Living Shorelines

Multi-Objective Approach and Pilot Projects

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North Bay Watershed Association
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Hard Infrastructure
Impacts to Shorelines and Wetlands

- Dredging, placement of fill, construction of structures
- Loss of habitat values and species
- Impacts to natural processes, often increases in erosion, high maintenance costs
- Worsening impacts w/ sea level rise, increased storm surge, flashier system

Potential Benefits
Nature-Based Infrastructure

- Enhanced habitat values- functions and services
- Increased species support and connectivity
- Erosion control and shoreline protection
- Climate adaptation and habitat resilience
- Cost effective, higher sustainability, less maintenance

Policy Support and Permitting

- **President's Climate Action Plan:**
  - Improve natural defenses
  - Protect biodiversity
  - Conserve natural resources in the face of climate change
  - Manage public/private lands to store carbon
- **ACOE Dec 2013- requires SLR consideration**

- **State of CA Safeguarding CA Plan**
- **State Coastal Commission LCP updates, SLR**
- **State Coastal Conservancy CC Priorities and SLR Guidance**
- **SF Bay BCDC policies- fill, SLR**

Maryland Living Shorelines Protection Act

- 580 acres of shoreline- Chesapeake, Atlantic
- preferred method of shoreline protection
- state public policy- protect natural habitat and shoreline processes
- have to demonstrate that it's not feasible before constructing bulkhead

States with Programmatic Permits- *partial list*

- Maryland
- Virginia
- South Carolina
- Alabama
- Mississippi

Regional Climate Adaptation Recommendations

1. Restore estuary-watershed connections.
2. Design complexity and connectivity into the Baylands landscape.
3. Restore and conserve complete tidal wetlands systems.
4. Plan for the Baylands to migrate.
5. Actively recover, conserve, and monitor wildlife populations.
6. Invest in planning, policy, research and monitoring.




