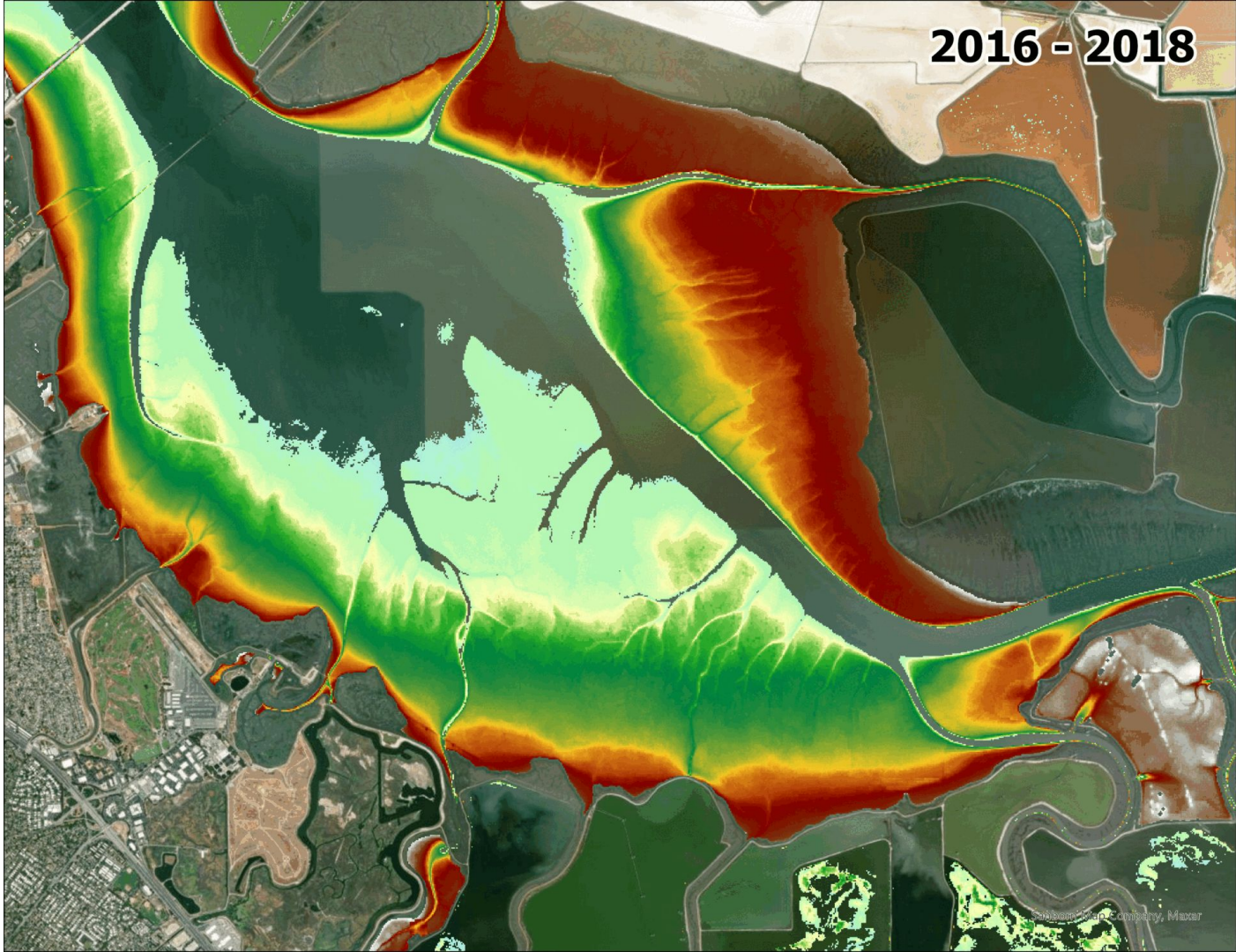


Unvegetated to Vegetated Ratio (UVVR)

- Derived from BHM 2020
- Similar to Percent Cover
- Ganju et al. (2017; 2022; 2024); Wasson et al. 2019

Mapping Intertidal Mudflats

Matching Modeled Tides with Satellite Imagery



Estuarine Fish

Estuarine Fish (SBSPRP AMP)

- Enhance **numbers of native adult and juvenile fish in foraging and rearing habitats**

California Halibut, *Paralichthys californicus*


Pacific Staghorn Sculpin, *Leptocottus armatus*


Northern Anchovy, *Engraulis mordax*

https://www.southbayrestoration.org/event/lunch-and-learn-science-fish-and-fish-habitats-south-bay-wetlands-levi-lewis-uc-davis-og-fish

Photos: U.C. Davis

Fish Monitoring (SBSPRP)

Ravenswood Restoration Project

2024 Interim Data Summary Report

February 2025 | 02953.00007.001

UC DAVIS
UNIVERSITY OF CALIFORNIA

Monitoring the Response of Fish Communities to Salt Pond Restoratior Final Report

Principal Investigator Dr. James A. Hobbs

Co-Investigator Dr. Peter Moyle

Fish Community Study; Lead Author- Nicholas Buckmaster

Sentinel Species Health; Lead Author- Dr. James A. Hobbs

Prepared for

South Bay Salt Pond Restoration Program

&

Resource Legacy Fund

Steelhead Smolt Outmigration and Survival Study: Pond A8, A7 & A5 Entrainment and Escapement.

Final Report

Prepared by:

James Hobbs, Ph.D, Principal Investigator
Jonathan Cook, Biologist
Felipe La Luz, Biologist
Department of Wildlife, Fish and Conservation Biology
University of California-Davis

Prepared for:

NOAA/NMFS
Santa Rosa, California Office
777 Sonoma Avenue, Room 325
Santa Rosa, CA 95404
And
South Bay Salt Pond Restoration Program
Don Edwards San Francisco Bay NWR
1 Marshlands Rd.
Fremont, CA 94555

Accreting Analytics

SB FFH Database & Literature Review *March 14, 2025*

Review of Wetland Fish Studies in South San Francisco Bay

ACCRETING
ANALYTICS LLC

PREPARED BY:

Levi Steele Lewis
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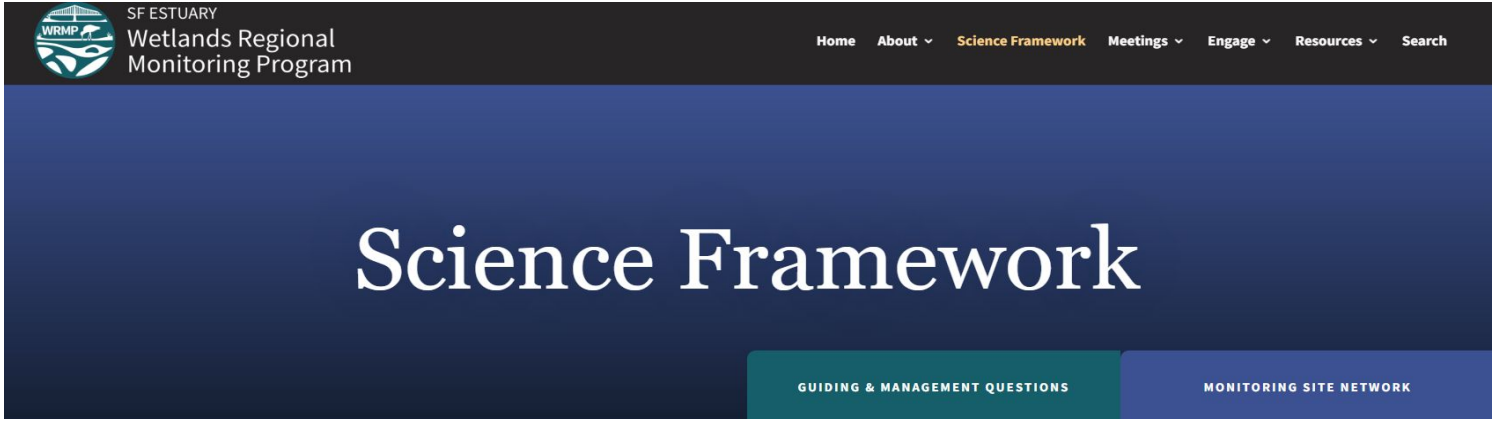
PREPARED FOR:

