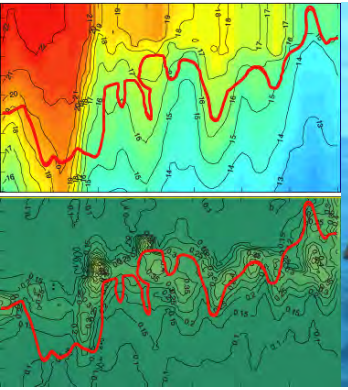
Spatial and temporal variability in the biophysical properties of the North Pacific Subtropical Frontal Zone during 1997-2011

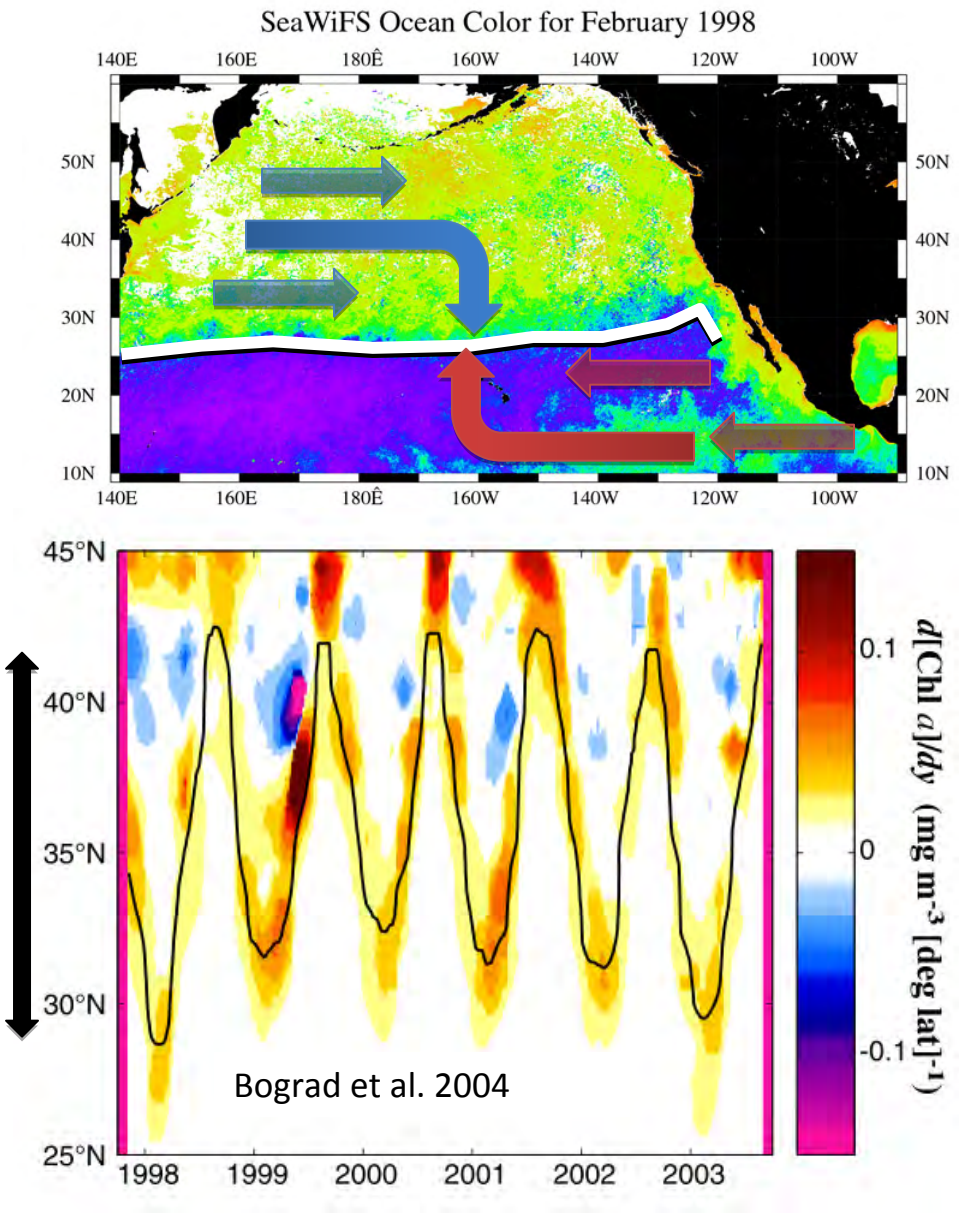



Evan A. Howell, Aimee L. Hoover, Steven J. Bograd, Jeffrey J. Polovina, and Michael P. Seki

The North Pacific Subtropical Frontal Zone

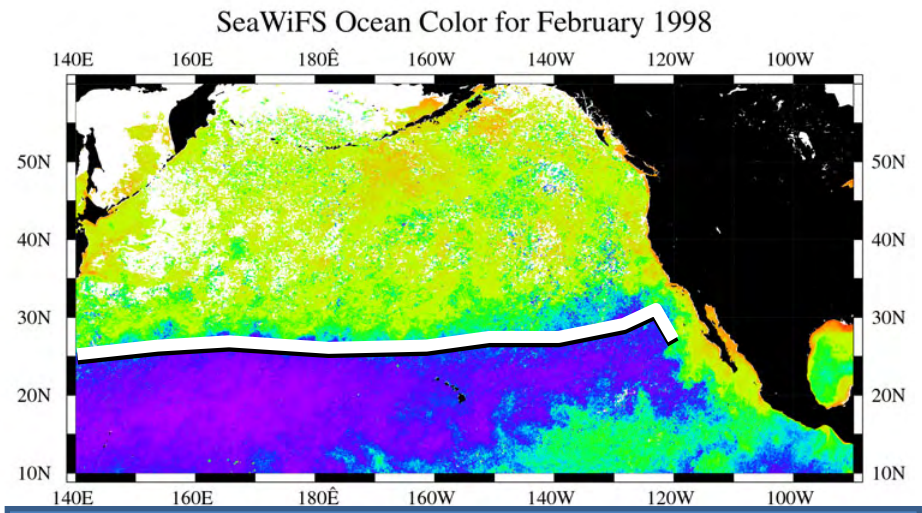
- Is the separation between the productive northern Subarctic Gyre (upwelling) and the oligotrophic southern Subarctic Gyre (downwelling)

- Area of high convergence with seasonal spatial variability
  - Convergence forced by wind fields
  - Increase in wind field during winter drives convergent frontal area south
  - Frontal zone can move up to 1,000 km from northern maximum (Aug-Sep) to southern minimum (Feb-Mar)



Importance of region

- Migration and forage pathway for numerous species)
  - geographically “fixed” (birds, fisheries, elephant seals)
  - “non-fixed” (turtles, swordfish, albacore)?
- Large seasonal and interannual changes in position of surface fronts
- Physical dynamics have effect on biological composition of region
- Series of physical and biological frontal zone including SSTF, STF, and TZCF



Recent studies have shown apparent expansion of the oligotrophic gyre using remotely sensed and modeled surface data (Polovina et al., 2008, 2011)

