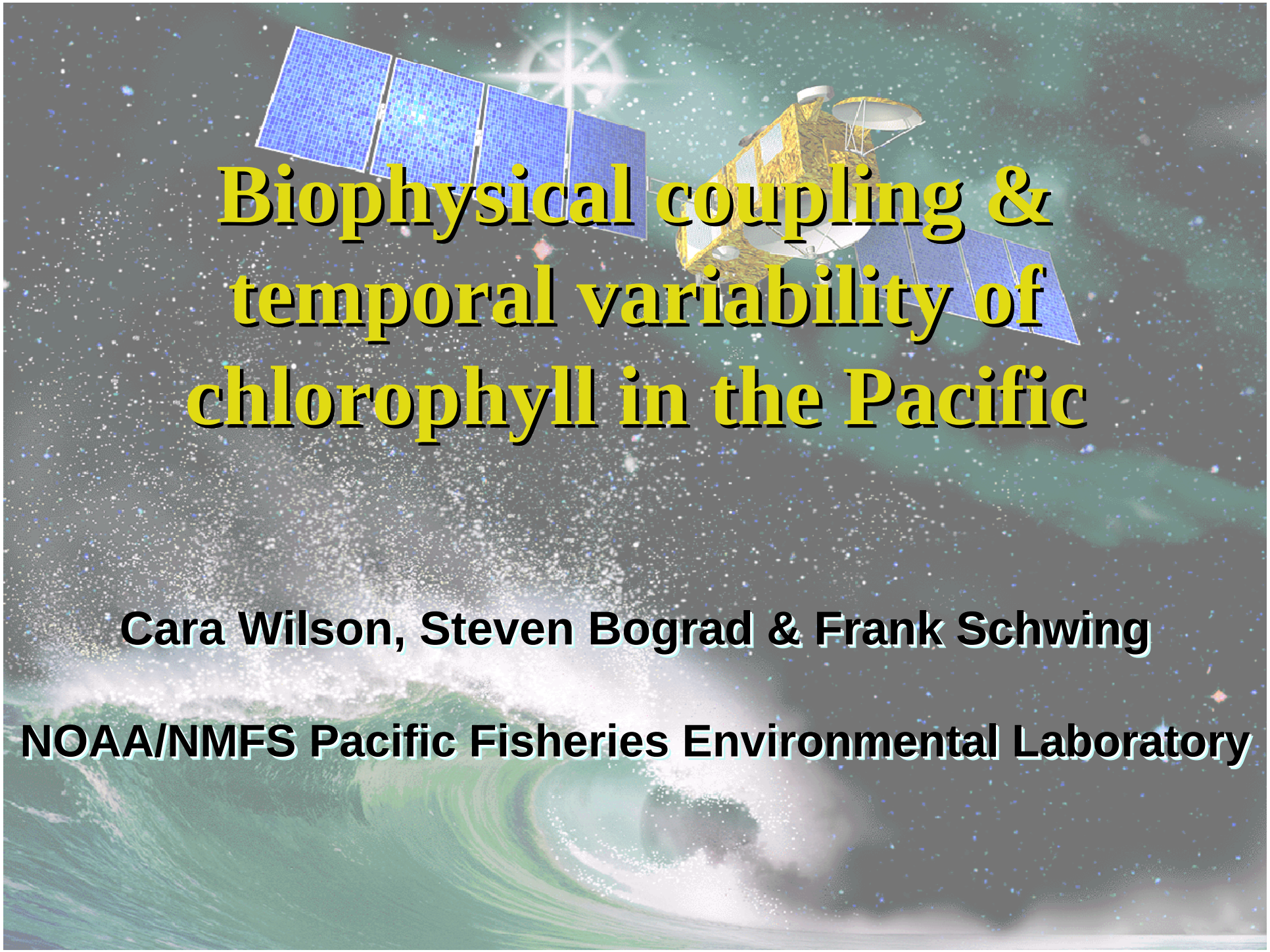


Biophysical coupling & temporal variability of chlorophyll in the Pacific

Cara Wilson, Steven Bograd & Frank Schwing

NOAA/NMFS Pacific Fisheries Environmental Laboratory

Question…

How do the various scales of climate variability project onto marine ecosystems (chlorophyll) ?

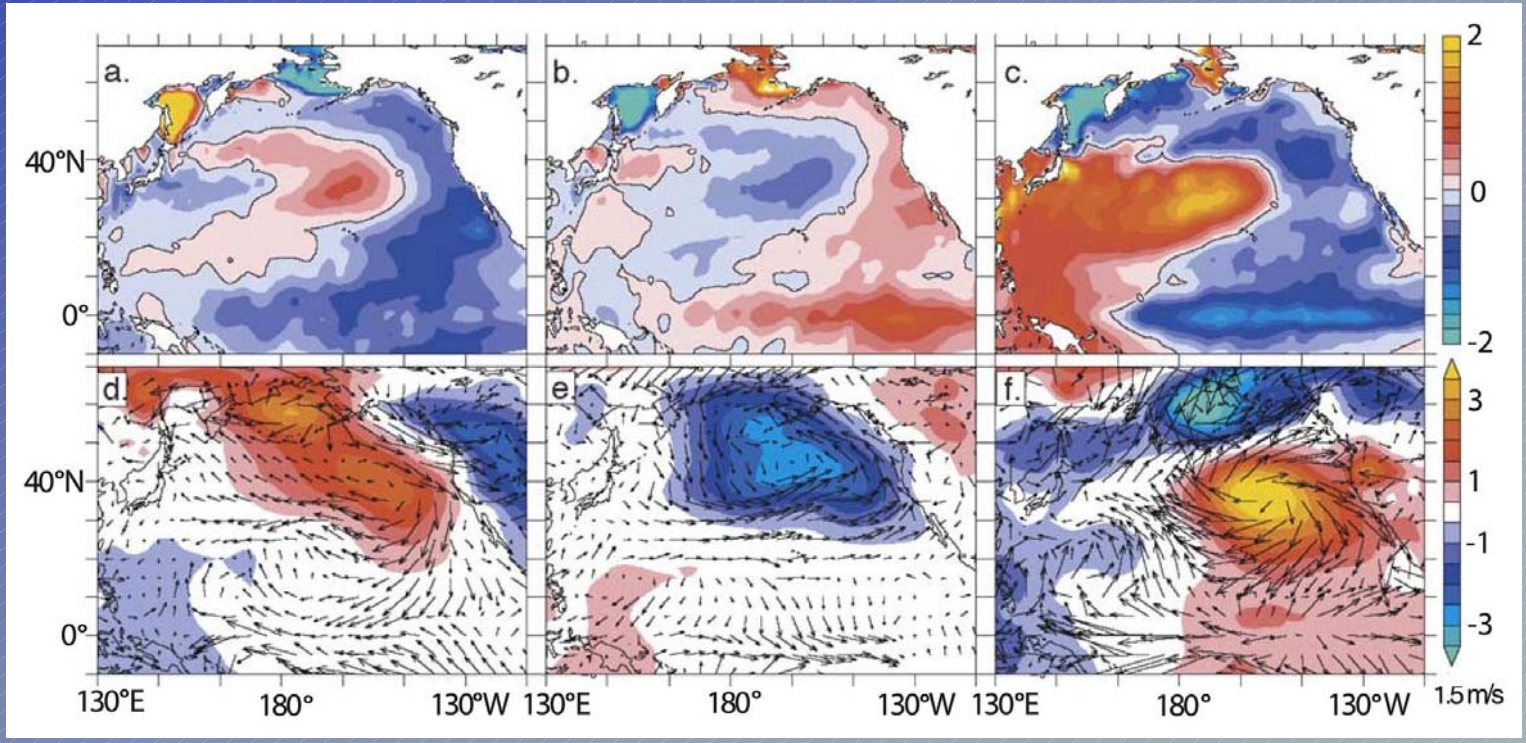
- **Difficult to resolve because of different scales of climate data and ecosystem data**
- **Climate data generally covers larger spatial scales and longer temporal scales than ecosystem data**

Different spatial patterns of temporal change

	Cool PDO	Warm PDO	Cool PDO
NJF:	1970-76	1977-1983	1999-2003

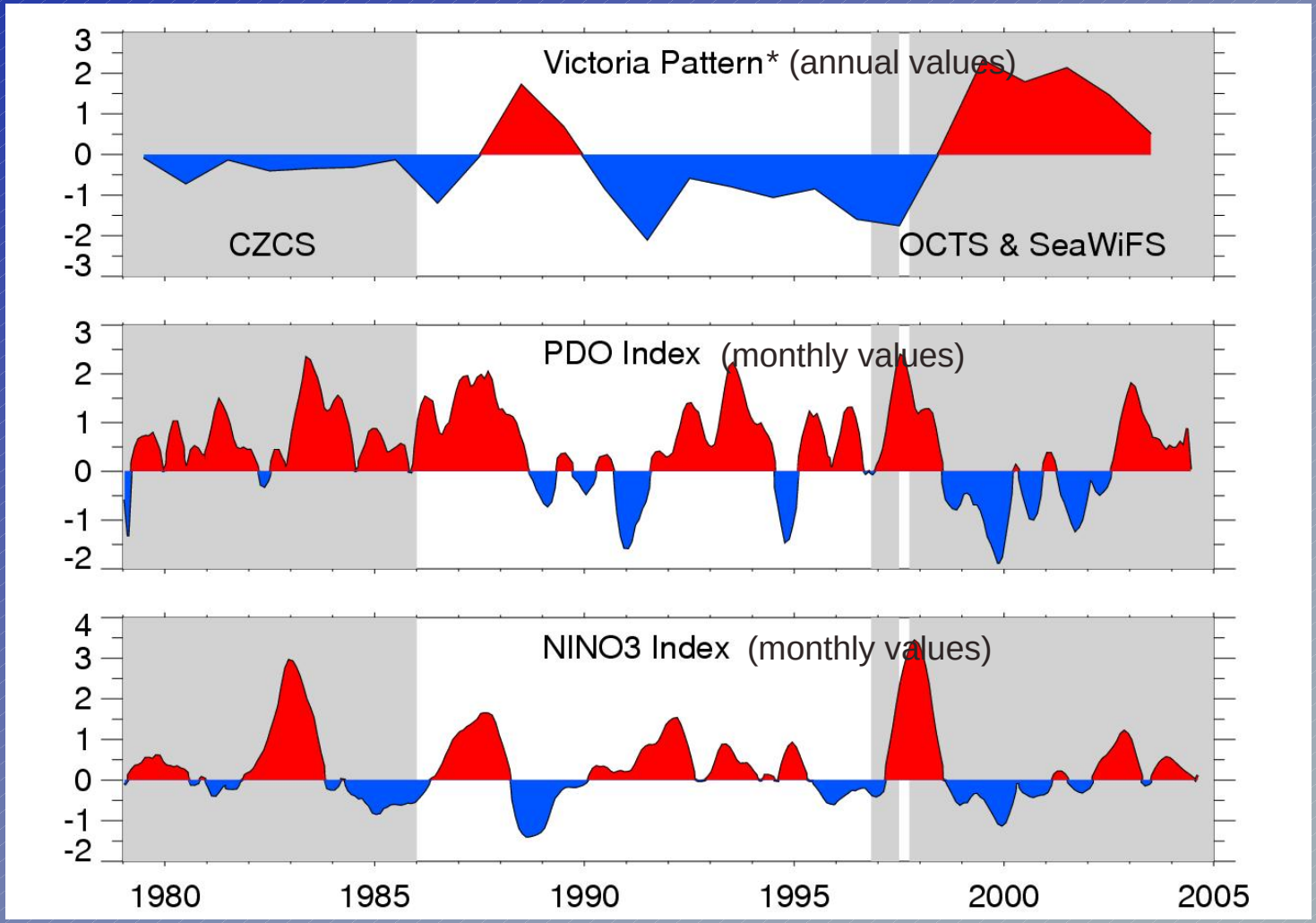
SST

SLP



from Peterson & Schwing [2003]

Different frequencies of temporal variability



*** from Bond et al. [2003]**

Dilemma…

How to address the question of both temporal and spatial variability with:

- **Traditional timeseries datasets with long time scales, but sparse spatial resolution**
- **Satellite datasets with high temporal and spatial resolution, but existing for only relatively short timescales**

Outline

- **Bio-physical coupling & chlorophyll**
- **Examine basin-scale variability in chlorophyll and bio-physical coupling with:**

  - SeaWiFS (1997-2004): El Niño dynamics
  - SeaWiFS & CZCS (1979-1986): TZCF

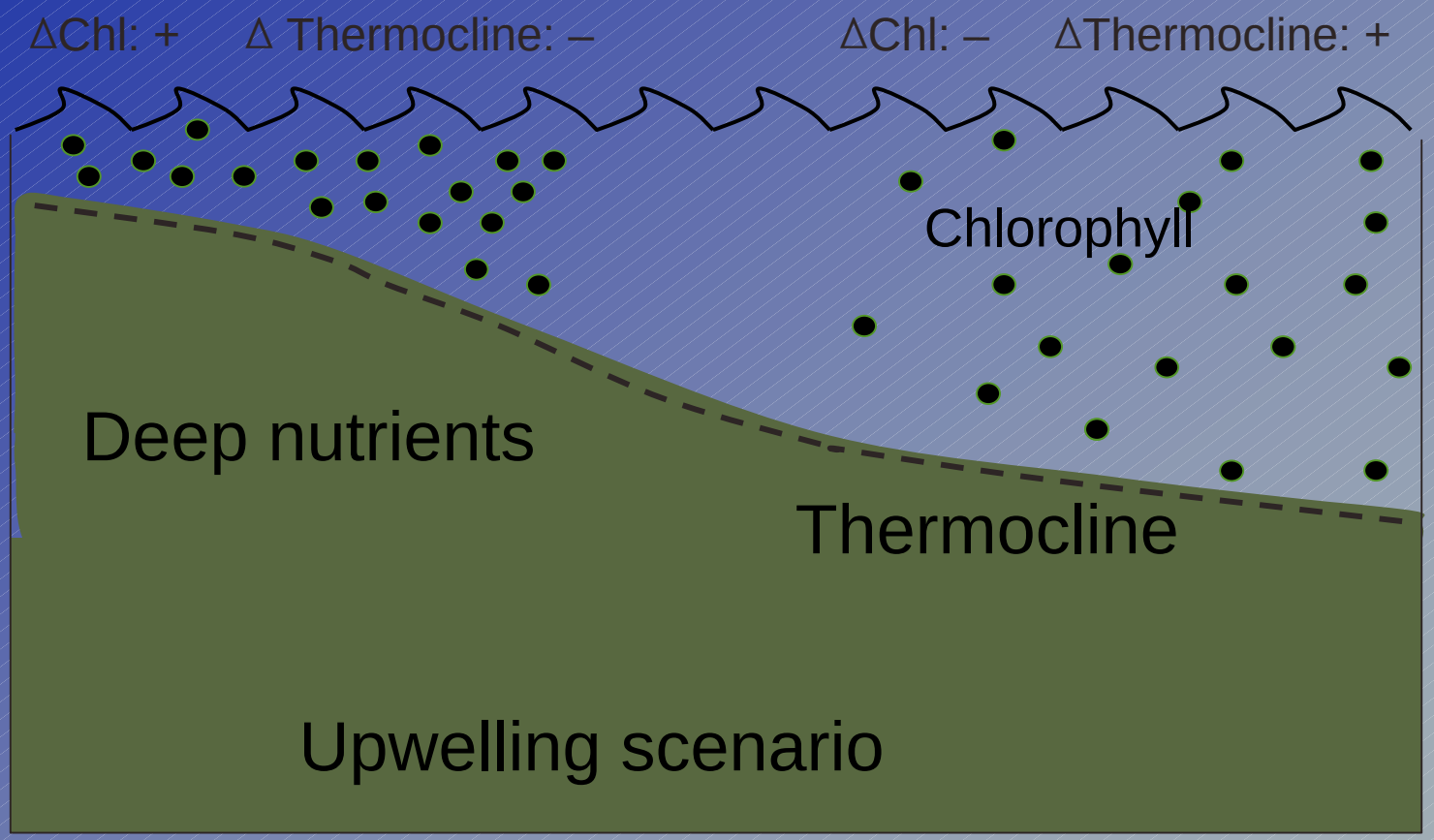
- **Summarize previous work looking at chlorophyll variability across different temporal & spatial scales (non-satellite)**
- **Indications of climate-scale variability in chlorophyll data?**

Part I

Bio-physical coupling and chlorophyll

Seasonal Dynamics

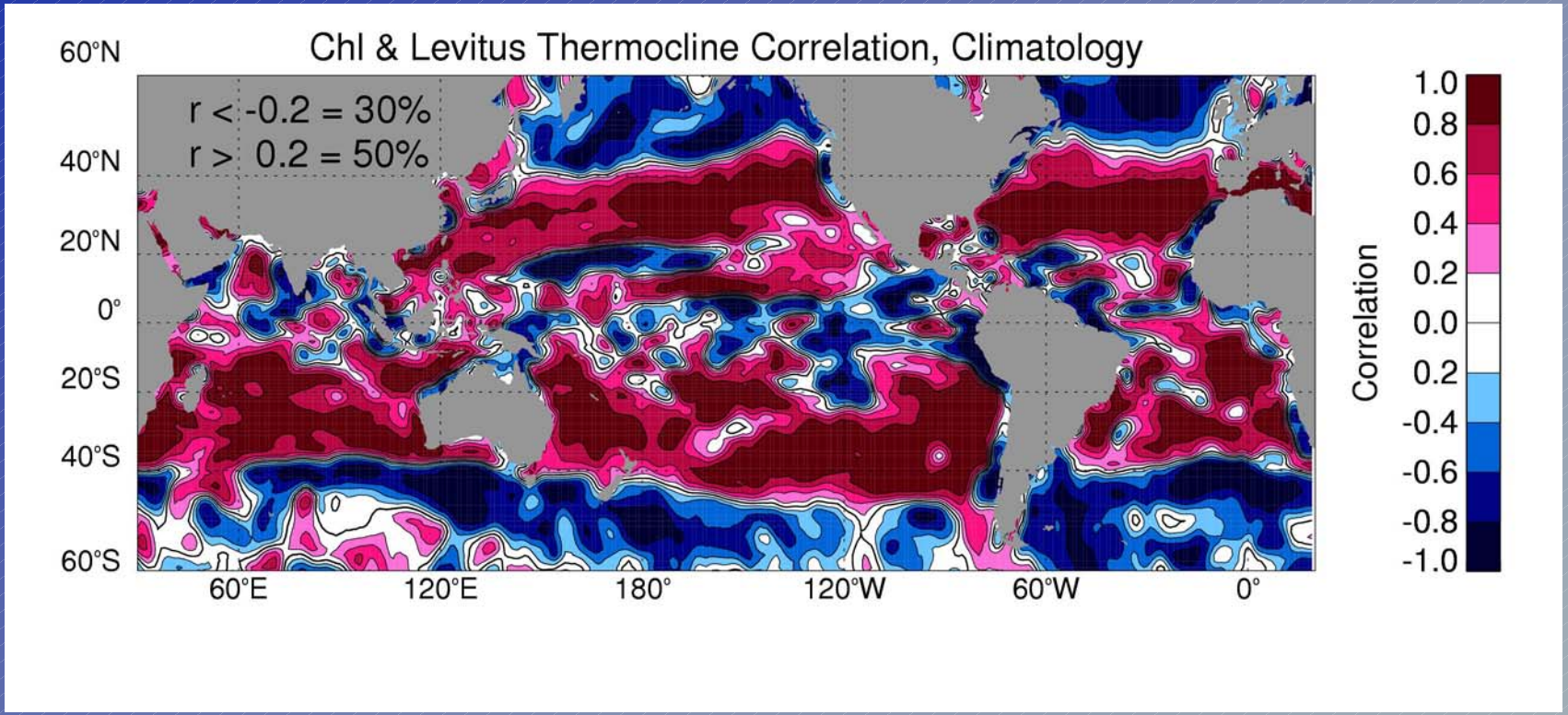
Regional differences in bio-physical coupling



