# Experimental Climate Adaptation

**Results to Date from Pilot Projects:**
**Active Tidal Marsh Revegetation, High Tide Refuge Island Construction, and Living Shoreline Reefs**


Coastal Conservancy

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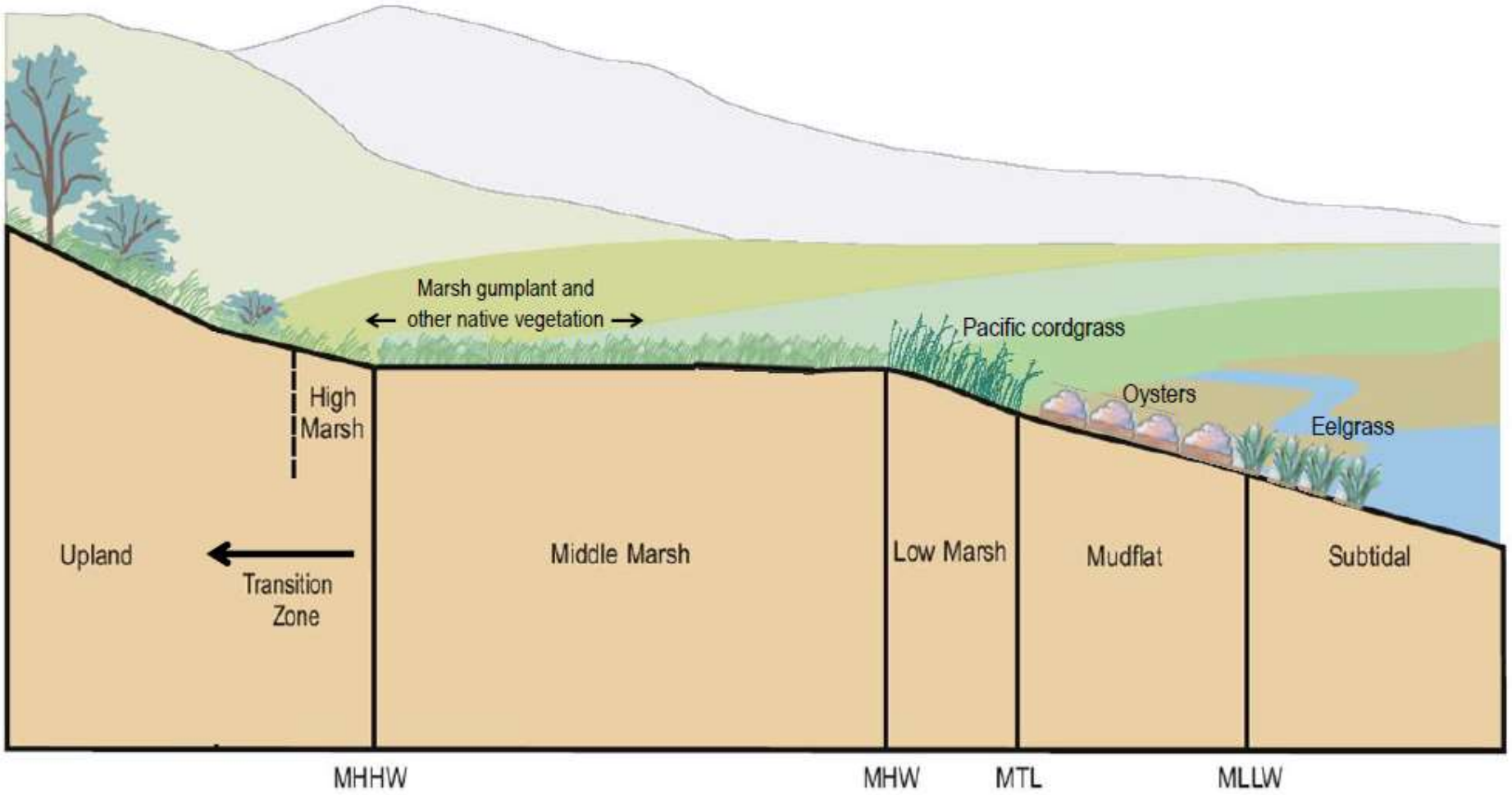
**California State Coastal Conservancy**



Bay Delta Conference
October 29, 2014
Sacramento, CA

# Complete tidal wetland system



# BEHGU Regional 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.




**Invasive Spartina Project**

- Focus on Ridgway's Rail
- Active tidal marsh plantings
- High Tide Refuge Islands

**SF Bay Living Shorelines Project**

- Intertidal and subtidal connectivity
- Oysters and eelgrass
- Biological and physical goals

## Cordgrass and Marsh gumplant
## *Spartina foliosa and Grindelia stricta*

- Builds habitat, traps sediments
- Food chain- seed and detrital food resources
- Foraging and breeding - Ridgway's Rail, others species

## Native Olympia Oysters:
## *Ostrea lurida*

- Heterogeneity = increased niche space
- Food source for other invertebrates, birds, fish
- Reproductive and physical structure

