# CASCaDE A Tool for Examining the Effect of Climate Change on the San Francisco Delta Ecosystem

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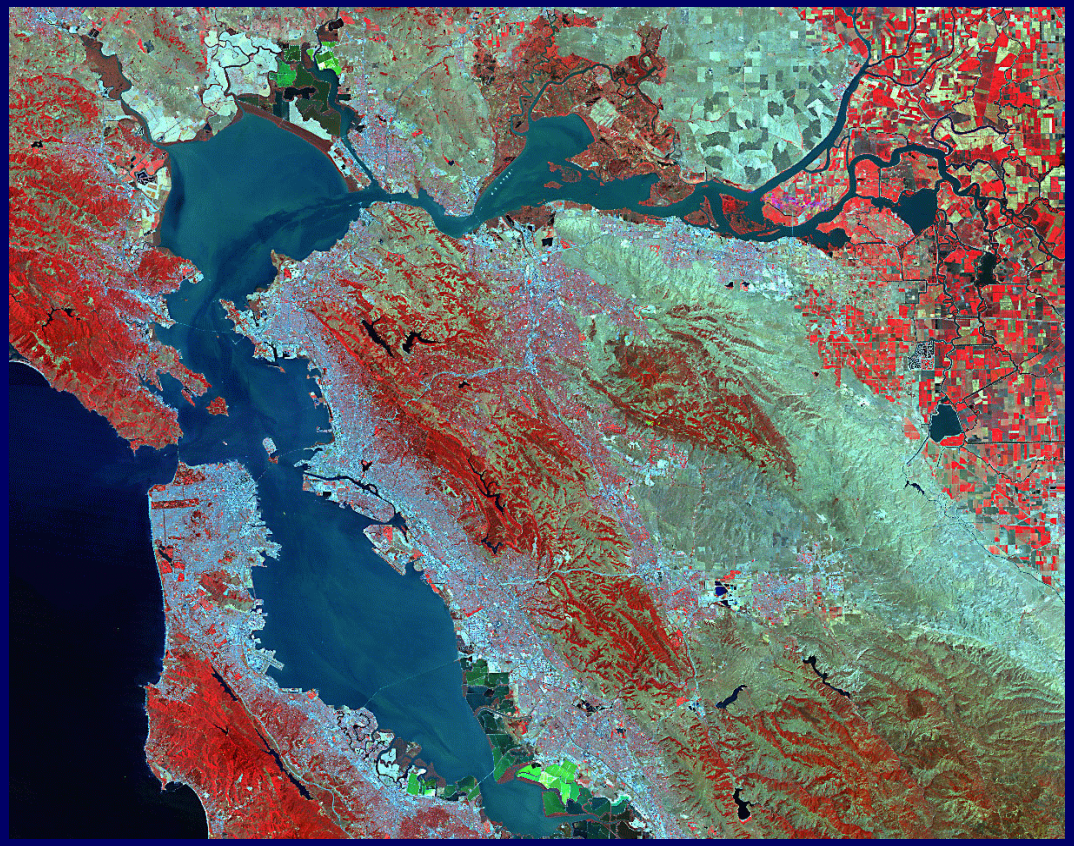
Collaborators: *Bill Bennett, Mark Stacey, Mick van der Wegen,Wayne Wagner, Christa Woodley*

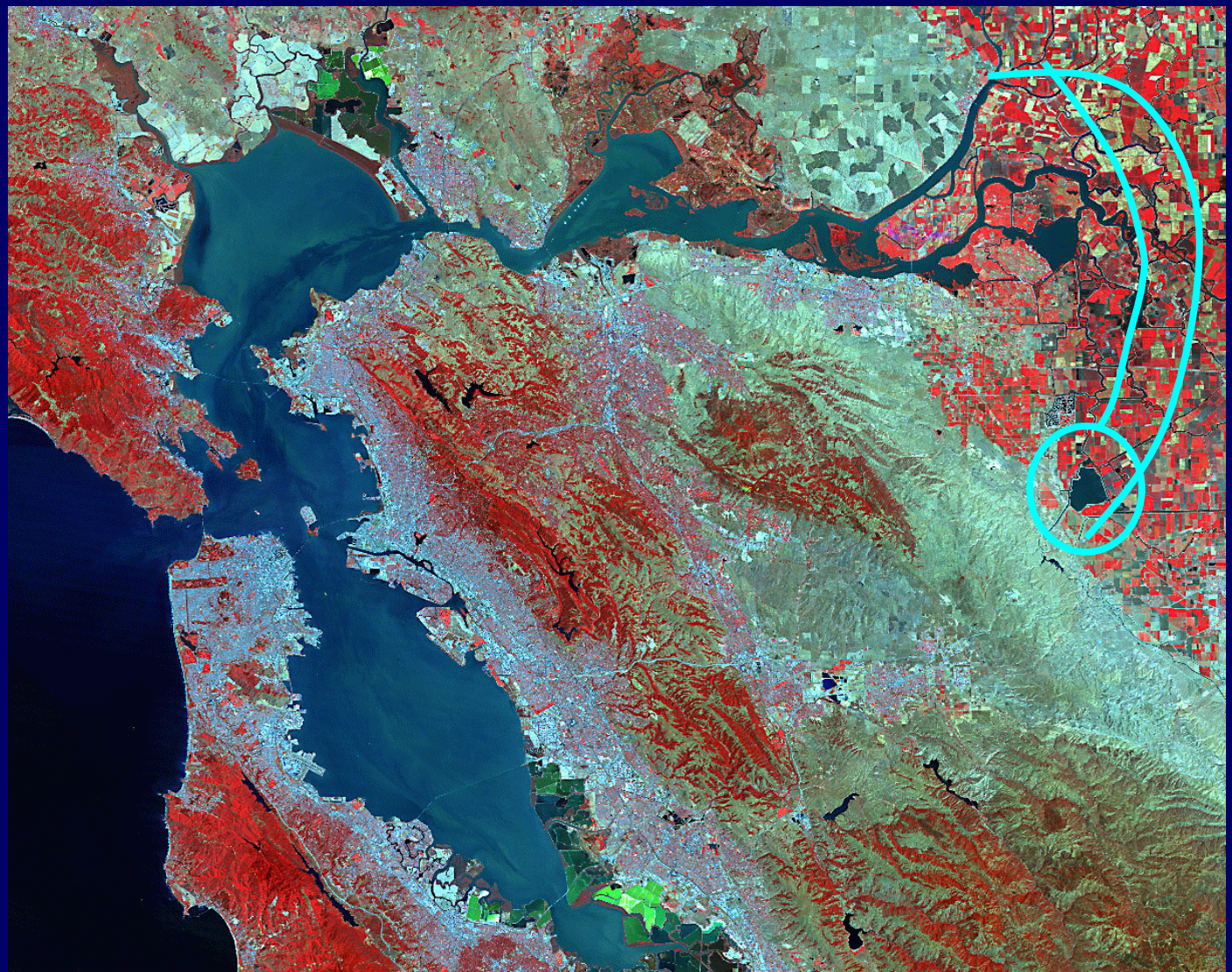
# Our question: How do we inform management and restoration decisions about changing climate in a system where water supply and ecosystem function must be balanced?



