Climate Variability and the 3D Structure of Coastal Upwelling

Michael Jacox

October 23, 2014

Collaborators: Andy Moore, Chris Edwards, Jerome Fiechter

How Do We Study Upwelling?

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 115, C04011, doi:10.1029/2009JC005576, 2010

Observations of increased wind-driven coastal upwelling off central California

M. García-Reyes[1] and J. Largier[1]

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 102, NO. C2, PAGES 3421–3438, FEBRUARY 15, 1997

Increased coastal upwelling in the California Current System

Franklin B. Schwing and Roy Mendelssohn
Pacific Fisheries Environmental Group, Pacific Grove, California

OPEN ACCESS Freely available online

PLoS one

Climatic Control of Upwelling Variability along the Western North-American Coast

Diego Macias[1]*, Michael R. Landry[2], Alexander Gershunov[3], Arthur J. Miller[3], Peter J. S. Franks[2]

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 117, C08012, doi:10.1029/2012JC008016, 2012

Ocean Sci., 6, 815–823, 2010
www.ocean-sci.net/6/815/2010/
doi:10.5194/os-6-815-2010

Ocean Science

What determines the spatial pattern in summer upwelling trends on the U.S. West Coast?

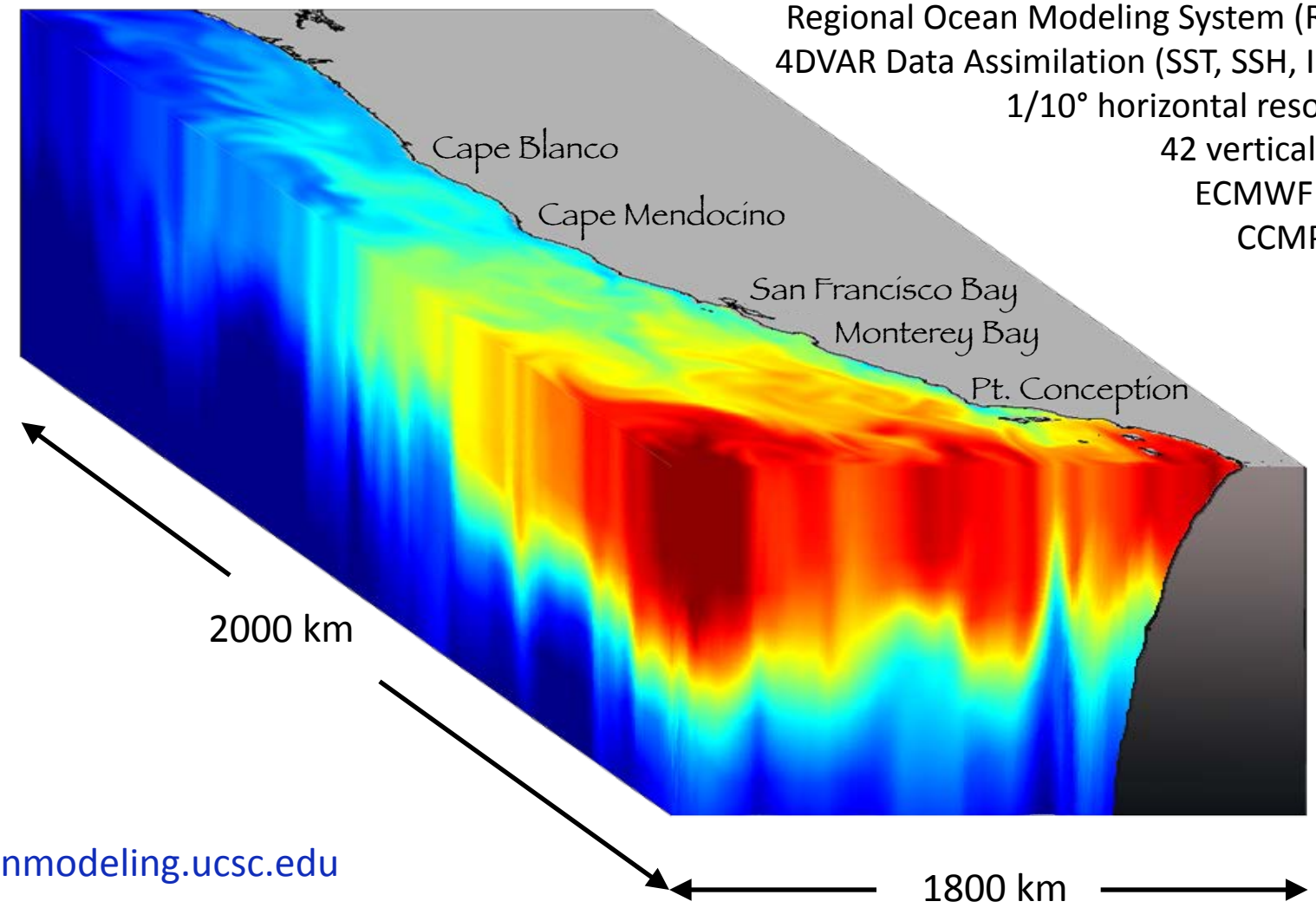
Hyodae Seo,[1] Kenneth H. Brink,[1] Clive E. Dorman,[2] Darko Koracin,[3] and Christopher A. Edwards[4]

Trends in coastal upwelling intensity during the late 20th century

N. Narayan, A. Paul, S. Mulitza, and M. Schulz
MARUM – Center for Marine Environmental Sciences and Faculty of Geosciences, University of Bremen, Germany

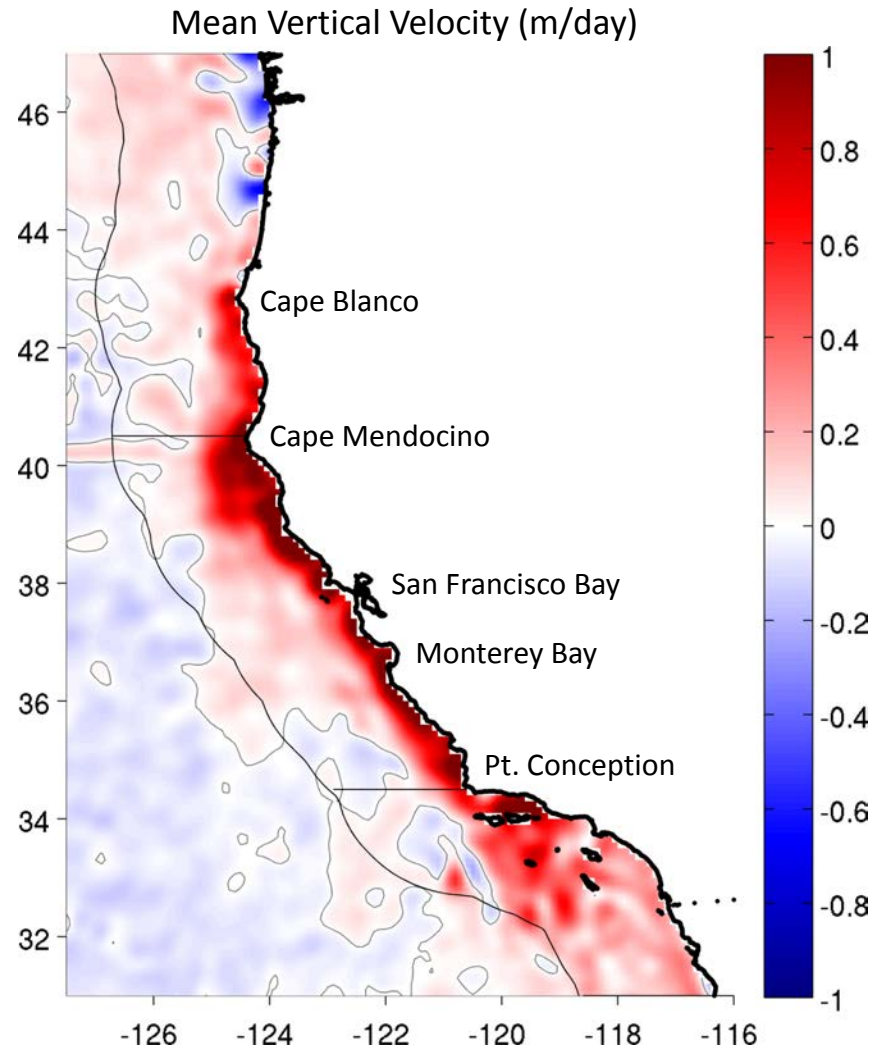
Model Configuration (1988-2010)

Regional Ocean Modeling System (ROMS)
4DVAR Data Assimilation (SST, SSH, In situ)
1/10° horizontal resolution
42 vertical levels
ECMWF fluxes
CCMP wind



oceanmodeling.ucsc.edu

An Overview of CCS Upwelling



Vertical velocity is calculated at 40m depth

Long-term mean upwelling extends approximately 200 km offshore

Three distinct regions (Dorman and Winant, 1995):