## Eelgrass:
## *Zostera marina*

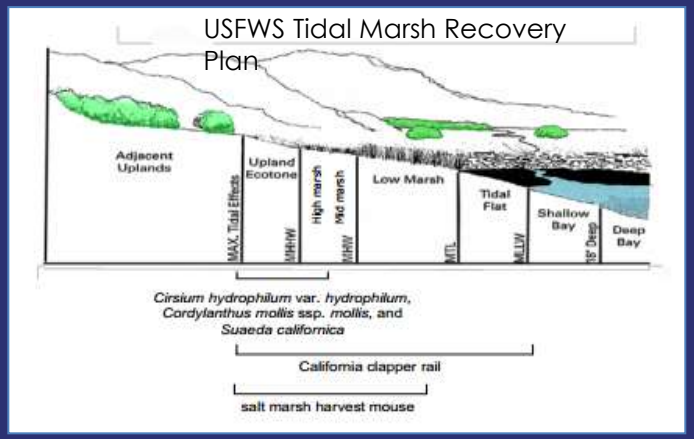
- Traps sediments, reduces erosion, sequesters carbon
- Builds habitat: epifauna, infauna, fish (e.g., pipefish)
- Foraging area for birds & marine mammals

| 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 |

# Active Revegetation and High Tide Islands

# ISP Restoration Approach

- Rapidly establish habitat features
- Reintroduce Spartina foliosa
- Greatest impacts of invasion and subsequent treatment -- Central and South Bay marshes
- Increase features in young restoration marshes
- Climate change stressors- sea level rise, erosion




Mowry Marsh

Novato Bayfront

Faber Marsh

# Revegetation Sites

## 2011-2015: 34 Sites

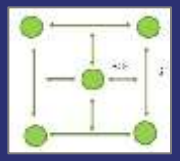
**Nursery propagation February- December**

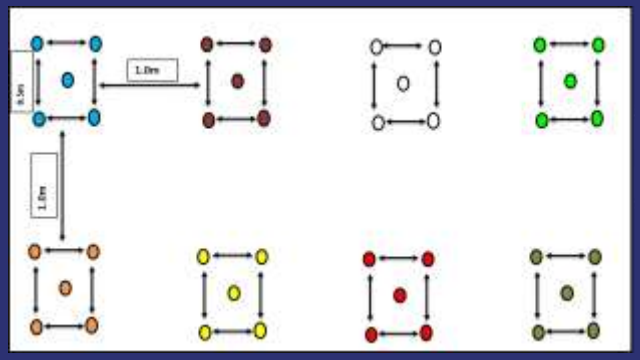
**Raised Beds- Amplify donor material**

**Large containers- establish structure quickly**

The Watershed Nursery Pt Richmond

## 2013-2014 Planting Design



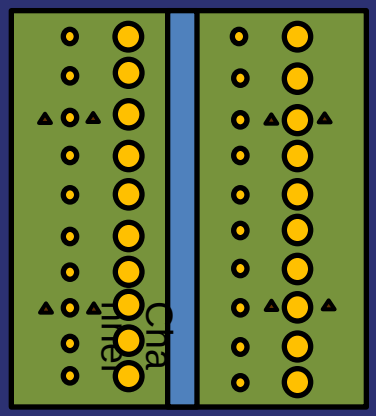


### *Spartina foliosa*

- Five plugs – basic planting unit
- Multiple sources
- Treatments – cages, source, habitat type, elevation, plug size, planting technique…

### *Grindelia stricta*

- High density plantings – 20 plants per patch
- Treatments – pot size, salt hardening…