SF Bay Living Shorelines Project

Intertidal and subtidal connectivity

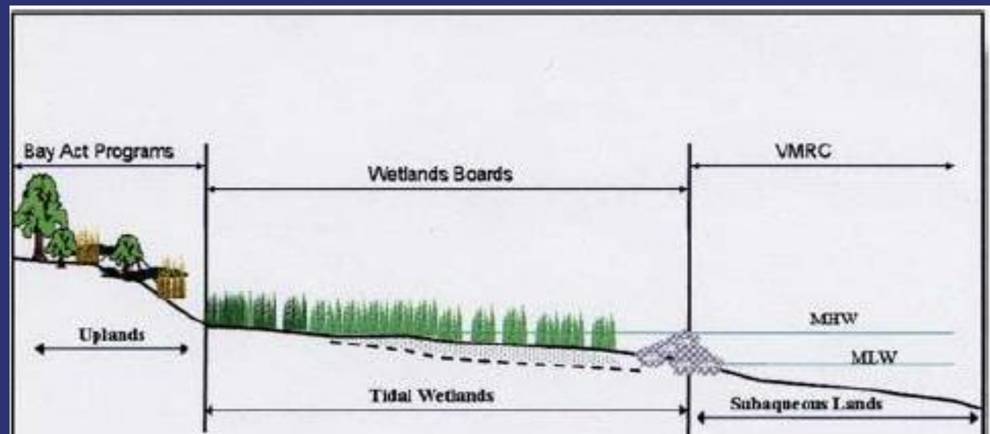
Native Olympia Oysters and eelgrass

Biological and physical goals

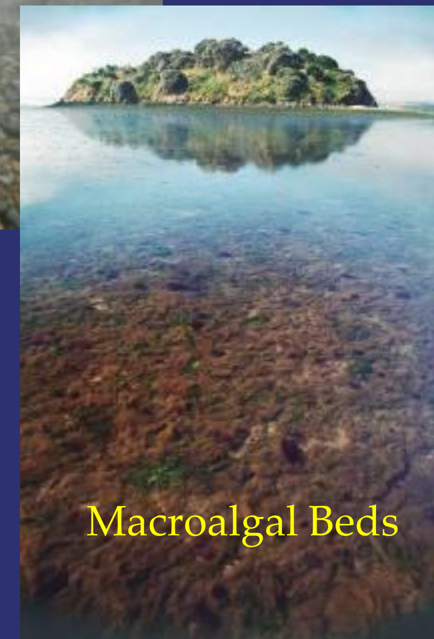
Transition Zones on Both Edges

Upland transition

Subtidal transition

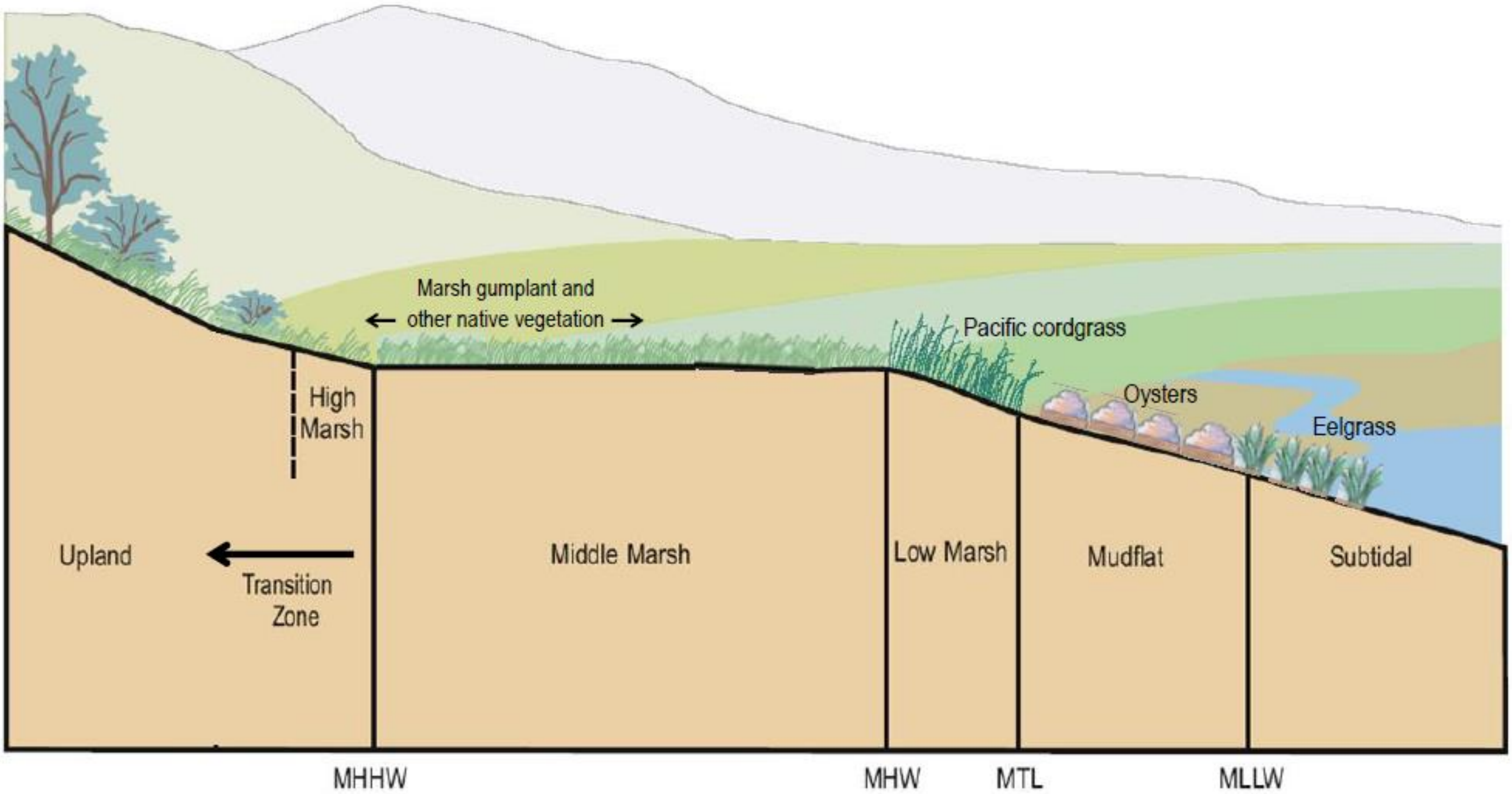


Wetland edges: sand bars, shell beds, kelp and eelgrass fringe, rocky intertidal



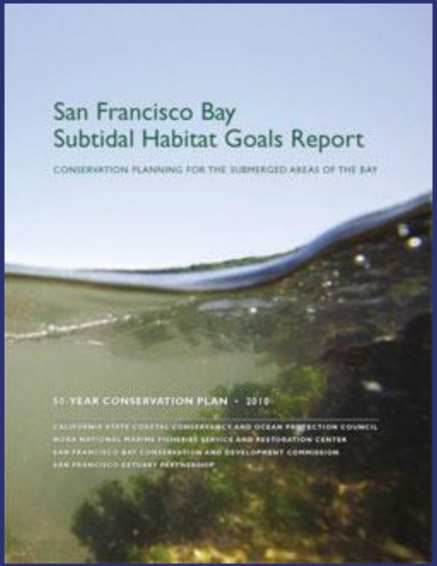
Shellfish Beds

Complete tidal wetland system



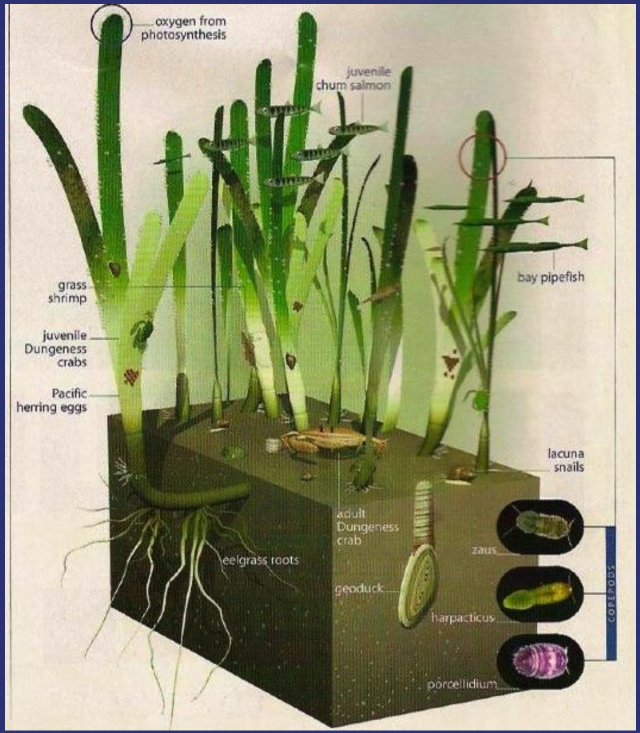
Multi-Habitat, Multi-Objective

- SF Bay Subtidal Habitat Goals
- Pilot scale, experimental approach
- Monitor biological use and physical benefits
- Pilot climate change adaptation
- Apply lessons learned to larger projects



Native Olympia Oysters:
Ostrea lurida

- Small: usually 1.5 – 2”
- Planktonic larvae, settle on hard substrate
- Filter feeders, water quality
- Heterogeneity = increased niche space
- Food source for other invertebrates, birds, fish



Eelgrass:
Zostera marina

- Rooted, flowering plant
- Spreads clonally and by seed
- Traps sediments, reduces erosion, sequesters carbon
- Builds habitat: epifauna, infauna, fish (e.g., pipefish)
- Foraging area for birds & marine mammals

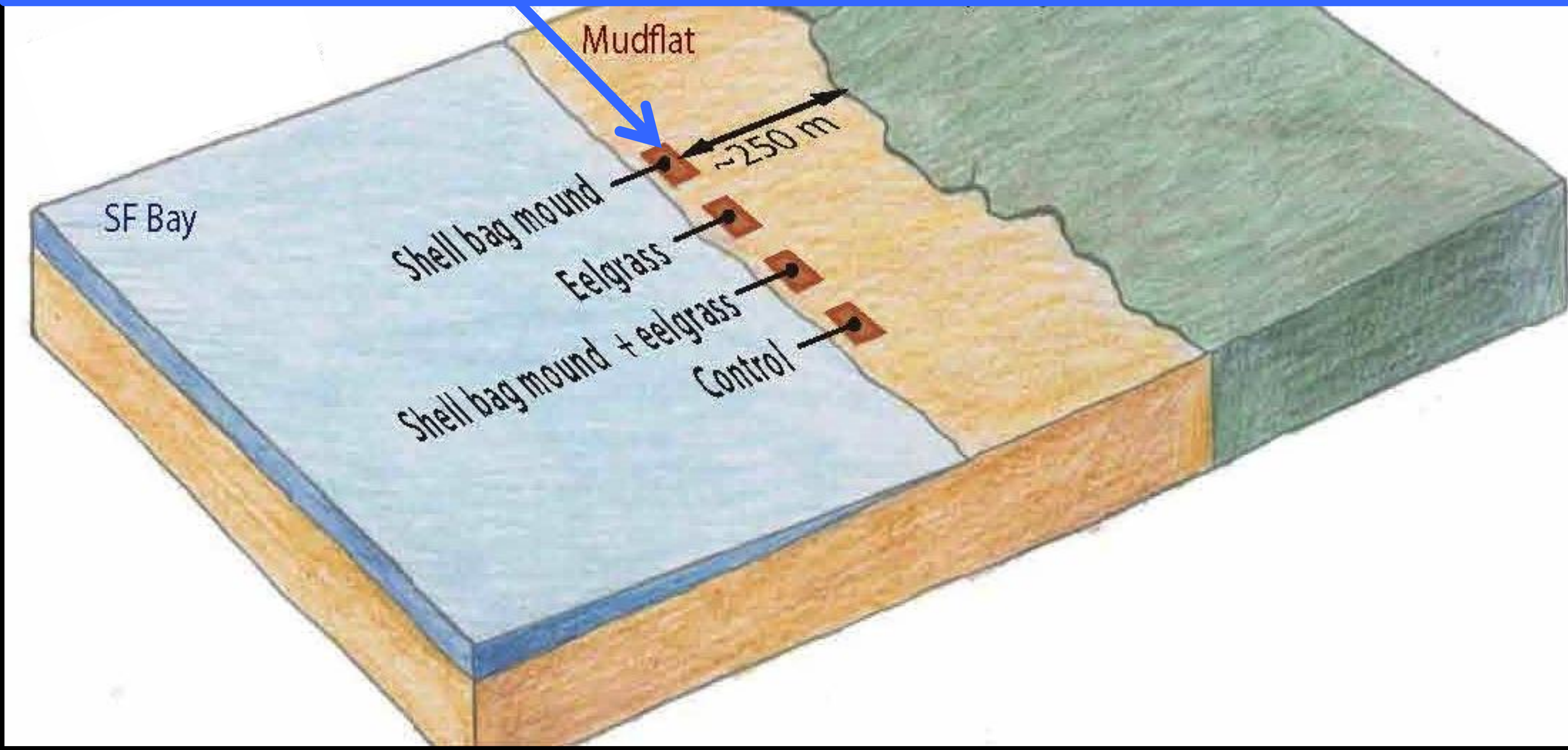
Ecosystem Functions	Ecosystem Services
enhance habitat for fish and wildlife	sediment accretion
increase food resources	wave attenuation
rearing/nesting support	minimize shoreline erosion
improve linkages and connectivity between habitat types	promote potential physical synergistic effects between habitats
assess interactions between habitat types that influence restoration success	test alternatives to traditional shoreline armoring