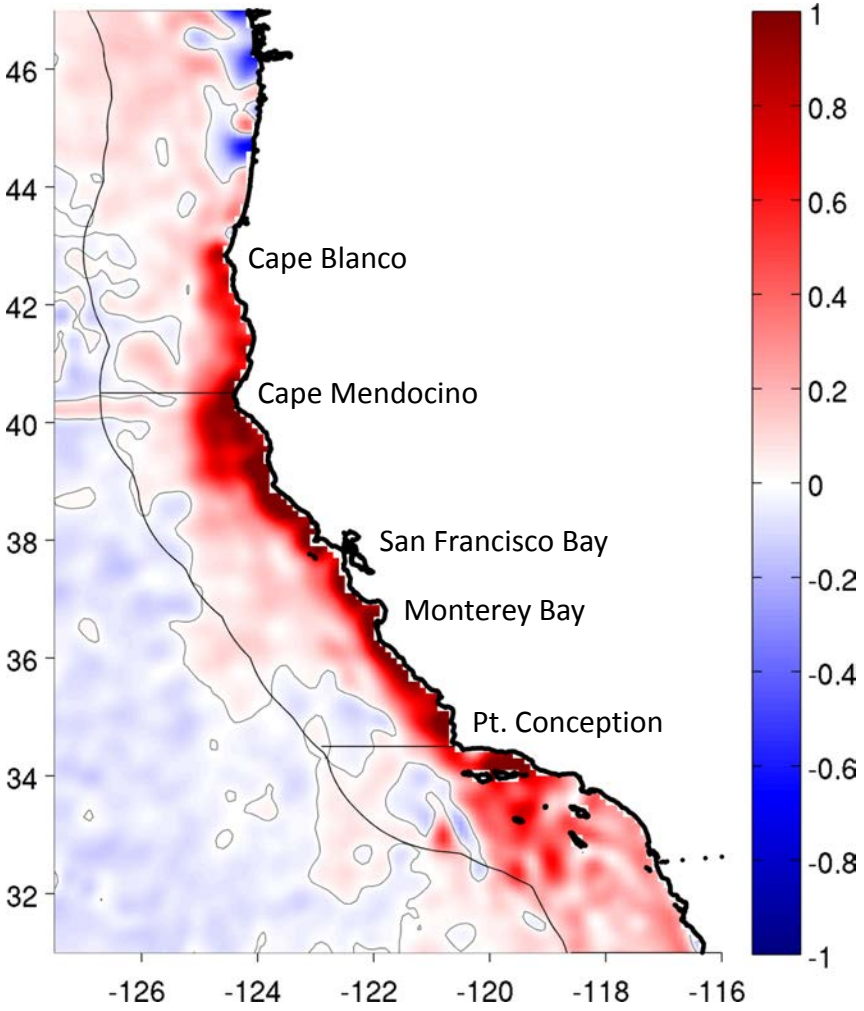
<u>North</u>
Storm track, variable forcing

<u>Central</u>
Persistent equatorward winds

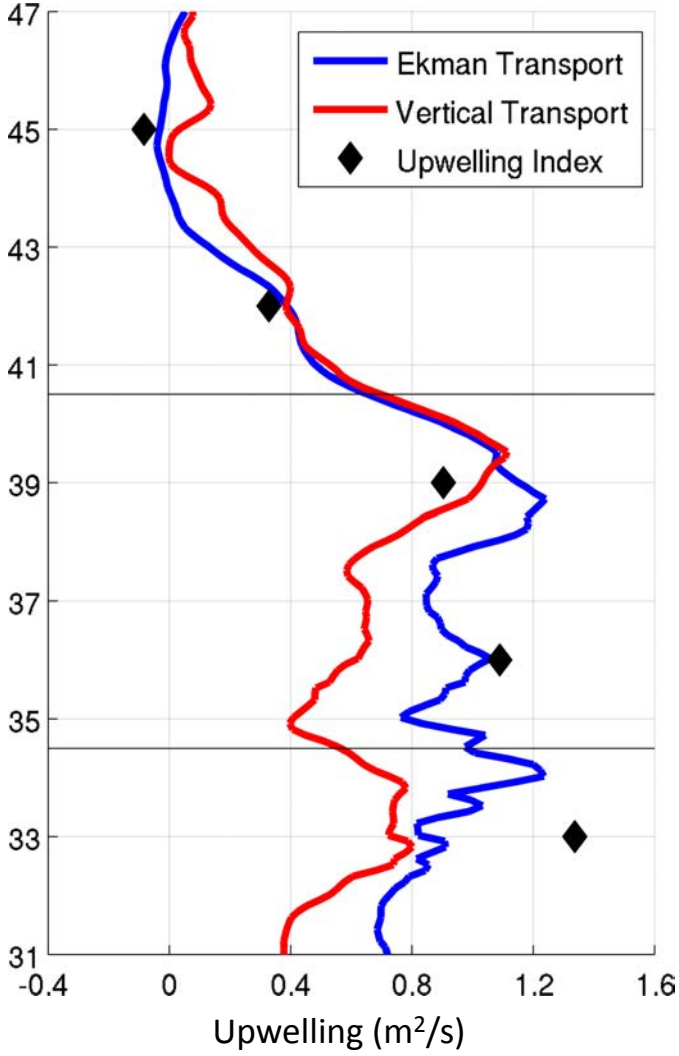
<u>South</u>
Sheltered from strong winds

An Overview of CCS Upwelling

Mean Vertical Velocity (m/day)



Mean Upwelling Transport



Discrepancies in Upwelling Estimates

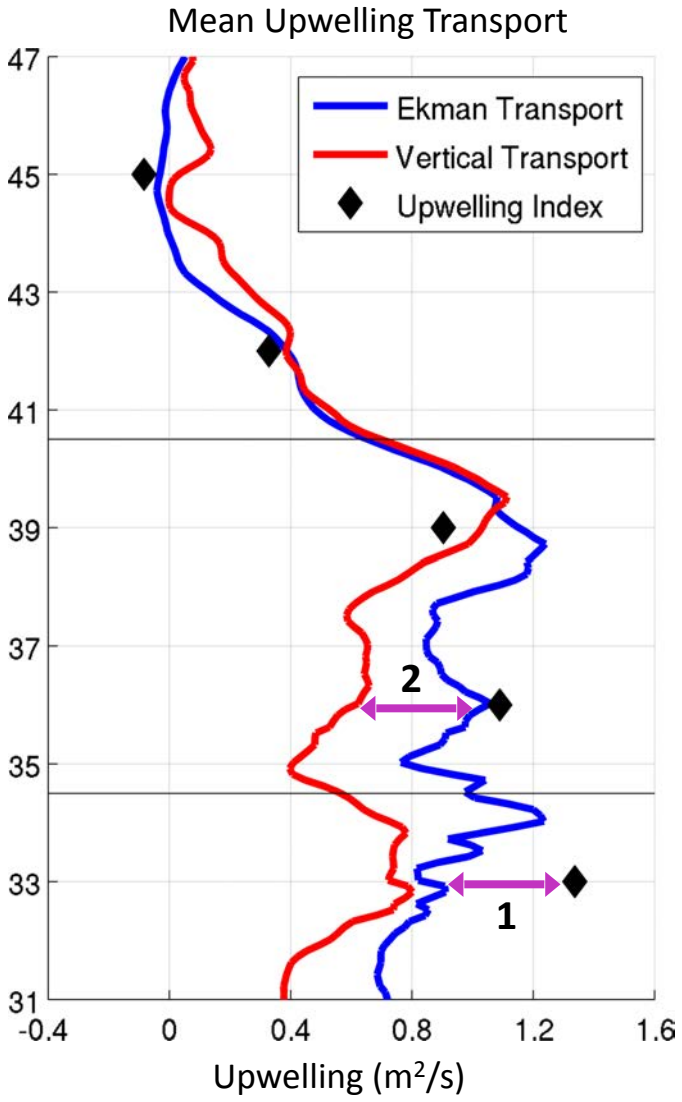
1. Upwelling Index overestimates Ekman Transport

Discrepancy between model wind and upwelling index wind (data issue)

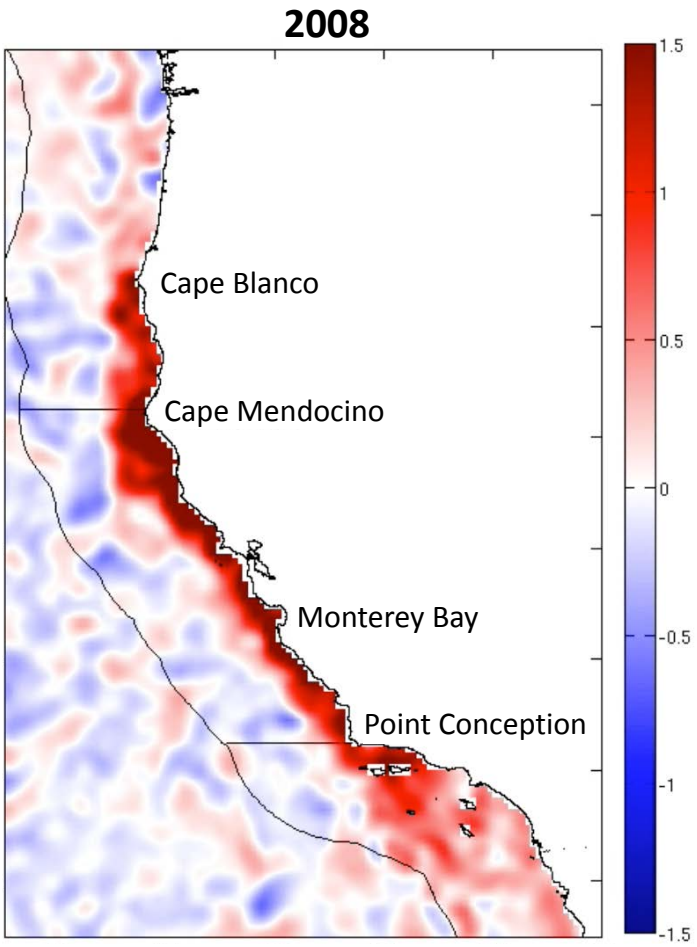
2. Ekman Transport overestimates upwelling

