

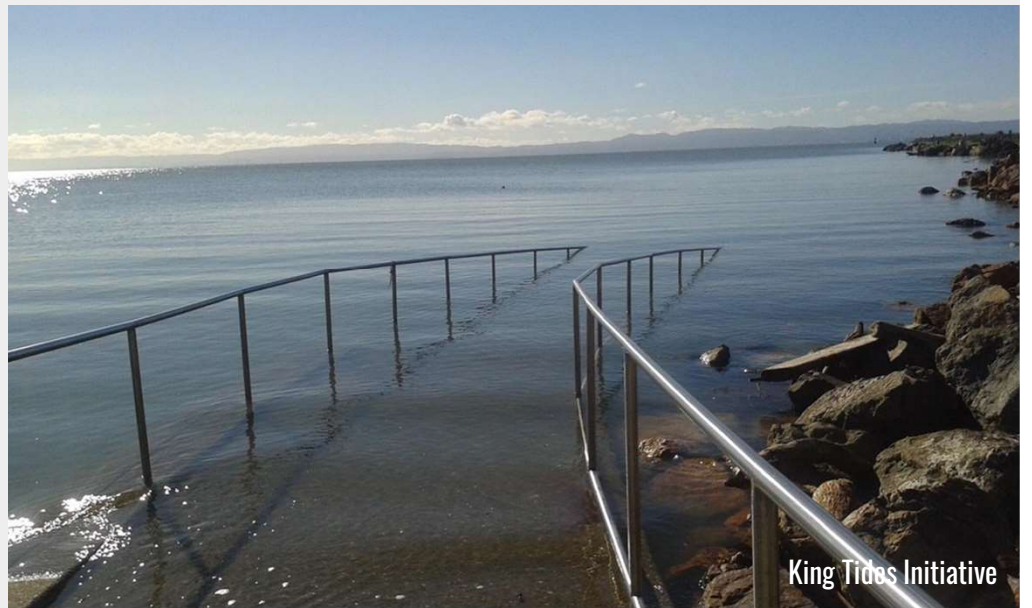
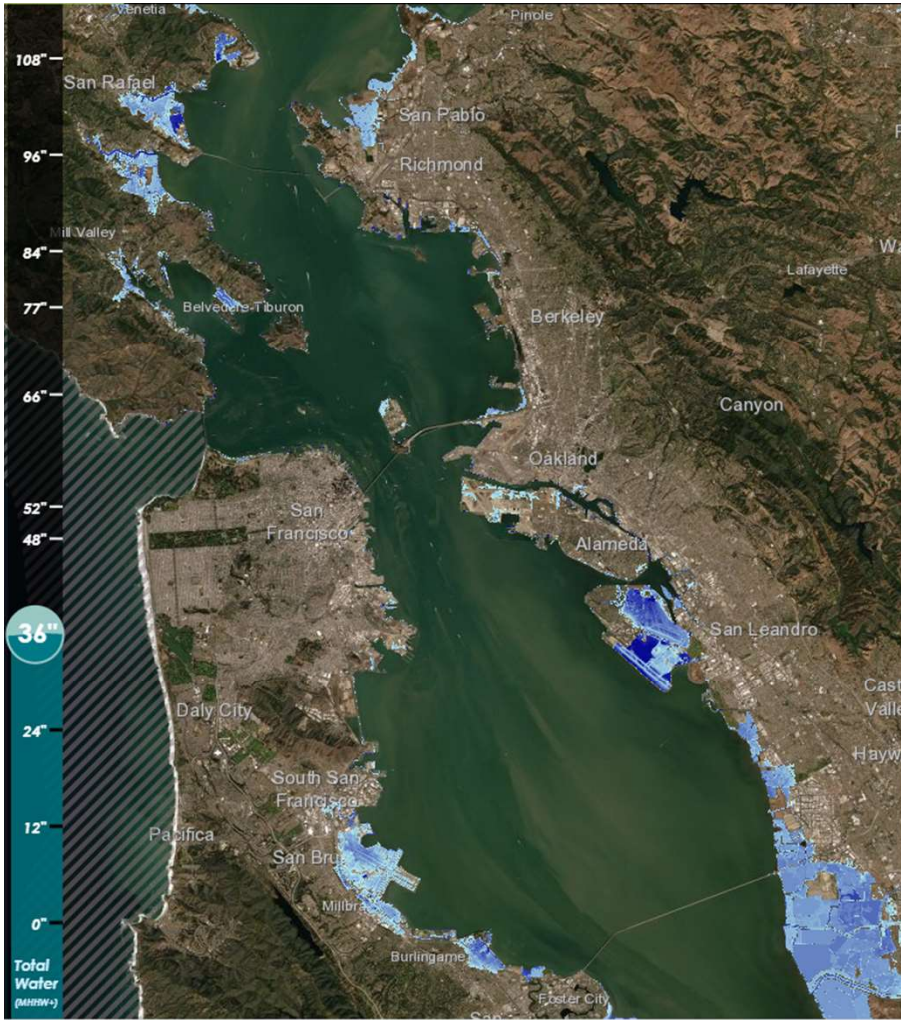


Harnessing the power of nature

to adapt to sea level rise
in SF Bay

Julie Beagle
US Army Corps of Engineers
San Francisco District

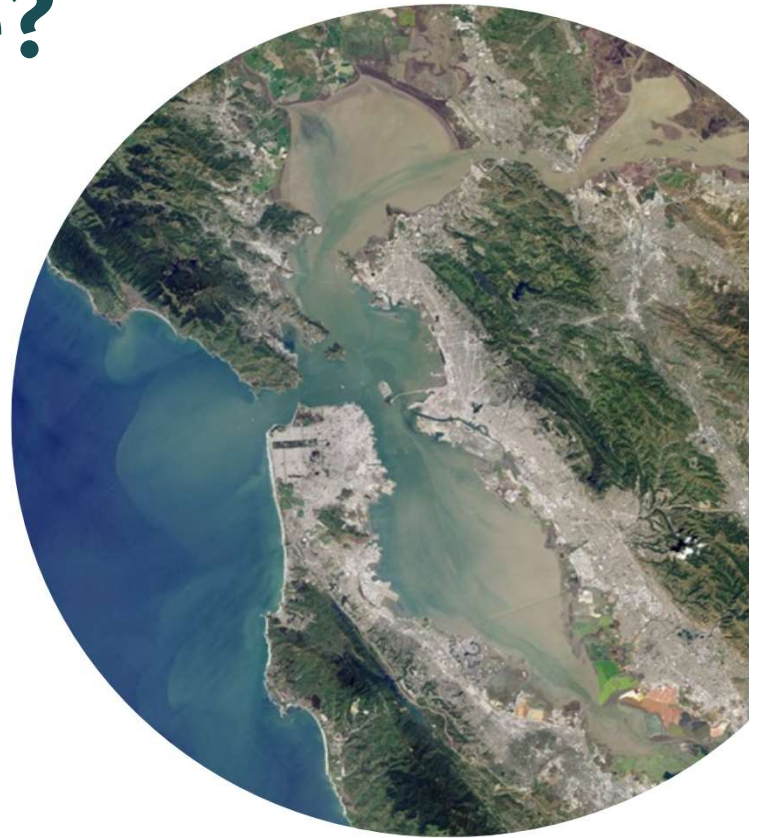
Sierra Club
13 May 2021



ART Bay Area Shoreline Flood Explorer

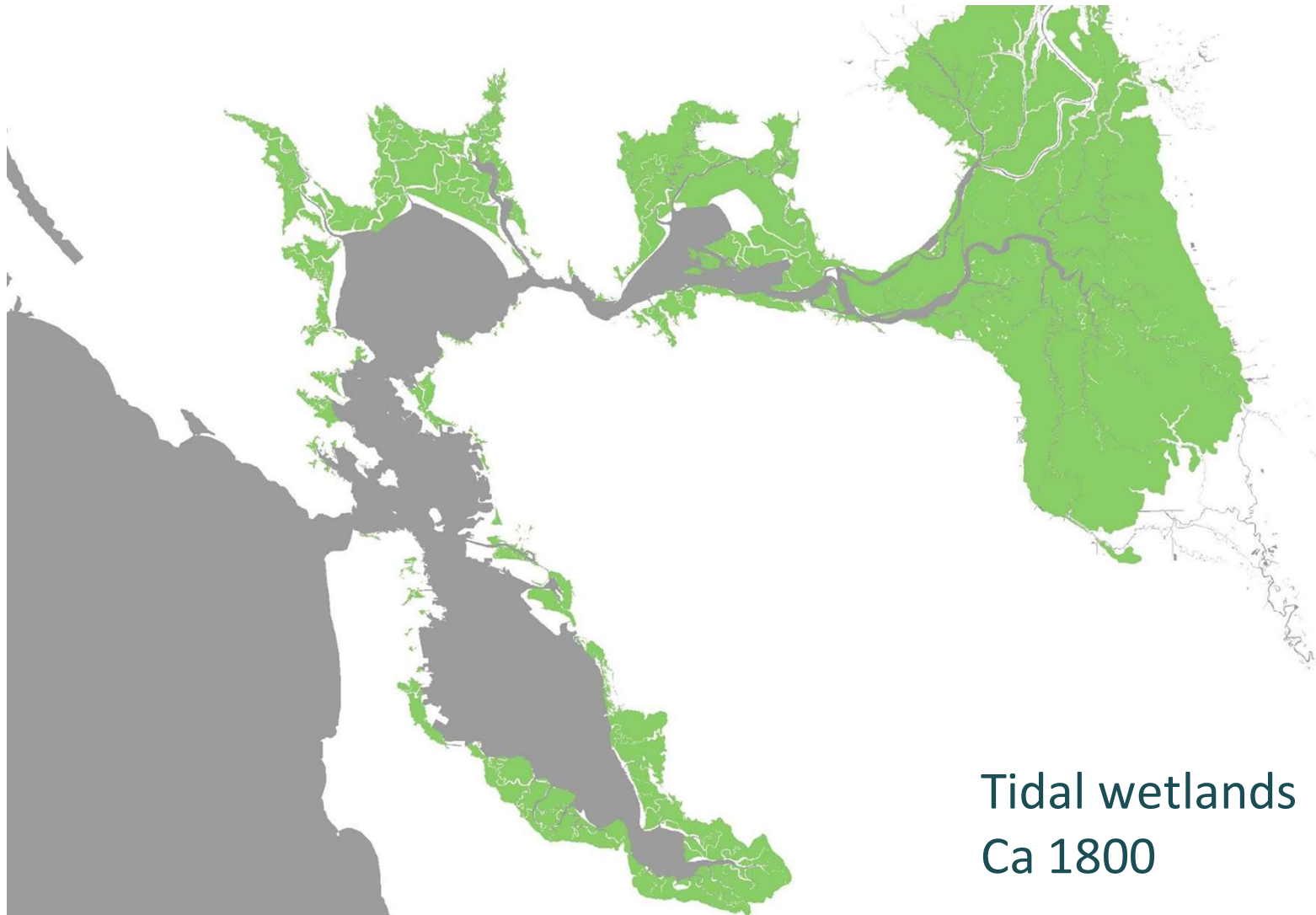
How did we get here?