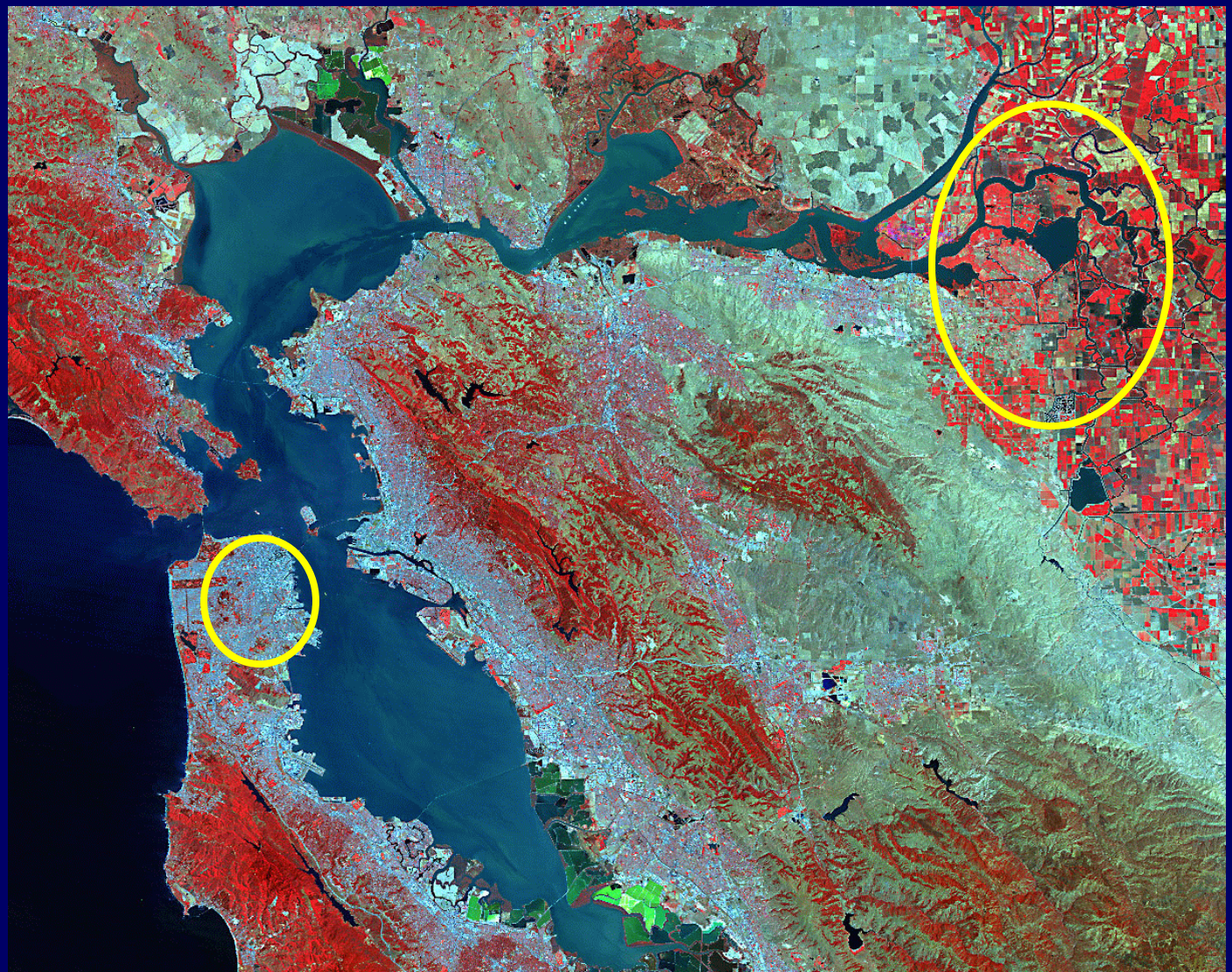
- Largest Pacific estuary
- 150,000 $km^2$ watershed
- Drinking water for 23 million
- $30B agricultural industry
- $8^{th}$ largest economy ??
- At risk from levee failures
- Largest tidal wetland in west
- Habitat for endangered species
- Site of 2 large scale restoration programs

Decisions are particularly difficult when so many anthropogenic and natural changes are occurring at a rapid rate. For example, we need to plan for challenges to our restoration sites,

…the planned and current water conveyance structures,



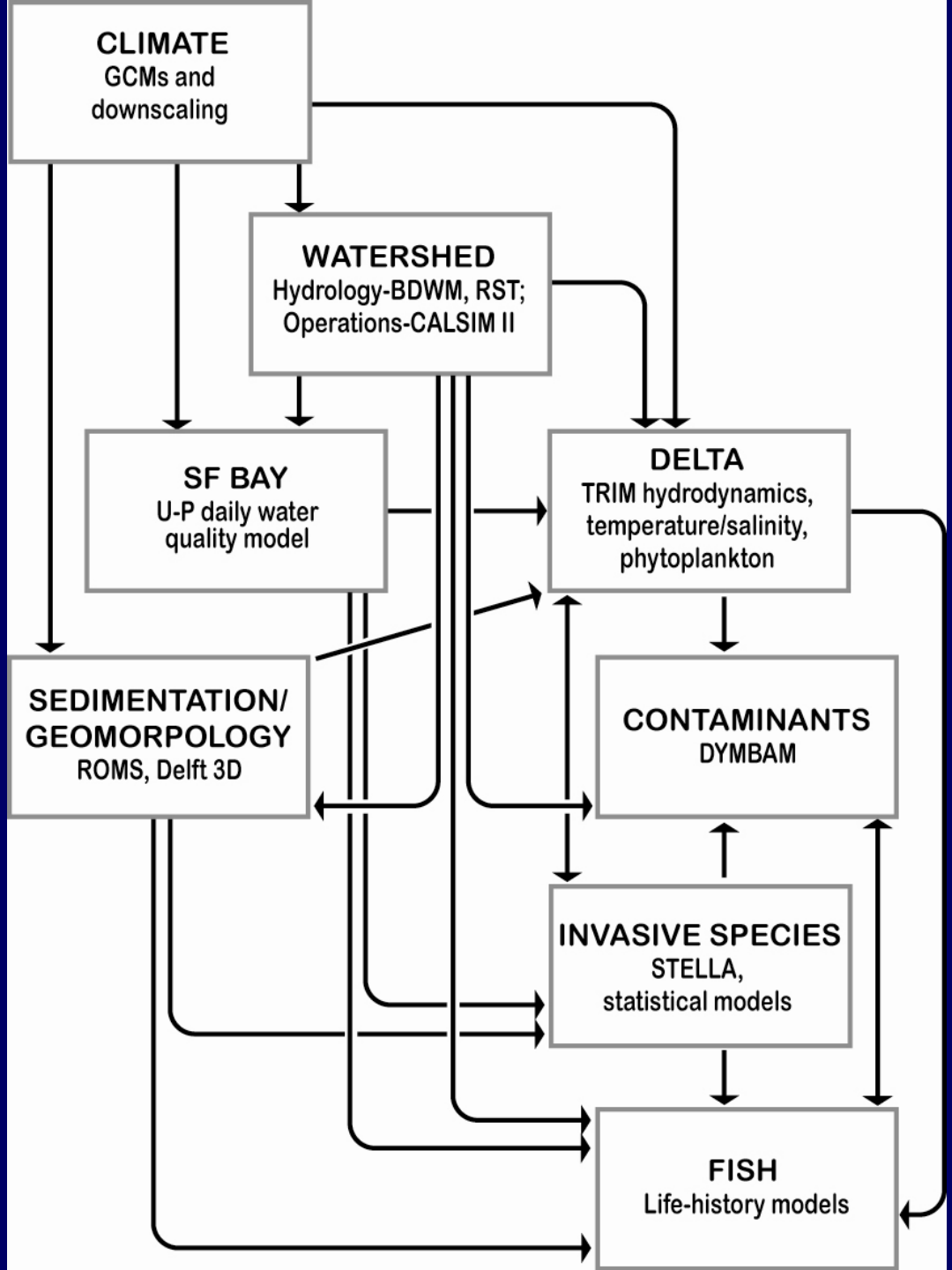
…and for catastrophic changes due to earthquakes and storms.



We chose to build a series of tools to look at scenarios of change (NOT predictions) – we can change scenarios