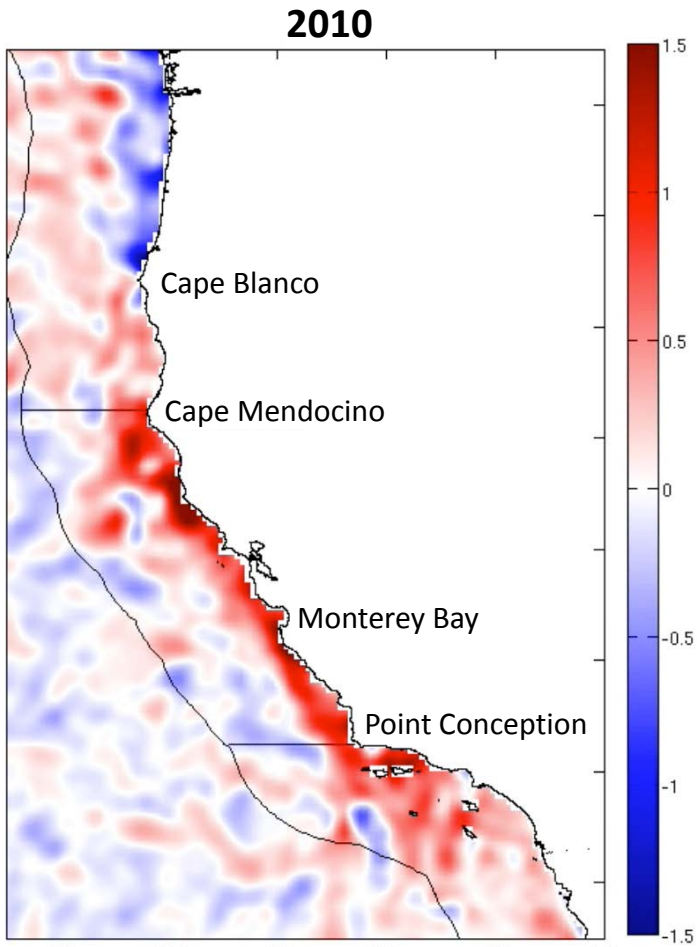
Discrepancy between wind-driven transport and vertical transport (dynamical issue)

Caused by cross-shore geostrophic flow
(*Marchesiello and Estrade,* 2010)



Capturing Interannual Variability *in 2D*





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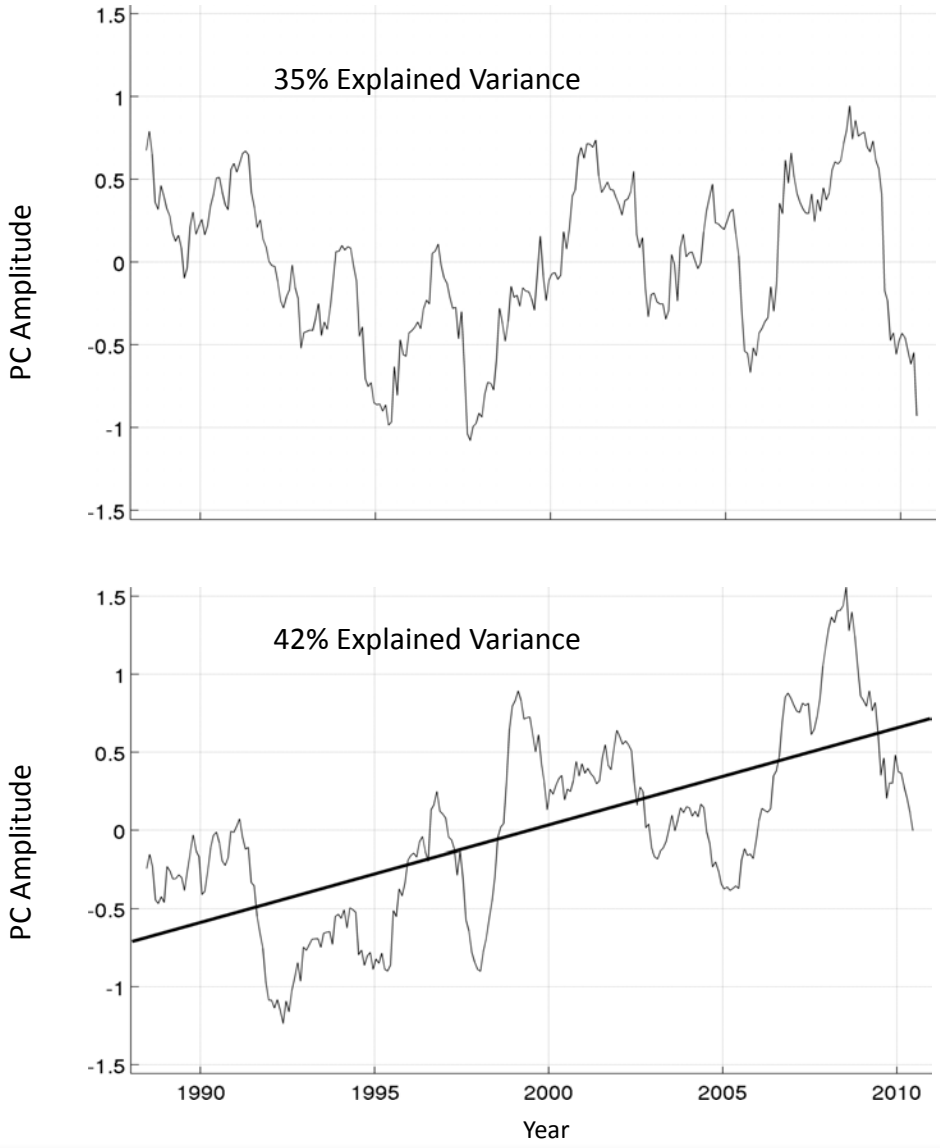

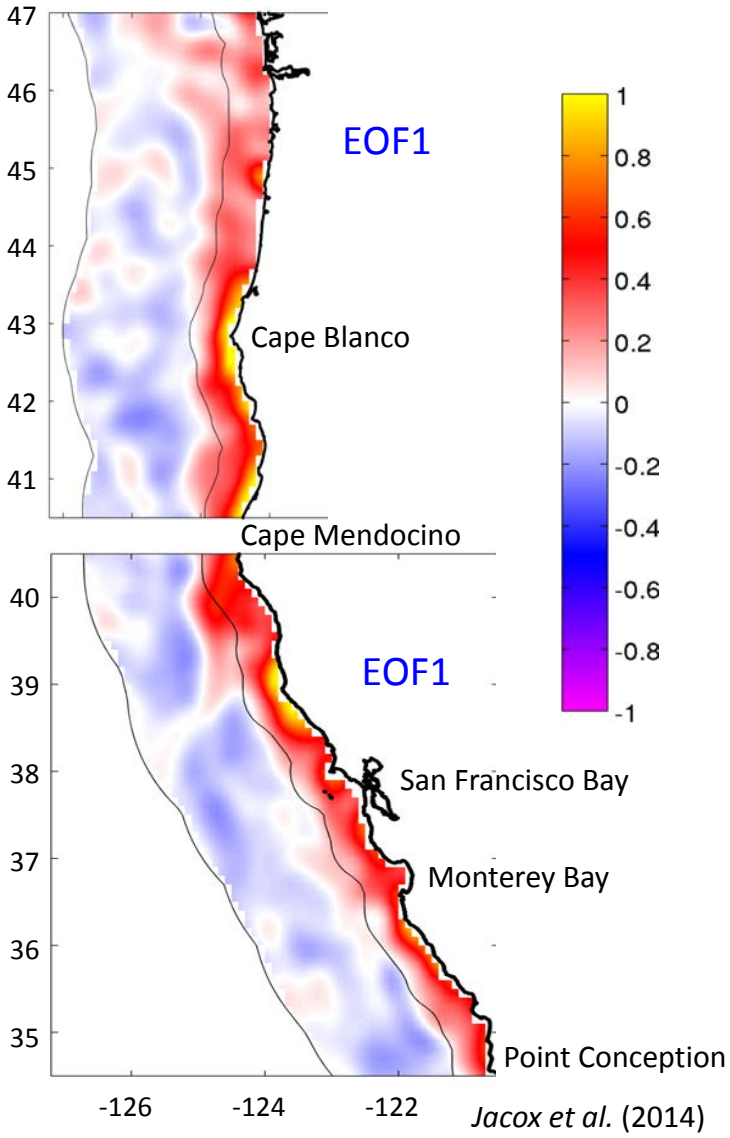

Jacox et al. (2014)

