CALIFORNIA DEPARTMENT OF FISH and WILDLIFE

Focus on Marine Resources

2014 Climate College

2014 Climate College – Lecture #2
March 10, 2014
1:00 PM - 3:00 PM

CDFW CLIMATE COLLEGE
California Department of Fish & Wildlife

NOAA Southwest Fisheries Science Center
Main conference room (Room 188)
110 Shaffer Road, Santa Cruz, CA

Welcome

CALIFORNIA DEPARTMENT OF FISH and WILDLIFE

Focus on Marine Resources

2014 Climate College

Reminders:

- CDFW Staff: please register for training certification (non-CDFW registration – reminders)
- Unit/Program-level recognition (check web page for updates on how to apply)
- First of four classes held near coastal areas throughout the state (remainder in Sacramento)
- Tribal perspectives on marine ecosystem management

CALIFORNIA DEPARTMENT OF FISH and WILDLIFE

2014 Climate College

Climate Science Program

- Activities
- Resources
- CDFW Climate College
- CDFW Climate Stakeholders
- CDFW Going Green
- Climate Change Case Studies
- Vulnerability Assessment Tools
- For Teachers
- National Adaptation Forum
- Western Association of Fish and Wildlife Agencies
- Director's Bulletins
- Legislation and Policy

CDFW Climate Science and Renewable Energy Branch
1416 9th Street
Sacramento, CA 95814
climatechange@wildlife.ca.gov

Home » Climate and Energy » Climate Change » Climate College

2014 California Department of Fish and Wildlife Climate College

In Spring 2014, CDFW will hold the second iteration of its Climate College, this time focusing on the state's Marine resources and featuring tribal perspectives on marine ecosystem management.

CDFW CLIMATE COLLEGE
California Department of Fish and Wildlife

The CDFW Climate College is intended to provide a basic foundation of knowledge for all staff and partners on climate change science and its impacts to fish, wildlife, and habitats. This iteration of the course will focus on how climate change affects the state's marine resources to enhance participants' understanding of marine-related climate change science, impacts to species and habitats, and the implications for marine region management and planning. In the interest of developing stronger partnerships between tribal nations and the Department, this course is being developed as a collaborative effort with tribal representatives, and will introduce traditional ecological knowledge (TEK). TEK can be defined as the "holistic, evolving practices and beliefs passed down through generations about the relationships of living beings to their environment" (Swinomish 2010, in National Strategy, 2013).

The course will describe California's unique challenges and opportunities in managing its 1,100 miles of coastline, bays/estuaries, and marine protected areas under climate impacts. The course will also discuss case studies to show examples of responses to climate impacts. Through this course, the Department will demonstrate California's continuing leadership in addressing climate impacts as well as managing natural resources through diverse input and coordination with similar efforts at the federal and local levels.

Lecture topics will cover atmospheric changes, physical oceanic changes, sea level rise, species response, and conservation planning. The lectures will also cover biological ocean changes such as primary productivity and related processes, and productivity/abundance/phenology. This course will also provide examples of adaptation strategies to address the issues discussed.

The course will consist of a 7-part lecture series scheduled to begin in February 2014, however specific course dates and times are still to be determined. Please check this web page for future updates. In the spirit of increasing climate literacy and partnership the course is **open to all partners and the public**. We encourage all who are interested to participate either in person or via WebEx.

http://www.dfg.ca.gov/Climate_and_Energy/Climate_Change/Climate_College/

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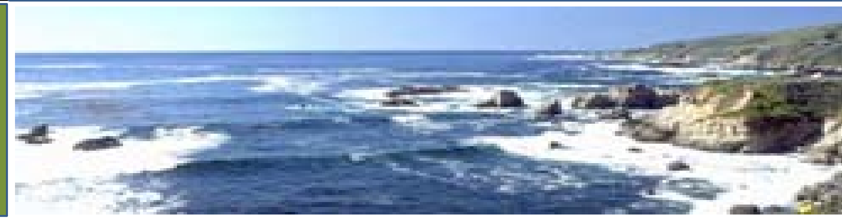


~For this class~

At the facility:

- Please sign in
- Please mute cell phones

Webex users:

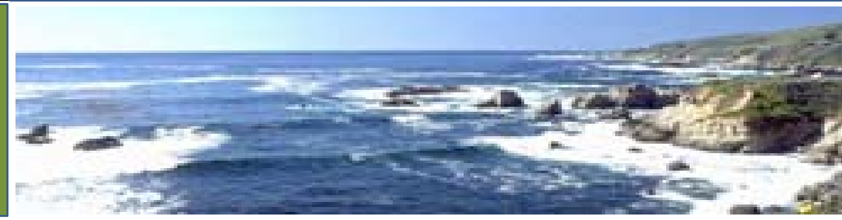
- Remote users will be muted for recording
- Please submit questions via “Chat” feature to the host following class presentation

Post-lecture discussion: Patrick Coulston, CDFW

CALIFORNIA DEPARTMENT OF FISH and WILDLIFE

Focus on Marine Resources

2014 Climate College



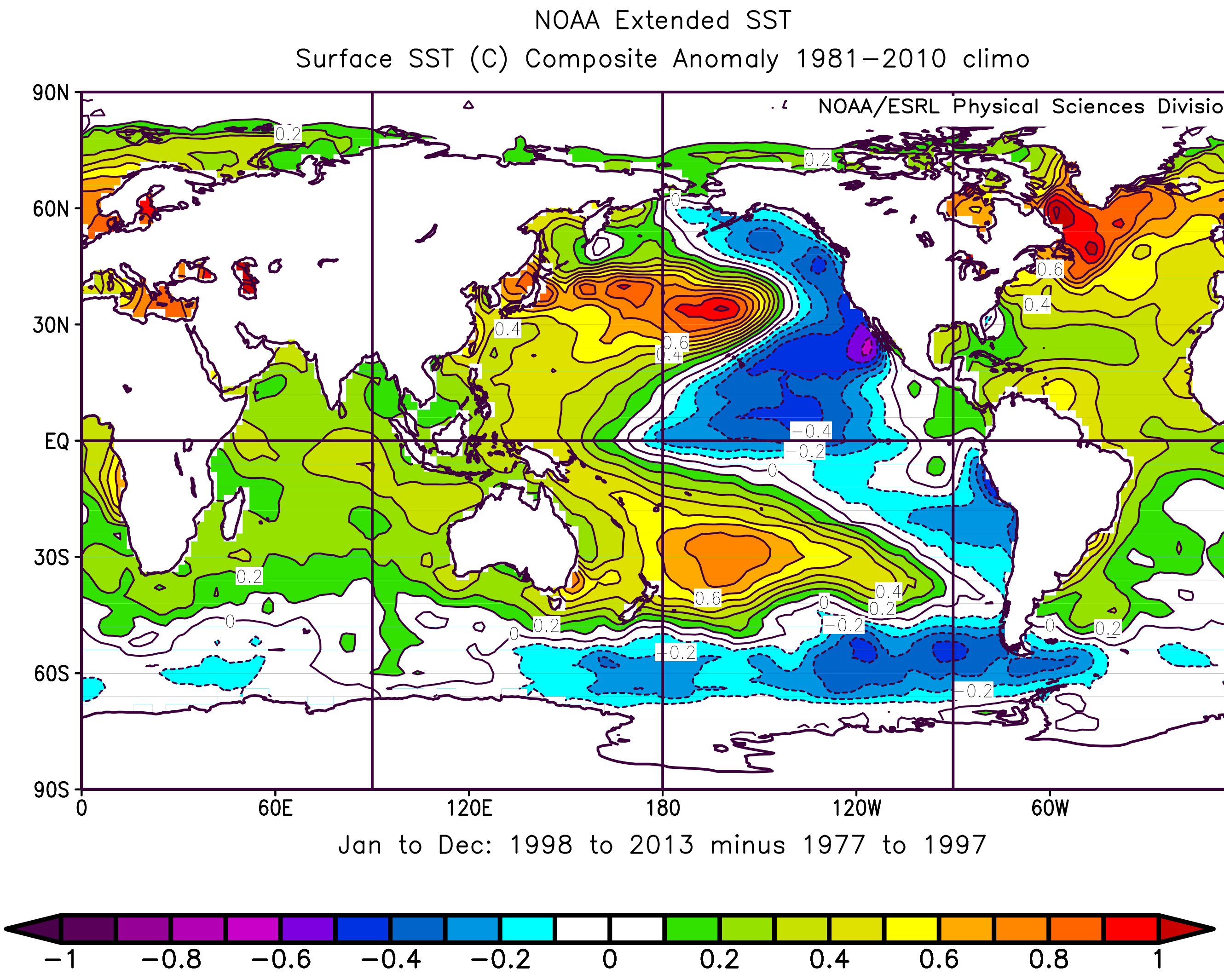
Nate Mantua
Research Scientist
NOAA
Southwest Fisheries Science Center

Climate Impacts on California's Marine Waters

Nate Mantua, NOAA/NMFS
Southwest Fisheries Science Center
Santa Cruz, CA

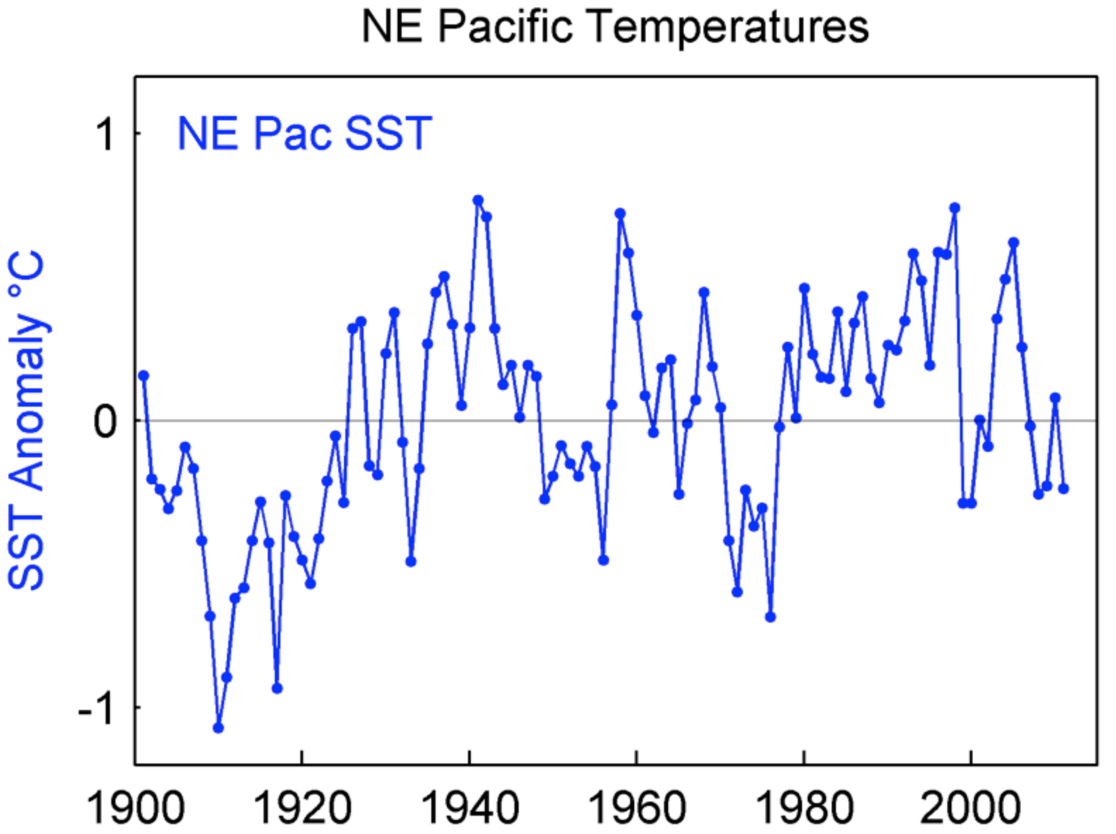
March 10, 2014

Global warming, but Eastern Pacific cooling: (1998-2013) – (1977-1997)



A rising baseline, with substantial variability

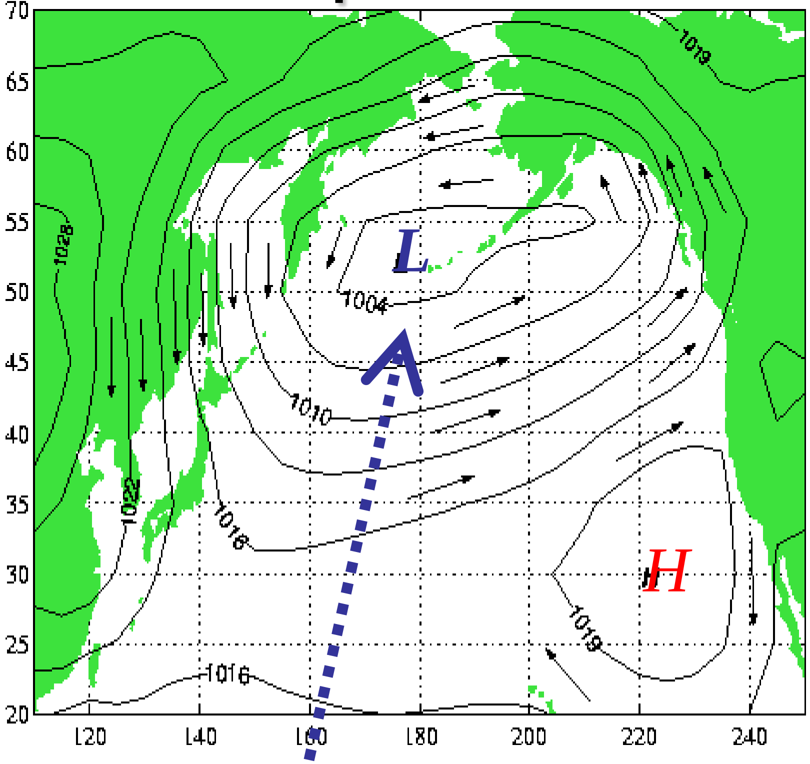
what's behind the trends and variations?



Outline for today's lecture

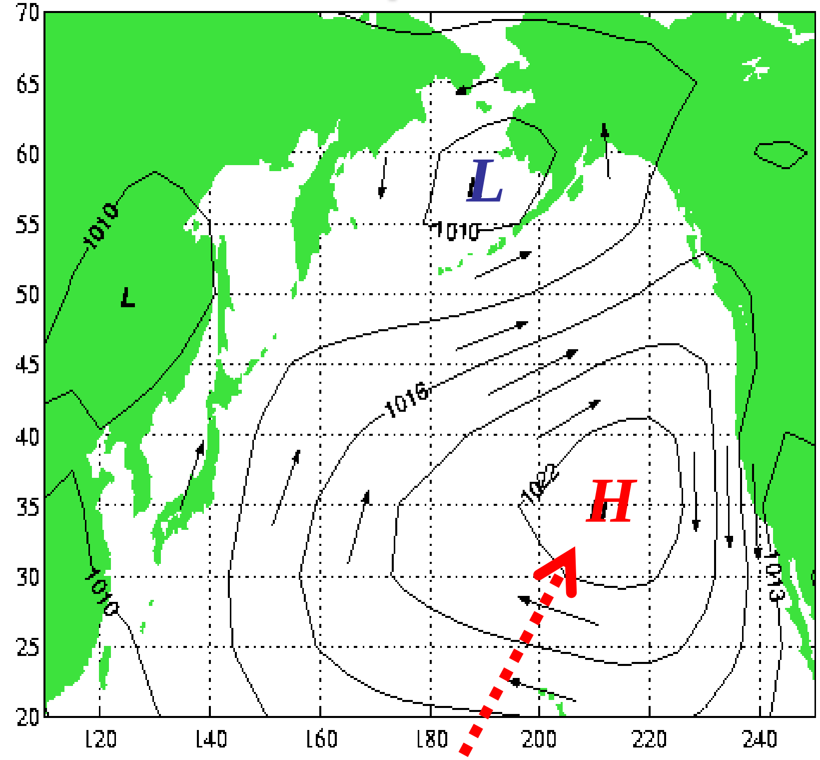
- The average year
- Variability between years and decades
- Future climate scenarios