# Alameda Flood Control Channel


**% Survivorship:**

**Year 1 *G. stricta* = 38%**

***S. foliosa* = 67%**

**Year 2 *G. stricta* = 75%**

***S. foliosa* = 66%**

Alameda Flood
Control Channel

# Hayward Shoreline Complex

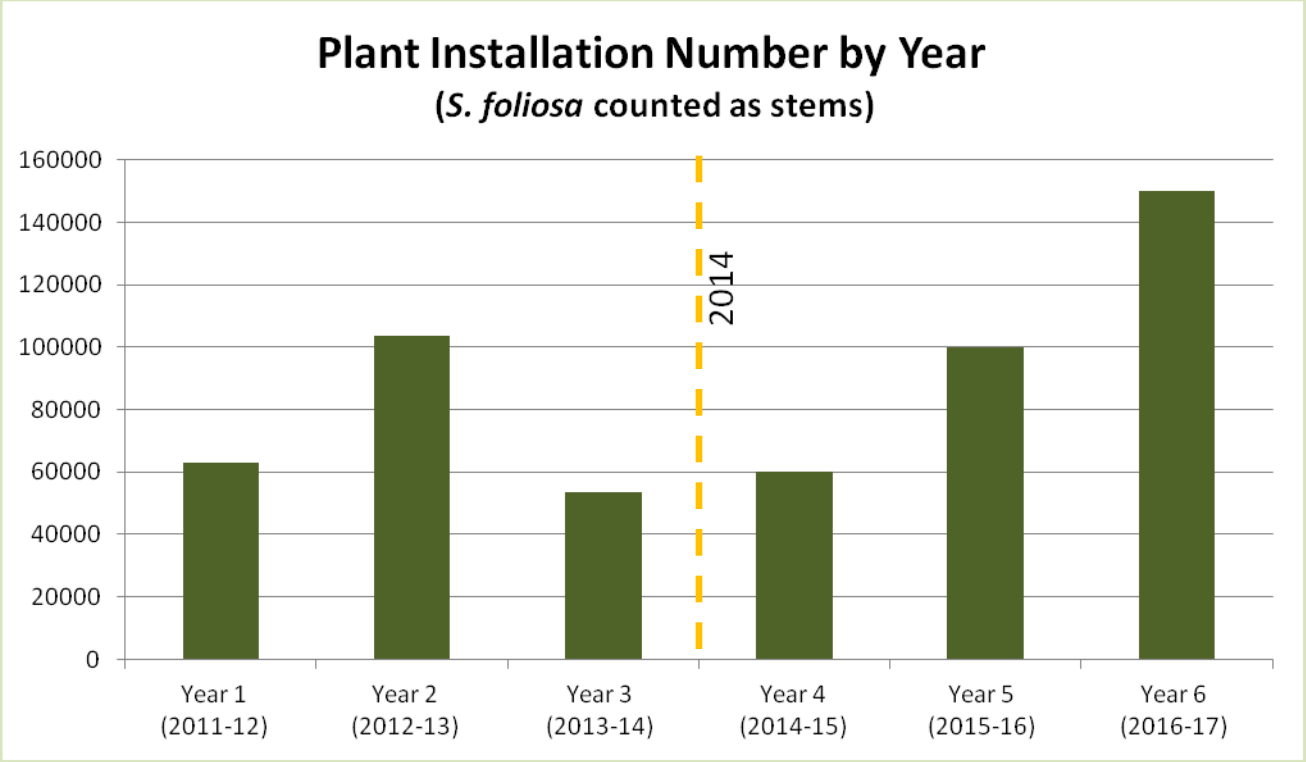

**% Survivorship:**

**Year 1 *G. stricta* = 60-62%**

**Year 2 *G. stricta* = 55-64%**

**Upland Tran. Zone = 43%**

# Plant Installation Numbers




*Total Installed to Date: ~ 240,000*

*Expected Total After Year 6: 500,000+*

# Need for High Tide Refugia

## Historical Marsh

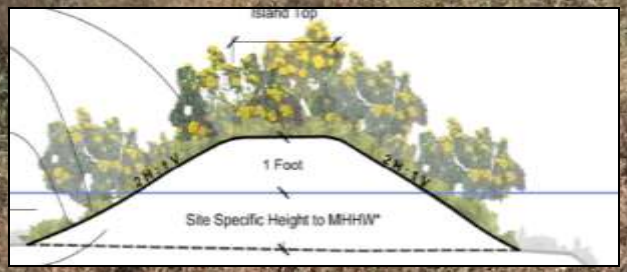
Laumeister Marsh
(Palo Alto Baylands Nature Preserve)

Gumplant

Photo credit: pahavit.livejournal.com

## Restored Marsh

Cooley Landing Marsh
(Ravenswood Regional Open Space Preserve)



