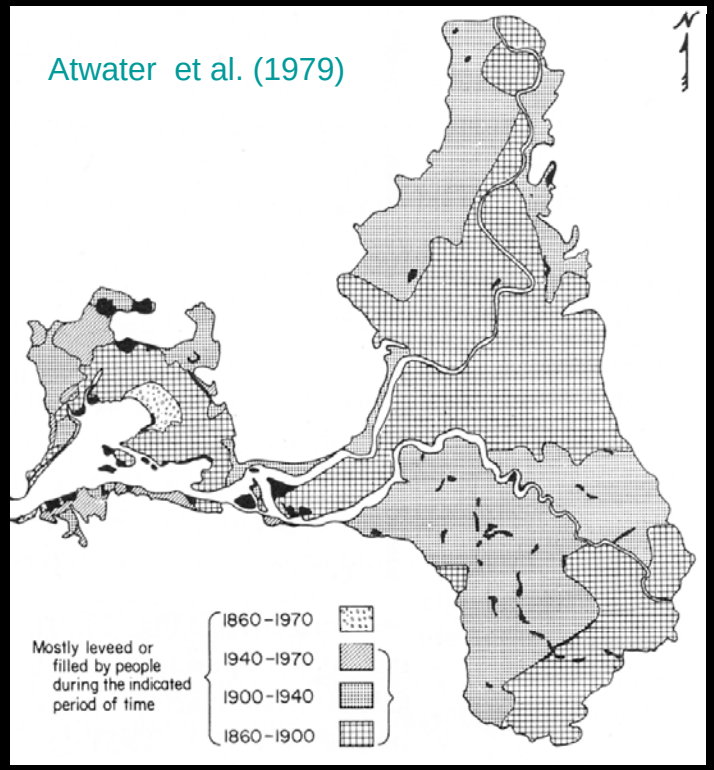
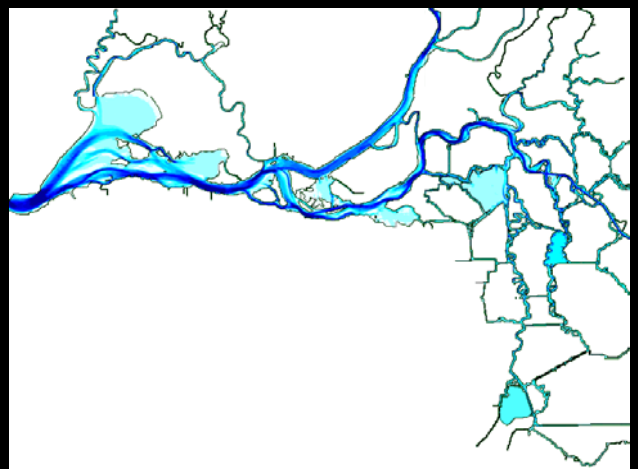
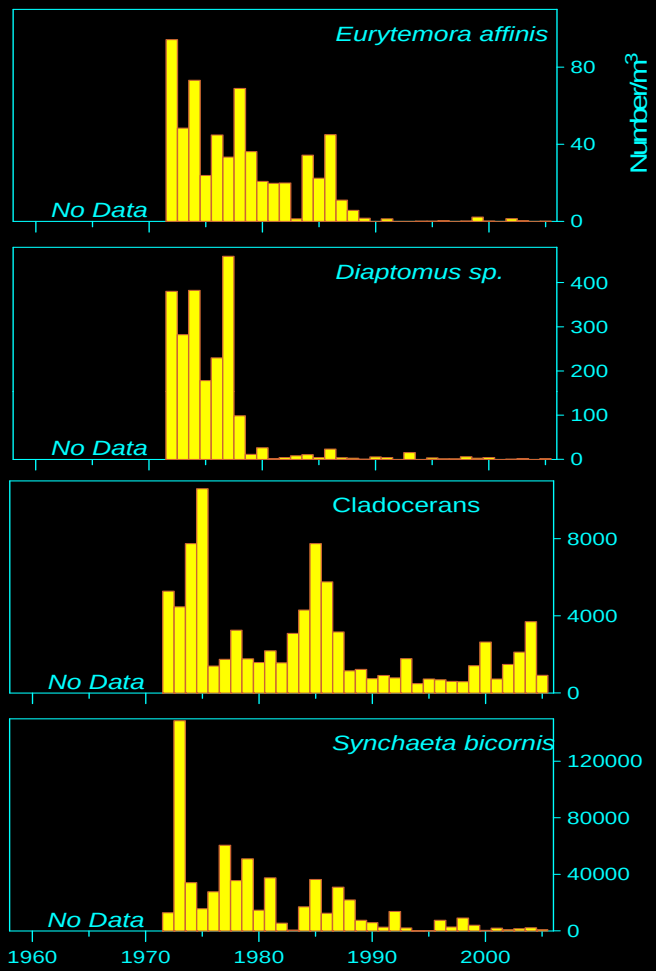
principles for large-scale restoration?

# #1 The Delta has been transformed over a period of 150 years



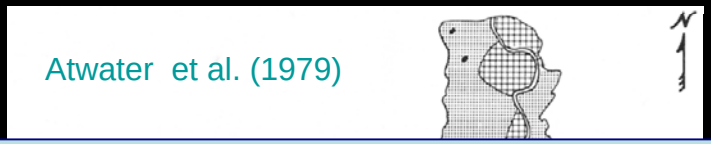






IEP EMP

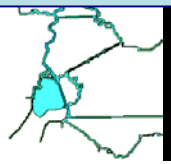
Don’t expect quick fixes

#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

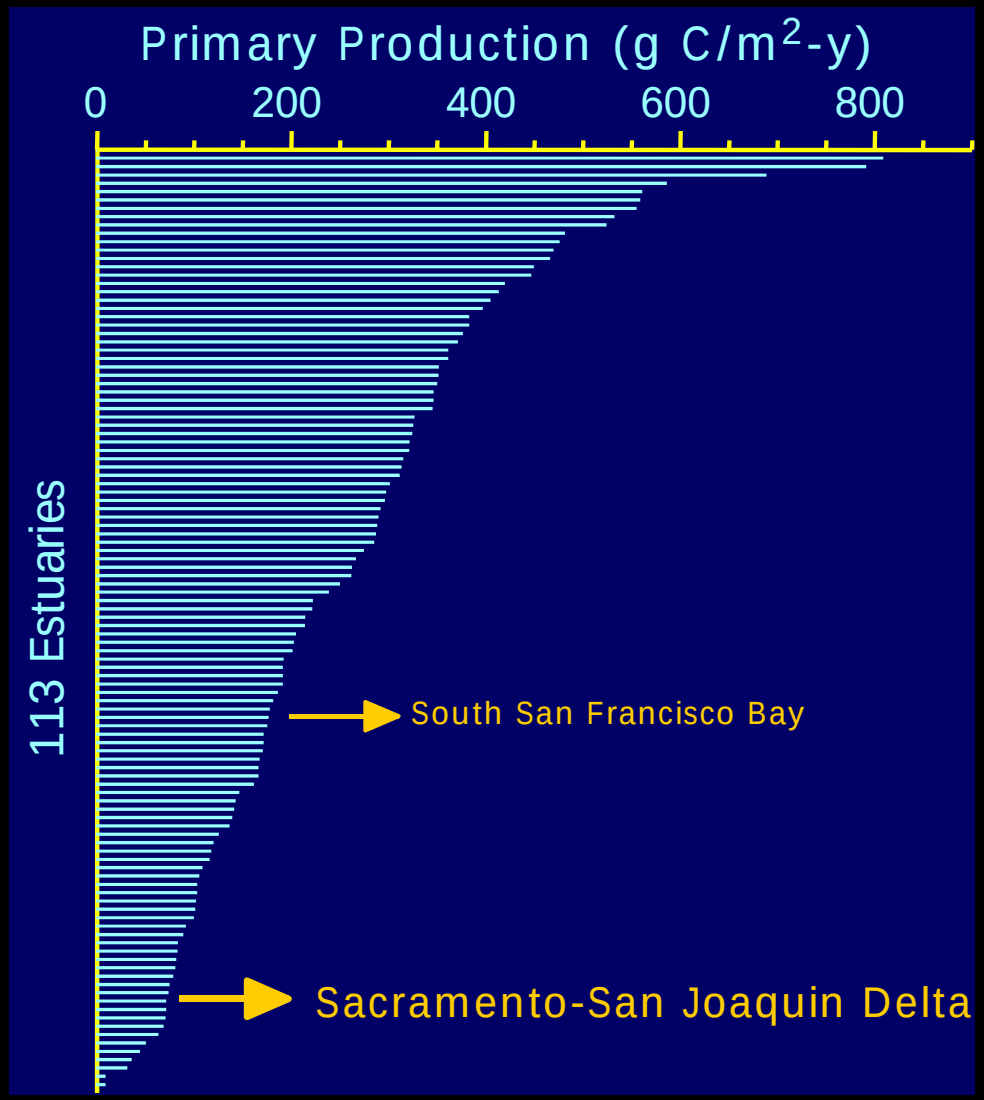
**BOLD** actions are required

#2 The Delta is a hyper-disturbed ecosystem

*We know enough … proceed boldly …* Chris Enright (yesterday)