Negative chlorophyll-thermocline correlation

Wilson & Coles, submitted, 2004

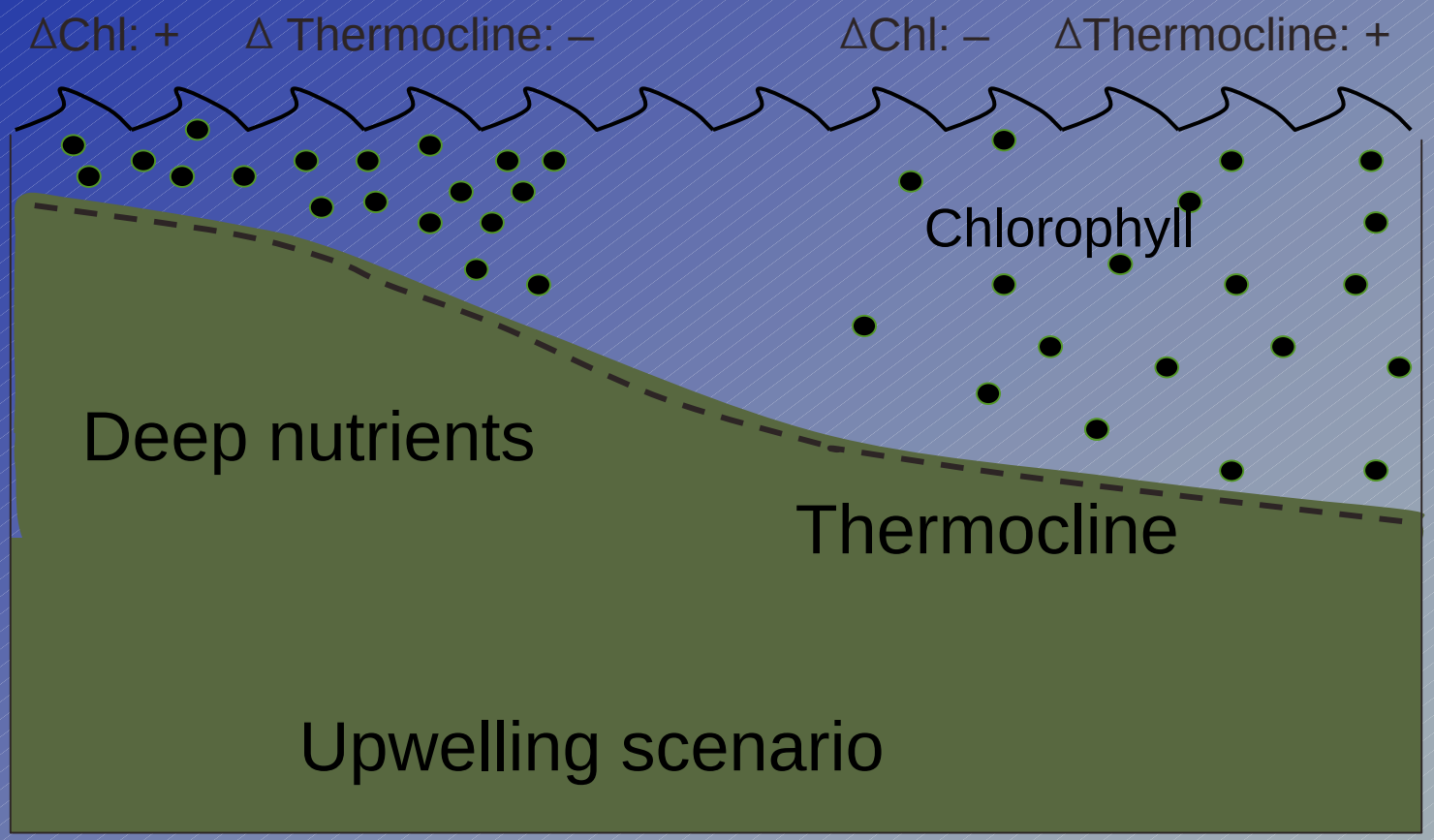
Regional differences in bio-physical coupling



Different relationships between chlorophyll & thermocline depth between the tropics, mid-latitudes and subpolar regions.

Wilson & Coles, submitted, 2004

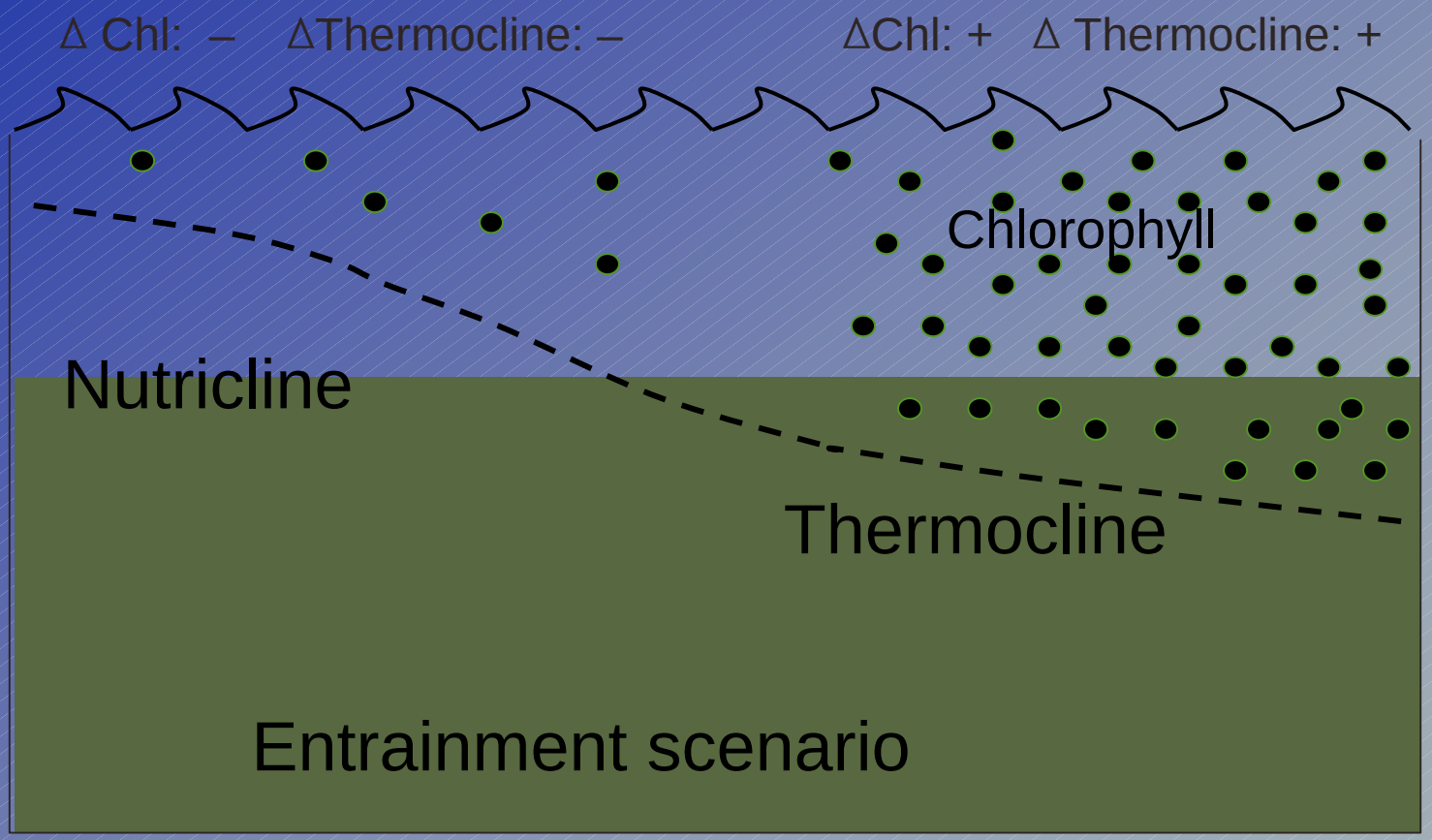
Regional differences in bio-physical coupling



Negative chlorophyll-thermocline correlation

Wilson & Coles, submitted, 2004

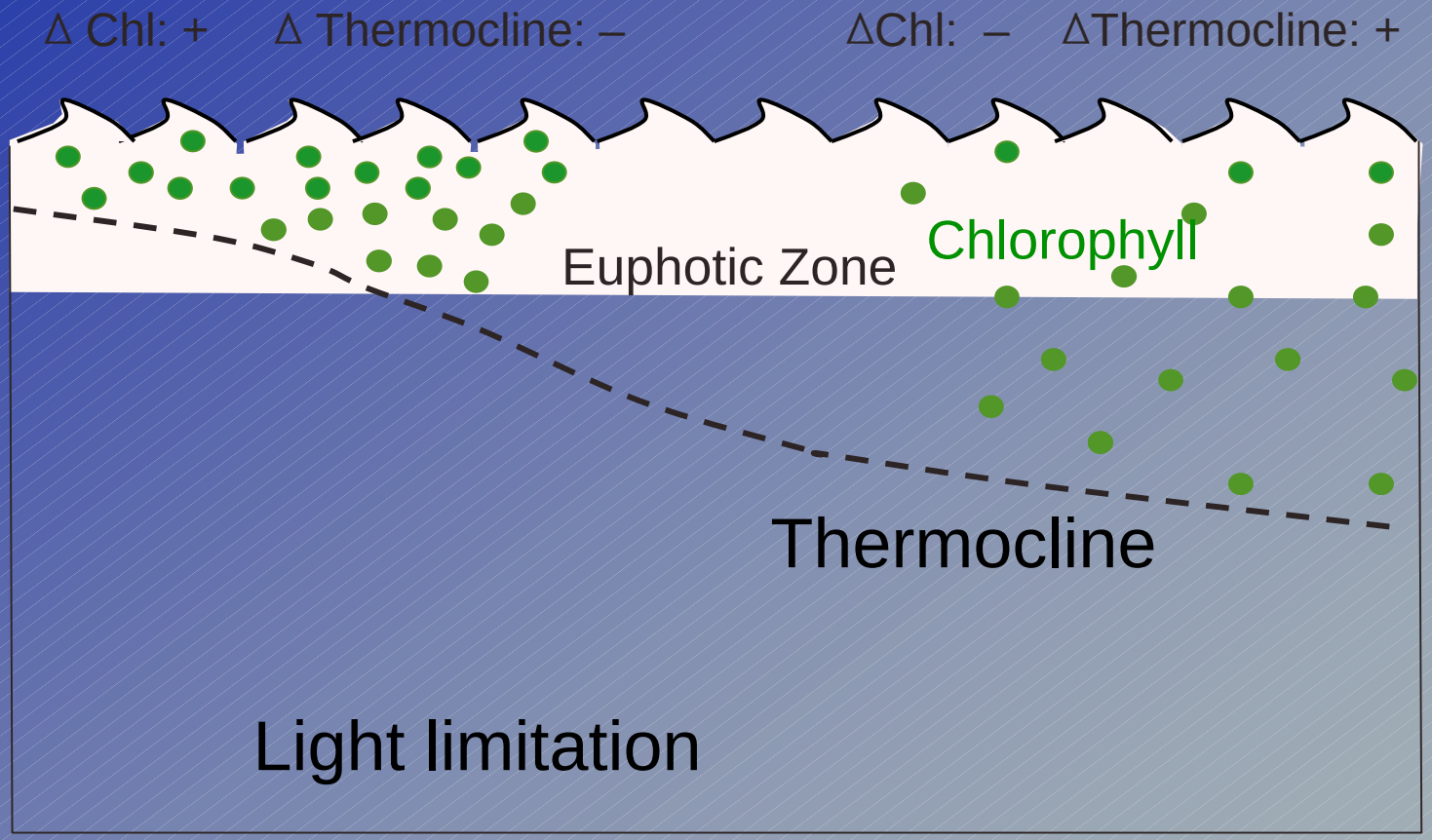
Regional differences in bio-physical coupling



Positive chlorophyll-thermocline correlation

Wilson & Coles, submitted, 2004

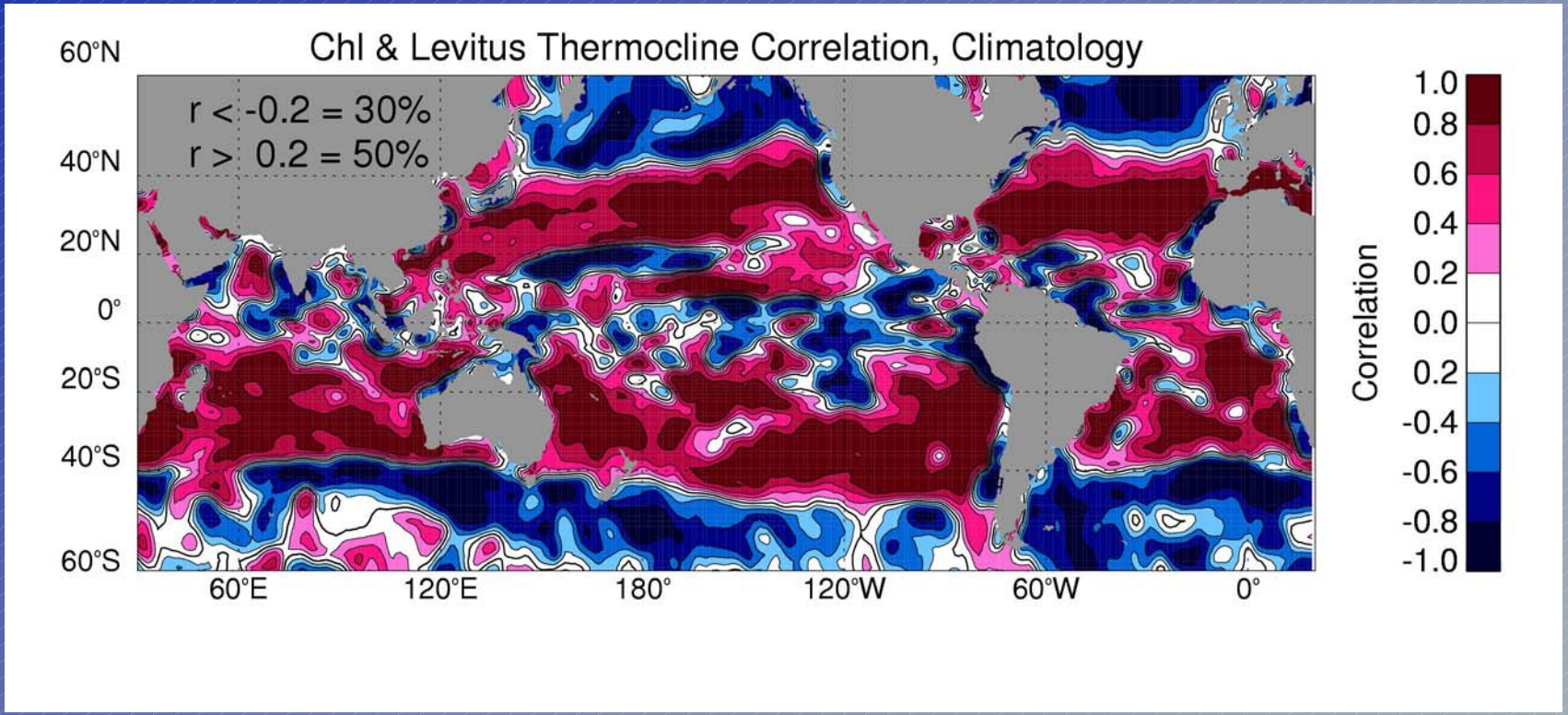
Regional differences in bio-physical coupling



Negative chlorophyll-thermocline correlation

Wilson & Coles, submitted, 2004

Regional differences in bio-physical coupling



Different relationships between chlorophyll & thermocline depth between the tropics, mid-latitudes and subpolar regions.