Winter winds
(Oct-March)
and pressure

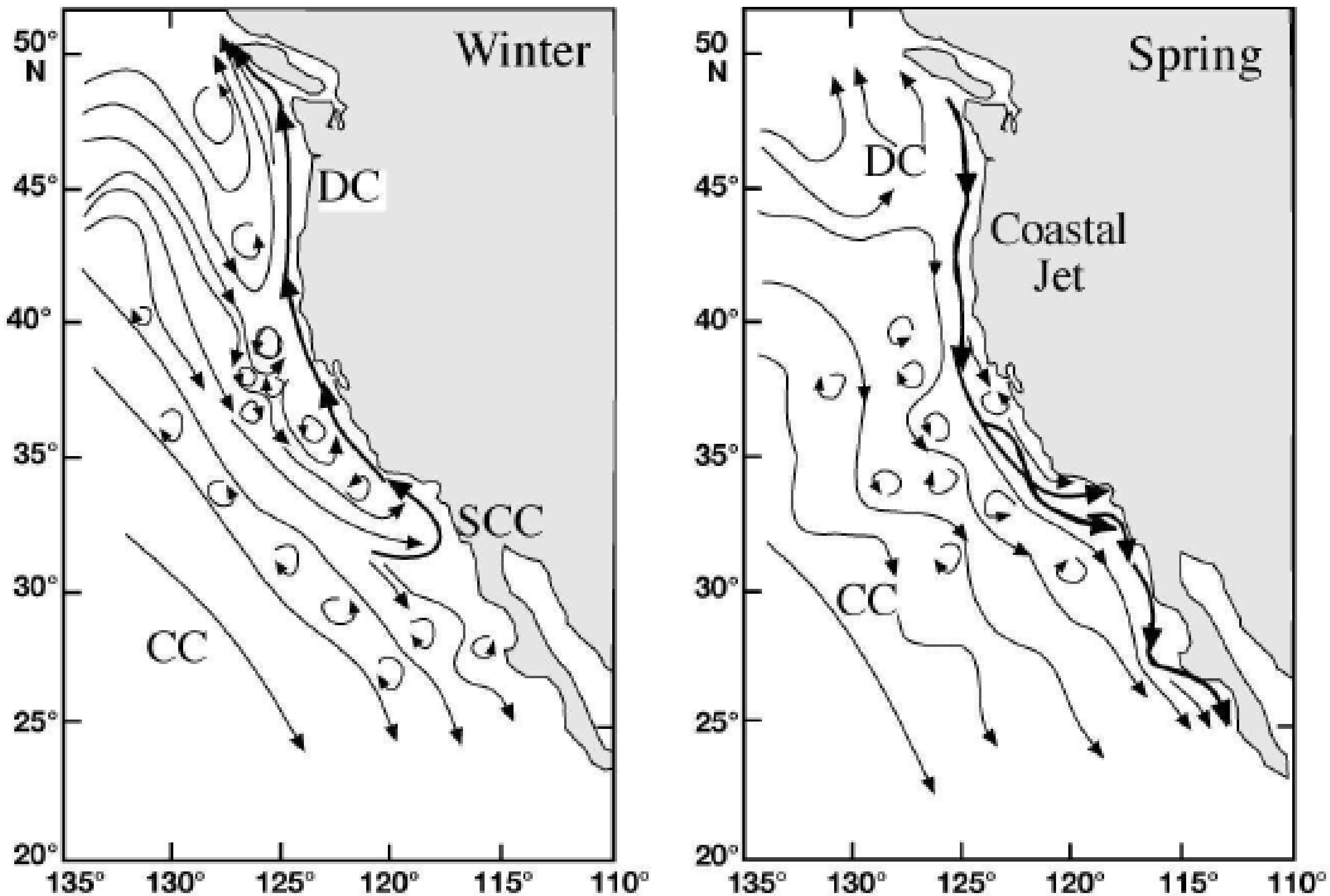


"Aleutian Low"

Summer winds
(April-Sept)
and pressure



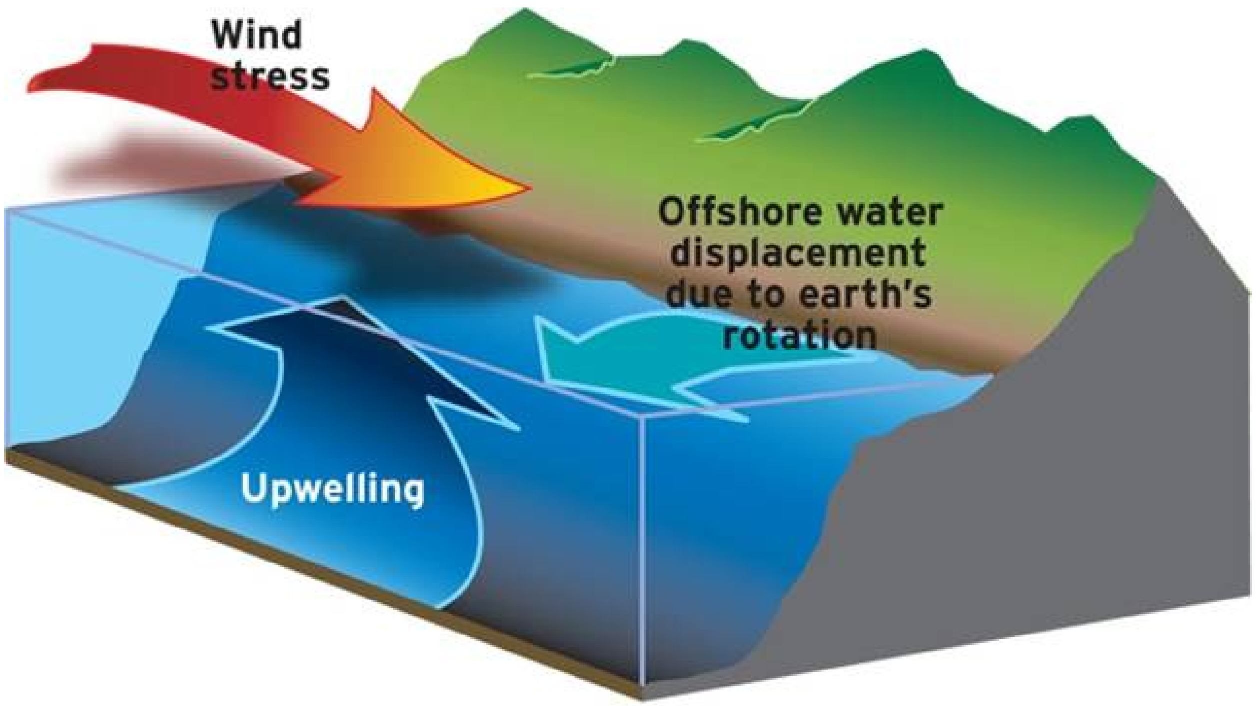
"Subtropical High"



- Alongshore currents over the continental shelf switch from poleward to equatorward following the "spring transition"

Figure from Strub and James (2000): Deep Sea Res.

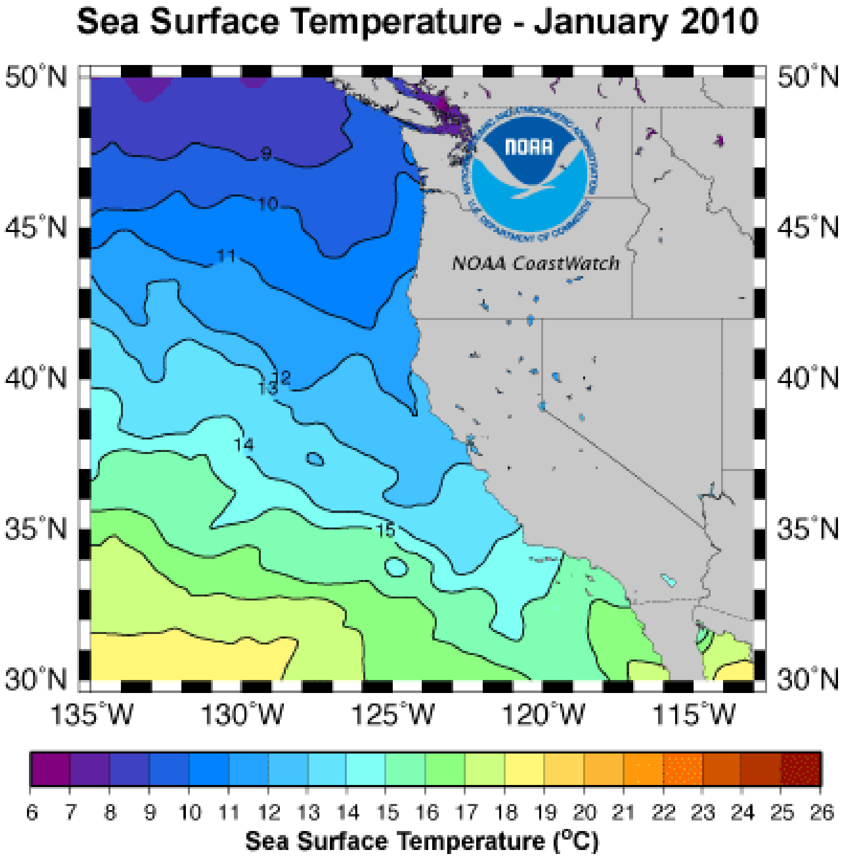
Coastal upwelling

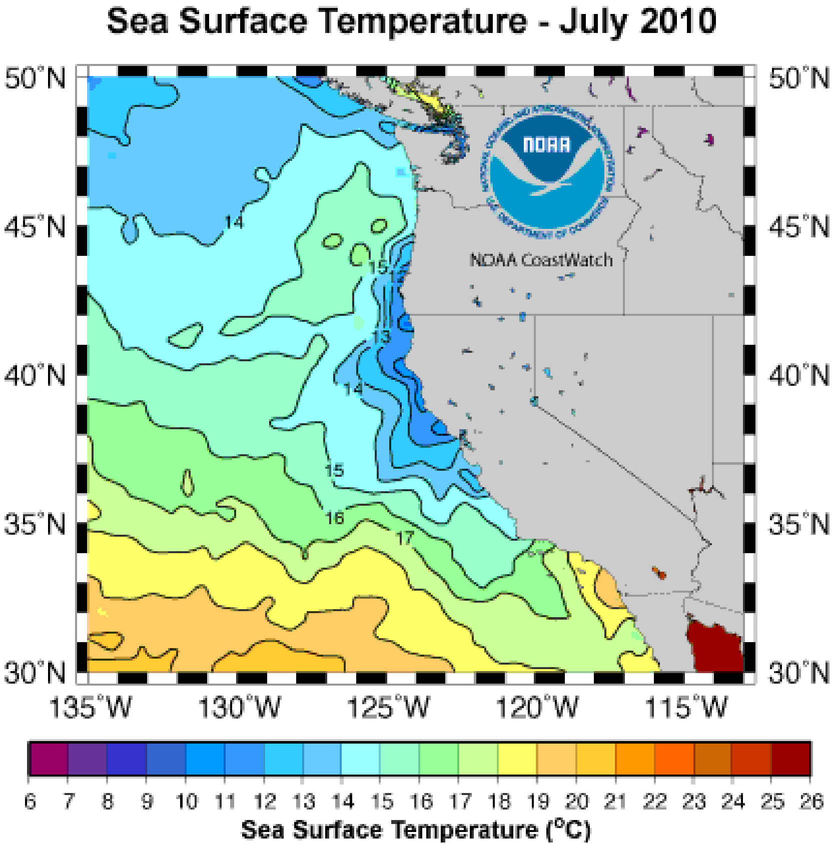


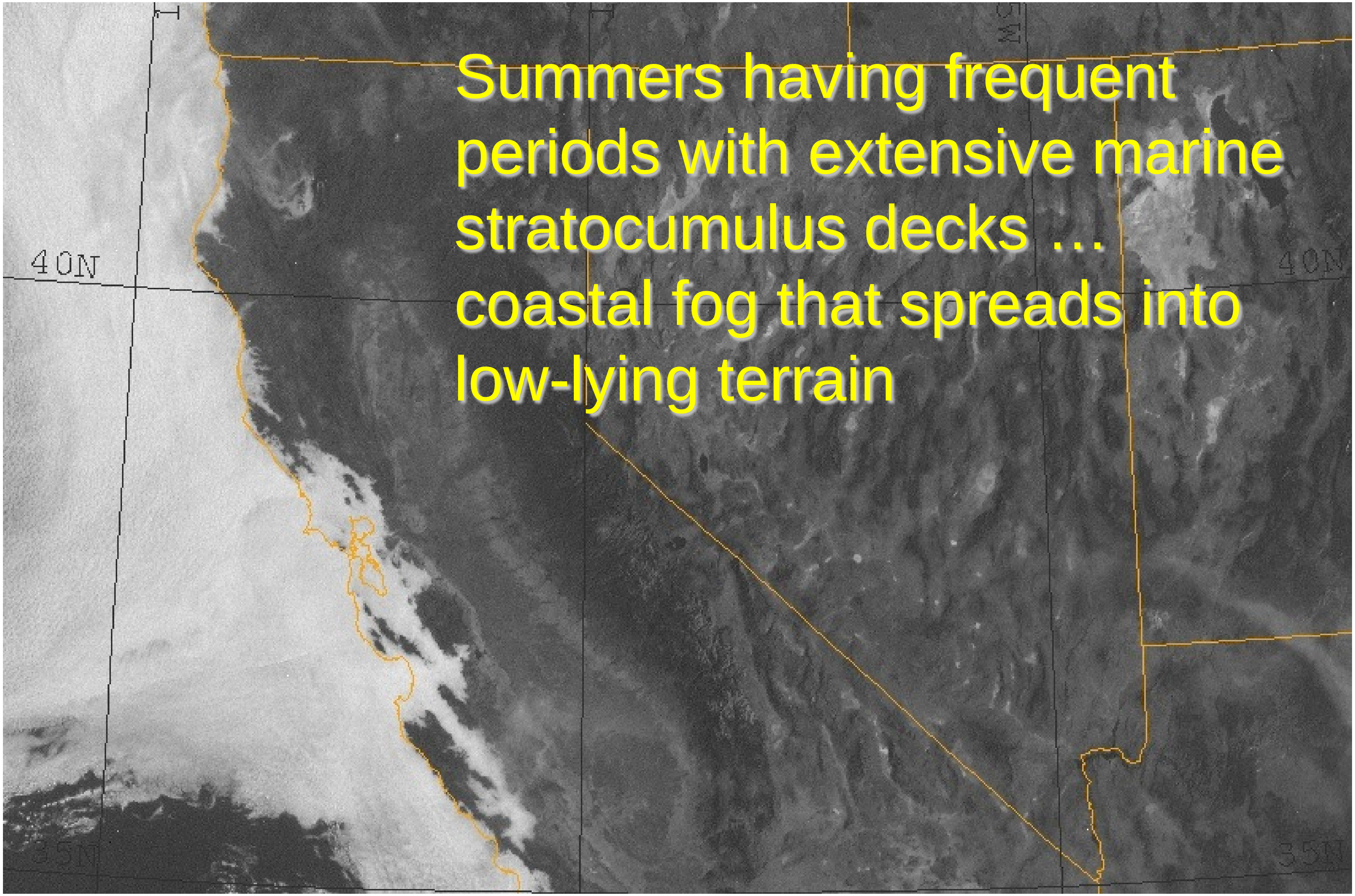
- Spring and summer winds from the north cause upwelling of cold, nutrient rich, carbon rich, and oxygen poor waters into the coastal waters of the western US

Fig from http://www.nwfsc.noaa.gov

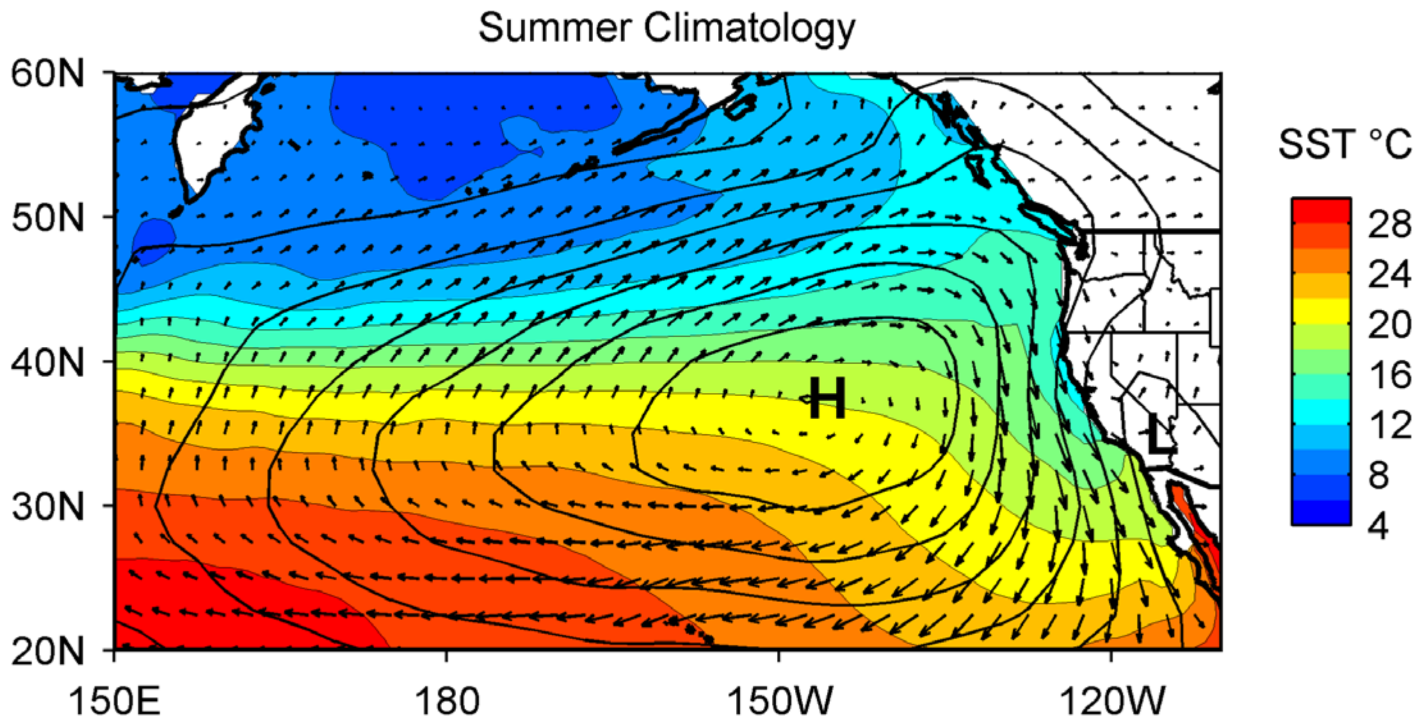
Winter vs. Summer SSTs






Summers having frequent periods with extensive marine stratocumulus decks …
coastal fog that spreads into low-lying terrain
40N
40N
35N
35N