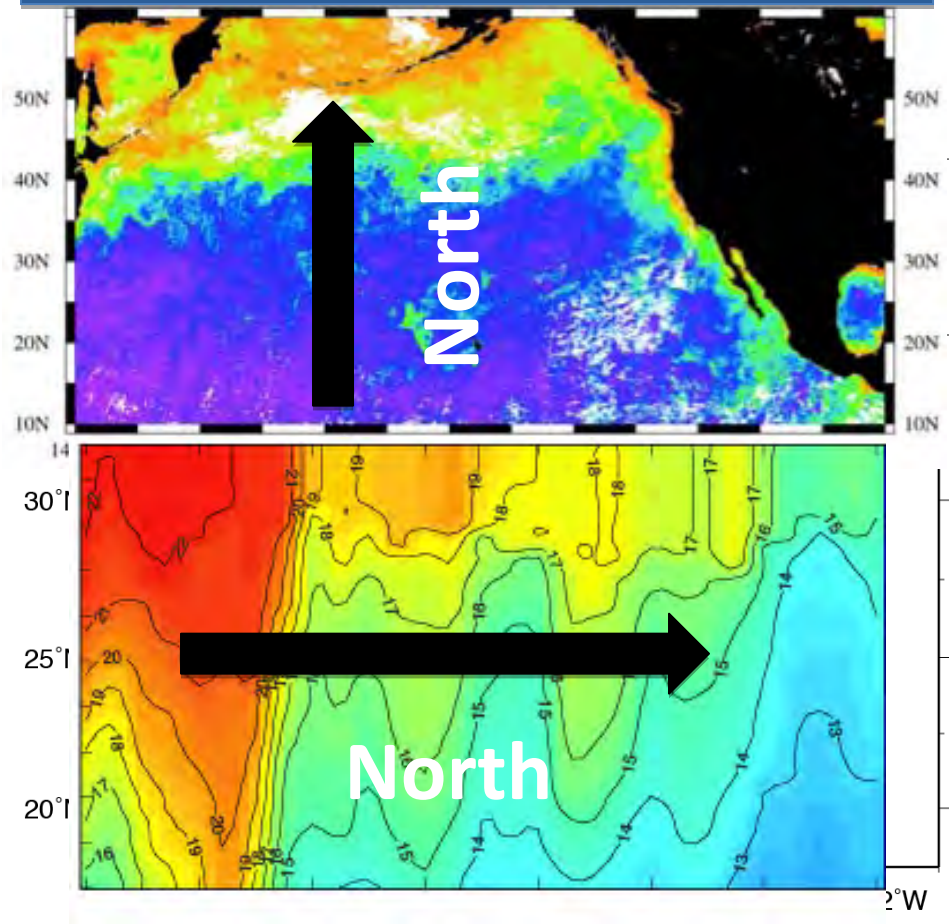
Is this expansion observed in subsurface waters?

If observed, what is the effect on biology?

Map of Study area, years of coverage

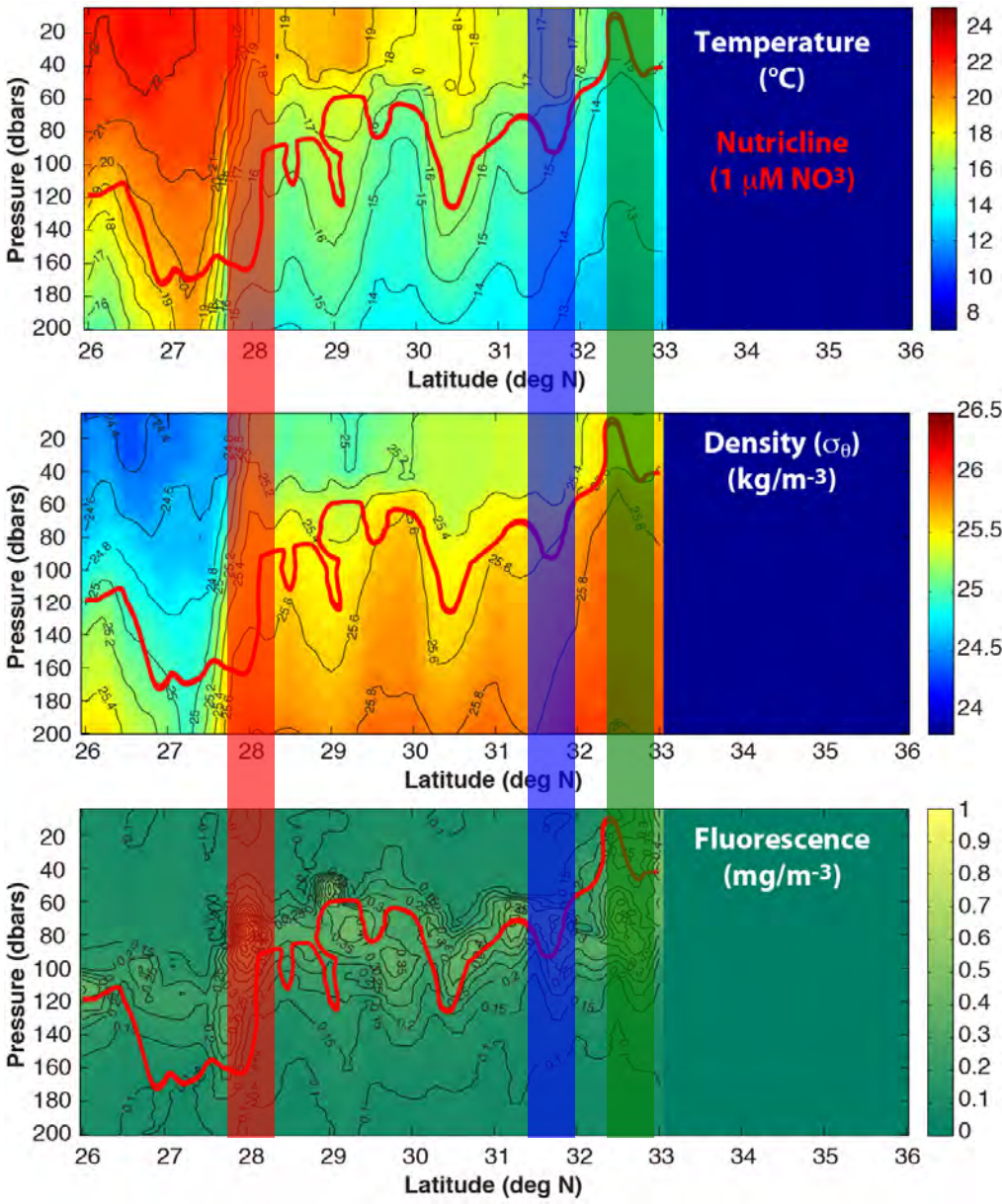
- Seven cruises along 158°W during Mar-May 1997-2011
  - 1997-2000 26°N-33/34°N
  - 2008-2011 26°N-36°N
- Measured:
  - Physics (T,S)
  - Chemistry (N,P,Si,O)
  - Biology (Chl-a, HPLC)
- Will Focus on specific years and parameters to highlight subsurface variability (0-200m)

GOAL: Expand surface view to subsurface



The Subtropical Frontal Zone: Subsurface (1998)