South Bay Salt Pond Restoration Proj. &
California Wildlife Foundation
201 University Ave., H-43
Berkeley, CA 94710



GUIDING QUESTION 4: How do policies, programs, and projects to protect and restore tidal marshes affect **the distribution, abundance, and health of pla imals?**

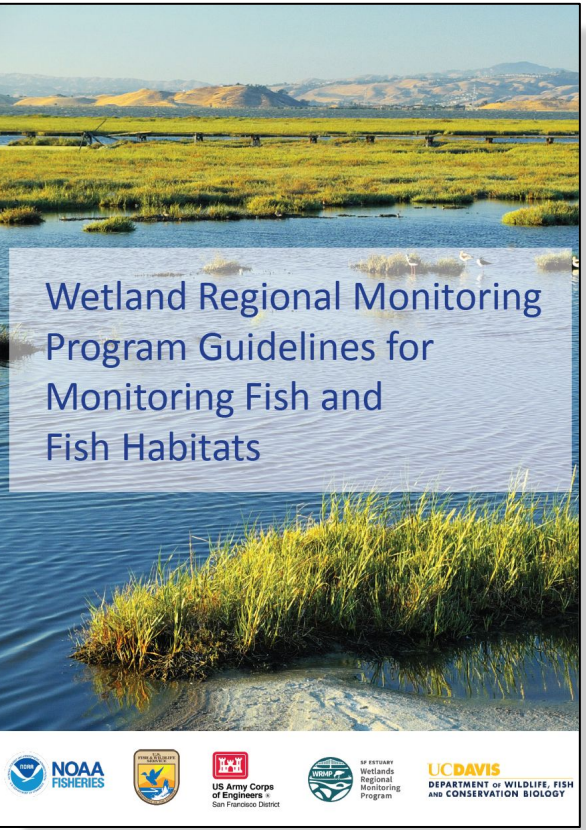
MANAGEMENT QUESTION 4A: How are **habitats for assemblages of resident species of fish and wildlife in tidal marsh ecosystems changing over time?**

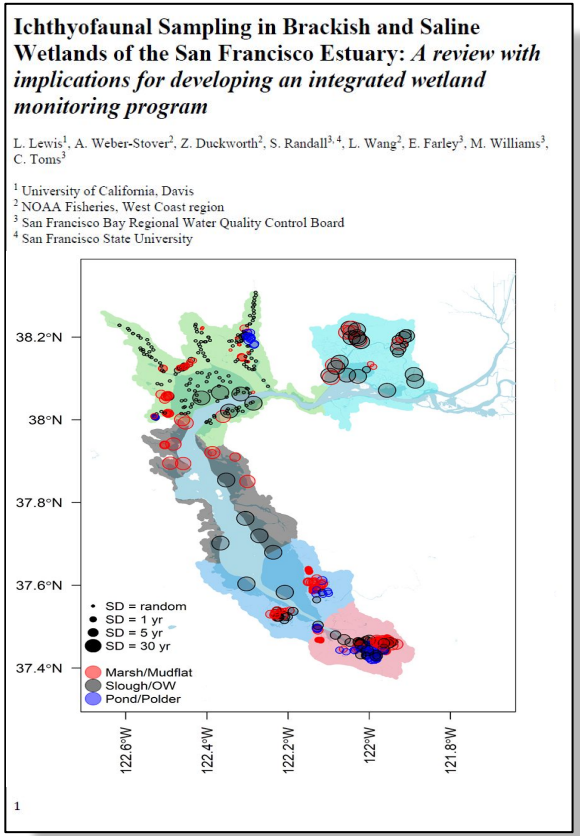
MANAGEMENT QUESTION 4B: How ar**e the distribution and abundance of key resident species of fish and wildlife of tidal marsh ecosystems changing over time?**

PRIORITY RECOMMENDED ACTION: Repeat surveys (detect change) of living organisms and their habitats (indicators), and standardize the metrics and reporting for indicators that are common to projects and baseline/subsequent ambient monitoring across the range of project designs and restoration practices.

Indicators: *abundance, diversity, biomass, sensitive spp, habitat (water) quality*

Slide courtesy of U.C. Davis





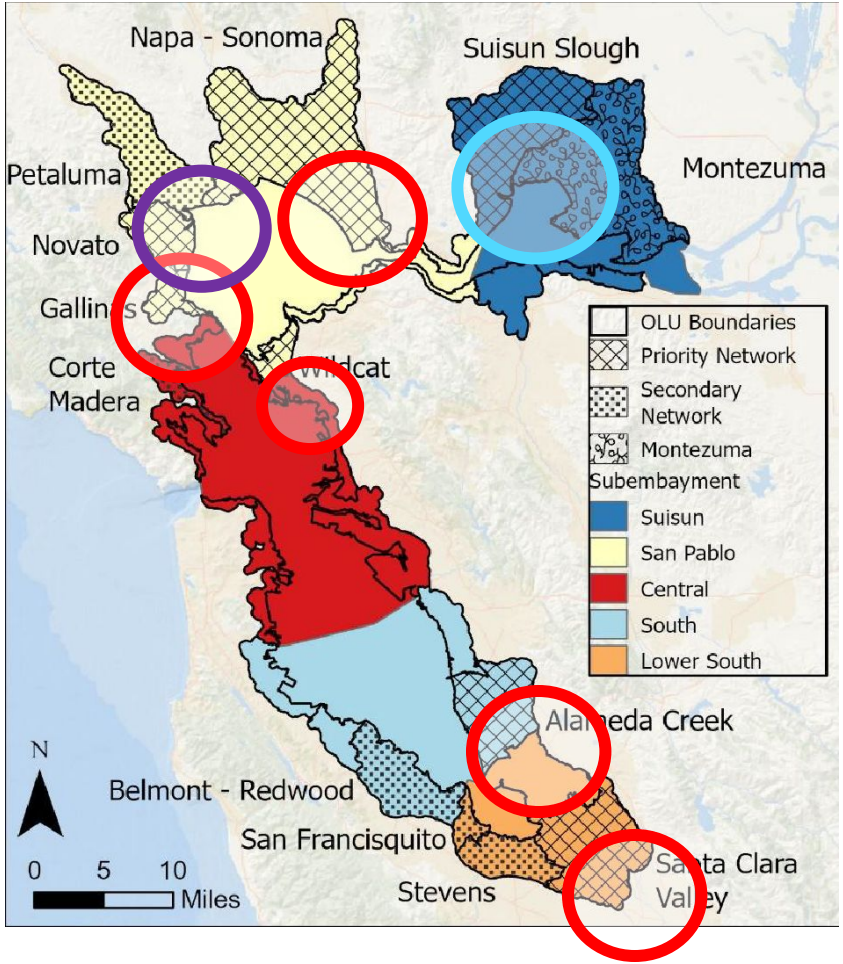
https://www.southbayrestoration.org/event/lunch-and-learn-science-fish-and-fish-habitats-south-bay-wetlands-levi-lewis-uc-davis-og-fish