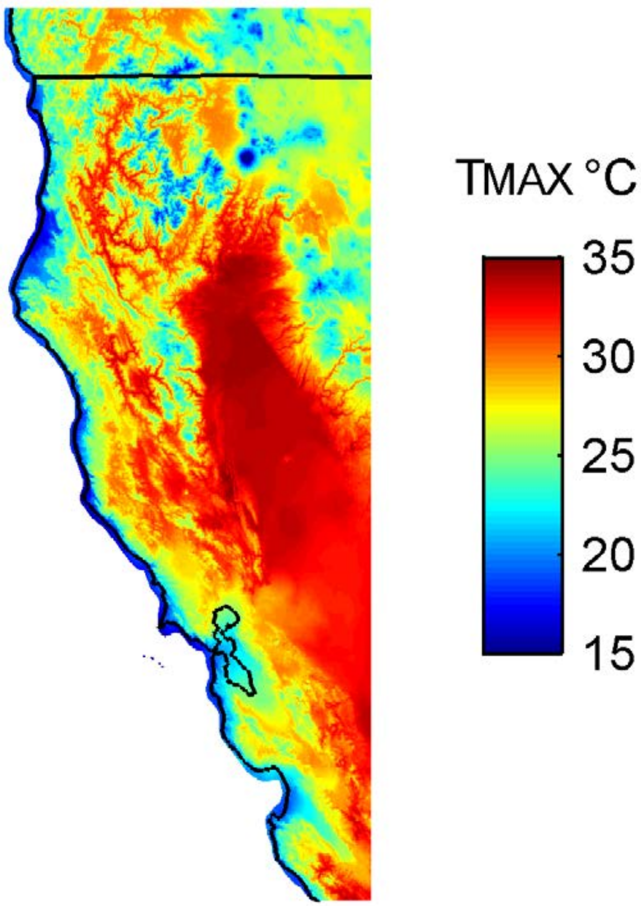
Summer Climate of the NE Pacific

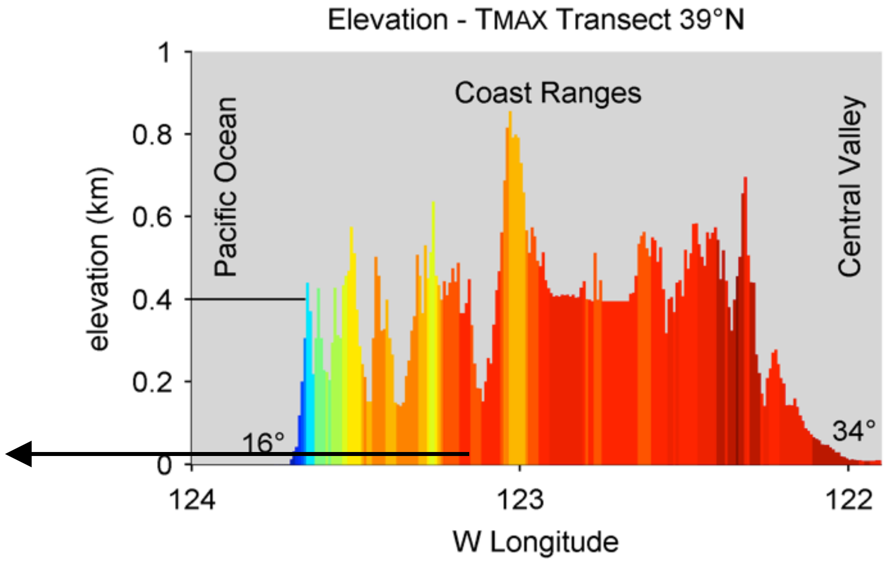


<u>Key elements</u>: North Pacific High, northerly alongshore winds, coastal upwelling, cold coastal SSTs and coastal stratus/fog

Johnstone and Dawson *PNAS* 2010

Summer Daily Maximum Temperatures: Northern California

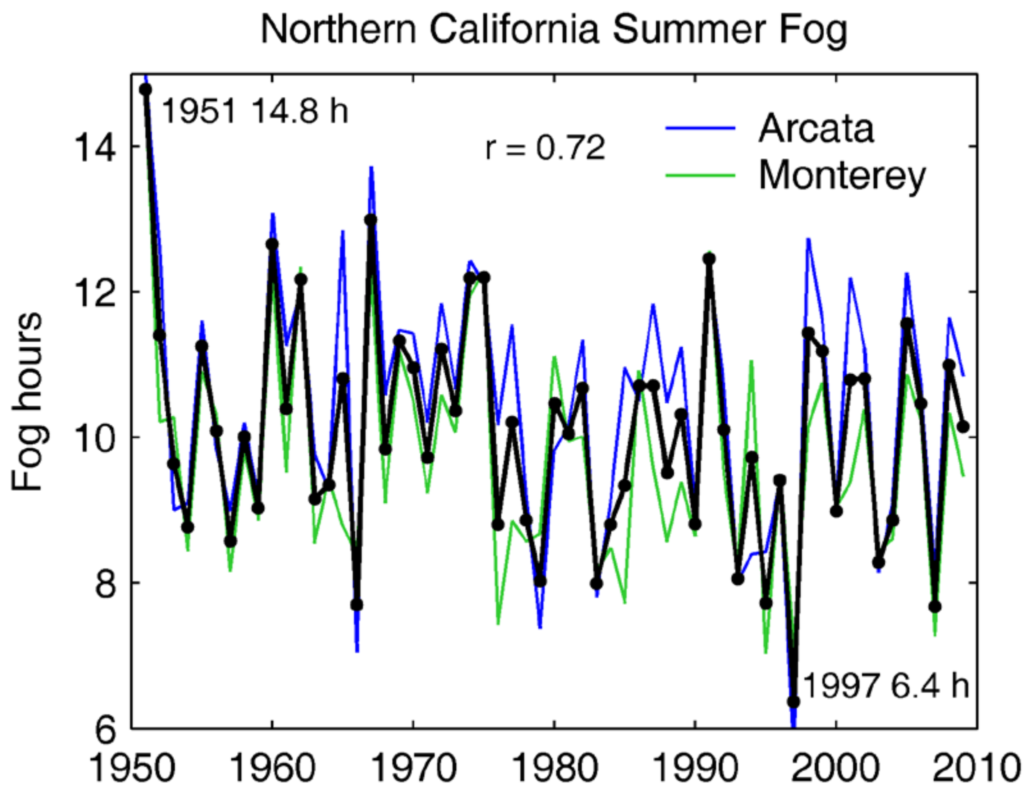




Capping inversion restricts marine layer to coastal elevations below ~ 400m

Johnstone and Dawson *PNAS* 2010

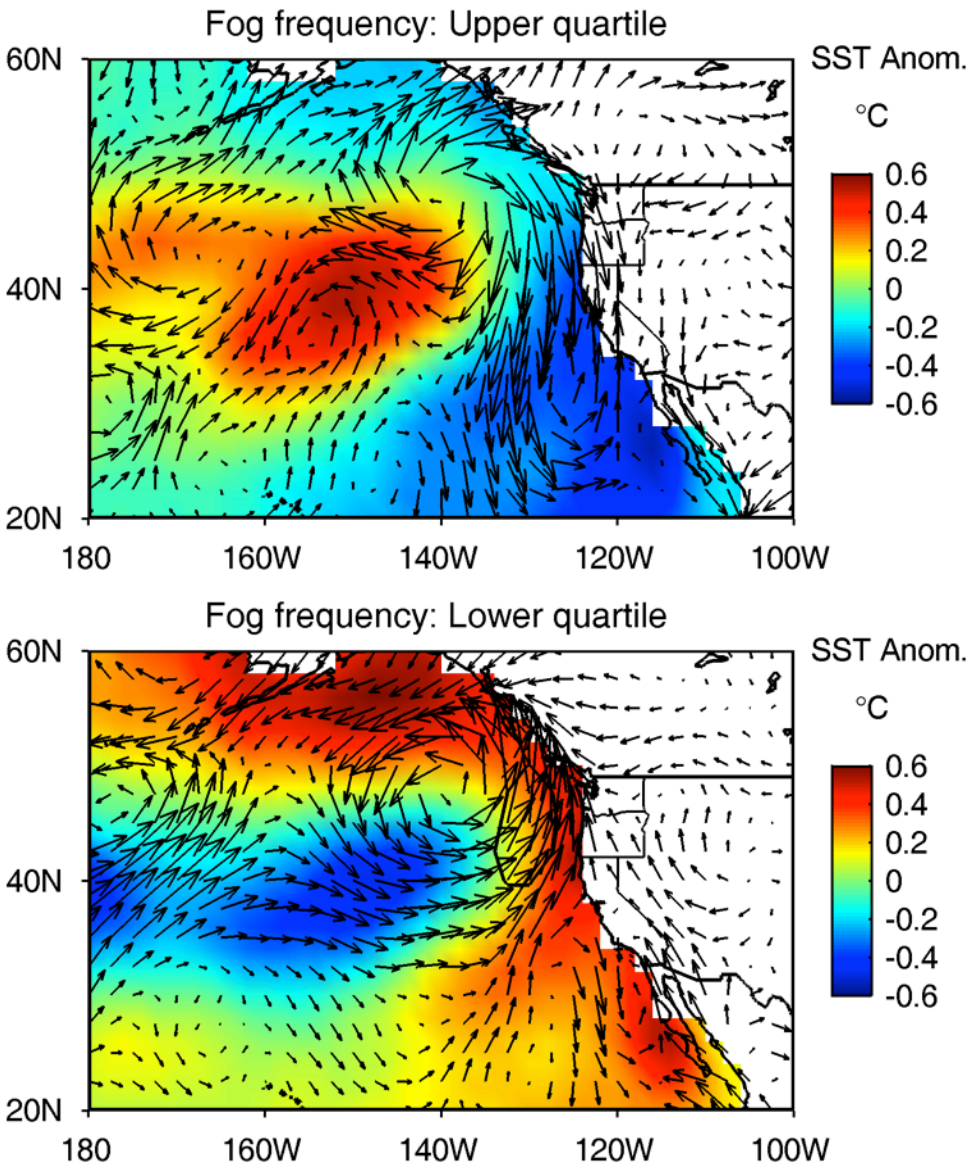
Interannual fog variability 1951-2009



Summer average “fog hours” vary by a factor of 2.3

Johnstone and Dawson *PNAS* 2010

Summer 1000 hPa wind, SST composite anomalies



Enhanced fog

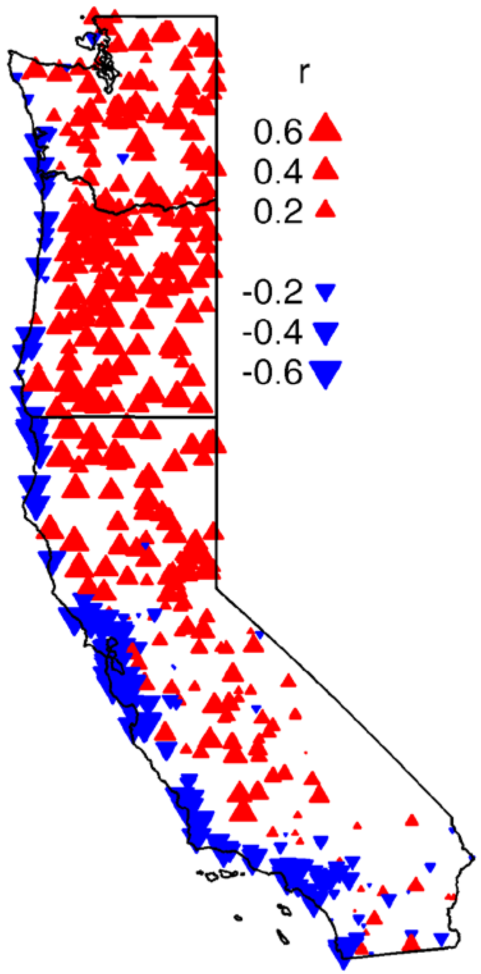
(upper quartile of summers)

Reduced fog

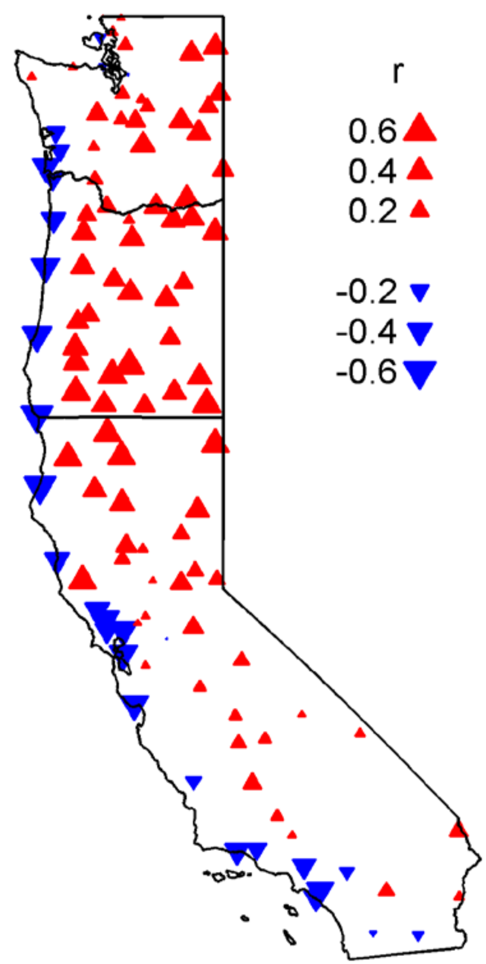
(lower quartile of summers)