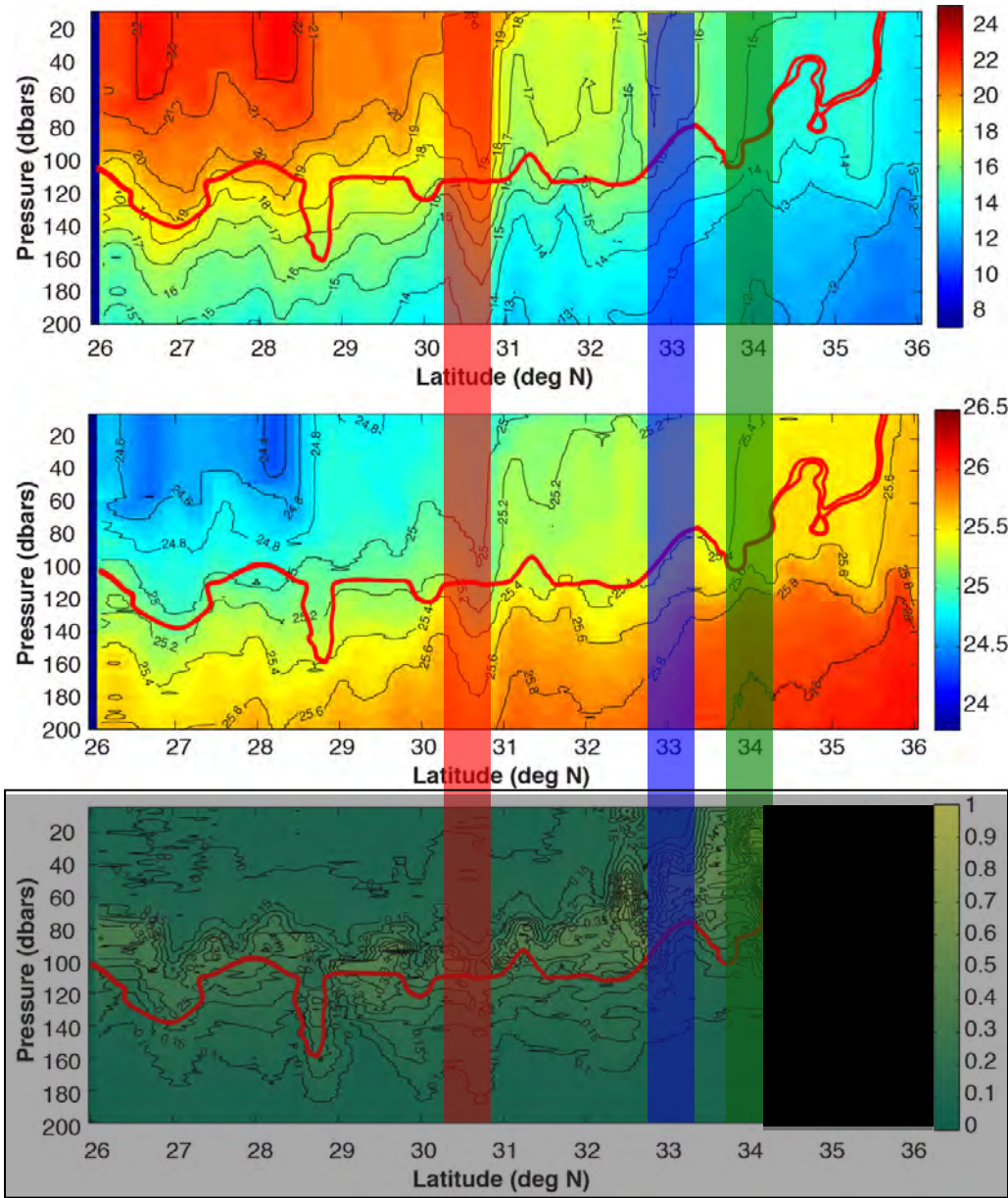
- Subsurface example for 1998 (Strong El Niño)*
- Temperature drives density
- Deep chlorophyll max at nutricline (1 μM NO_3)
  - shifts in depth based on fronts (SSTF, STF, TZCF)
  - mesoscale variability
  - Surface manifestations to north (TZCF)



*see Seki et al. 2002 for additional data

The Subtropical Frontal Zone: Subsurface (2011)

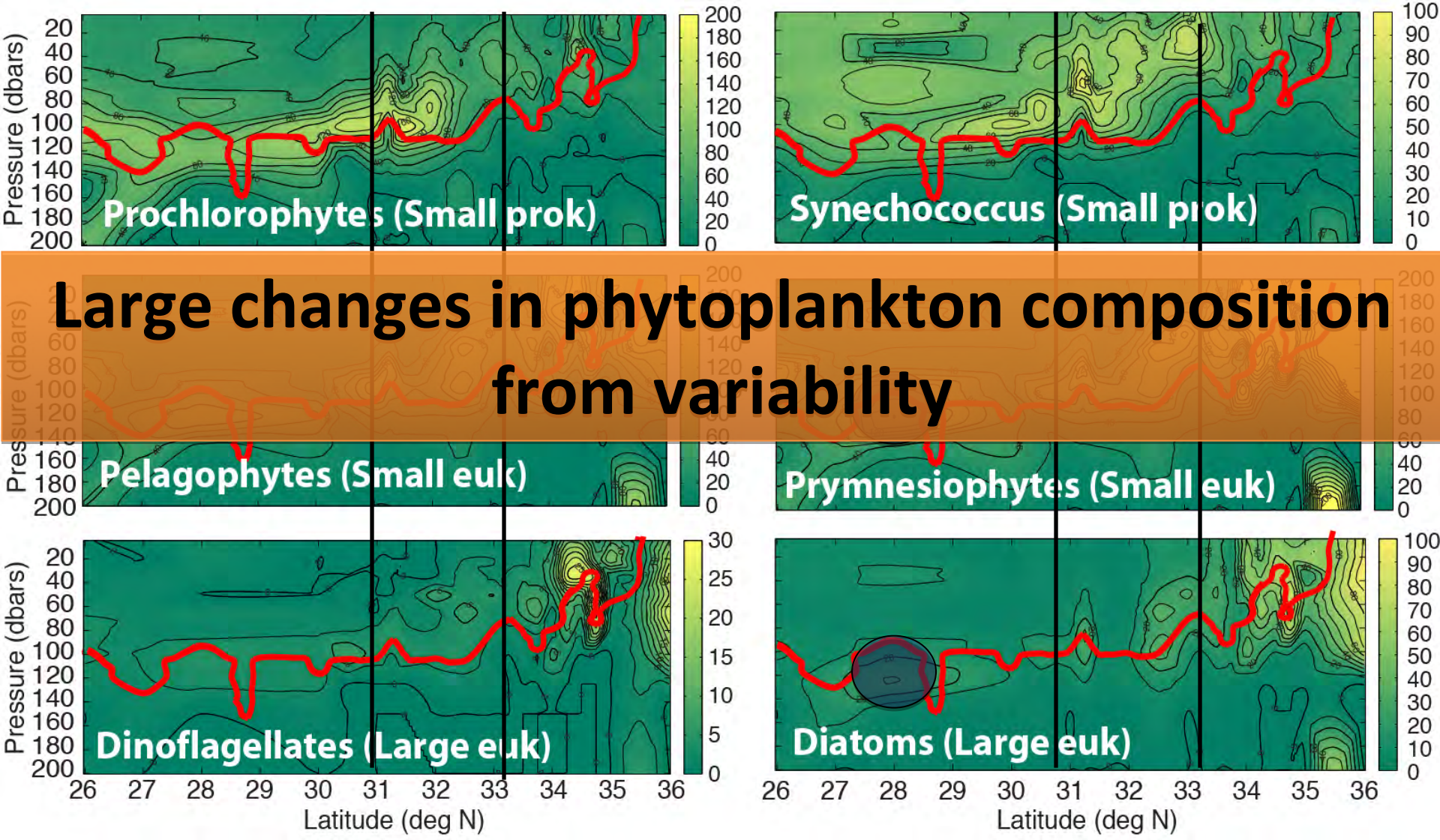
- Another subsurface example (2011)
- Less mesoscale variability
- Temperature and chlorophyll fronts are further north than 1998
- Cruise went further north (36°N), can see higher chlorophyll waters in north
- What is phytoplankton composition?