- Issue 1: History matters
- Issue 2: Lands below sea level
- Issue 3: History of inequality
- Issue 4: Water from all sides
- Issue 5: Many cooks in the kitchen



Issue 1: **History matters**

We built on top of the Baylands and in floodplains and **now these areas are sinking and flooding.**



Tidal wetlands
Ca 1800

SFEI

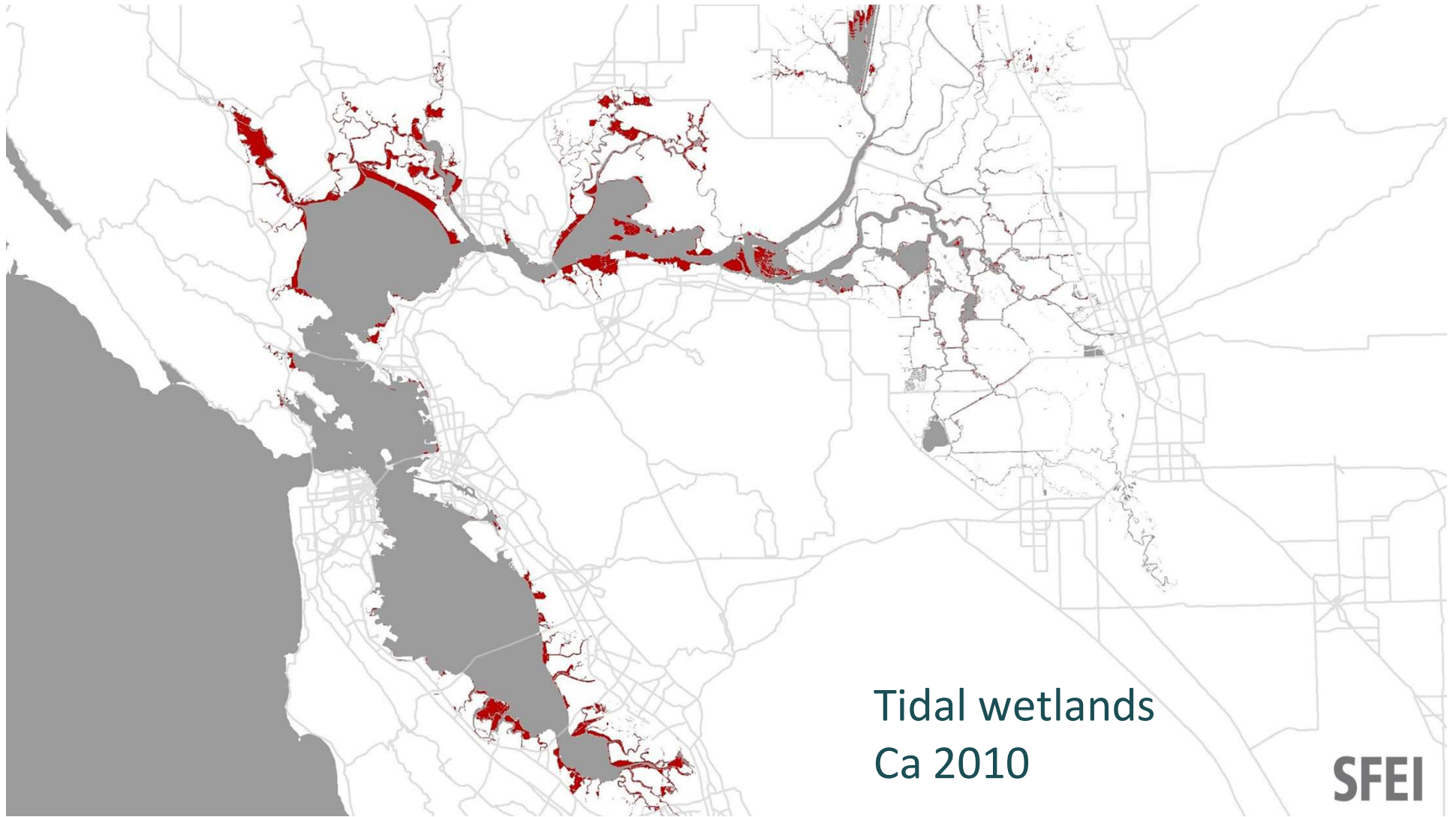
1952

Development History

Low-level fill development

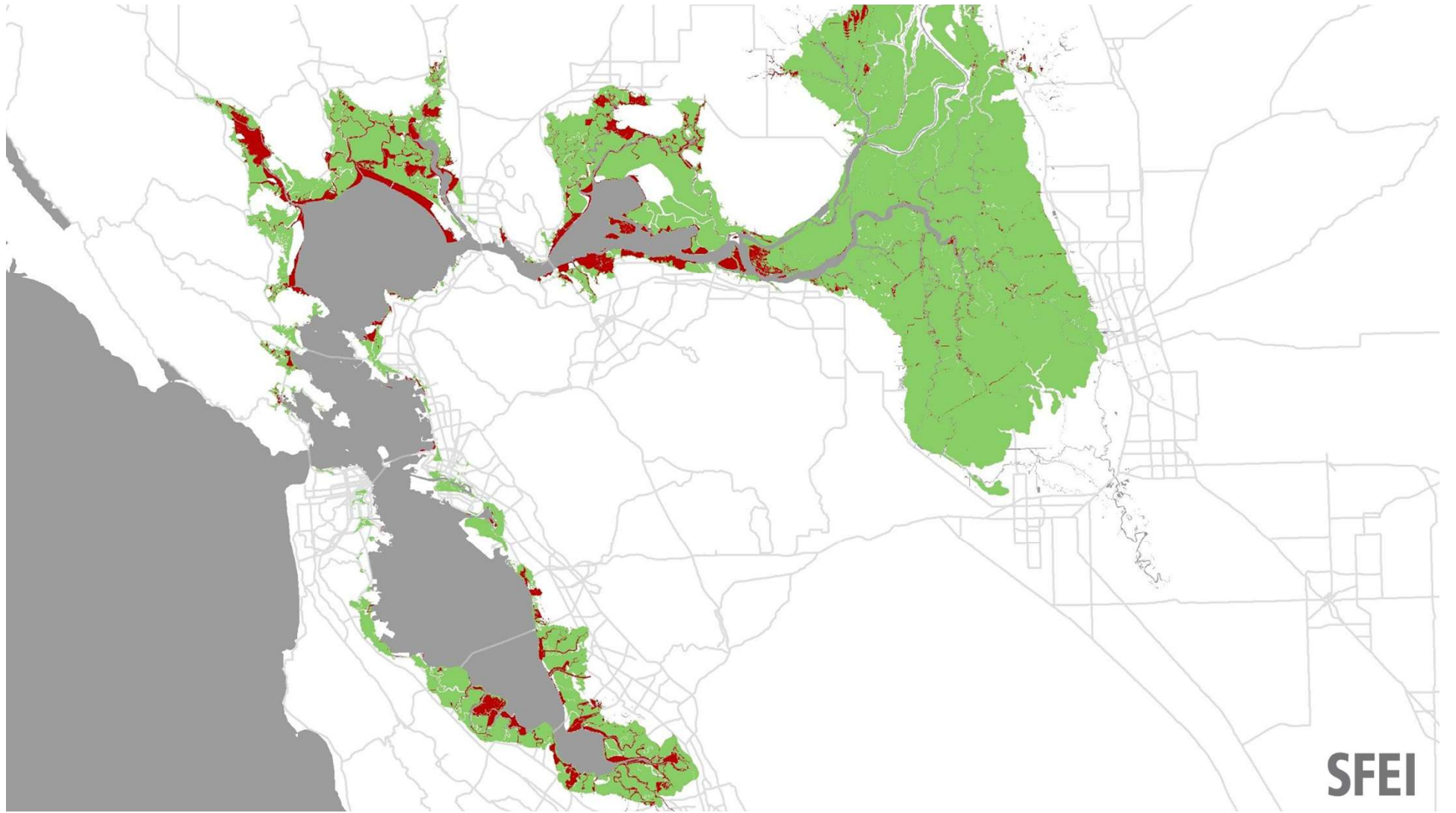
High-level fill development





Tidal wetlands
Ca 2010

SFEI

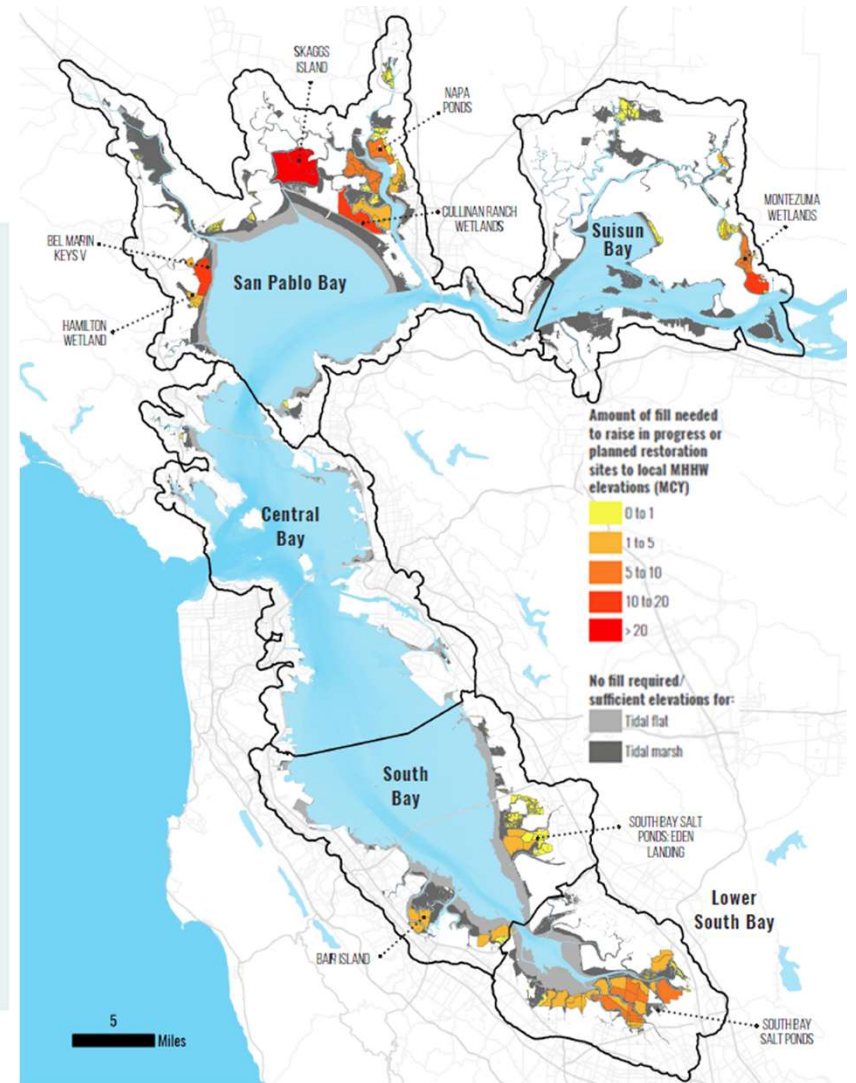
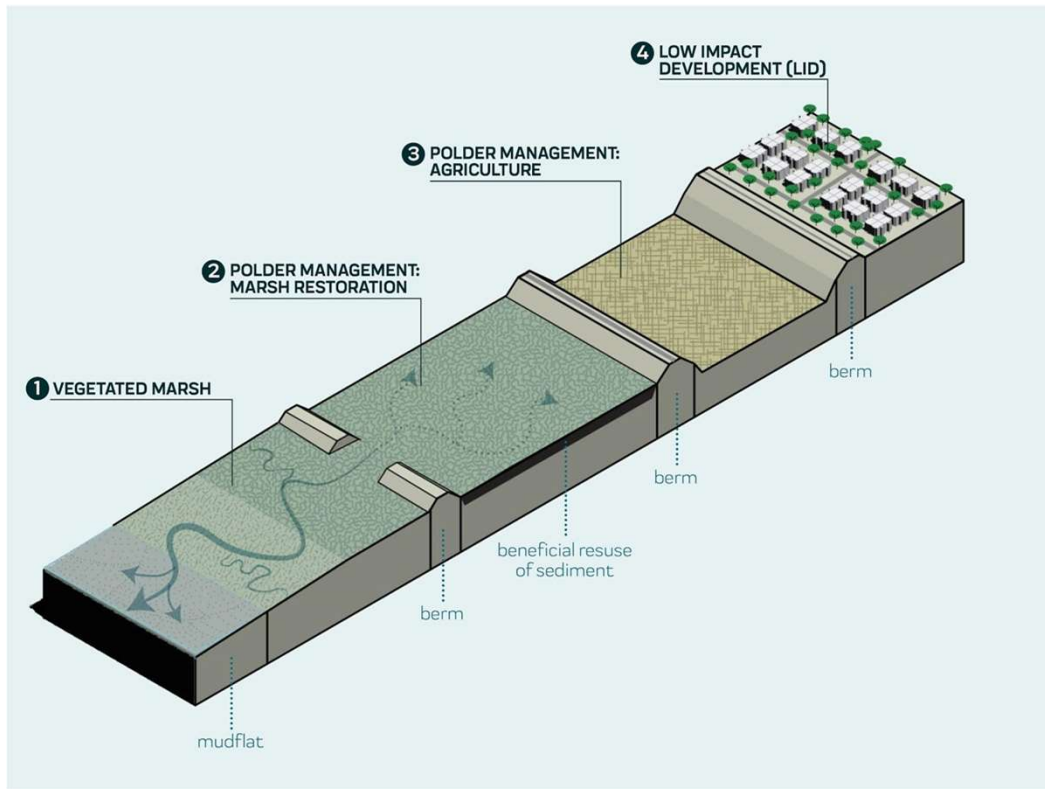