**BOLD** actions are required

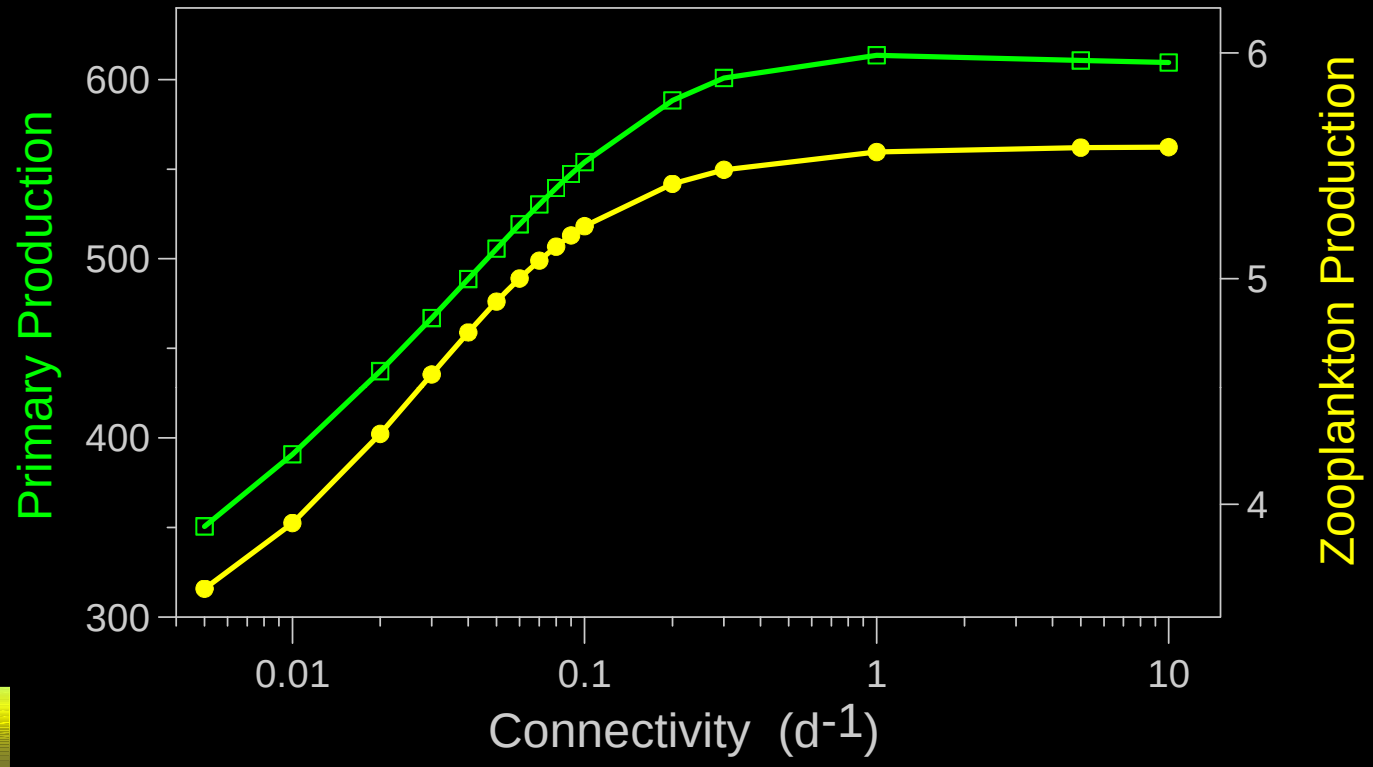
# #3 The Delta is a low-productivity ecosystem

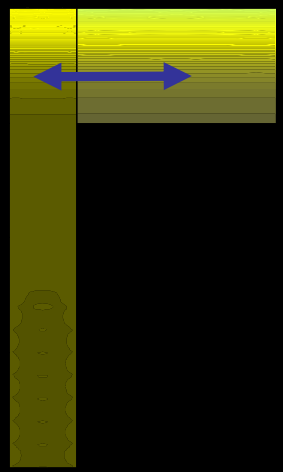



10$^{th}$ percentile

Recognize constraints on the outcomes of restoration actions

# #4 Ecosystem productivity is determined by habitat connectivity

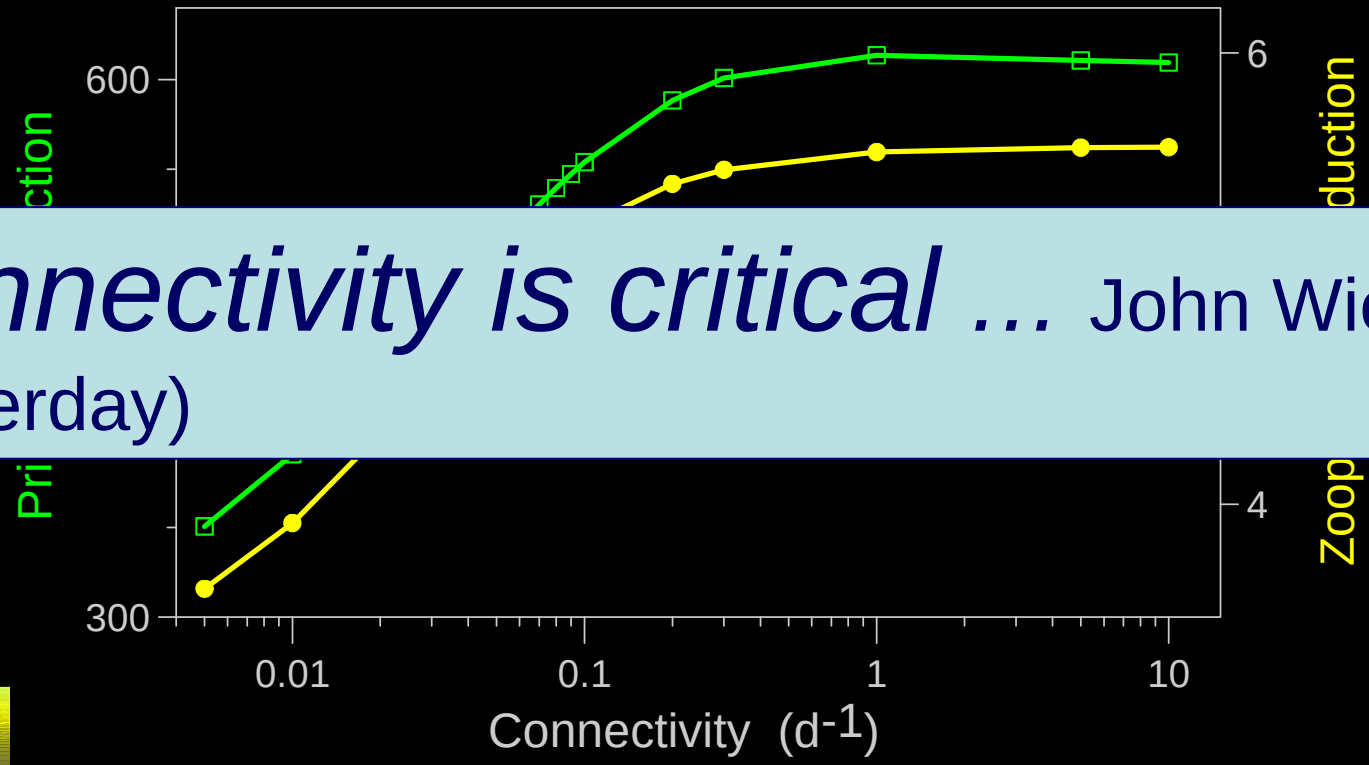


Cloern (2007)

Include connectivity in restoration design

#4 Ecosystem productivity is determined by habitat connectivity




*Connectivity is critical …* John Wiens (yesterday)