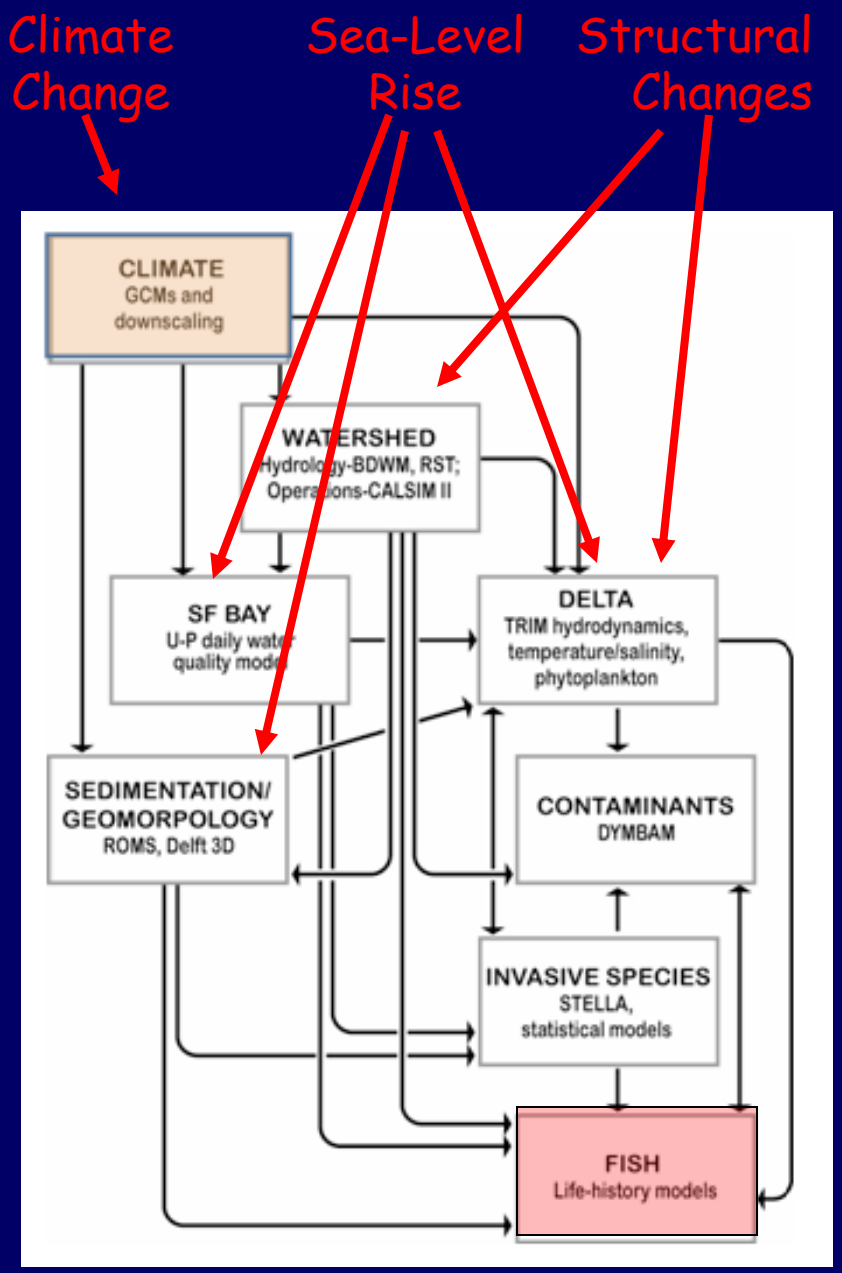
# CASCaDE Project

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

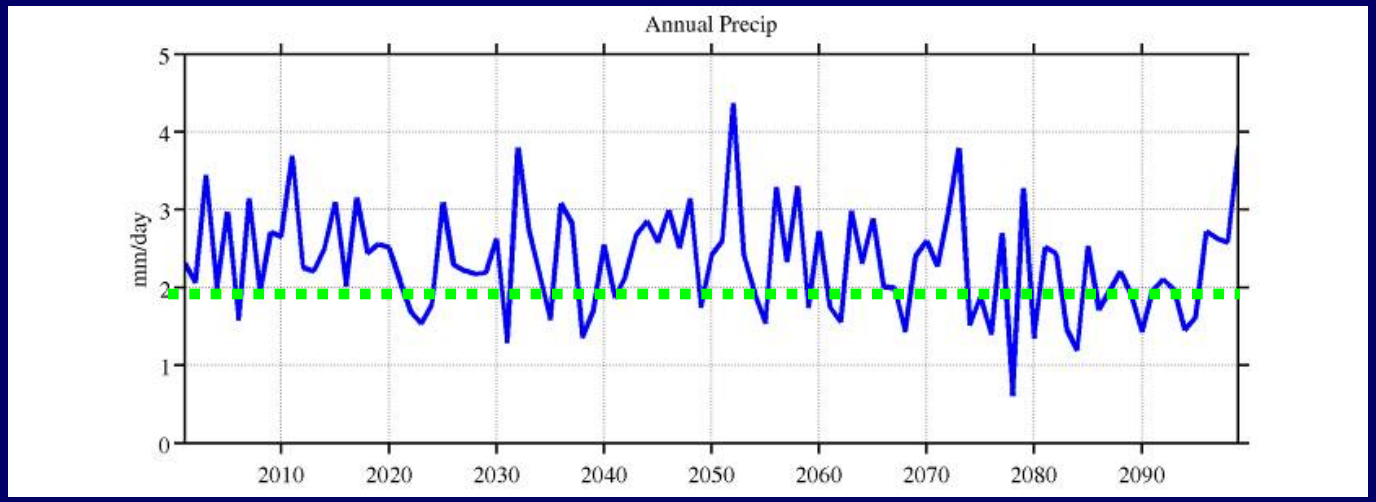


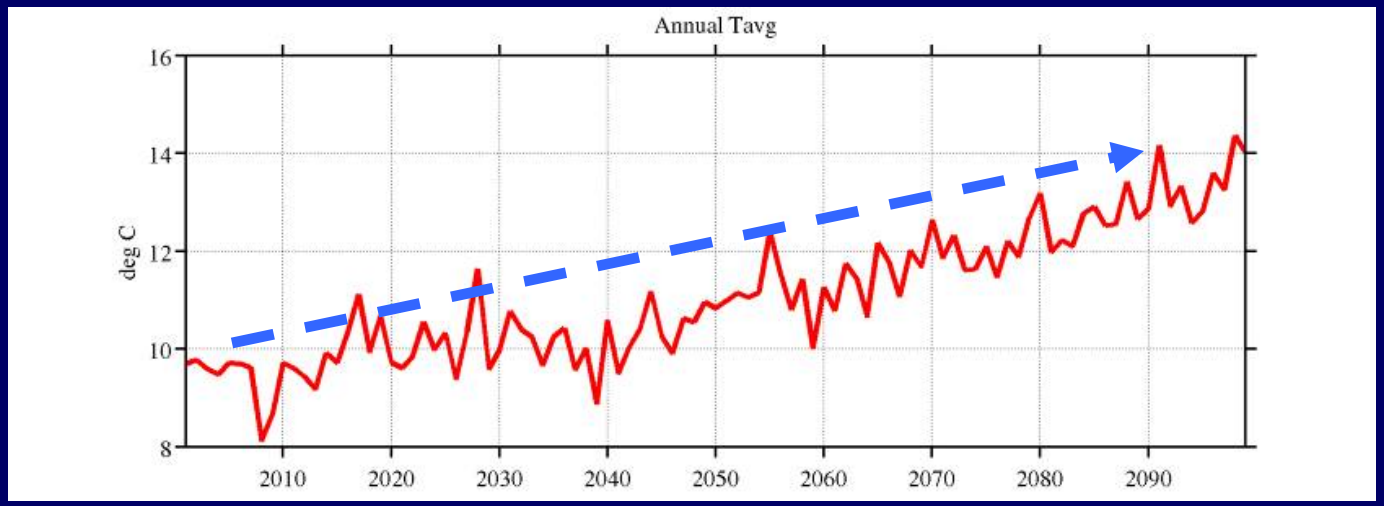
# CASCaDE's strength is in the interrelated 'cascade' of models

- Integrate processes
- Characterize responses to simultaneous forcings
- Highlight critical sensitivities



In response to our scenarios, we look at trends, thresholds, and indices that are relevant to ecological processes or management.

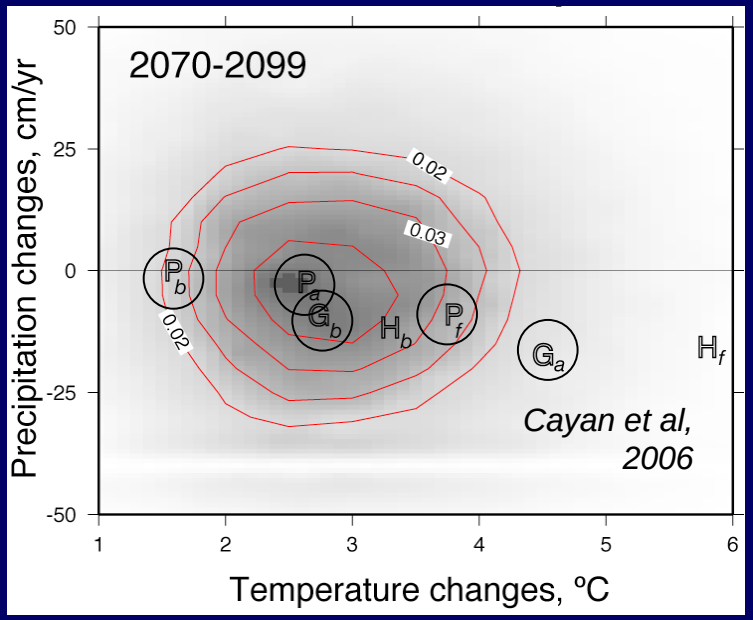


# We started by targeting four climate scenarios from amongst 100+ recent climate-change projections

Consistent with California Climate Scenarios Assessment, 2006 and 2008

- Medium warmer and drier *(GFDL-B1)*
- Much warmer and drier *(GFDL-A2)*
- Not so much warmer with no ppt change *(PCM-B1)*
- Medium warmer with no ppt change *(PCM-A2)*




