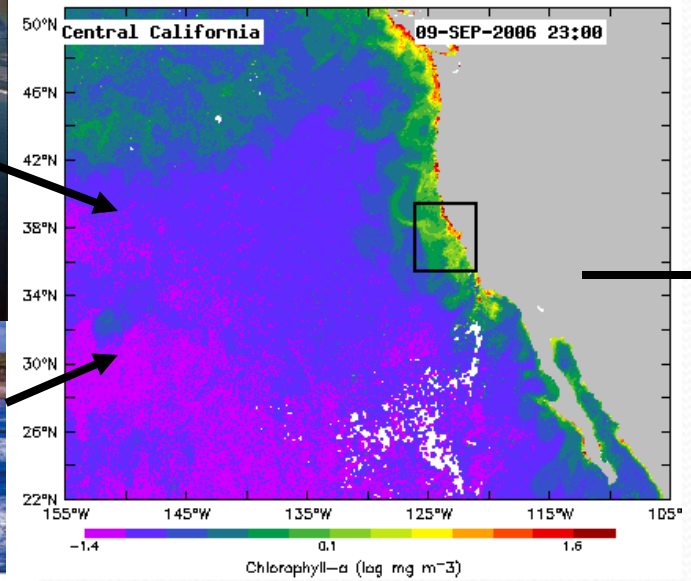
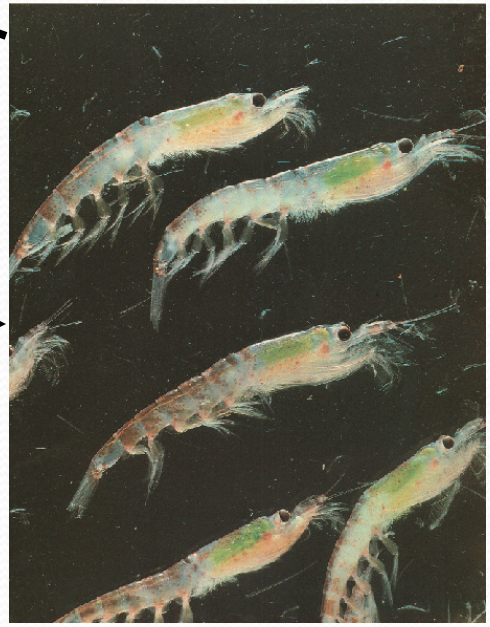
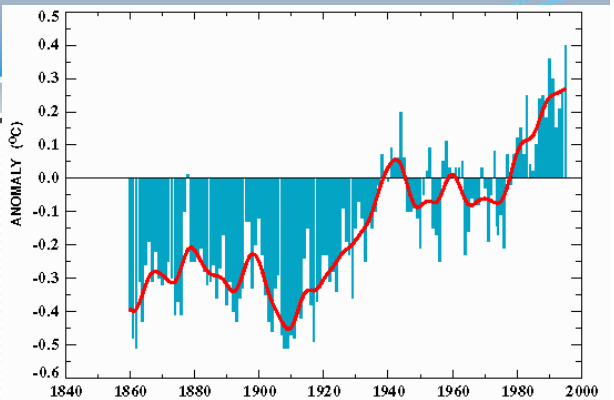
Think Like a Fish:
How Climate Change Affects Marine Populations

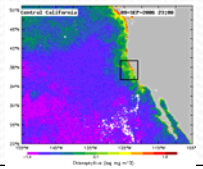
Frank Schwing
NOAA Fisheries
Southwest Fisheries Science Center/
Environmental Research Division
Pacific Grove CA