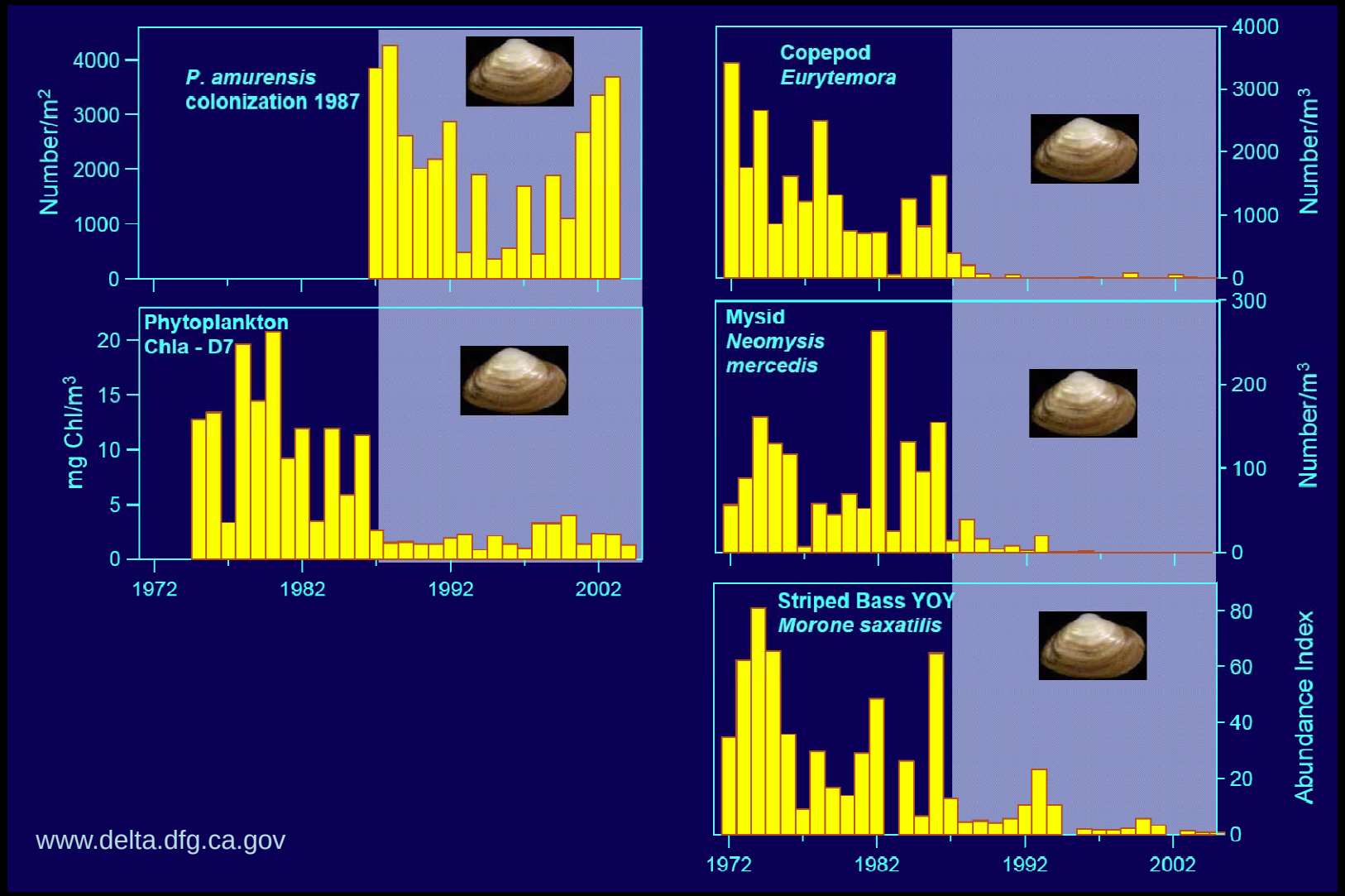
*Yolo bypass is a food bank …*

Ted Sommer (yesterday)

Include connectivity in restoration design

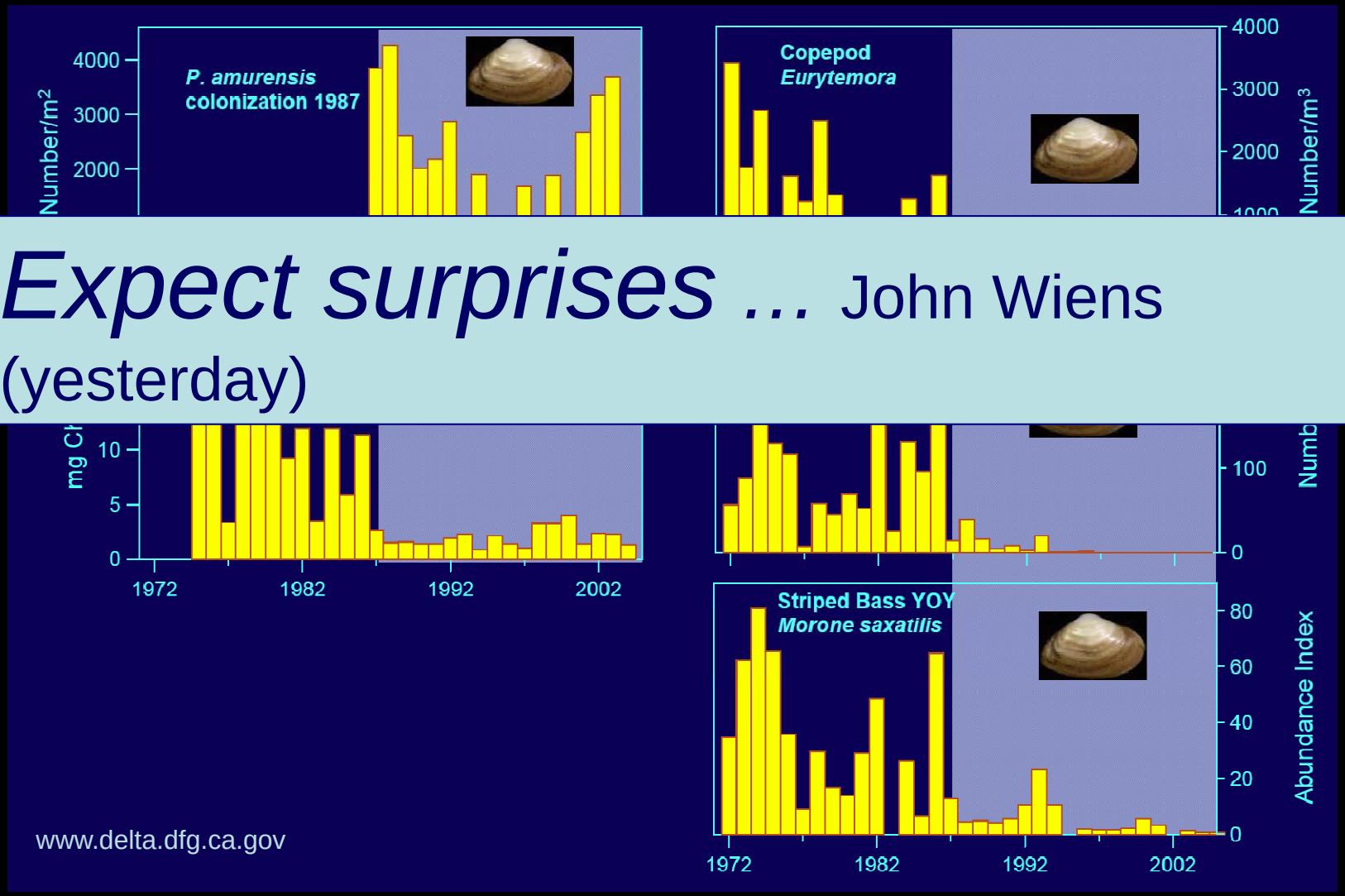
Cloern (2007)

# #5 Ecosystems always surprise us




Expect unexpected outcomes; monitor and adapt

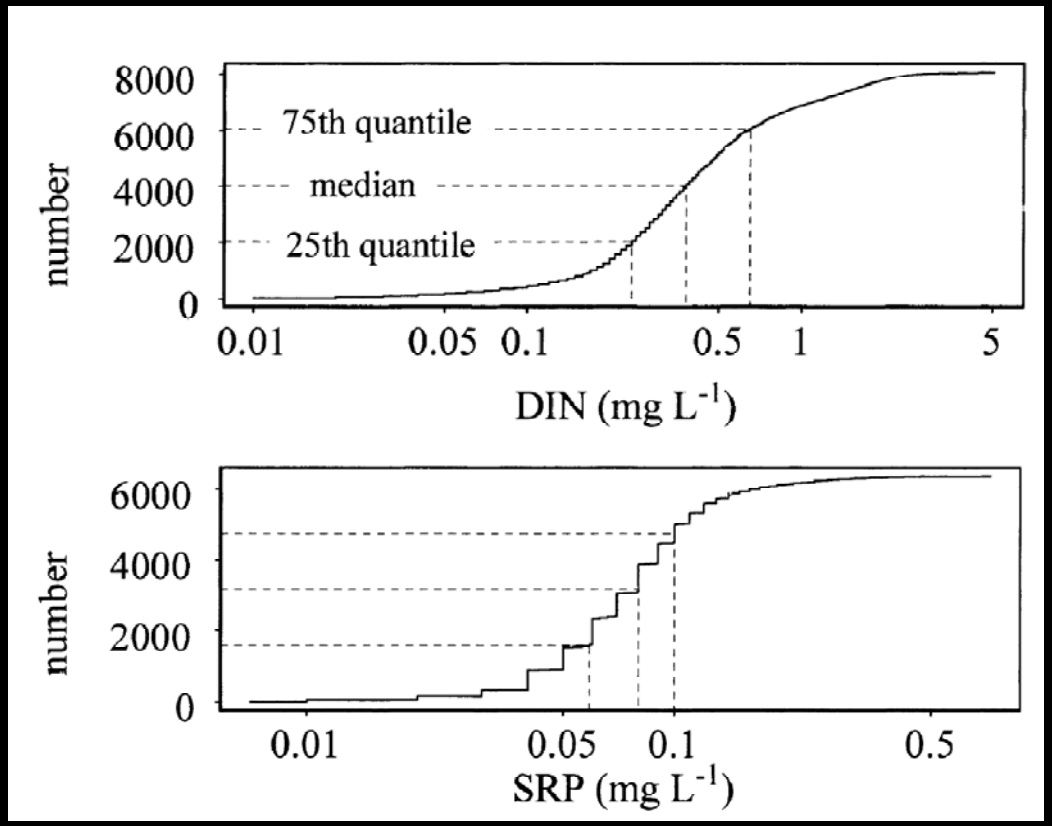
#5 Ecosystems always surprise us




*Expect surprises* … John Wiens (yesterday)