# Conceptual Design

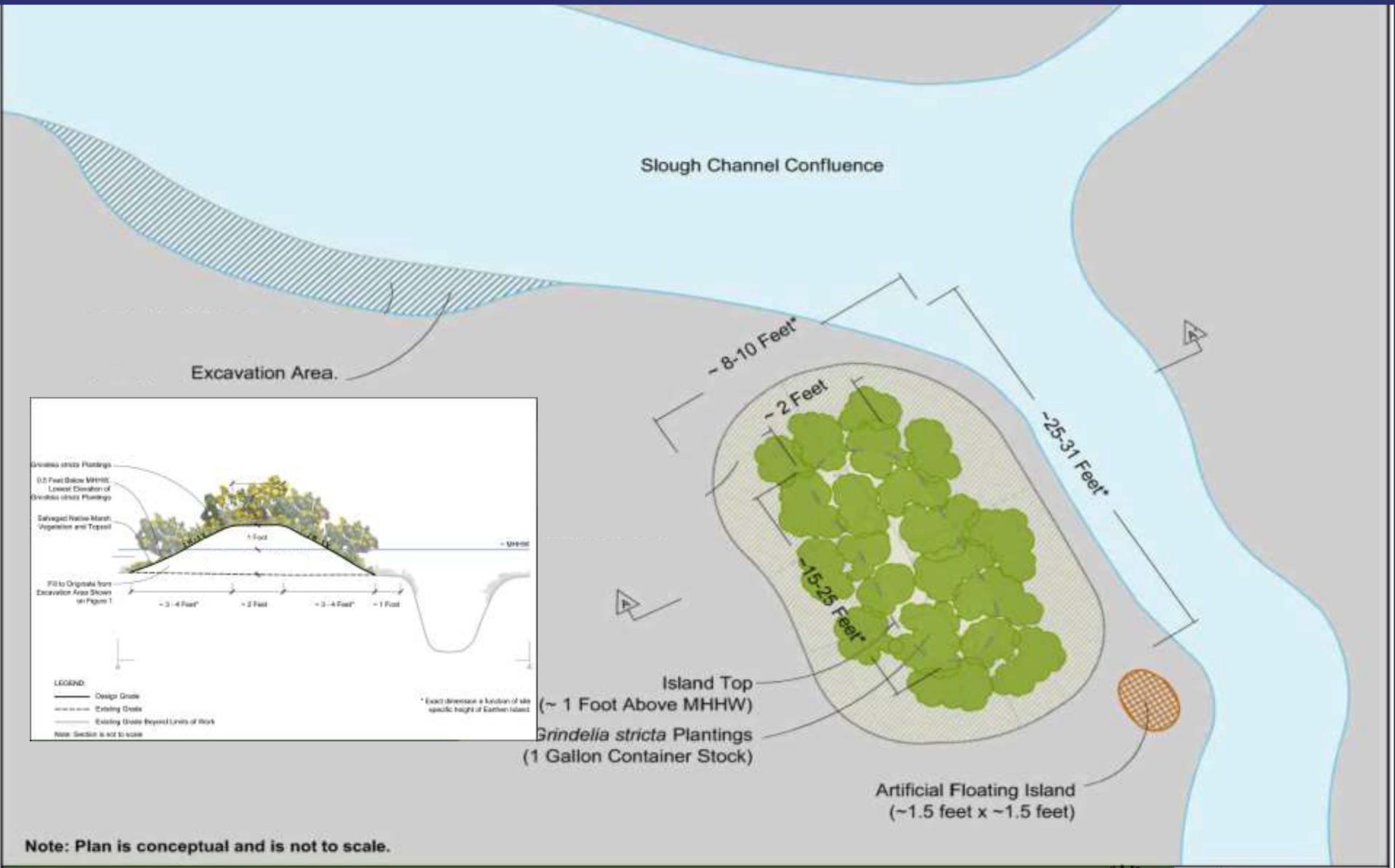



**Figure 1: Typical Plan View**
Earthen Refugial Island Conceptual Plan

San Francisco Estuary Invasive Spartina Project

# Construction

## Marsh Protection, Sod Removal

# Monitoring

**Topography**

- Earthen island profile
- Excavation area depth



**Vegetation**

- Gumplant height
- Gumplant survival

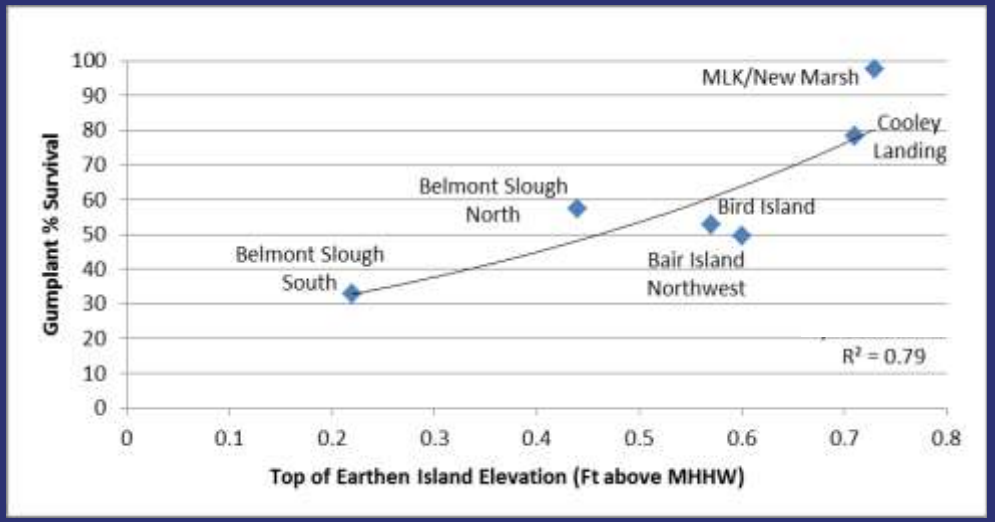