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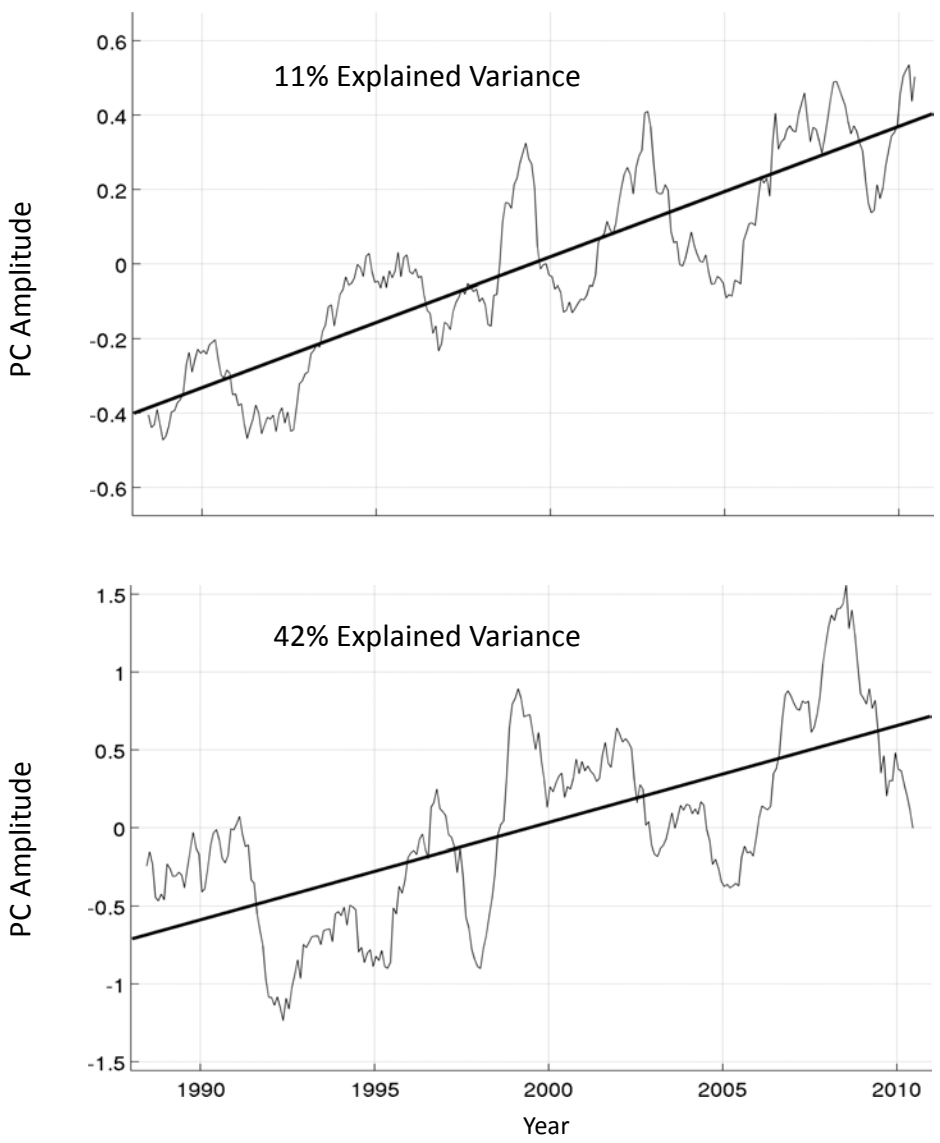
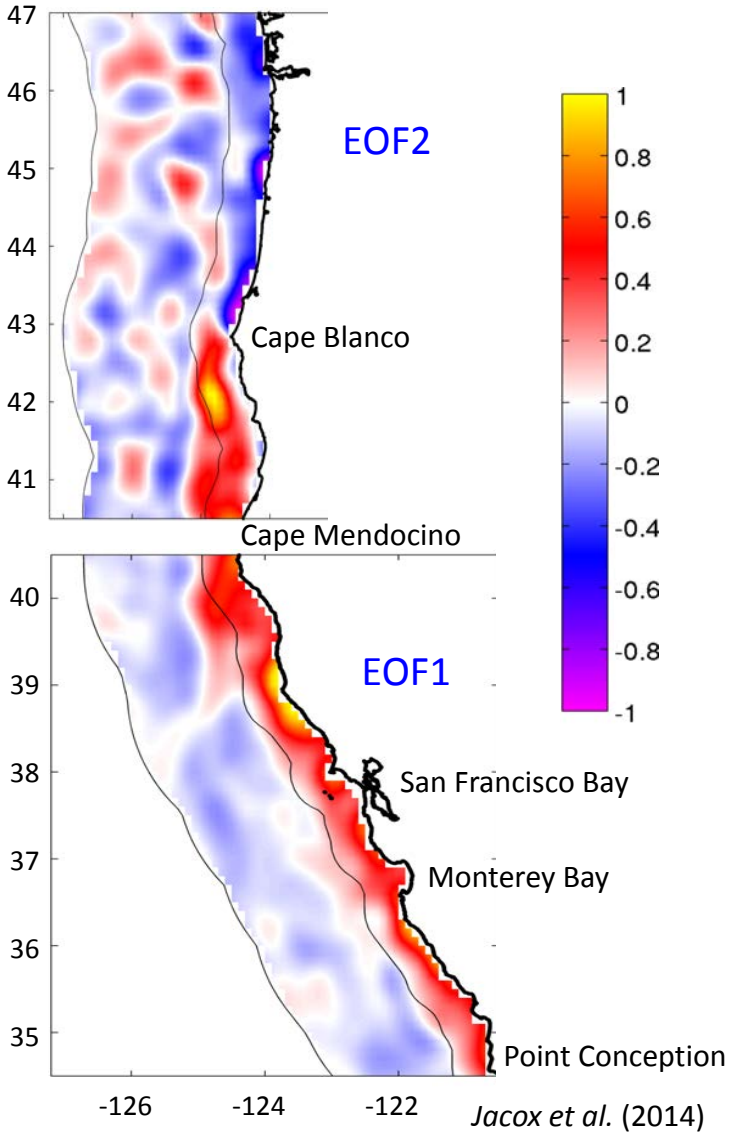
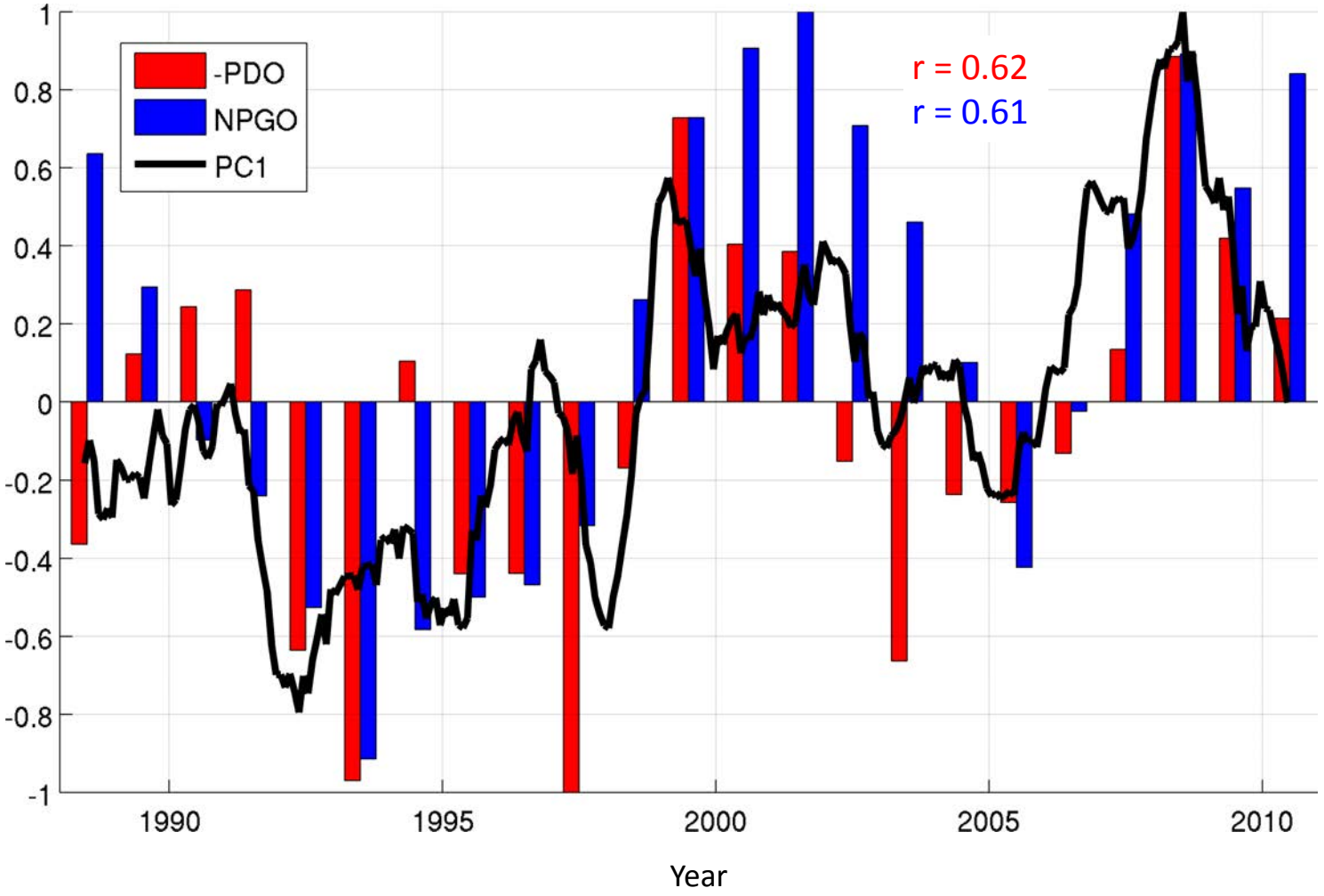




Jacox et al. (2014)