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Issue 2: Lands below sea level

Some areas are severely subsided and **protected by fragile levees.**

The Bay's polder problem



Issue 3: **History of inequality**

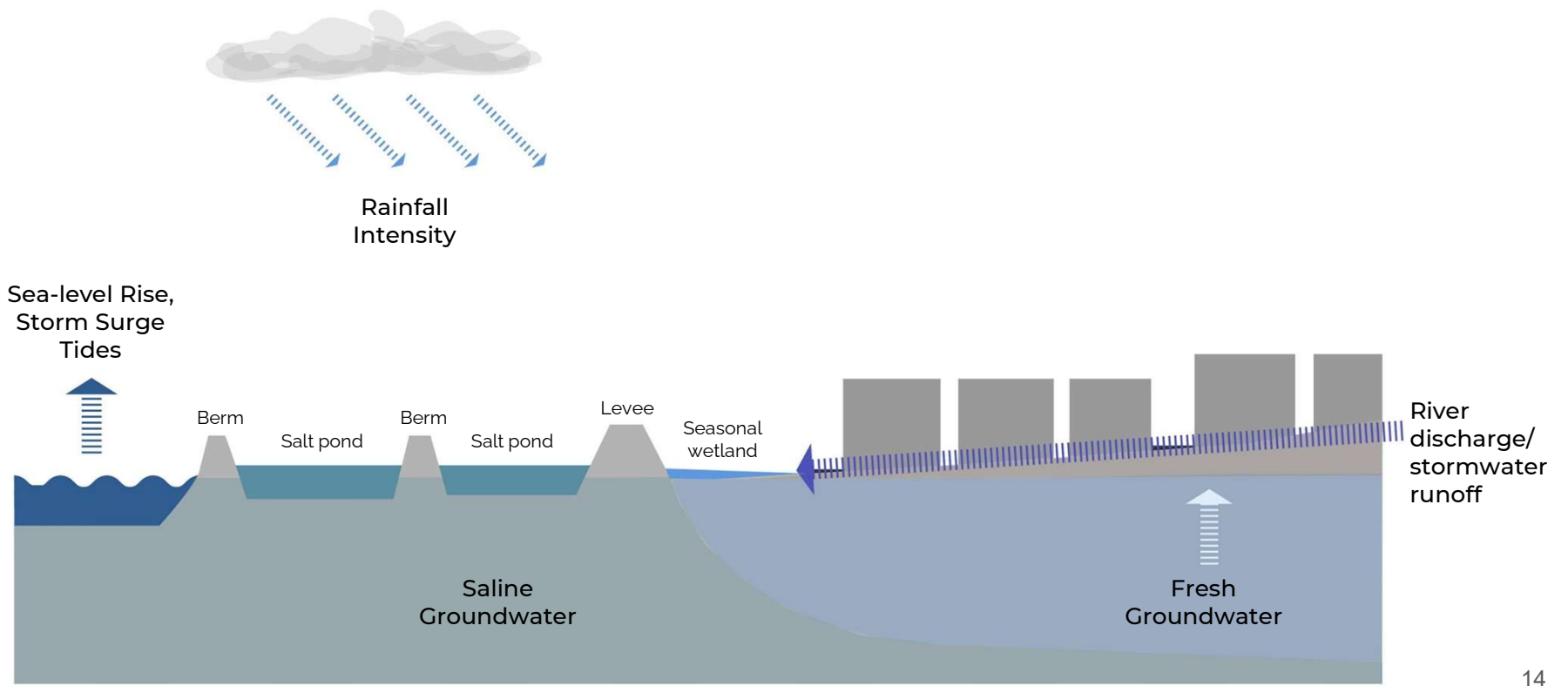
Redlining in the Bay Area forced the historically marginalized to live in the **lowest lying areas that flood the most regularly.**



Issue 4: **Water from all sides**

Sea level rise is only **one part** of the problem.

Increased precipitation from atmospheric river events and rising groundwater are not fully incorporated into flood models.



Diagrammatic only: not to scale

Issue 5: **Many cooks in the kitchen**

Different jurisdictions have generally pursued **shoreline planning separately**, yet this approach does not confer the greatest value or benefits.

A regional approach is needed.

Sea level rise
will not stop at
city boundaries.





What is nature-based adaptation?

Actions that **harness biodiversity and ecosystem services** to **reduce vulnerability** and **build resilience** to climate change.



Eelgrass



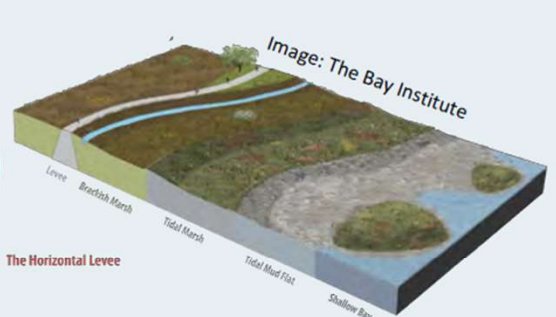
Oysters



Mudflats



Marshes



Ecotone levee
(marsh + levee)

Range from fully natural → Hybrid (natural + engineered)



Photo by Marin CDA staff

Local sea level rise adaptation planning

- Challenge of transitioning from vulnerability assessments to adaptation solutions
- Lots of interest in nature-based options, where are they appropriate?
- Challenge of “go-it-alone” land use decisions
- **Goal:** Develop a **framework process and set of tools** to support the transition from vulnerability assessment to adaptation strategies at a useful scale



STEP 1

**Plan using
nature's
boundaries**

*(instead of traditional
boundaries)*

STEP 2

**Identify
adaptation
measures that
could work well
in a given place**

*(and use nature as much
as you can)*

STEP 3

**Use when
bringing
stakeholders
together to
envision a
resilient future**

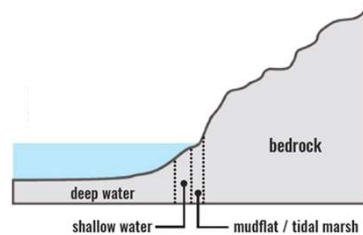




Defining geomorphic units

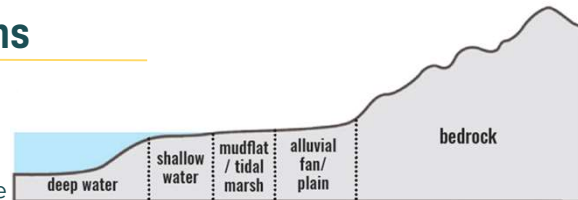
1 Headlands & small valleys

Watershed size: small
Slope: steep
Bayland width: narrow
Distance to deep water: small



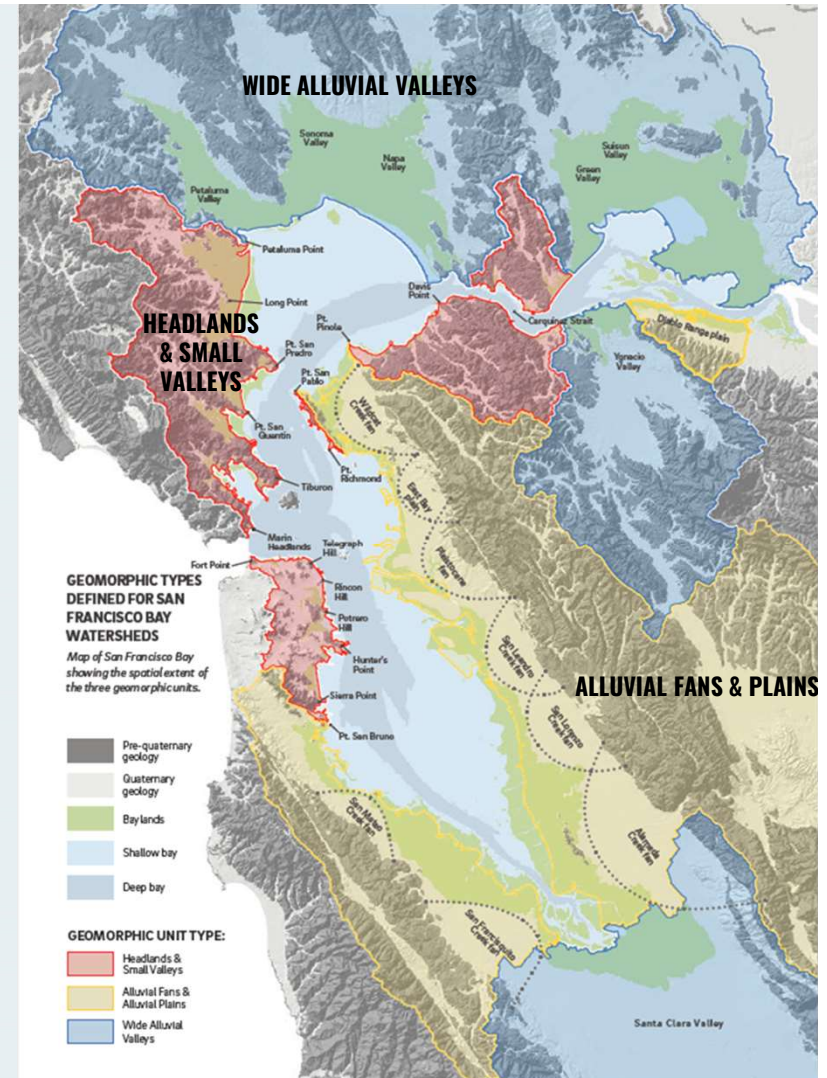
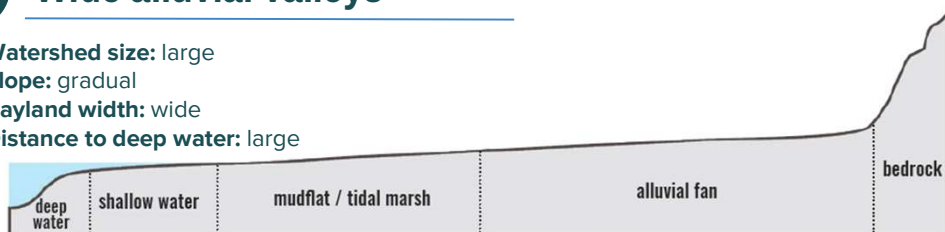
2 Alluvial fans & plains

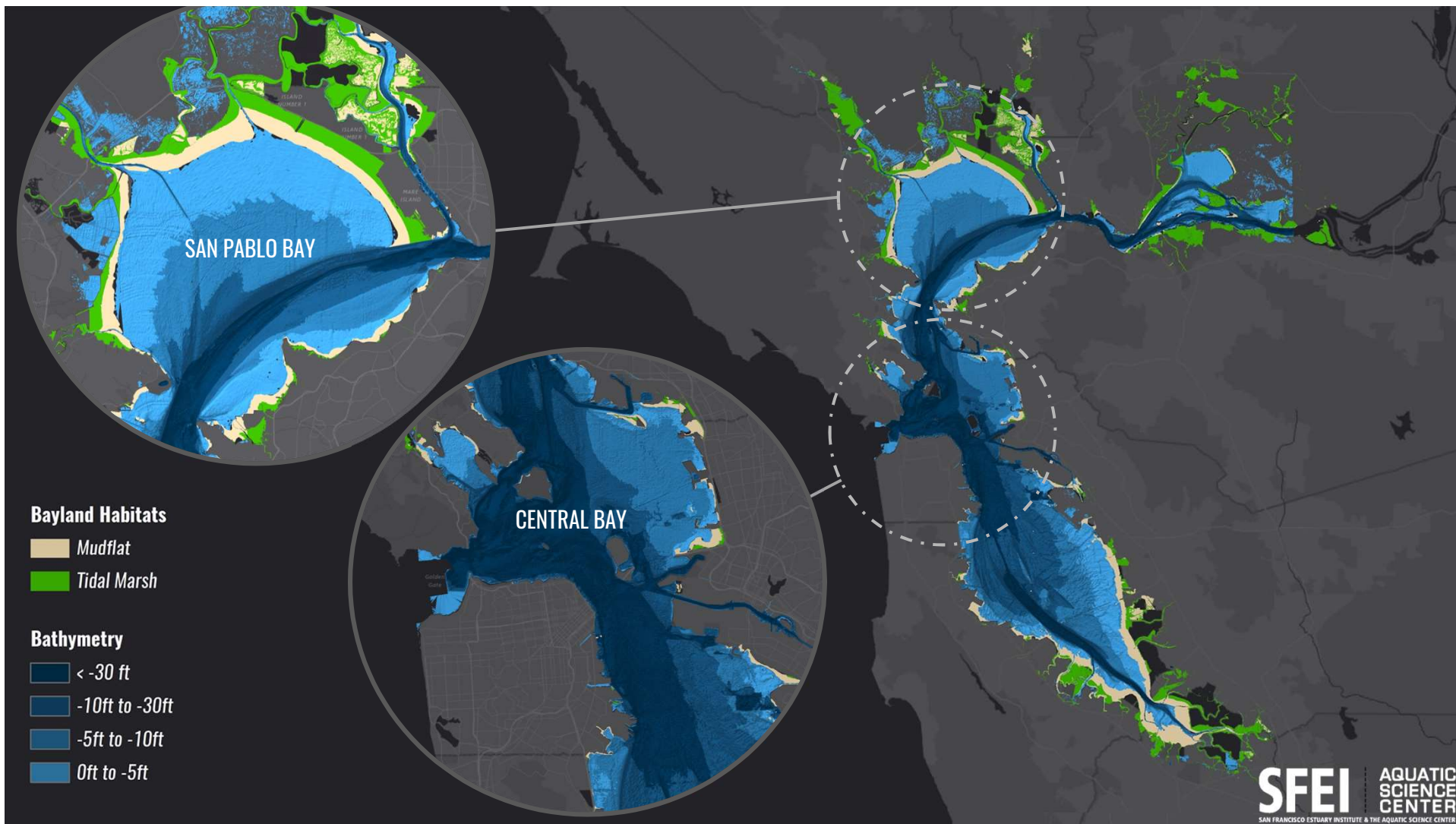
Watershed size: intermediate
Slope: moderate
Bayland width: intermediate
Distance to deep water: intermediate



