principles for large-scale restoration?
#1 The Delta has been transformed over a period of 150 years

Atwater et al. (1979)

[Map showing the transformation of the Delta over time]

[Graphs showing population changes of different species over time]

Don’t expect quick fixes
#1 The Delta has been transformed over a period of 150 years

Most of us won’t be alive when we’re done restoring the Great Lakes … Karen Rodriguez (yesterday)

Trajectories of change will be decadal … Chris Enright (yesterday)

Don’t expect quick fixes
#2 The Delta is a hyper-disturbed ecosystem

**BOLD** actions are required
#2 The Delta is a hyper-disturbed ecosystem

We know enough ... proceed boldly ... Chris Enright (yesterday)

BOLD actions are required
#3 The Delta is a low-productivity ecosystem

Primary Production (g C/m²·y)

0  200  400  600  800

113 Estuaries

South San Francisco Bay

Sacramento-San Joaquin Delta

10th percentile

Recognize constraints on the outcomes of restoration actions
Ecosystem productivity is determined by habitat connectivity

Include connectivity in restoration design

Cloern (2007)
Ecosystem productivity is determined by habitat connectivity

Connectivity is critical … John Wiens (yesterday)

Yolo bypass is a food bank … Ted Sommer (yesterday)

Include connectivity in restoration design
#5 Ecosystems always surprise us

Expect unexpected outcomes; monitor and adapt
Expect surprises … John Wiens (yesterday)

Expect unexpected outcomes; monitor and adapt
The Delta is highly enriched in N and P

9 of 8000 samples   N limited

9 of 6000 samples   P limited

Jassby et al. (2002)

Nutrient reductions might be necessary
#7 The Bay-Delta is influenced by connectivity to the ocean and land

Cloern et al. (2007)

Dave Schoellhamer

Design restoration actions from a large-scale systems perspective
#7 The Bay-Delta is influenced by connectivity to the ocean and land

A levee breach in Suisun Marsh will have regional effects on salinity … John Burau (yesterday)

Scale Matters ….. John Wiens (yesterday)

Design restoration actions from a large-scale systems perspective
The Bay-Delta is influenced by climate shifts

Take a long term perspective that recognizes climate oscillations

Di Lorenzo et al. (2008)
The climate system is changing

Winter Storms

Heat Waves

Extreme Sea Level

Plan for increased frequency of extreme events
#9 The climate system is changing

Winter Storms

Restoration needs to consider future conditions .... Climate change is the elephant in the room ... John Wiens (yesterday)

Plan for increased frequency of extreme events
#10 We can link climate-watershed-hydrodynamic-sediment-biological models

Use model-based scenarios to assess outcomes of restoration actions
key questions and uncertainties?
Trajectories of Recovery?

Thresholds in the Recovery of Eutrophic Coastal Ecosystems
Restoration attempts to return an ecosystem to its historic trajectory … Karen Rodriguez (yesterday)

We can fail for lots of different reasons ..... Stuart Siegel (yesterday)
Responses of target species to increasing frequency & intensity of extreme events? *multi-year droughts, heat waves, storm surges, winter storms*
Causes of the recent POD? related to the 1998-99 climate shift?

Maeotius catch in otter trawls, Suisun Marsh

Alpa Wintzer
Sustainability of Delta smelt? the future Delta will be warmer, clearer

Wayne Wagner & Mark Stacey

Dave Schoellhamer
The dilemma of restoring at-risk species … John Wiens (yesterday)
Will new pelagic habitats be colonized by *Corbicula*?

*Importing Habitat*

*Exporting Habitat*

Franks Tract

Lucas et al. (2002)

Mildred Island
Will new pelagic habitats be colonized by *Corbicula*?

*Importing Habitat*  
*Exporting Habitat*

**Extent to which invasive clams divert new primary production?...**

Steve Crooks (yesterday)

Franks Tract  
Lucas et al. (2002)  
Mildred Island
Growing problems of cyanobacterial blooms? ‘cyanos like it hot and slow’
Can we raise the public funds and political will to take BOLD actions, monitor and adapt over the long term, design from a large-scale systems perspective, and expand investments in coordinated research?