The Central CCS Response to PDO/NPGO



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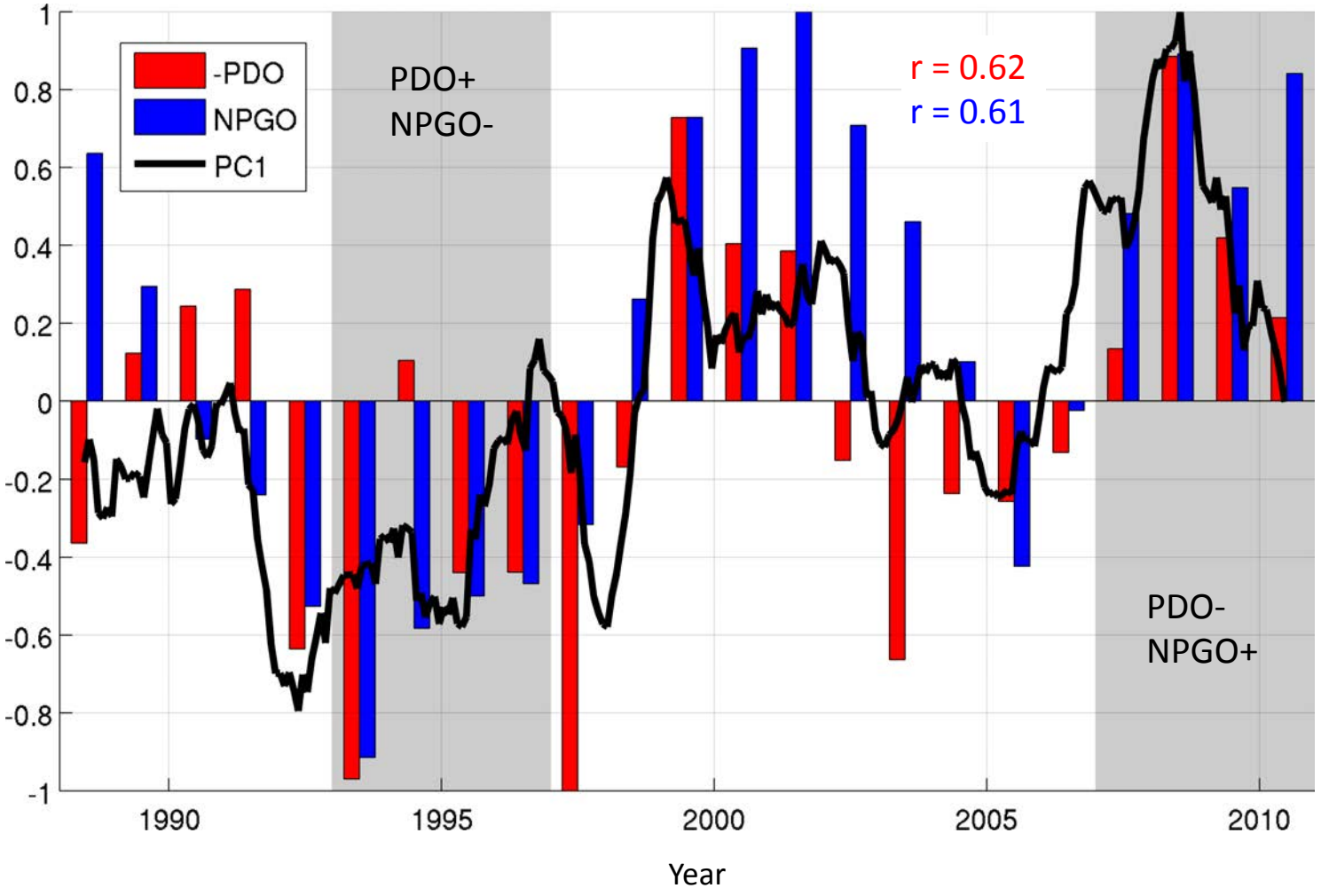
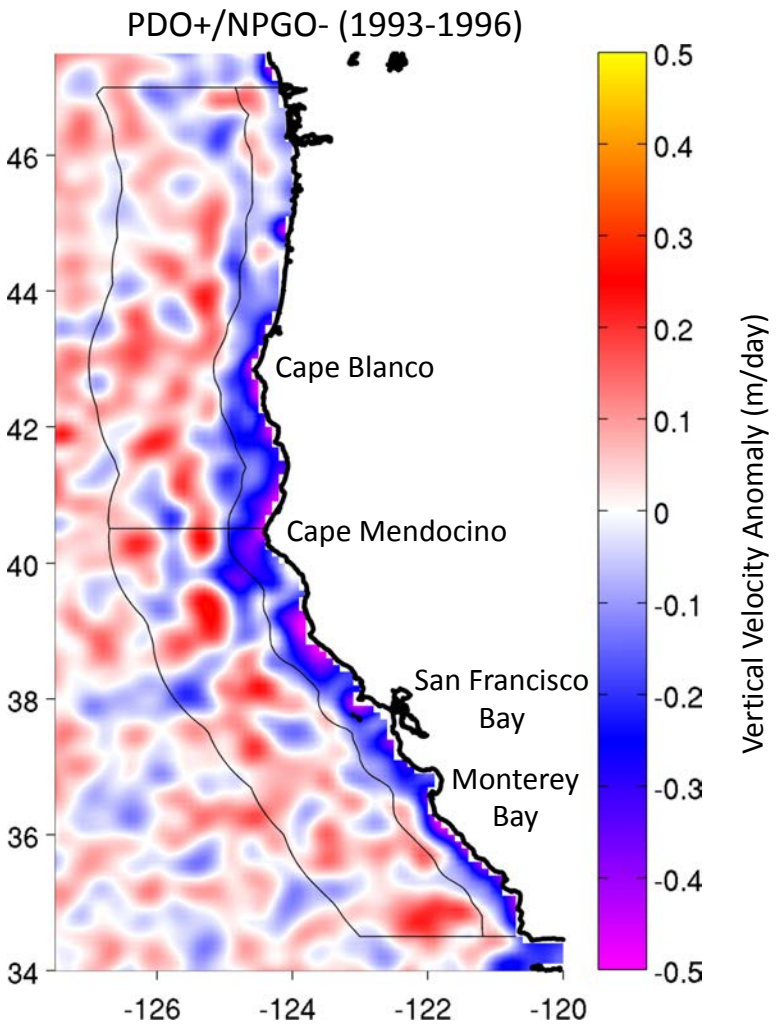
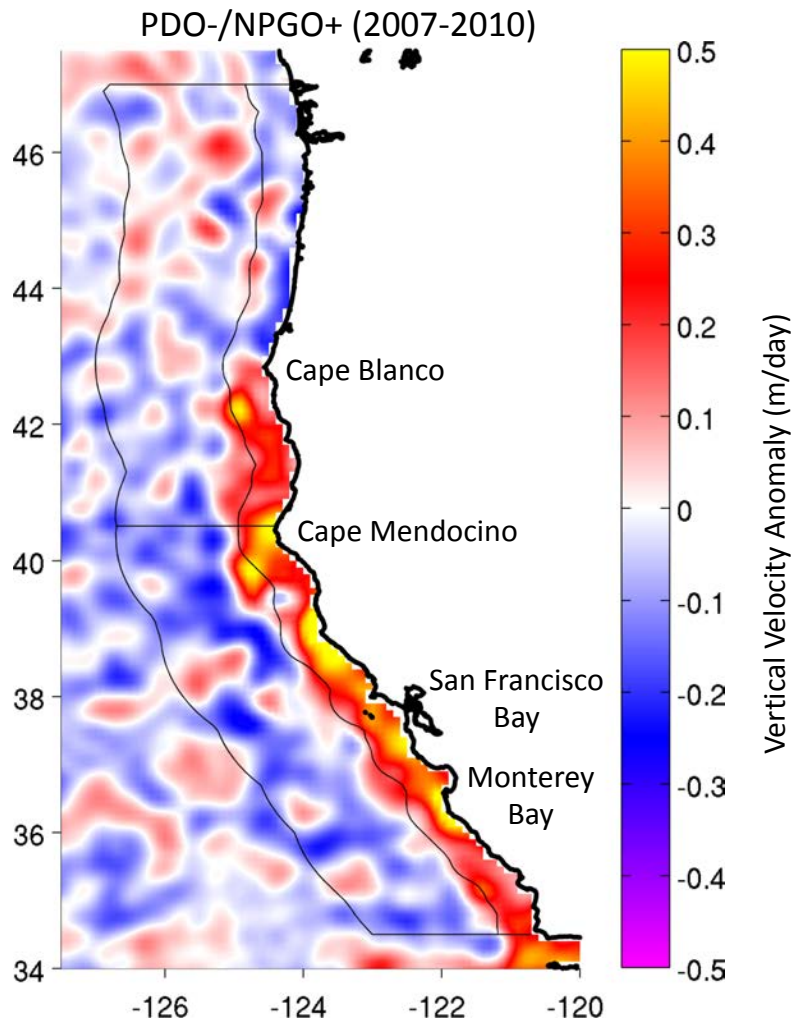


Jacox et al. (2014)