Slide courtesy of U.C. Davis

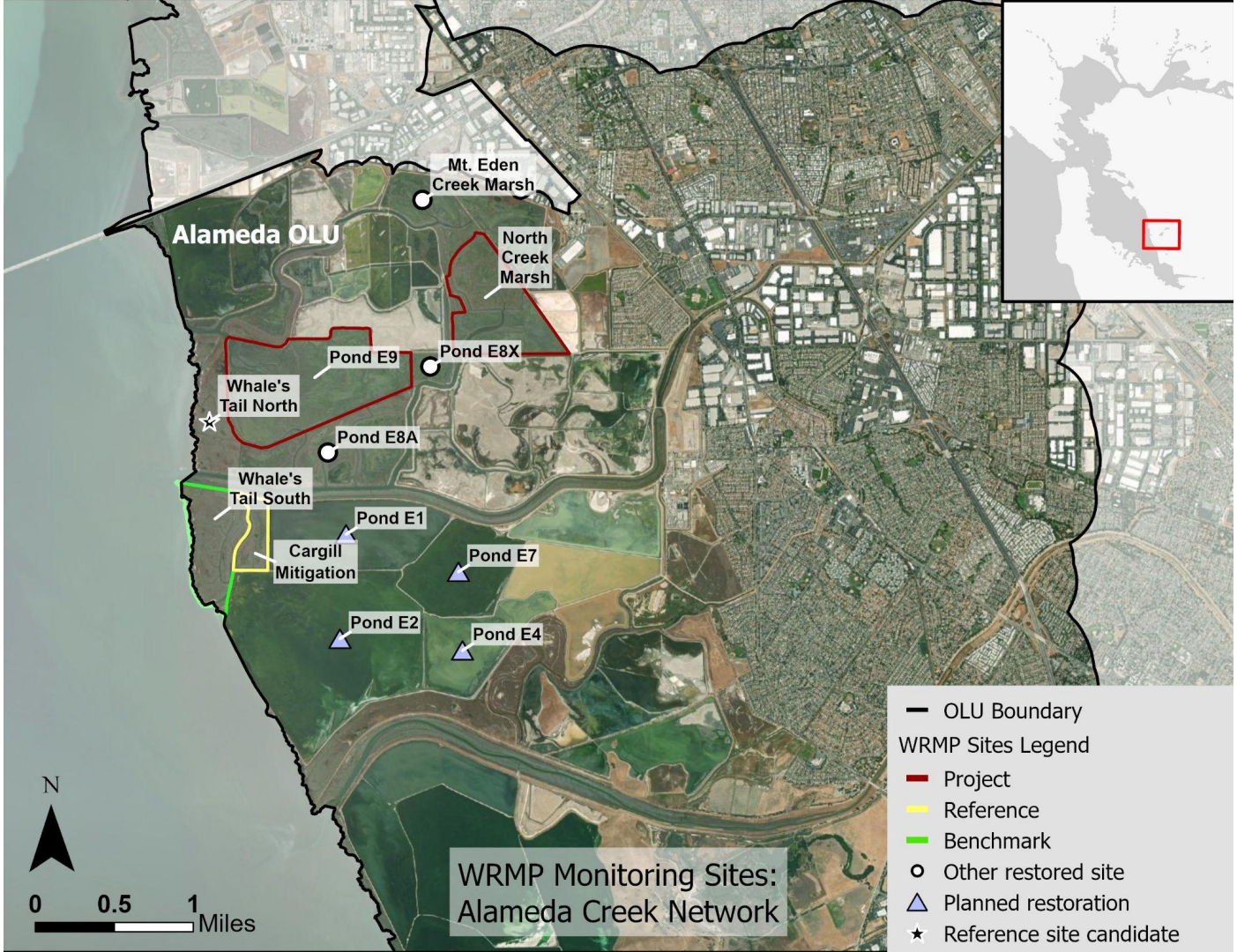
WRMP Fish Monitoring

Priority Site Networks

- **Suisun subregion:**
  - Suisun Slough network
- **San Pablo Bay subregion:**
  - Gallinas-Novato
  - Napa-Sonoma
  - Wildcat
- **South Bay subregion:**
  - Alameda Creek
- **Lower South Bay subregion:**
  - Santa Clara Valley