Mike Dettinger, Dan Cayan

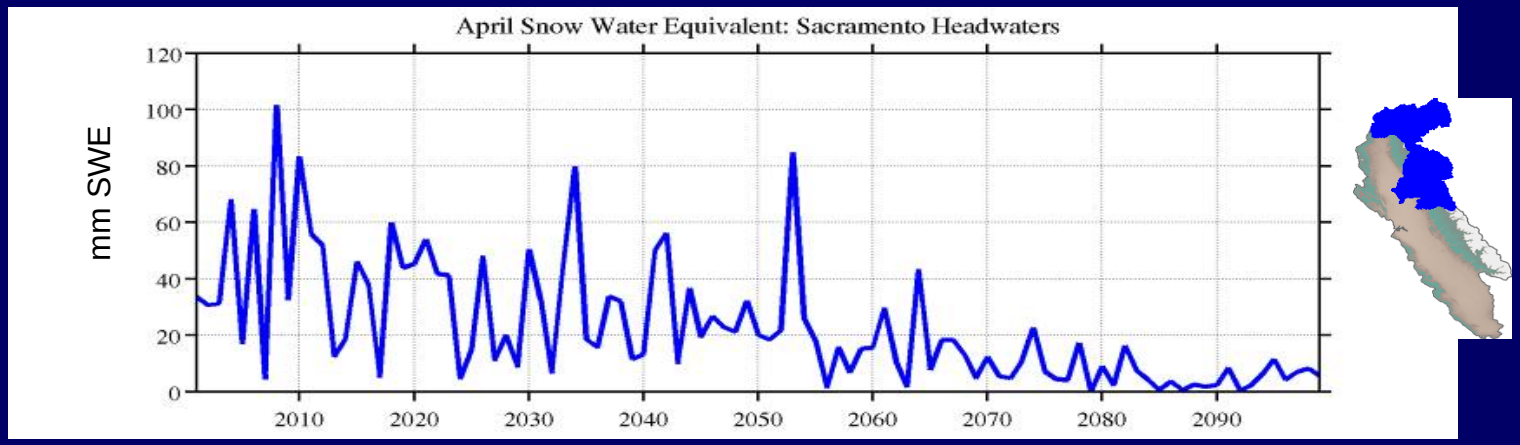
We will look at three examples where we use scenarios of climate change to illustrate how these changes cascade through to ecological changes.

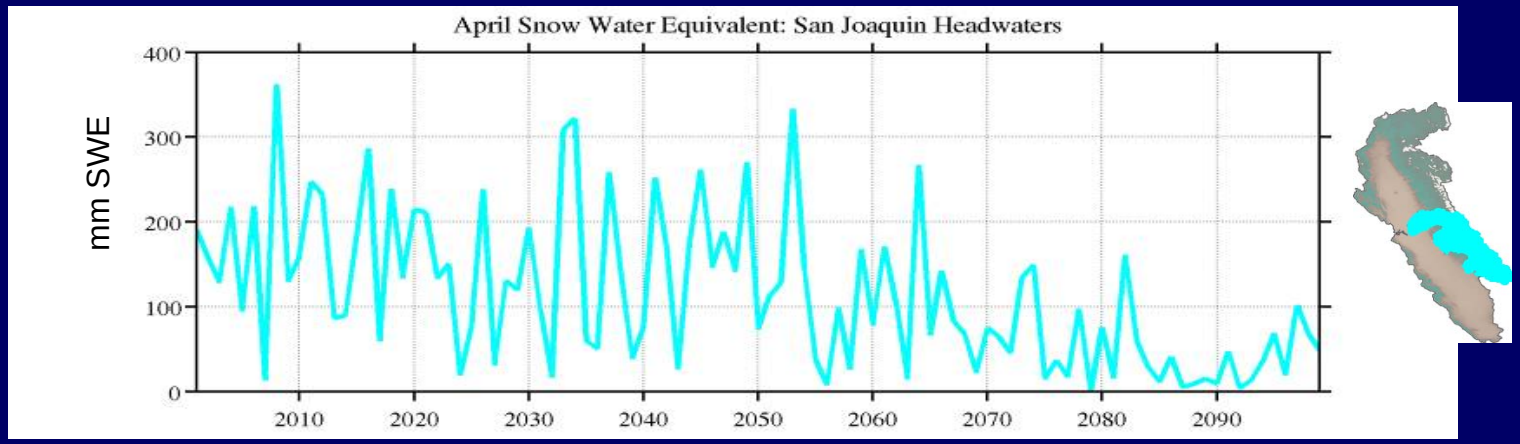
# # 1 Water Supply

The California Water Atlas (1978)