Expect unexpected outcomes; monitor and adapt

# #6 The Delta is highly enriched in N and P



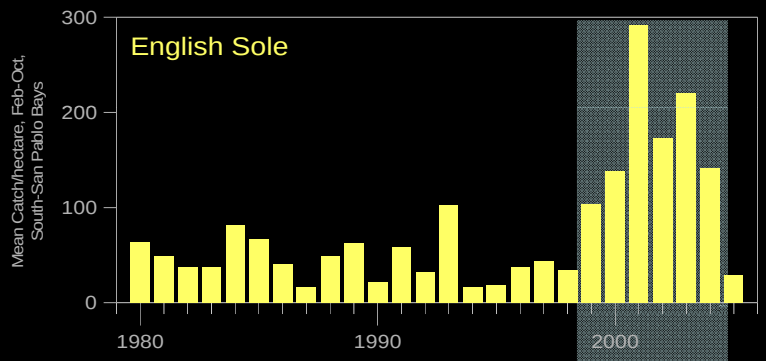

9 of 8000 samples N limited

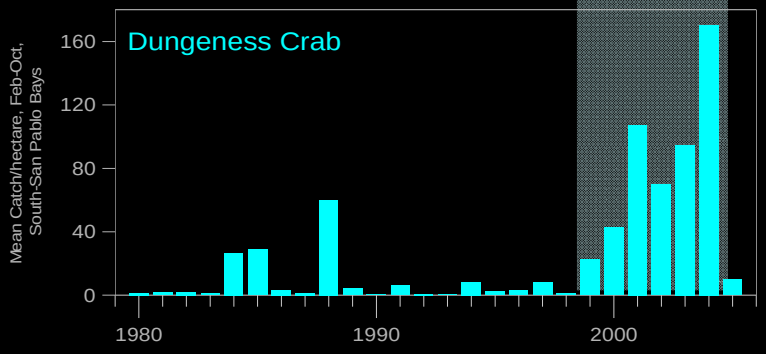
9 of 6000 samples P limited

Jassby et al. (2002)

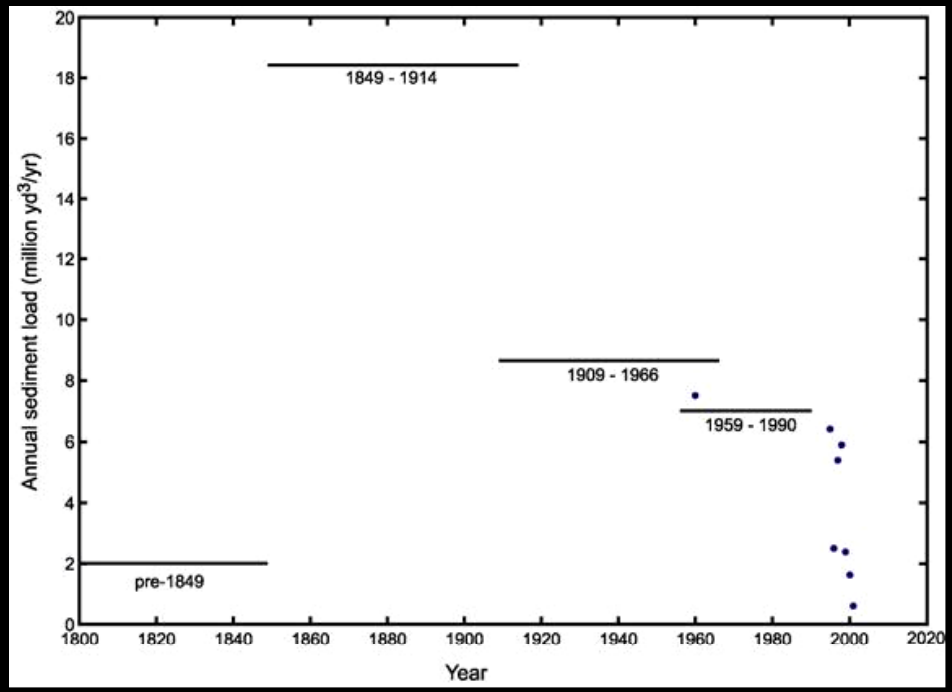
Nutrient reductions might be necessary

# #7 The Bay-Delta is influenced by connectivity to the ocean and land



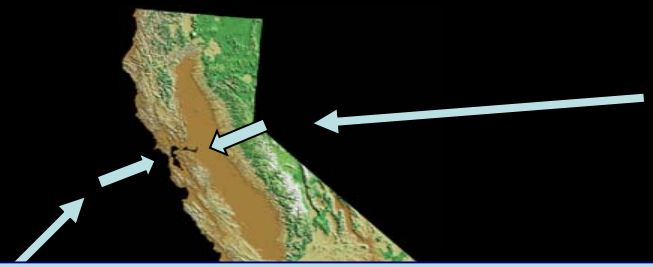

Cloern et al. (2007)

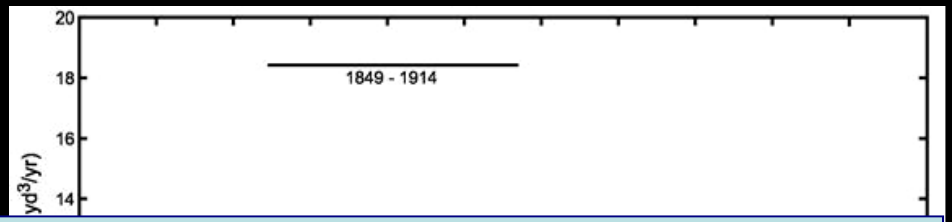



Dave Schoellhamer

Design restoration actions from a large-scale systems perspective

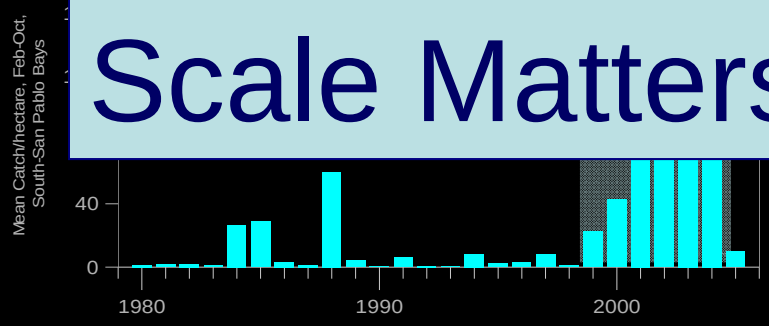
#7 The Bay-Delta is influenced by connectivity to the ocean and land






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

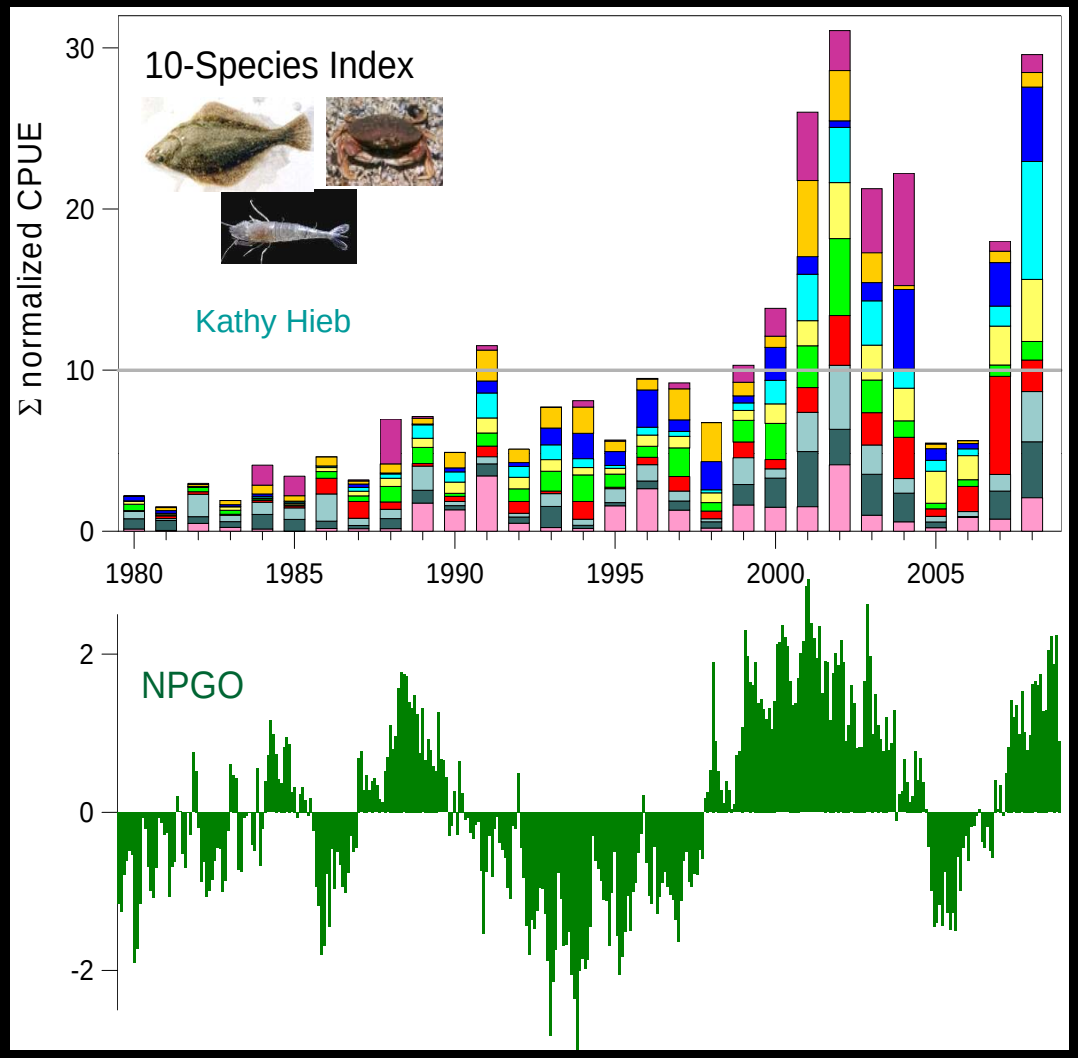
Scale Matters ….. John Wiens (yesterday)