Project location

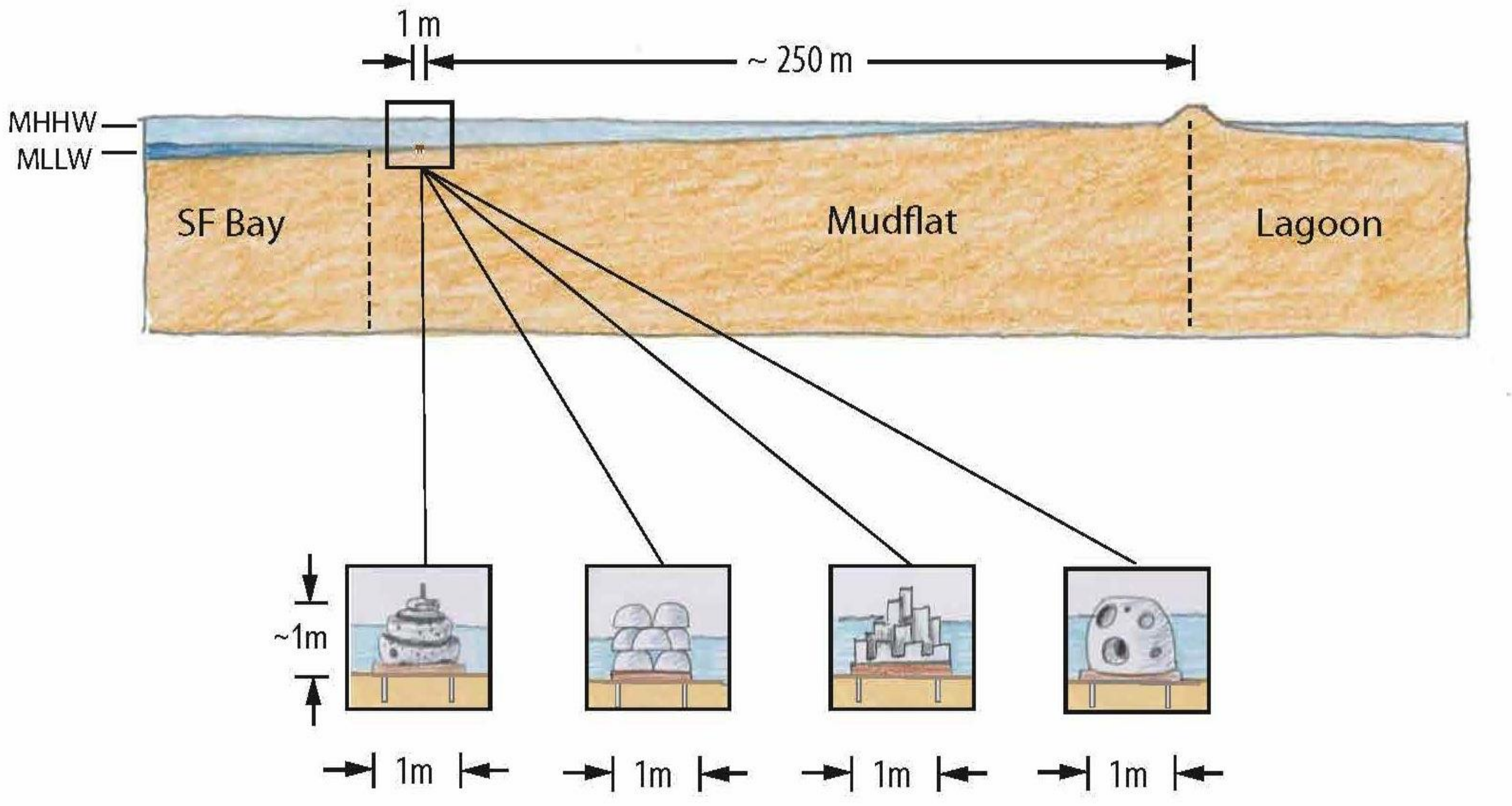
San Rafael (TNC)

Hayward (ELER)