Noah Knowles: Watershed Model with Operations

# Snowpack trends for all scenarios is shown to diminish as more of the precipitation arrives as rain.

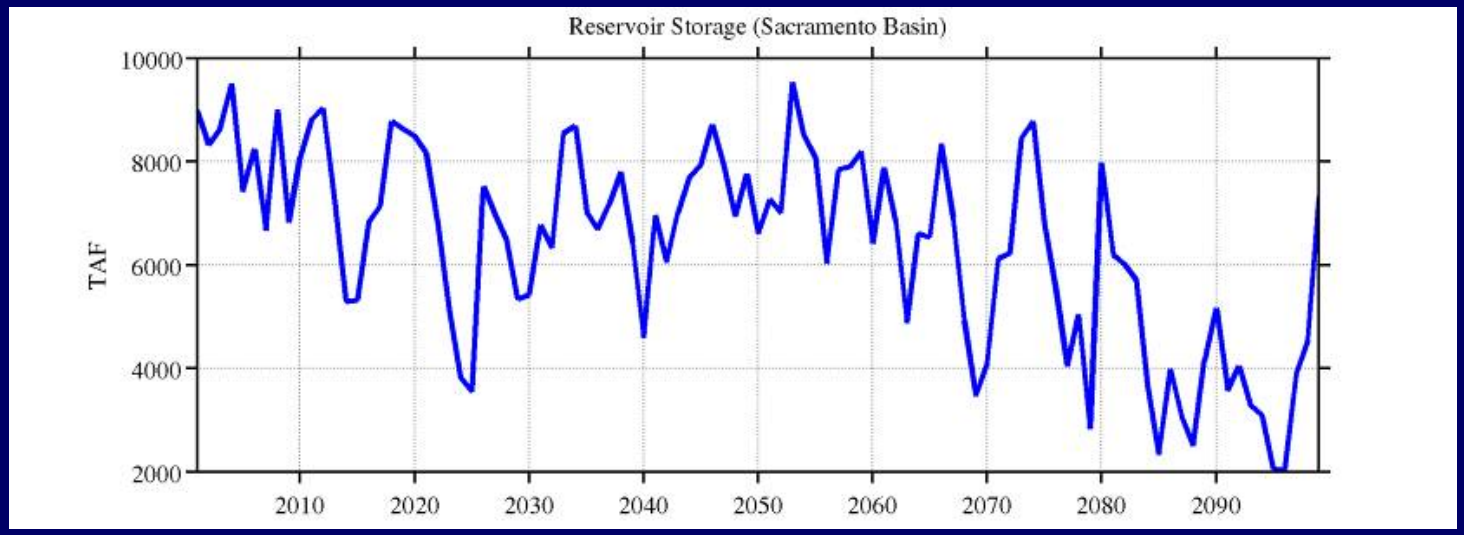


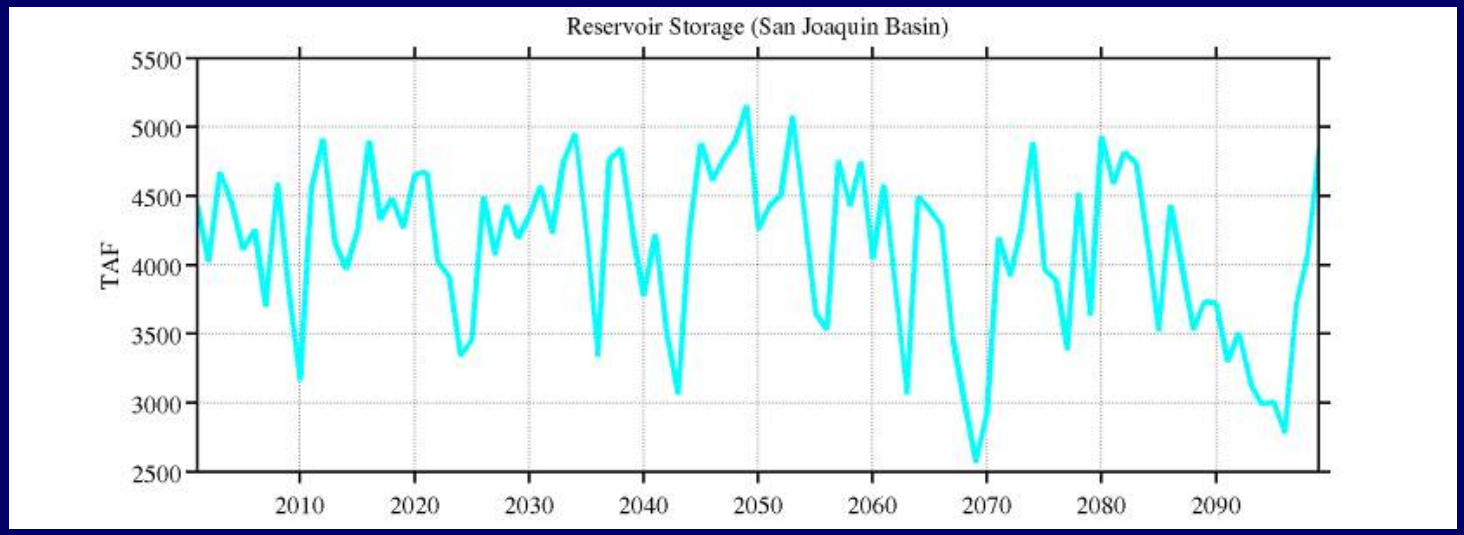

Noah Knowles
Jan 29, 1PM, Session A

# The resulting downward trend in reservoir storage has implications to the Delta ecosystem.

GFDL-A2 Reservoir Storage

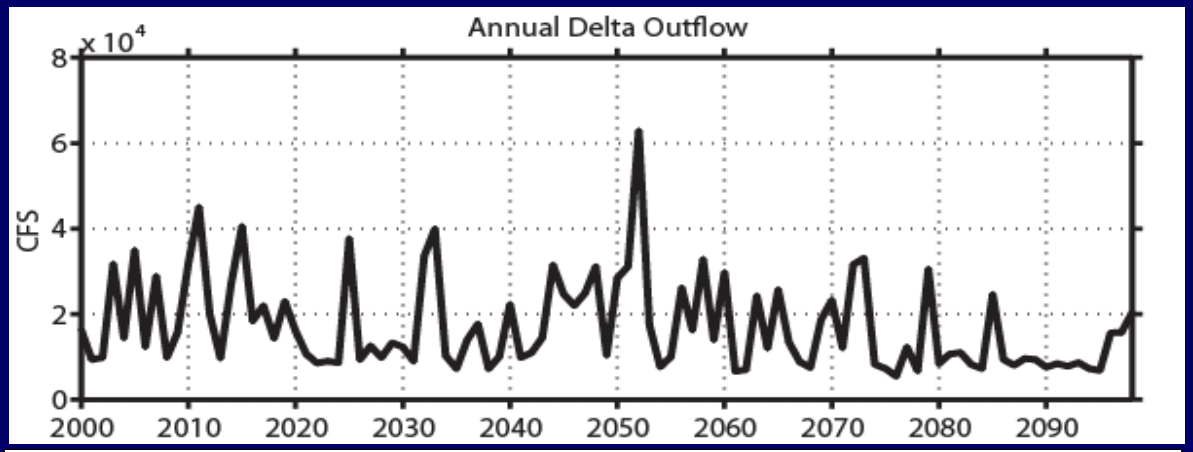


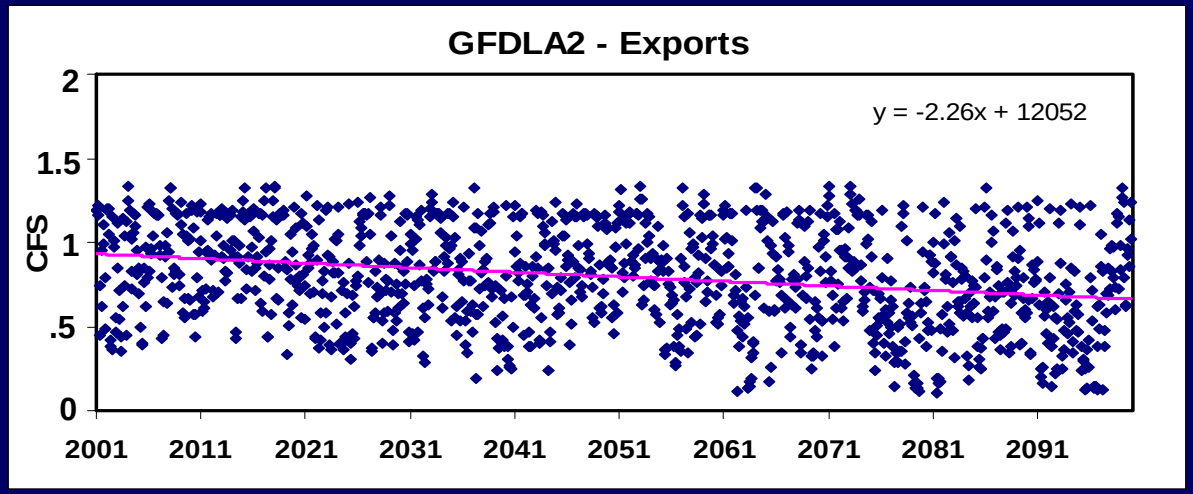

North




South

# The reduction in reservoir storage will result in reduced freshwater into the Bay and an overall trend downward in exports.





http://www.chinadaily.com.cn/china/2006-08/17/xin_3308031717203692474511.jpg

The system is presently "maintained" by dikes that may breach at single locations or catastrophically at multiple locations.

# 2 Structures

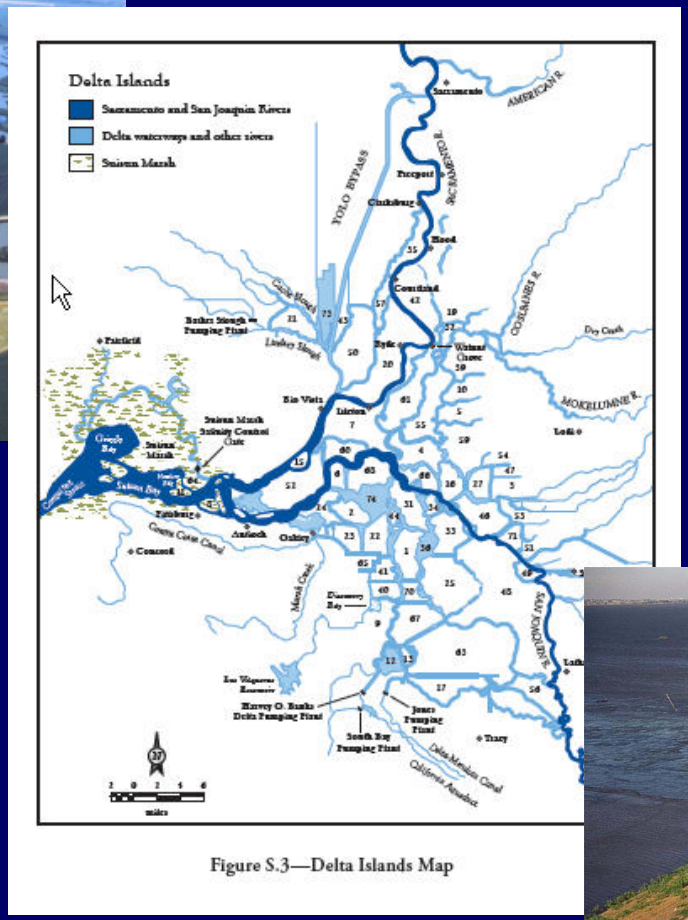
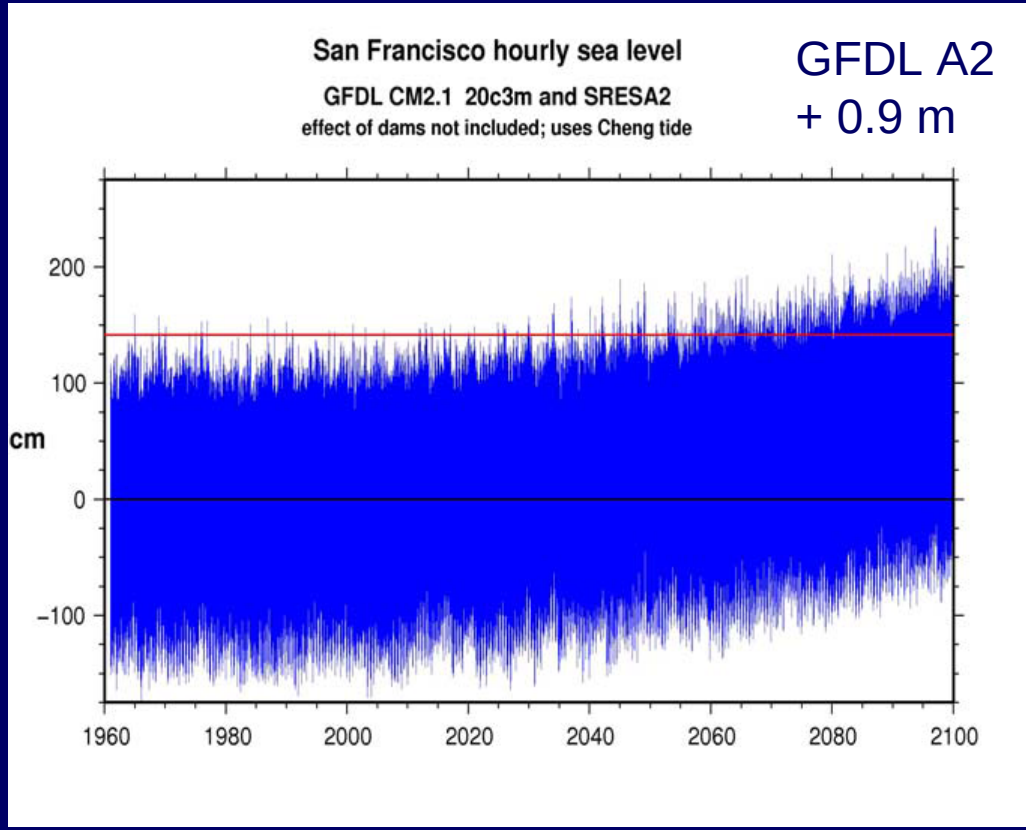