3 Wide alluvial valleys

Watershed size: large
Slope: gradual
Bayland width: wide
Distance to deep water: large





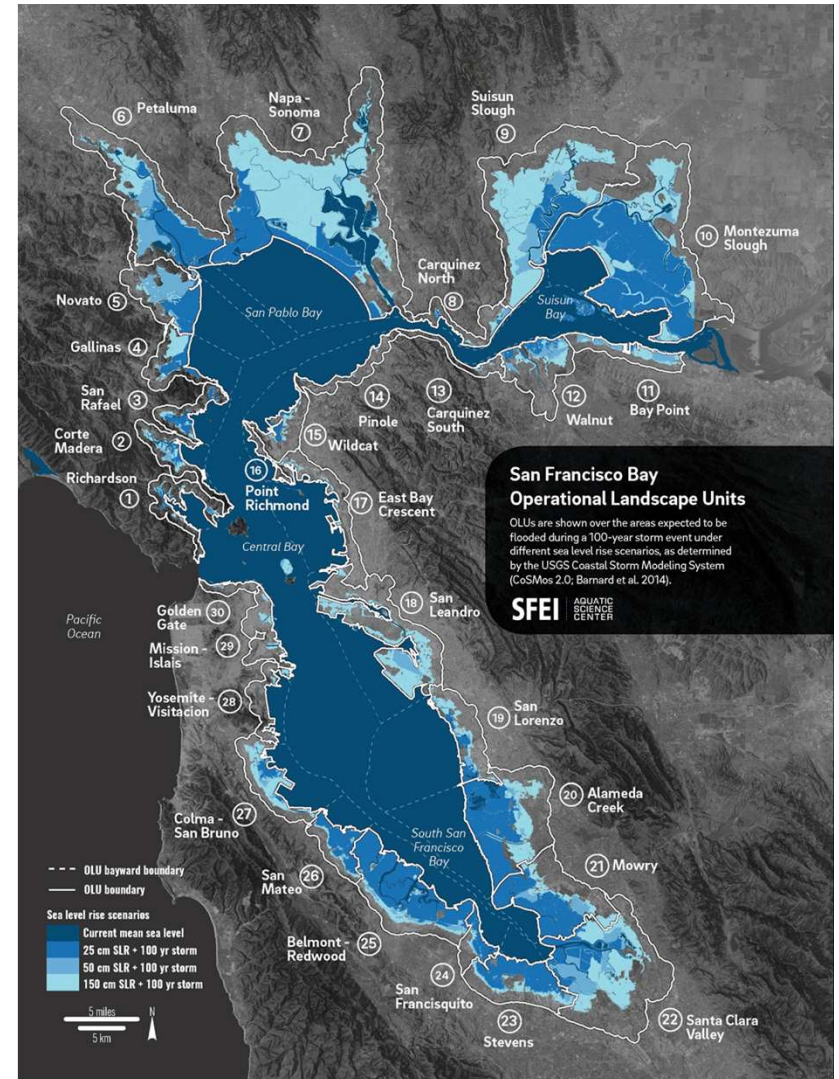
Nature's Boundaries

Operational Landscape Units

Areas with shared geophysical and land use characteristics *suited for a particular suite of nature-based measures*

- **Connected hydrologically (tie to watersheds)**
- **Land potentially inundated by SLR under H++ scenario (OPC 2017)**

SFEI



Adaptation measures

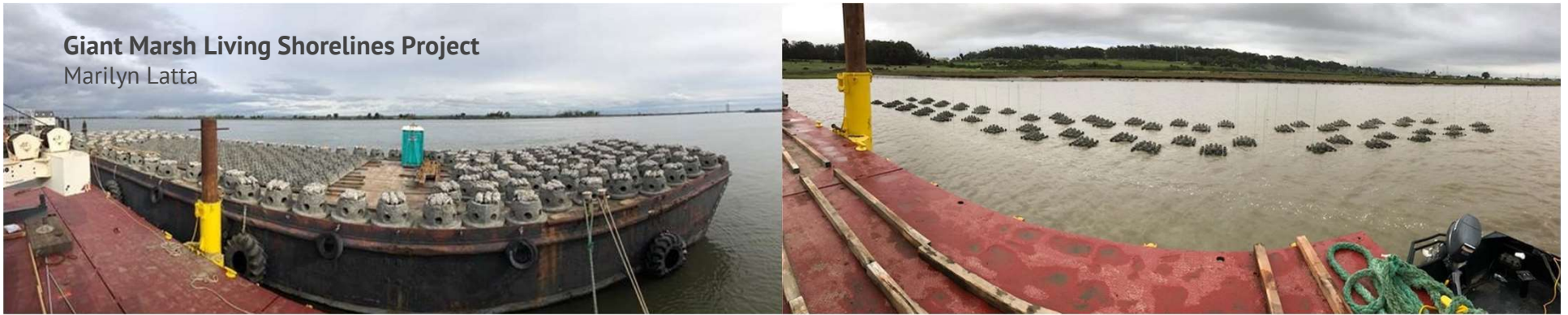
Nature-based measures

- Oyster reef creation
- Submerged vegetation restoration
- Mudflat augmentation
- Beach creation (sand, cobble, shell)
- Marsh restoration (various)
- Polder management
- Horizontal levee creation
- Migration zone preparation
- Creek to bay connections
- Green stormwater infrastructure

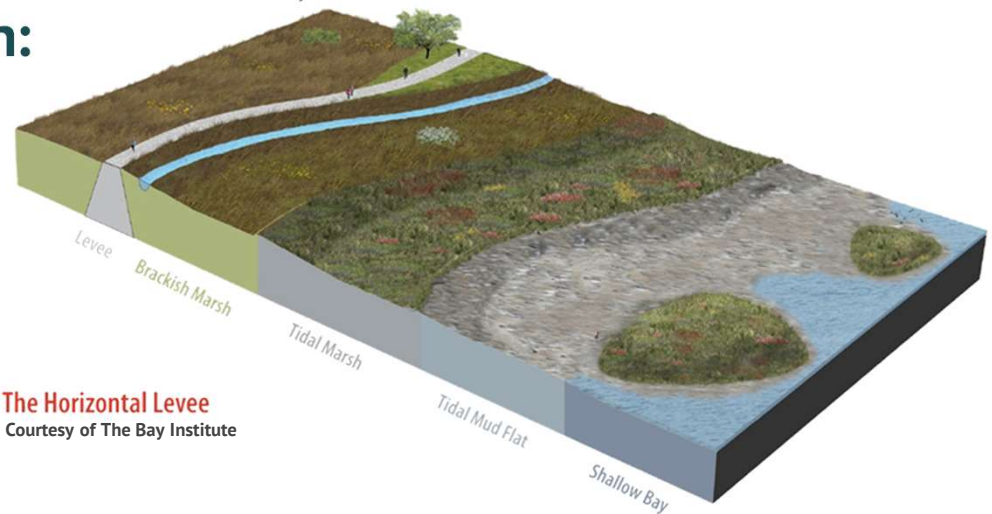
Regulatory, financial, policy tools

- Zoning and overlay zones
- Setbacks, buffers, and clustering
- Building codes and building retrofits
- Rebuilding and development restrictions
- Conservation easements
- Tax incentives and special assessments
- Geologic Hazard Abatement District
- Transfer of Development Rights
- Buyouts

Living shorelines: oyster reefs



Coastal storm-surge approach: tidal marsh & horizontal levee



The Horizontal Levee
Courtesy of The Bay Institute

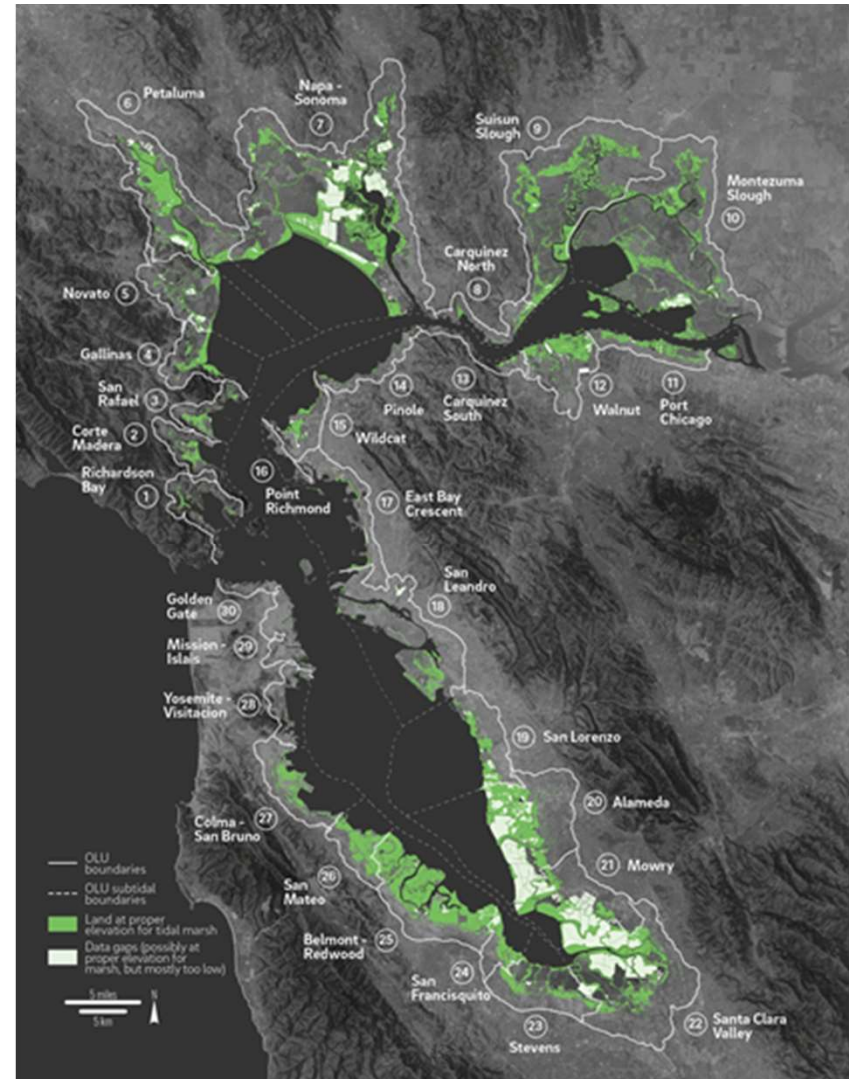
Arambaru beach enhancement project
Peter Baye, Roger Leventhal