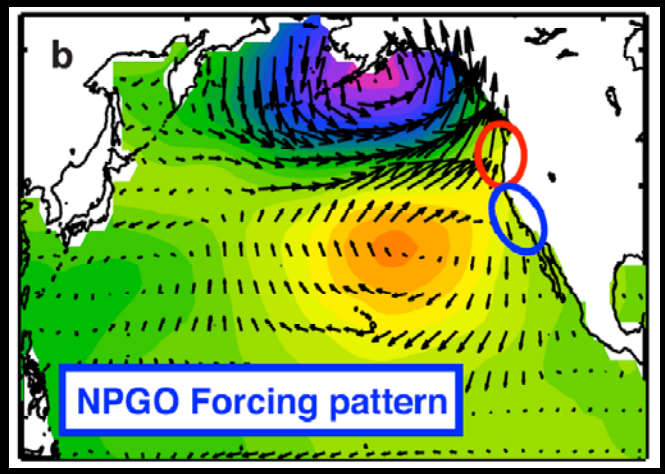



Cloern et al. (2007)

Design restoration actions from a large-scale systems perspective

# #8 The Bay-Delta is influenced by climate shifts



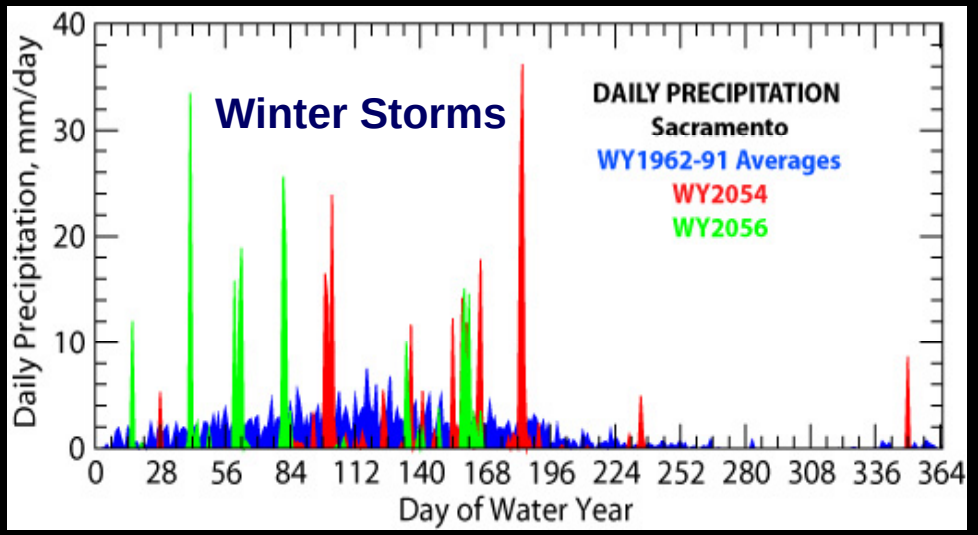



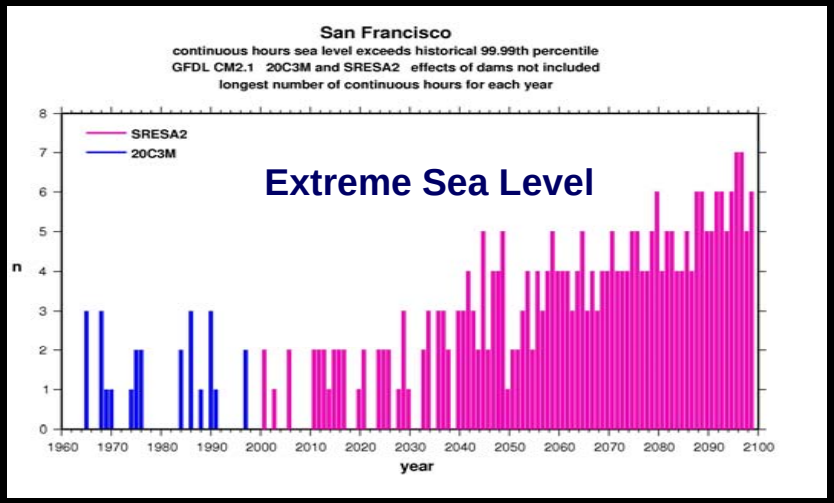

Di Lorenzo et al. (2008)