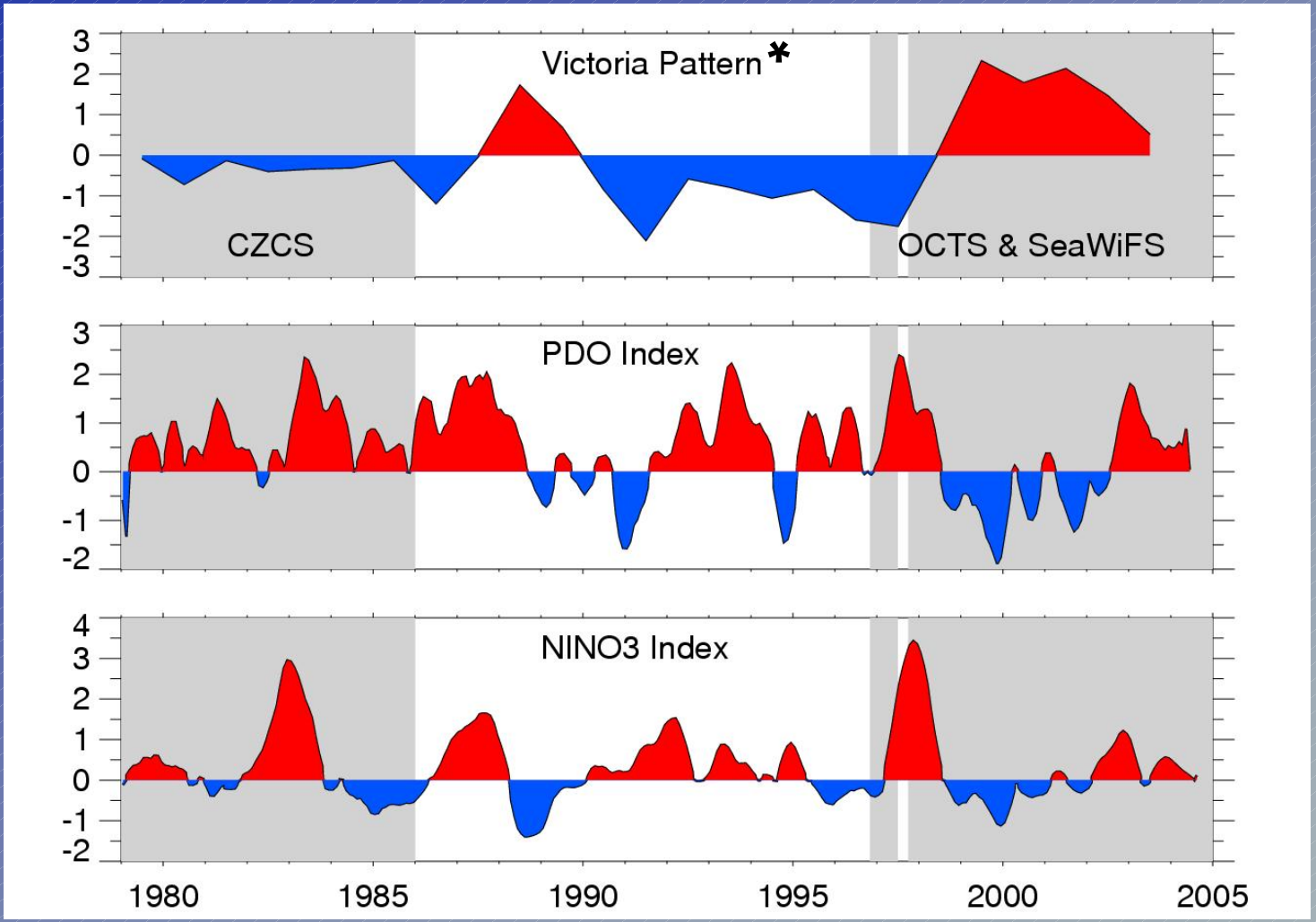
Wilson & Coles, submitted, 2004

Part IIa

SeaWiFS Variability 1997-2004

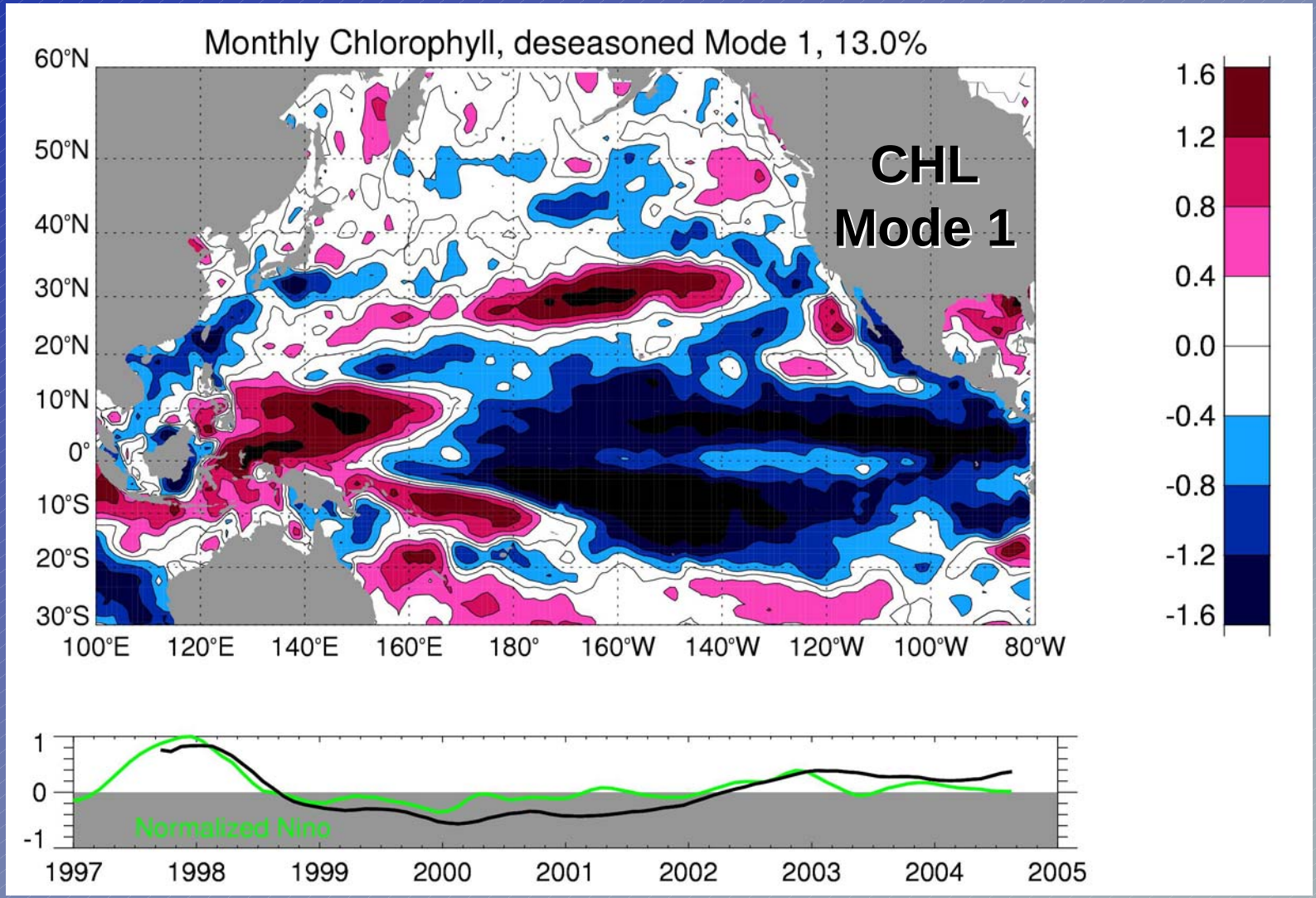
El Niño Dynamics

Different frequencies of temporal variability

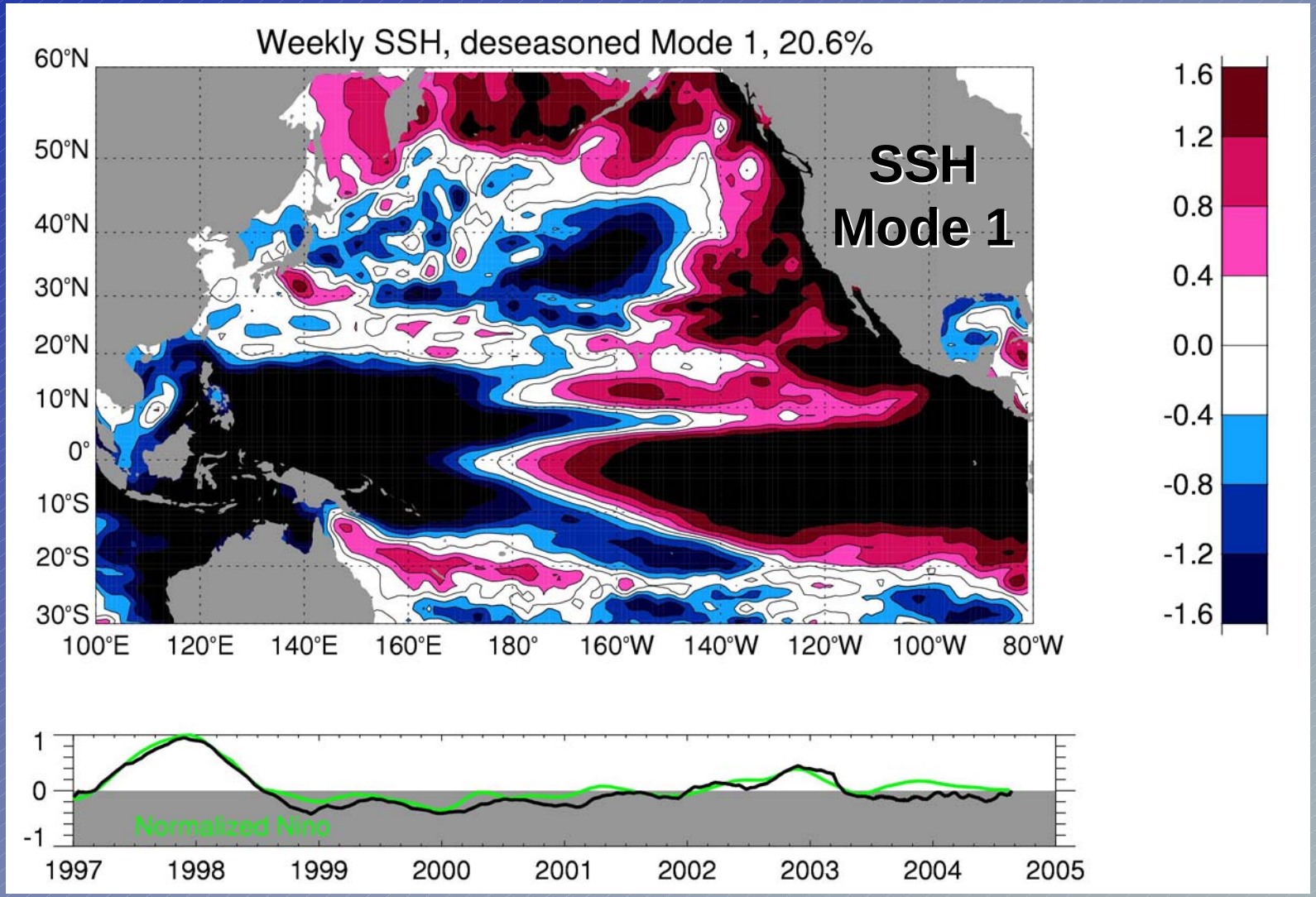


*** from Bond et al. [2003]**

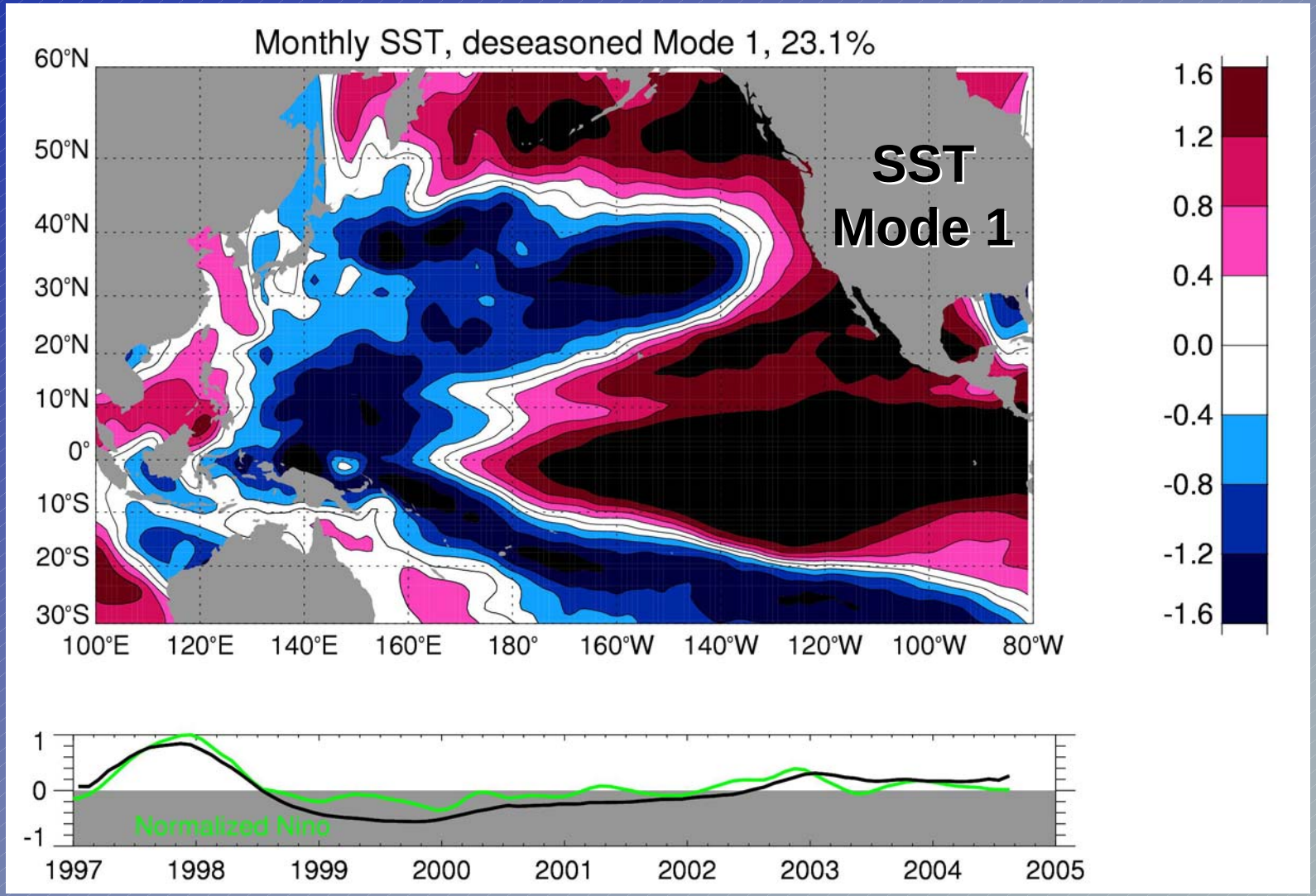
Chlorophyll Variability & El Niño



SSH Variability & El Niño



SST Variability & El Niño

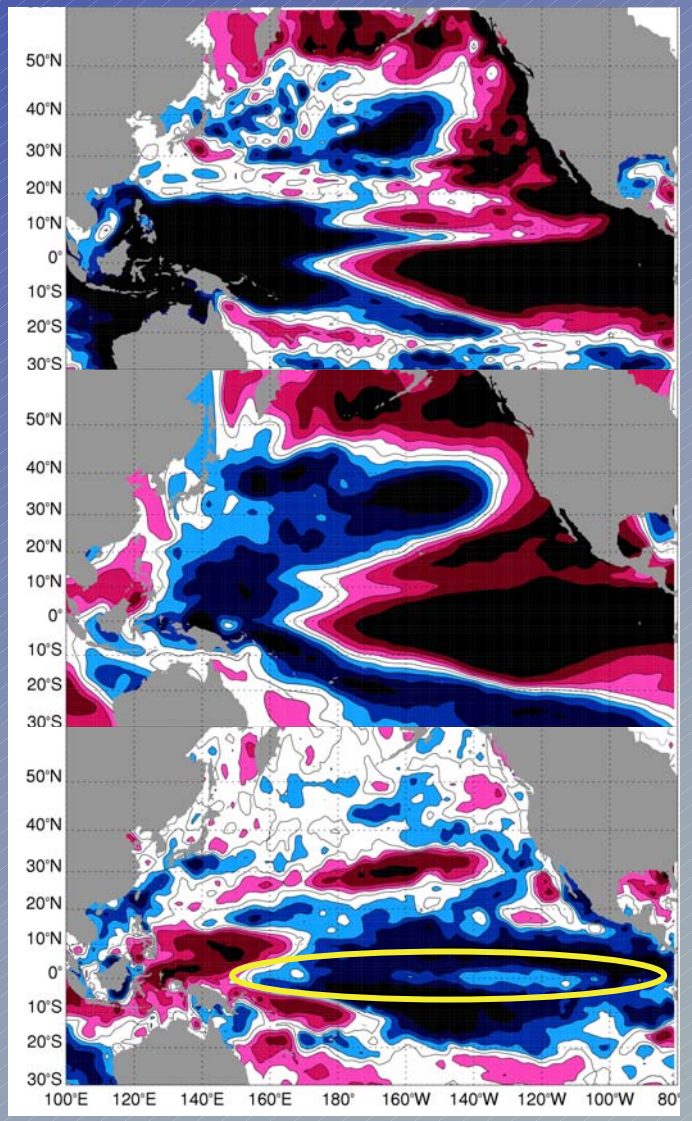


Bio-physical Coupling