Phytoplankton indicator Pigments (2011)

Depth-related variability in phytoplankton

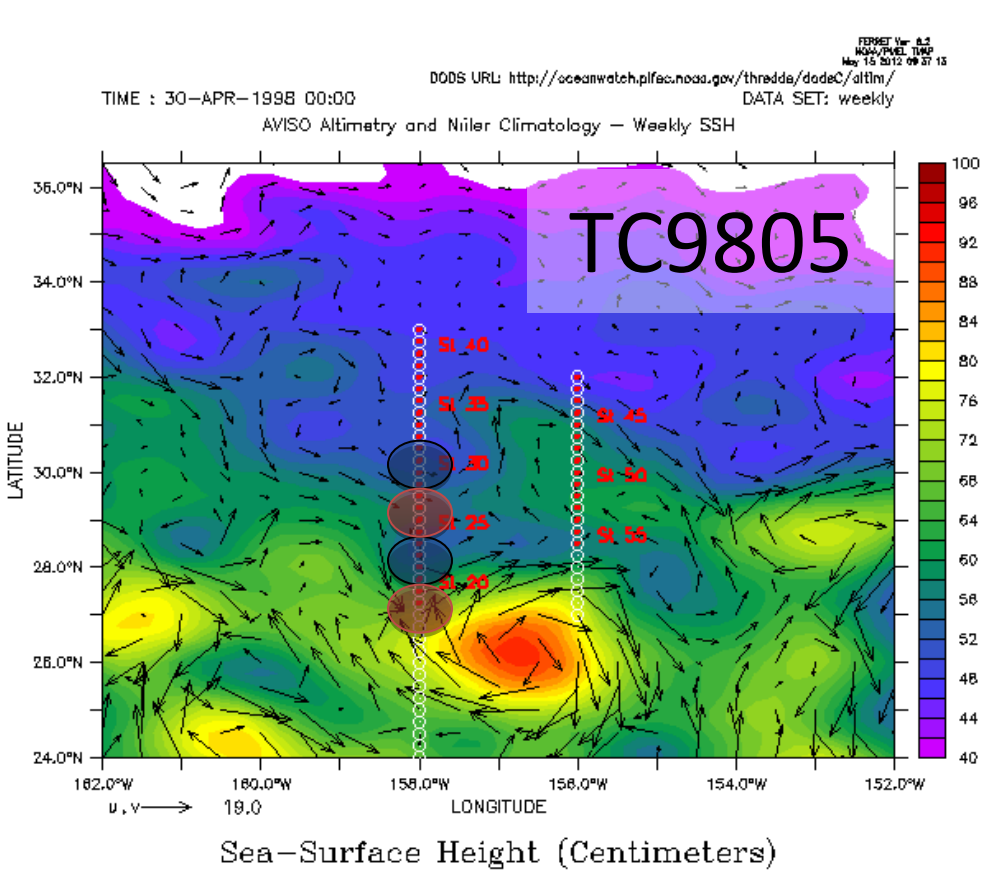
Smaller phytoplankton in upper layers (recycled NO_3) vs deep/front (new NO_3)

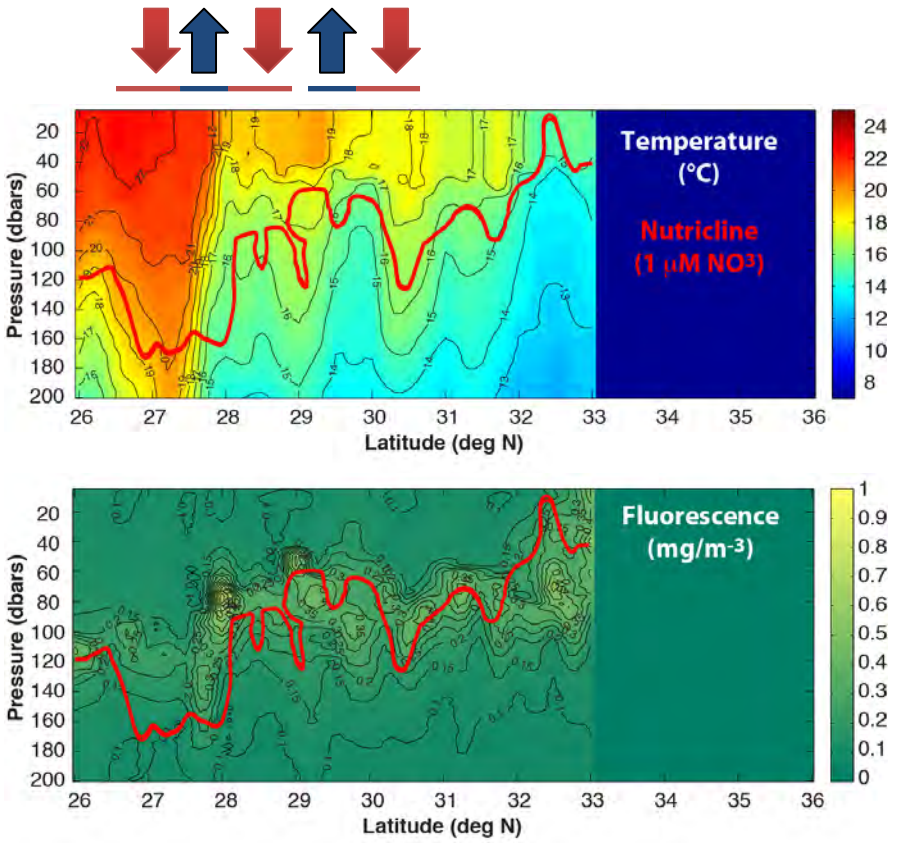


Large changes in phytoplankton composition from variability

Mesoscale variability

- Mesoscale variability occurs in the form of jets and eddies
- Can cause shoaling/depression of nutricline/MLD