Take a long term perspective that recognizes climate oscillations

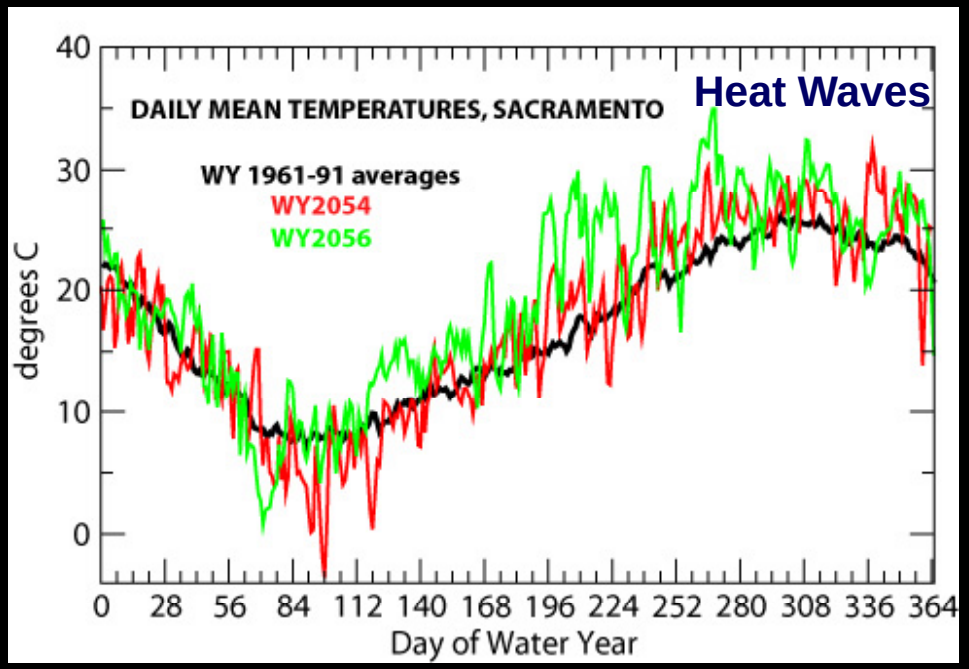
# #9 The climate system is changing

Mike Dettinger



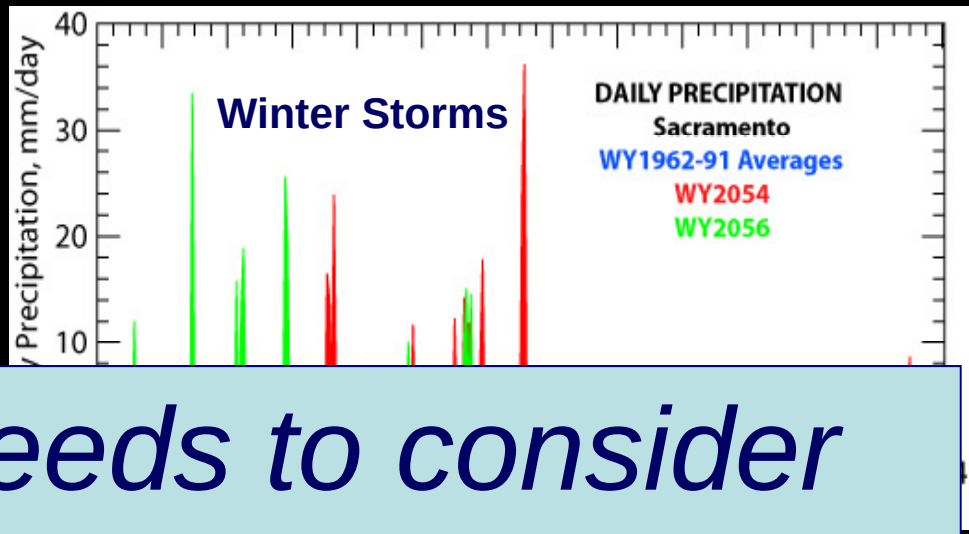

Dan Cayan

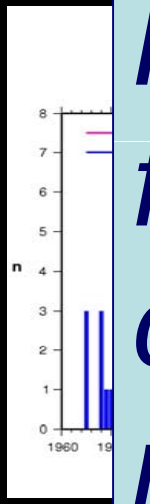



Plan for increased frequency of extreme events

# #9 The climate system is changing

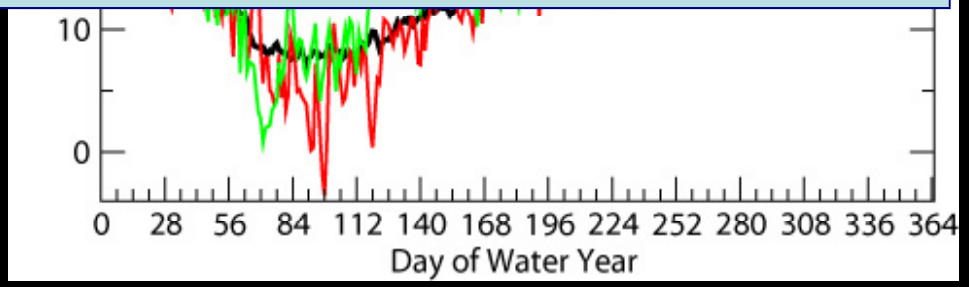
Mike Dettinger



Dan C

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



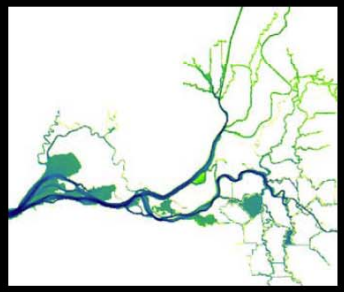

Plan for increased frequency of extreme events

# #10 We can link climate-watershed-hydrodynamic-sediment-biological models

Global Climate Models

**C**omputational
**A**ssessments of
**S**cenarios of
**C**hange in the
**a**
**D**elta
**E**cosystem

Downscaled To Region



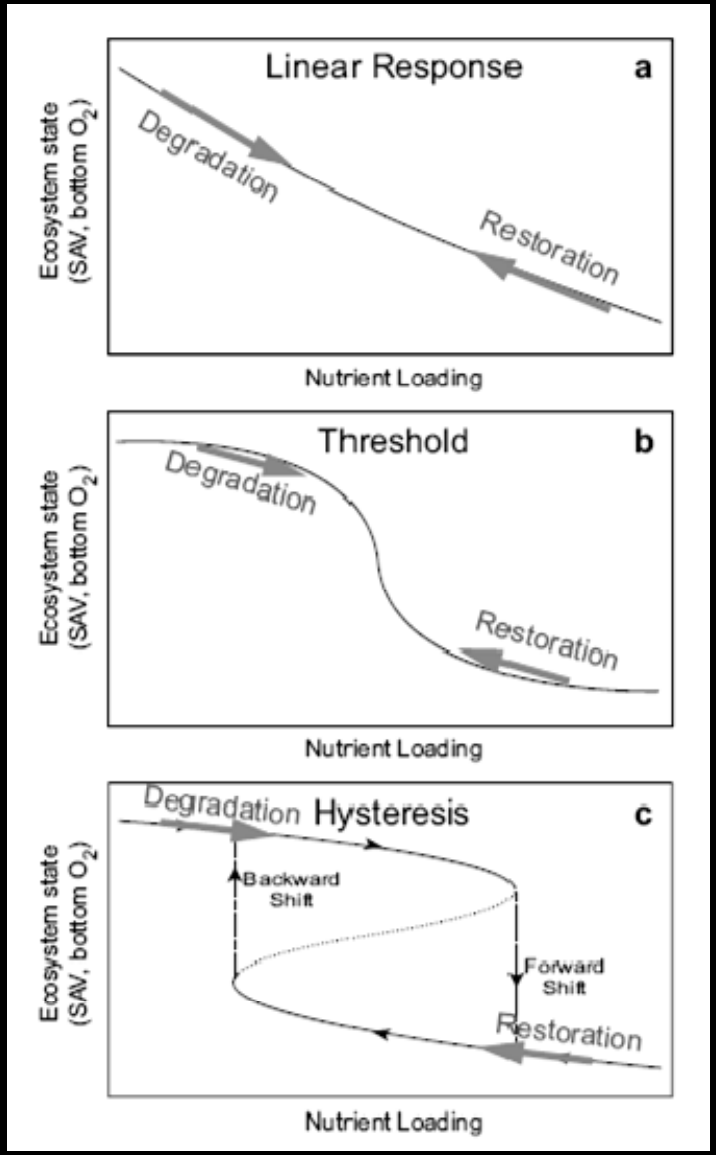
Delta Model

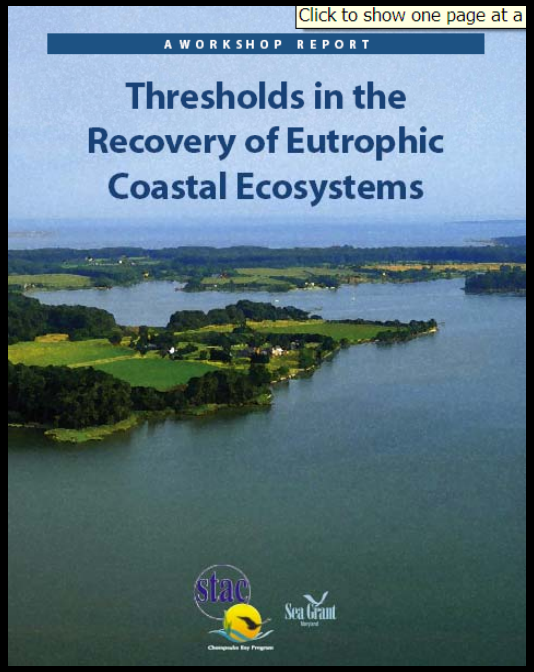
Watershed Model

Use model-based scenarios to assess outcomes of restoration actions

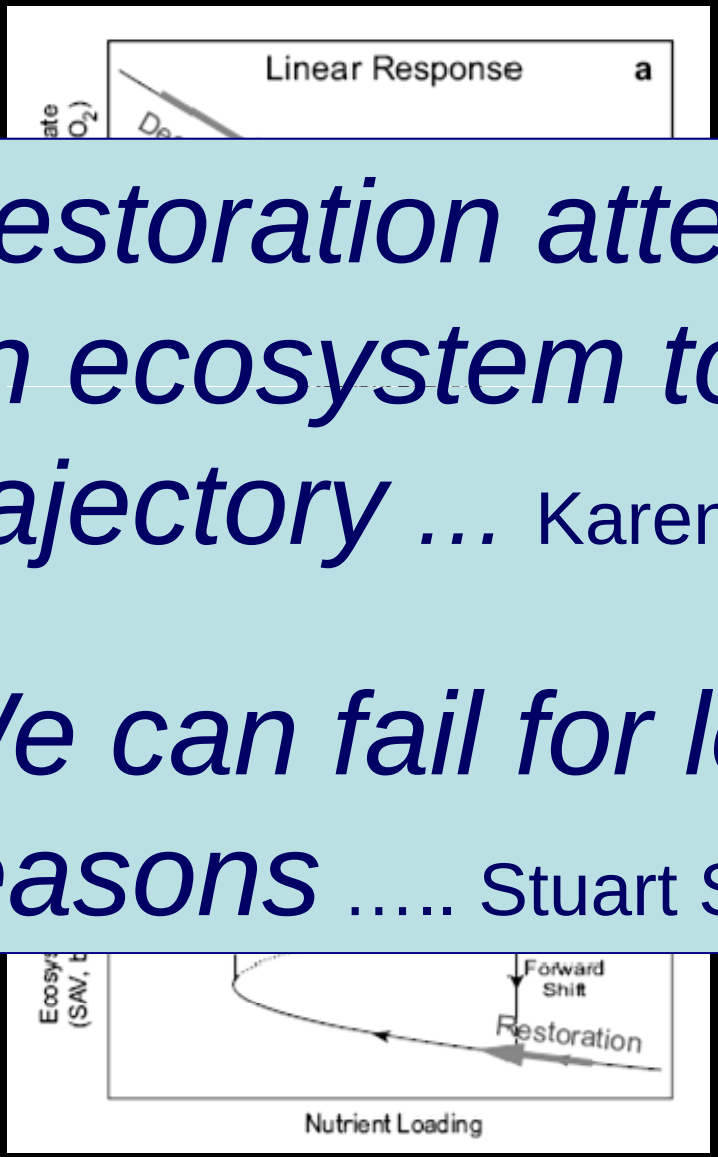
# key questions and uncertainties?

# Trajectories of Recovery?



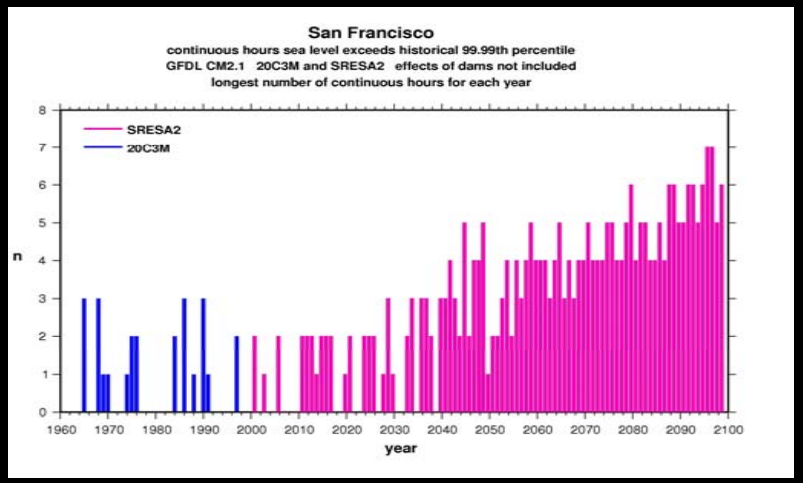
Trajectories of Recovery?