The Central/Northern CCS Response to PDO/NPGO





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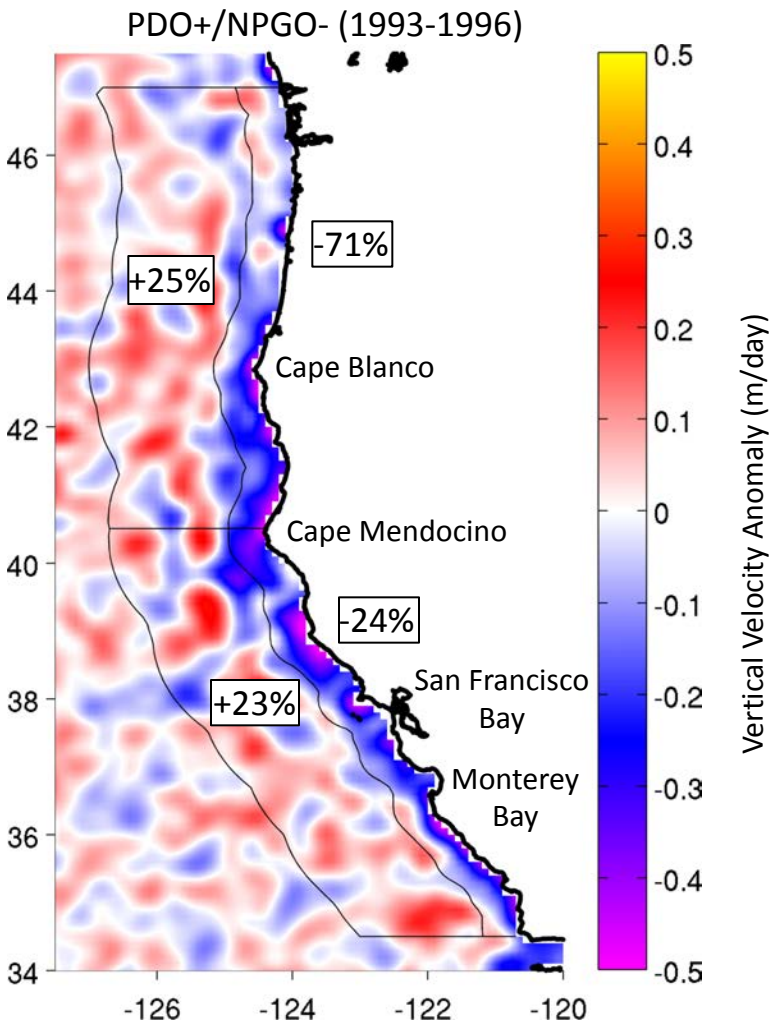
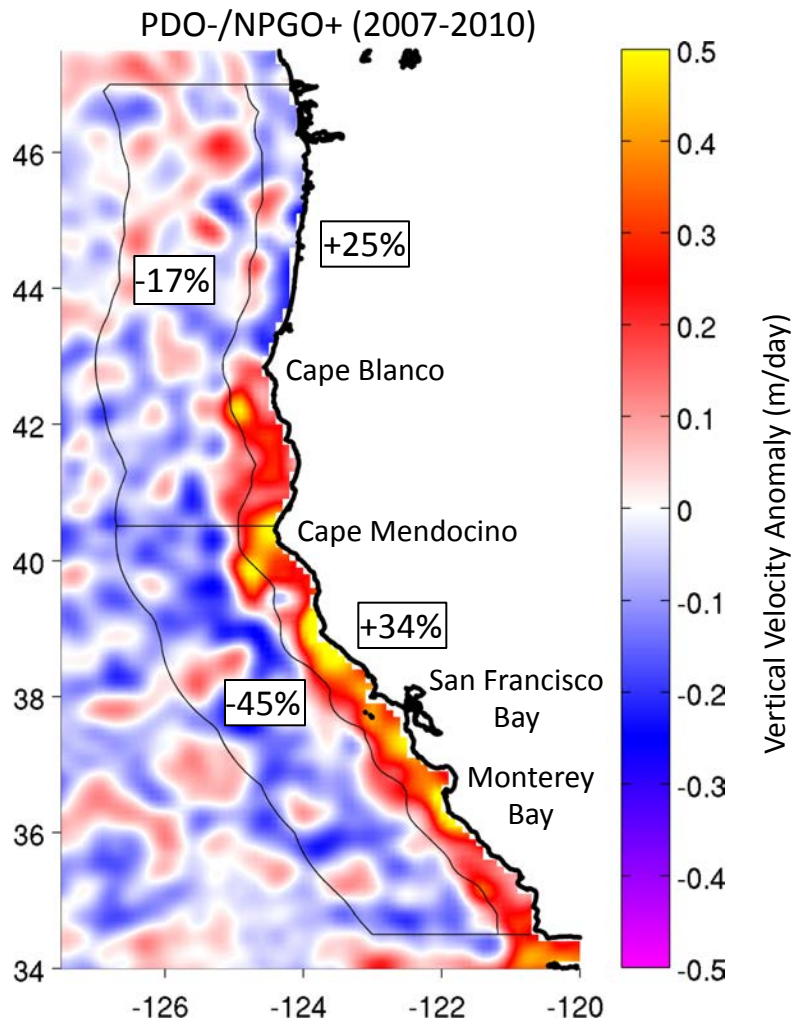
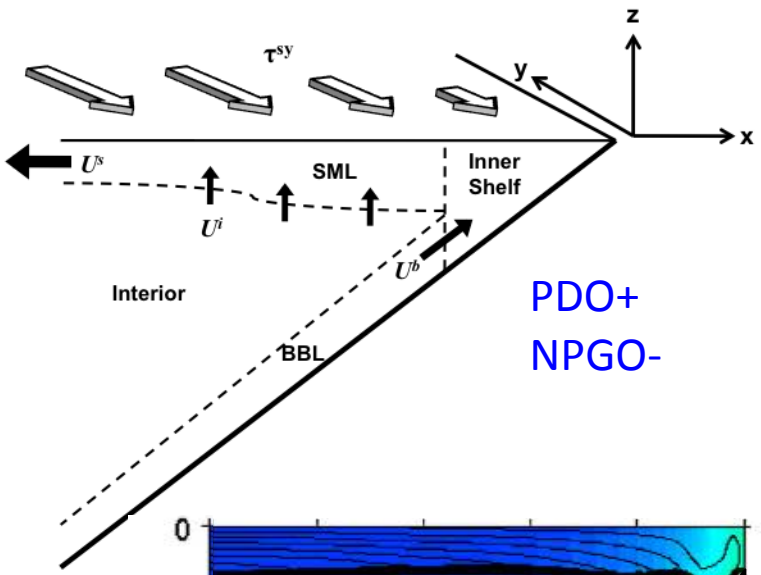


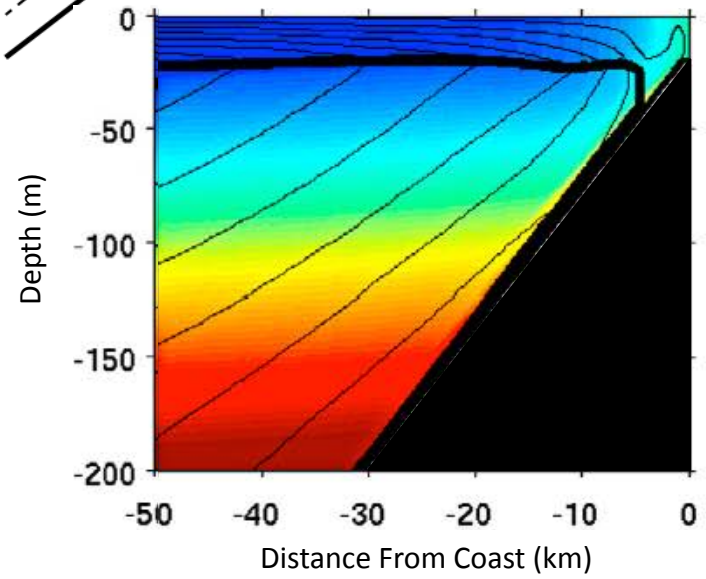


Jacox et al. (2014)

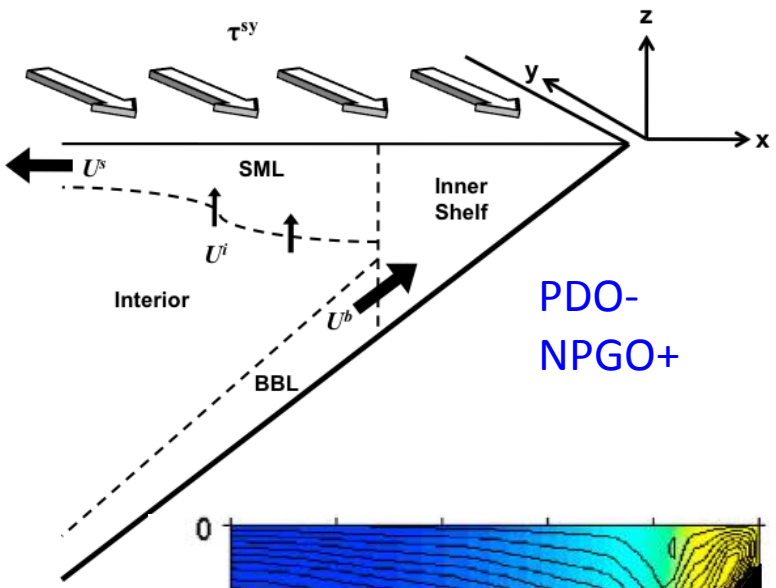
Upwelling Response to Coastal Wind Profiles