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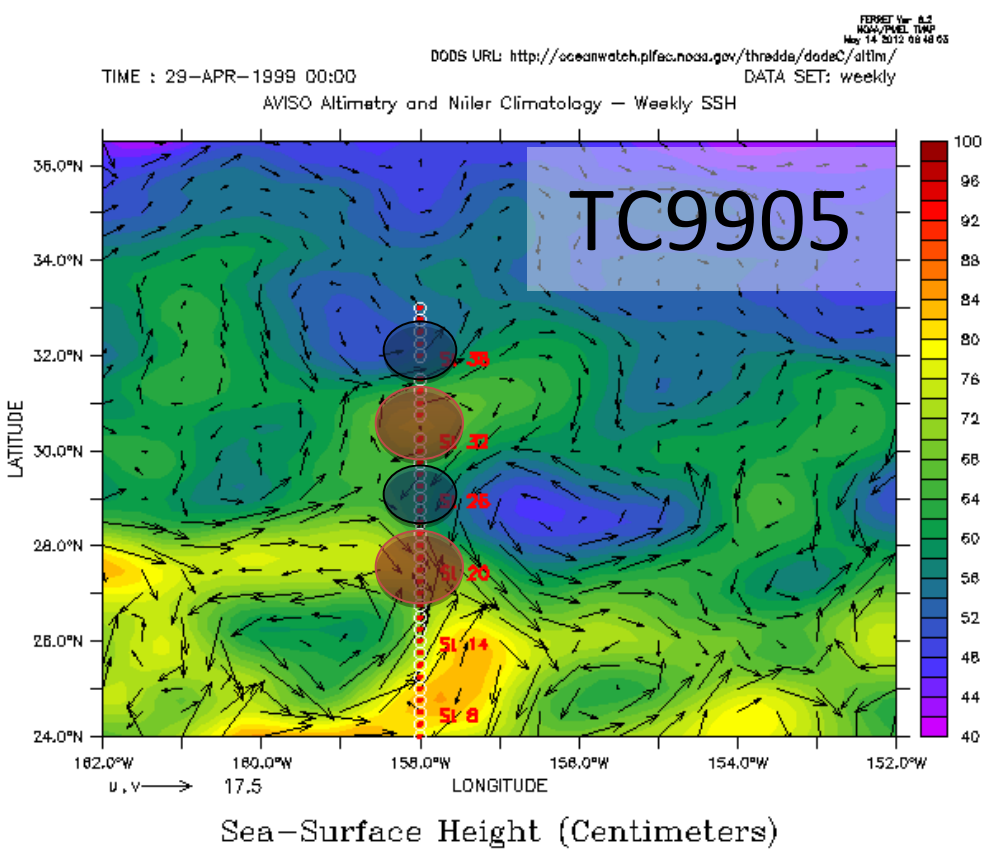
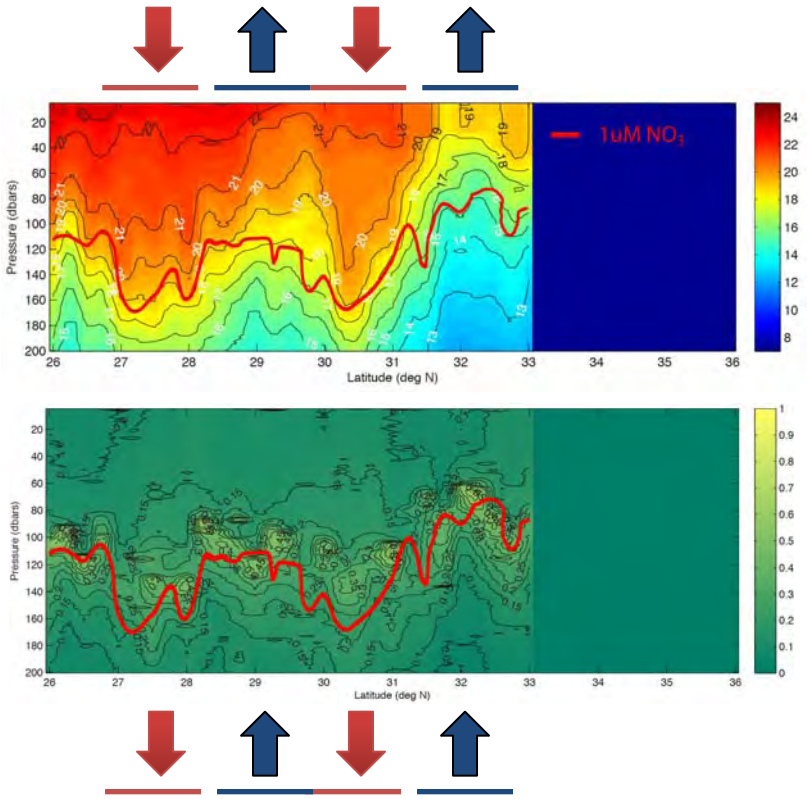
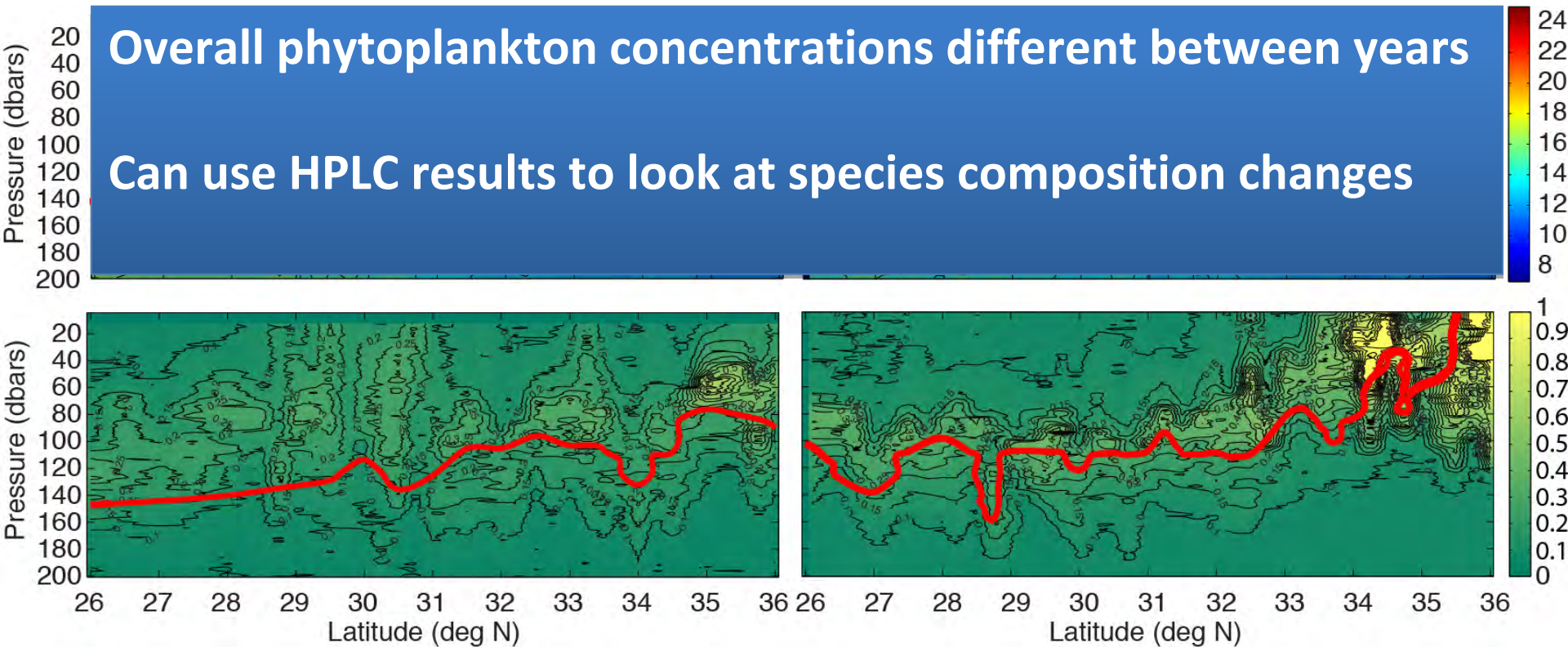