“Bottom up” Ecosystem Drivers

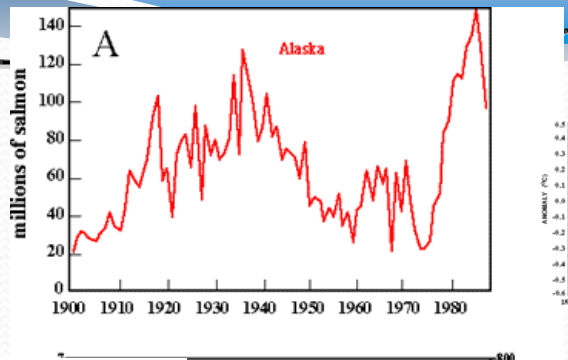


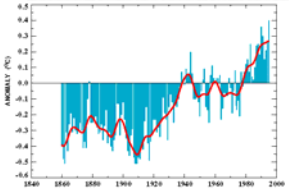


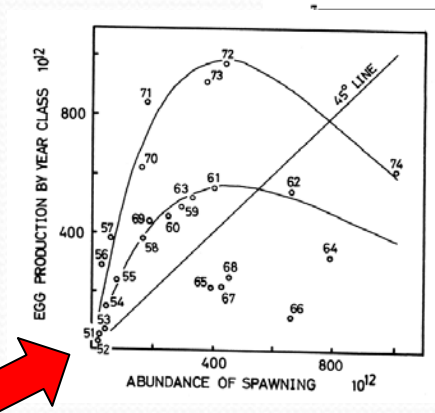


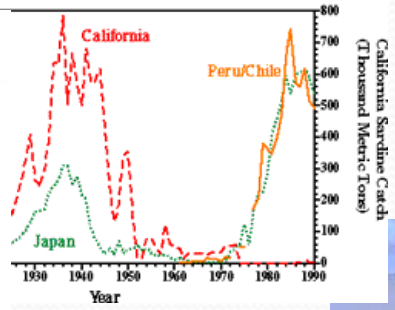


“Top down” & Human Drivers

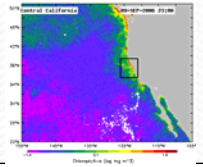


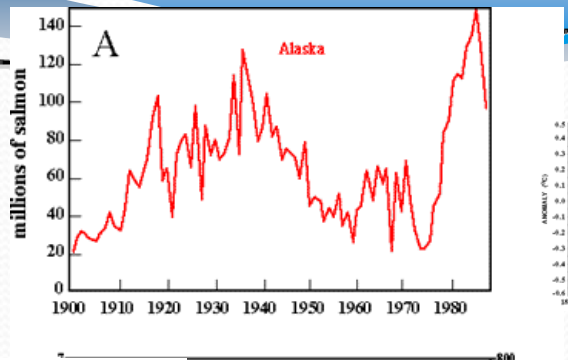


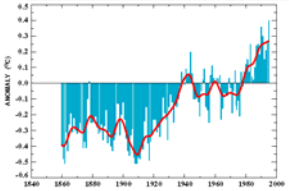


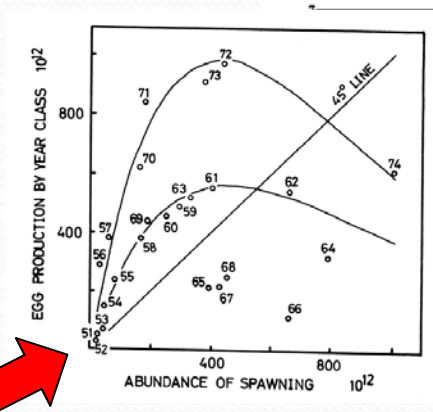


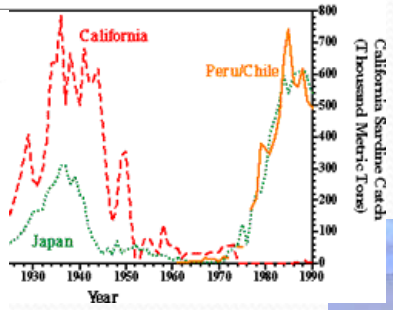
Organisms process their environment



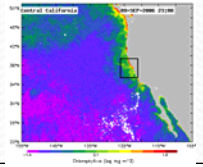








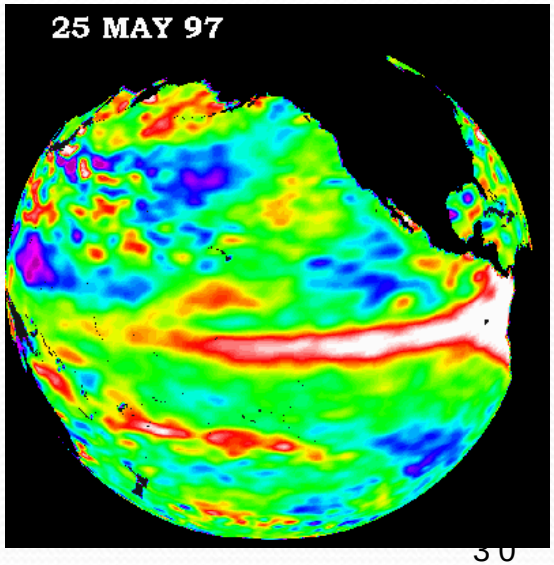
Scientists “Think Like a Fish”

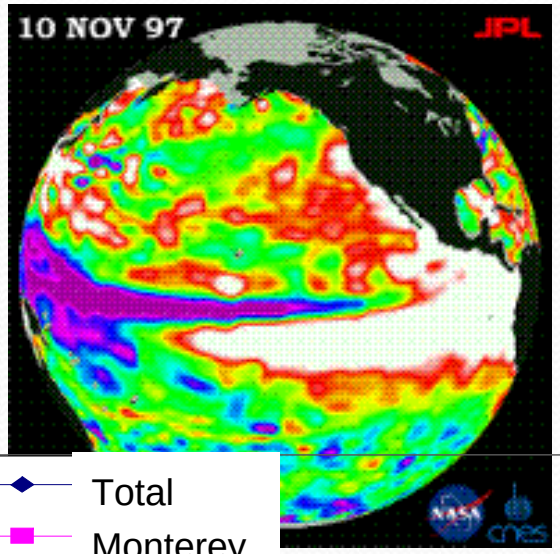


Key Questions

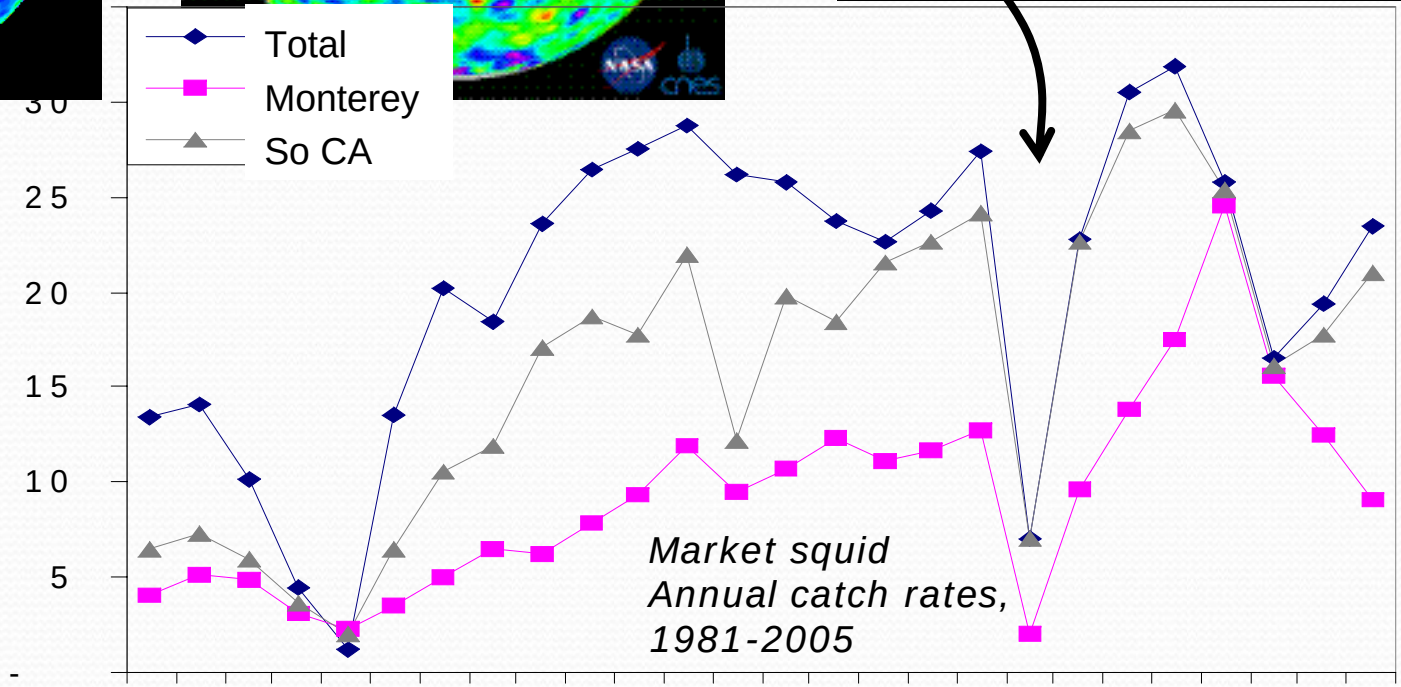
- What environmental factors shape marine ecosystems and their populations?
- How are they are influenced by climate and environmental variability?
- What are the primary ecological, economic, and cultural consequences?
- How will we mitigate and adapt to these impacts?