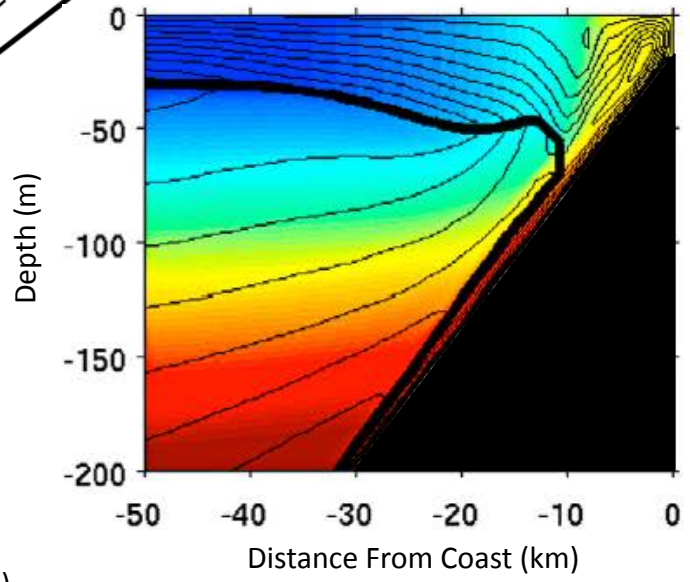
PDO+
NPGO-



1988-2010

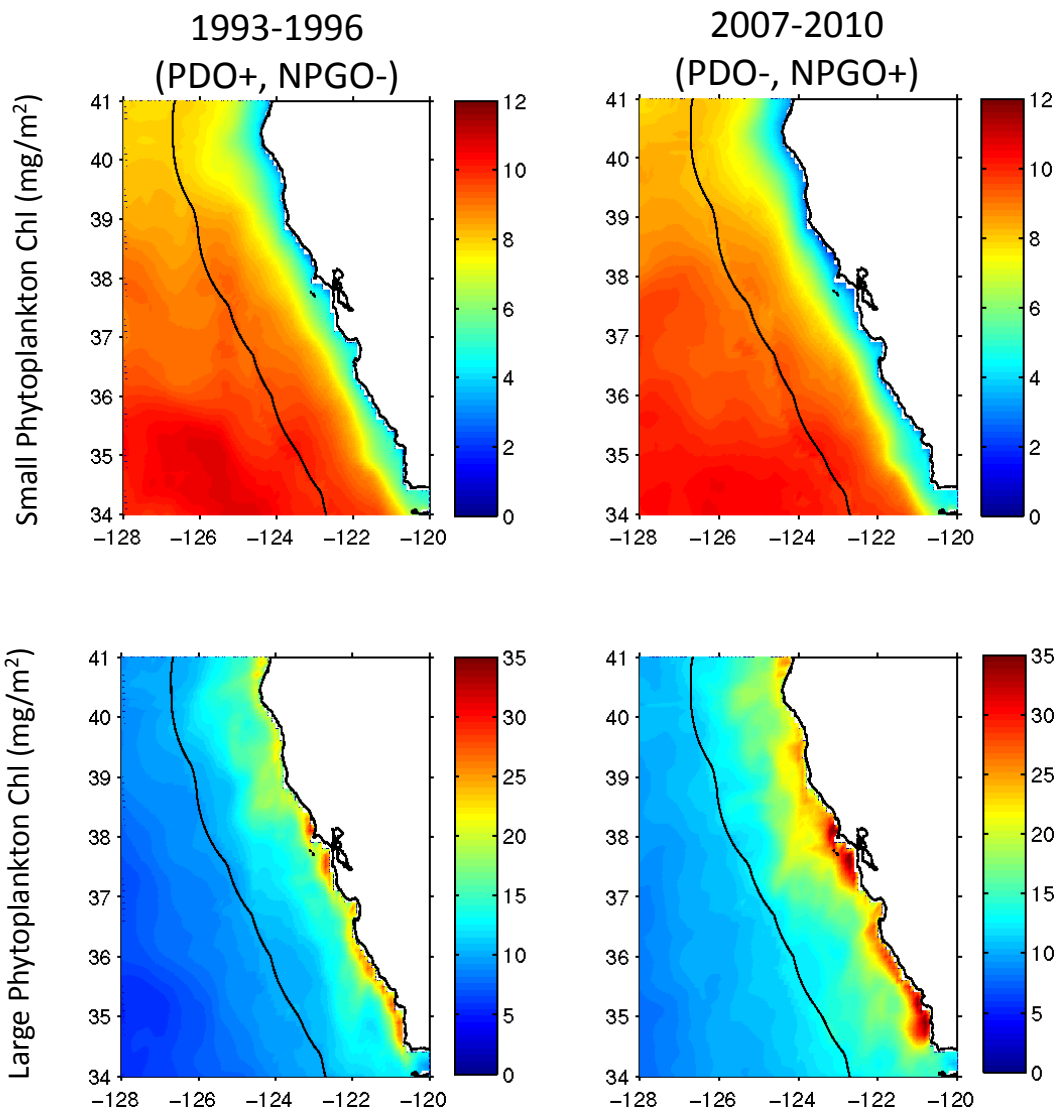


PDO-
NPGO+



Jacox and Edwards (2012)

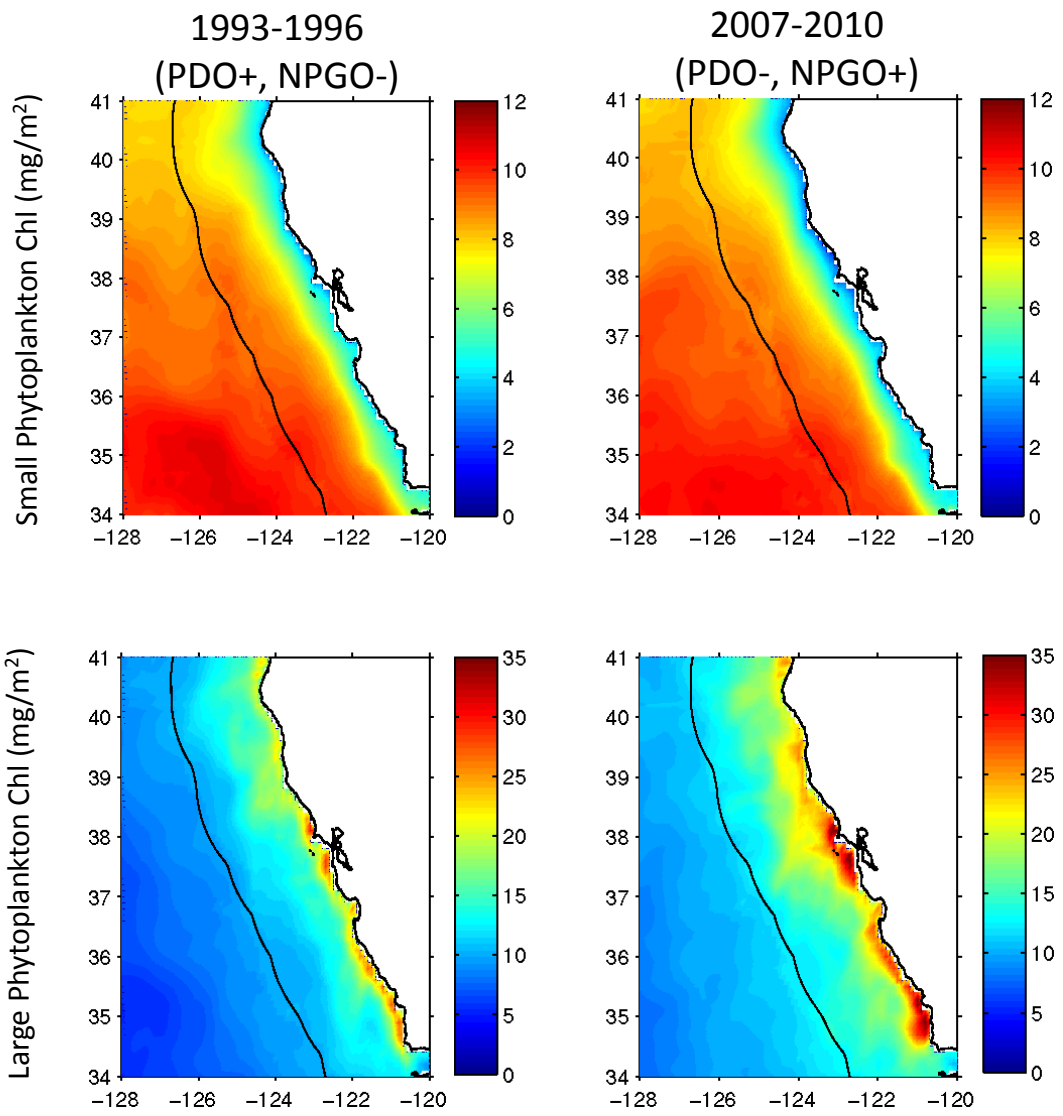
A Hypothesis on Biological Implications



NEMURO biogeochemical model coupled to ROMS:

Two phytoplankton:
Small (nanophytoplankton)
Large (diatoms)

A Hypothesis on Biological Implications



NEMURO biogeochemical model coupled to ROMS:

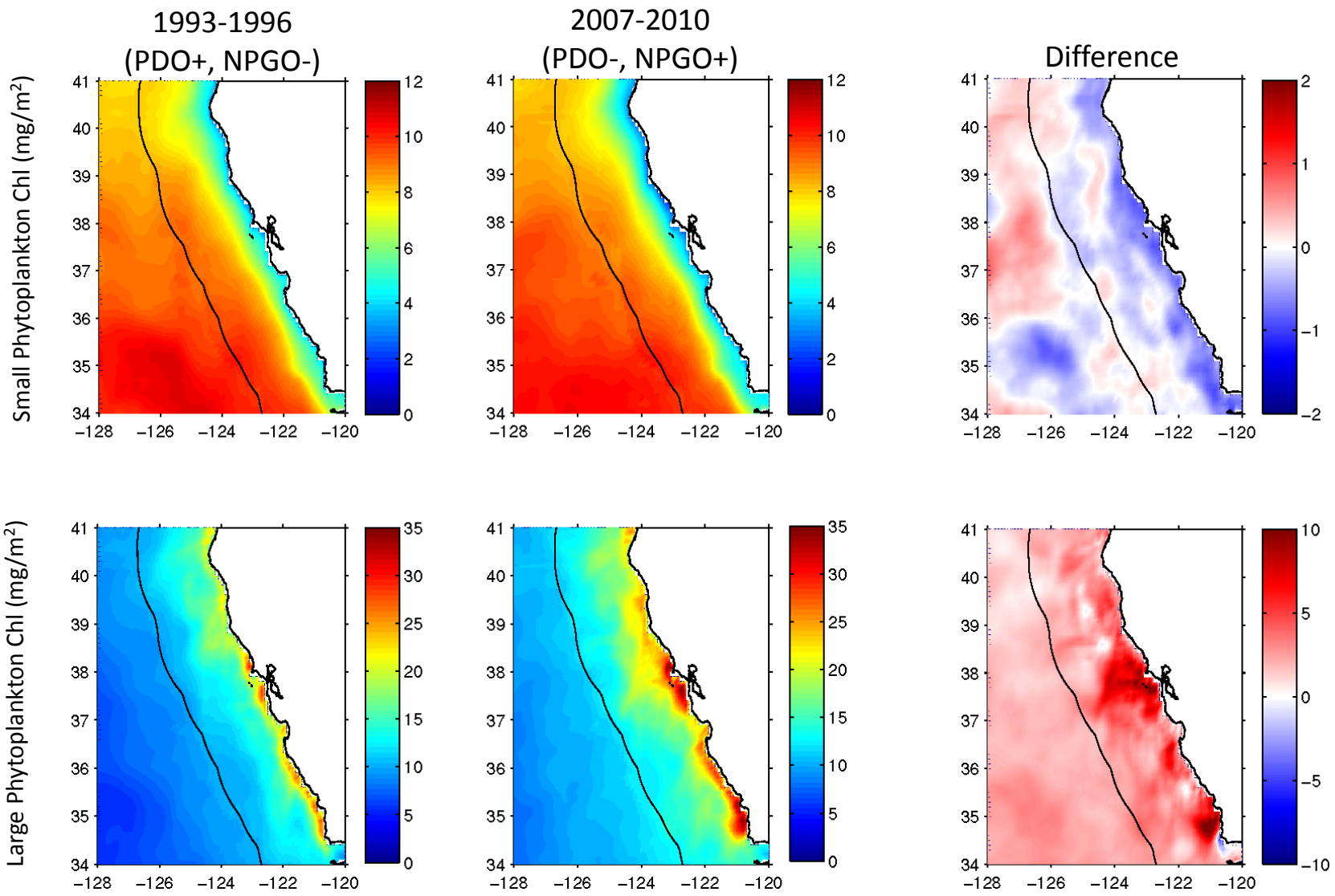
Two phytoplankton:
Small (nanophytoplankton)
Large (diatoms)