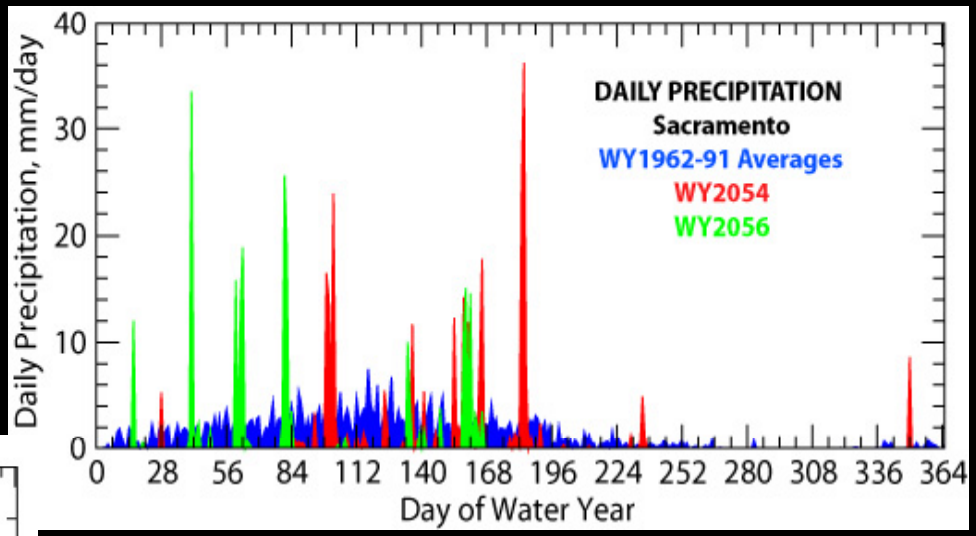


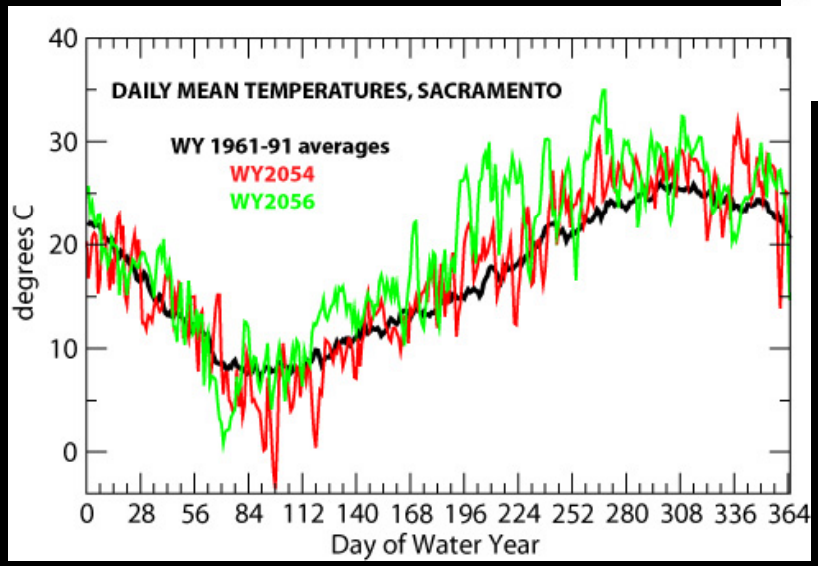

*Restoration attempts to return an ecosystem to its historic trajectory …* Karen Rodriguez (yesterday)

*We can fail for lots of different reasons* ….. Stuart Siegel (yesterday)

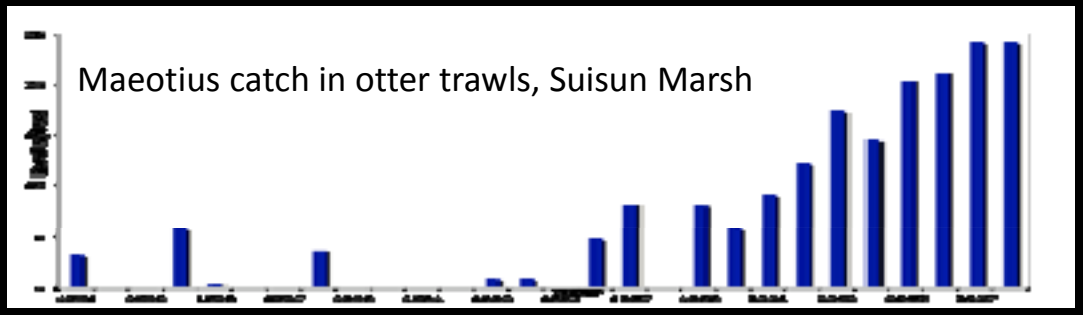
Responses of target species to increasing frequency & intensity of extreme events ? *multi-year droughts, heat waves, storm surges, winter storms*



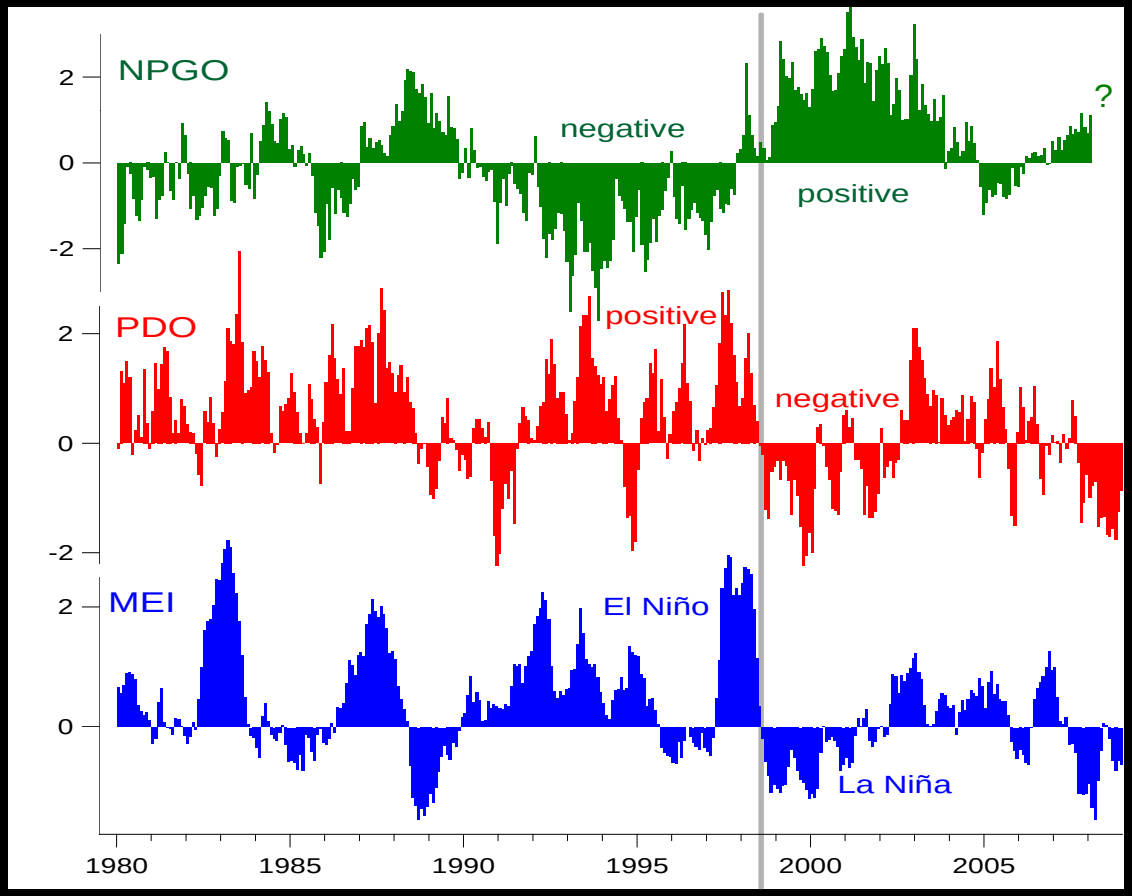



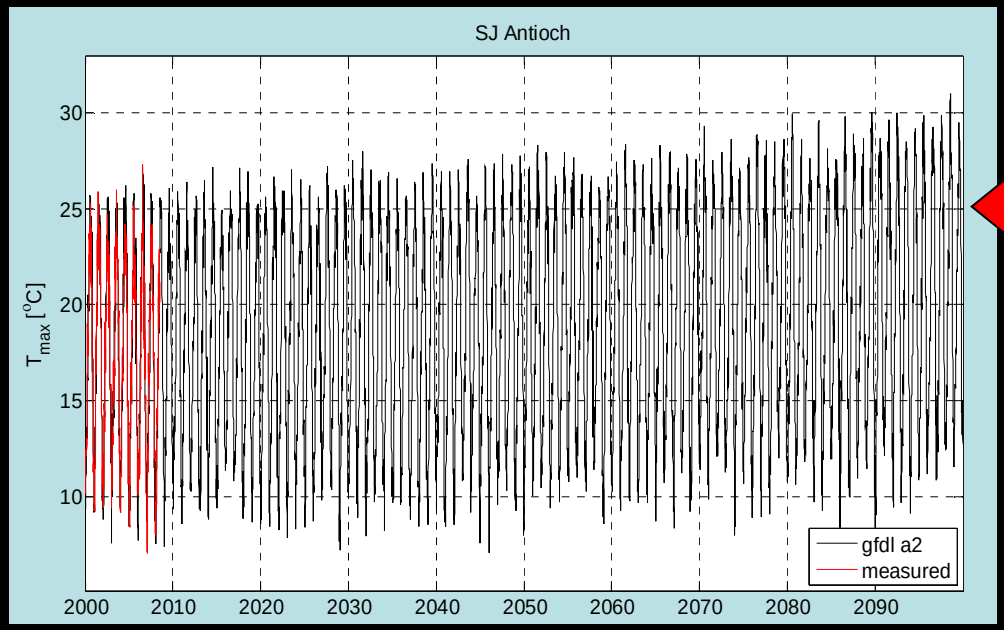
# Causes of the recent POD? *related to the 1998-99 climate shift?*