Interannual Variability Affects Catch

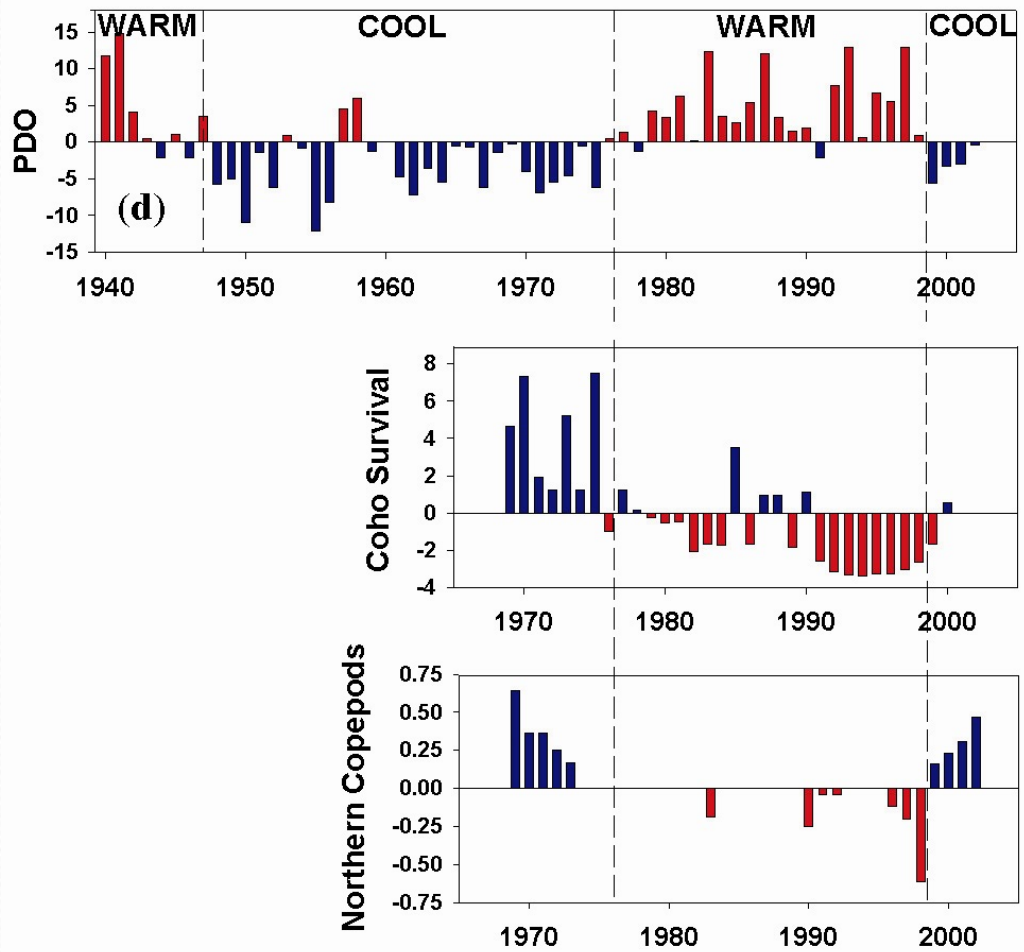




El Niño
(images from NASA)