SSH

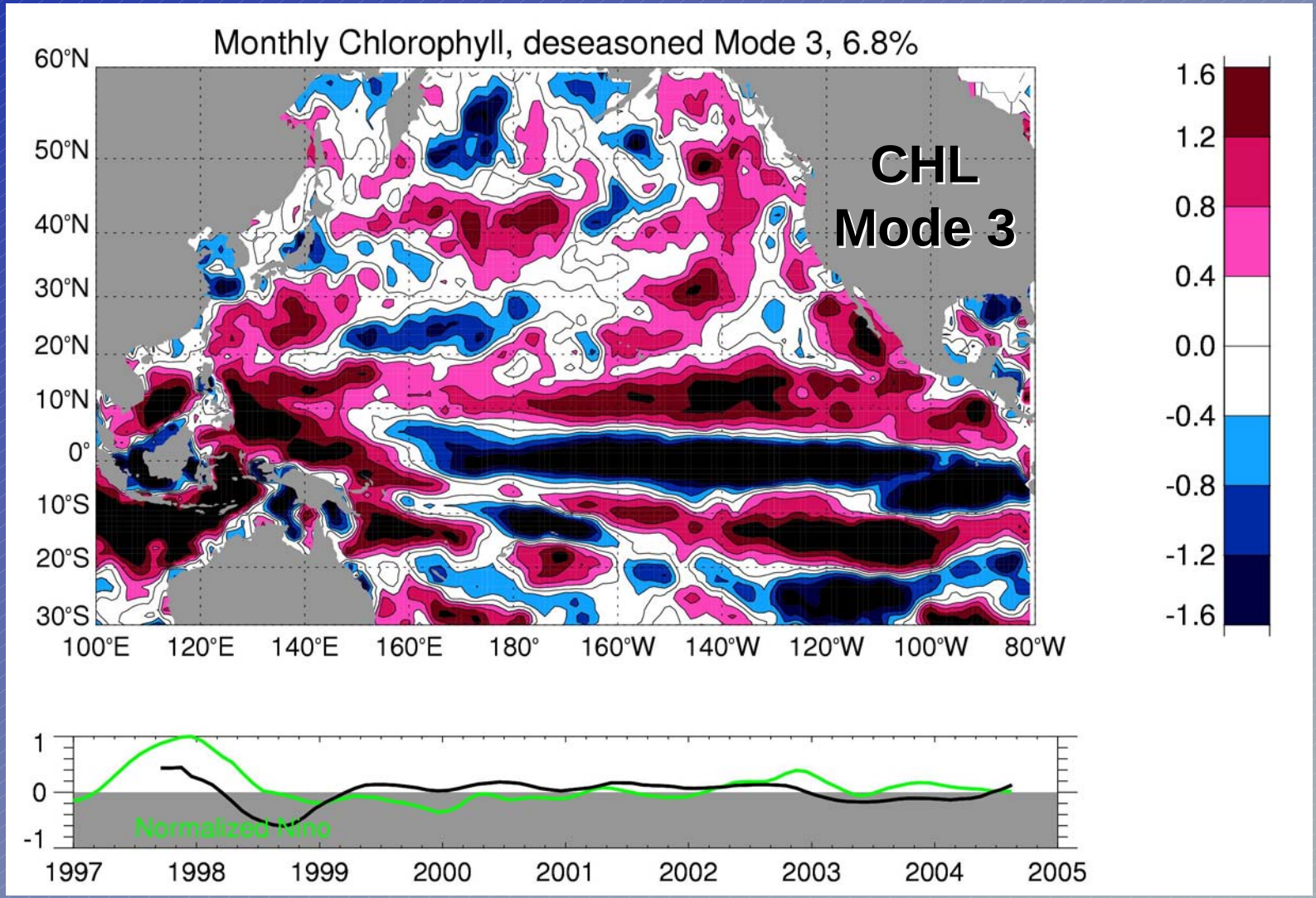
SST

Chlorophyll

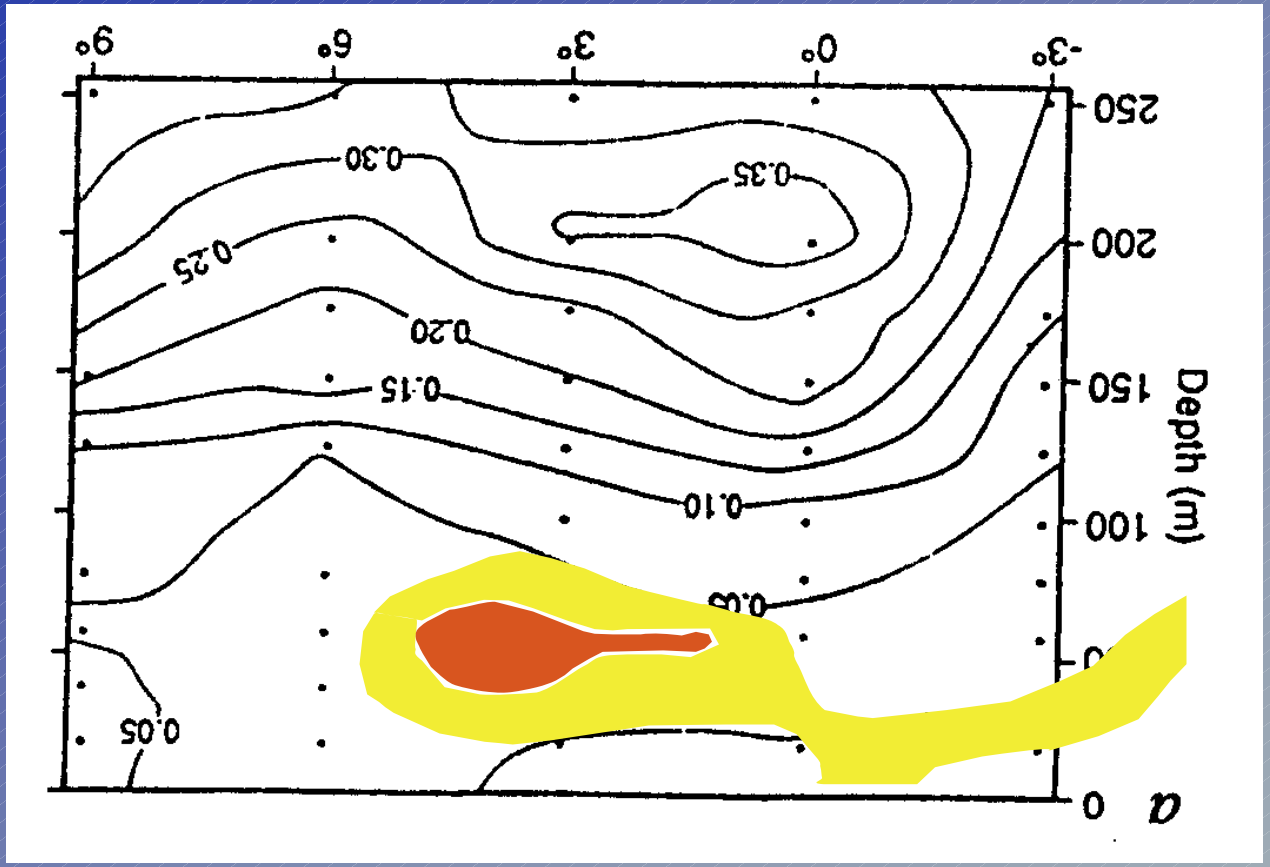


Spatial components of 1st EOF mode

Equatorial Chlorophyll Variability



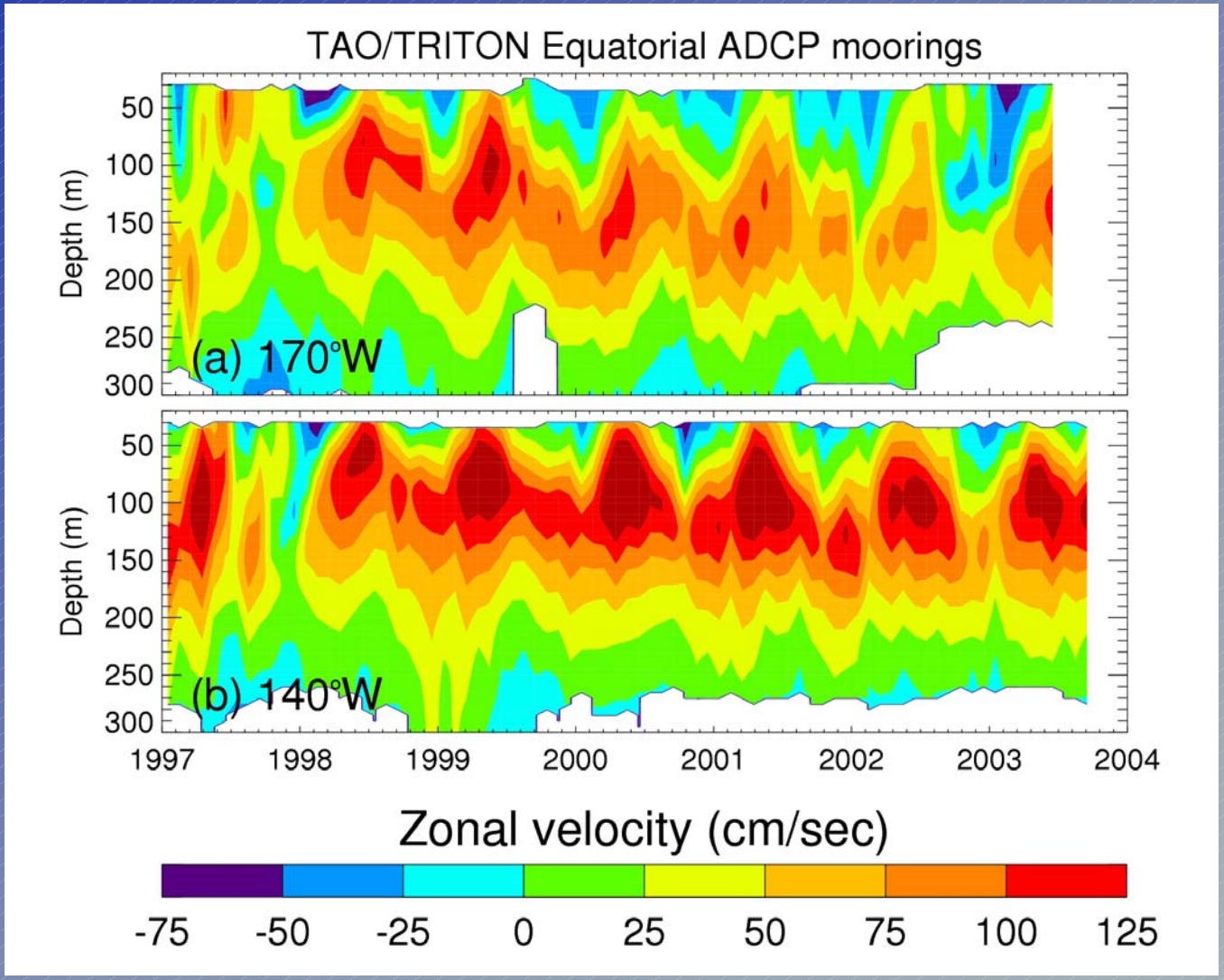
Iron & the EUC



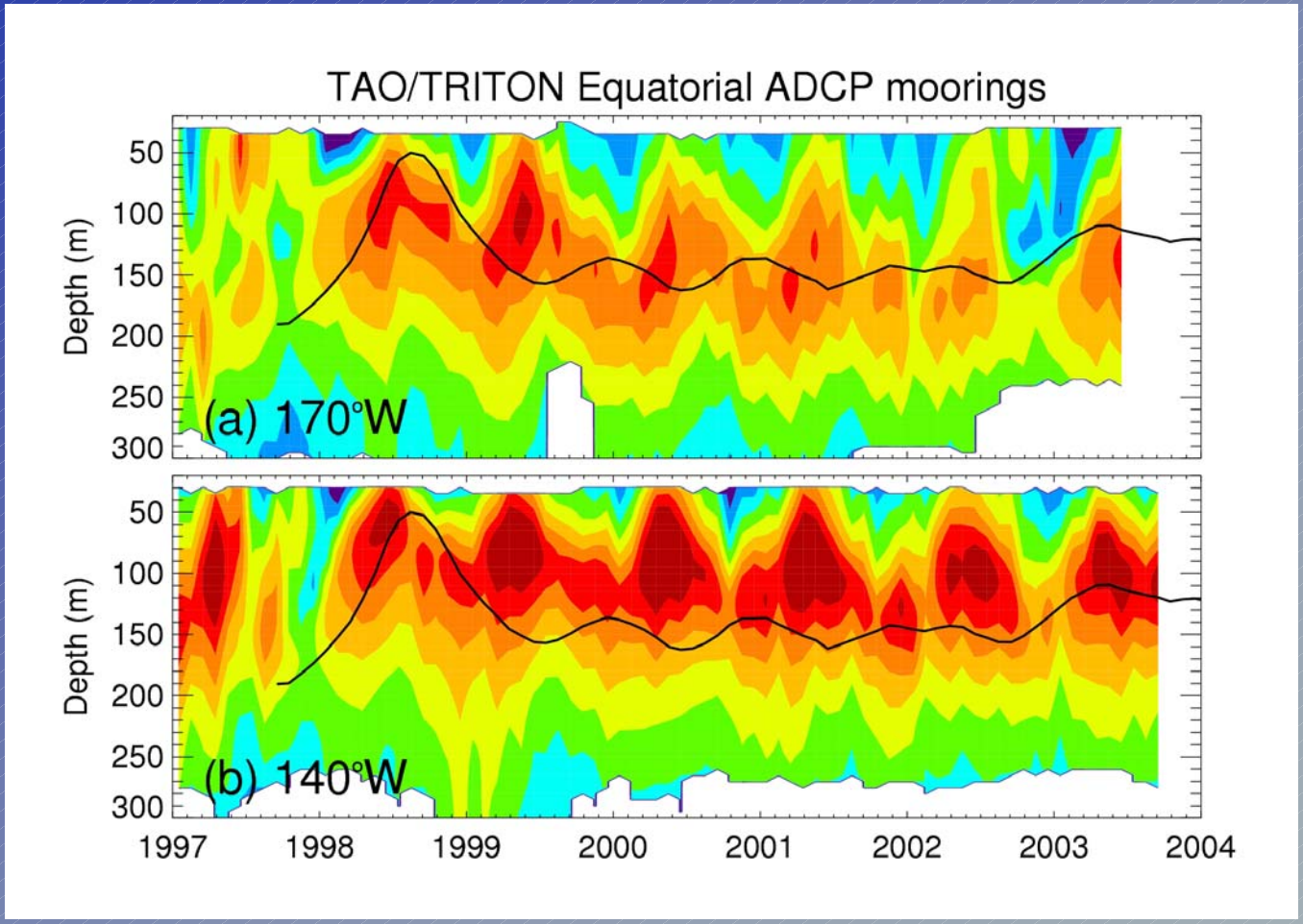
Latitude (at 140°W)

From Coale et al. [1996]

Chlorophyll Variability & El Niño



Chlorophyll Variability & El Niño



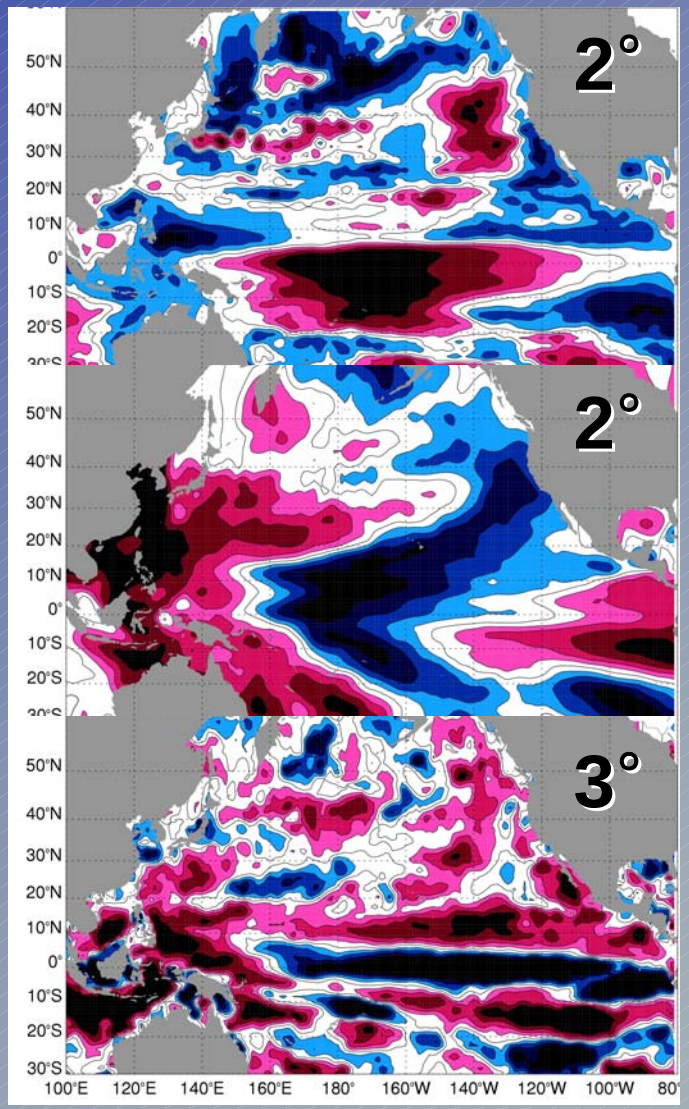
SeaWiFS Chlorophyll Mode 3 Temporal Component