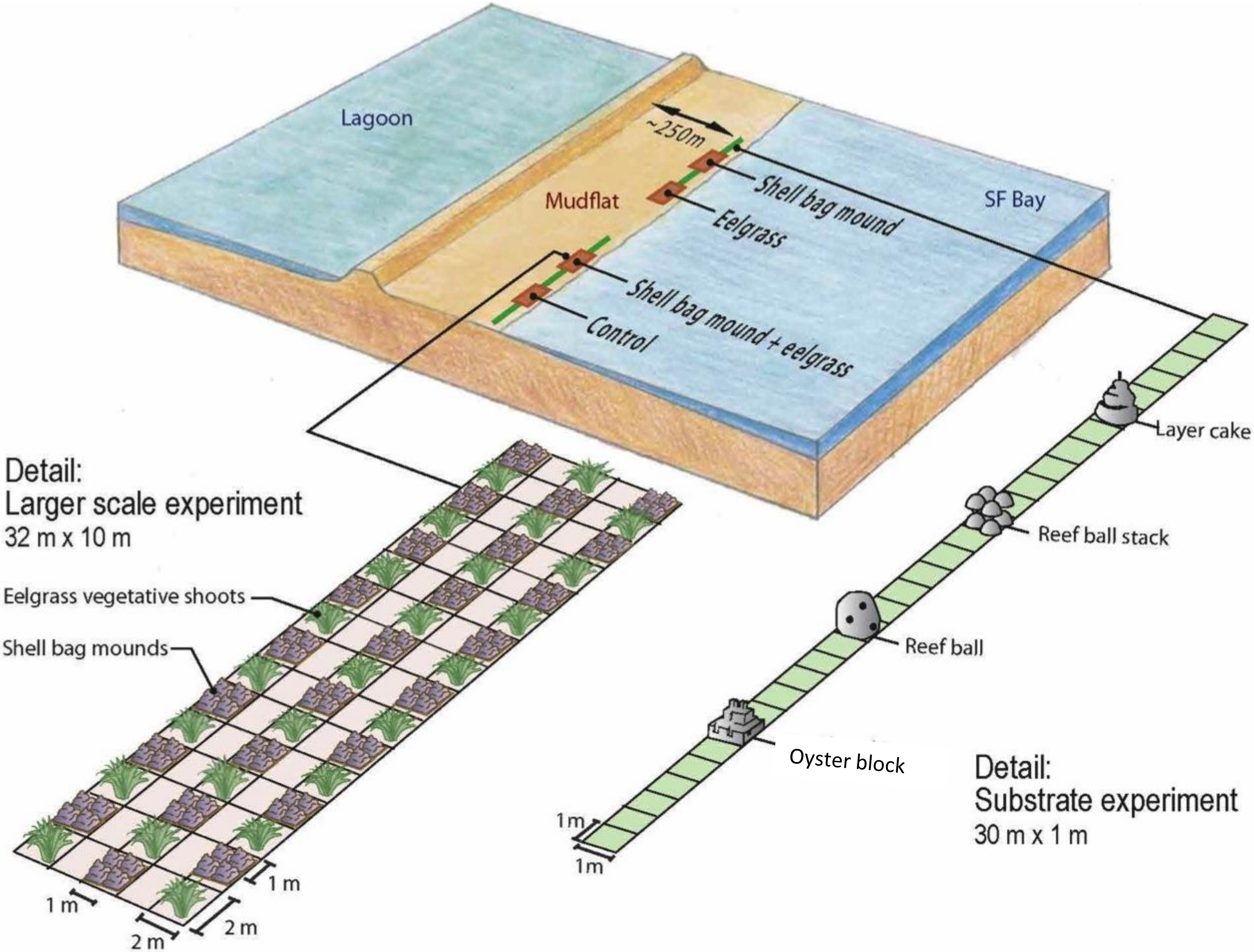
Design basics of large-scale project



Smaller-scale test of “Baycrete” substrates



Project Design, San Rafael (TNC) site



Native Oyster Settlement Substrates

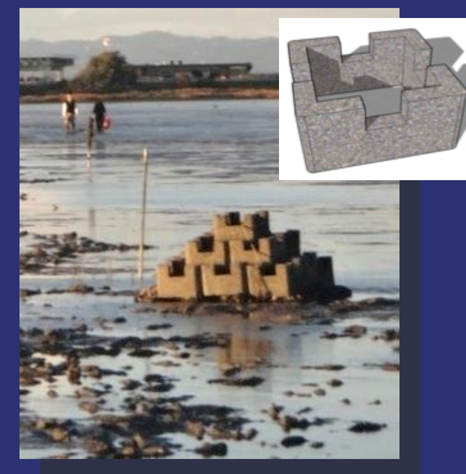
Large plots: 10 x 32m

Series of shell bag mounds

"Baycrete" small scale substrates

Reef Balls

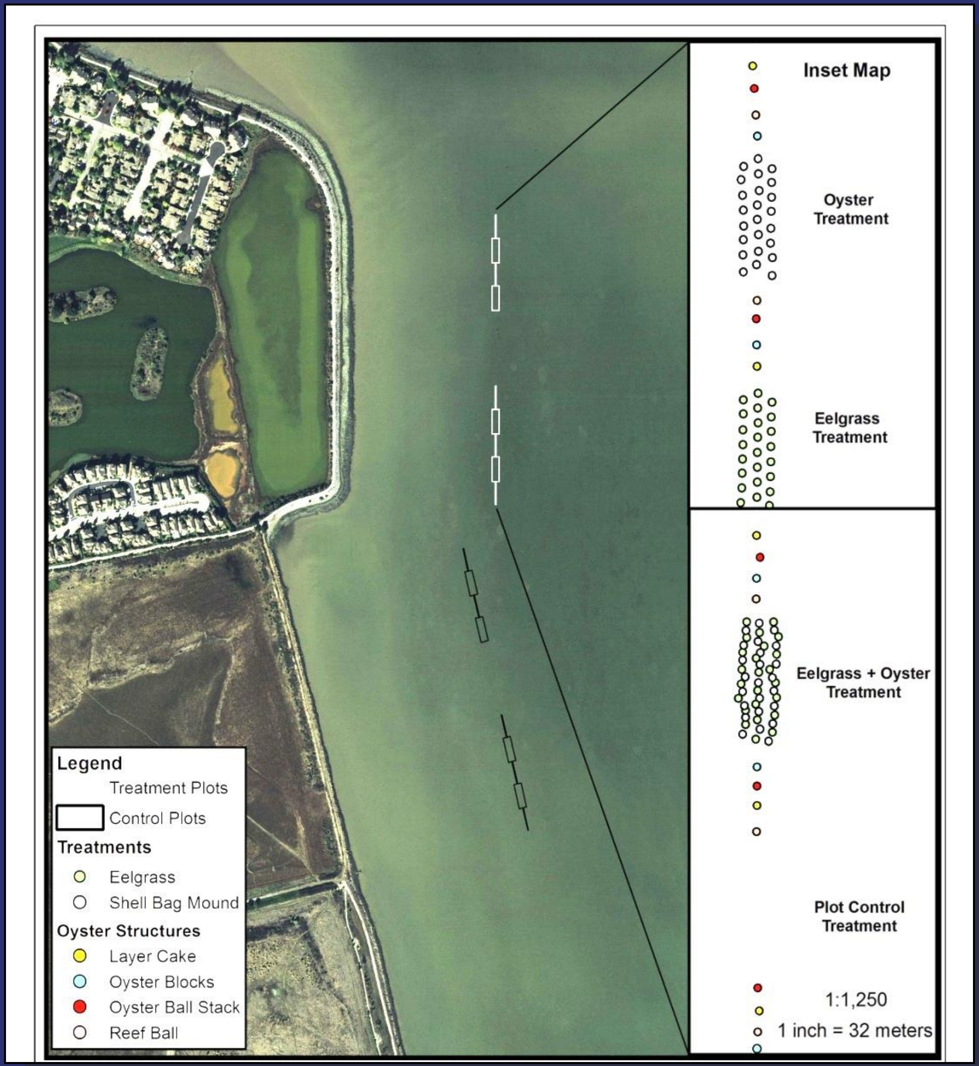
Oyster Blocks



Reef Ball Stacks

Layer Cake

San Rafael (TNC)