Northern CA summer Fog correlations with land T_{MAX}

435 NWS Co-op Stations



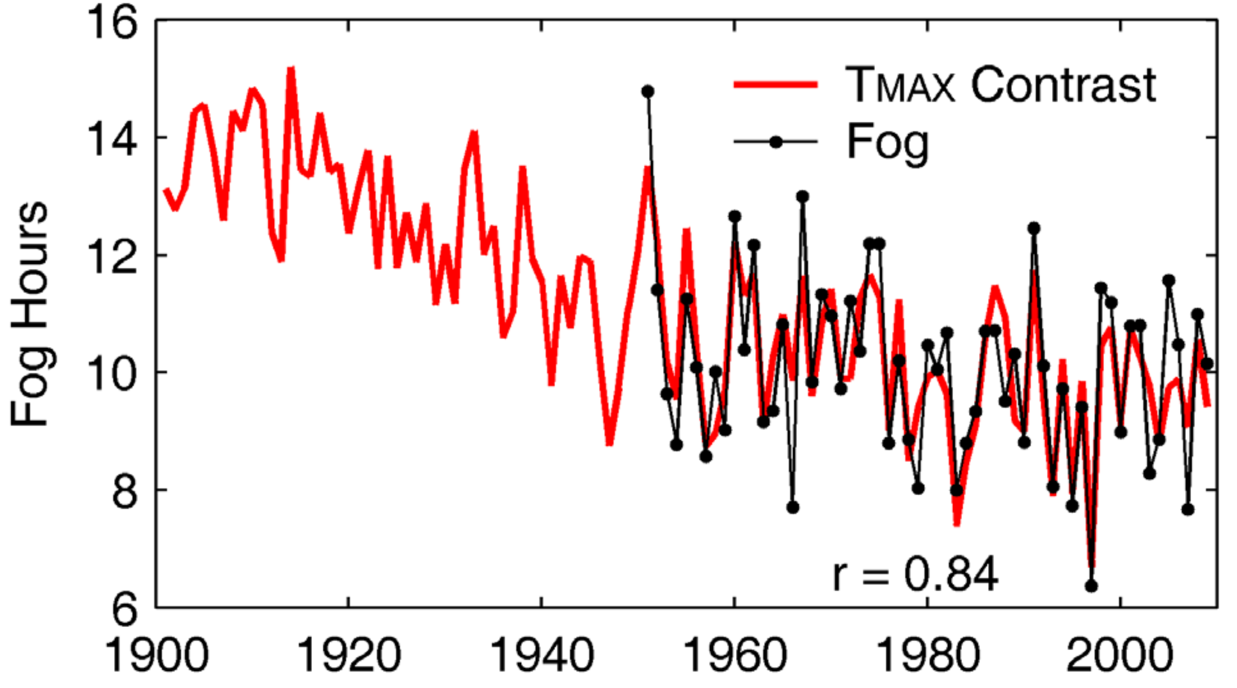
114 Long-term USHCN stations



Johnstone and Dawson *PNAS* 2010

T_{MAX} Inland-Coast Contrast 1901-2008

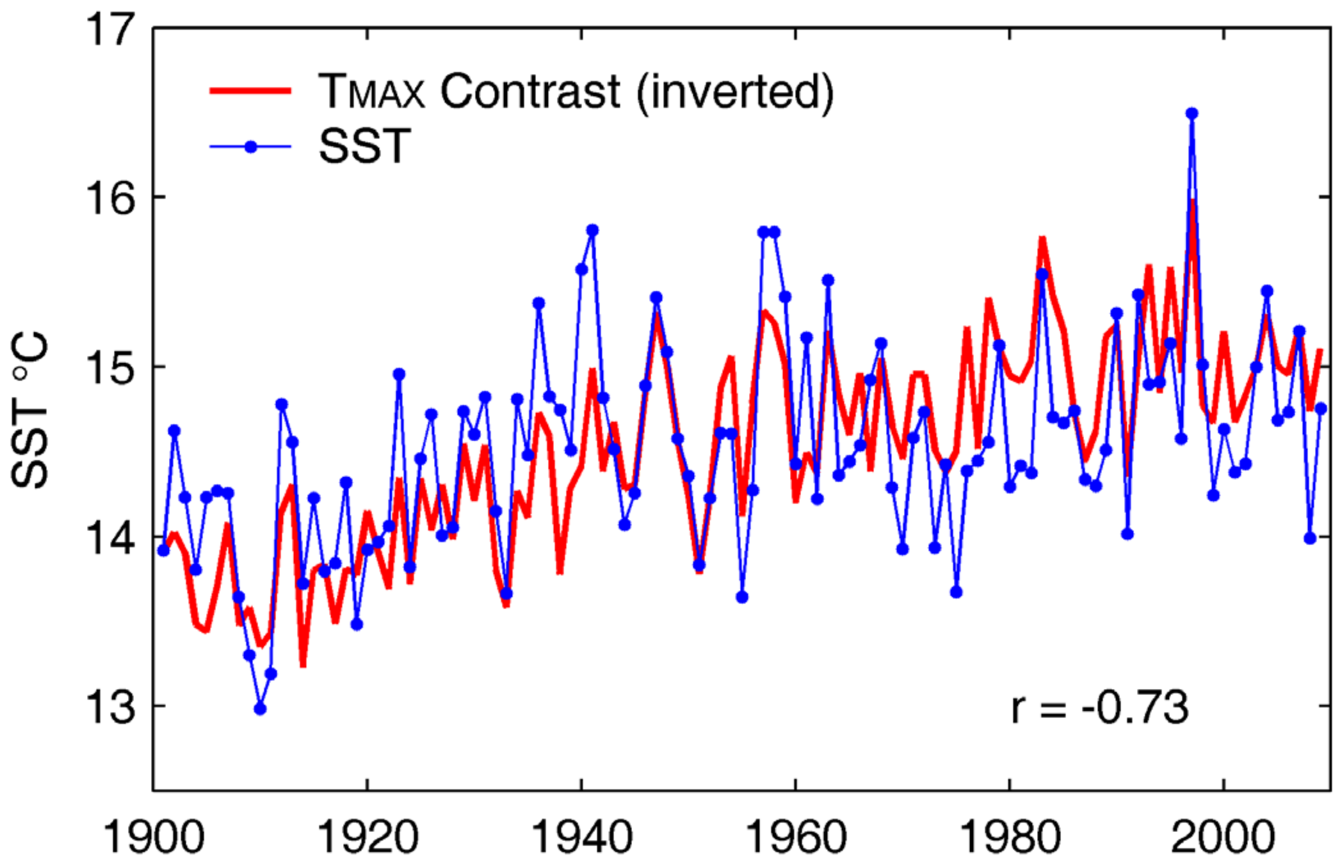
Fog correlation: r = 0.84



Suggests fog duration was ~3 hrs greater (+33%) in the early 20th century

Johnstone and Dawson *PNAS* 2010

T_{MAX} Contrast, Northern California SST 1901-2009
r = -0.73



Johnstone and Dawson *PNAS* 2010

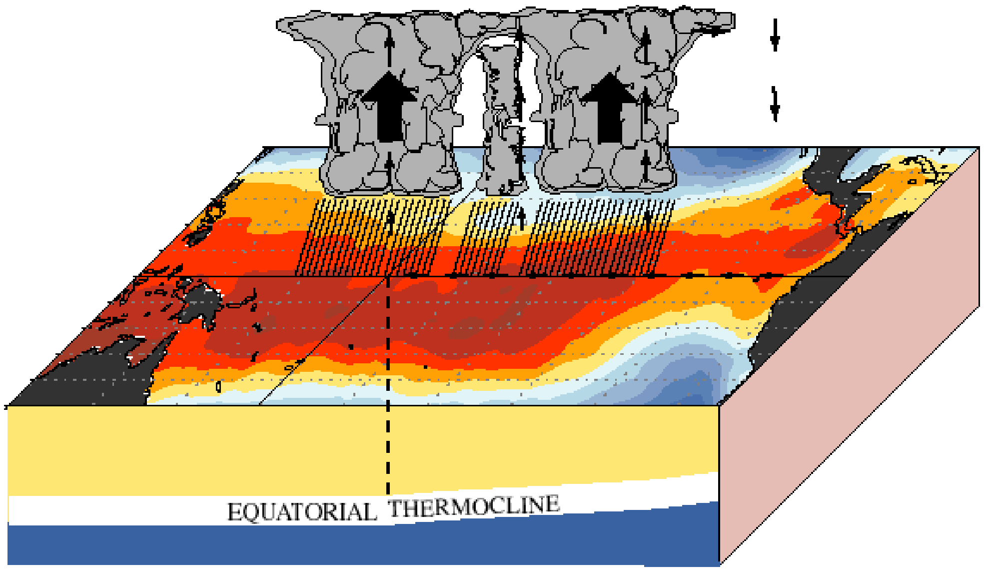
Ok, so what's behind the trends and variations?

"Board up the houses! Round up the stock! Lock up the women and children! Here comes El Niño!!"

Sacramento Bee, August 1997

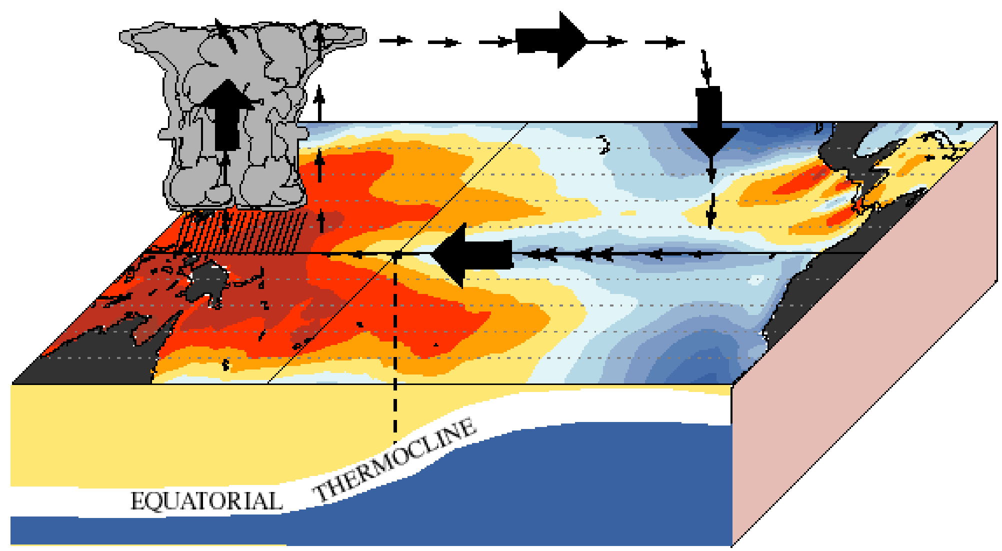
El Niño

December - February El Niño Conditions



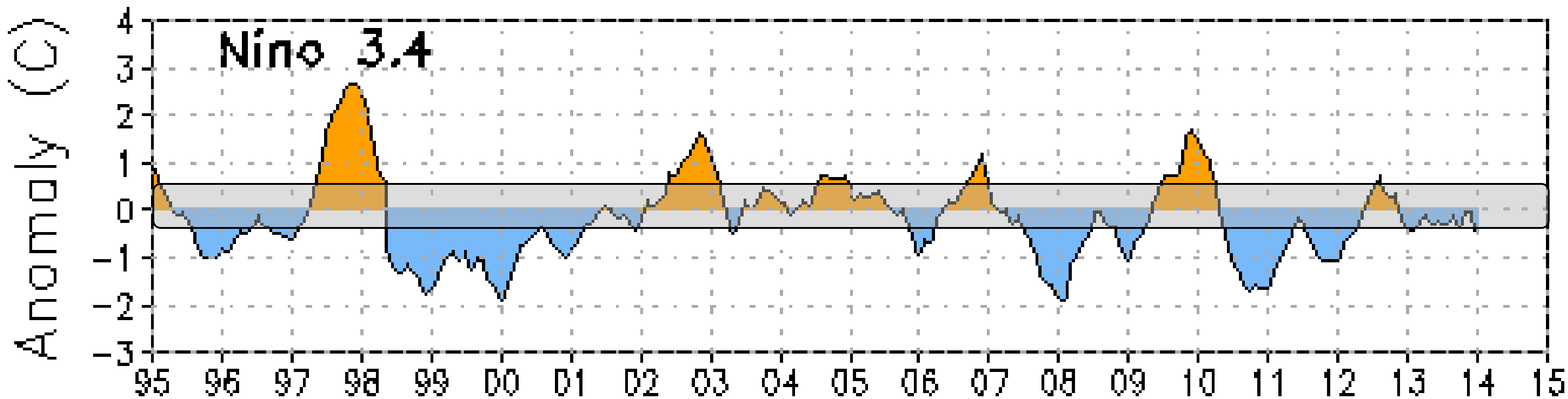
La Niña

December - February La Niña Conditions



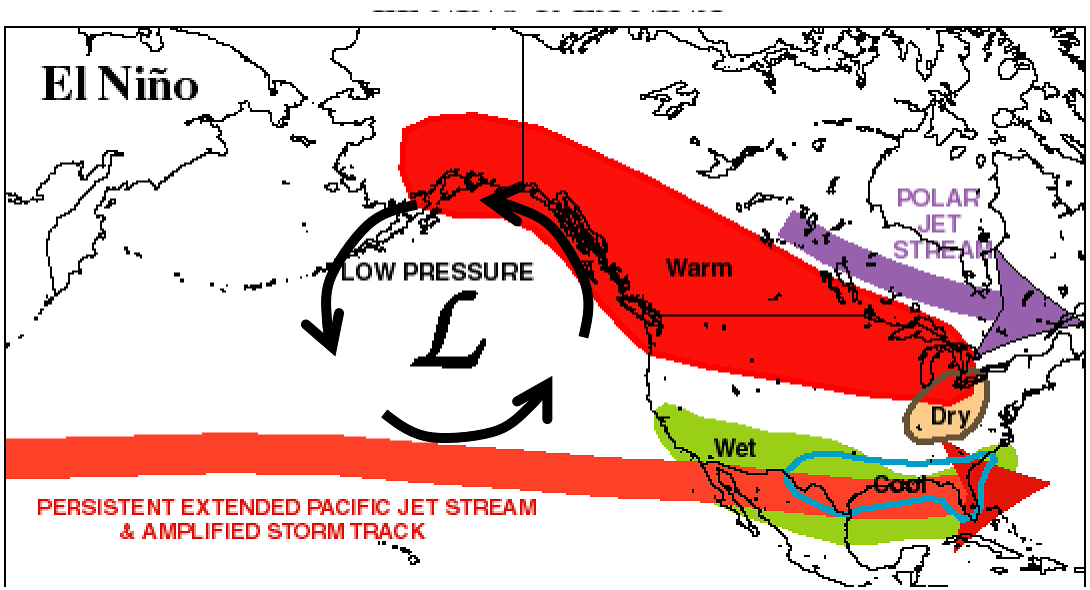
A Time History for ENSO

We typically have an El Niño once every 4 years on average.
We typically have La Niña once every 4 years too.



NOAA's official rule states: "a warm or cold event (El Niño or La Niña) occurs when the SST index exceeds +/- 0.5° C for a 3 month average…"

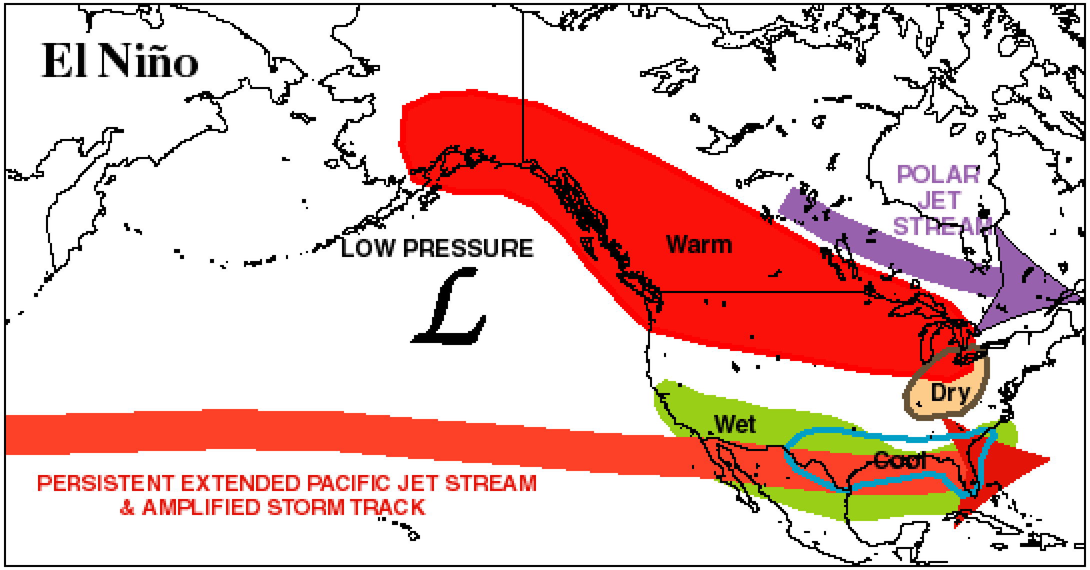
ENSO Impacts on North America's cool-season climate

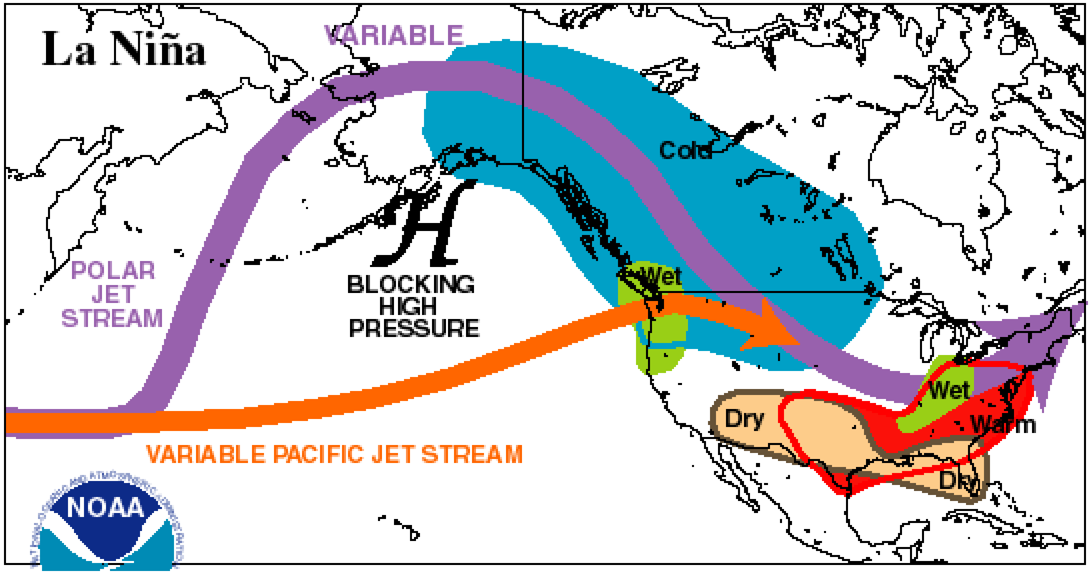


During El Niño winters, the Aleutian Low tends to be more intense, and its location is shifted south and east of its long term average position.
The sub-tropical branch of the Pacific jet stream also tends to be very strong, and this leads to an active storm track running from Japan to S. California/N. Mexico.