Marsh restoration

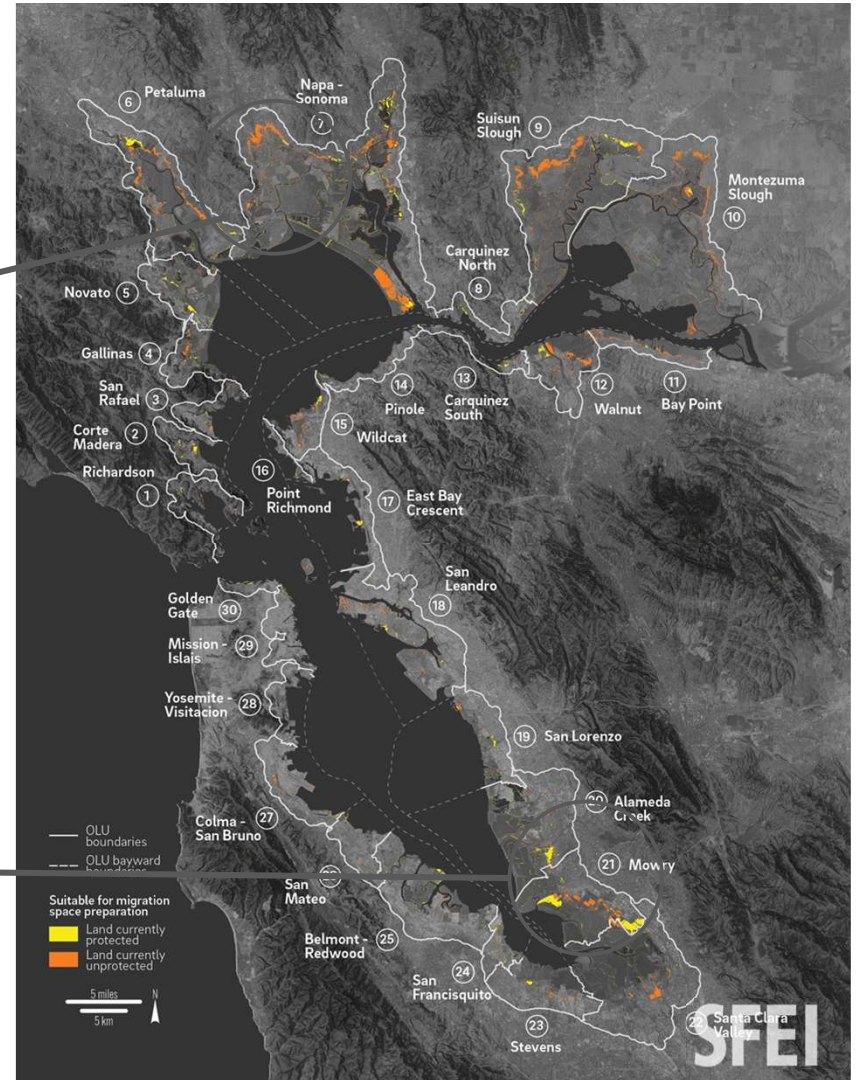
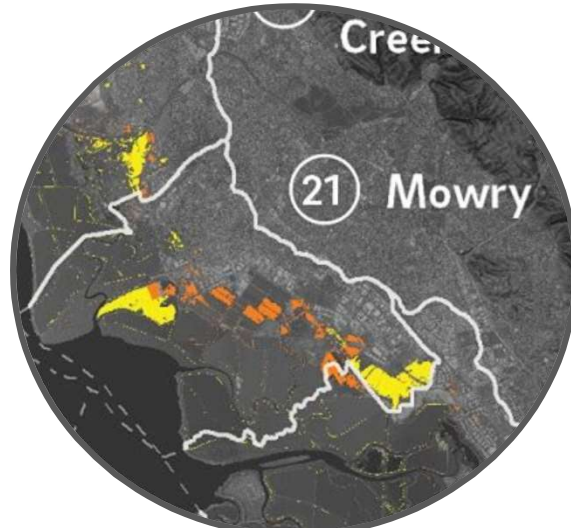
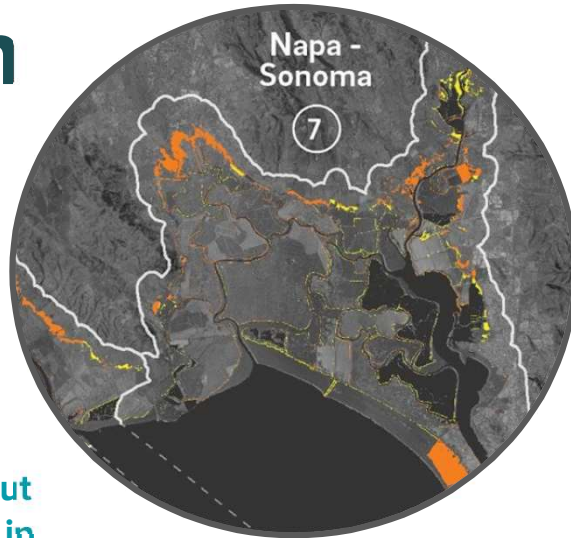
Methods:

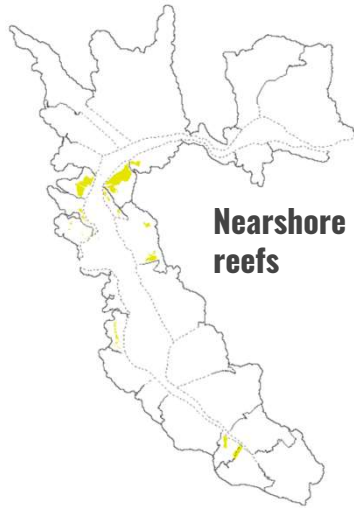
- Identify areas currently at the right elevation to potentially support tidal marshes using z^* (~MSL and ~HAT)
- Assess width of marsh needed to knock 100-year waves down to ~1 ft (0.3 m)



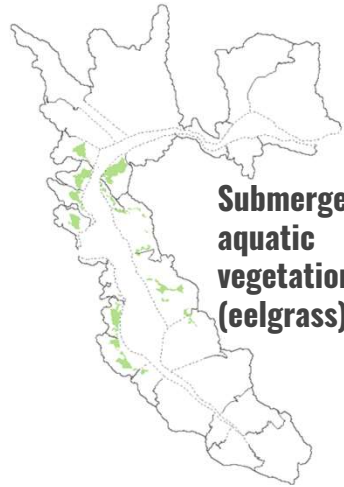
Migration space

Identify areas that are above tidal range now, but will be within tidal range in the future (areas where wetlands could migrate)





Nearshore reefs



Submerged aquatic vegetation (eelgrass)



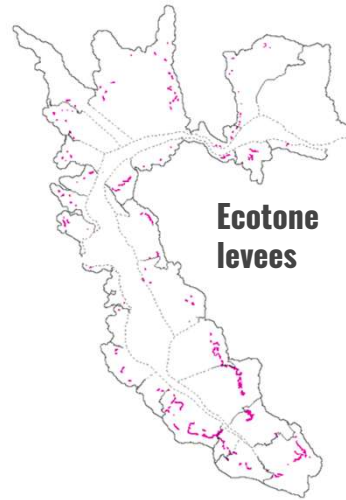
Beaches



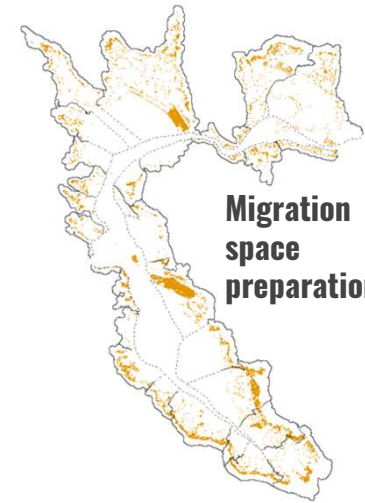
Tidal marshes



Polder management



Ecotone levees



Migration space preparation

Suitability of nature-based measures

Suitability Rating

- Limited suitability
- ◐ Some suitability
- High suitability

	Nearshore reefs (p. 66)	Submerged aquatic vegetation (eelgrass) (p. 68)	Beaches (p. 72)	Tidal marshes (p. 76)	Polder management (p. 80)	Ecotone levees (p. 84)	Migration space preparation (p. 88)
1. Richardson	●	●	●	◐	○	◐	○
2. Corte Madera	●	●	●	◐	◐	◐	◐
3. San Rafael	●	●	●	◐	◐	◐	○
4. Gallinas	◐	●	○	●	●	◐	●
5. Novato	○	○	○	●	●	◐	●
6. Petaluma	○	○	○	●	●	○	●
7. Napa - Sonoma	○	○	○	●	●	◐	●
8. Carquinez North	○	○	○	●	○	◐	●
9. Suisun Slough	○	○	○	●	●	◐	●
10. Montezuma Slough	○	○	○	●	●	○	●
11. Bay Point	○	○	○	●	●	◐	●
12. Walnut	○	○	○	●	●	●	●
13. Carquinez South	○	○	○	◐	○	●	●
14. Pinole	●	○	●	◐	○	◐	○
15. Wildcat	●	●	●	●	◐	●	●
16. Point Richmond	●	●	●	○	○	○	○
17. East Bay Crescent	●	●	●	◐	○	●	○
18. San Leandro	○	●	●	◐	◐	○	○
19. San Lorenzo	○	●	●	●	◐	●	◐
20. Alameda Creek	○	○	●	●	●	●	●
21. Mowry	○	○	○	●	●	●	●
22. Santa Clara Valley	○	○	○	●	●	●	●
23. Stevens	◐	○	○	●	●	◐	◐
24. San Francisquito	●	○	○	●	◐	●	◐
25. Belmont - Redwood	○	○	●	●	●	●	○
26. San Mateo	○	●	●	◐	◐	◐	○
27. Colma - San Bruno	○	●	●	◐	○	◐	○
28. Yosemite - Visitacion	●	●	●	○	◐	○	○
29. Mission - Islais	○	●	●	○	○	○	○
30. Golden Gate	○	○	●	○	○	○	○