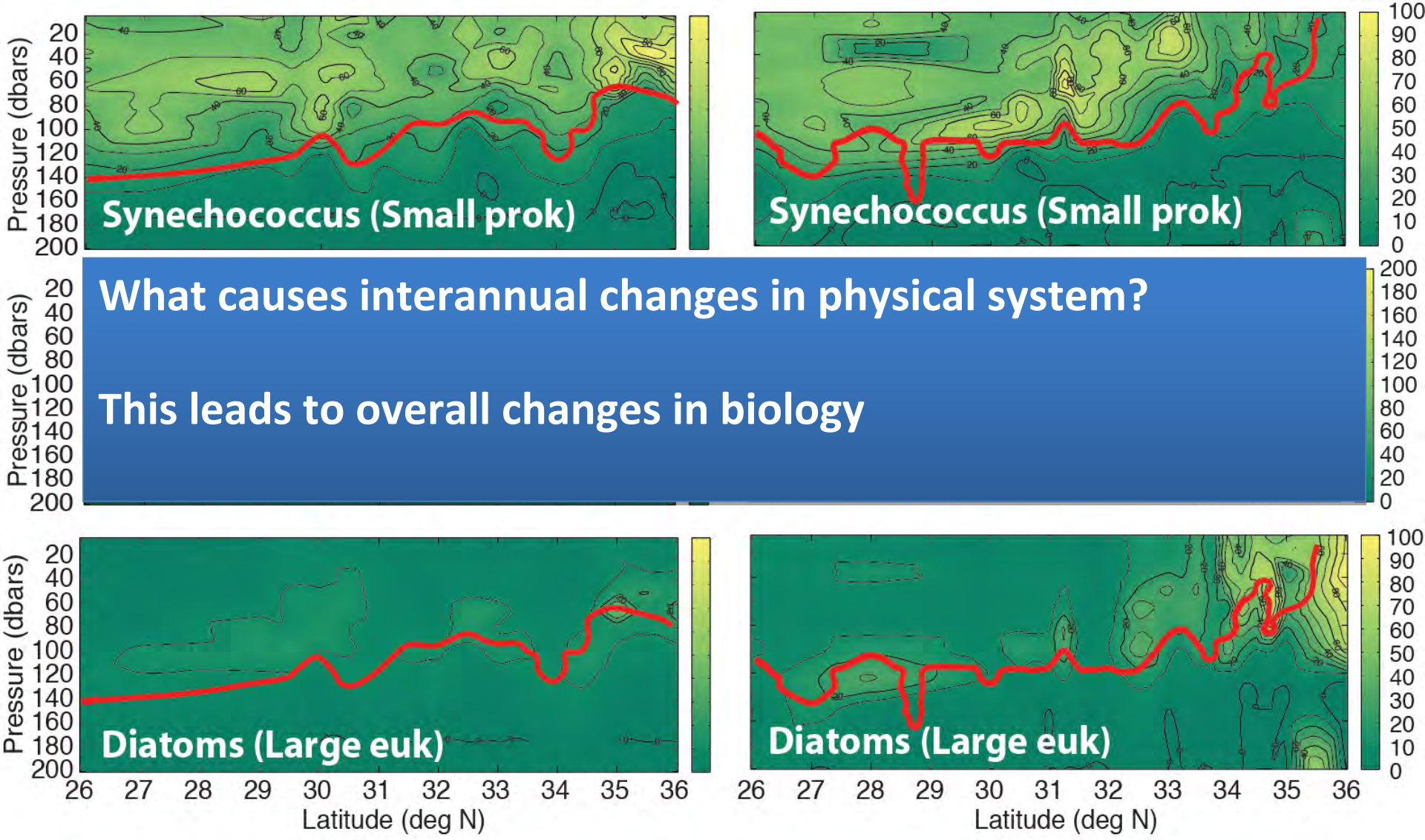
Interannual variability and phytoplankton

- Can see large differences in physics and overall phytoplankton from year to year
- 2009 very stratified physical system compared to 2011
- Surface chlorophyll front constrained far to north



Indicator Pigments (2009, 2011)

- 2009 more stratified physical system, biological front constrained to north, less eukaryotic phytoplankton