ENSO Impacts on North America's cool-season climate

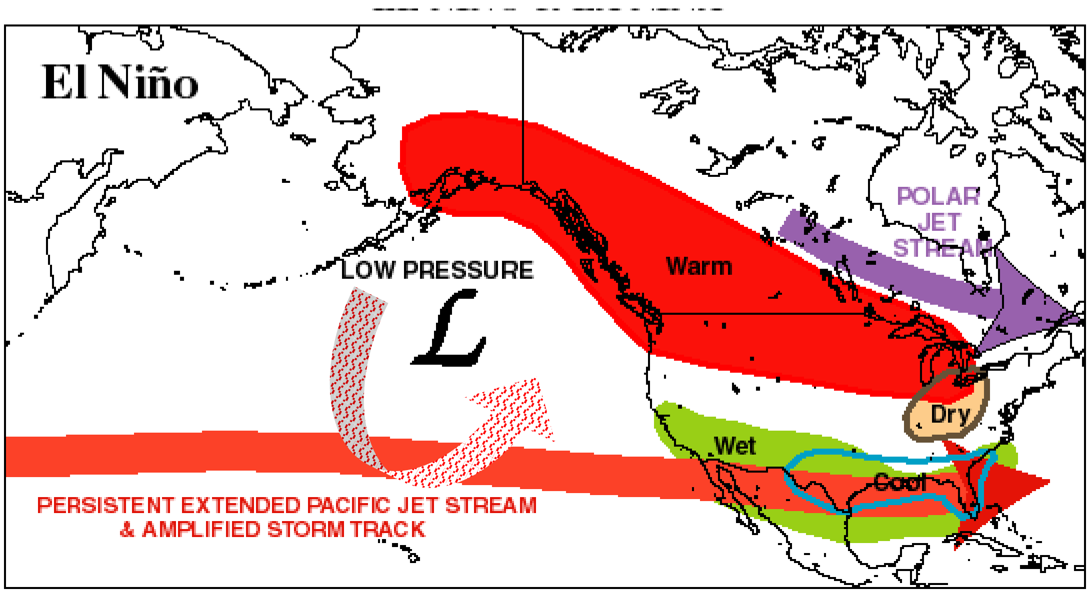
During La Niña winters there tends to be a variable jet stream that follows a path around a blocking ridge of High pressure centered in the Gulf of Alaska -- the Aleutian Low is typically weak and displaced to the far western Pacific.





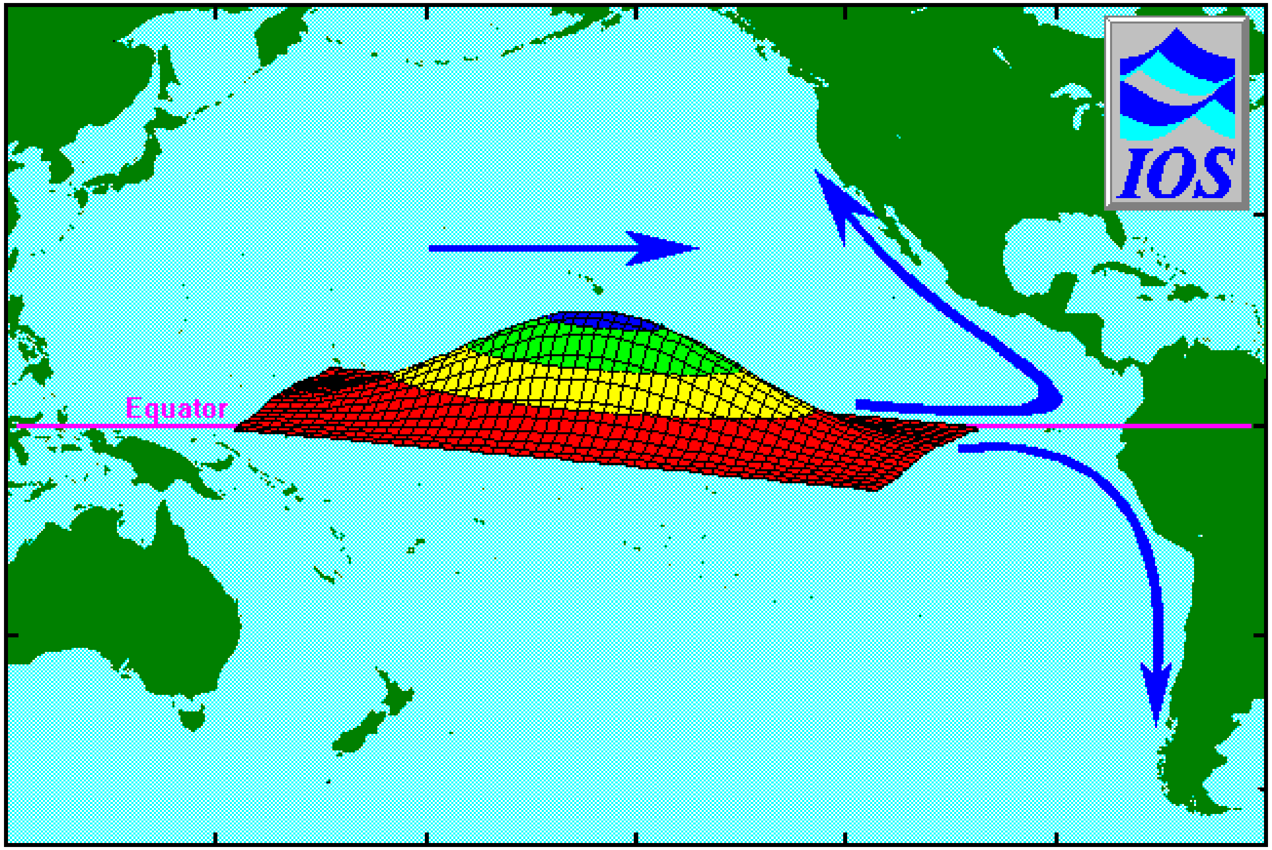
Note that La Nina winters tend to have a variable jet stream, either pointed right at us from the w/sw or pulling cold air down from the nw.

Typical winter winds and jet stream during El Niño winters



An intense Aleutian Low warms and stratifies the coastal ocean by causing onshore Ekman transports and intense coastal downwelling in winter

Coastally trapped kelvin waves from the tropics moving poleward along the west coast of the Americas

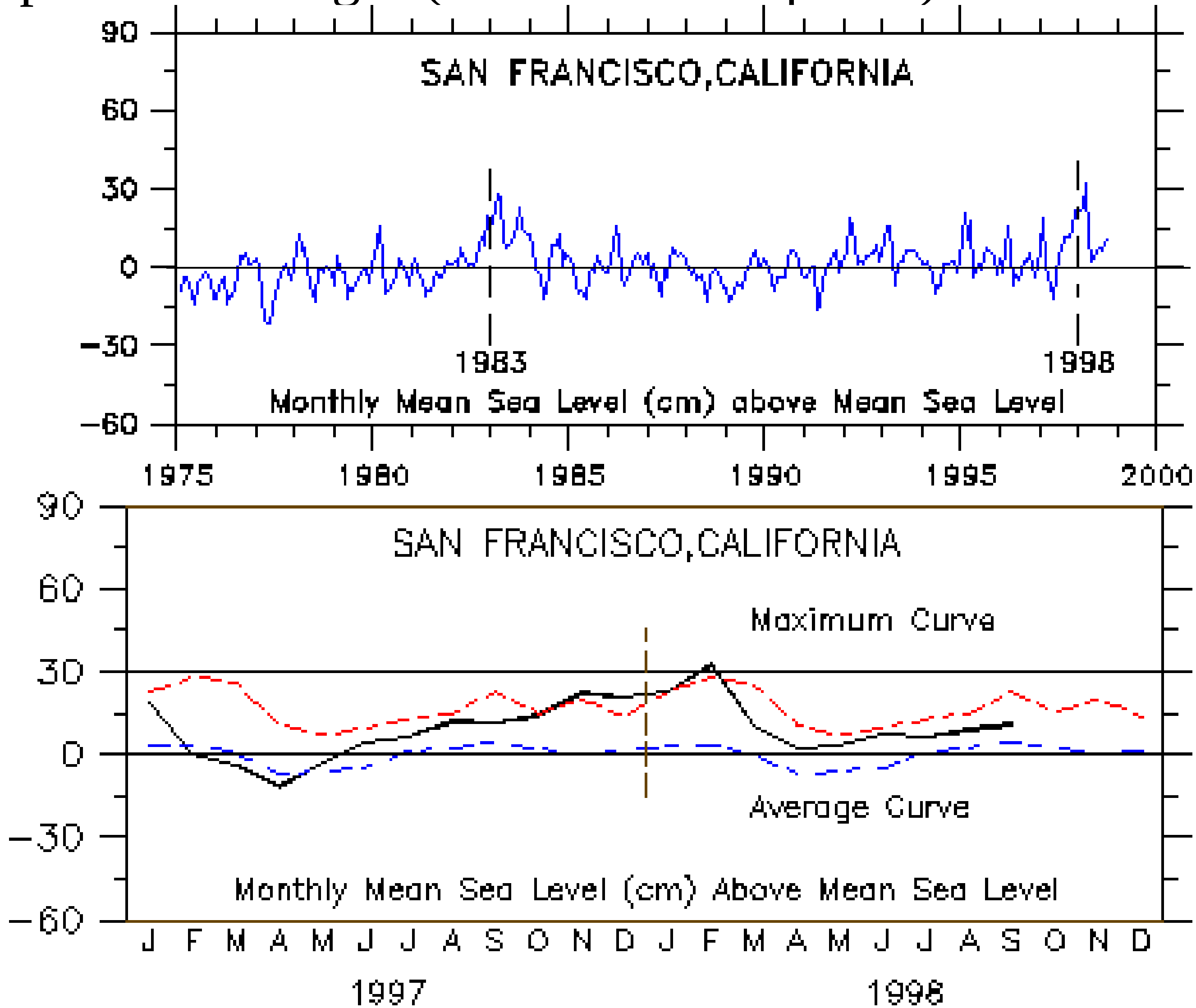


Poleward propagating coastally trapped Kelvin waves raise the sea surface height, force the thermocline downward, and generate poleward currents in the upper layer of the ocean right along the coast

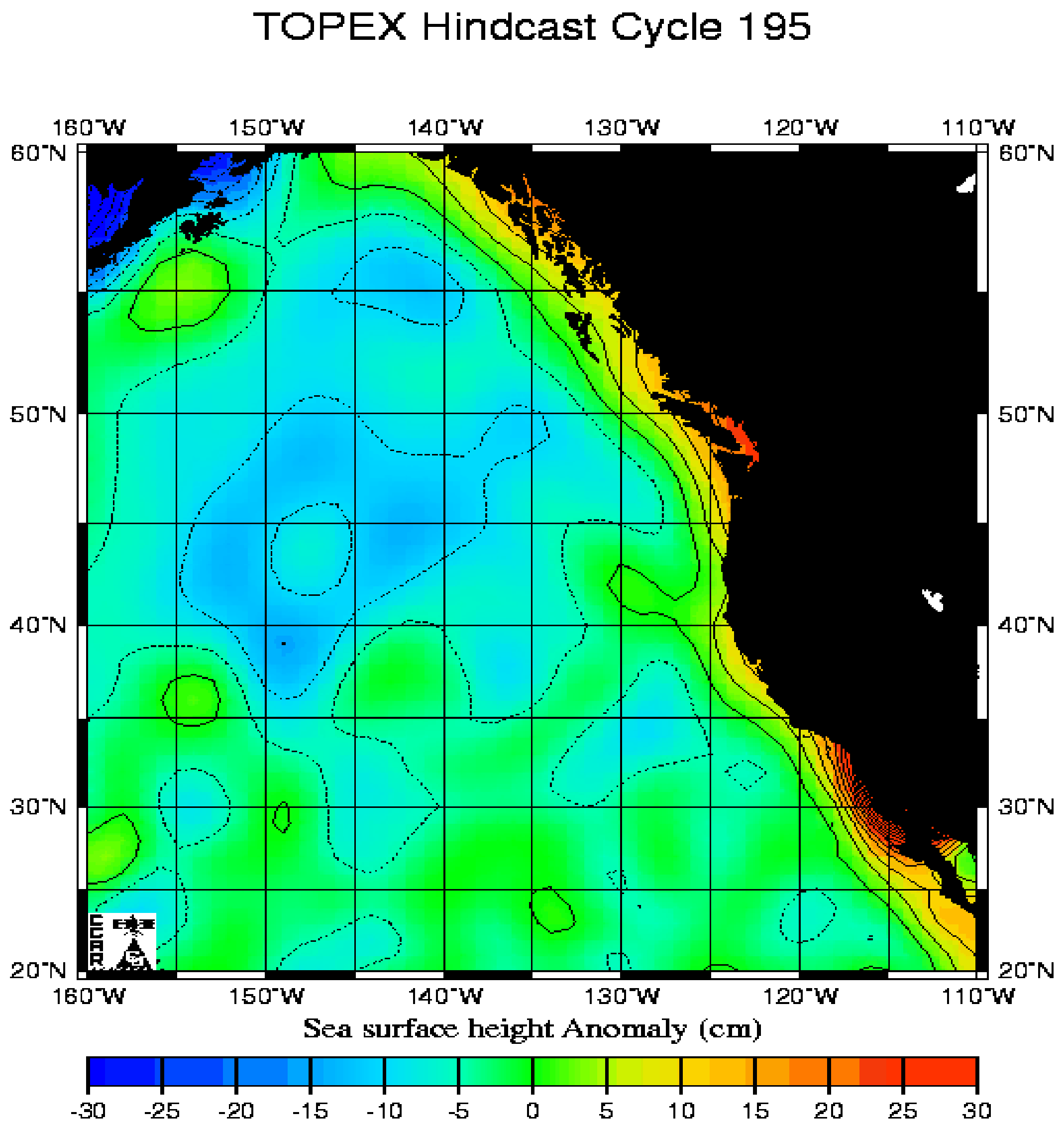
Institute of Ocean Sciences (IOS), Sydney, British Columbia

Coastal Sea level variations: +/- 1 foot at SF due to coastally trapped waves + persistent winds causing onshore Ekman transport + coastal ocean temperature changes (warm water expands)

Along the Pacific coast of both North and South America, remote and local wind forcing associated with ENSO cause changes in the coastal ocean