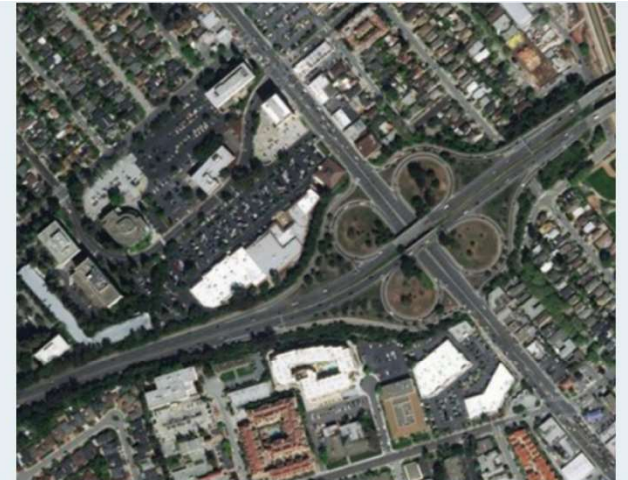
Open space

Suburban edge



Urban neighborhoods

Office parks and commercial

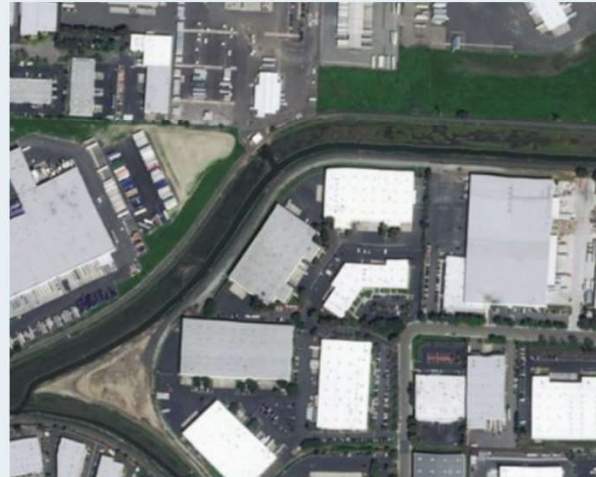


Secondary job centers

Dense mixed use



SFEI AQUATIC SCIENCE CENTER
SAN FRANCISCO ESTUARY INSTITUTE & THE AQUATIC SCIENCE CENTER



Adaptation measures

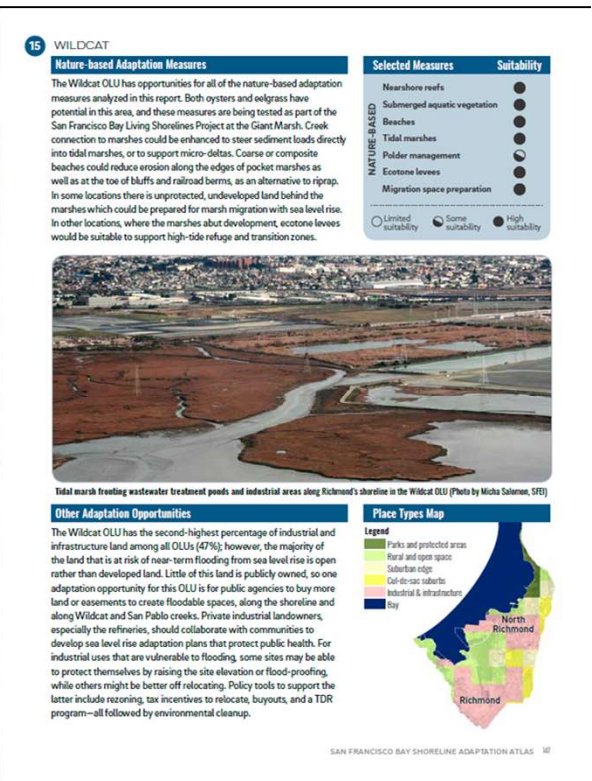
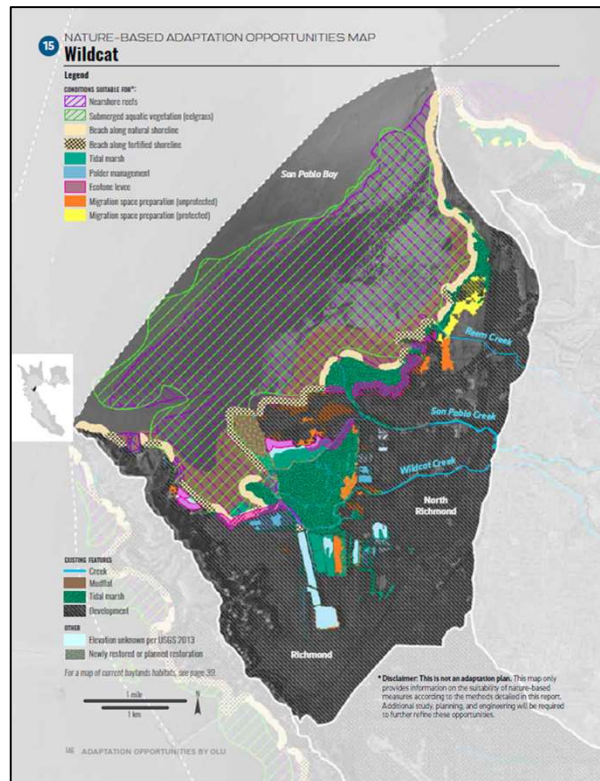
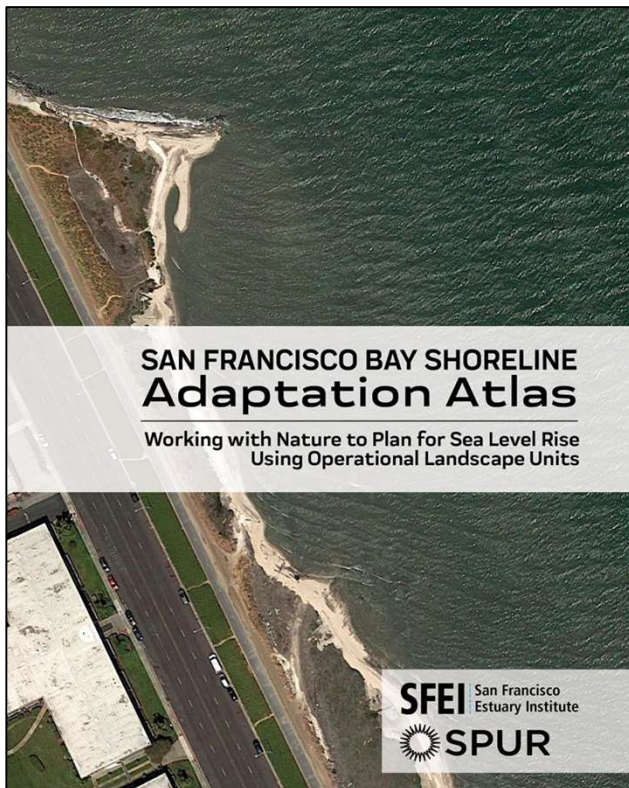
Nature-based measures

- Oyster reef creation
- Submerged vegetation restoration
- Mudflat augmentation
- Beach creation (sand, cobble, shell)
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- Polder management
- Horizontal levee creation
- Migration zone preparation
- Creek to bay connections
- Green stormwater infrastructure

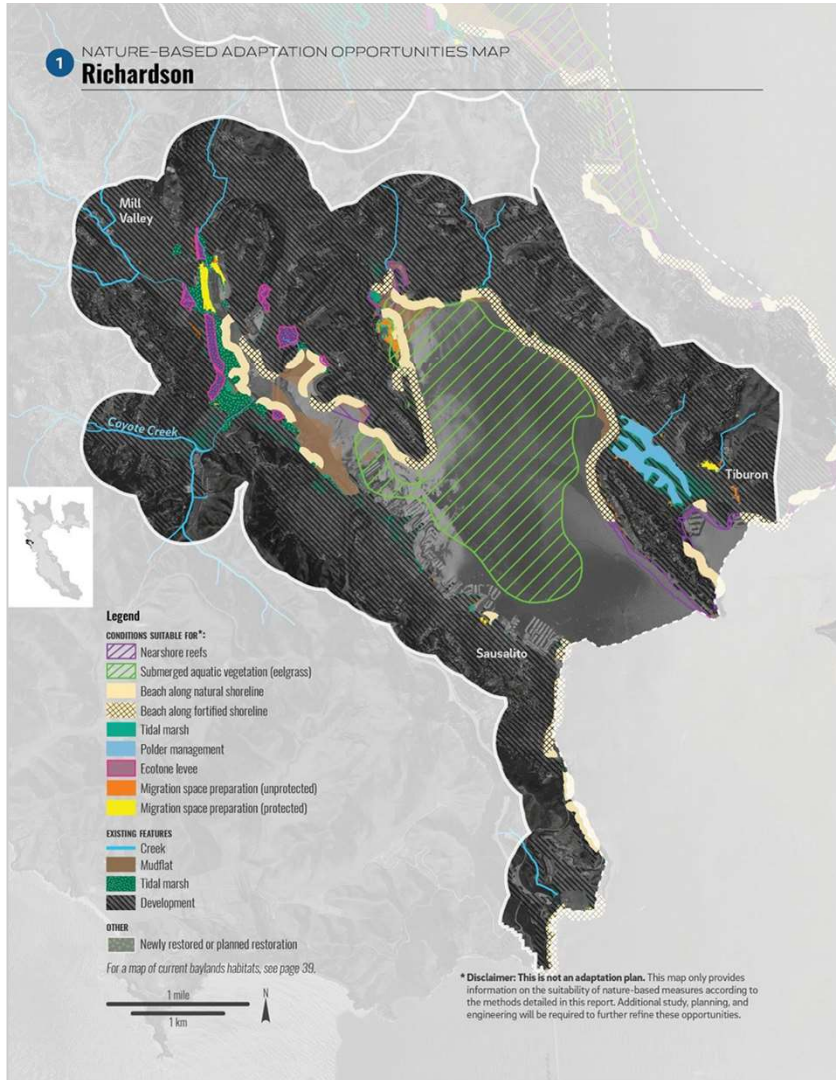
Regulatory, financial, policy tools

- Zoning and overlay zones
- Setbacks, buffers, and clustering
- Building codes and building retrofits
- Rebuilding and development restrictions
- Conservation easements
- Tax incentives and special assessments
- Geologic Hazard Abatement District
- Transfer of Development Rights
- Buyouts

The result: a spatially-explicit framework to guide adaptation efforts



1 NATURE-BASED ADAPTATION OPPORTUNITIES MAP
Richardson



1 RICHARDSON

Nature-based Adaptation Measures

The Richardson OLU has limited space near the Bay with steep headlands confining a small valley that restricts both development and natural habitat. There are also opportunities for natural and nature-based adaptation such as marshes. The mouth of Coyote Creek is an area prone to flooding and for creating an ecotone levee. Sediment supply to the marsh has been impeded by the presence of levees as well as low sediment concentrations in the Bay, and so thin-layer placement of sediment should be considered. Setting back the levees near the mouth of Coyote Creek to reduce backwater effects along the shoreline and the floodplain. Nearshore reefs and submerged aquatic vegetation would provide habitat and migration space for species. Beaches could help stabilize eroding shorelines, or along eroding shorelines such as has been piloted at Aramburu Island. Coarse beach faces could also be used to protect existing marsh scarps from wave erosion. Green stormwater infrastructure could be implemented in the upper watershed to slow down runoff, reduce fluvial flooding in the developed valleys, and slow the conveyance of floodwater to the Bay.

- Oyster reefs
- Horizontal Levees
- Beaches
- Eelgrass
- Creek connections

Selected Measures	Suitability	
NATURE-BASED	Nearshore reefs	●
	Submerged aquatic vegetation	●
	Beaches	●
	Tidal marshes	◐
	Polder management	◑
	Ecotone levees	◑
Migration space preparation	○	
○ Limited suitability ◐ Some suitability ● High suitability		



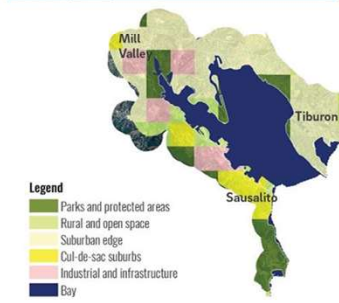
Housing along Sausalito's shoreline in Richardson OLU (Photo by Shira Bezalet, SFEI)

Other Adaptation Opportunities

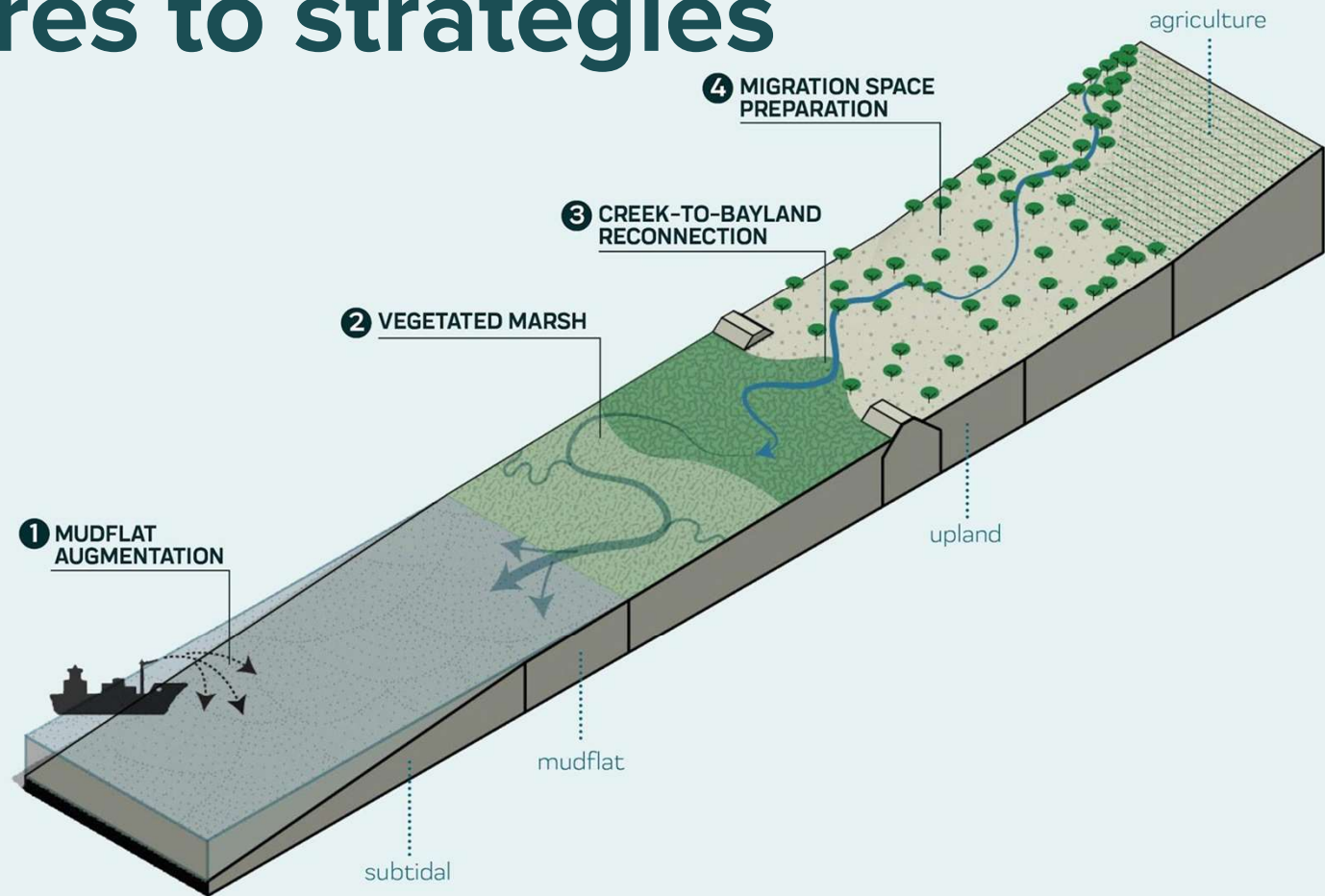
The predominant place types in Richardson are suburban edge, rural and open space, and industrial and infrastructure (10%). Over time, the place types most susceptible to sea level rise are cul-de-sac suburbs. For parks and protected areas, suitable strategies include securing wetlands transition zone through easements or buyouts, allowing sea level rise to take its course. For industrial and infrastructure, and suburban edge, suitable strategies include not intensifying development, elevating roads and buildings, re-zoning areas moving infrastructure or commercial activities to higher ground through re-zoning.