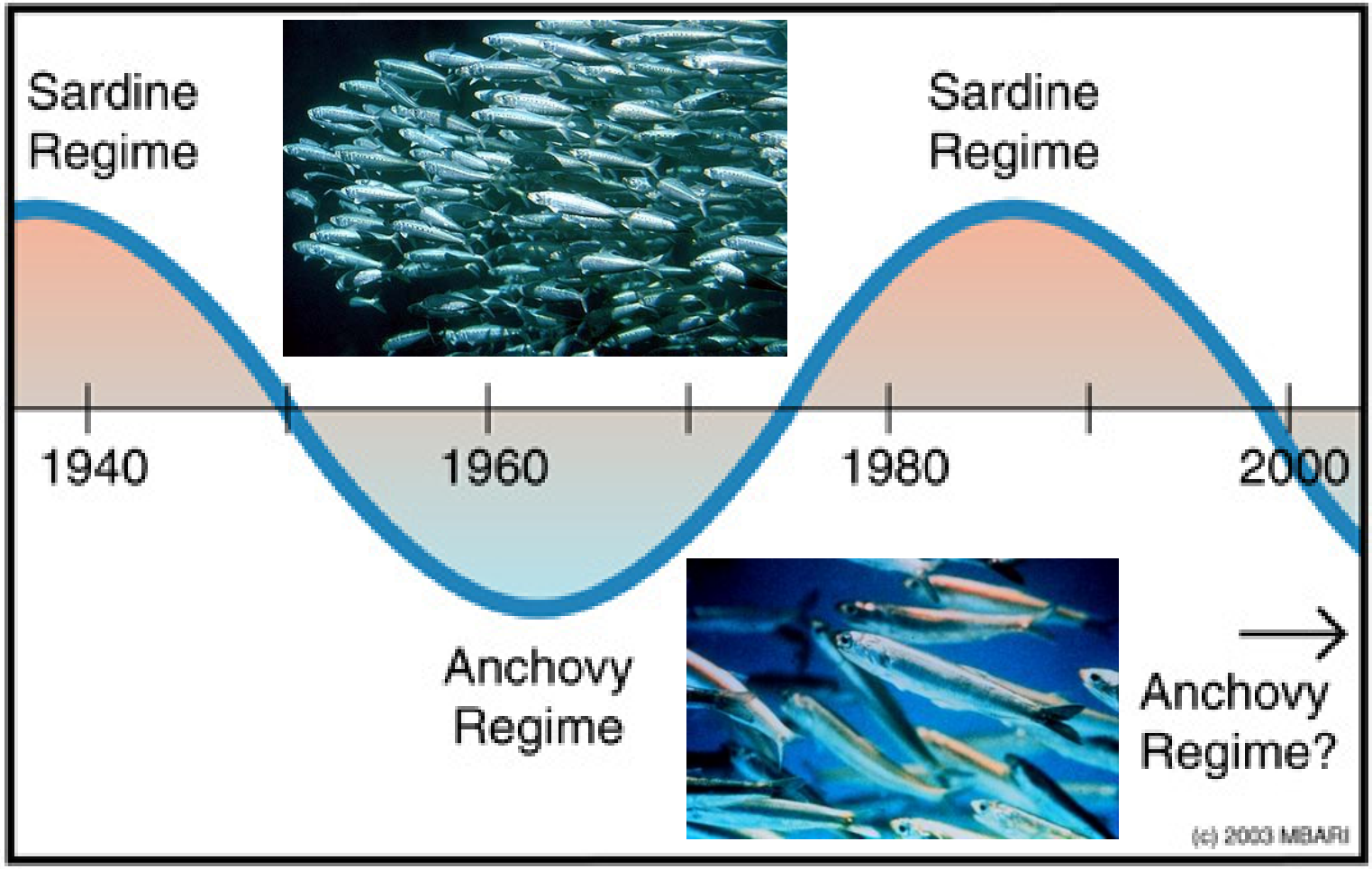


Interdecadal climate variability (regime shifts) changes ecosystem structure and productivity



(from Peterson and Schwing, 2003)