Hypothesis:
Intense nearshore upwelling (PDO-, NPGO+) favors large phytoplankton

Widespread weak upwelling (PDO+, NPGO-) favors small phytoplankton.

(*Rykaczewski and Checkley*, 2008)

A Hypothesis on Biological Implications



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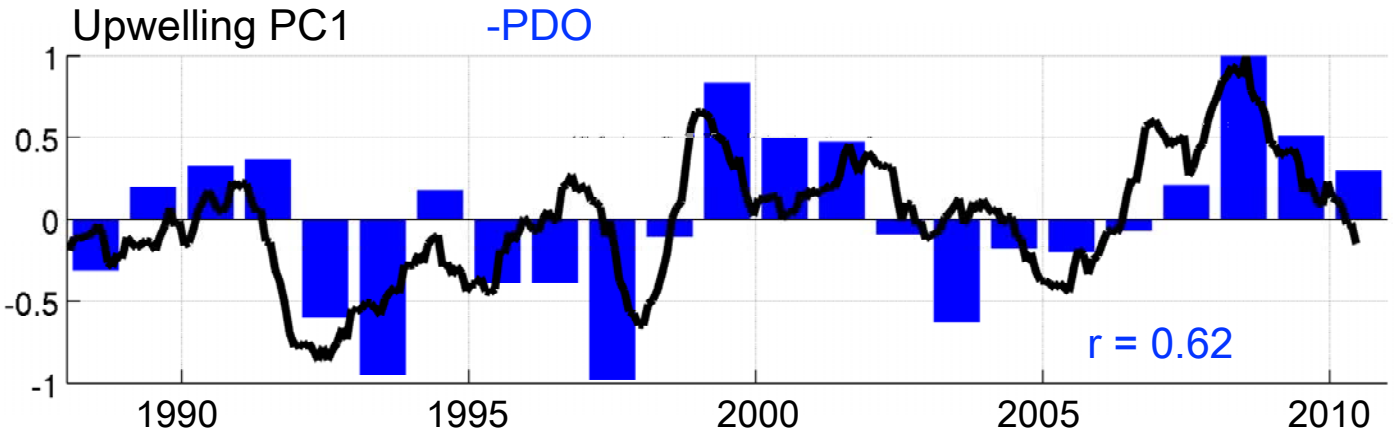
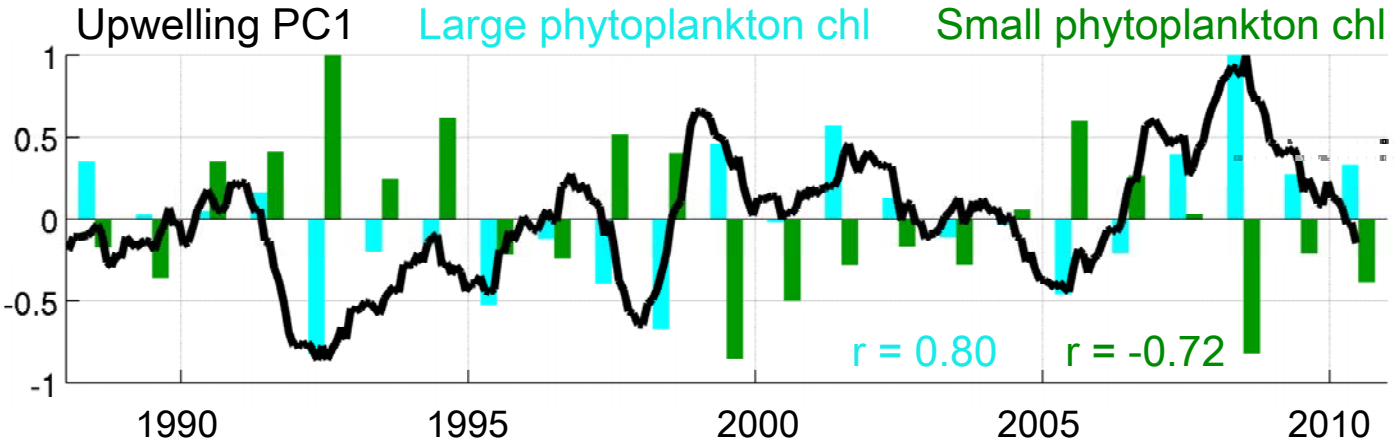
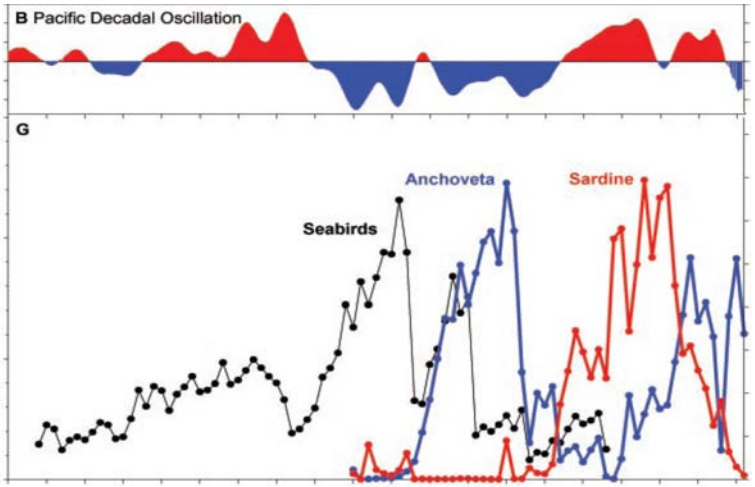




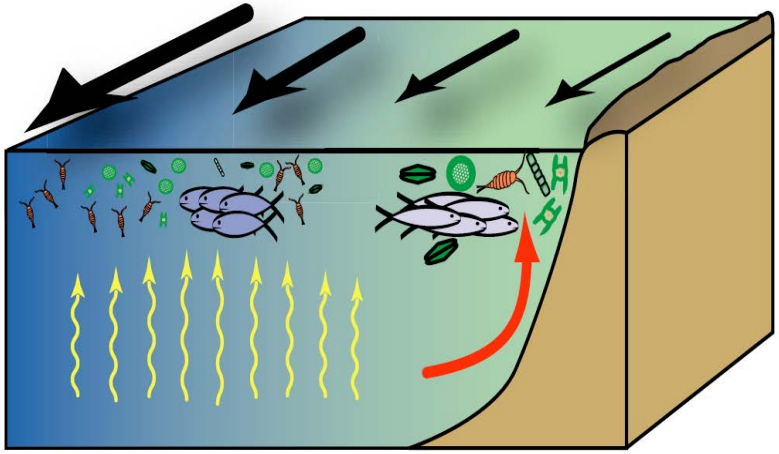
Sardines and Anchovies: A Physical Mechanism?

PDO+ = Sardines, PDO- = Anchovies

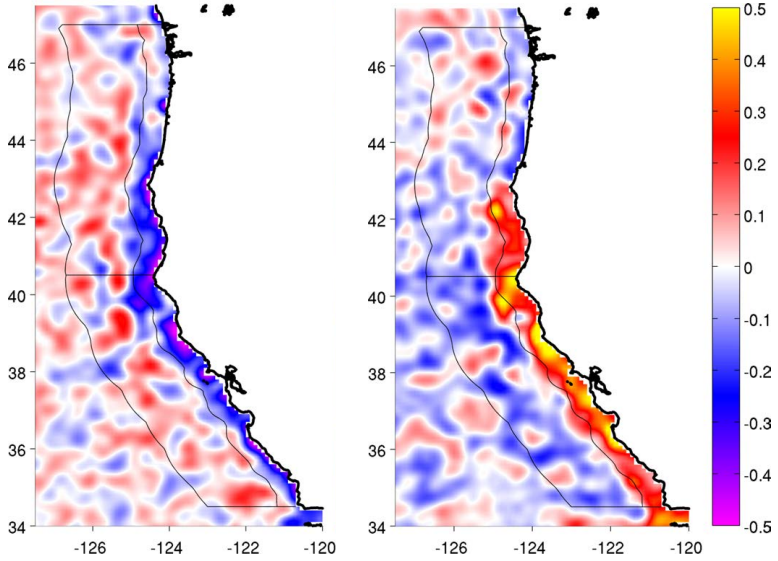


Chavez et al. (2003)

Weak upwelling = Sardines, Strong upwelling = Anchovies



Rykaczewski and Checkley (2008)



PDO+

Widespread weak upwelling

Sardines

PDO-

Intense coastal upwelling

Anchovies