- Easements, buyouts
- in open/ protected areas
- Not intensifying development,
- elevating roads, buildings, re-zoning

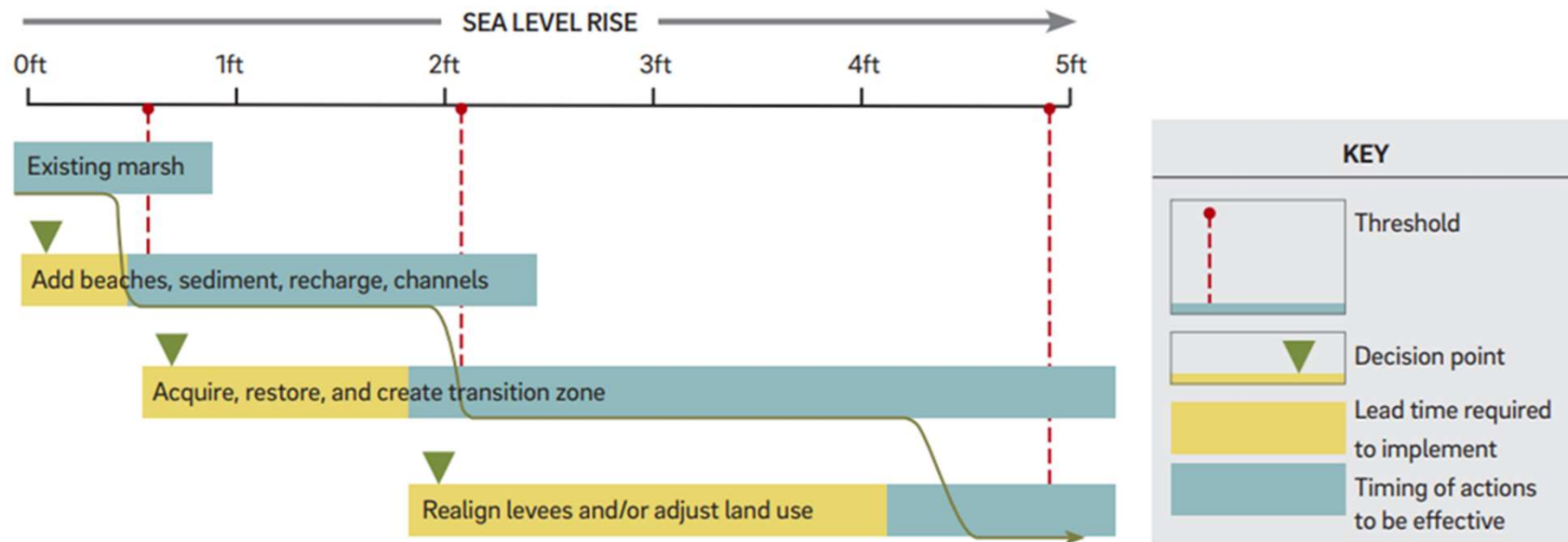
Place Types Map



Measures to strategies



Adaptation pathways



Conceptual phasing of measures triggered by sea-level rise, rather than a chronological timeline (adapted from Goals Project 2015).

How can this be used?

- As a toolkit to bring together stakeholders around a given shoreline unit
- A resource to assist environmental review and permitting
- Guidance for developers and project applicants
- Local, regional planners, and communities creating adaptation plans and policies
- Guidance for policy changes within regional agencies



Nature News



BAY NATURE

City and Regional Goals Clash as Newark Pushes Ahead With Low-Density Housing in A Bayshore Flood Zone

by *Mukta Patil*

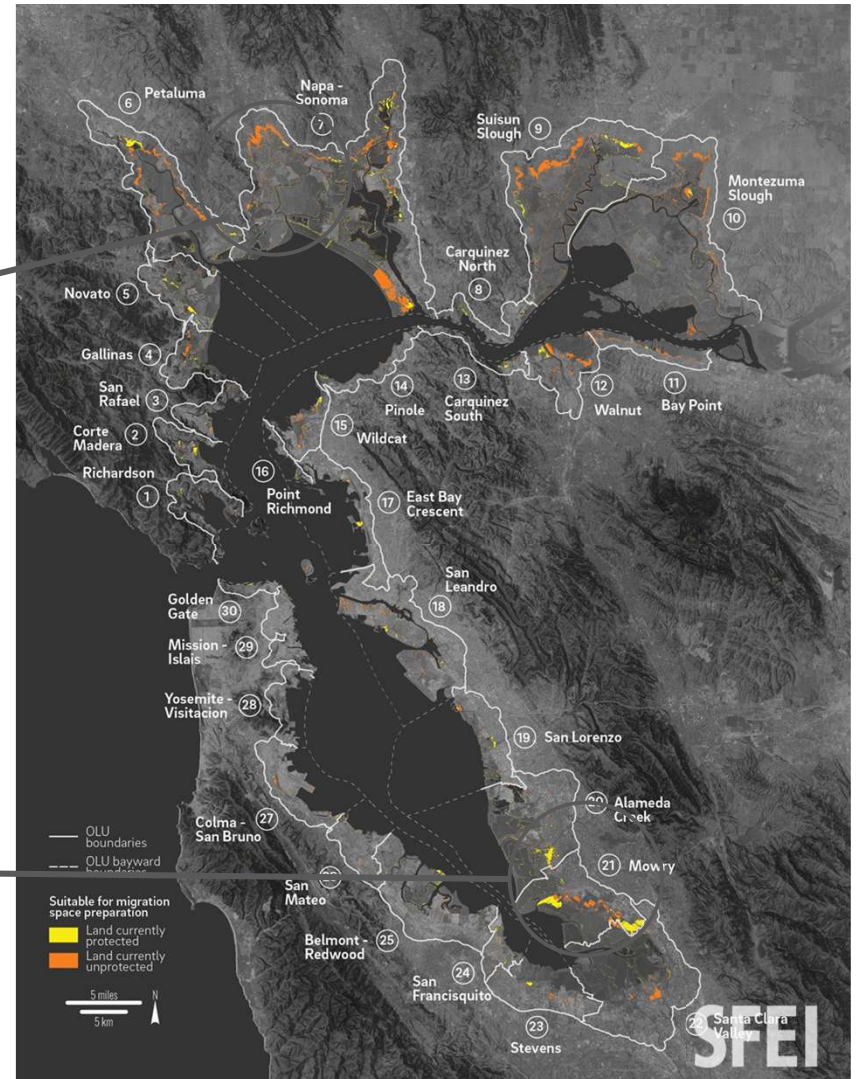
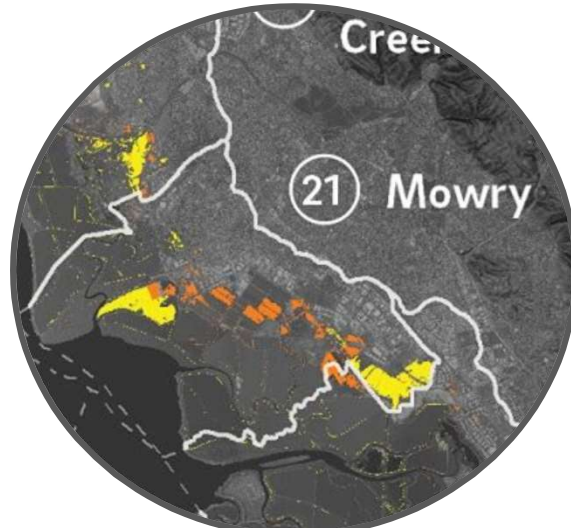
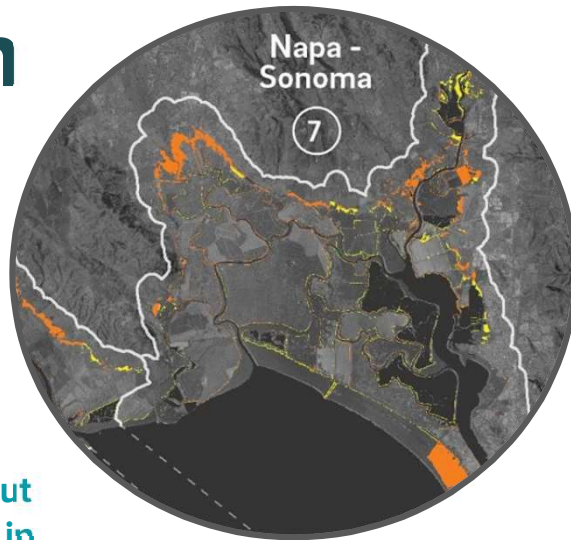
March 9, 2021

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
Florence LaRiviere has fought to protect marshes in the Bay Area for decades. In the 1960s she joined a small group of residents to push for the creation of what would become the Don Edwards San Francisco Bay Area National Wildlife Refuge, a now-30,000-acre haven along the shores of the South Bay that provides habitat for migratory birds and several special