Photos, S. Kiriakopolos

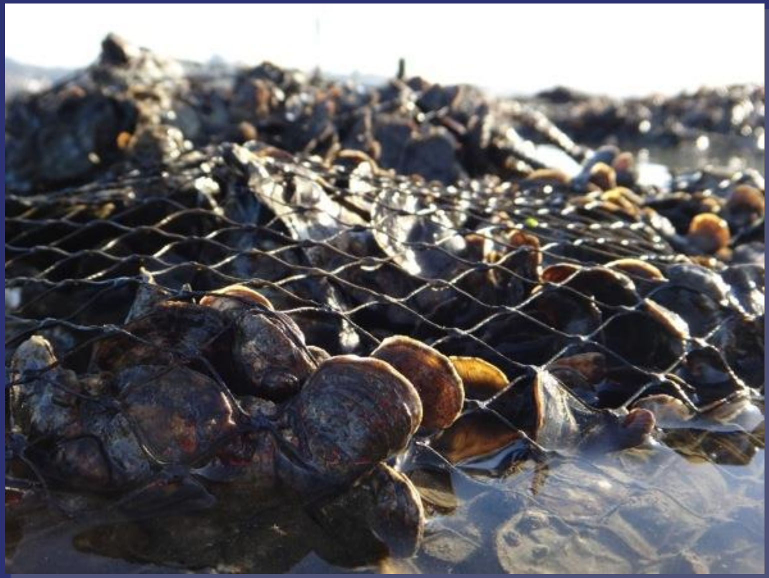
Construction

Construction Prep: Pacific Oyster Shell Bags

Photos, M. Latta

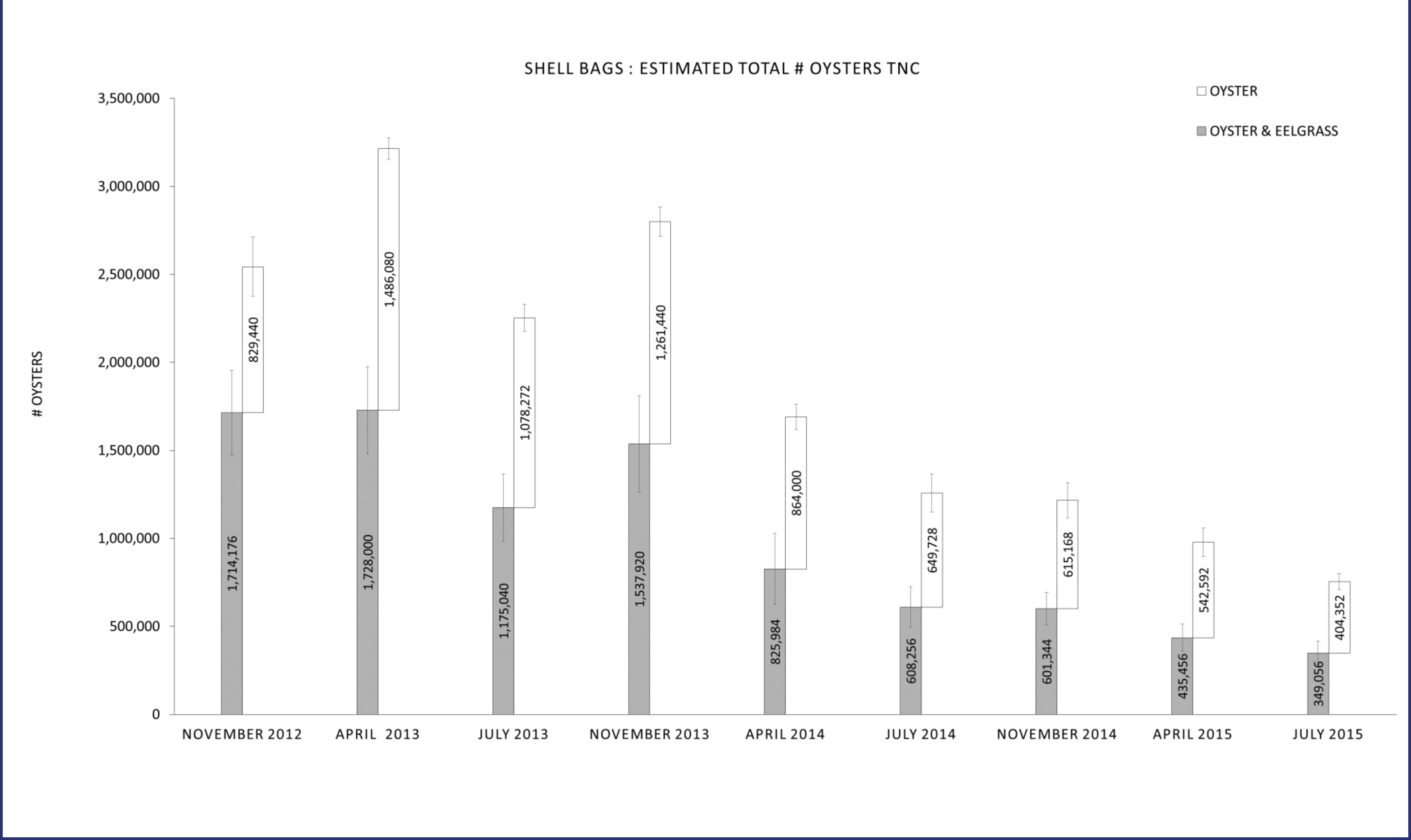
Preliminary results - San Rafael

- **< 3.8 million oysters at height of recruitment**
- **Currently ~750,000 oysters**
  - **Survival rates, annual recruitment fluctuations**
  - **Food resource for many species**