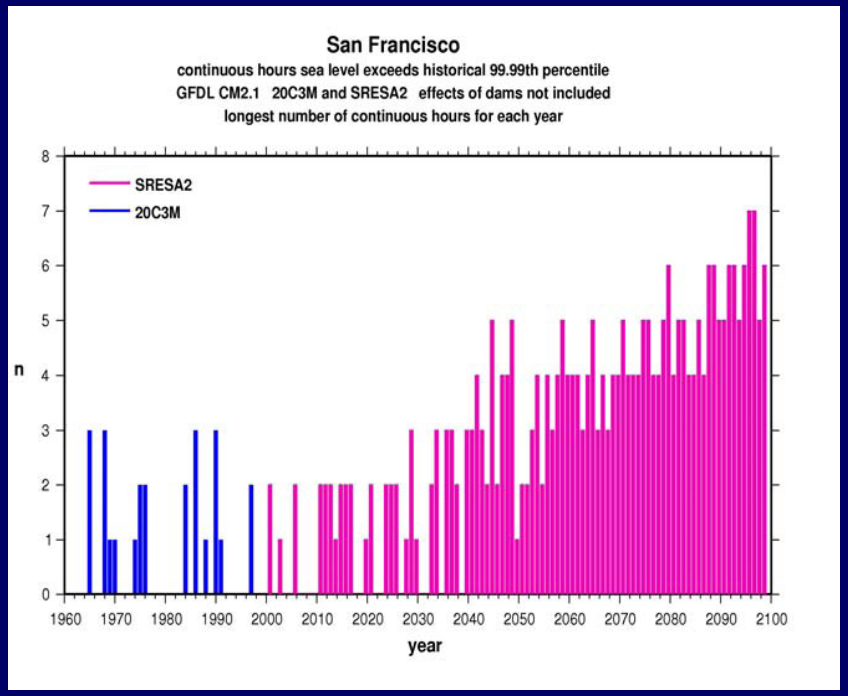

Figure S.3—Delta Islands Map

We find that under our scenarios, sea level rises considerably by 2100, which is likely to strain natural and anthropogenic structures.



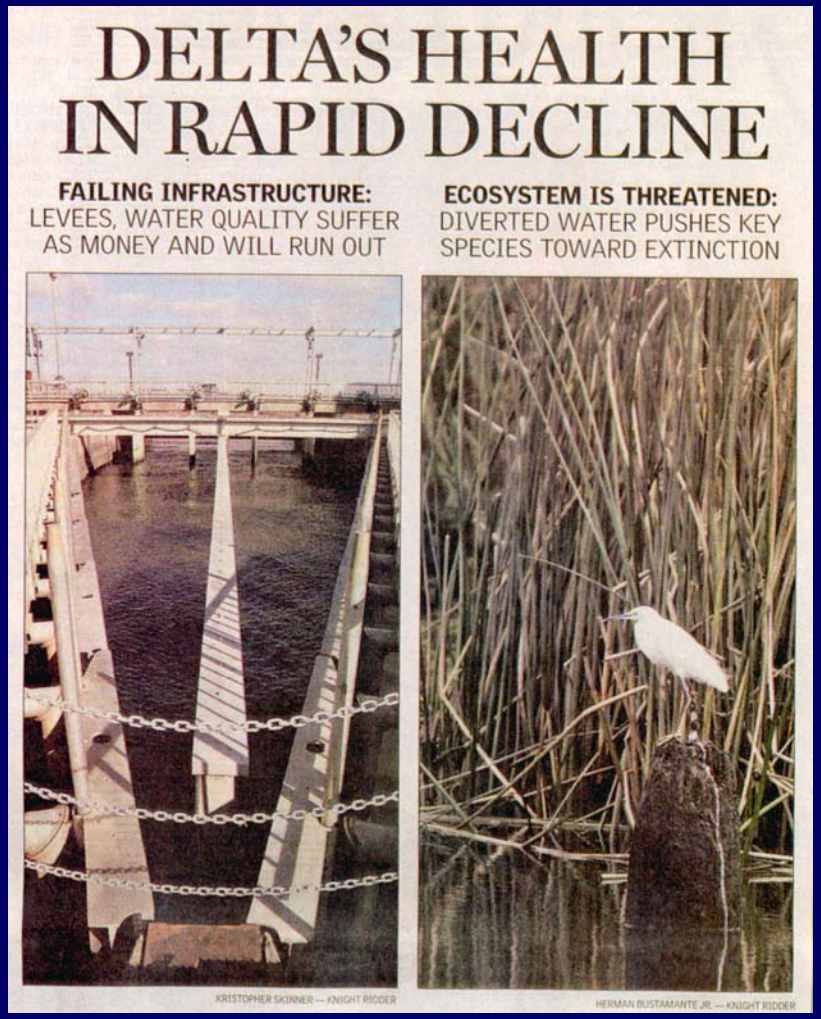

Dan Cayan: Global Climate and Sea Level Model
Jan 29 8:50AM

http://swr.nmfs.noaa.gov/hcd/HCD_webContent/nocal/SFBAYrestPrgm.htm




The frequency of high open coast sea levels in combination with large fresh water flows will increase considerably. The resulting combination of increased sea level & storm surges may prove catastrophic to some structures and stressful to some wetlands & restorations.

The stress between water for people and water for the ecosystem will get greater.



