Eelgrass (Zostera marina): Critical habitat in estuarine waters

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What are seagrasses?
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- vascular plants
- angiosperms
Clonal Expansion

Seed Dispersal

Photos: C. Pickerell
Seagrasses:
50 species, 12 genera, 2 families
Most beds monospecific, on soft sediment
All species are clonal
All have flexible blades
Some intertidal, some subtidal
Need high water clarity
Seagrass beds

Improve water quality--reduce particle loads
Stabilize sediments
Play a significant role in global carbon and nutrient cycling
Examples of “foundation” or habitat forming species

Sand dune grasses | Giant kelps | Reef corals | Oysters and marsh grasses
---|---|---|---
Sea grasses | Pine trees | Subtidal mussels | Large rain forest trees

“Foundation species” essentially form the basis upon or within which the entire community is built
Edge effects, habitat modification, and facilitation by seagrass

Cores of infauna: polycheates, oligochaetes, amphipods, isopods

Fig. 5. Mean (±) and 95% confidence intervals ($\bar{x} \pm t_{0.05, S}$, vertical line) for number of species per core and number of individuals (L-Tr) per core for the six stations along the transect across a Zostera bed at Sandy Point, July 1972. (L-Tr indicates data were log-transformed [log (x+1)] statistical calculations performed in the transformed space, and back-transformed to the original scale for presentation in figures.)
Threats to seagrass beds

Mechanical damage from boating, fishing

Dredging, filling, shading by structures

Increased nutrient loading

Organic loading--dissolved oxygen reductions

Siltation

Toxic chemicals--oil

Wasting disease

Harvesting
Restoration in other regions has taken many forms.
What will work locally?
Eelgrass, *Zostera marina*

Only seagrass in the soft sediments of San Francisco and nearby bays

Photo: J. Stalker
In San Francisco Bay

Photos: Merkel and Associates
Recent and continuing threats
The potential for eelgrass restoration in SF Bay

(Merkel and Associates 2004)
What do we need to know to successfully restore eelgrass in San Francisco Bay?
Can capitalize on both in restoration

In San Francisco Bay, high flowering rates, at least one annual bed--try seeding techniques!
Spathes continue to develop within detached reproductive shoots (DeCock, 1980)

Flowering shoots often float and can be transported long distances from donor meadows (McRoy, 1968)

This method of dispersal has recently been shown to have the potential to transport seeds up to 34 km (Harwell & Orth, 2002)
Buoy-deployed seeding, aka “seed buoys” (Pickerell et al. 2005)

Photos: J. Stalker
Buoy Deployed Seeding (BuDS)
Initial questions:

Is seeding a viable option for San Francisco Bay eelgrass restoration?

Where should we get the seed? (Are all donor beds equally good choices for flower collection?)

How do we choose appropriate restoration sites? (location in bay, sediments, etc.)
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Is seeding a viable option for San Francisco Bay eelgrass restoration?
Mesocosm and field experiments

Where should we get the seed? (Are all donor beds equally good choices for flower collection?)
Field surveys, mesocosms and field experiments

How do we choose appropriate restoration sites? (location in bay, sediments, etc.)
Sediment inoculation experiment, sediment texture experiment, field experiment
Donor site selection:

Perennial: Point Molate and Bay Farm Island

Annual: Crown Beach

March

August
Mesocosms
Donors:
Pt. Molate
Crown Beach
Bay Farm Island

Technique: Seed Buoys

Additional treatment:
Inoculation with donor bed sediment

Replication: 3 mesocosms w/ one buoy each

Total seed buoys (mesocosms) in experiment:
$3 \times 2 \times 3 = 18$
Mesocosms
Donors:
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Mesocosm Recruitment

Point Molate

Bay Farm Island

Crown Beach
- control
- inoculated

Shoots per mesocosm

Dates: 3/1, 4/1, 5/1, 6/1, 7/1, 8/1, 9/1, 10/1
Mesocosm experiment lessons:

Seed bag technique worked

All donor seed sources resulted in seedlings

Inoculation of sand with donor-site sediments may aid restoration at sandy sites

Seedlings maintained levels of genetic diversity found in donor populations (Sarah Cohen and Brian Ort)
Mesocosm experiment lessons:

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*How about in a more natural setting?*
Field trials of eelgrass restoration techniques

Donors:
Pt. San Pablo
Keller Beach
Crown Beach

Restoration sites:
Marin Rod and Gun Club
Marin Country Day School
Richardson Bay (Audubon)

Techniques:
Seed Buoys
TERFS
broadcast seeding
Donor site selection and monitoring of flowering phenology

Perennial:
Point San Pablo

Annual:
Crown Beach
April

Keller Beach
August

Photos: K. Boyer
Two seeding techniques:
Bouy-deployed seeding
Hand broadcasting
Vegetative shoot transplants with modified TERFS*

*Transplanting Eelgrass Remotely with Frames System
™University of New Hampshire, Short et al. 2002
<table>
<thead>
<tr>
<th>Donor</th>
<th>Marin Rod and Gun Club</th>
<th>Marin Country Day School</th>
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<tbody>
<tr>
<td>Crown Beach</td>
<td>117</td>
<td>458</td>
</tr>
<tr>
<td>Keller Beach</td>
<td>639</td>
<td>1610</td>
</tr>
<tr>
<td>Point San Pablo</td>
<td>581</td>
<td>2567</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>1337</strong></td>
<td><strong>4635</strong></td>
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Lessons from Experimental Restoration studies

Seed buoy technique worked in mesocosms and in field at two sites (far exceeded success of TERFS and broadcast seeding)—experimental restoration instead of trial and error.

Seedlings from perennial and annual donors recruited—annual more successful in mesocosms but not in field—sediment effects?

Genetic diversity of donors maintained by BuDs technique.
How about Tomales Bay?
Eelgrass coverage from California Department of Fish and Game surveys in 1992, 2001, and 2002.

W = Walker Creek
B = Big Tree Cove
C = Cypress Grove
M = Marconi Cove
TN = Tomasini Cove North
T = Tomasini Cove
$r^2 = 0.57$
$p < 0.0001$
What is the role of varying densities of *Gracilaria* on eelgrass in Tomales Bay?

Field experiment with cages to enclose/excose algae:
- Control (no manipulation of algae)
- 0 g algae (removal)
- 325 g algae (average found in surveys)
- 1700 g algae (average maximum across surveyed sites)
Tomales Bay—pristine?

Nutrients, mercury, pathogens

Macroalgae seems to be increasing—Due to nutrients?

Macroalgae at high densities has negative impacts on eelgrass—suggest watching water quality closely

Restoration lessons from SF Bay? need to test techniques in other locations
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