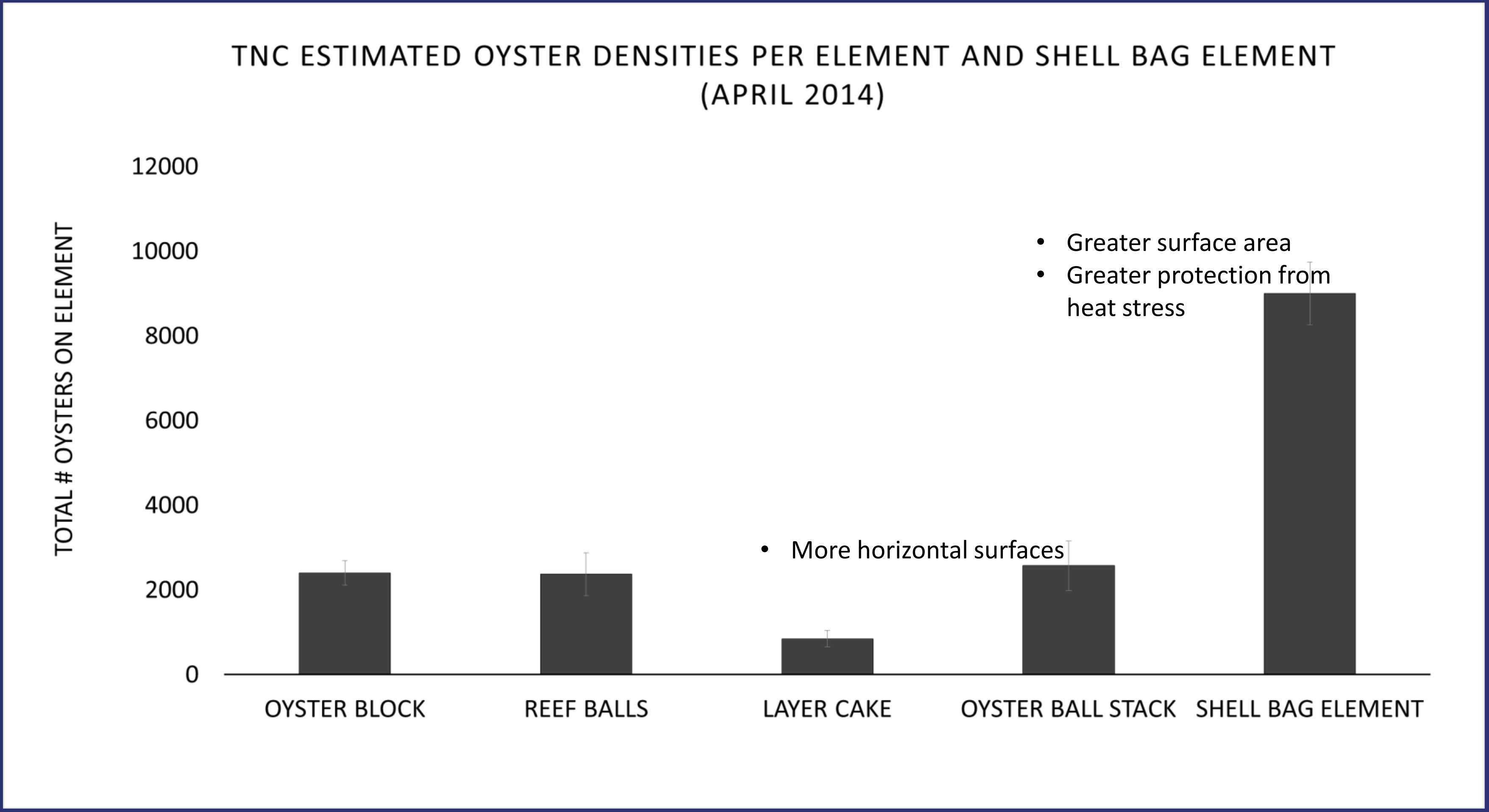


Photos, S. Kiriakopolos

Establishment of oysters

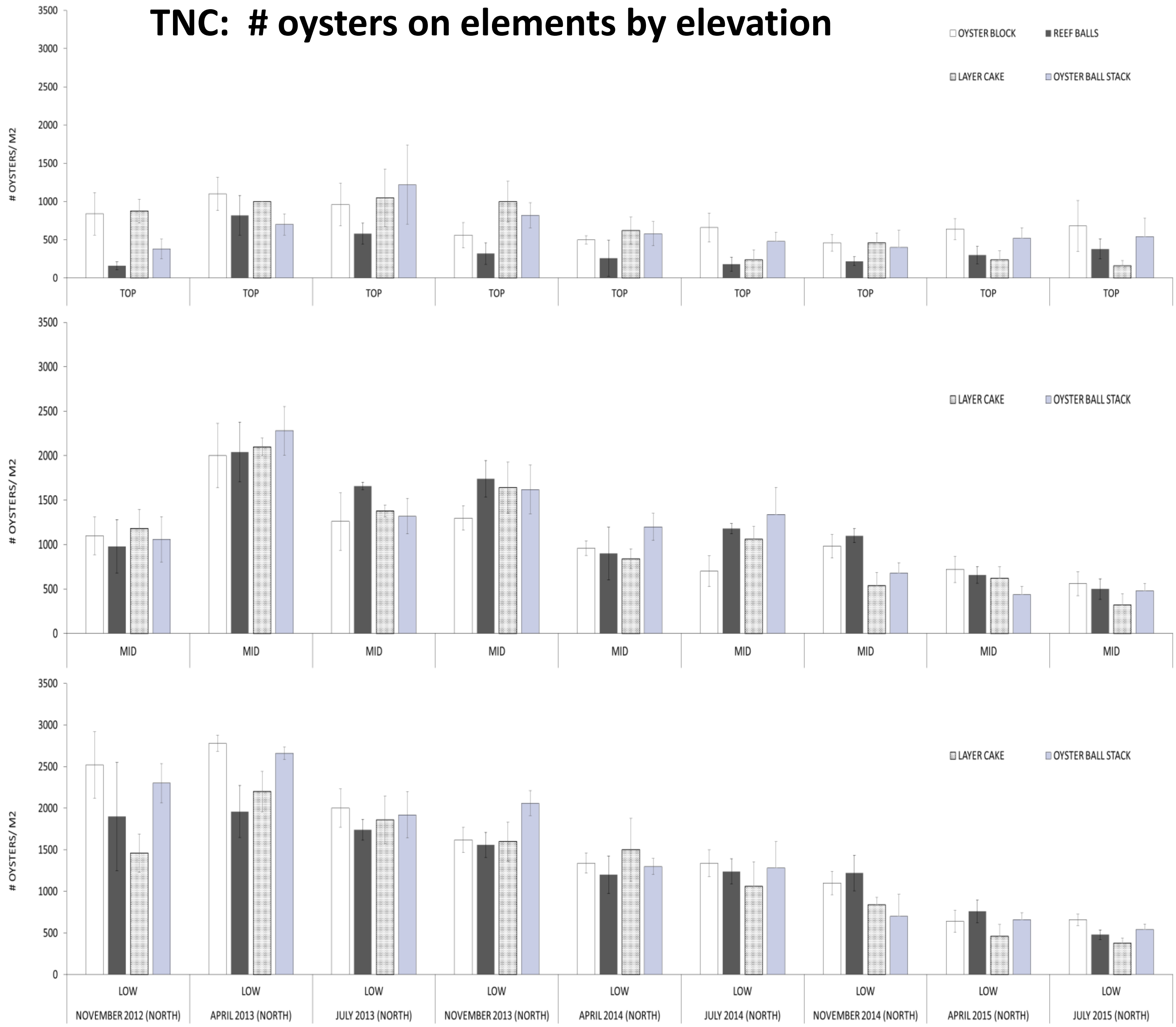


Comparison of treatments

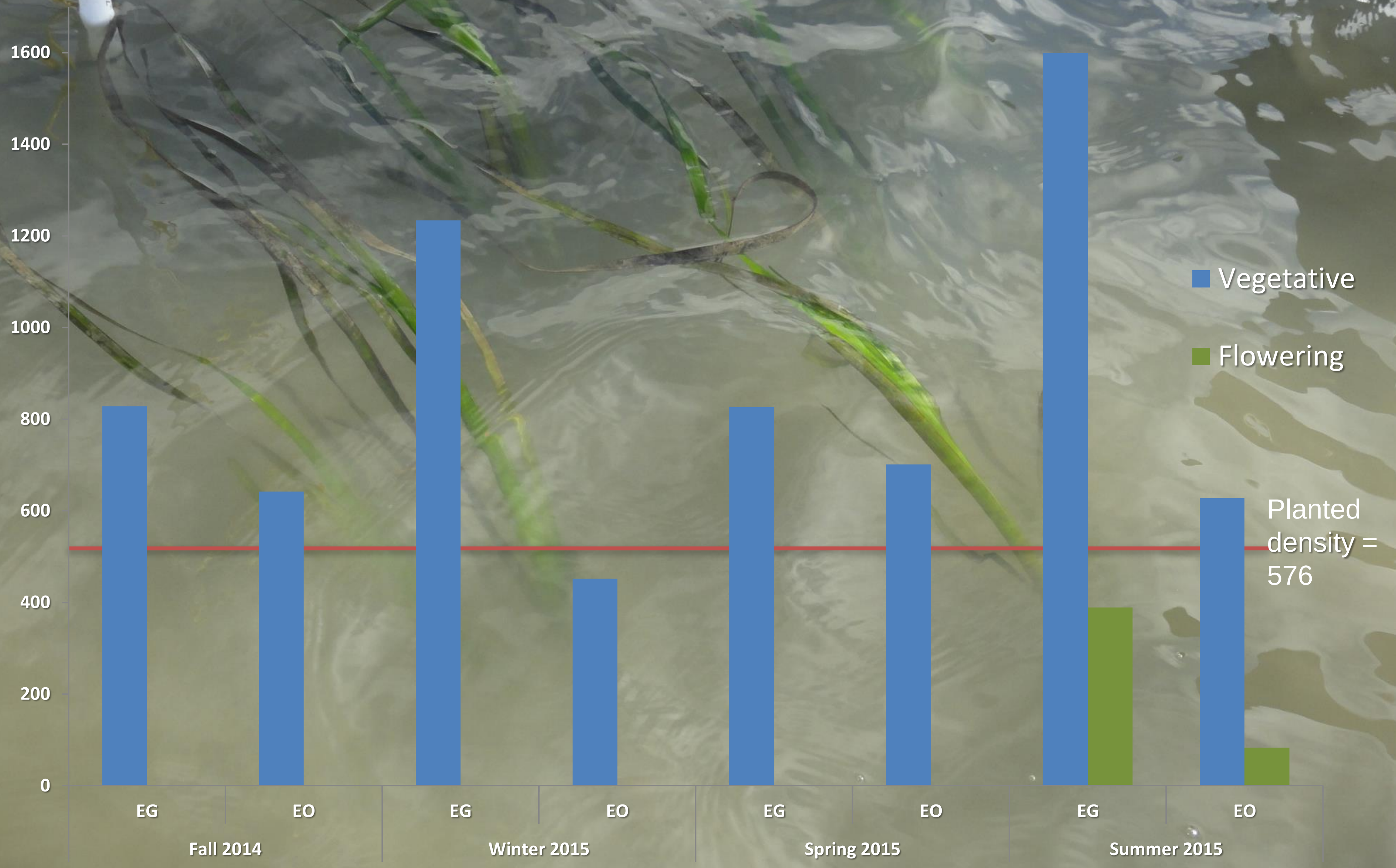


Shell bag units have the most oysters, layer cakes the least

TNC: # oysters on elements by elevation

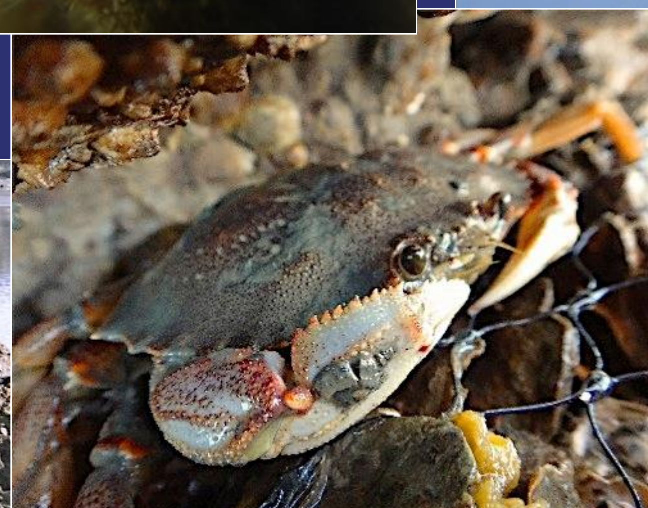


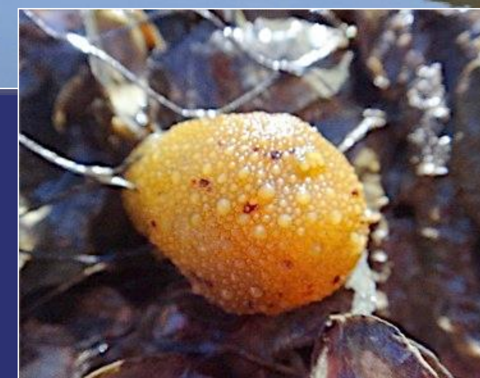
Eelgrass Densities



Preliminary results - San Rafael

So much life out there



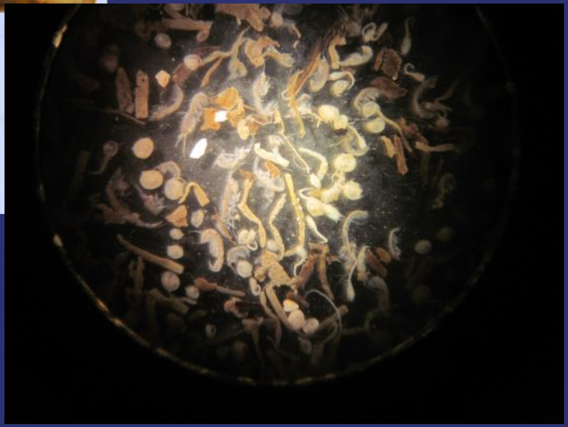


Photos, S. Kiriakopolos

Preliminary results - San Rafael

Native fish and invertebrates associated with physical structure

- Juvenile Dungeness Crabs
- Bay Shrimp
- Red Crabs
- CA Rock Crabs
- Bay Pipefish