Bio-physical Coupling

SSH

SST

Chlorophyll

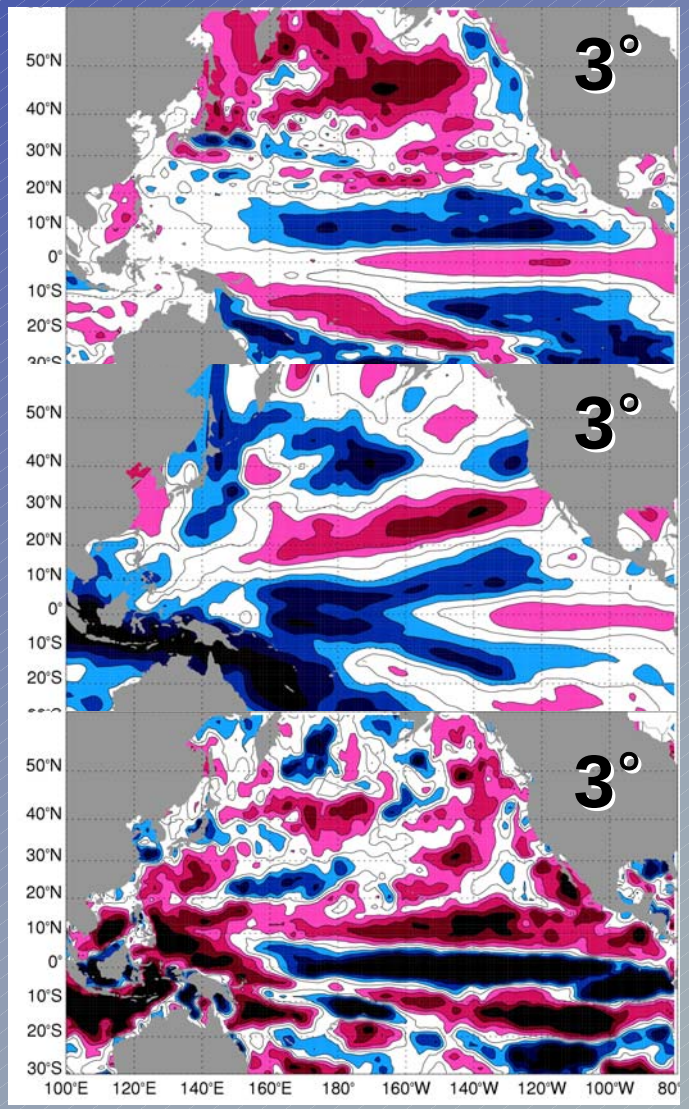


Bio-physical Coupling

SSH

SST

Chlorophyll



Temporal Components

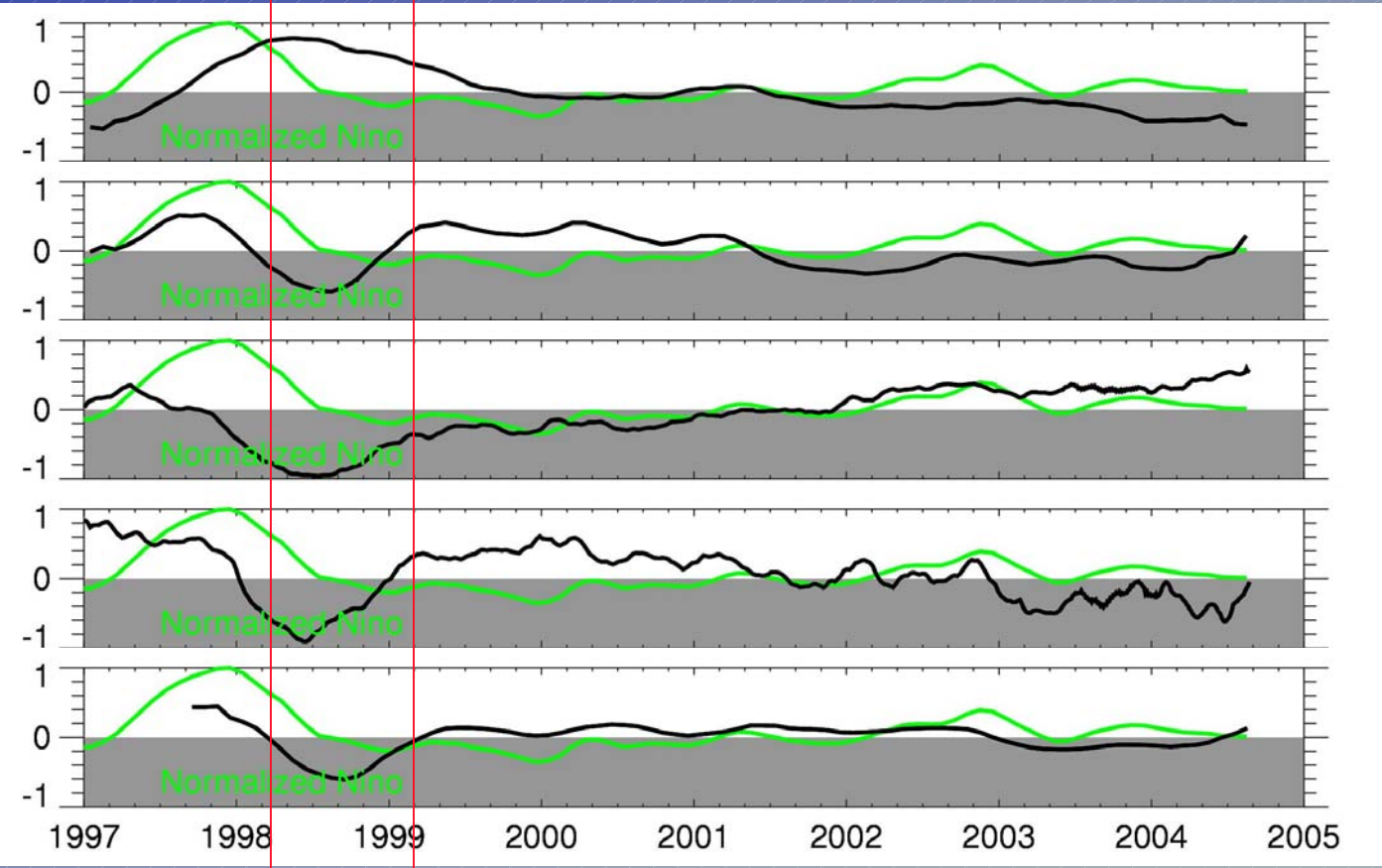
SST 2°

SST 3°

SSH 2°

SSH 3°

CHL 3°

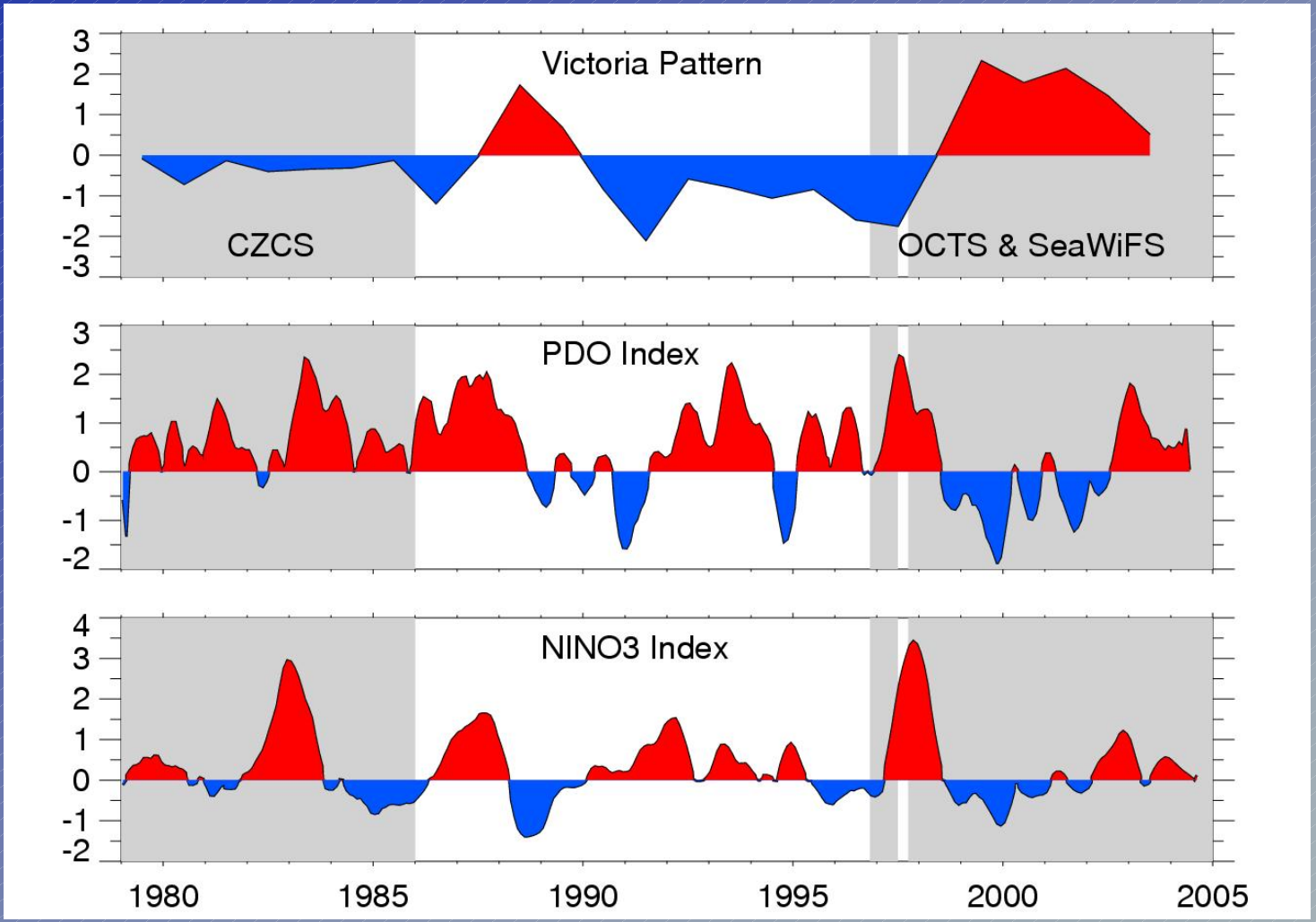


Part IIb

CZCS (1979-1986)
versus
SeaWiFS (1997-2004)

TZCF variability

SeaWiFS (97-04) versus CZCS (79-85)



Transition Zone Chlorophyll Front (TZCF)

The TZCF is an important migratory and foraging pathway in the North Pacific.

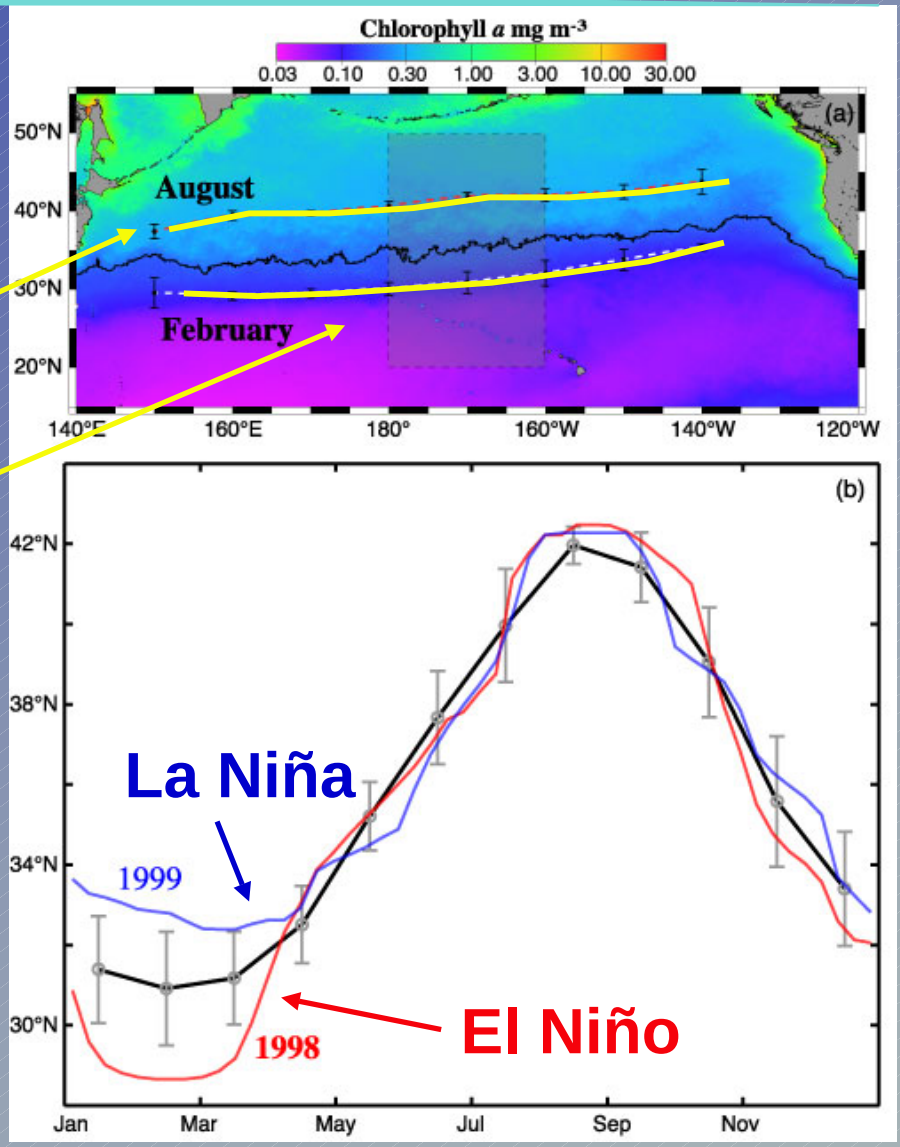
Seasonal variability

summer **winter**

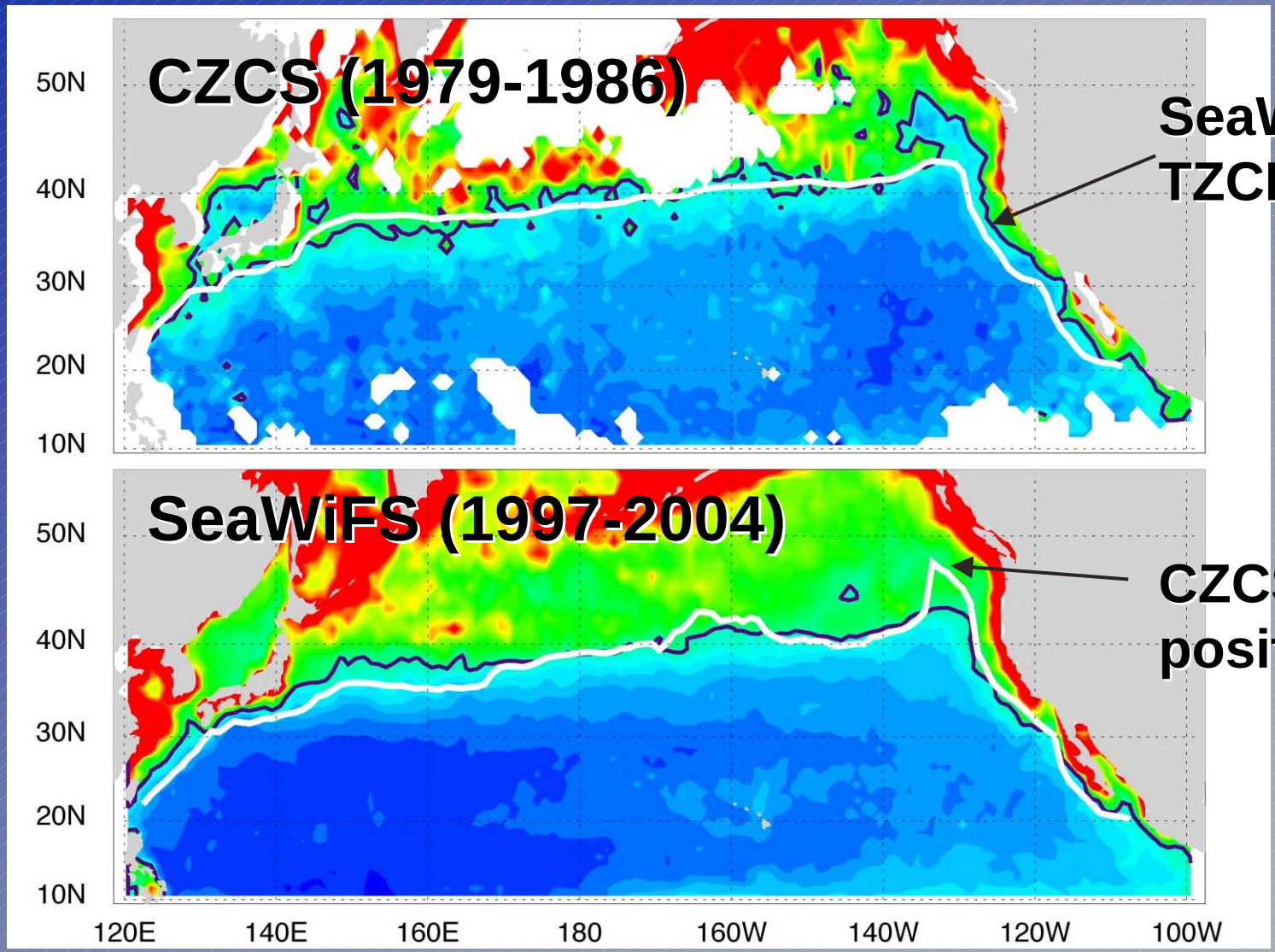
ENSO variability

Interannual variability??

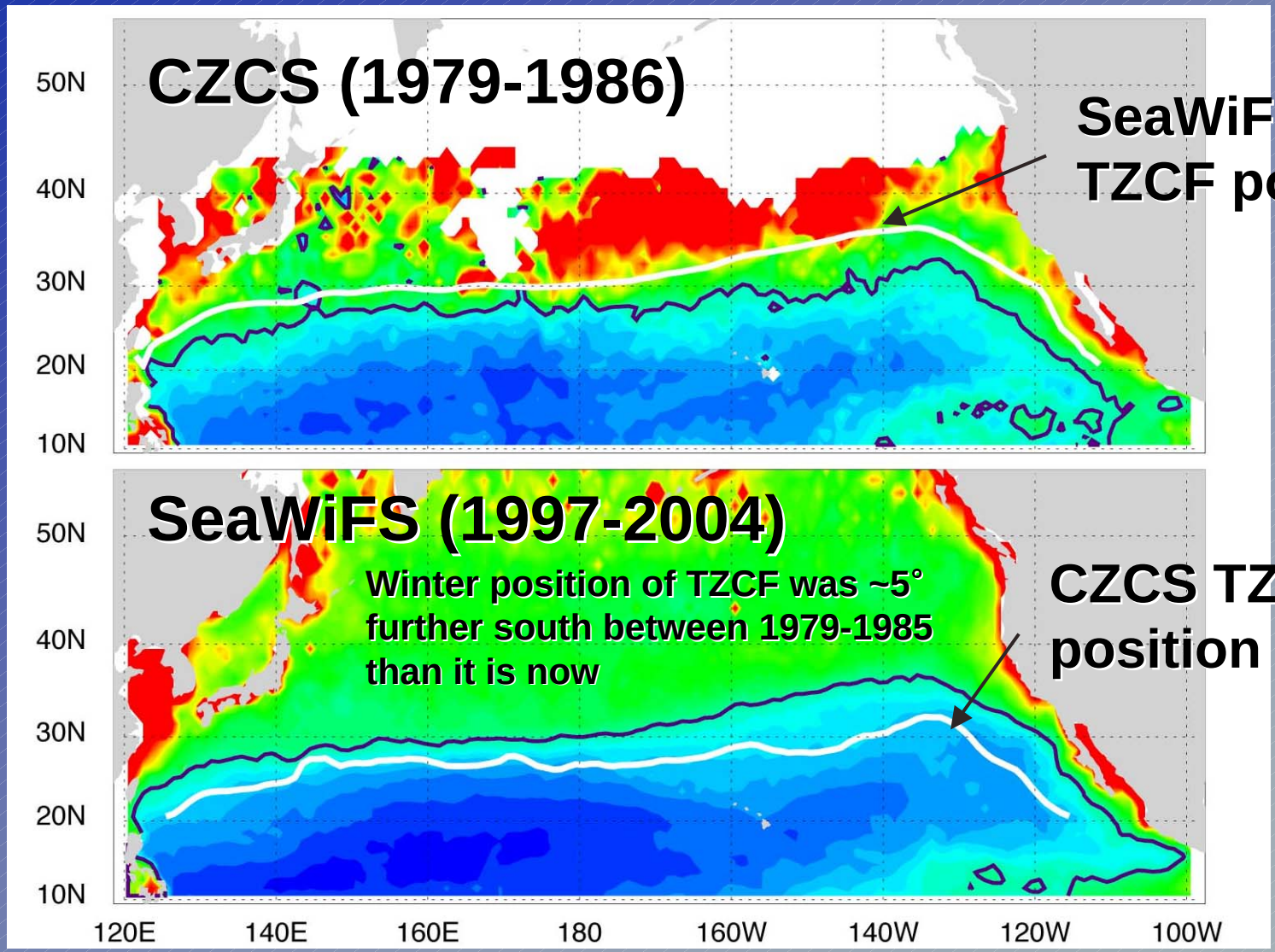
from Bograd et al. [2004]



July TZCF

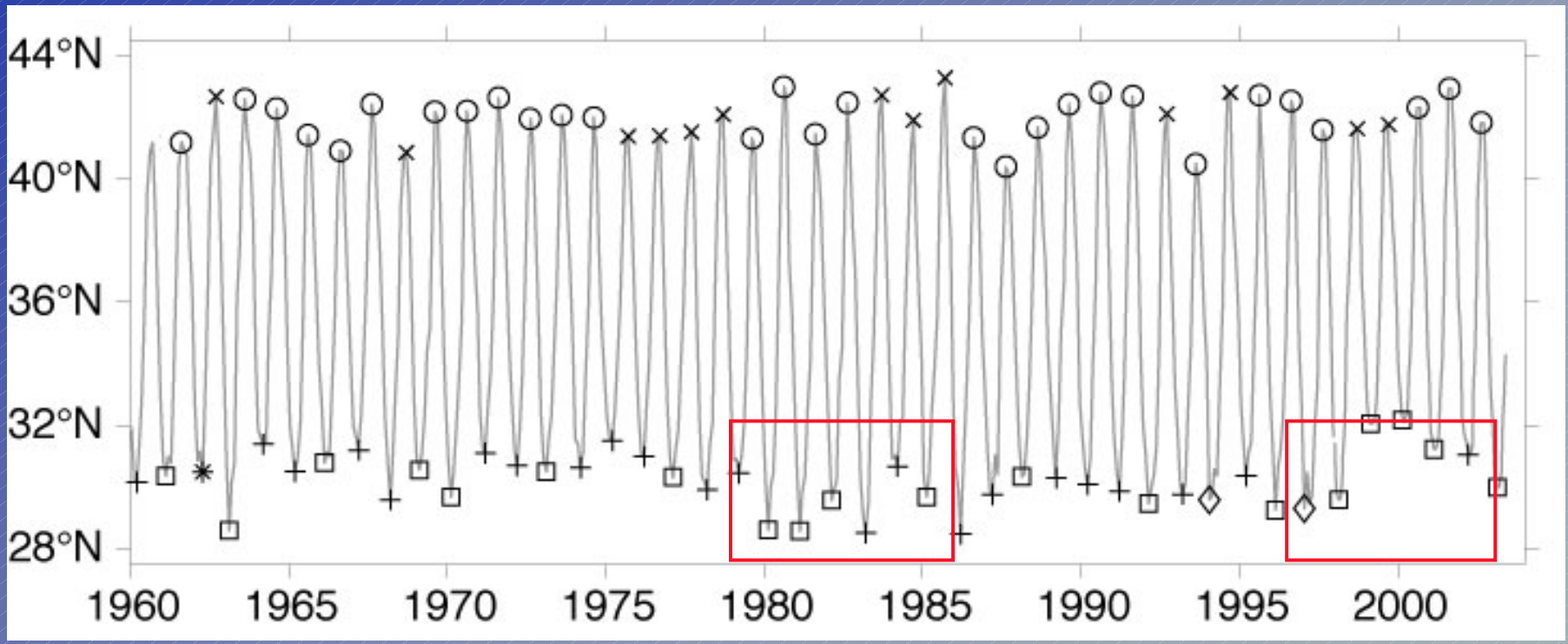

CZCS (1979-1986)
SeaWiFS
TZCF position
SeaWiFS (1997-2004)
CZCS TZCF
position
50N
40N
30N
20N
10N
120E
140E
160E
180
160W
140W
120W
100W