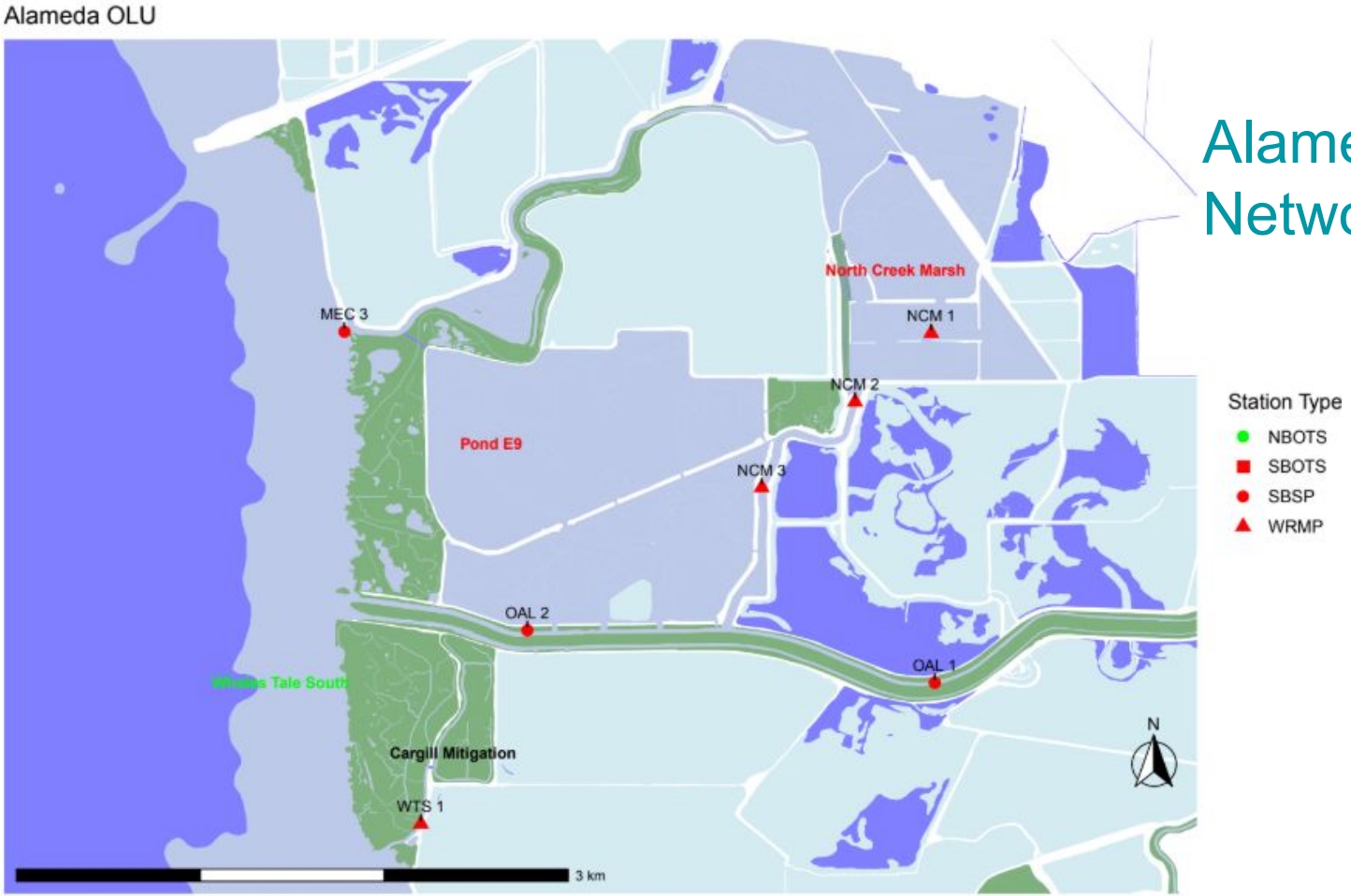
Slide courtesy of U.C. Davis



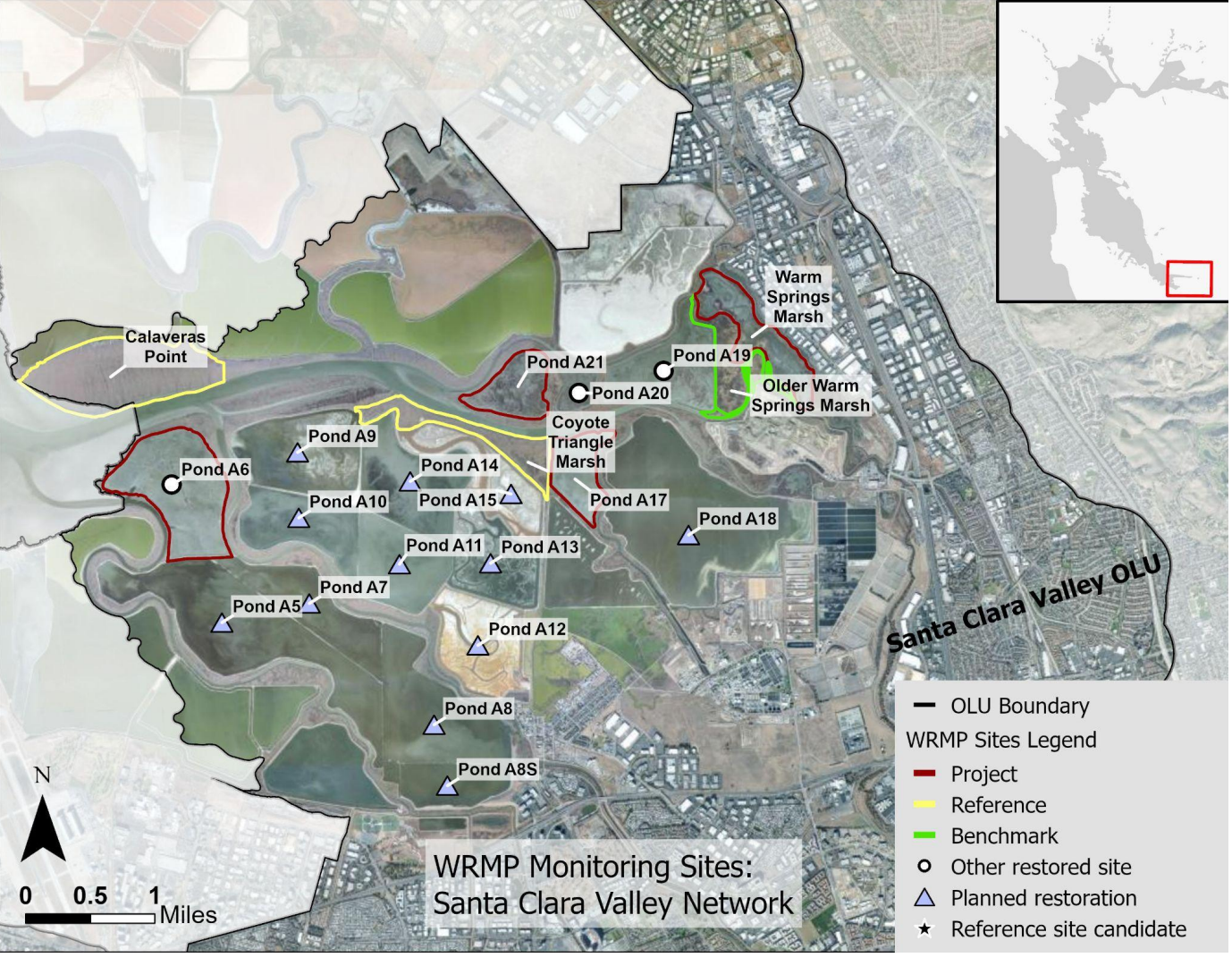
South Bay:

Alameda Creek Network

Alameda Creek Network



Slide courtesy of U.C. Davis

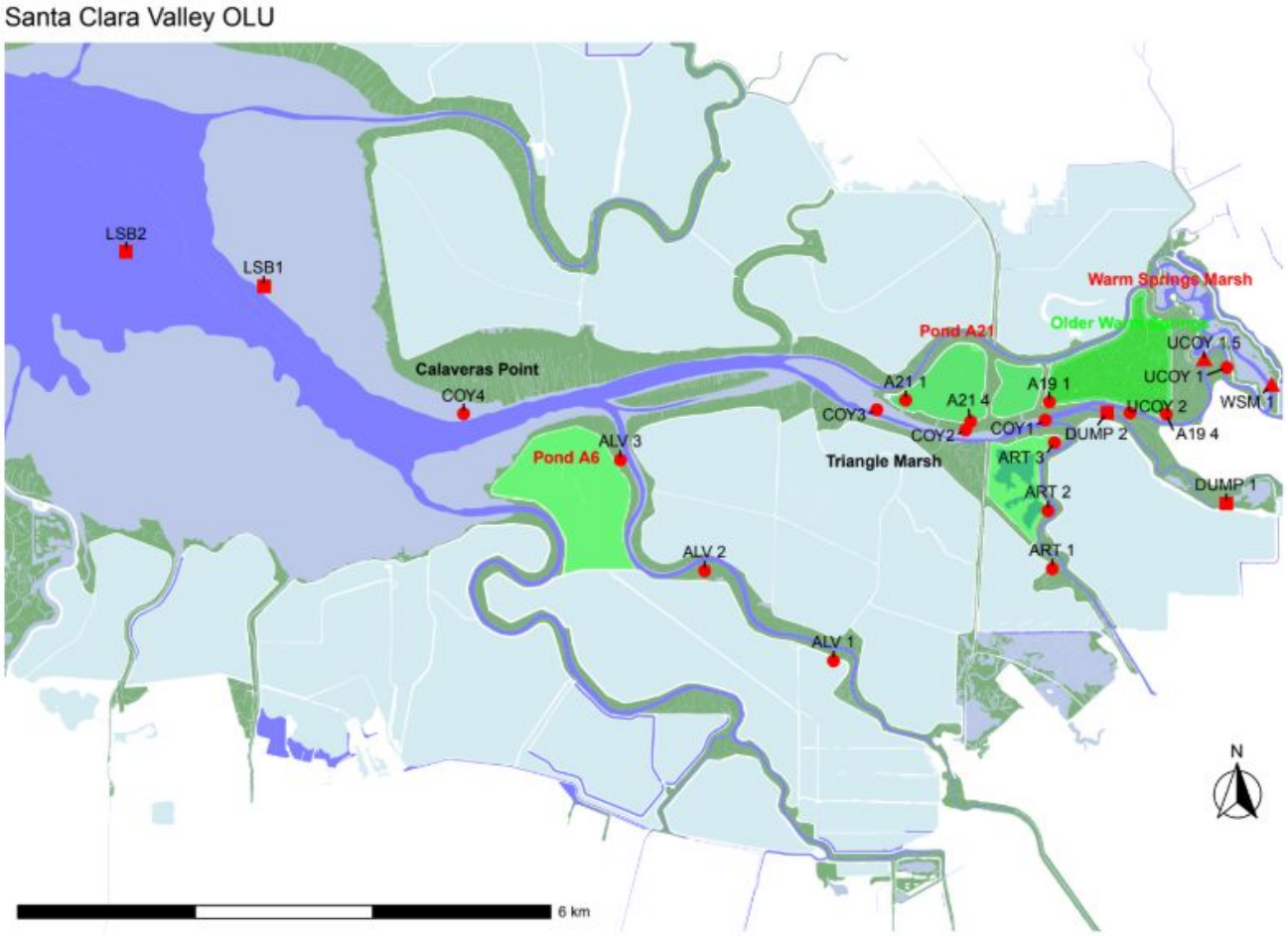


Lower South Bay:

Santa Clara Valley Network

Lower South Bay:

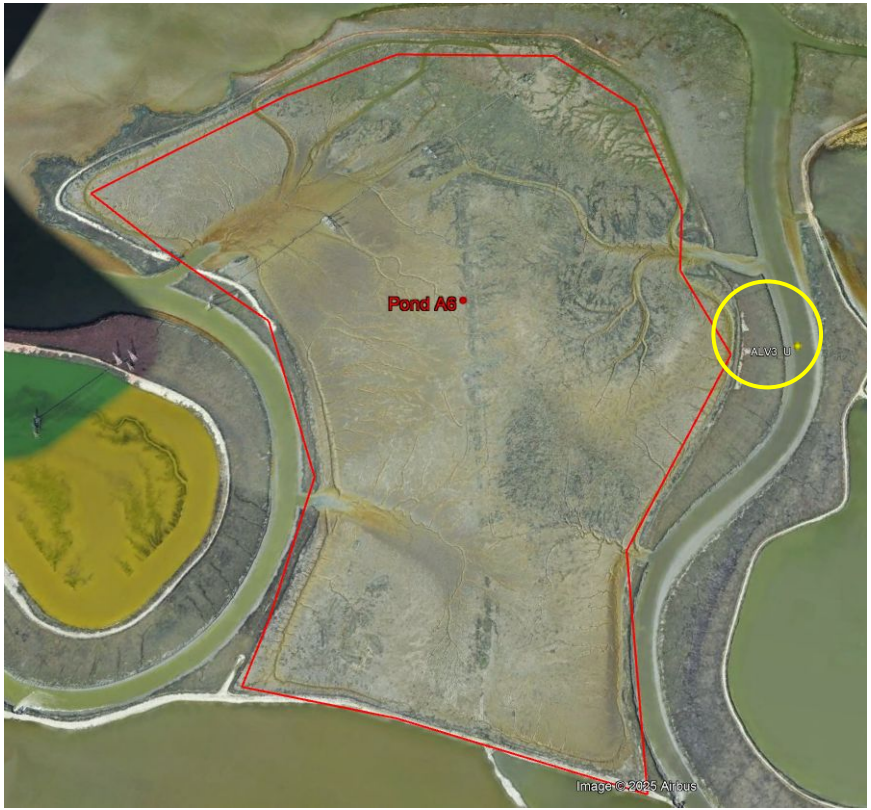
Santa Clara Valley Network



Slide courtesy of U.C. Davis

Pond A6 – Project Site

SBOTS: Legacy Site – ALV 3
WRMP: ALV 3



Slide courtesy of U.C. Davis

Follow Results: Eden Landing Trawls (April 8, 2025)

https://www.ogfishlab.com/2025/04/08/fish-in-the-bay-april-2025-wrmp-eden-landing-trawls/

WRMP Website: https://www.wrmp.org/

https://www.southbayrestoration.org/

Sediment Dynamics

Sediment Dynamics (SBSPRP AMP)

- Accretion rate sufficient to reach vegetation colonization elevations
- No decrease in S.Bay intertidal and subtidal habitats (mudflats, shallow and subtidal channels areas)
- No long-term net loss of vegetated tidal marsh in the S.Bay

Photo: Sarah Pearce

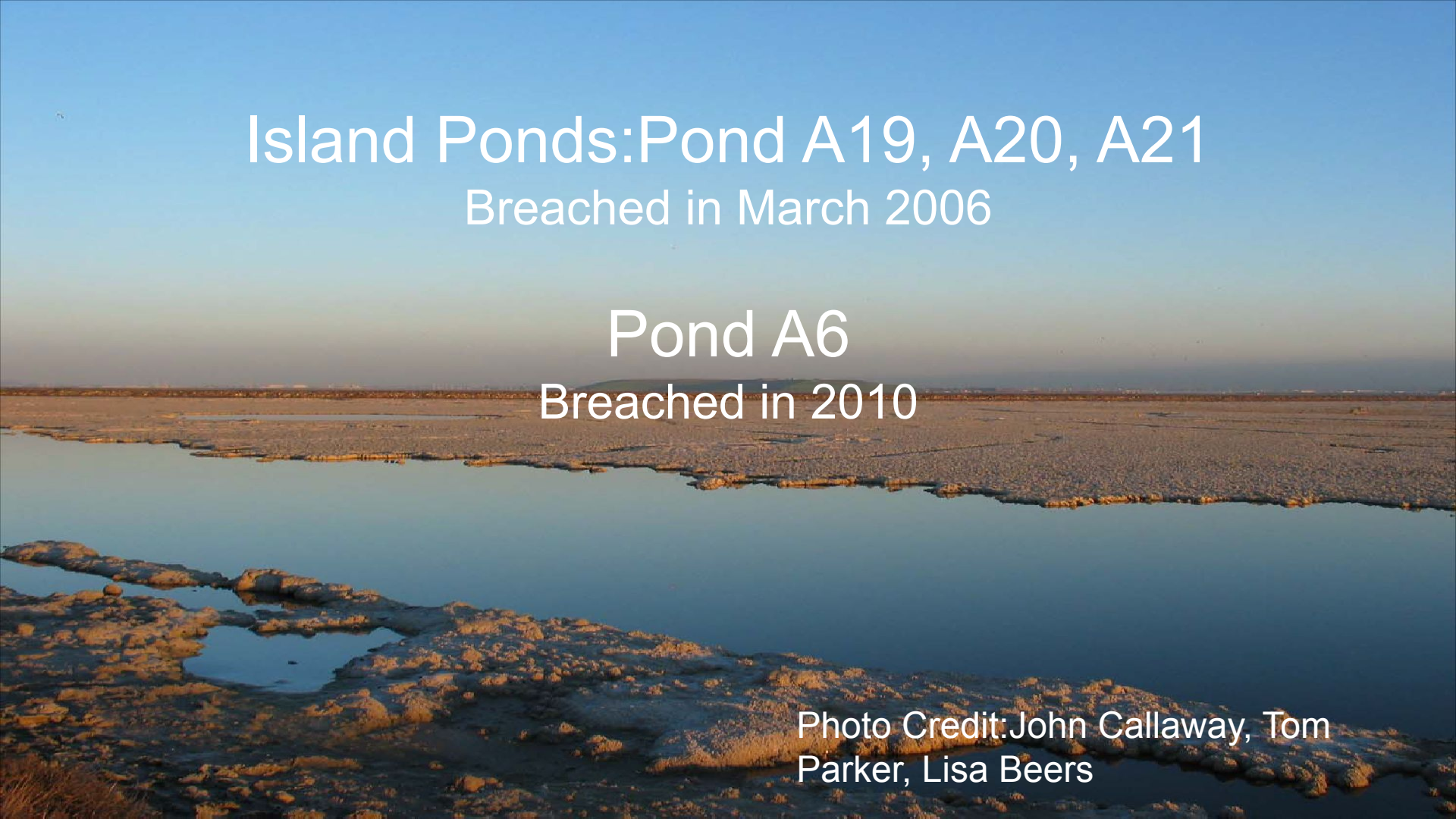

Island Ponds:Pond A19, A20, A21
Breached in March 2006
Pond A6
Breached in 2010
Photo Credit:John Callaway, Tom Parker, Lisa Beers

Photo Credit:John Callaway, Tom Parker, Lisa Beers

WRMP guiding questions

- *Guiding Question 1: Where are the region's tidal marsh ecosystems, including tidal marsh restoration projects, and what net landscape changes in area and condition are occurring?*

- *Guiding Question 2: How are external drivers, such as accelerated sea level rise, development pressure, and changes in runoff and sediment supply, impacting tidal marsh ecosystems?*

- *Guiding Question 3: What new information do we need to better understand regional lessons from tidal marsh restoration projects, advance tidal marsh science, and ensure the continued success of restoration projects?*