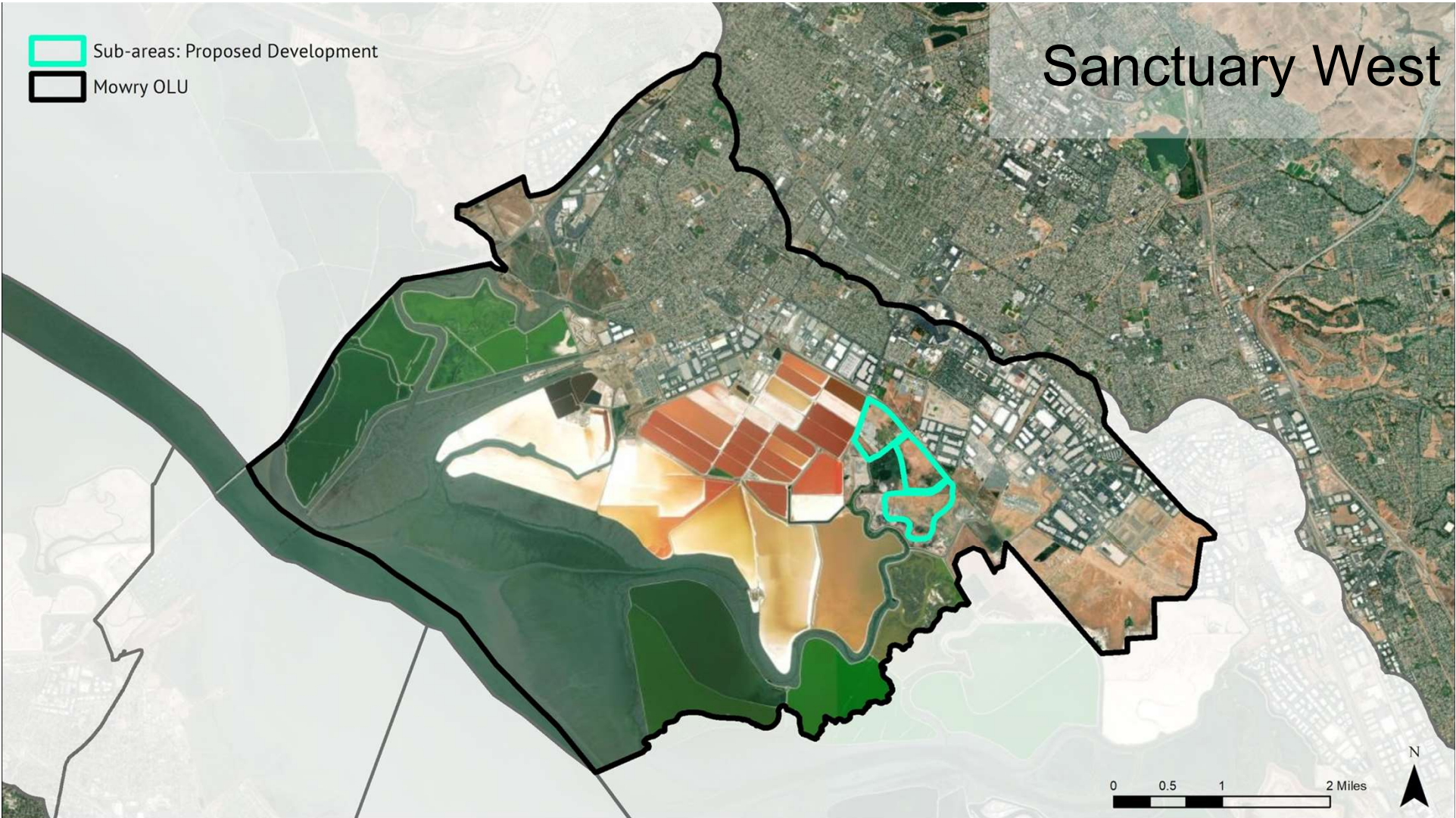
Migration space example

Identify areas that are above tidal range now, but will be within tidal range in the future (areas where wetlands could migrate)



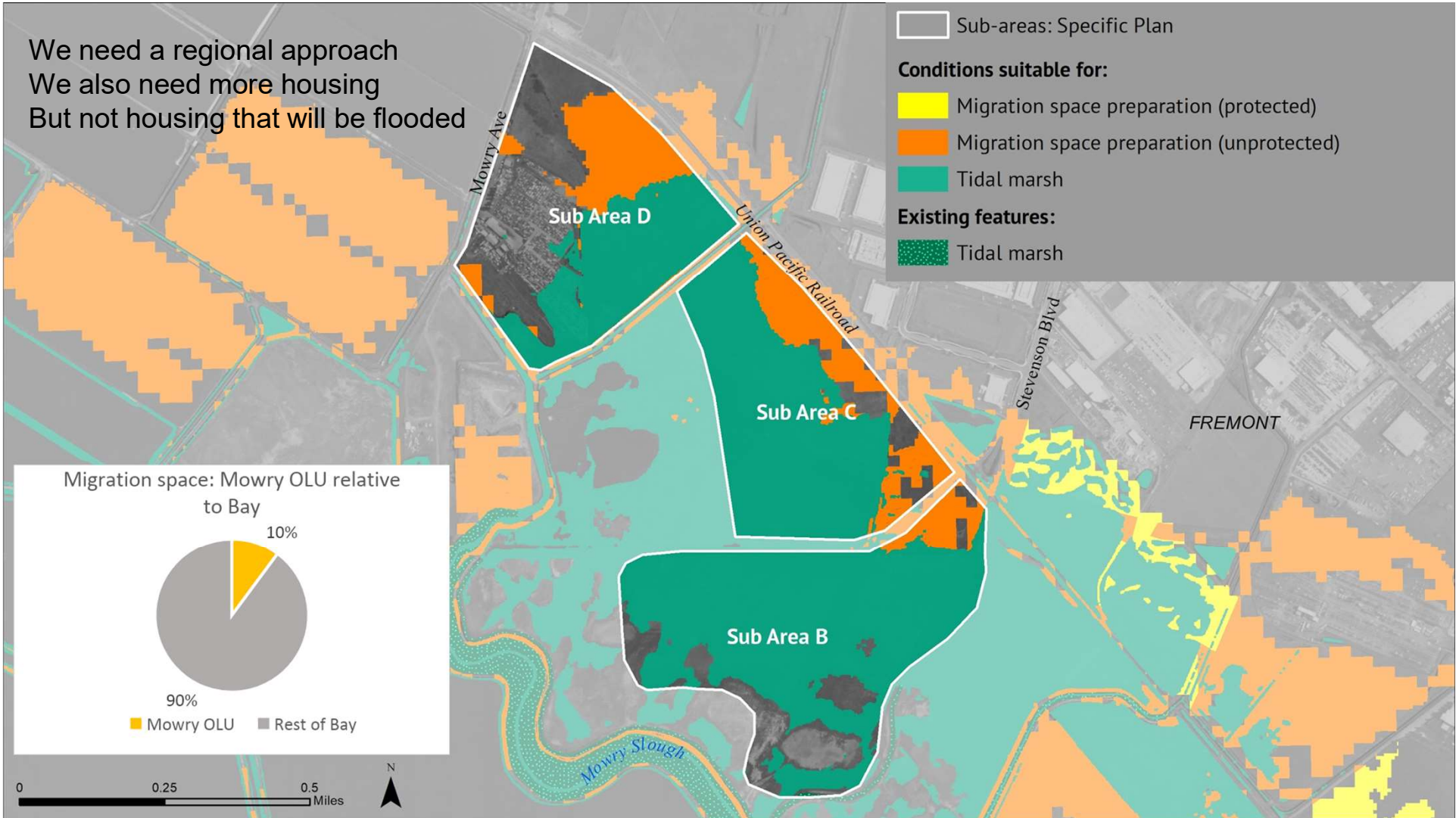
Sanctuary West

-  Sub-areas: Proposed Development
-  Mowry OLU

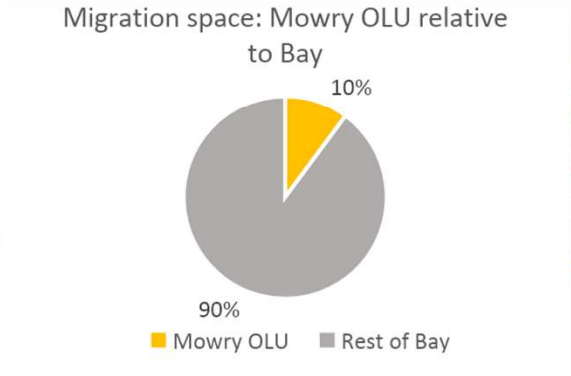




We need a regional approach
We also need more housing
But not housing that will be flooded



- Sub-areas: Specific Plan
- Conditions suitable for:**
 - Migration space preparation (protected)
 - Migration space preparation (unprotected)
 - Tidal marsh
- Existing features:**
 - Tidal marsh





Need for sediment

- USACE dredges navigation channels yearly
- Cheaper to take the material off shore
- We need to reuse the sediment in a smart way, collaboratively if we want to design with nature for climate resilience

The Mercury News

San Francisco Bay: Protection from costly...



NEWS > ENVIRONMENT

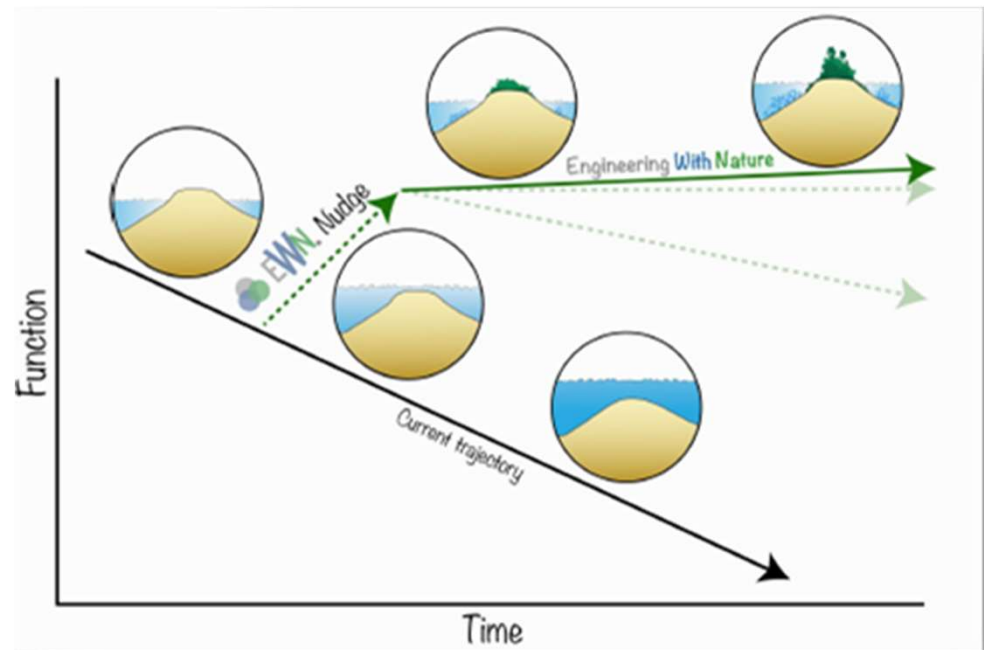
San Francisco Bay: Protection from costly disasters is being thrown away, scientists say

Sea level rise threatens billions in flood damage, but dredged mud to raise shoreline isn't being used



Engineering With Nature at USACE

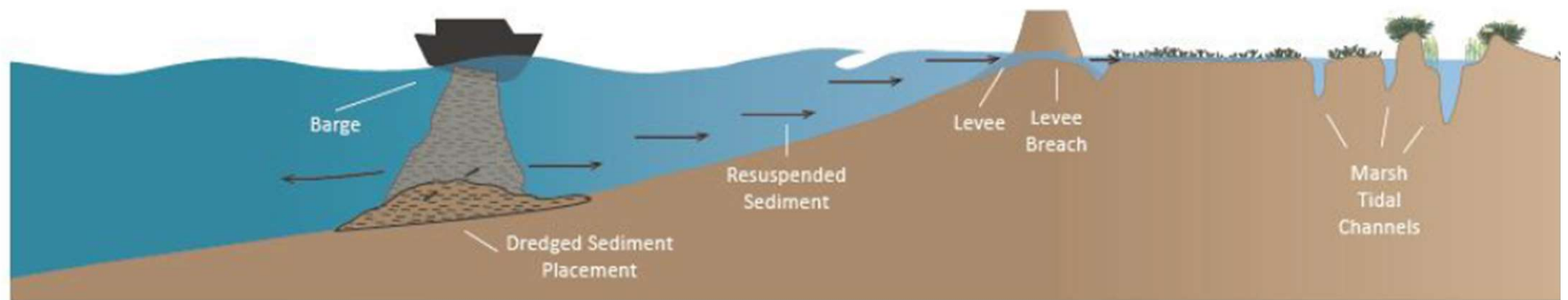
- “Run to where the ball is going to be”: Where will landscape features create the most value in the future?
- Size it right: nature-based features are scalable, affordable, and innovative.
- Solutions are place-based: Local knowledge and systems thinking.



Shallow water placement pilot

- Beneficial reuse of dredged materials
- Using natural transport processes to move material onshore
- Creates resilience for mudflats and marshes
- Innovative, cost-effective
- Needs modeling, monitoring to quantify impacts and benefits

Shallow-Water Placement



We can adapt to sea level rise if we:

- **Add more tools to our toolbox**
- **Speed up**
- **Design with nature**
- **Empower and center communities**
- **Work together**

THANK YOU

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Collaborators:

**Katie McKnight, Ellen Plane, Sam Safran,
Jeremy Lowe, Letitia Grenier, SFEI
Laura Tam, Resources Legacy Fund
And many others**



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Funded by: S.F. Bay Regional Water Quality Control Board

With additional funding from the Bernard and Anne Spitzer Charitable Trust, the Marin Community Foundation, the Seed Fund, the Gordon and Betty Moore Foundation, and Google