January TZCF



Long-term TZCF variability

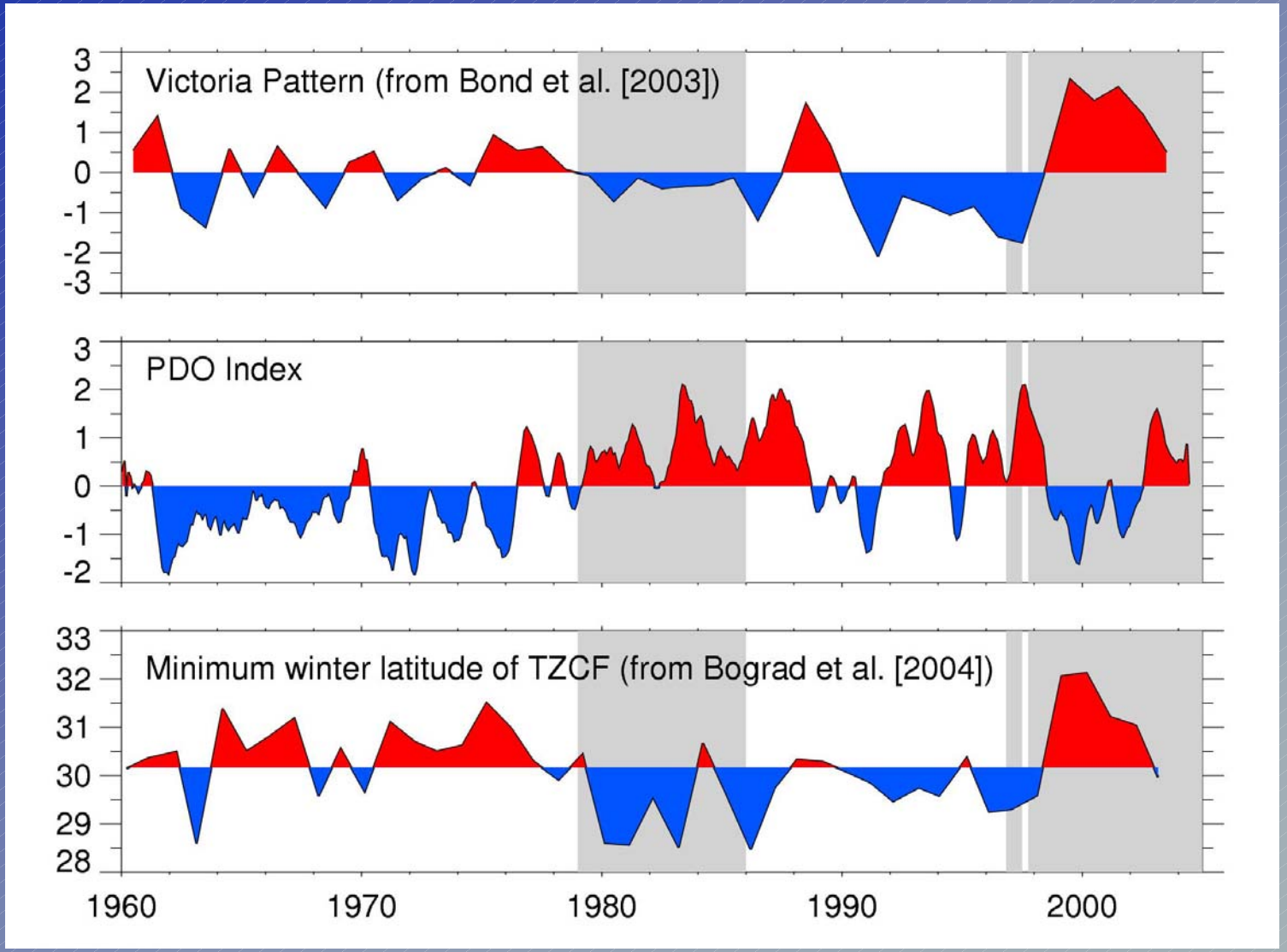
Latitude of the 18˚C SST isopleth, a proxy for the TZCF



CZCS **SeaWiFS**

from Bograd et al. [2004]

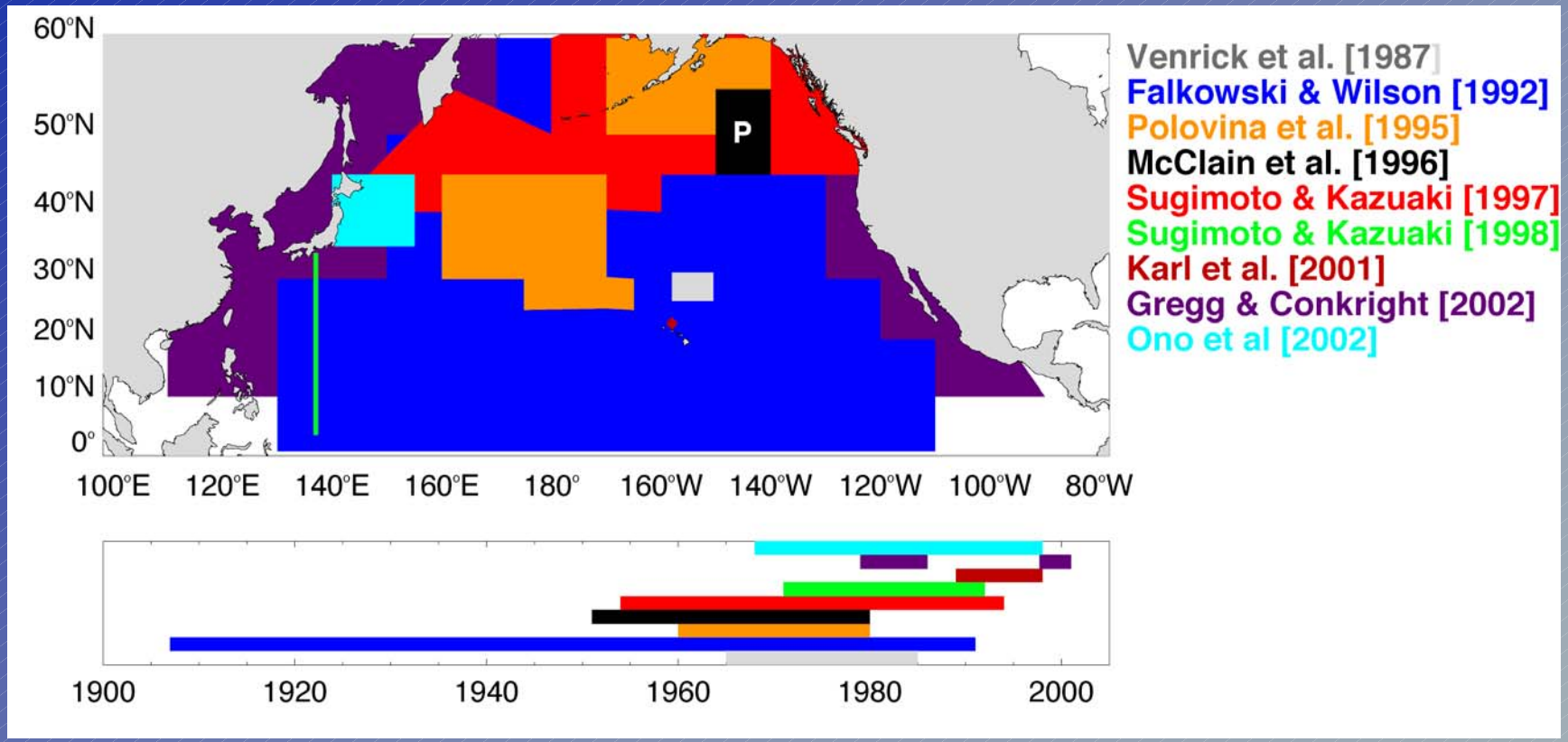
Long-term TZCF variability



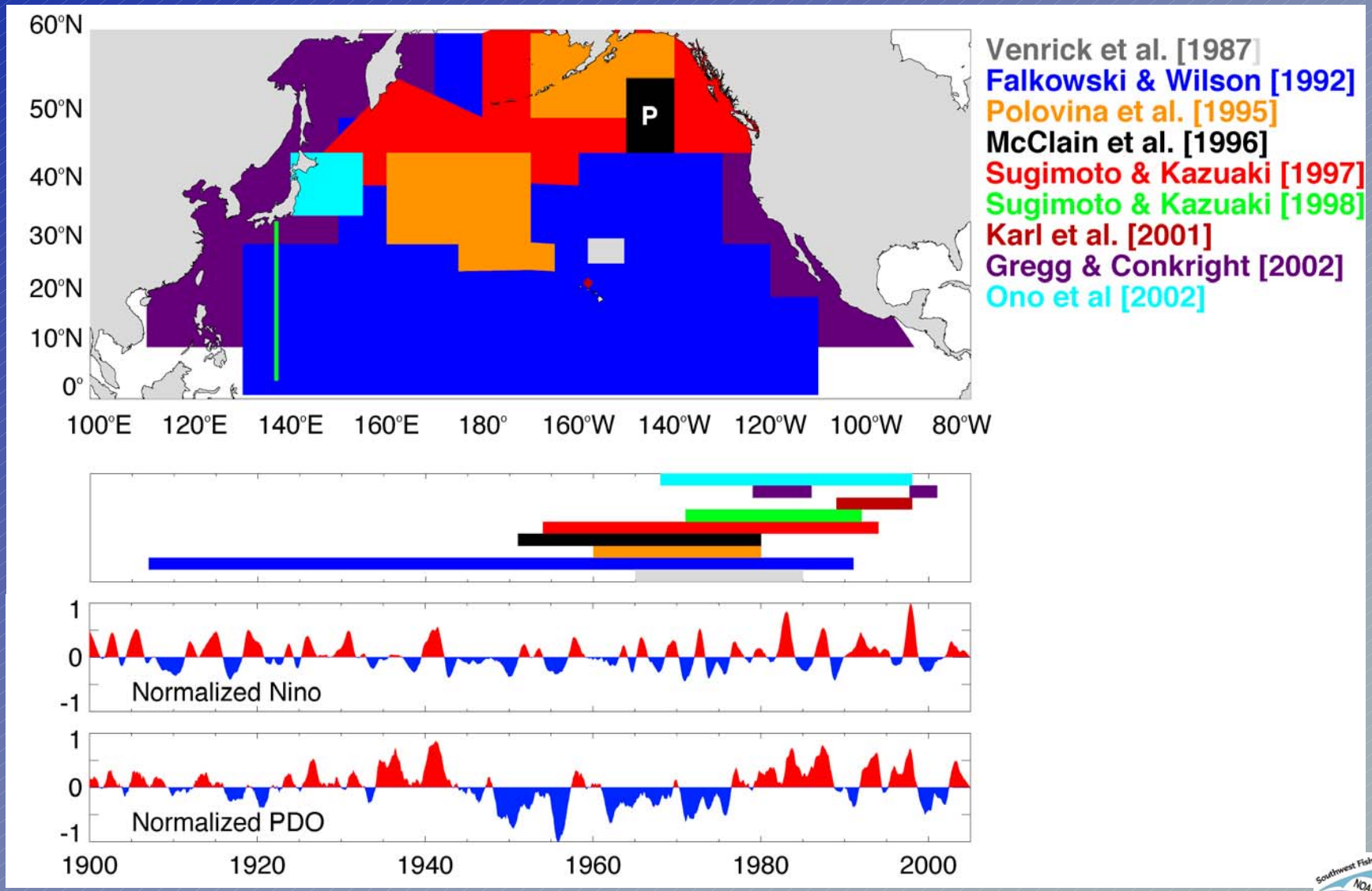
Part III

Summary of regional studies

Summary of previous studies



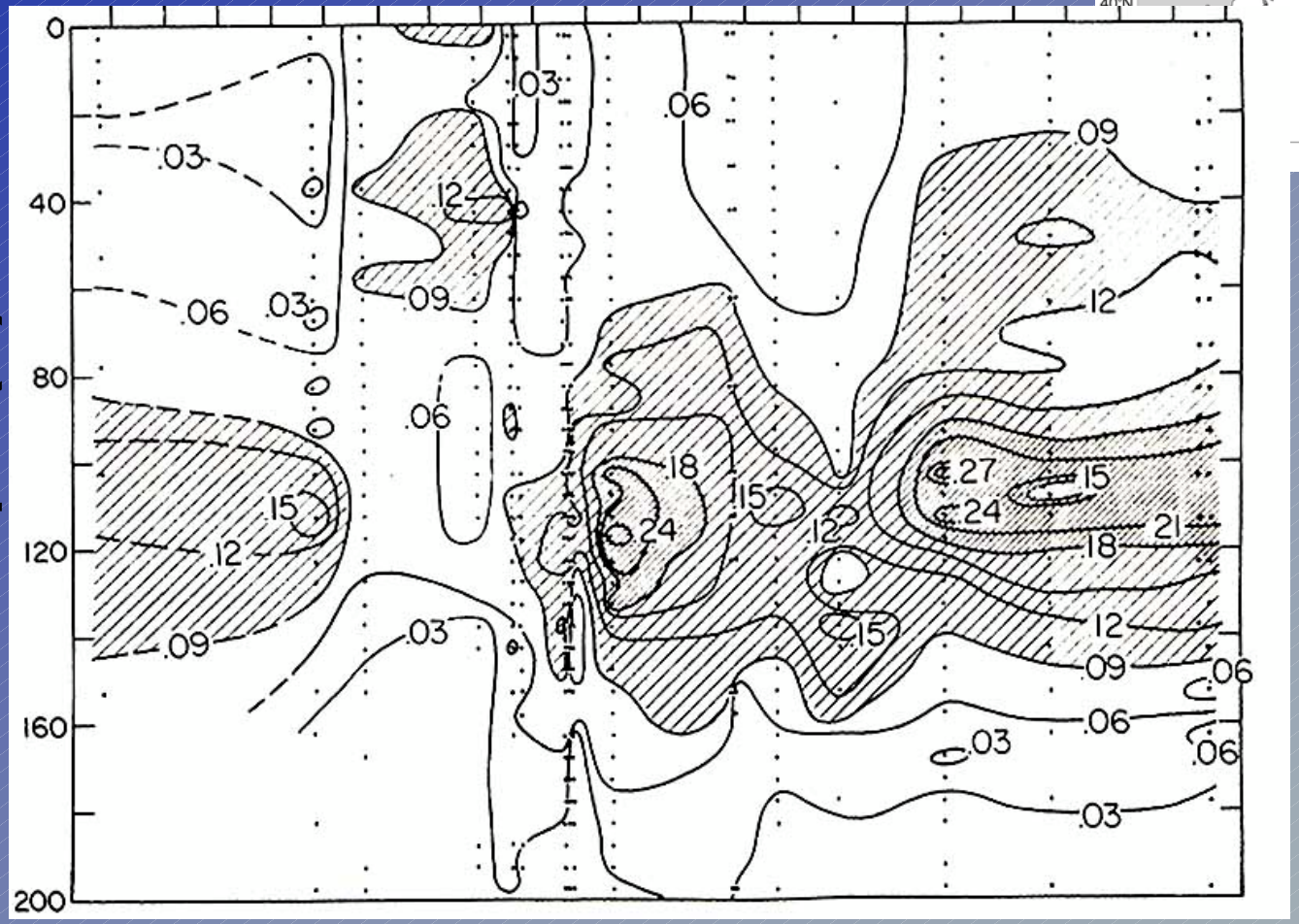
Summary of previous studies

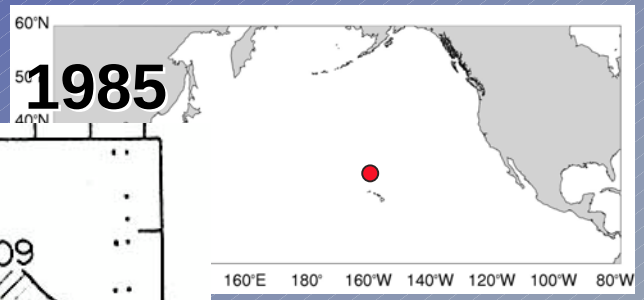


Chlorophyll increasing?

Some indications that chlorophyll is increasing...

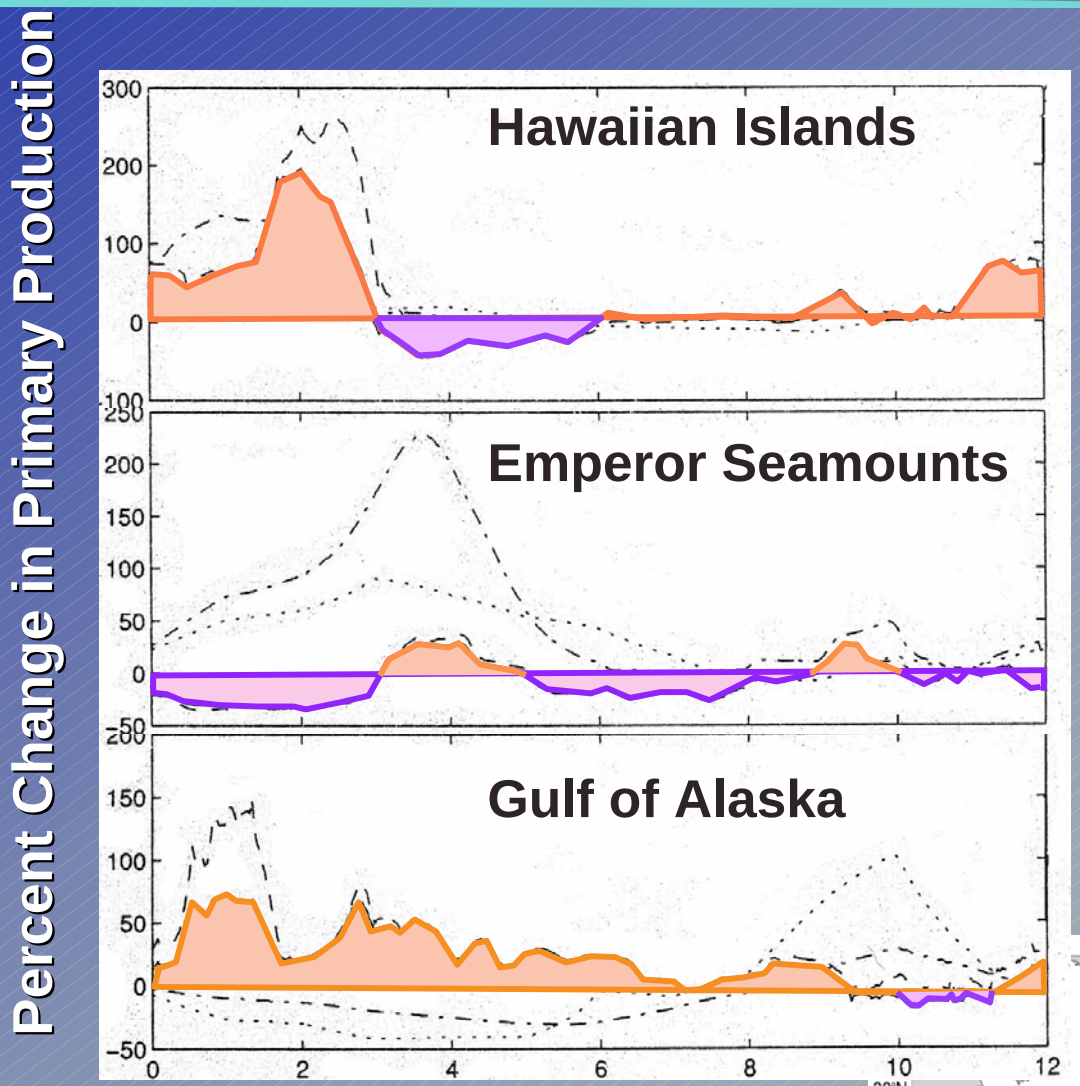
from Venrick et al. [1987]





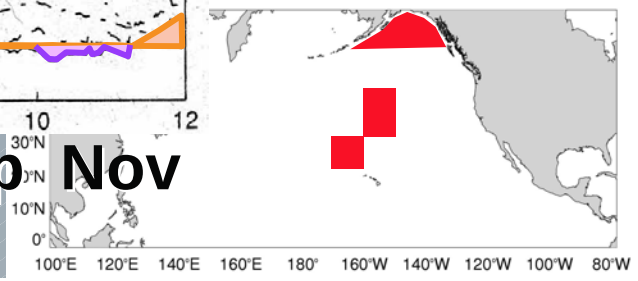
from Polovina et al. [1995]