**Soil (after 5 months only)**

- pH
- Salinity

**Ridgway Rail Response (after 2-3 years)**

- **planning underway**

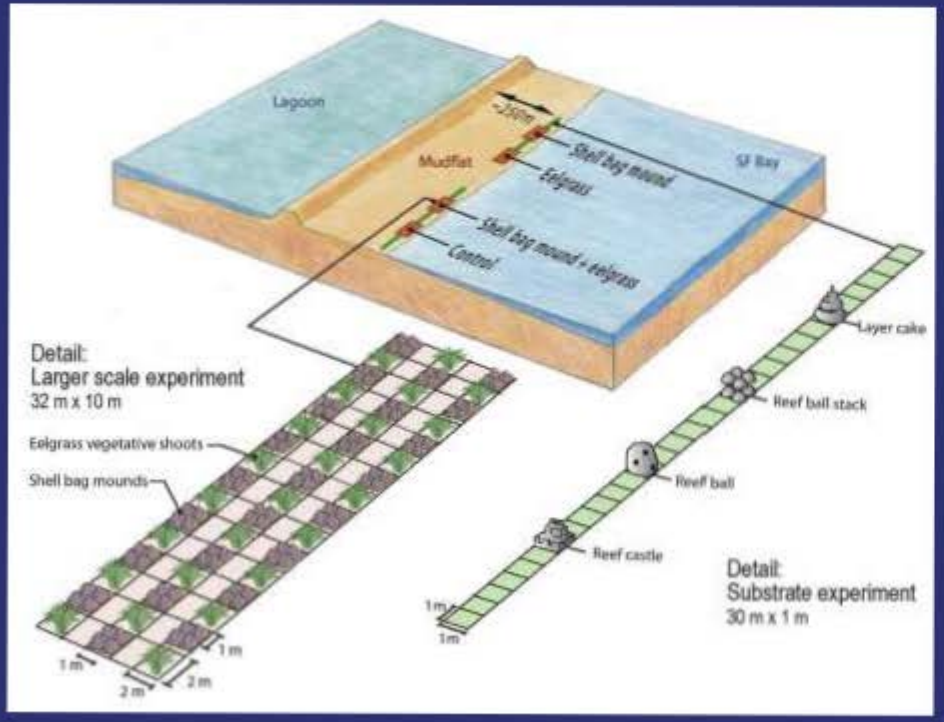
**Gumplant survival varied with elevation**

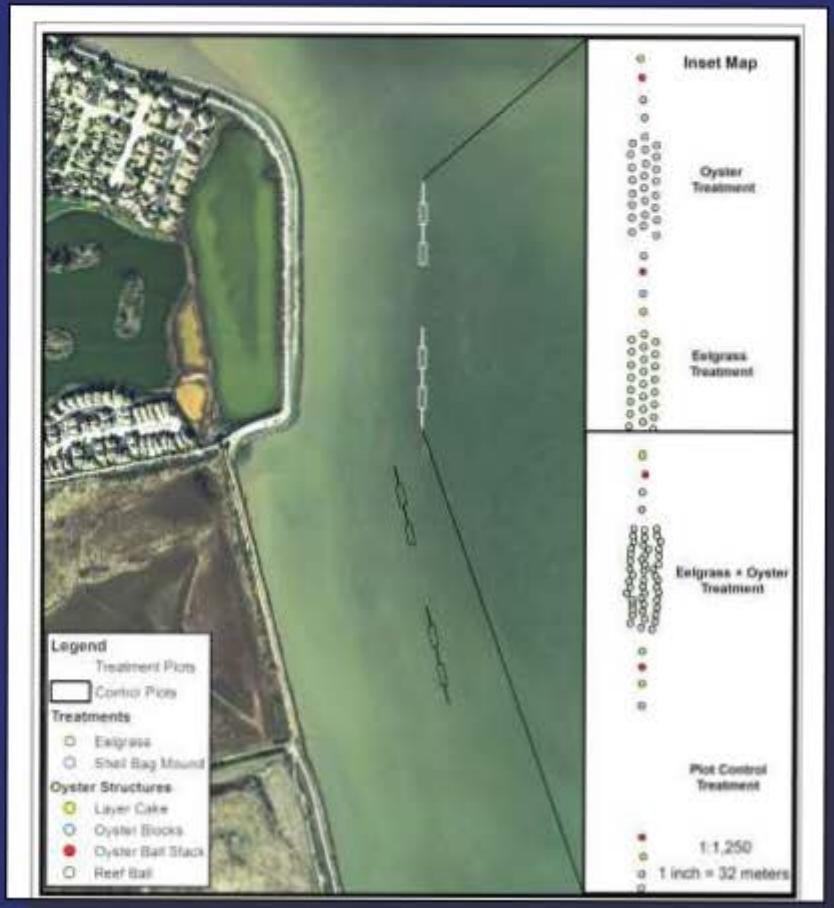


# Monitoring

| | Dec 2012 | May 2013 | Sept -Oct 2013 |
|---|---|---|---|
| Cooley Landing |  |  |  |
| Bair Island |  |  |  |
| MLK/ New Marsh |  |  |  |