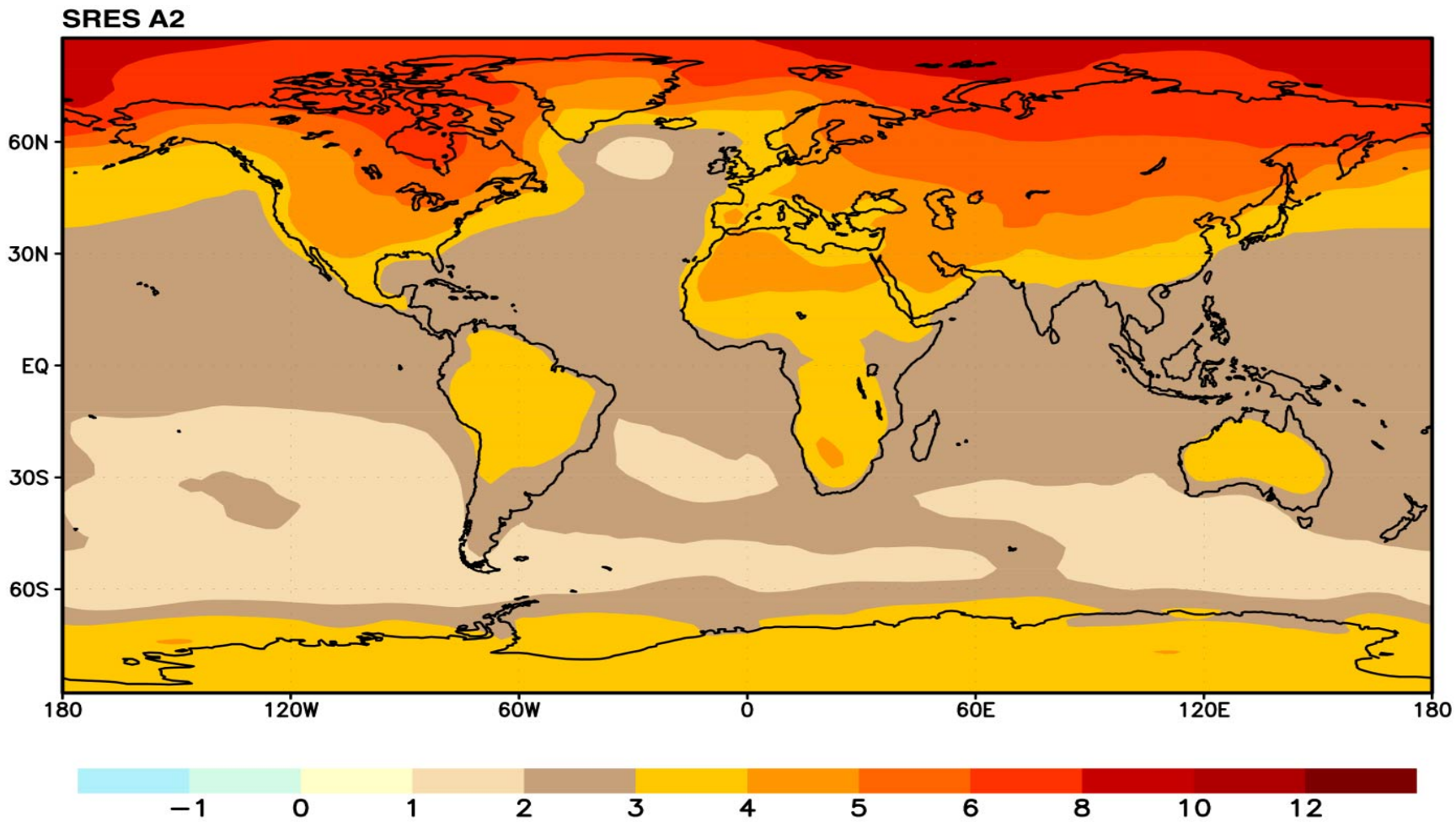
Regime Shifts Have Winners and Losers



Seven Climate Change Issues for California Ocean Resources

- Ocean warming: impacts on ranges, production, seasonal cycles, invasives
- Sea level rise
- Freshwater supply & management
- Ocean circulation and transport
- Ocean acidification & changing chemistry
- Increases in extremes and variability
- Attribution of climate signals impacting ecosystems: long term change vs. natural variability

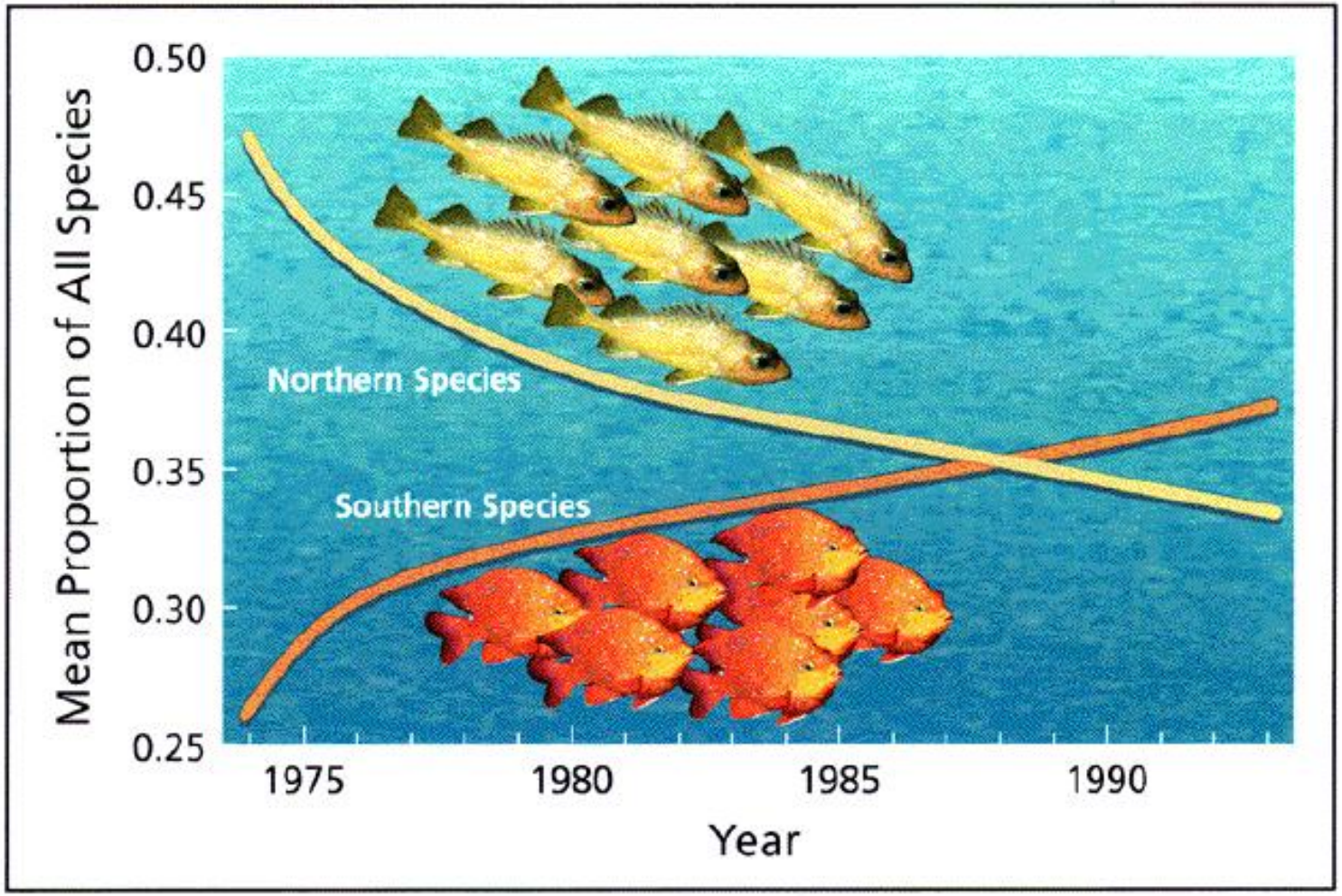
Land areas are projected to warm more than the oceans with the greatest warming at high latitudes



Annual mean temperature change, 2071 to 2100 relative to 1990:

Global Average in 2085 = 3.1°C

Warming Seas – Shifting Populations



(from Union of Concerned Scientists)