DELTA'S HEALTH IN RAPID DECLINE

**FAILING INFRASTRUCTURE:** LEVEES, WATER QUALITY SUFFER AS MONEY AND WILL RUN OUT

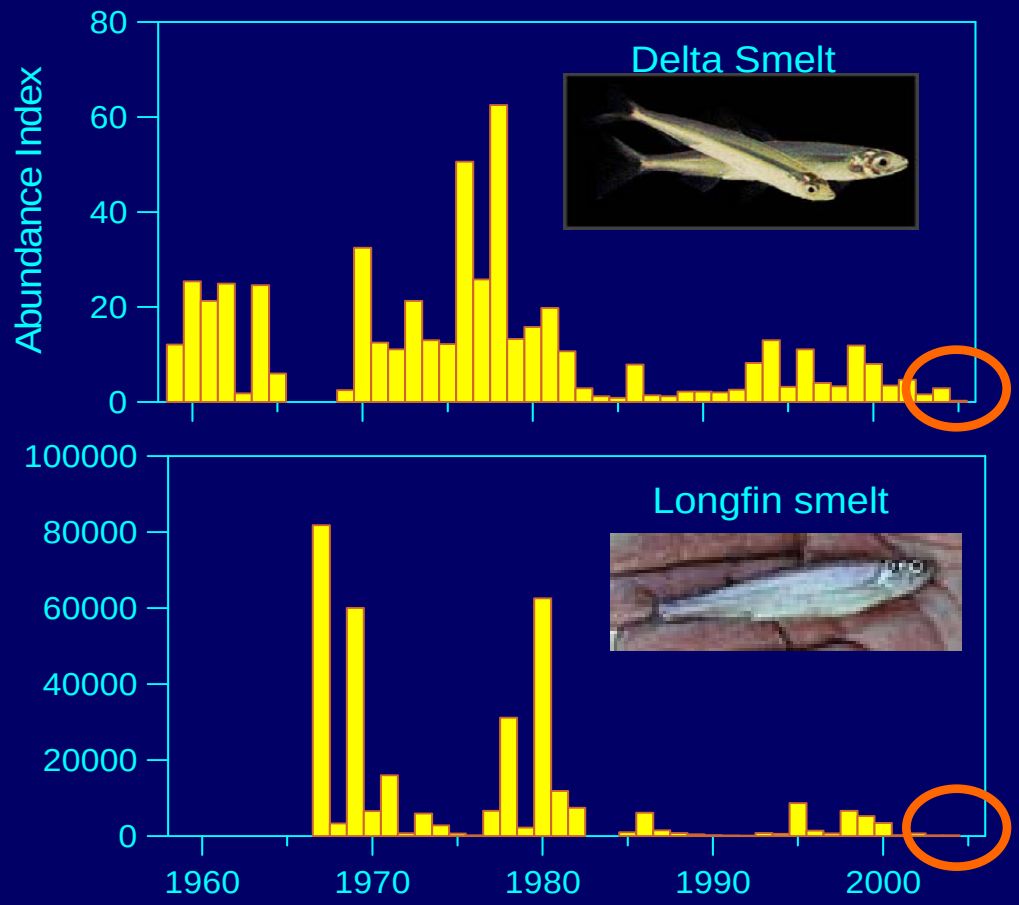
**ECOSYSTEM IS THREATENED:** DIVERTED WATER PUSHES KEY SPECIES TOWARD EXTINCTION

KRISTOPHER SKINNER — KNIGHT RIDDER

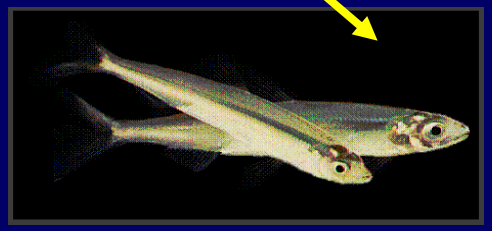
HERMAN BUSTAMANTE JR. — KNIGHT RIDDER

# 3 Changing Salt Field

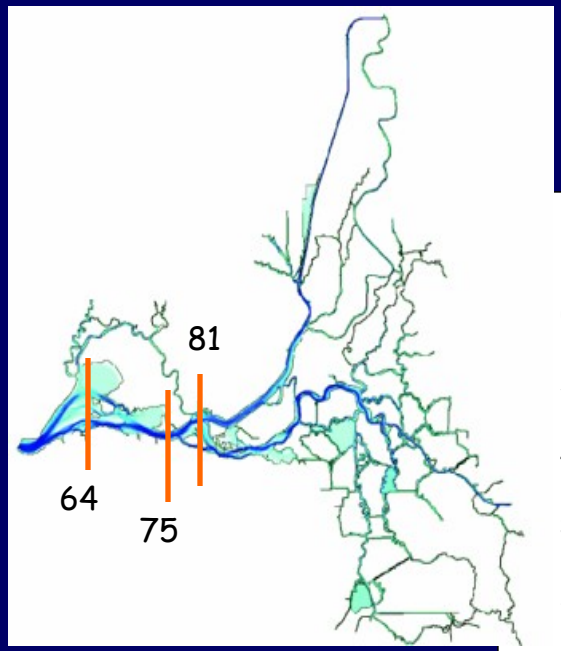
The decline of some fish species has resulted in listing species as threatened/endangered, altering freshwater exports, and causing ecologists to question if this is a food, habitat or contaminants problem.



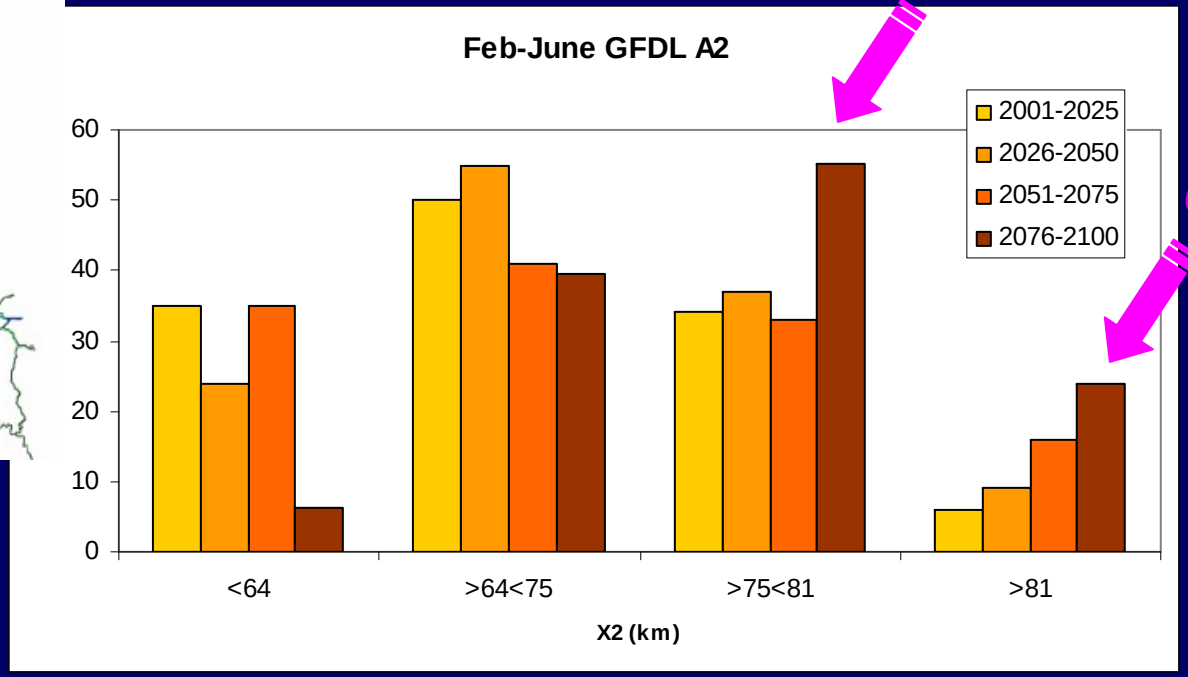

Have we altered the carrying capacity?



A salinity standard (X2) was developed to protect fish and water supply. The position of X2 in the estuary is correlated with the success of some fish species either due to habitat or food supply.