# SF Bay Living Shorelines Project


Lagoon
Mudflat
SF Bay
~250m
Shell bag mound
Eelgrass
Shell bag mound + eelgrass
Control
Detail:
Larger scale experiment
32 m x 10 m
Eelgrass vegetative shoots
Shell bag mounds
1 m
1 m
2 m
2 m
Layer cake
Reef ball stack
Reef ball
Reef castle
1m
1m
Detail:
Substrate experiment
30 m x 1 m


Inset Map
Oyster Treatment
Eelgrass Treatment
Eelgrass + Oyster Treatment
Plot Control Treatment
1:1,250
1 inch = 32 meters
Legend
Treatment Plots
Control Plots
Treatments
Eelgrass
Shell Bag Mound
Oyster Structures
Layer Cake
Oyster Blocks
Oyster Ball Stack
Reef Ball

# Native Oyster Settlement Substrates

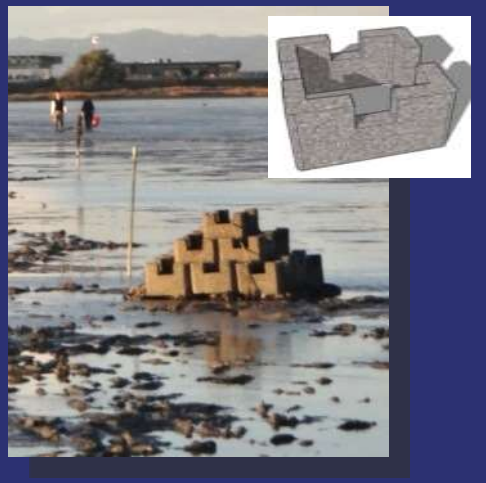
## Large plots: 10 x 32m

### Series of shell bag mounds

## “Baycrete” small scale substrates

### Reef Balls

### Oyster Blocks



### Reef Ball Stacks

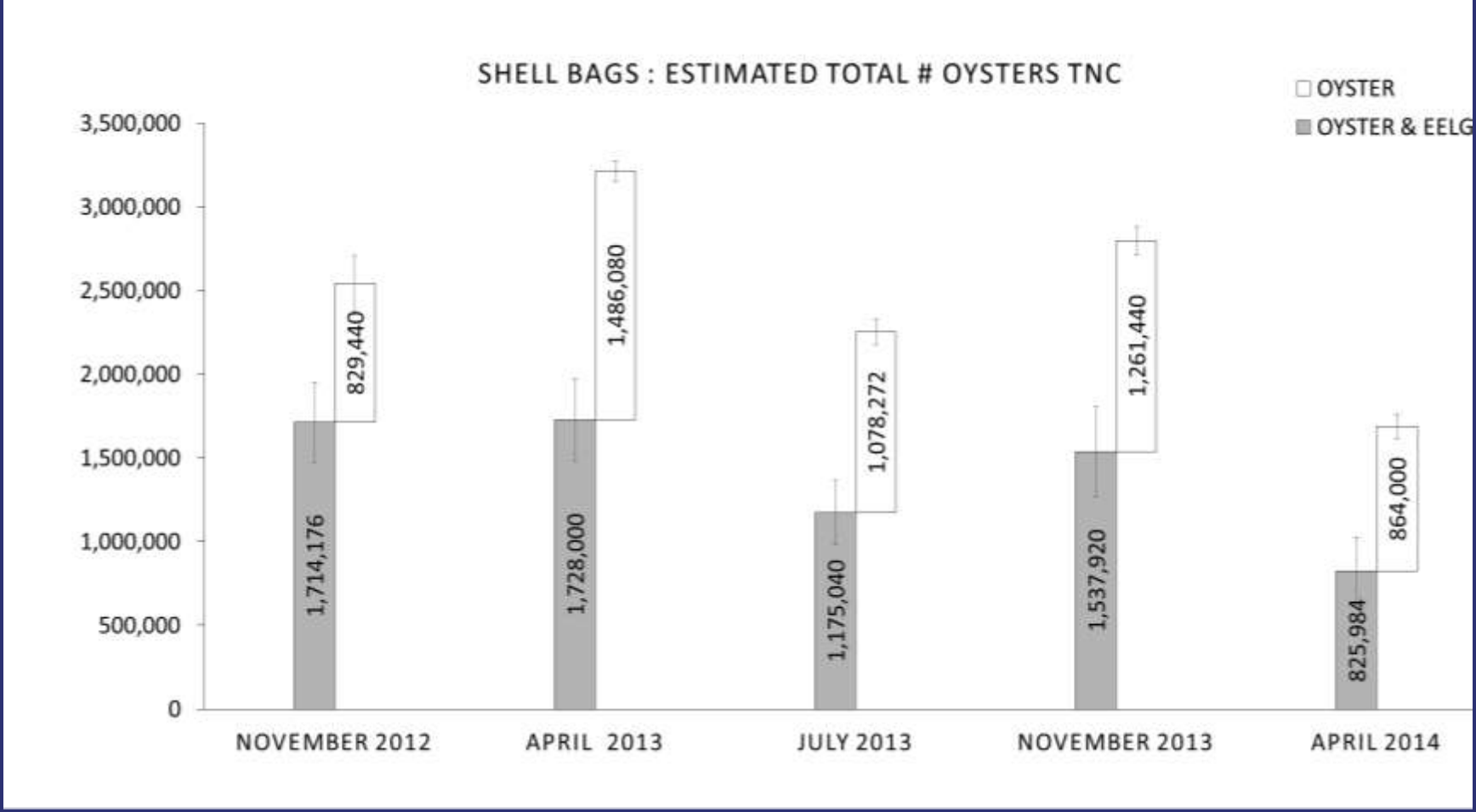