Earlier Seasonal Snowmelt and Runoff

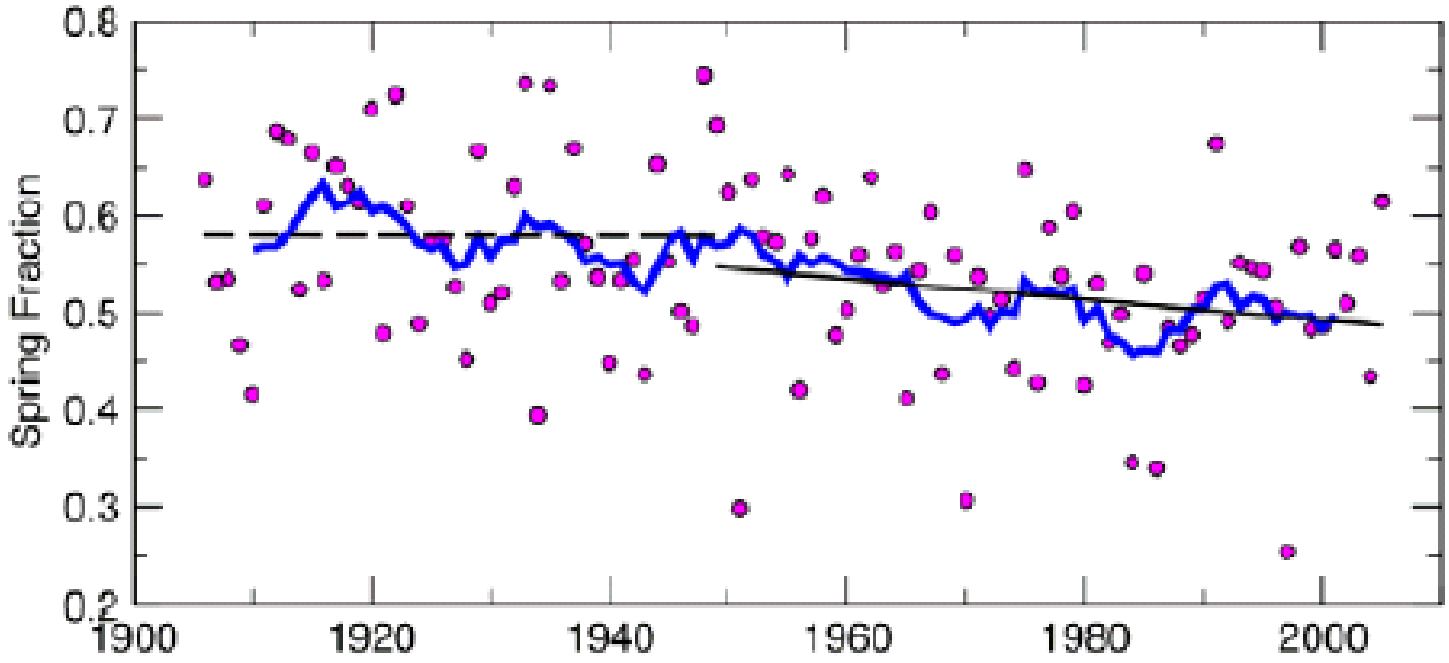
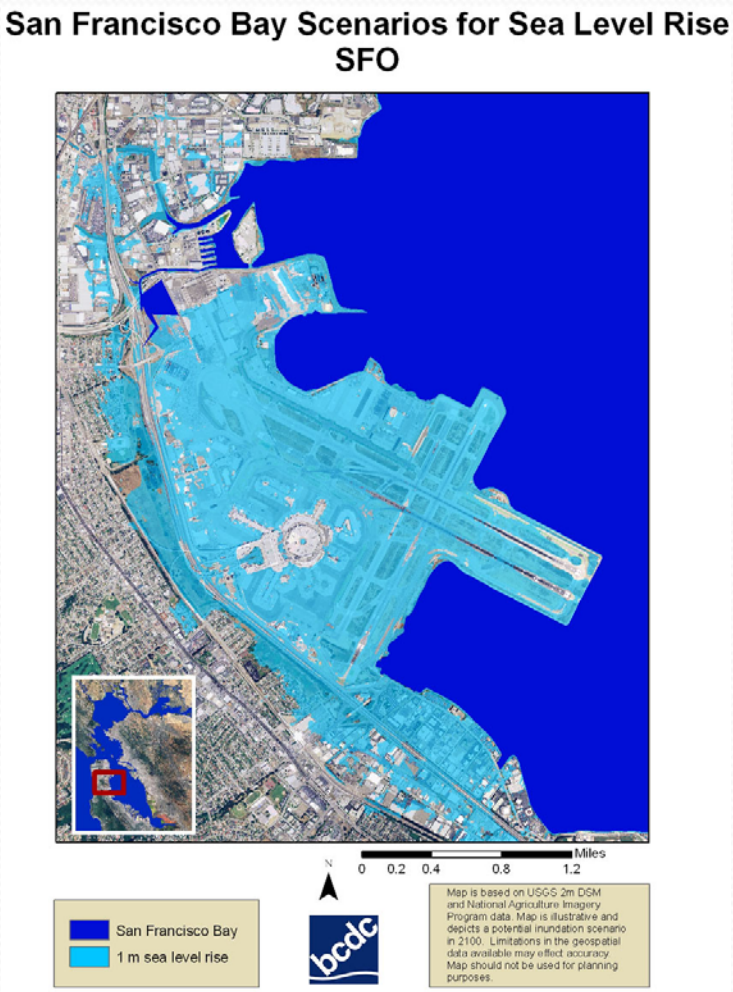
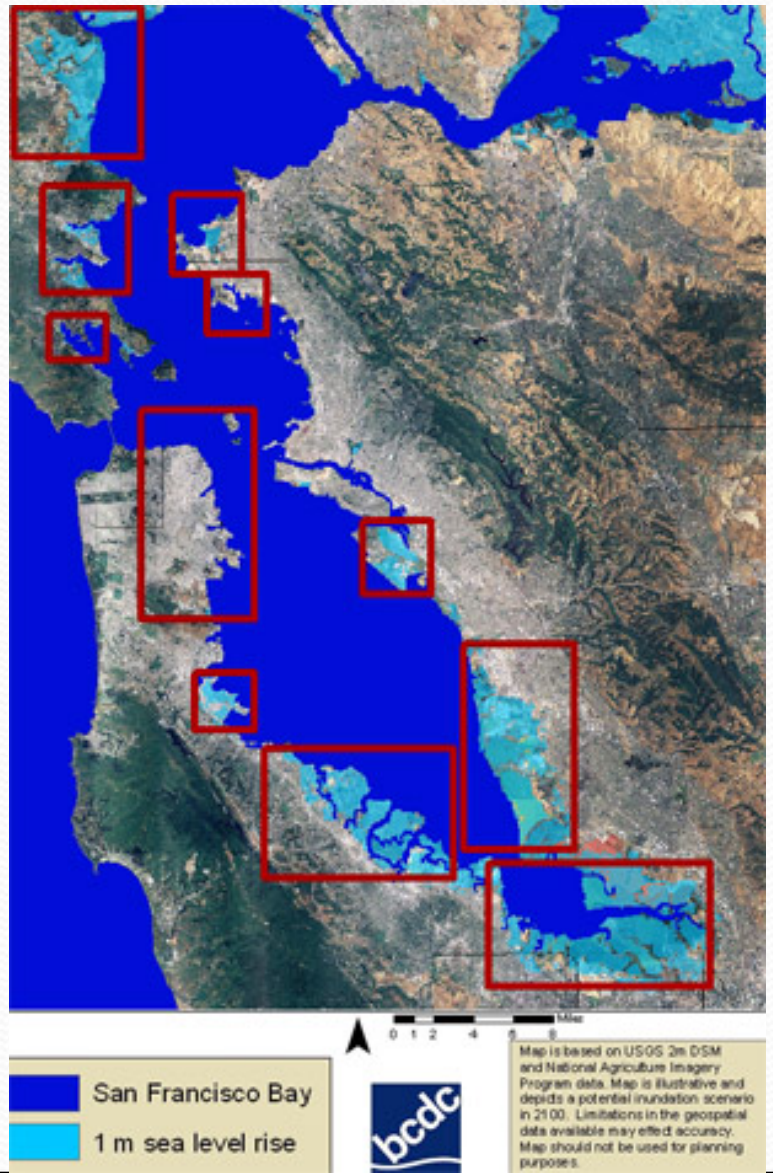


