Eelgrass restoration in San Francisco Bay: a primer

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Eelgrass – why restore?

Global distribution
Losses in many regions

Eelgrass, *Zostera marina*
Eelgrass – why restore?

Losses of associated fauna

Foundational habitat

Juvenile Dungeness crab

Pacific herring eggs

Bay pipefish

Photos, S. Kiriakopolos
Eelgrass – why restore?

Losses of services, including:

- Sediment stabilization
- Uptake of nutrients
- Uptake of CO₂
- C sequestration in sediments
- Localized increase in pH (countering acidification)
Historic and ongoing impacts in San Francisco Bay

- Marina development
- Mooring scars
- Construction and shading from overwater structures
- Oil spills
San Francisco Bay Subtidal Habitats
Submerged Aquatic Vegetation

- Eelgrass (Zostera marina)
- Sago pondweed (Stuckenia pectinata)
- Widgeon grass (Ruppia maritima)

Merkel 2003, 2009
Boyer and Kirlakopolos 2010
NOAA 2006, 2009

23,440 acres of predicted eelgrass habitat
2800 acres

Order of magnitude more eelgrass possible?

Merkel and Associates 2005, 2014
Goals and motivations

2010 baywide goal:
8000 acres of restoration in 50 years

Mitigate Cosco Busan oil spill:
36 acres in 9 years, starting 2014

Recent shift in motivation: contribute to shoreline protection / ameliorate ocean acidification
Funding

Bond funding through Coastal Conservancy
NOAA Restoration Program / NMFS
Cosco Busan oil spill responsible parties / NFWF
PGE settlement with Herring Fisherman’s Association
Ocean Protection Council / Prop 1
Measure AA / Restoration Authority
Restoration – how do we do it?

First: site selection

Start with biophysical model

New effort to update model: collaboration with CA Audubon and Merkel & Associates

Merkel and Associates 2005
Restoration – how do we do it?

Then, test plots critical: start small, scale up
**Restoration – how do we do it?**

Can capitalize on two reproductive modes

- **Clonal Expansion**
- **Seed Dispersal**

**Use transplants?** Adult plants less vulnerable than seeds/seedlings, instant restored bed

**Use seeds?** Enhanced genetic diversity and possibly resiliency, minimal damage to donor beds
Restoration – how do we do it?

Two transplant methods work well: mostly logistics

Bamboo stake transplants

Paper stick transplants

Direction of ephemeral flow
Top of bank represents CDFG boundary
Direction of ephemeral flow

Photos, S. Kiriakopulos
Restoration – how do we do it?

Seeding can be valuable, but we now do after we test the site by transplanting.
Restoration – how do we do it?

Donor material: mix or match?

Genotypic or allelic richness = resiliency to stress, other functions (e.g., Hughes and Stachowicz 2009, Reynolds et al. 2012)

Significant genetic structure: 5 beds genetically distinct from each other (Ort et al. 2012, 2014)
Restoration – how do we do it?

2015 COSCO BUSAN DARP 0.5-ACRE EELGRASS PLOTS

BAMBOO STAKES

|------------|-------------------------|------------|----------------|-------------|------------|

PAPER STICK ANCHOR UNITS

RESERVED AREA FOR SEED BUOYS IF BAREFOOT PLOTS ARE SUCCESSFUL

Merkel & Associates and Boyer Lab

Pt. Molate

Richardson Bay

Bareroot plots are successful

How do we do it?
Restoration – how do we do it?

Preliminary support for matching donor and site
Local plants sometimes establish best
But finding that mixing hedges bets

Merkel & Associates and Boyer Lab
Monitoring – what works best?

Interferometric sidescan sonar, coupled with density and qualitative measures

Marin Rod and Gun Club, San Rafael, October 2016

Example of "clipped" blades due to bird herbivory

Herring eggs on restored eelgrass at Richardson Bay (Dec. 2018)
Defining success

Eelgrass present and expanding clonally
Self-seeding
Resilient to disturbances

But...not expected in all years
Complications: interannual variation and climate change

Greatest rainfall on record in winter 2016/17
Plants damaged, but recovering
Restoration takes sustained effort

2017: salinity ~10 ppt for 4 mo

Loss of oysters, eelgrass, and other associated species
Complications: interannual variation and climate change

Also, increased frequency of heat waves

Reduced survival of eelgrass transplants in summer 2019
Expecting and planning for climate variability

- Identify refuges that limit salinity or heat stress
- Distribute projects to hedge bets
- Adjust timing
Experiment and monitor to learn

- Sustain effort
- Test sites and scale up
- Communicate results
- Update goals and expectations
Thank you!

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