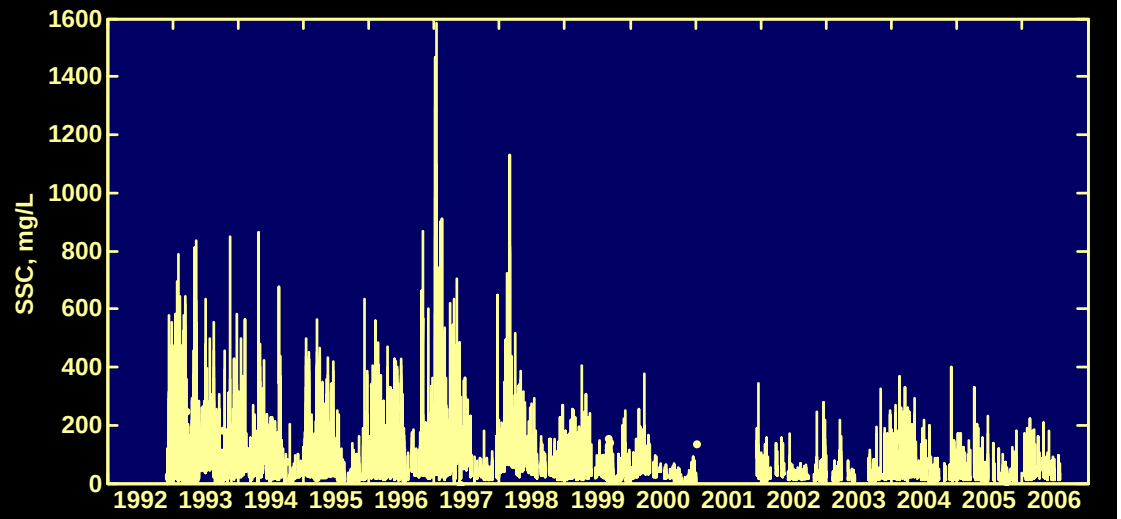

Alpa Wintzer



# Sustainability of Delta smelt? *the future Delta will be warmer, clearer*

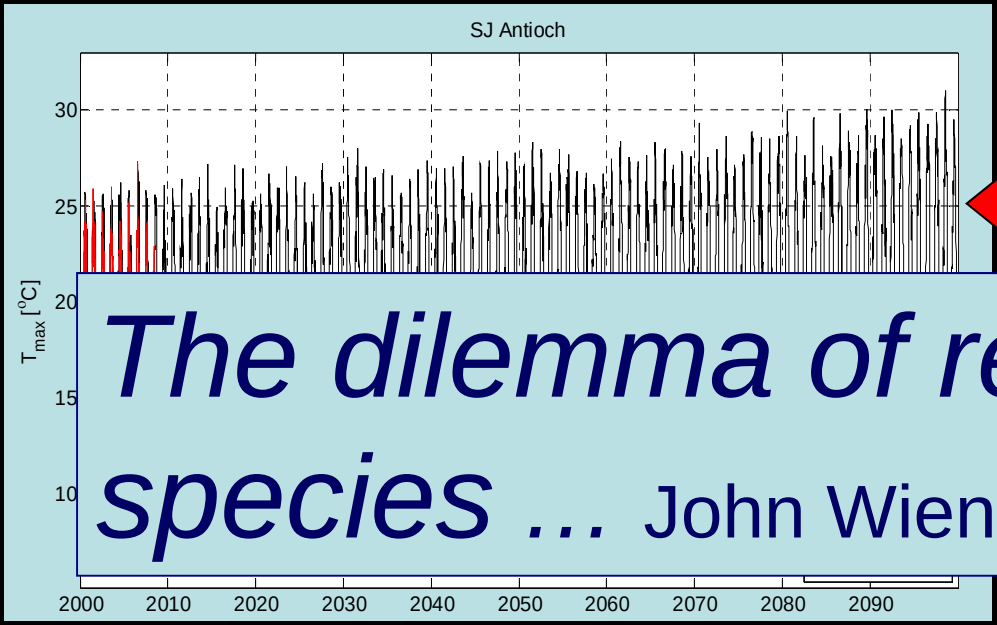



Wayne Wagner & Mark Stacey



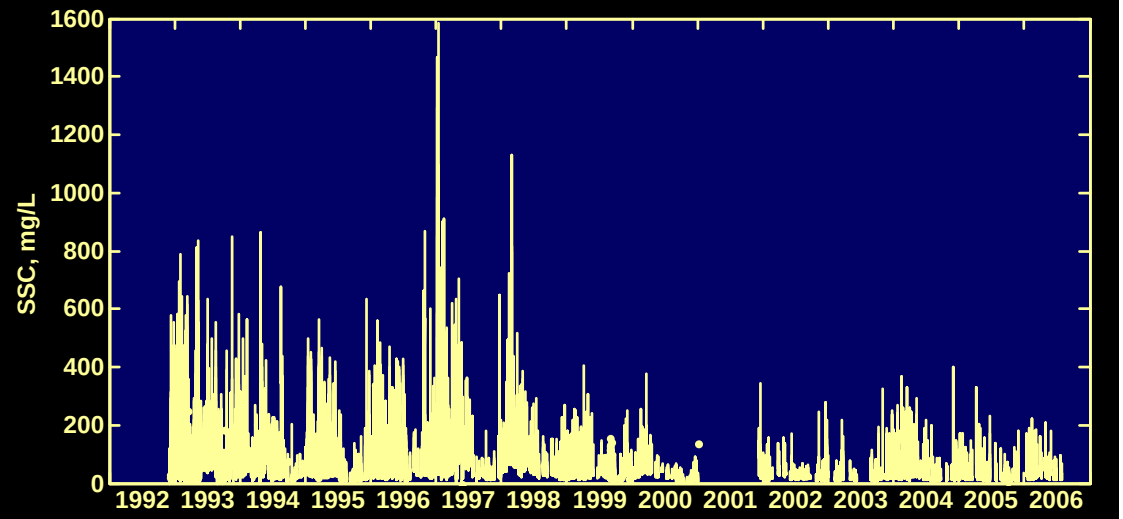

Dave Schoellhamer

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




# *The dilemma of restoring at-risk species* … John Wiens (yesterday)

Wayne Wagner & Mark Stacey

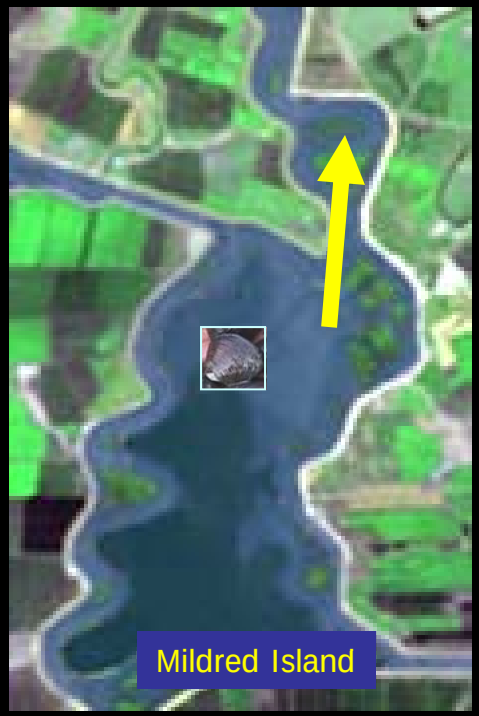



Dave Schoellhamer

Will new pelagic habitats be colonized by *Corbicula*?

*Importing Habitat*

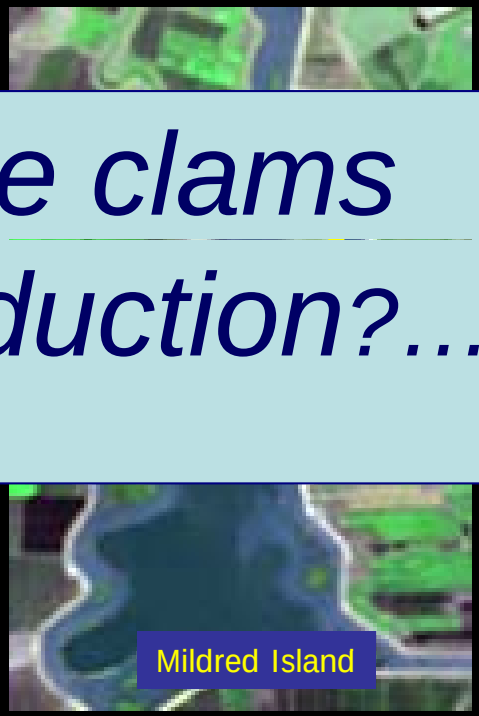
*Exporting Habitat*



Will new pelagic habitats be colonized by *Corbicula*?

*Importing Habitat*

*Exporting Habitat*




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

Steve Crooks (yesterday)

# 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?*