Figure 2-17 Annual April through July Unimpaired Runoff in the Central Valley Compared to Total Unimpaired Annual Runoff

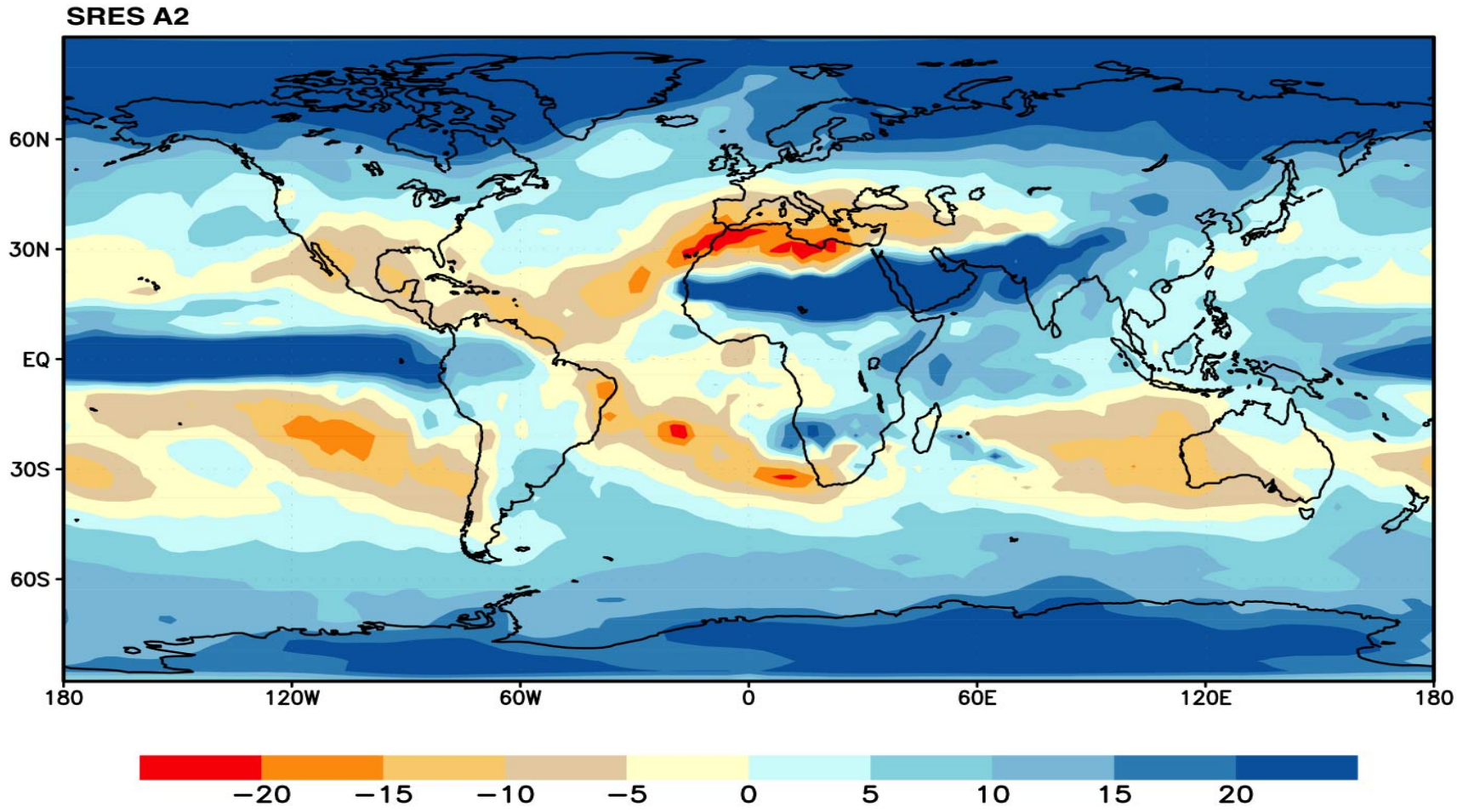
Source: Dettinger, 2005a. (Updated by original author).
Explanation: Individual points depict yearly combined values for the Sacramento River at Bend Bridge (near Red Bluff), Feather River into Lake Oroville, Yuba River at Smartville, American River below Folsom Reservoir, Stanislaus River into New Melones Reservoir, Tuolumne River into Don Pedro Reservoir, Merced River into Lake McClure, and Kings River into Pine Flat Reservoir. The blue curve is the nine-year moving average of annual values. The dashed line is the linear trend prior to 1945. The solid line is the linear trend after 1945.