White Sturgeon, Leopard sharks, and Steelhead
-- repeat visits to reefs
(acoustic receivers detecting tagged fish)

Photos, S. Kiriakopolos

Preliminary results - San Rafael

Many species reproducing

Gravid shrimp

Oysters brooding

Brooding rates of 25% from year-one oysters

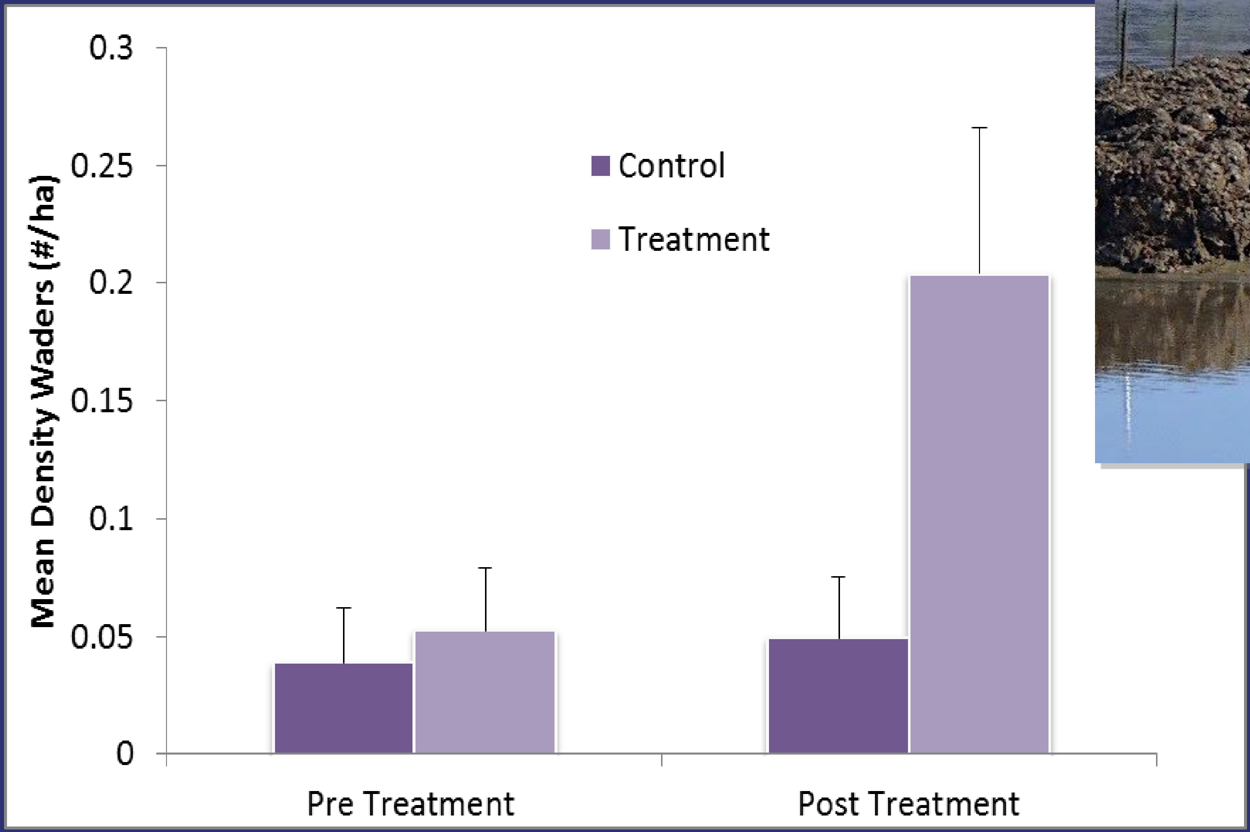
Goby eggs on oyster shell

Nudibranch egg casings

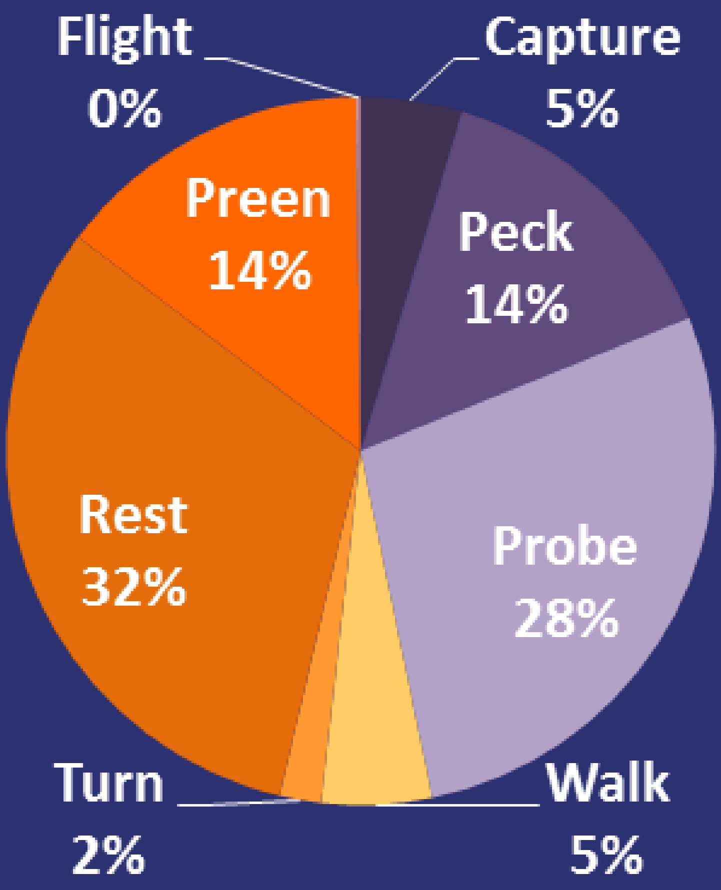
Photos, S. Kiriakopolos

Preliminary results - Birds

- Wading birds and Black Oystercatchers increased significantly
- Suggests increased fish foraging opportunities
- In the sediments: # of unique invertebrate taxa increased, from 14-22 taxa



Black Oystercatcher behavior on TNC reefs



- Mean proportion of time spent in various behaviors
- 47% of time spent in foraging behaviors (shades of purple)