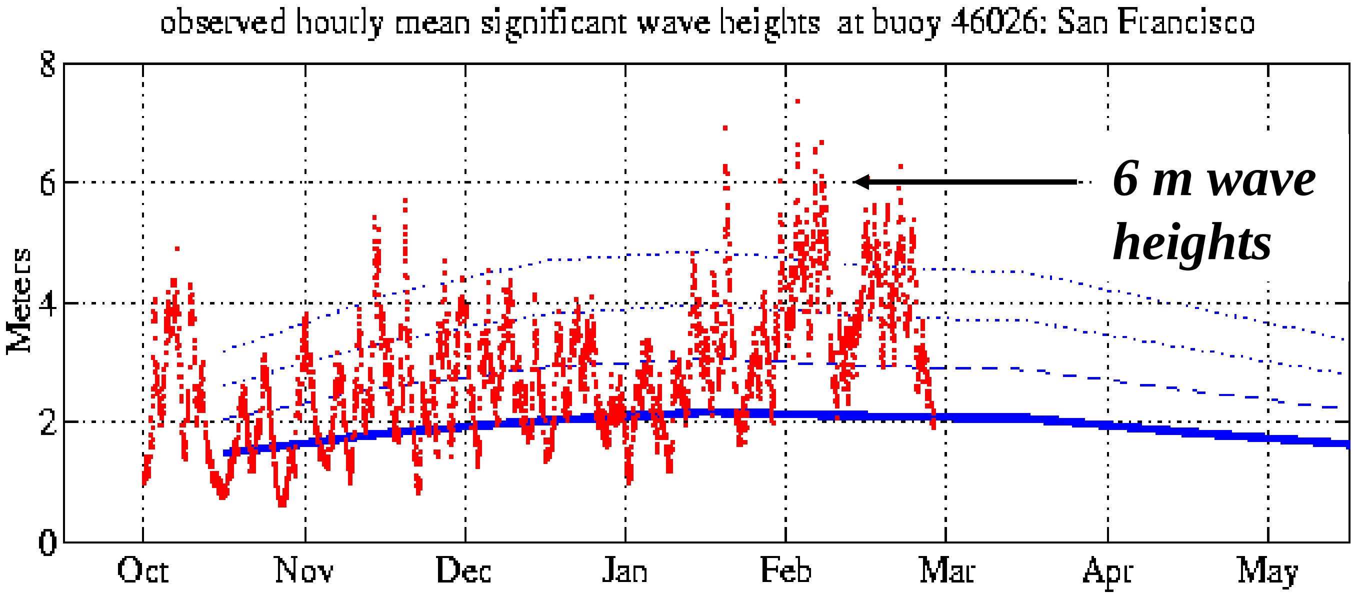


NOAA/PMEL Sea Level Center

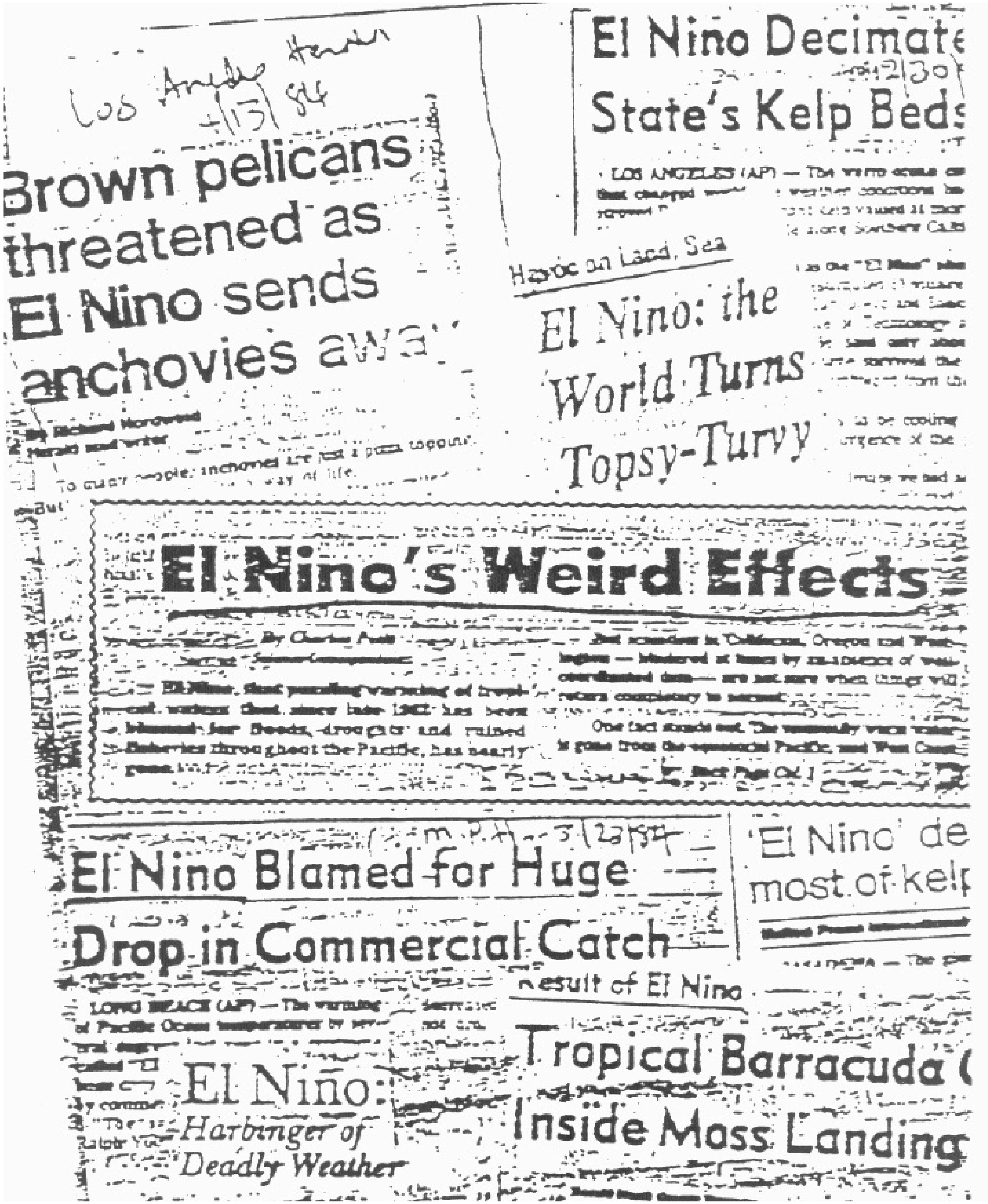


Dec 1997-Jan 1998 Sea Level Height Anomalies

Huge ocean swells due to El Niño's influence on the storm track and surface winds: +20 feet at SF

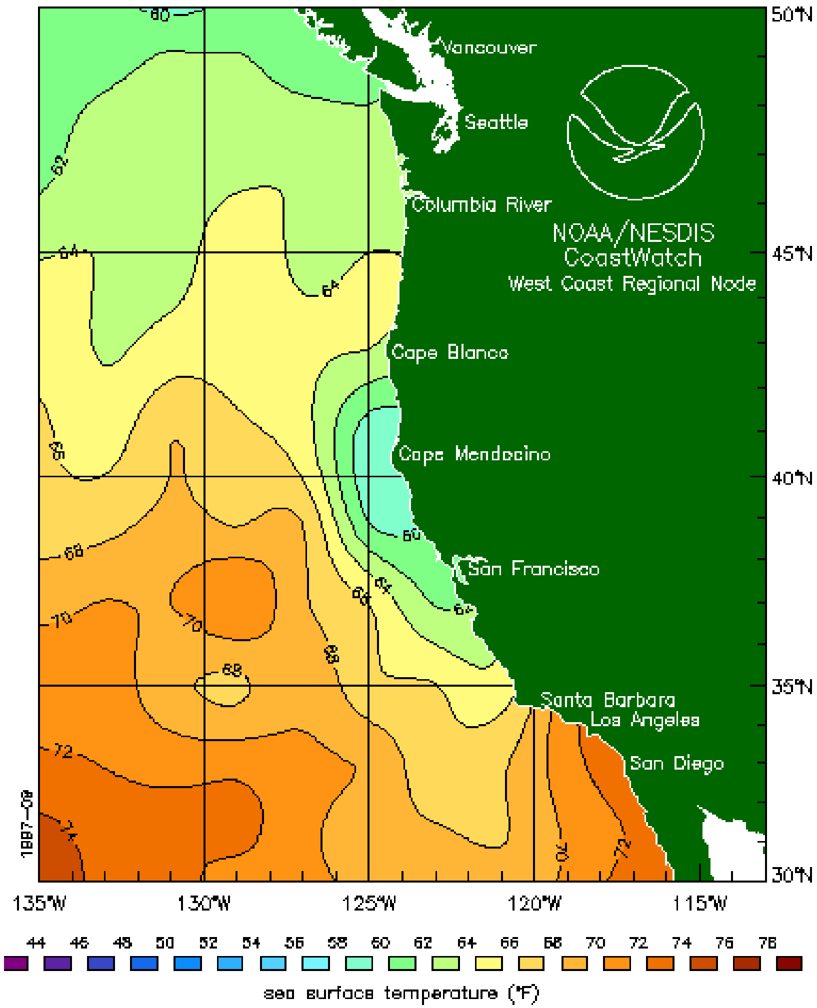


1997-1998

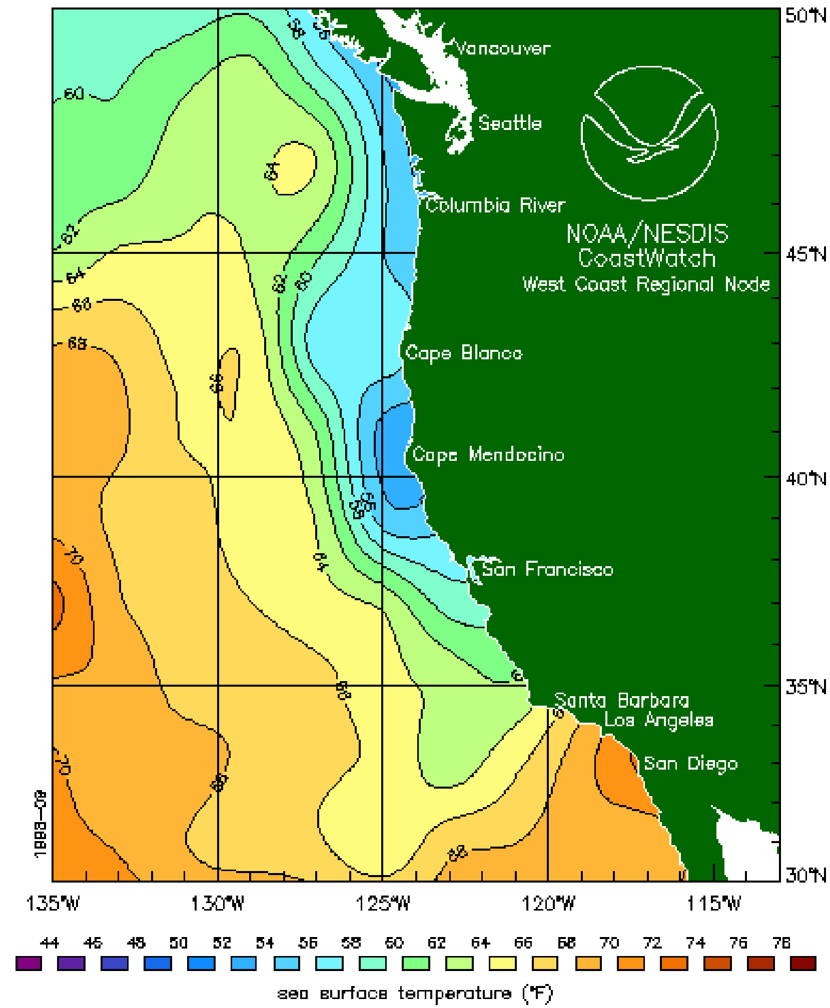


West Coast news in 1983-84

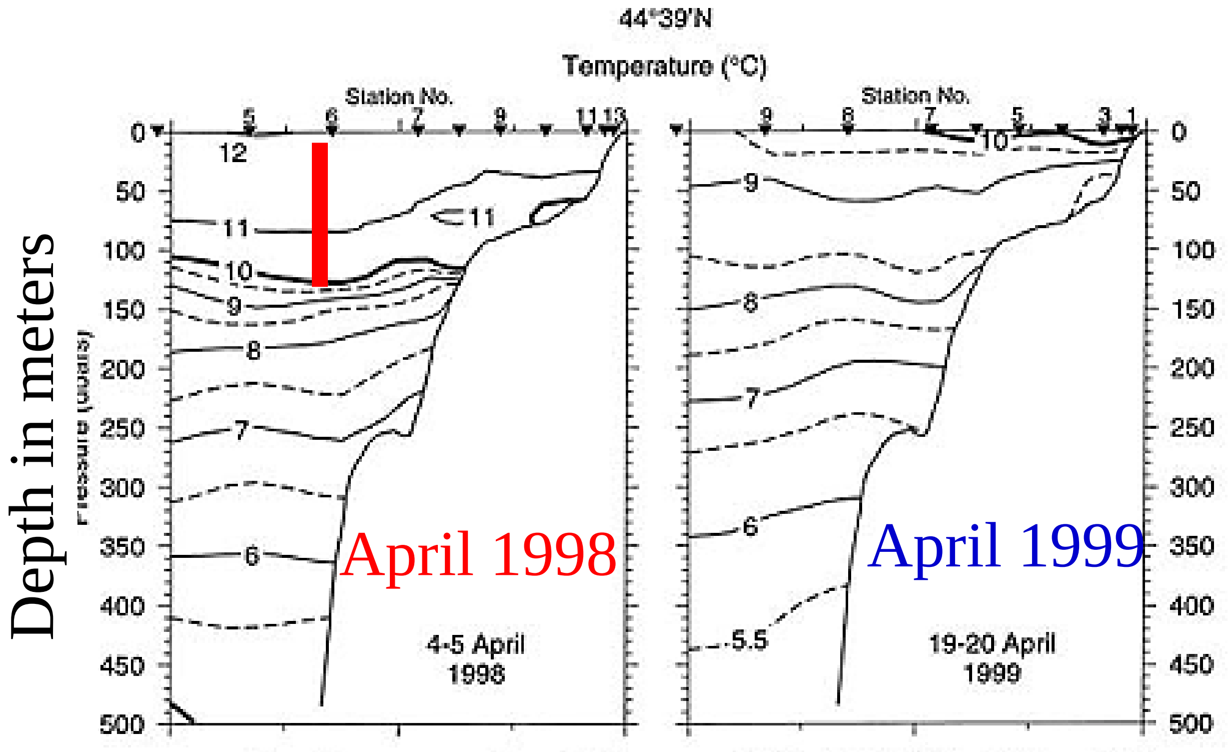
Sept 1997 El Niño



Sept 1998 La Niña



“Newport Line” (central Oregon coast) upper ocean temperatures

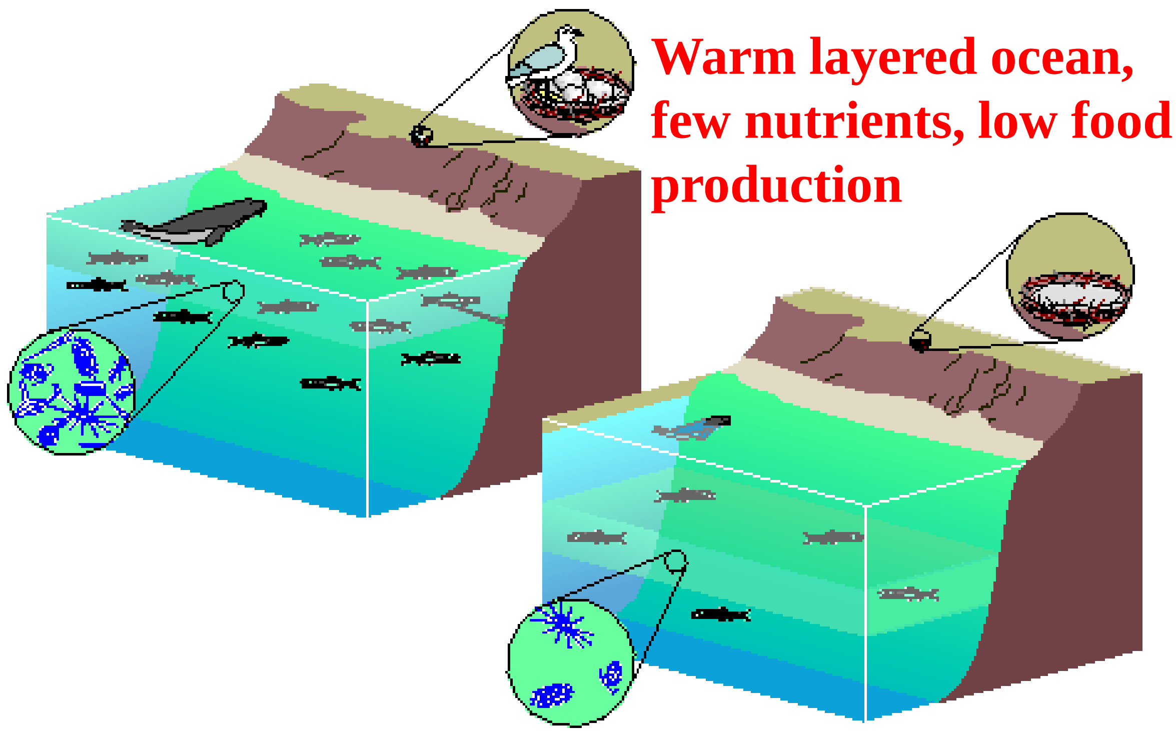


A thick layer of warm (low density) water at the surface can cut off the nutrient supply…

Upwelling without nutrients yields no benefits to phytoplankton!