1977-88 vs. 1960-76

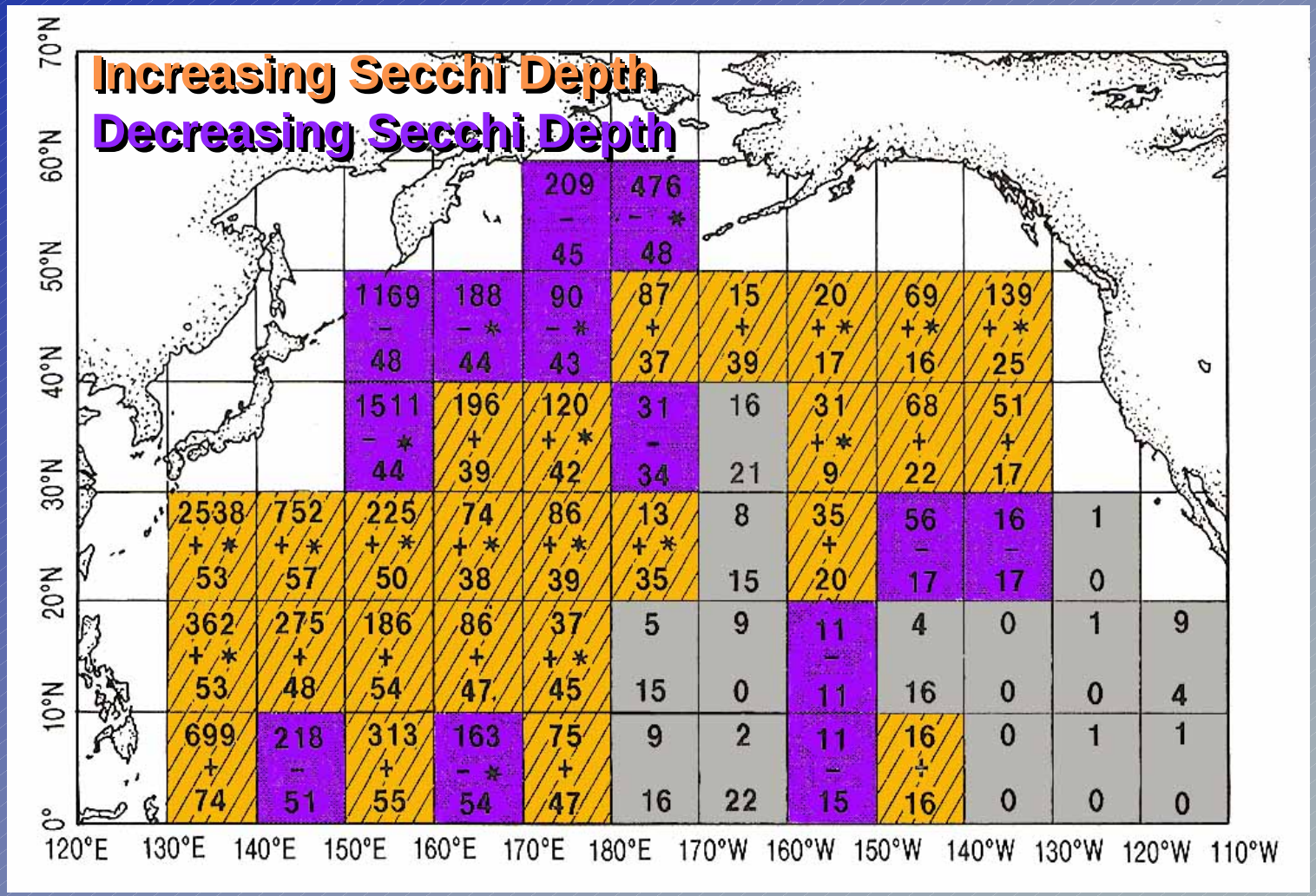


Winter Increase

Year-round Increase



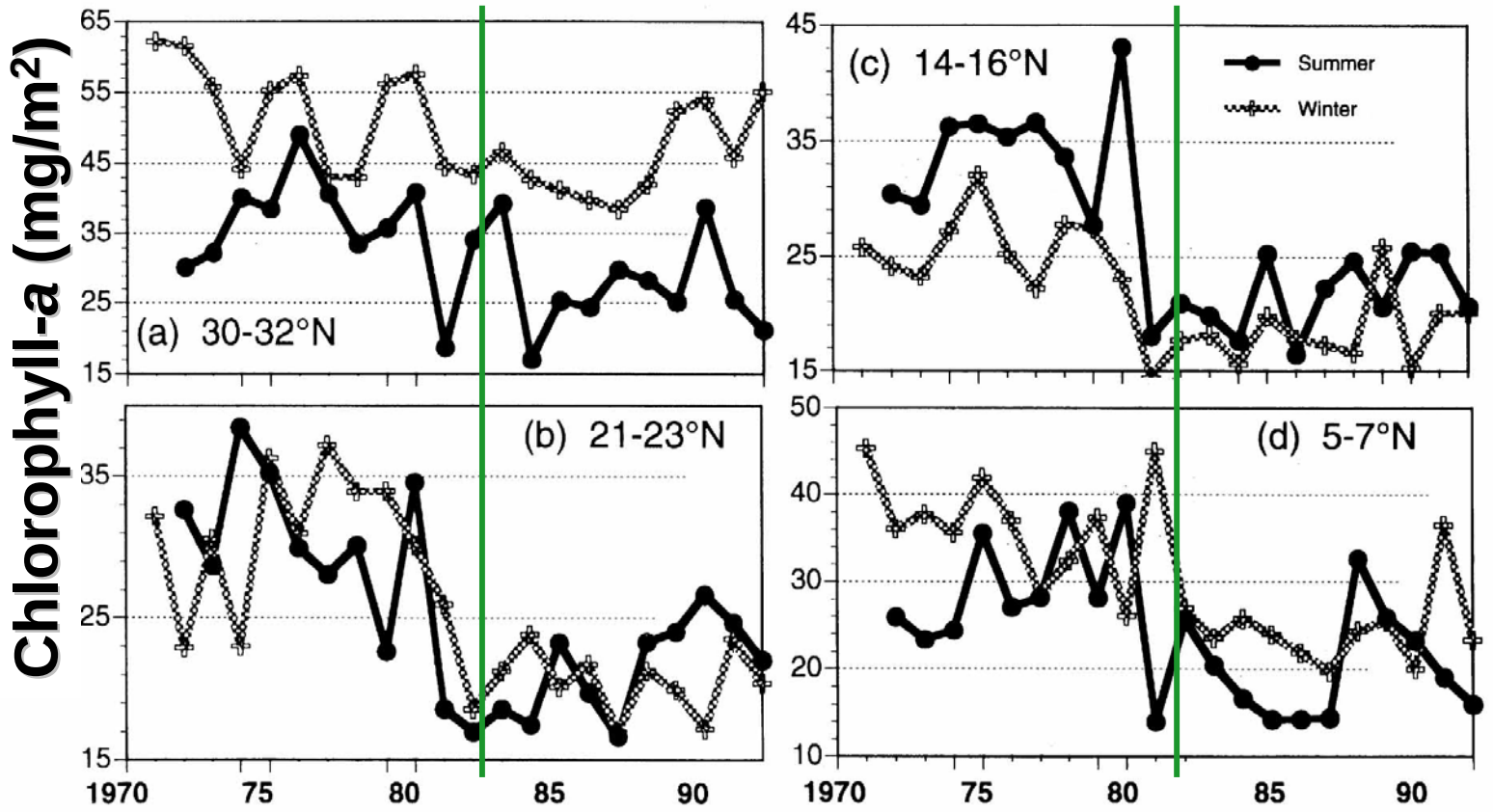
from Falkowski & Wilson [1992]

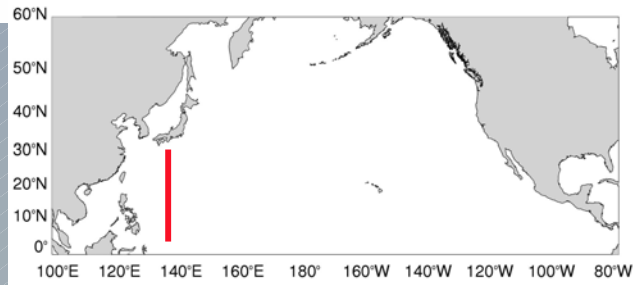


Chlorophyll decreasing?

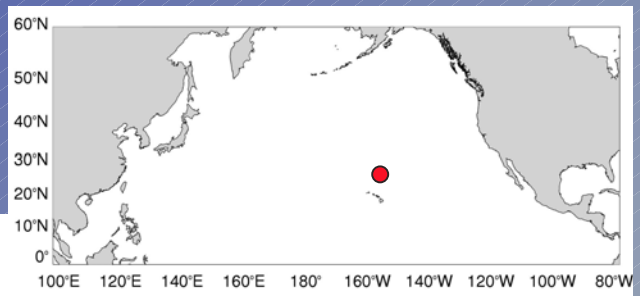
But there are also indications that chlorophyll is decreasing...

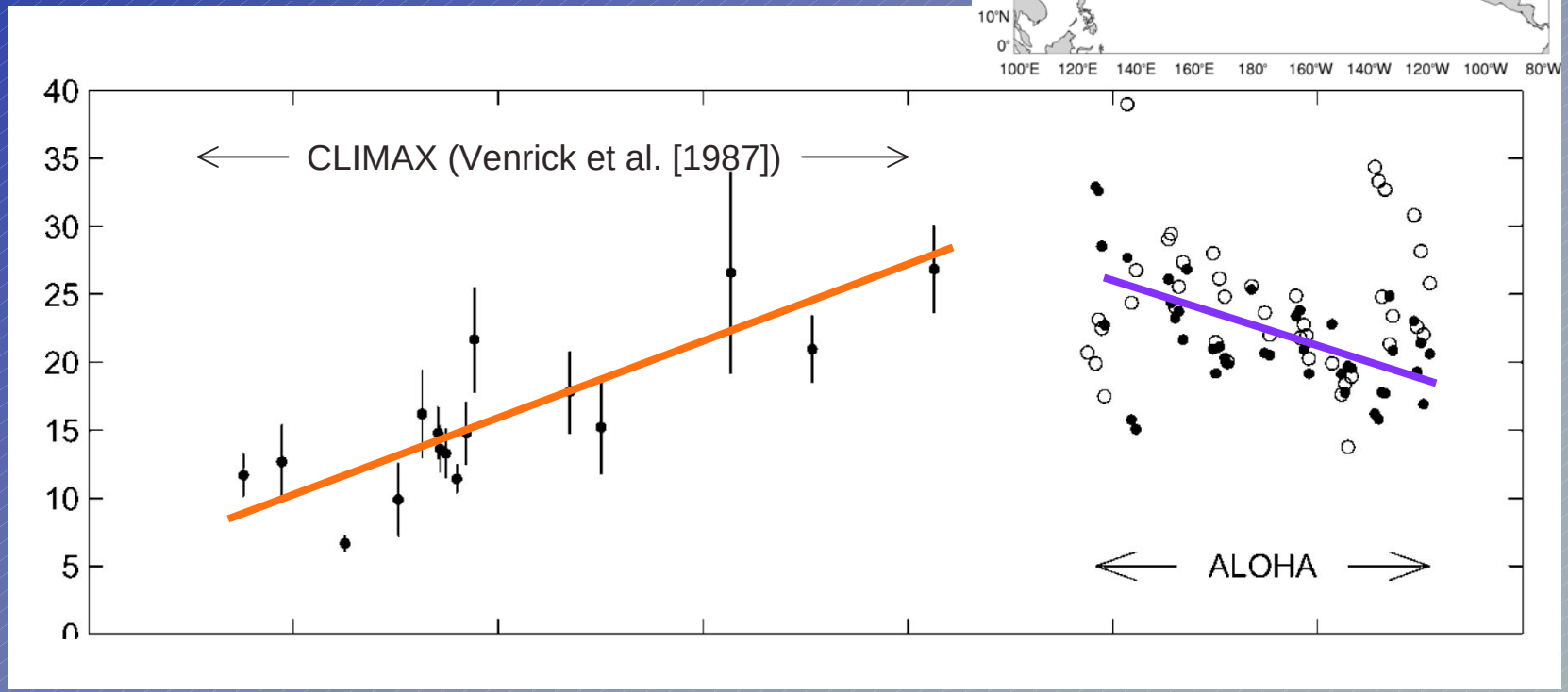
from Sugimoto and Tadokoro [1998]



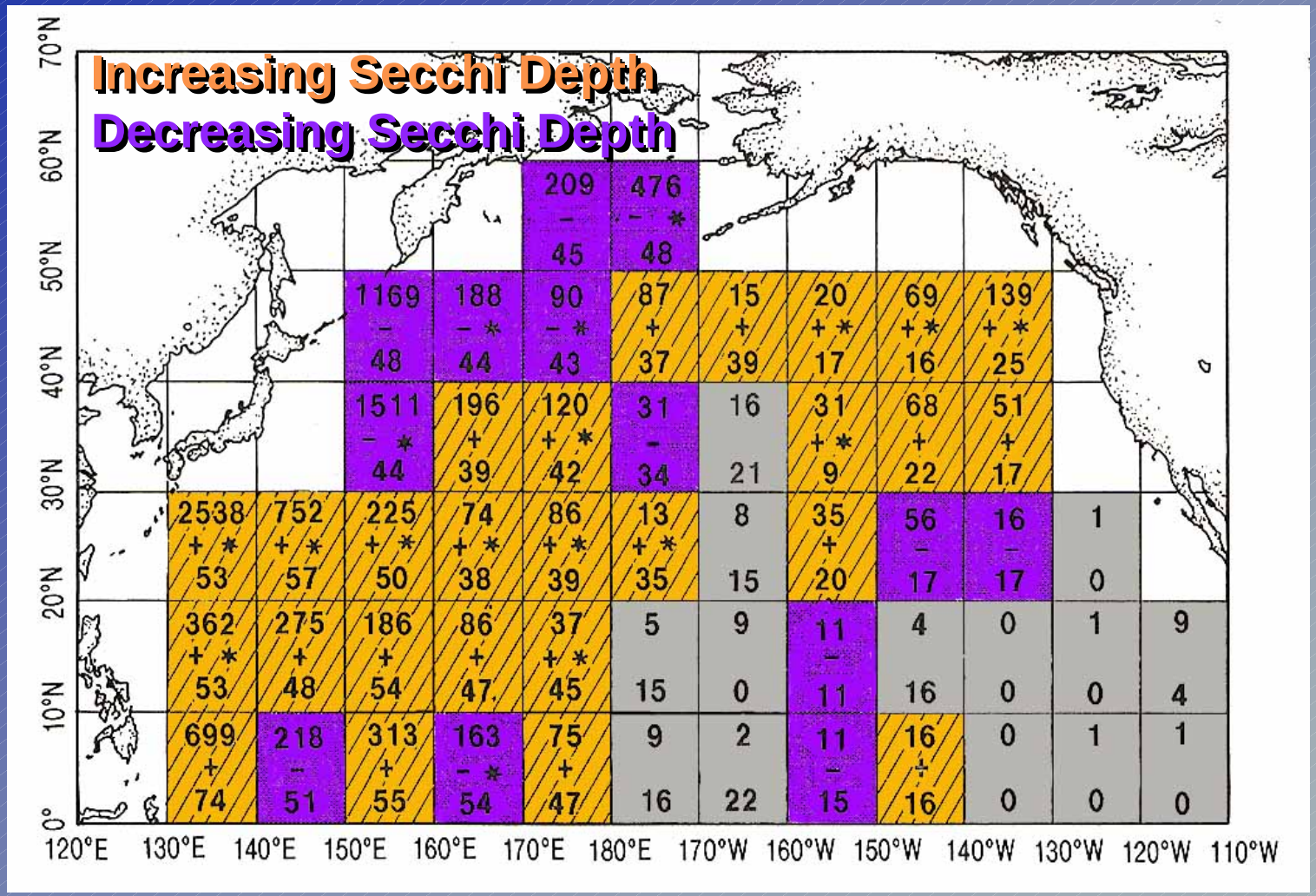


from Karl et al. [2001]





from Falkowski & Wilson [1992]

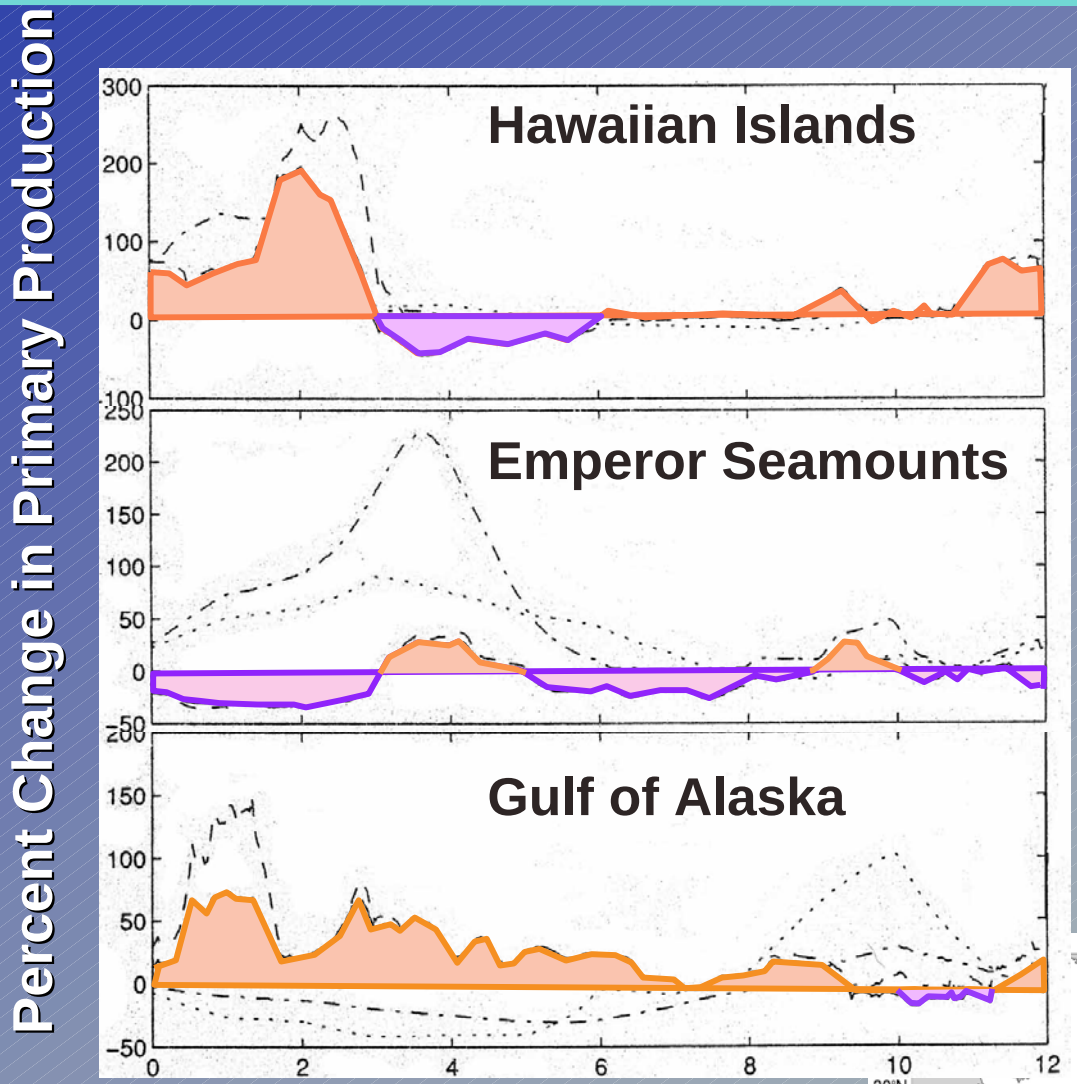


No Chlorophyll trend?