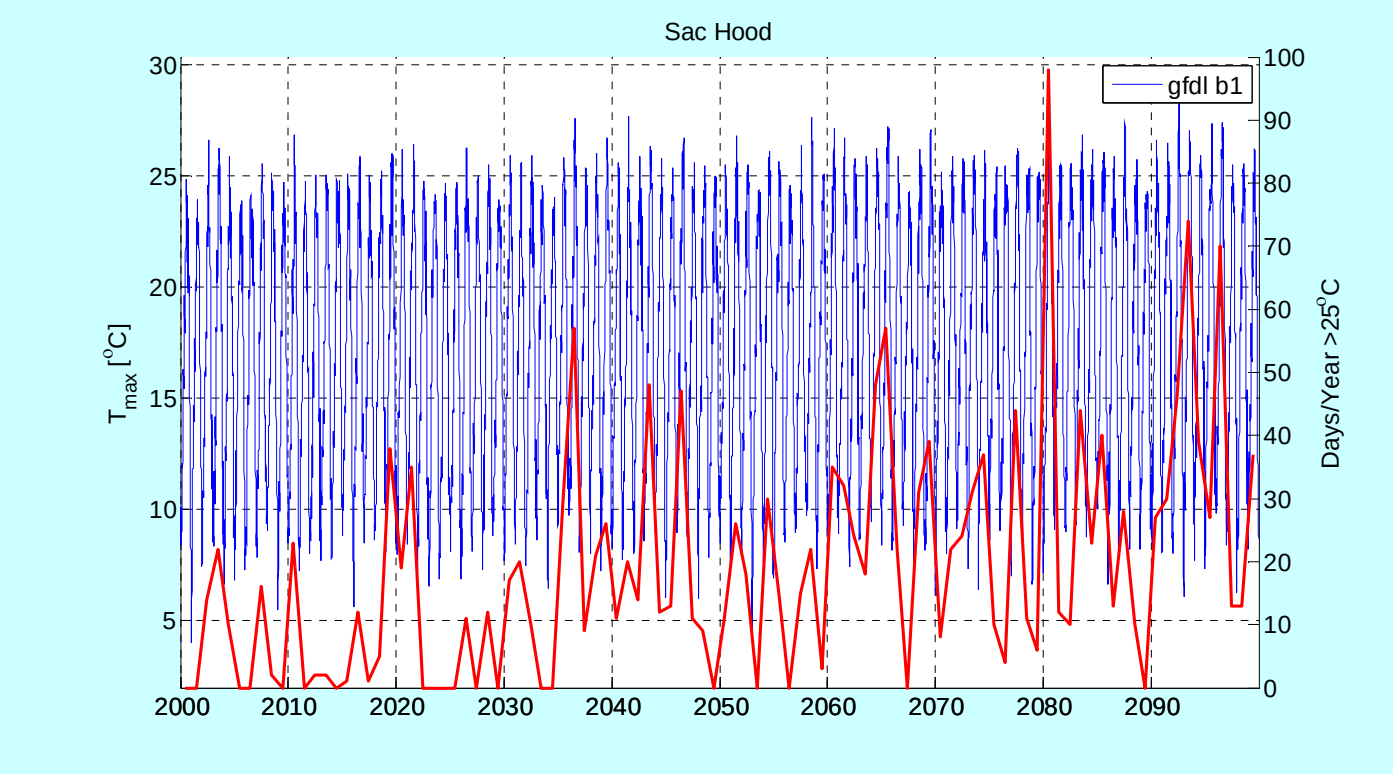

Ouch!




Ouch!

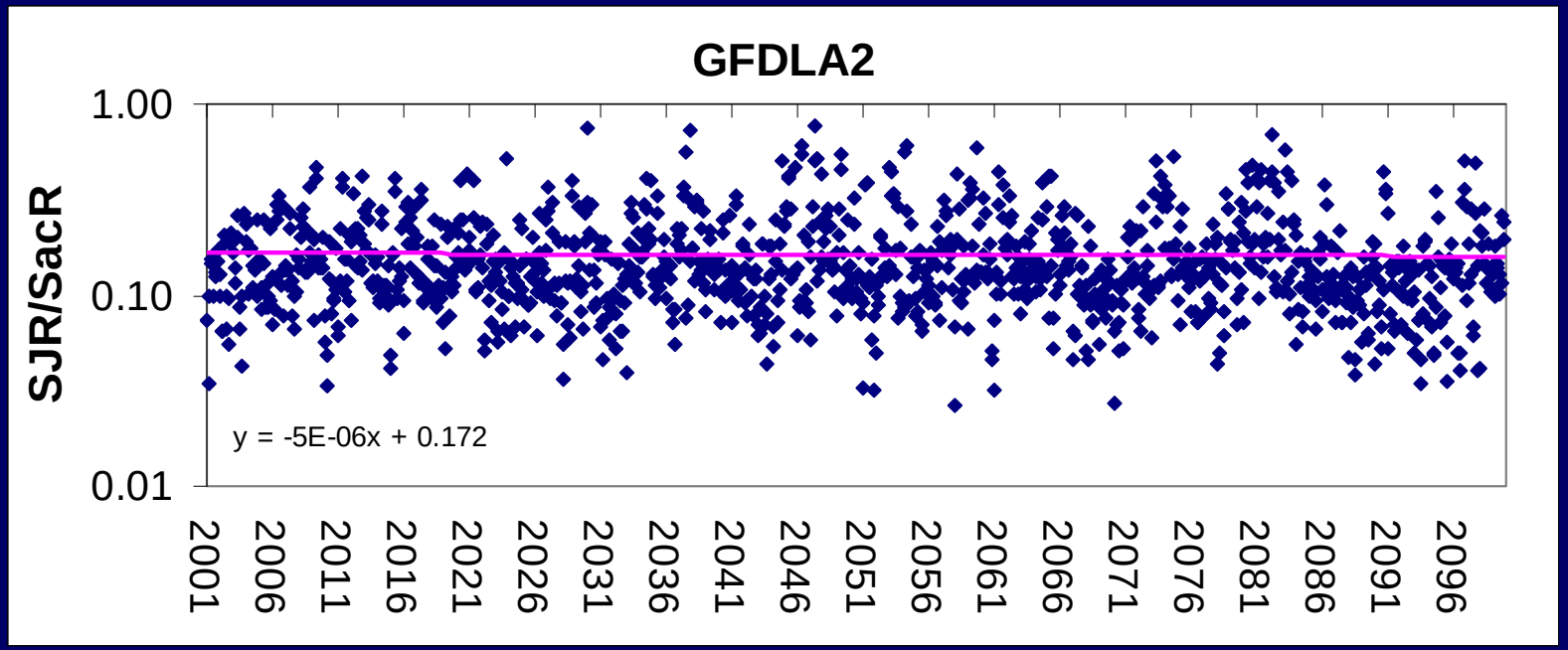
A sample message: it will be more difficult to maintain the standard.

We can also look for thresholds and change in frequency of thresholds within a time series to develop trends in stress for fish and biota.



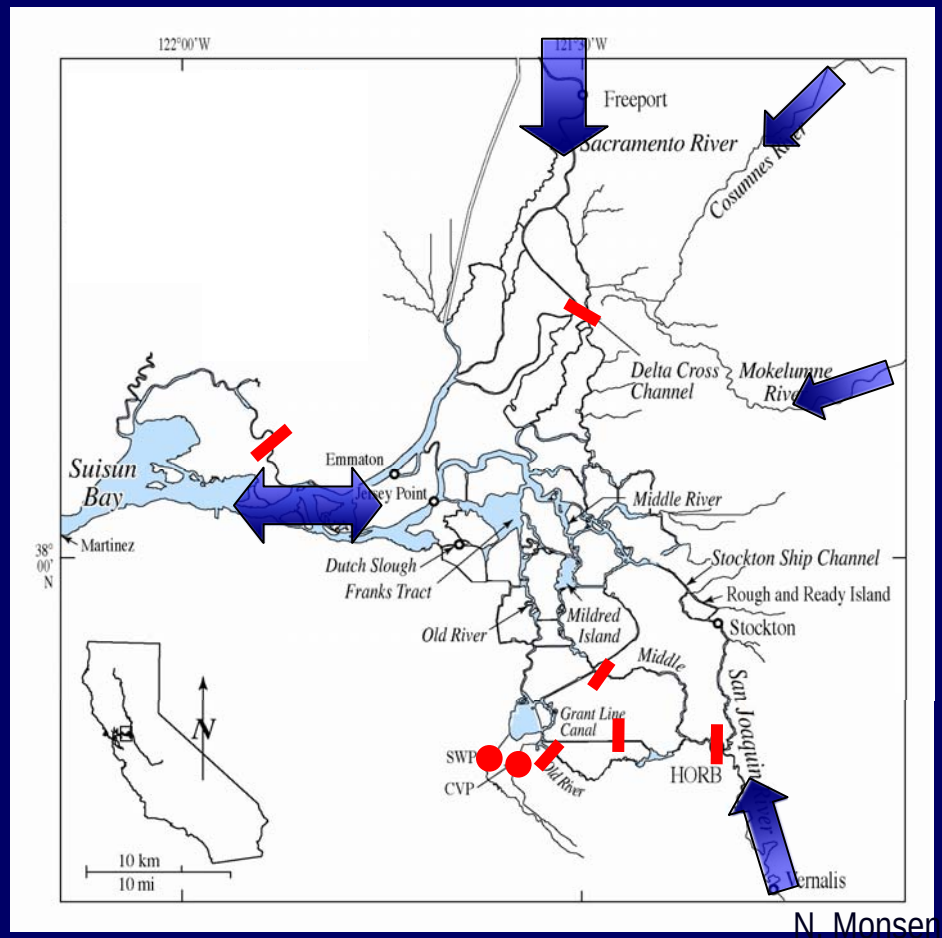

Larry Brown
Jan 30, 1:40PM, Session D

By looking at the trend in the ratio of the outflow of the two major rivers we can examine potential changes in contaminant sources to the Delta if the riverine sources remain constant. In this example we find the ratio to be constant.




That is interesting however…..

…ratios may mean little if present structures are altered or new ones built. Indices such as these give us a starting point for thought experiments while the hydrodynamic model can show us changes in mixing and transport.




N. Monsen

Nancy Monsen
Hydrodynamic
Model

# Where we started: "This is hard enough, let's not make it harder."

CASCADE was born from our desire to understand how climate change would interact with natural and anthropogenic changes in the system. It is not our goal to predict change. It was and is a tool building exercise. Second, by using scenarios we can examine trends and thresholds for systems most at risk without the ever present distraction of which climate model is best.