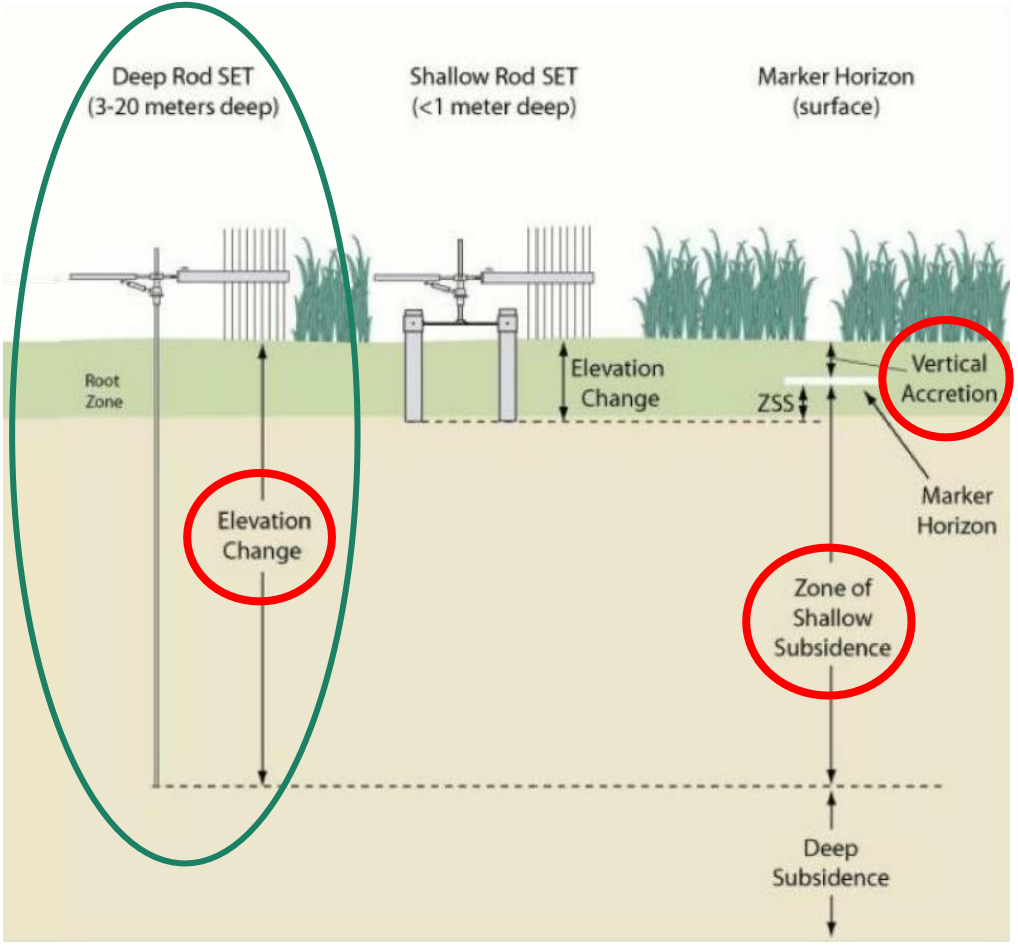
Using surface elevation tables (SETs) to monitor marsh elevations along a tidal and salinity gradient in San Francisco Bay-Delta with the WRMP

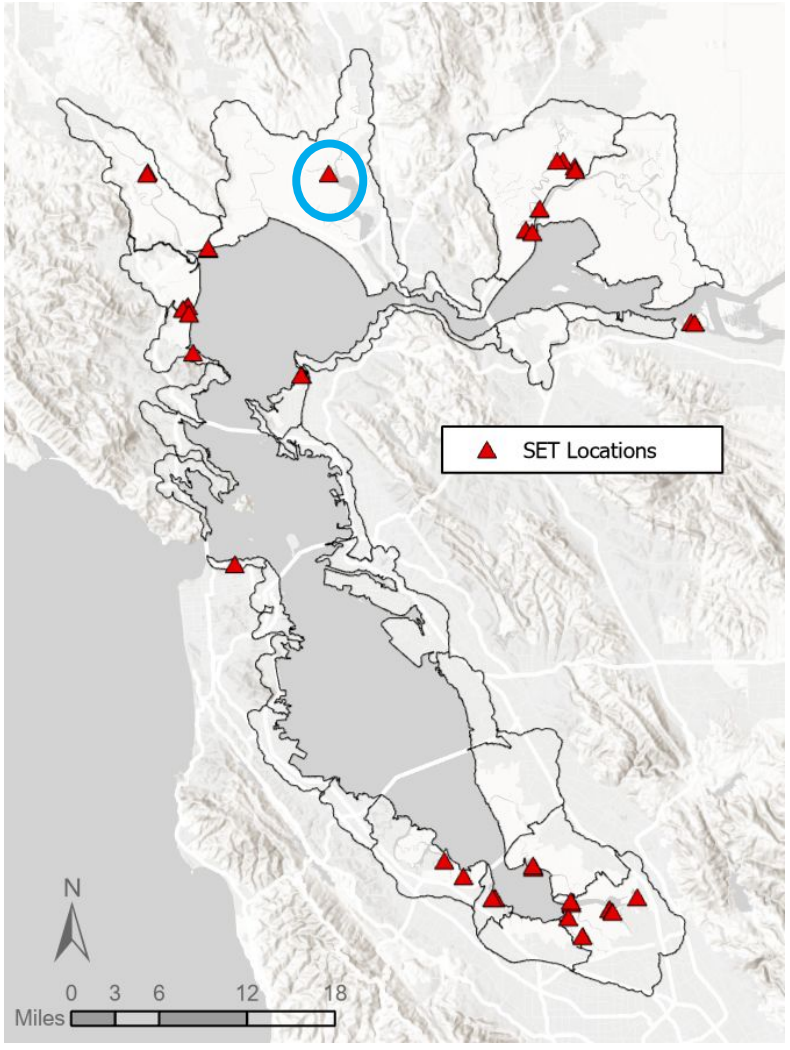
Karen M. Thorne, Lyndsay L. Rankin, McKenna L. Bristow