Preliminary results - Physical changes

Total station

15 cm sediment accretion along reefs

Acoustic Doppler Current Profiler

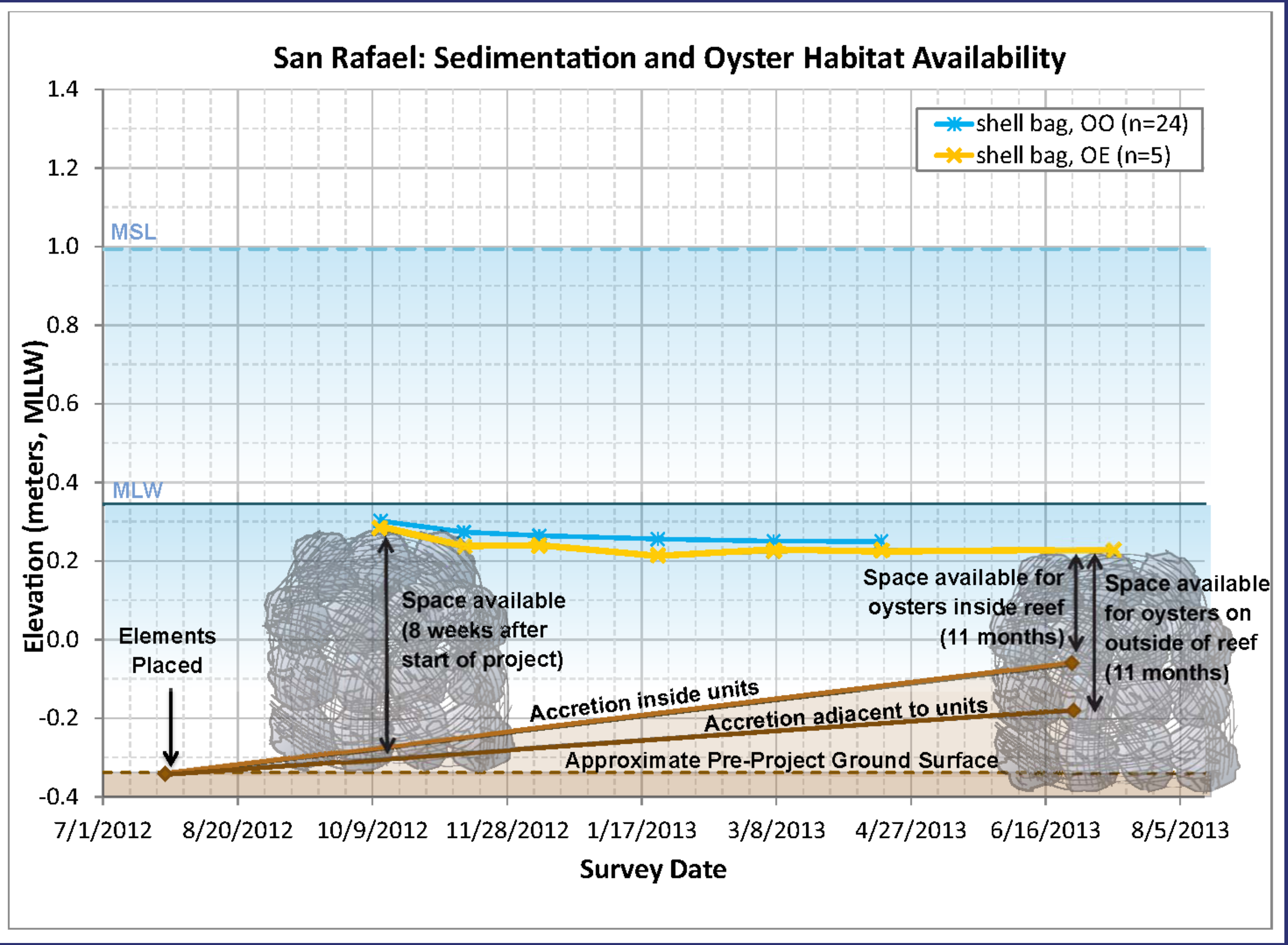
24 cm in center

Wave energy

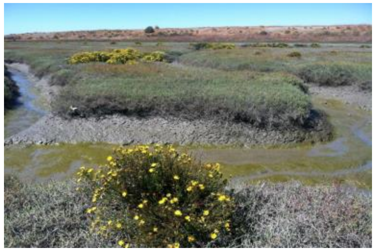
- **most energy lost on broad mudflat**
- **but reef extracts 30-50% more at MSL water levels**

Continuous Ambient WQ

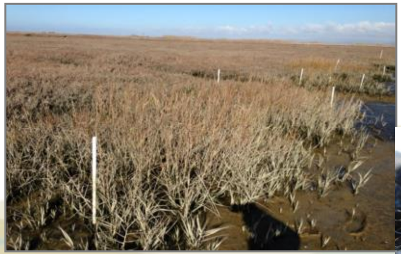
Settlement and Sediment Accretion



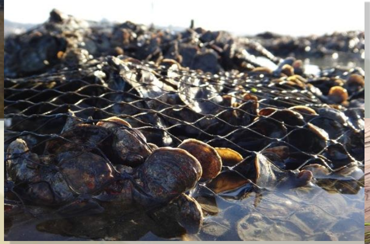
Restore COMPLETE SYSTEMS

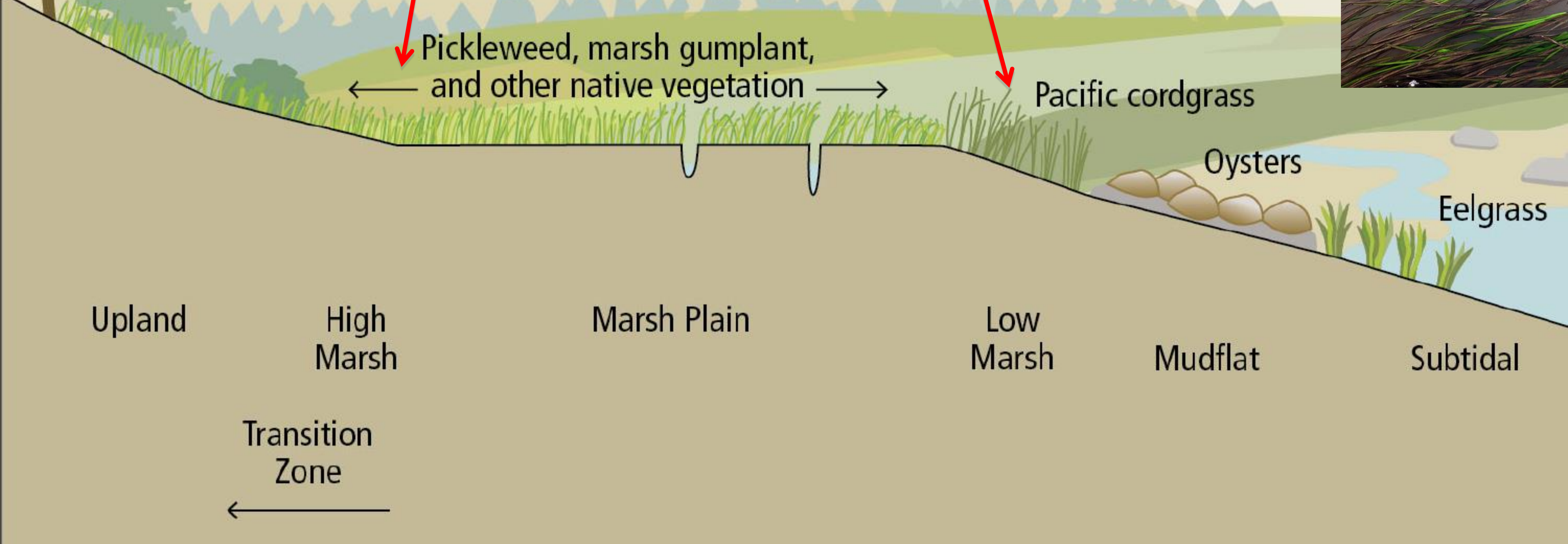


Marsh Gumplant: ***Grindelia stricta***



Pacific cordgrass: ***Spartina foliosa***





Phase Two- Integrated Restoration

Climate Adaptation requires Multi-Objective Approaches

Shoreline Protection with Biological and Physical Goals

Design to address Sea level rise and erosion

Additional Pilot Projects needed – BMP’s and Design Criteria

Increased capacity needed
- **design**
- **permitting**
- **implementation**

Policy changes- bay fill, thoughtful experimentation

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www.sfbaylivingshorelines.org