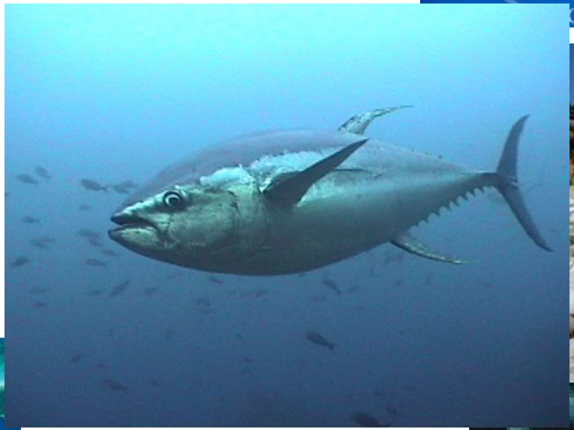
The California Current System food web

When the upper ocean is cool, it is weakly stratified, there are abundant nutrients, high phytoplankton production, and large lipid-rich “boreal” or “subarctic” zooplankton like krill (*Euphausia pacifica* and *Thysanoessa spinifera)* that feed higher trophic levels (forage fish, sea birds, piscivorous fish, marine mammals…)



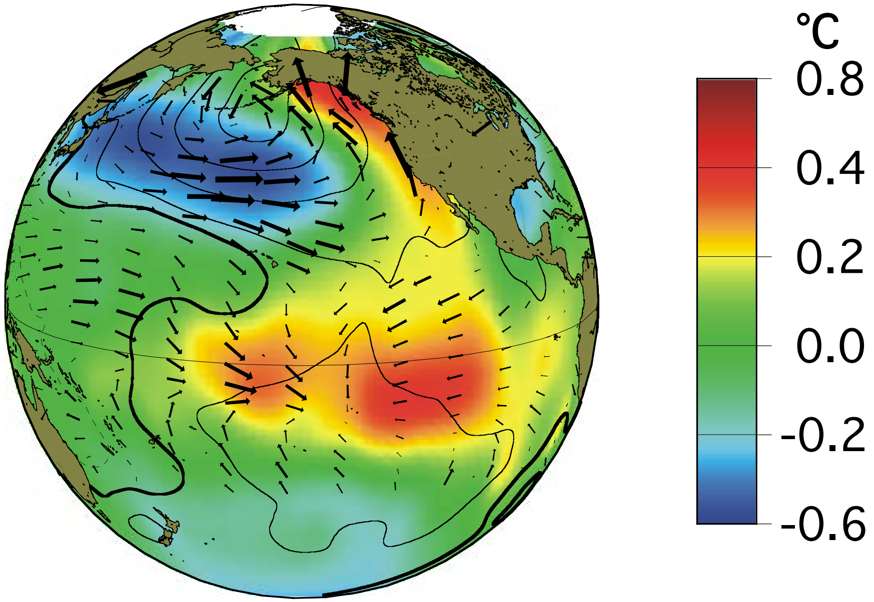
West Coast Nekton in 1997-98

- Major changes in the distribution of pelagic fishes and squid lead to important “top-down” impacts on coastal food-webs too

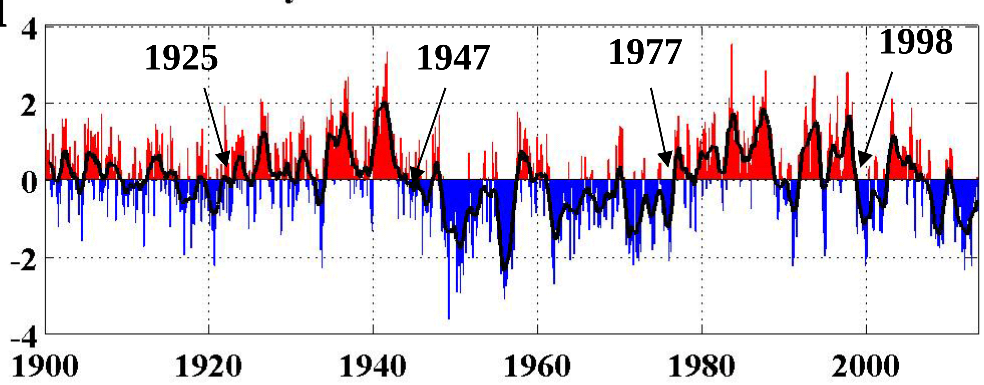




The Pacific Decadal Oscillation

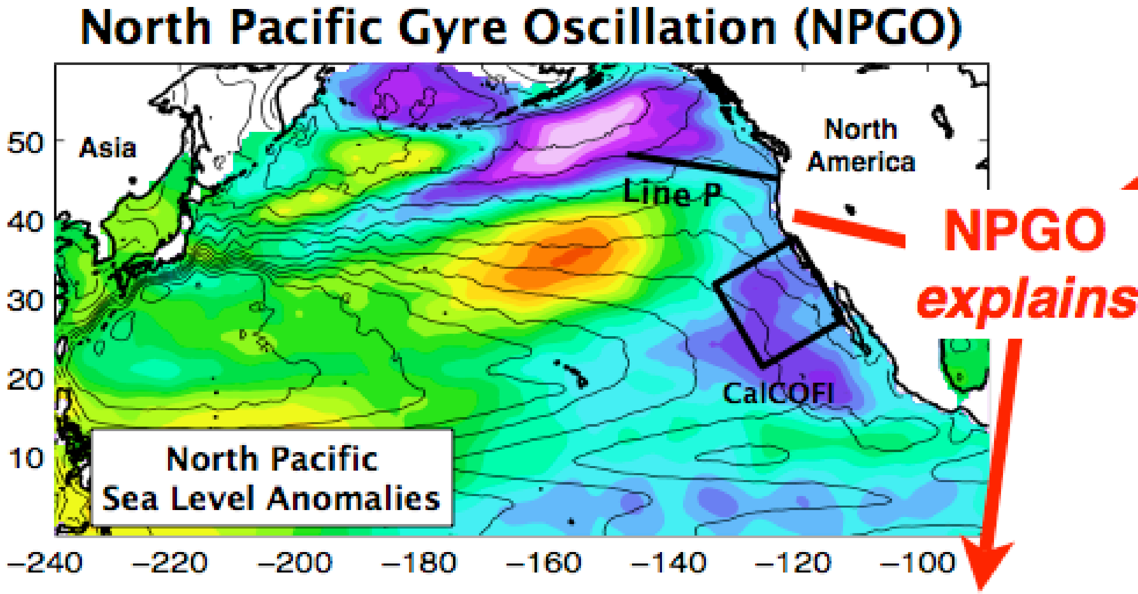
- an El Niño-like pattern of climate variability
- 20 to 30 year periods of persistence in North American and Pacific Basin climate
- warm extremes prevailed from 1925-46, and again from 1977-98; a prolonged cold era spanned 1947-76; the latest cold era began in 1998
- ENSO is an important driver of PDO variations

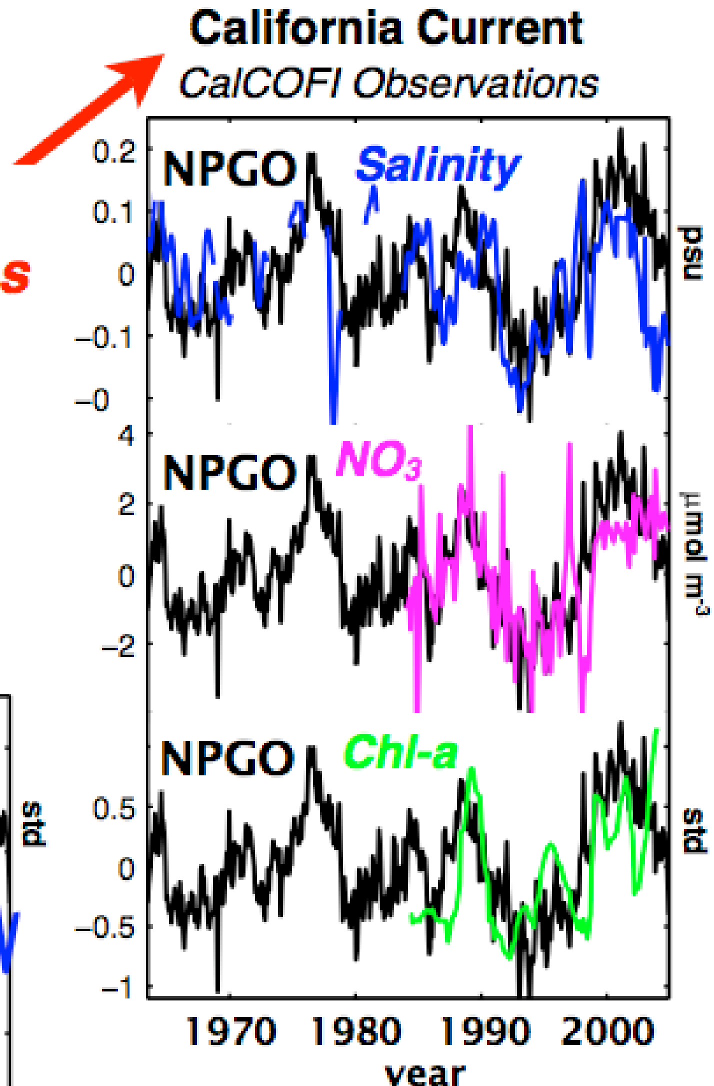


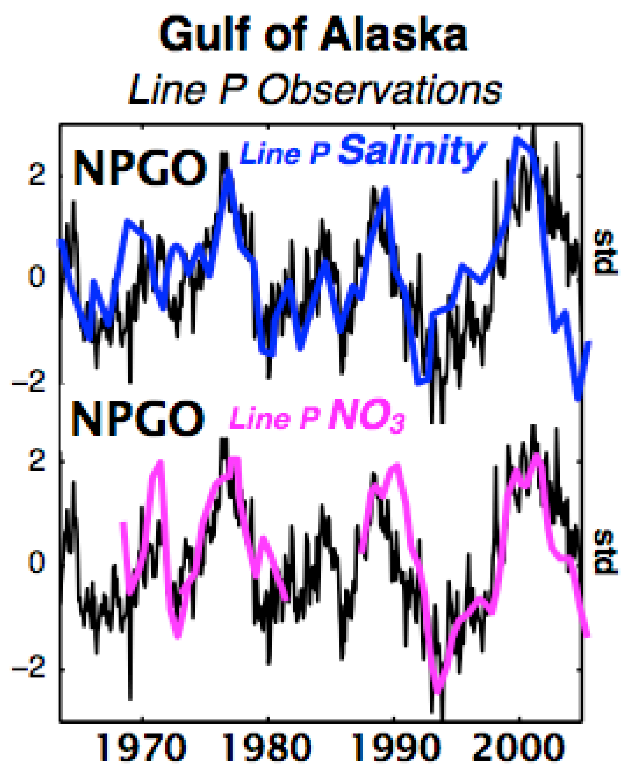
monthly values for the PDO index: 1900-2013



Mantua, Hare, Zhang, Wallace and Francis, BAMS 1997





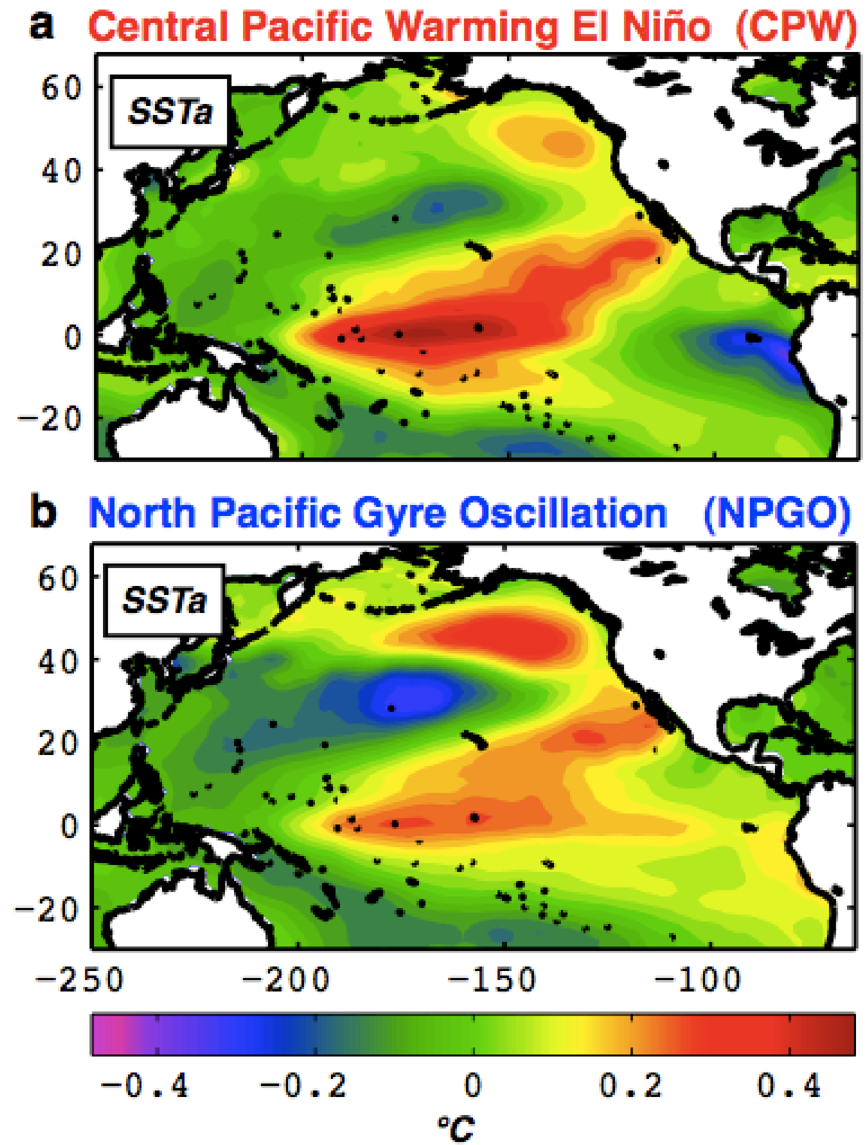


The **NPGO** *index measures changes in the* ***North Pacific gyres circulation*** *and explains key physical-biological ocean variables*

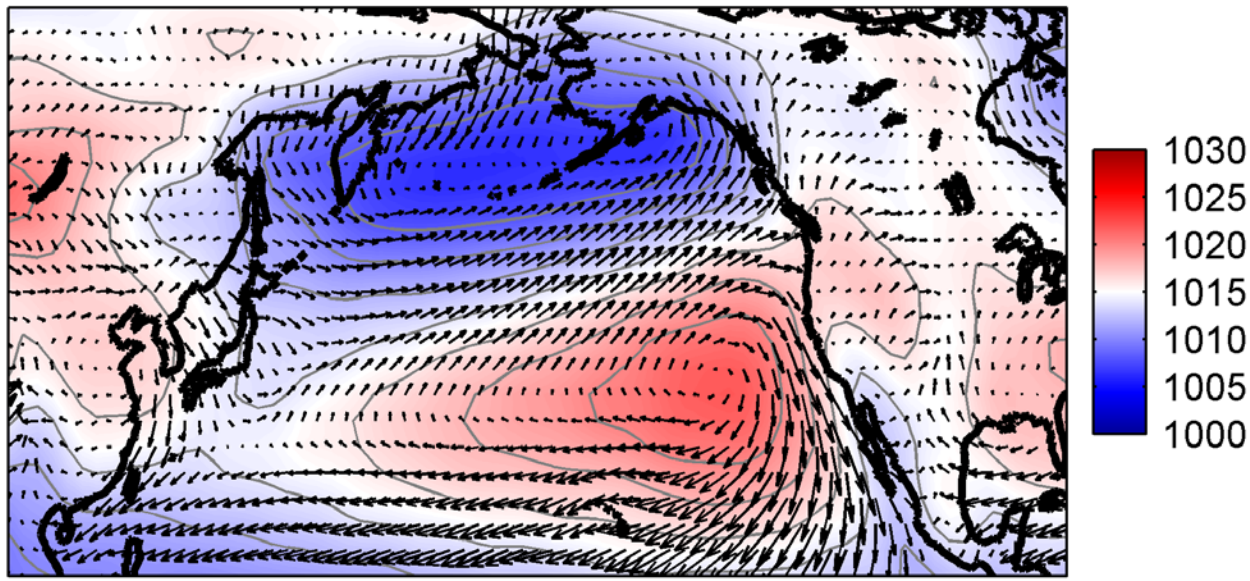
Di Lorenzo et al., 2008

http://www.o3d.org/npgo/

- Di Lorenzo et al (2010) show that decadal variations in the NPGO are forced by atmospheric teleconnections to “Central Pacific Warming” El Niño variability between 1950 2009

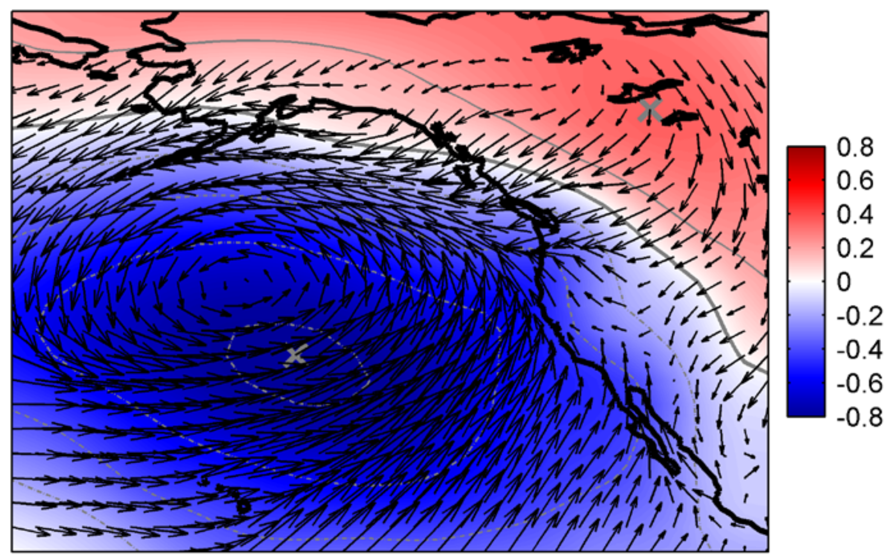


Mean wind, Pressure



NE Pacific SLP and wind pattern that causes temperature variations

When this pattern amplifies, the Aleutian Low intensifies and/or the North Pacific High weakens; winds are more counterclockwise in the NE Pacific