SF Bay - 1m Sea Level Rise Projection



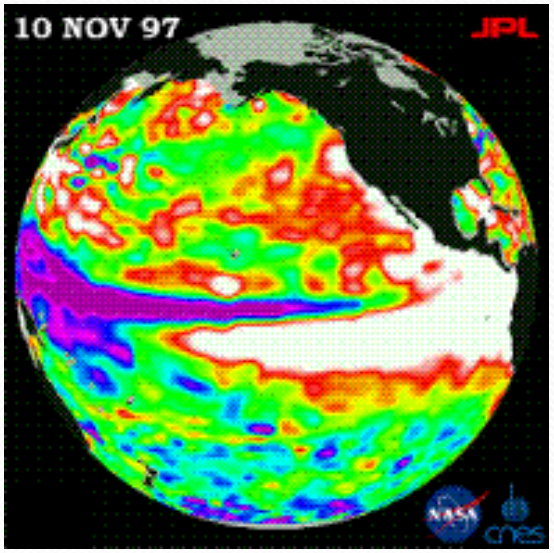


Some areas are projected to become wetter, others drier with an overall increase projected



Annual mean precipitation change: 2071 to 2100 Relative to 1990

Enhanced Extreme Climate Events



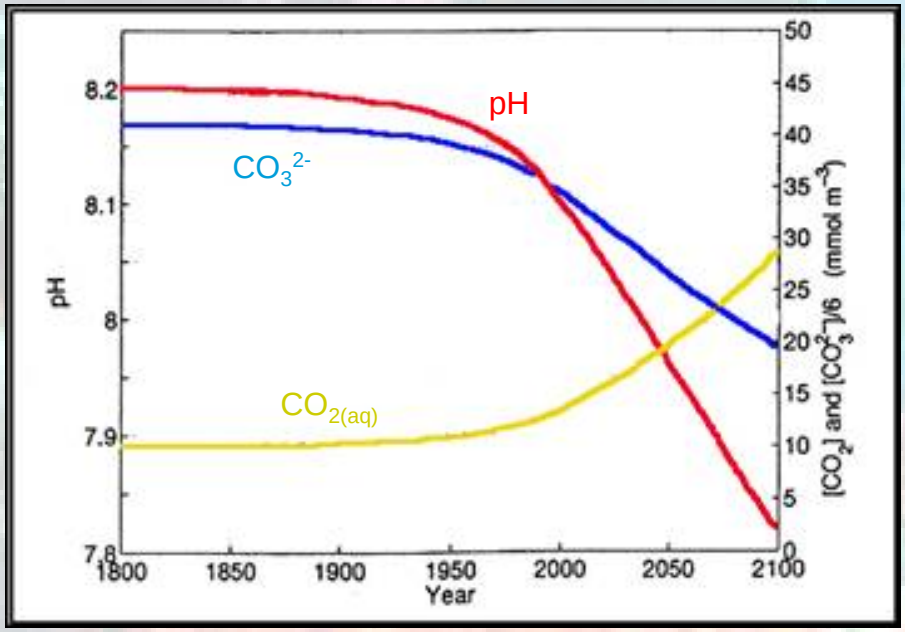
(NASA)

(USGS)

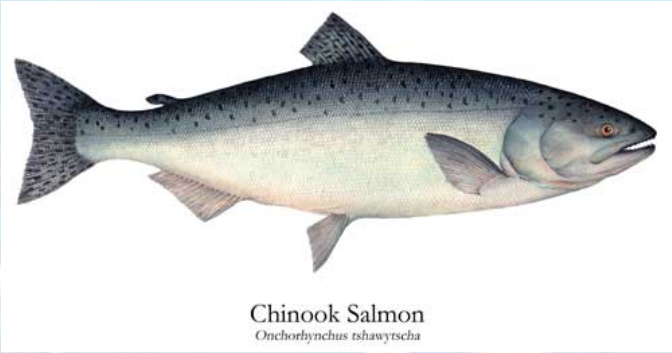
(USGS)

(USGS)

Ocean Acidification: A Consequence of Greenhouse Gasses



Wolf-Gladrow et al., 1999



- Potential impacts on shelled plankton, coral reefs (shallow and deep), bivalves and crustaceans, and food chains

Summary

- Climate change is natural, as well as human-induced
- Climate change is global, but ecological and human effects are local/regional
- Global climate change is already impacting California
  - *Water resources will be most critically impacted*
  - *Rising temperatures & sea level have ecological consequences*
  - *Extreme events and seasonal shifts a growing concern*
  - *Acidification is an unknown*
- Coastal regions *relatively* insulated from climate change

Research Priorities

- Ecological **observations** to detect the impacts of climate variability and change on coastal ecosystems, at local and regional scales
- Climate-forced bio-physical **models** to aid in resource management
- Ecological **indicators** to document the impacts of climate variability on ecosystems
- Regular **assessments** of ecosystem status and tendency for management and decision-making
- Climate **information** integrated into management plans and decisions

Management Actions

- Reduce carbon and GHG emissions
- Make science-based decisions, focused on most critical impacts of climate change
- Reduce other pressures on natural and human systems
- Prepare infrastructure for adaptation & mitigation
- Enhance system resilience
- Utilize Integrated Ecosystem Assessments (IEAs) and other decision support tools