U.S. Geological Survey, Western Ecological Research Center, Davis, CA

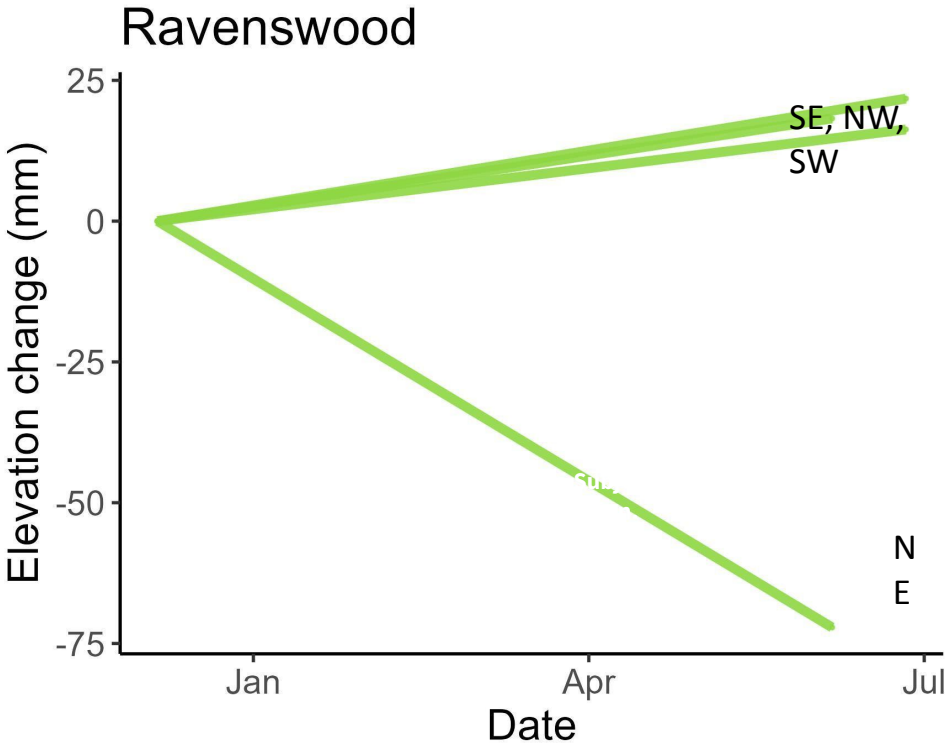
USGS
science for a changing world

Surface Elevation Tables



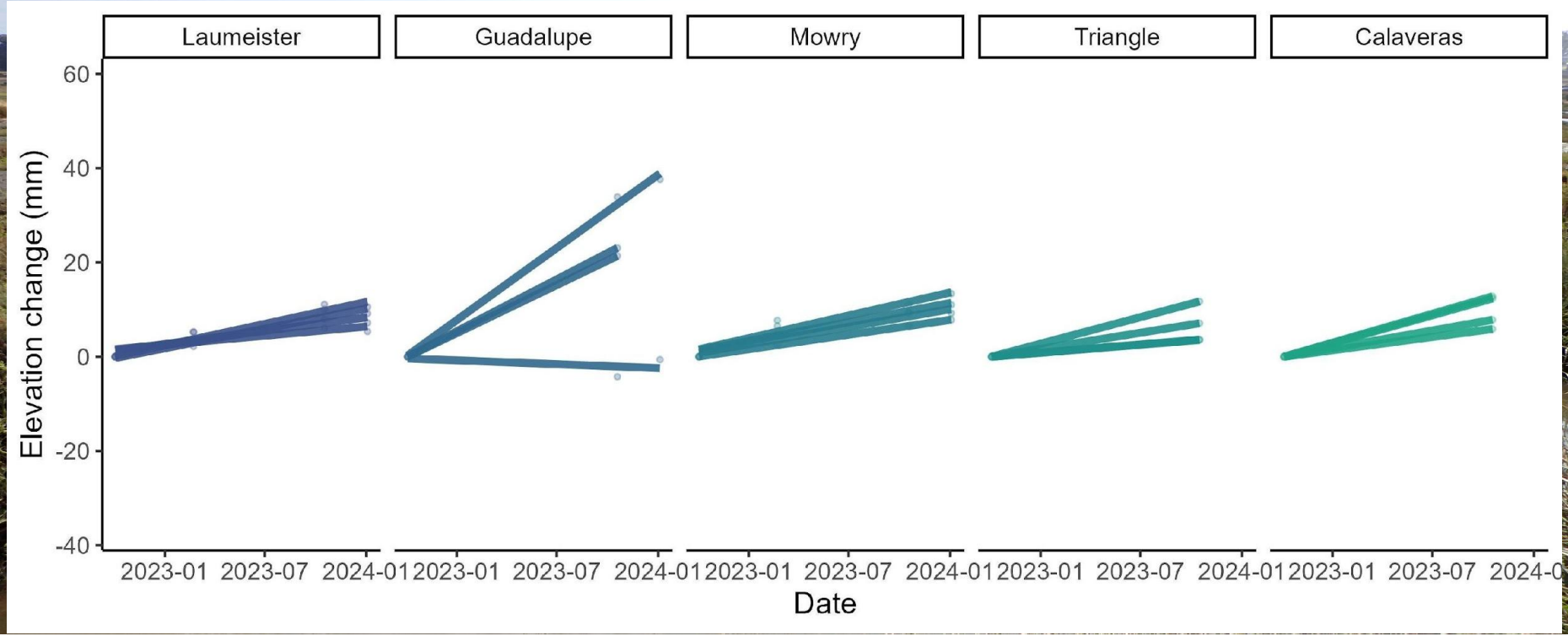


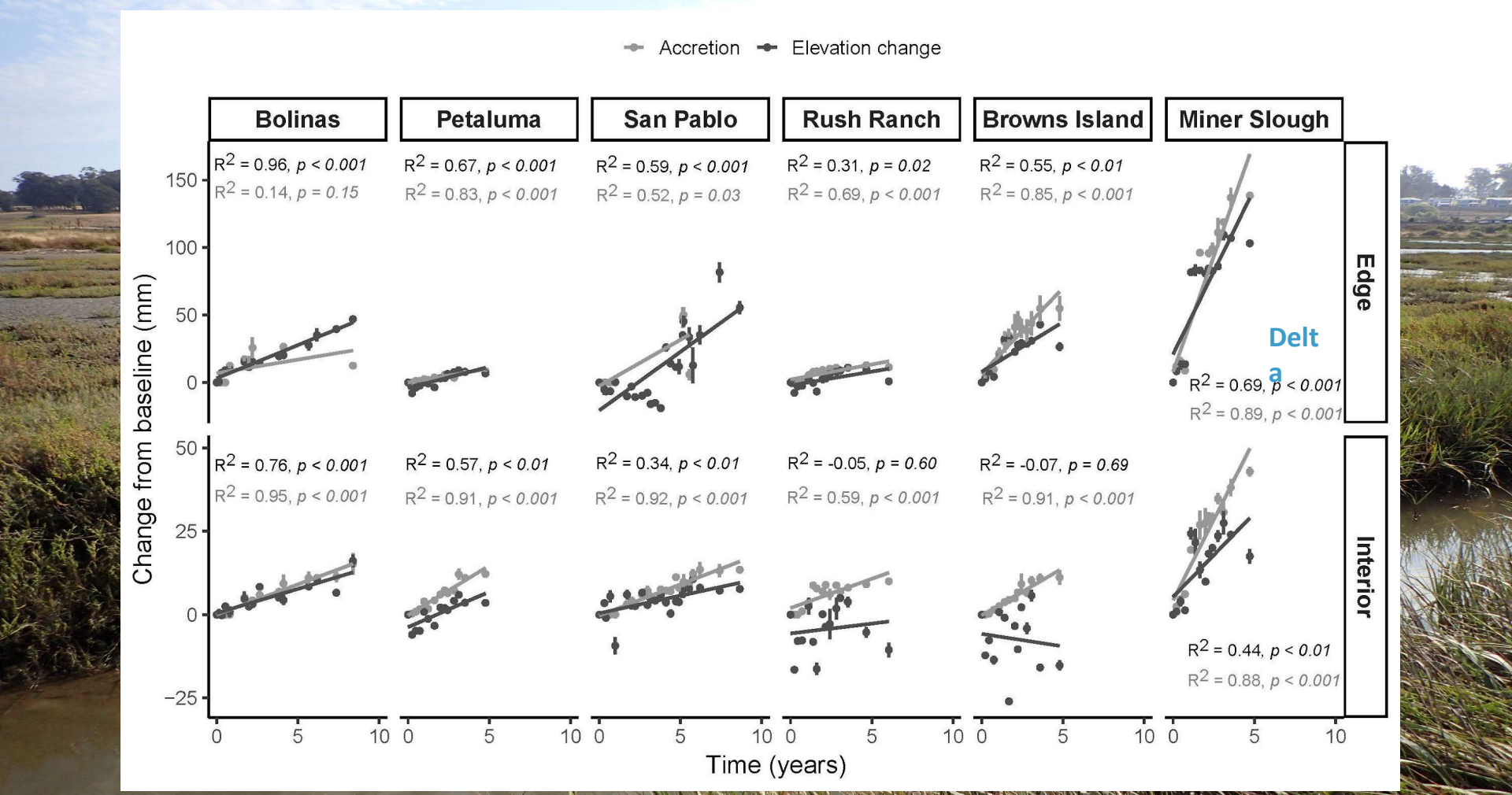
December 2023 - Newly Restored Pond R4



USGS
science for a changing world

2022 South SF Bay





Thorne, K. M., Bristow, M. L., Rankin, L. L., Kovalenko, K. E., Neville, J. A., Freeman, C. M., & Guntenspergen, G. R. (2023). Understanding Marsh Elevation and Accretion Processes and Vulnerability to Rising Sea Levels Across Climatic and Geomorphic Gradients in California, USA. *Estuaries and Coasts*, 1-21.