# Construction Summer 2012

# Preliminary results - San Rafael

**In two years, >1.5 million oysters present on shell mounds.**

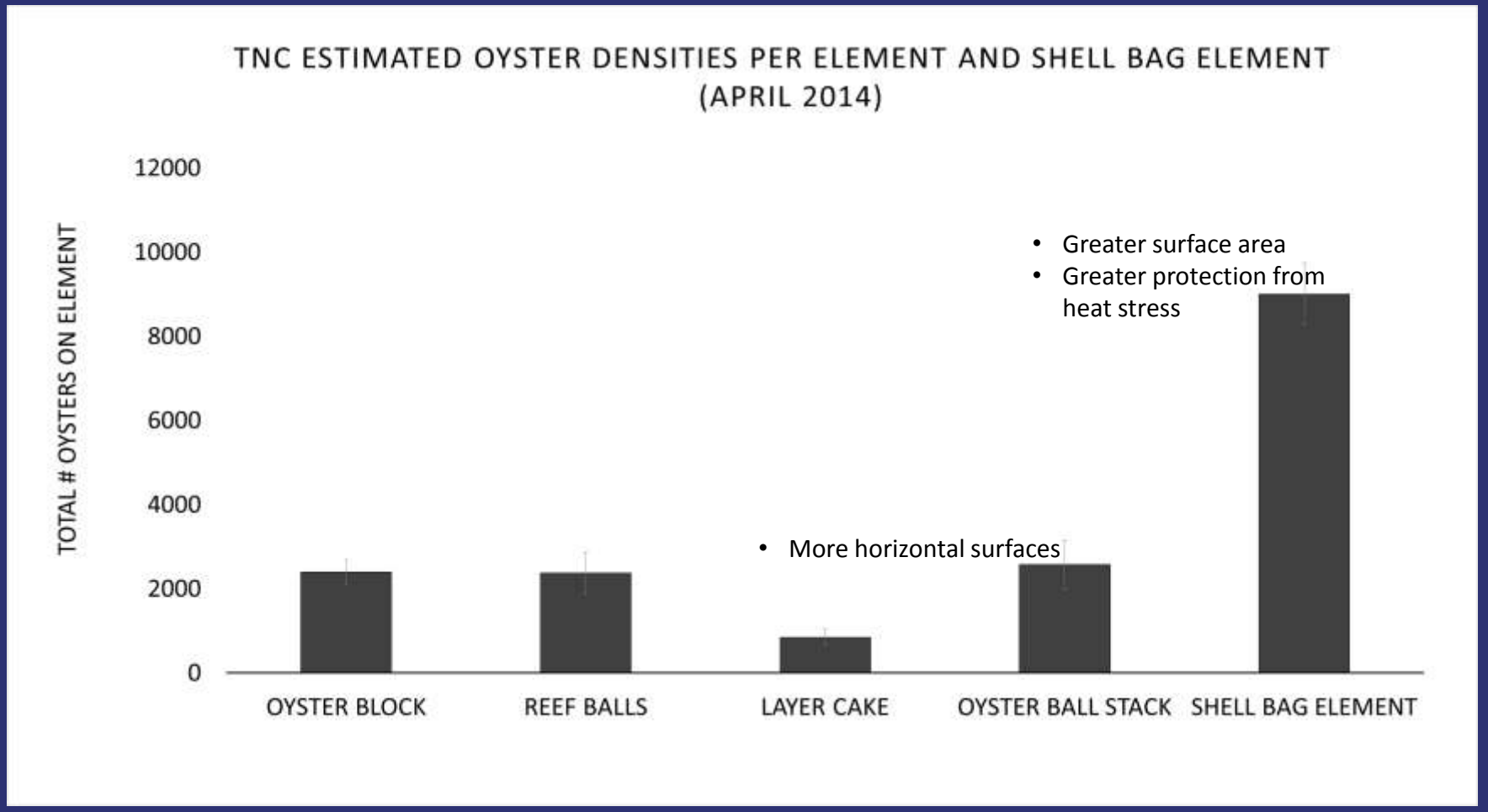
Photos, S. Kiriakopolos

# Establishment of oysters

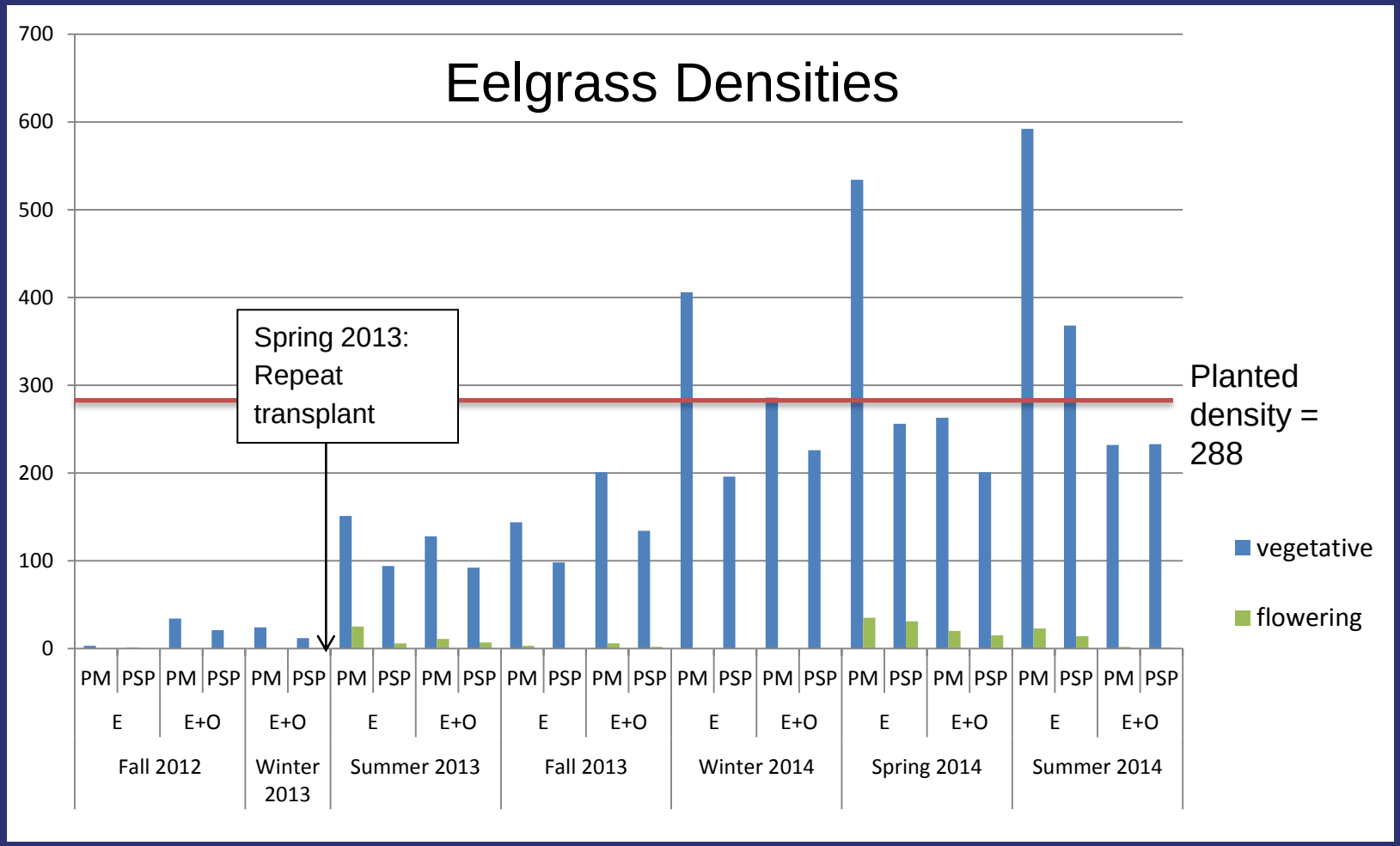



**Estimated population from San Rafael shell bags**

# Comparison of treatments




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




- Eelgrass establishing well – 120% of initial planted density overall
- Eelgrass only plot density higher than Eelgrass + Oyster reef (abrasion?)
- Point Molate donor performing better in Eelgrass plot (donor better matched?)
- Some flowering suggests we'll have seedling recruitment

# 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 and Green Sturgeon, Leopard Sharks, Striped Bass, Chinook Salmon -- extended visits to reefs**
**(acoustic receivers detecting tagged fish)**

Photos, S. Kiriakopolos

# Preliminary results - Physical changes

Total station

**15 cm sediment accretion along reefs**

Acoustic Doppler Current Profiler



Continuous Ambient WQ

**Wave energy**

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

# Climate Adaptation requires Multi-Objective and Multi-Habitat Approaches

- Link to Subtidal and Baylands Habitat Goals Recs
- Pilot scale, experimental approaches
- Design integration of key features
- Evaluate ecosystem functions and services
- Share preliminary results
- Apply lessons learned- keep testing at additional sites

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**www.spartina.org**

**www.sfbaylivingshorelines.org**