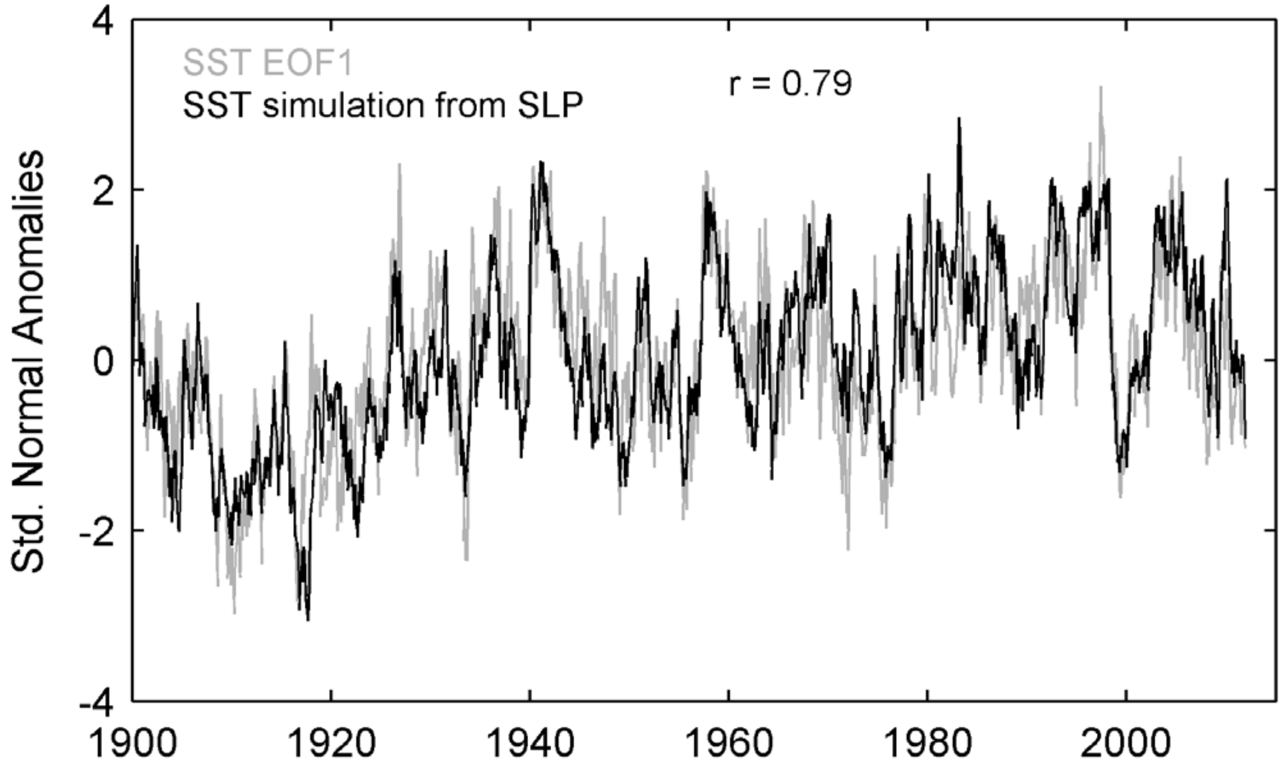
Johnstone and Mantua, in review

Monthly SST modeled from SLP:

$$SST_t = 0.86\, SST_{t-1} + 0.26\, SLP_t + \varepsilon_t$$

This SLP index is correlated with the PDO index, NPGO index, and ENSO index (0.43, 0.43, 0.61, respectively)

(Johnstone and Mantua, in review)

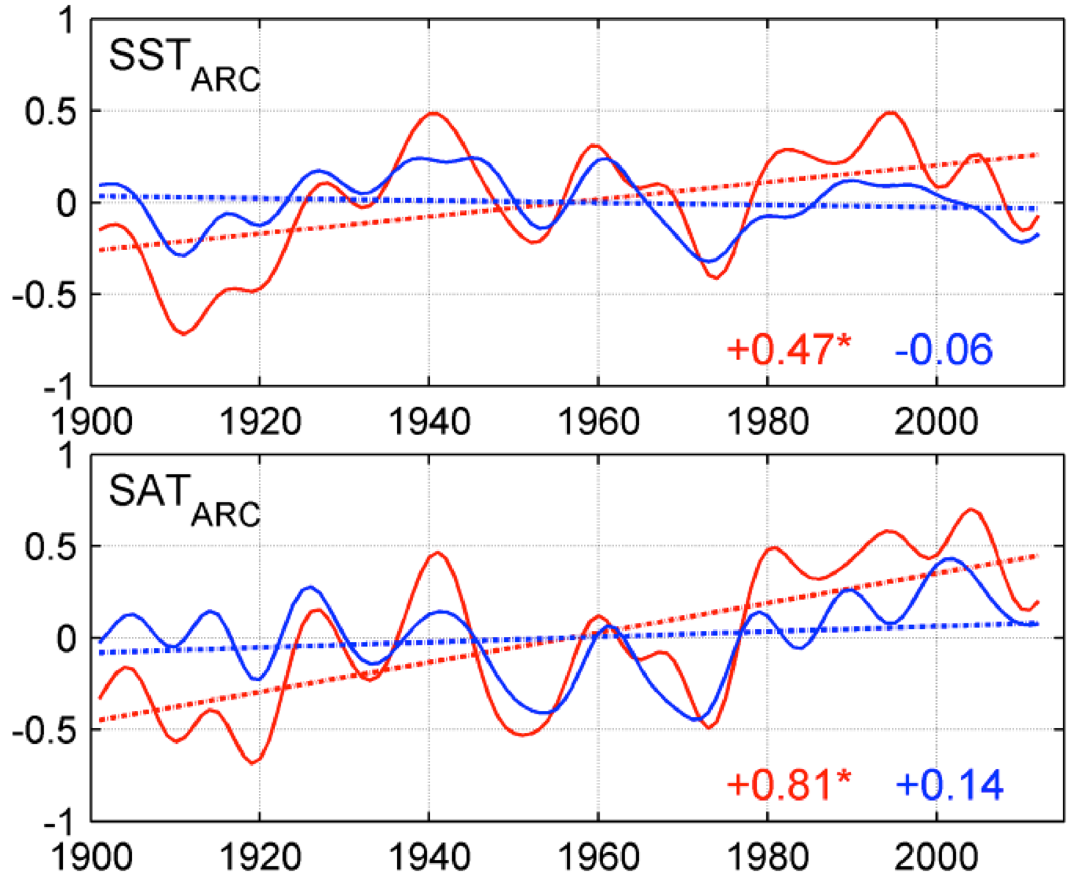


Most of the trend in NE Pacific temperature records can be attributed to trends in sea level pressure (from 1900-2012)

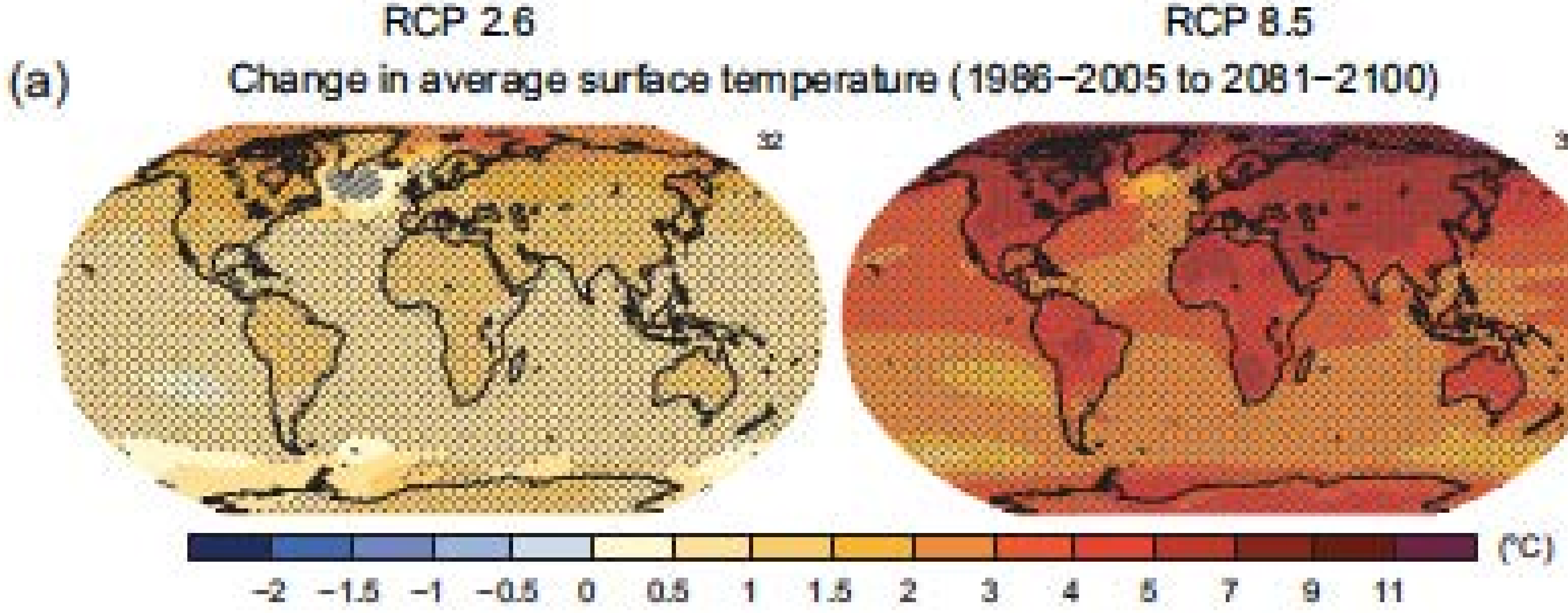
- red curves and trends reflect observed temperatures

- blue curves depict residuals after removal of the annual SLP1 index by simple linear regression

10 year low-pass filtered



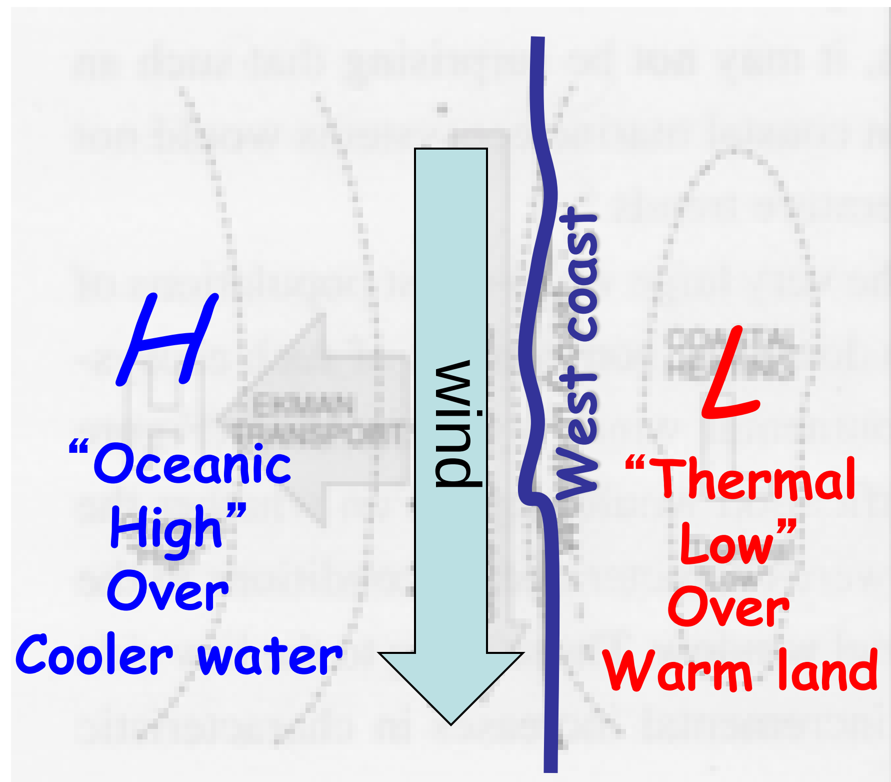
Climate Model SST projections
(IPCC WG1 2013)



- Future climate scenarios point to more upper ocean warming, increased stratification … but what about winds?

Global warming *and* Coastal Cooling?

- Because the land warms faster than the ocean, this may intensify the sea level pressure gradient between the *oceanic High* and *Thermal Low* over land, which would intensify upwelling winds… which would cool the ocean even more, and further increase the temperature contrast
- And what about other changes in the North Pacific High?



See Bakun (1990): Science and (1996): *Patterns in the Ocean*, p 223-227

some pressing questions

- What will happen to regional-scale upwelling winds?
  - Timing, magnitude, variability across timescales ranging from days to decades …

- How will increases in stratification interact with possible changes in winds to alter the upwelling of cooler, nutrient-rich, carbon-rich, and oxygen poor waters?

- What will happen to El Niño cycles in a warming climate?
  - Will they become more or less frequent, more or less intense?

- Will future ecosystem responses to radiatively-driven warming look like those caused by wind-driven warming of the past?

Further reading

- El Niño and climate prediction

  http://www.pmel.noaa.gov/tao/elnino/report/el-nino-report.html
- The NPGO

  http://www.o3d.org/npgo/
- The PDO

  http://jisao.washington.edu/pdo
- Climate change research for California

  http://www.climatechange.ca.gov/research

  (note that one research gap is a regional-scale perspective on climate change and the coastal ocean)

A great review article

Progress in Oceanography 83 (2009) 49–64

Contents lists available at ScienceDirect

Progress in Oceanography

journal homepage: www.elsevier.com/locate/pocean

ELSEVIER

Patterns and processes in the California Current System

David M. Checkley Jr. [a,*], John A. Barth [b,1]

[a] Scripps Institution of Oceanography, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA 92093-0218, United States
[b] College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR 97331, United States

CALIFORNIA DEPARTMENT OF FISH and WILDLIFE

Focus on Marine Resources

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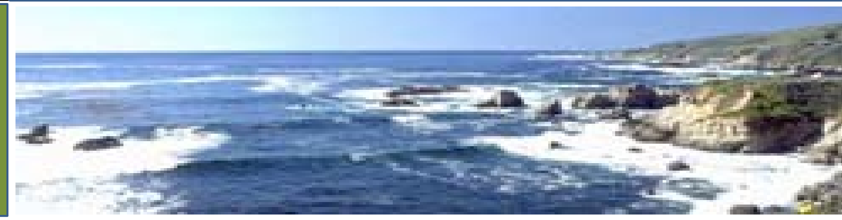

Questions/Discussion

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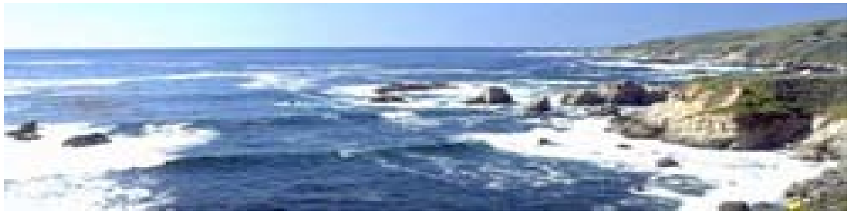


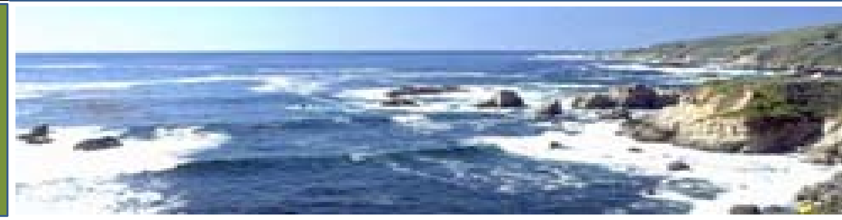
Next Class: Thursday, April 3rd, 2:00-4:00 pm

- Winds/upwelling
- California Current/Counter Currents

-Art Miller, Scripps Institute
-Francisco Chavez, MBARI

-Monterey, CA

http://www.dfg.ca.gov/Climate_and_Energy/Climate_Change/Climate_College/



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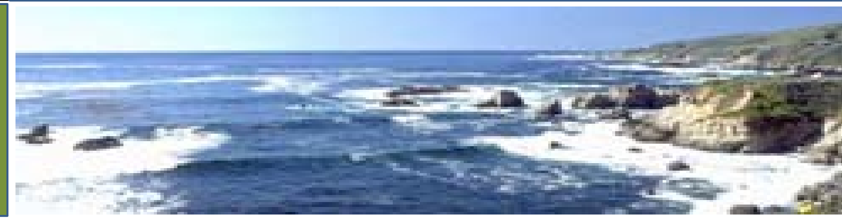

Thank you