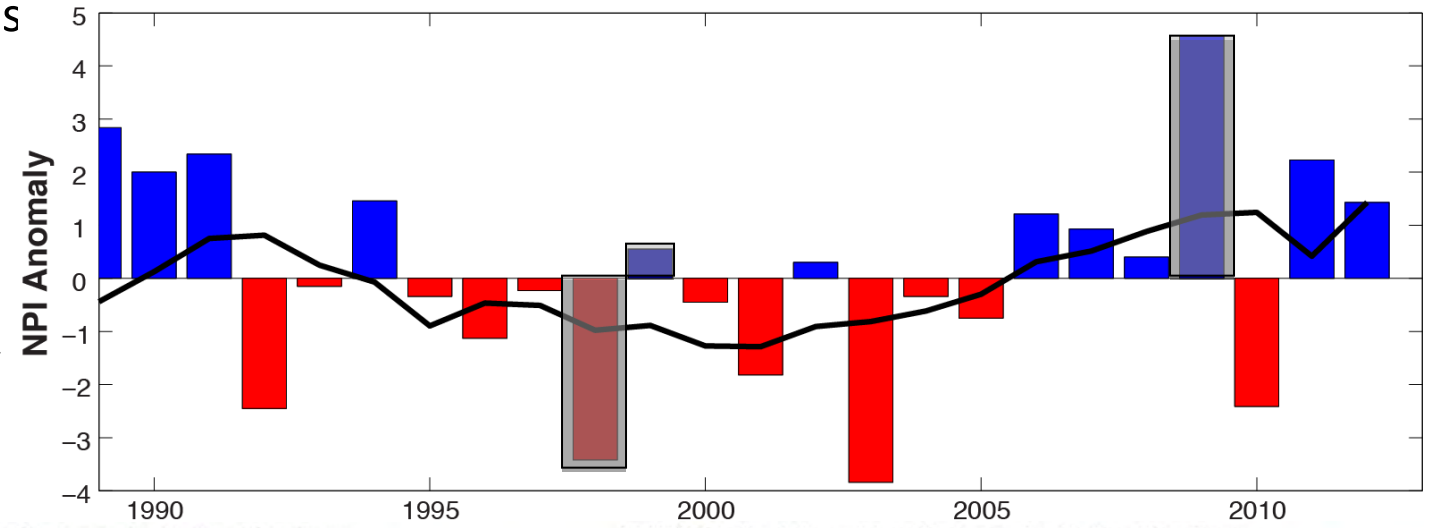
Wind Variability

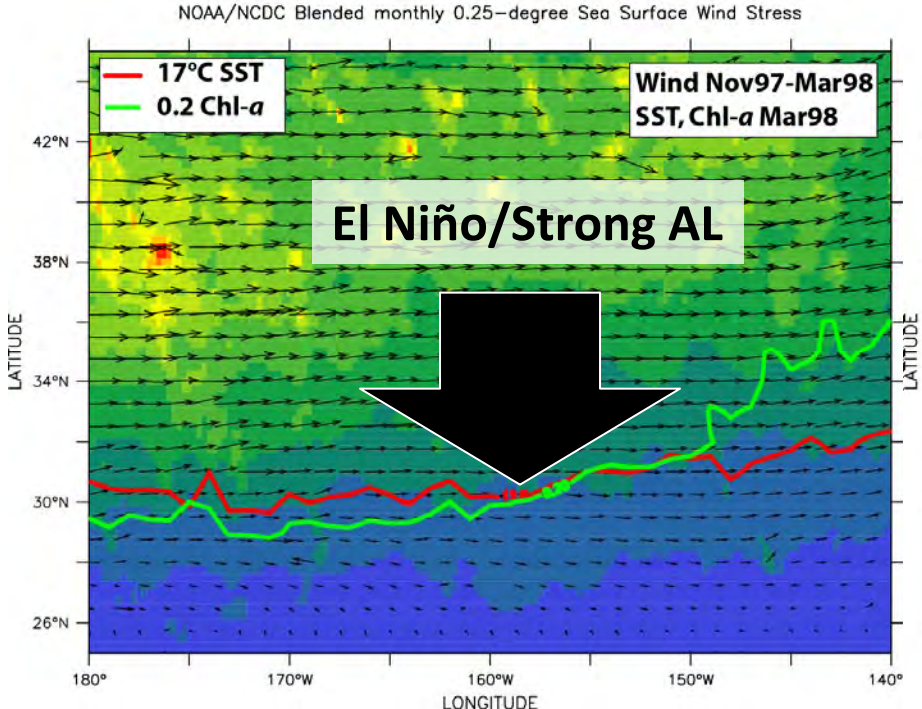
STFZ South, Increased PP

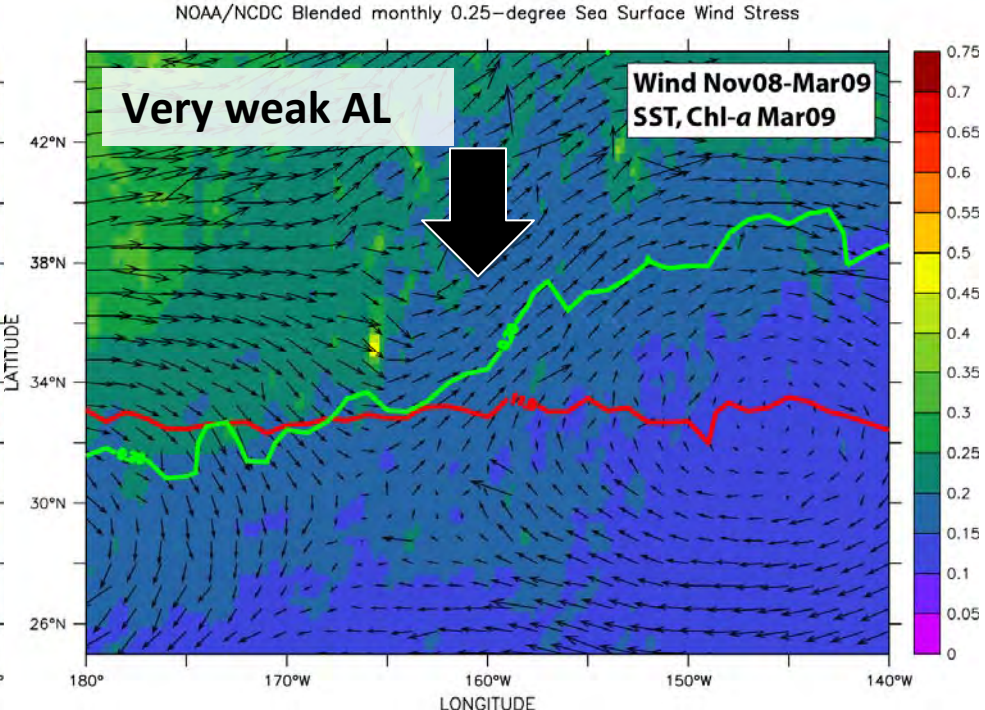
STFZ North
Decreased PP

Winter wind patterns from strength of Aleutian Low (NPI)