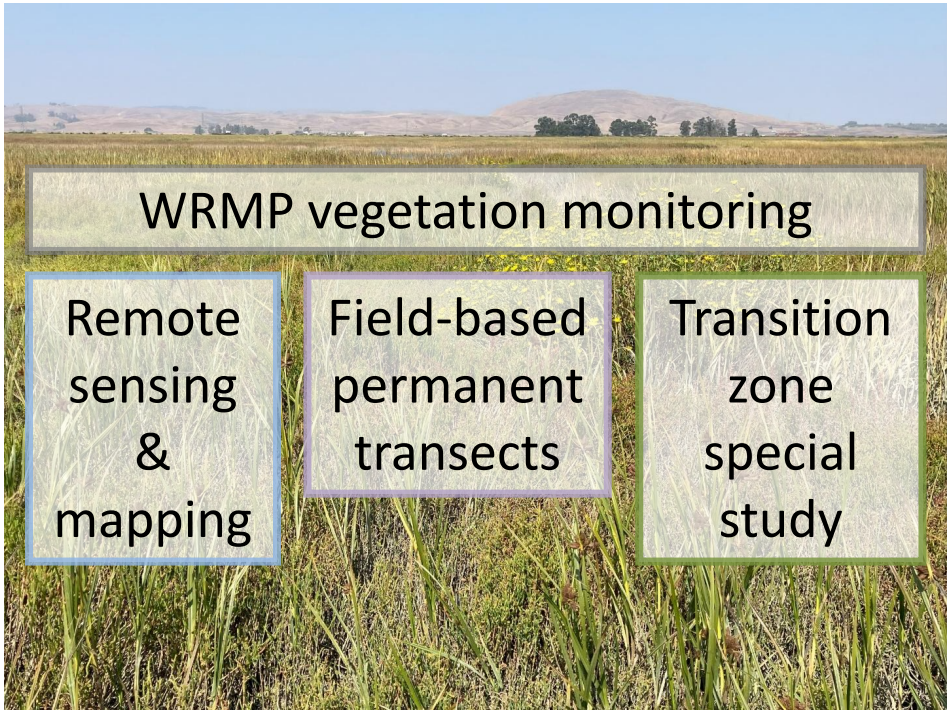
Vegetation

Vegetation monitoring for the WRMP in the San Francisco Bay Estuary

Christopher Janousek, Lisa Beers, Aviva Rossi, Trevor Williams

Oregon State University

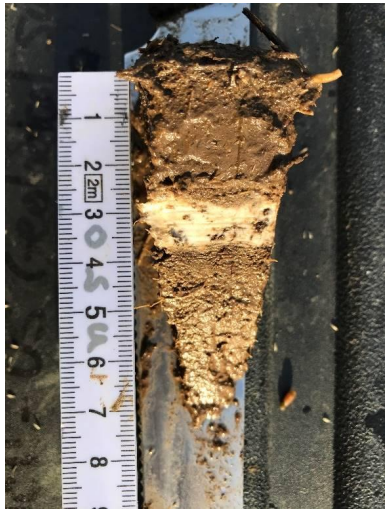
- *Field transects based WRMP vegetation SOP*
- Winter 2024/2025: Establish permanent transects at 18 sites including elevation surveys; groundwater monitoring
- Summer-fall 2025: First round of veg sampling



WRMP/South Bay Sites = 2025

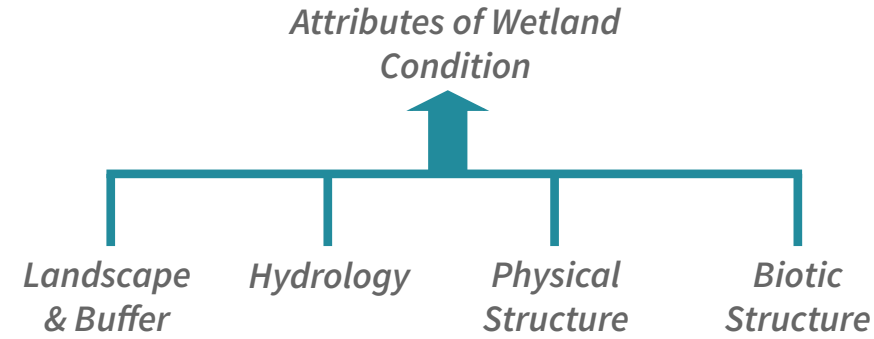
Network (sub-region)	Site	Site type	Owner/manager
Santa Clara Valley	Laumeister (LAU)	Benchmark	USFWS
Santa Clara Valley	Coyote Triangle (COY)	Reference	USFWS
Santa Clara Valley	Pond R4 (R04)	Project (2023)	USFWS
Alameda Creek	Whales Tail (WHA)	Benchmark	CDFW
Alameda Creek	Cargill (CGL)	Reference (1998)	CDFW
Alameda Creek	Mt Eden Creek (EDC)	Project (2008)	CDFW
Novato-Gallinas	China Camp (CHC)	Benchmark	CA St Parks
Novato-Gallinas	McInnis (MCI)	Reference	CDFW/Marin Co Parks
Novato-Gallinas	Sonoma Baylands (SON)	Project (1996)	USFWS
Wildcat-Pinole	Pt Pinole (PPI)	Benchmark	EBRPD
Wildcat-Pinole	Giant (GIA)	Reference	EBRPD
Wildcat-Pinole	Dotson (DOT)	Project (2016)	EBRPD
Napa-Sonoma	Raccoon, ancient (RIB)	Benchmark	CDFW
Napa-Sonoma	Pond 2A (P2A)	Project (1995)	CDFW
Napa-Sonoma	Bull Island (BUI)	Reference (1968)	CDFW
Suisun	Rush Ranch (RRA)	Benchmark	Solano Land Trust
Suisun	Hill Slough East (HSE)	Reference	CDFW
Suisun	Hill Slough Restored (HSR)	Project (2021)	CDFW

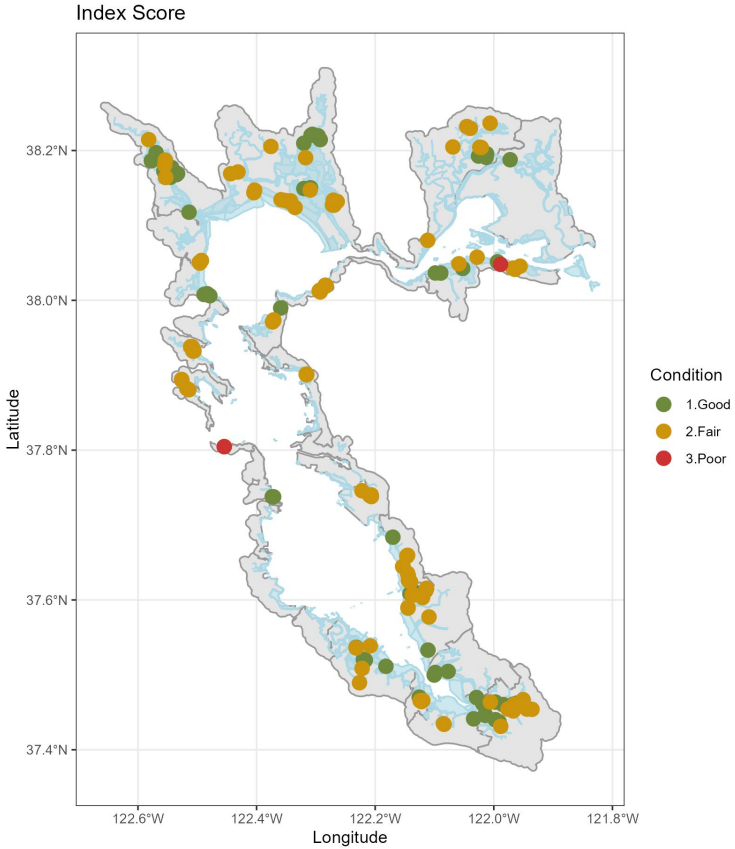
- Wetland surface elevation (RTK-GNSS)
- Vegetation cover, composition, diversity (plots)
- Soil pore water salinity (refractometer)
- Short-term sediment accretion (feldspar marker horizons)
- Piezometers)



CRAM

- California Rapid Assessment Method (CRAM) for Perennial Estuarine Wetlands
- Rapid field assessment of tidal marsh conditions across space and time





Celebrating Collaboration

- Project and landowner monitoring
- Cost savings/resource sharing
- Broader sharing of monitoring efforts
- Regional context for monitoring results

Thank You!