Shift in 2006 to weaker Aleutian low

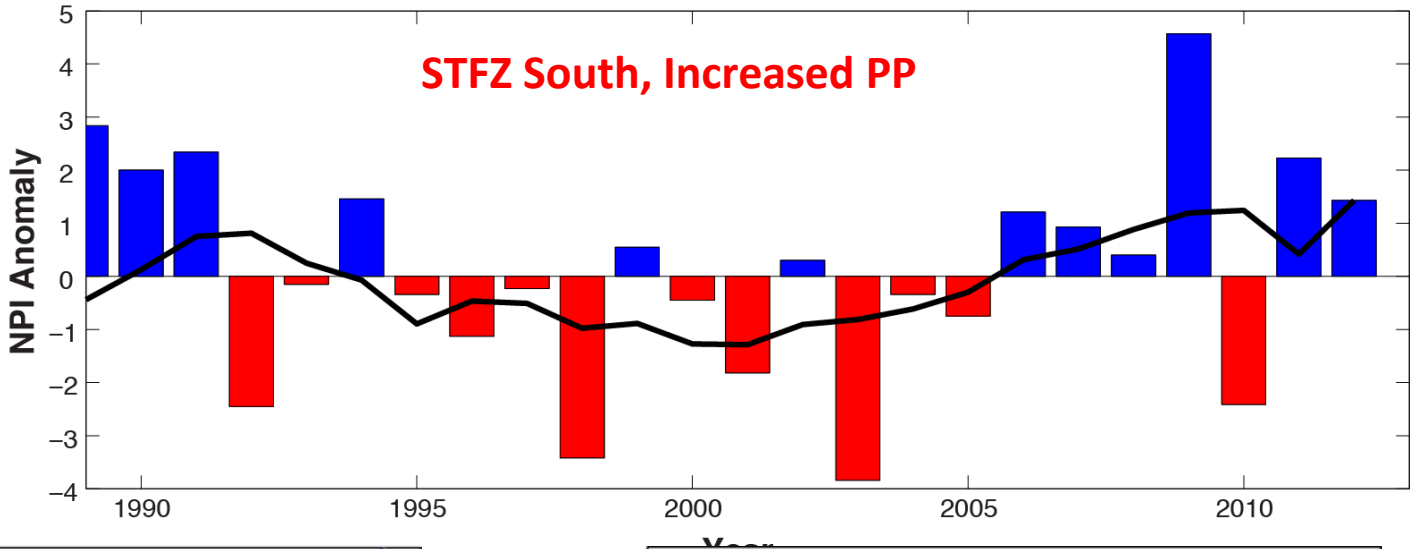


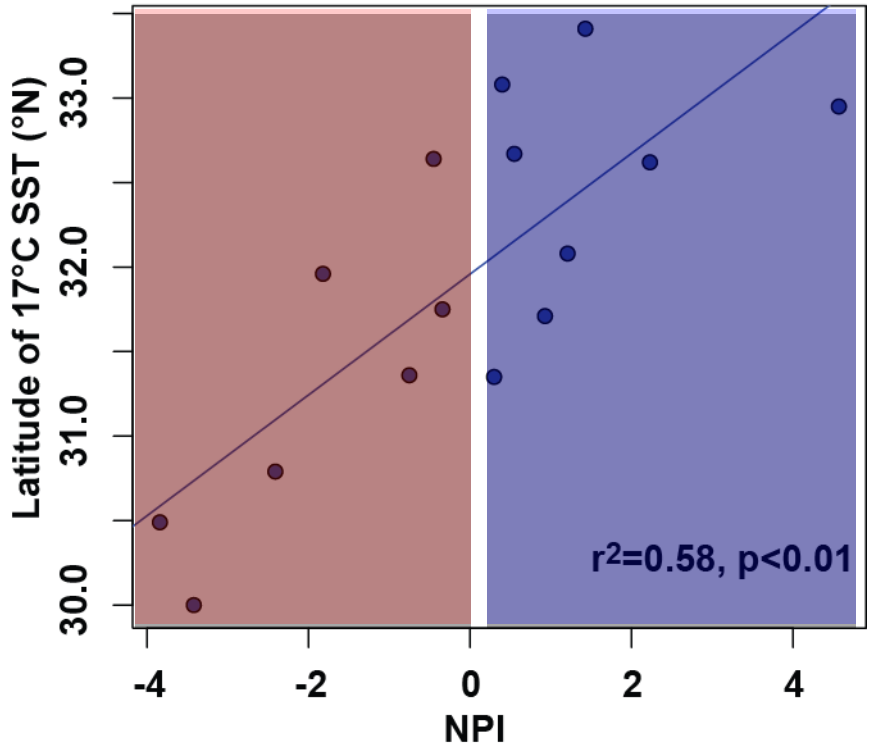


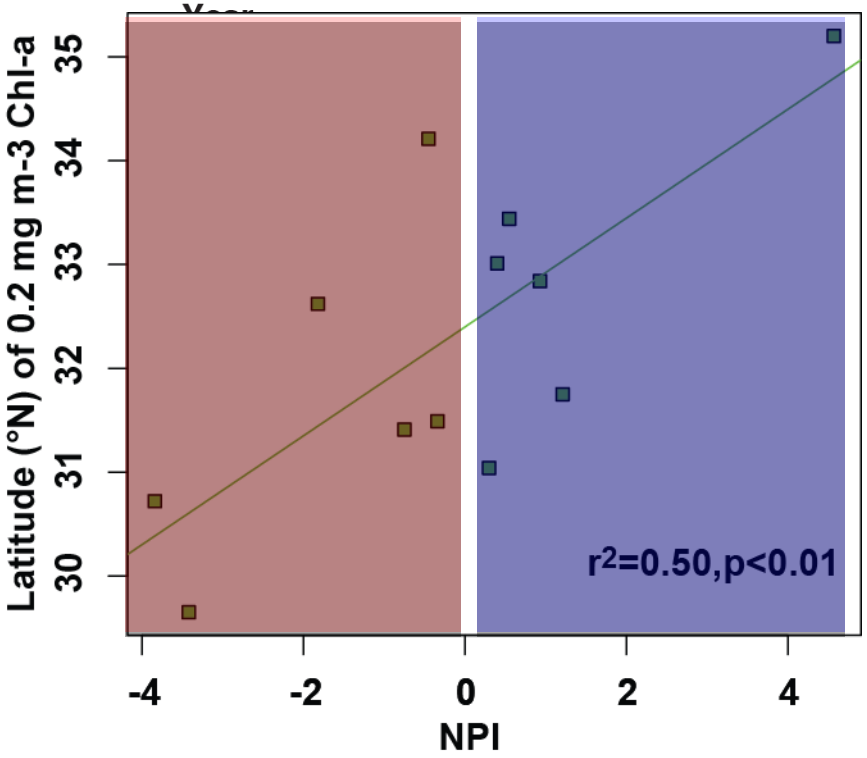


Large-scale forcing on frontal position

Positions of SST and Chl-a fronts tied to winds/AL

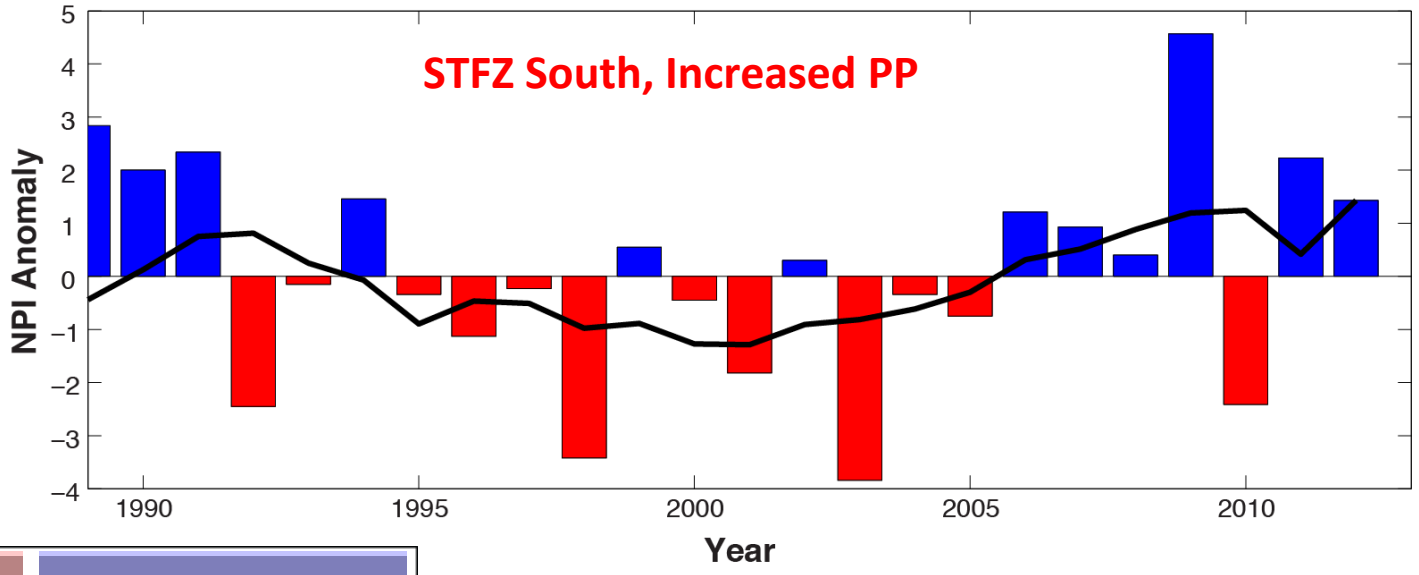


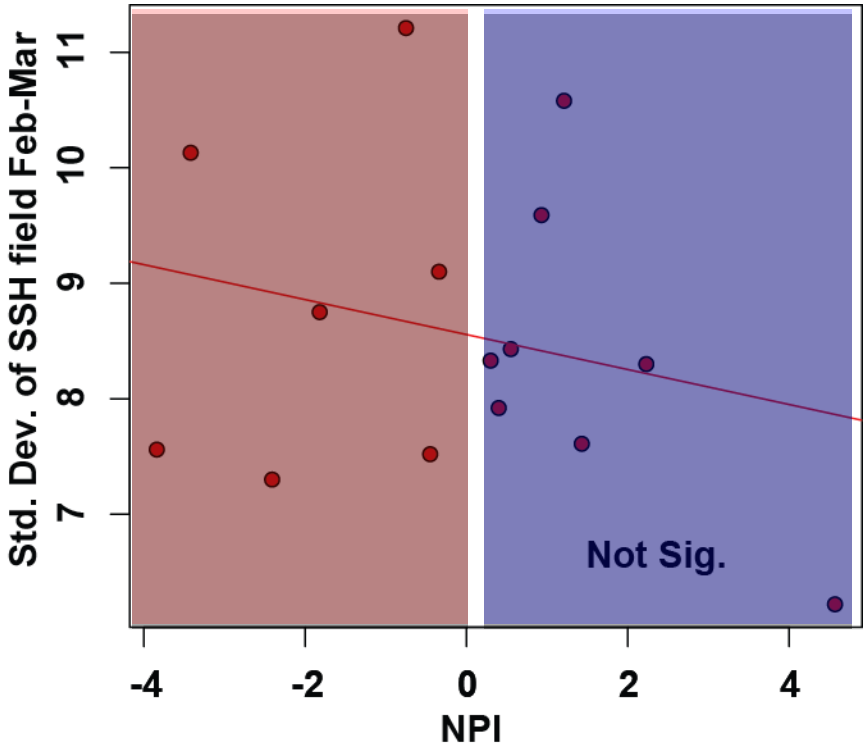




Large-scale forcing relationships

Mesoscale variability not tied only to winds/AL





Variable	Correlation	p-value
NPGO	0.39	<0.01
NPGO + NPI	0.56	<0.01

Summary

- North Pacific Subtropical Front dynamic area with variability on different scales
  - Mesoscale variability drives small changes in phytoplankton response and species composition
  - Interannual variability changes position and structure of fronts with larger effect on pp response and composition
    - This has effects on species that use the fronts (ENSO), more so on “fixed” species (bio-energetic cost)
    - Stratified years with smaller phytoplankton – longer food chains?
  - Longer-term variability may also change baseline position of frontal system
    - Linked to wind fields (NPI good index?)
    - Less mesoscale variability in weak Aleutian low periods, yet may be interaction with other physical modes of variability (e.g. NPGO)
  - Climate models predictions to future
    - Trends in oligotrophic expansion surface
    - Continued northern movement of temperature and chlorophyll fronts