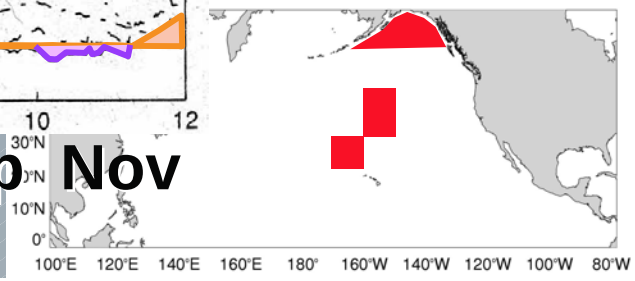
And in some places no clear trend...

from Polovina et al. [1995]

1977-88 vs. 1960-76



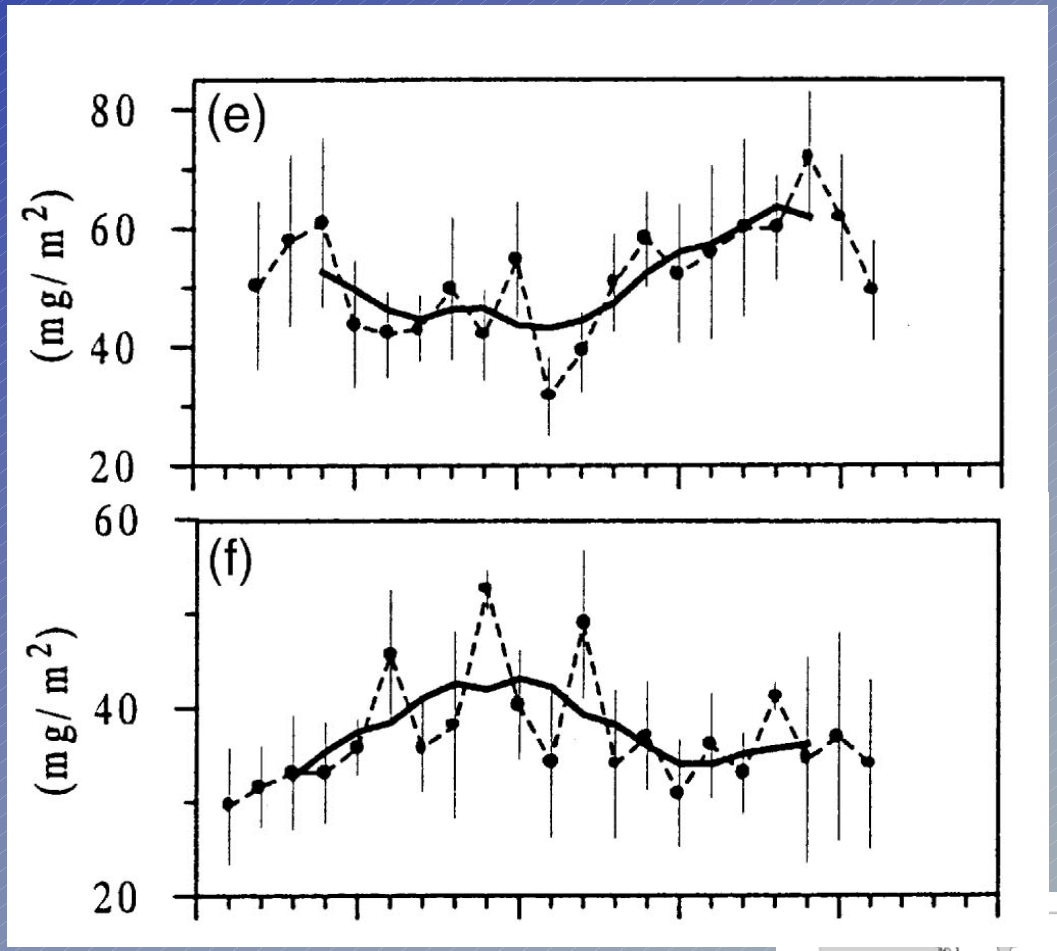
No obvious change

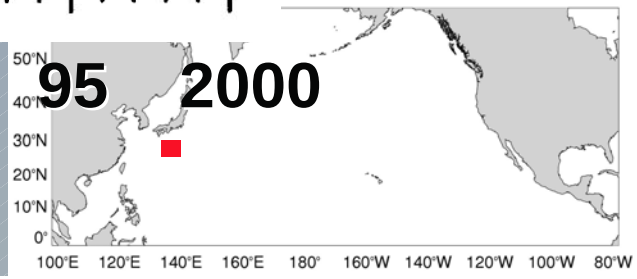


from Limsakul et al. [2001]

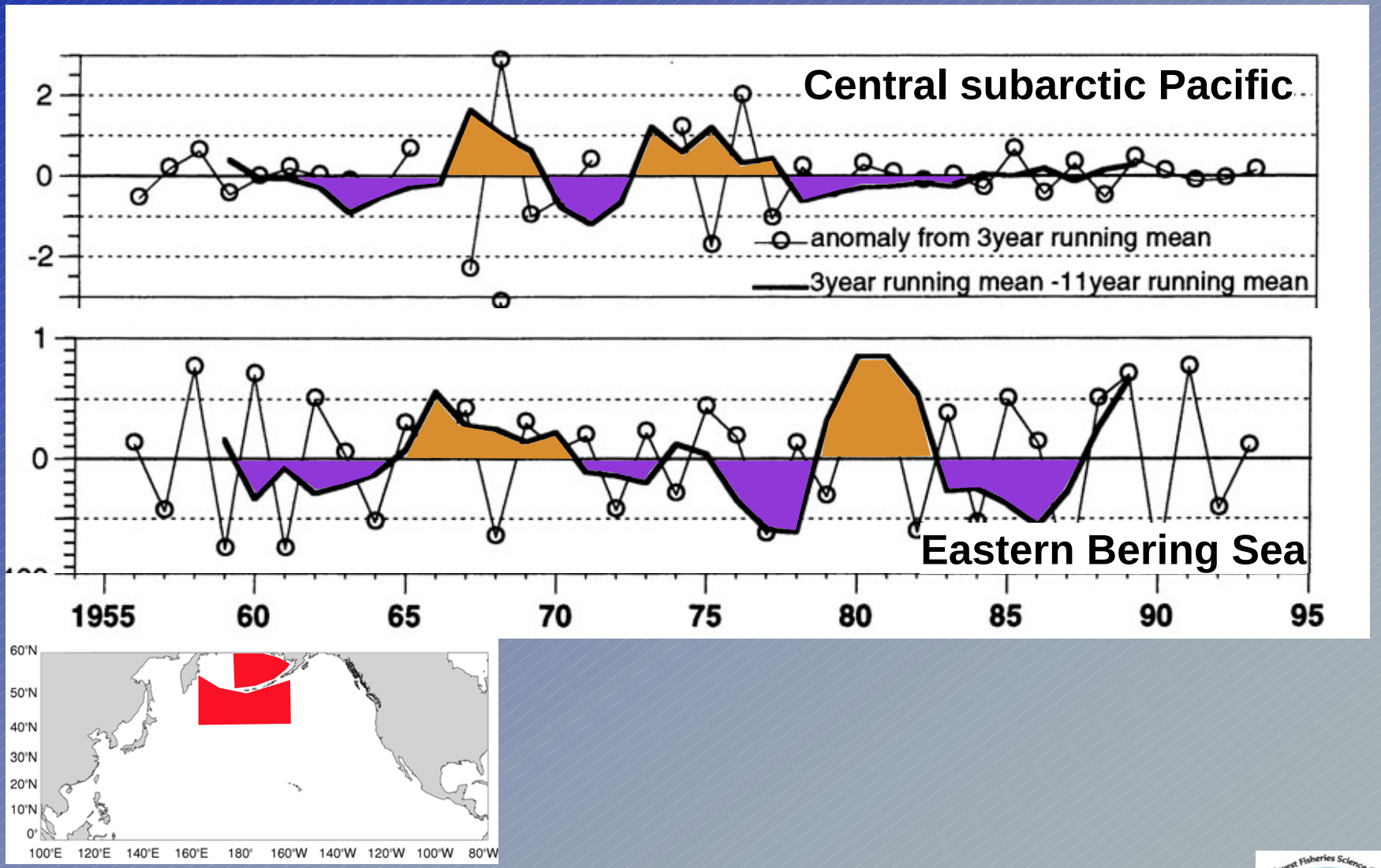
Winter Chlorophyll

Summer Chlorophyll



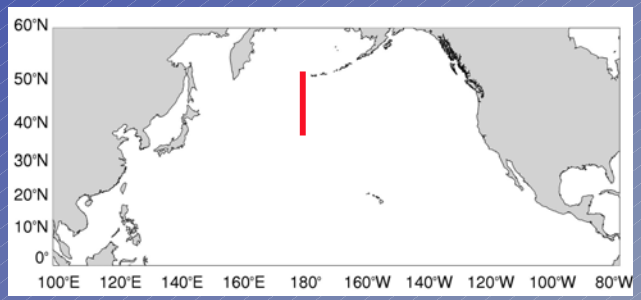


from Sugimoto and Tadokoro [1997]

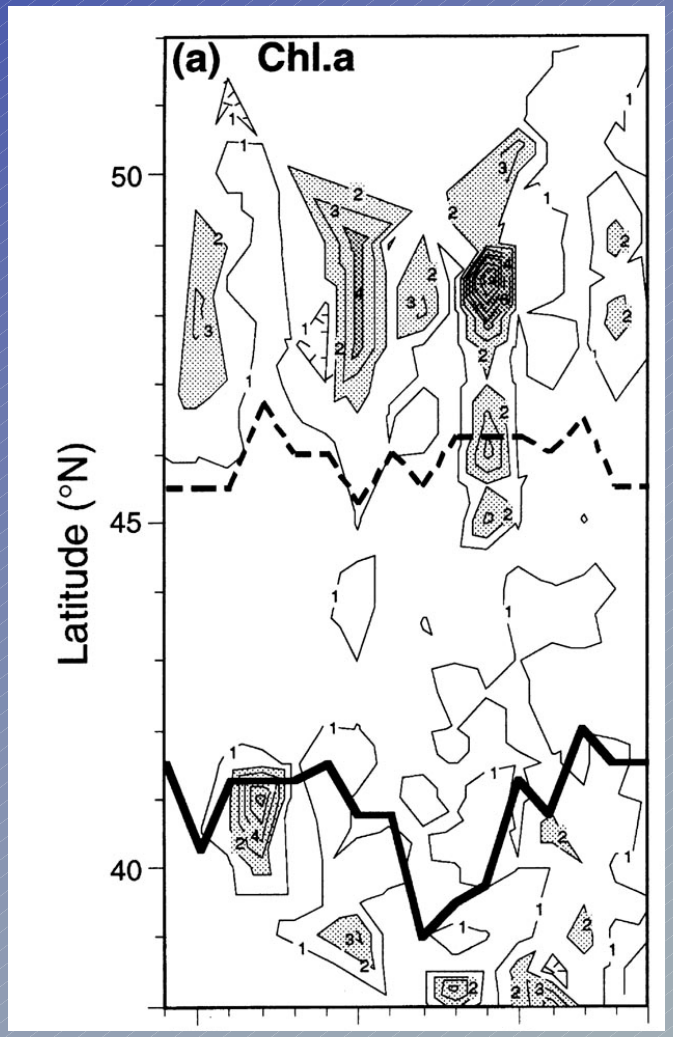


from Sugimoto and Tadokoro [1997]

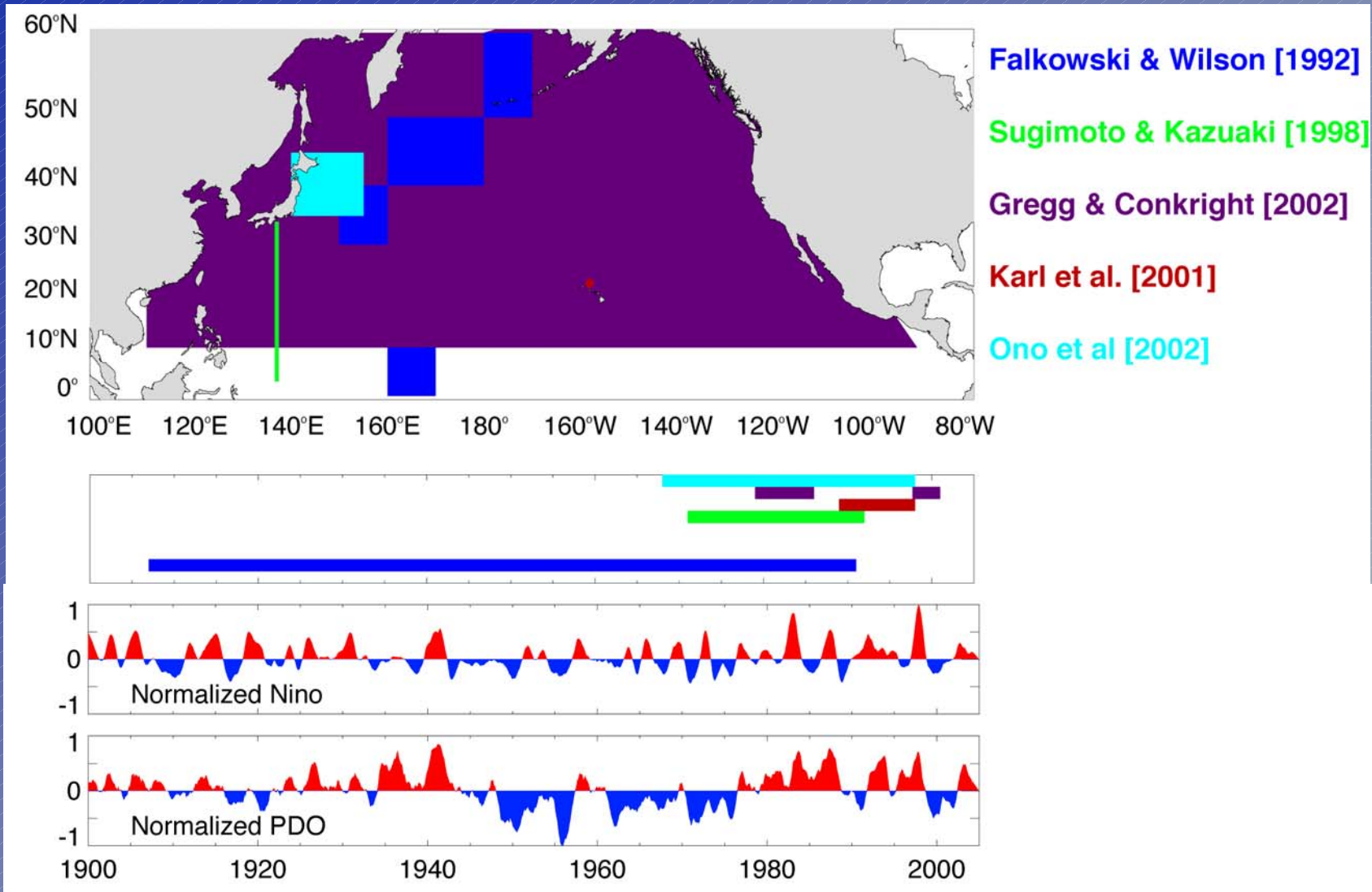
Increase during 1985-1990 between 45˚-50˚N



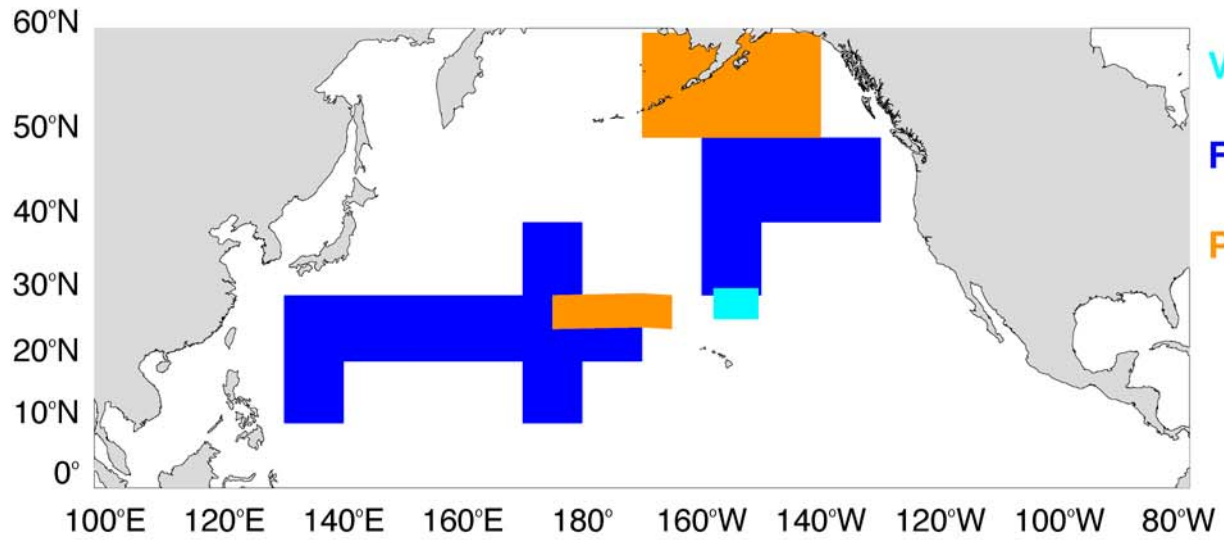
Data along 180˚



Chlorophyll decreasing…



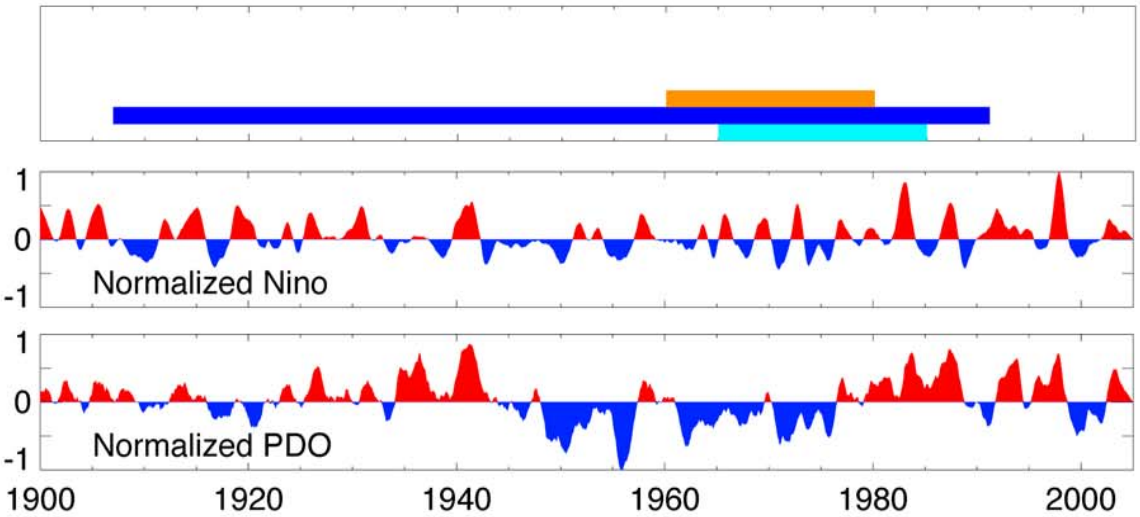
Chlorophyll increasing…



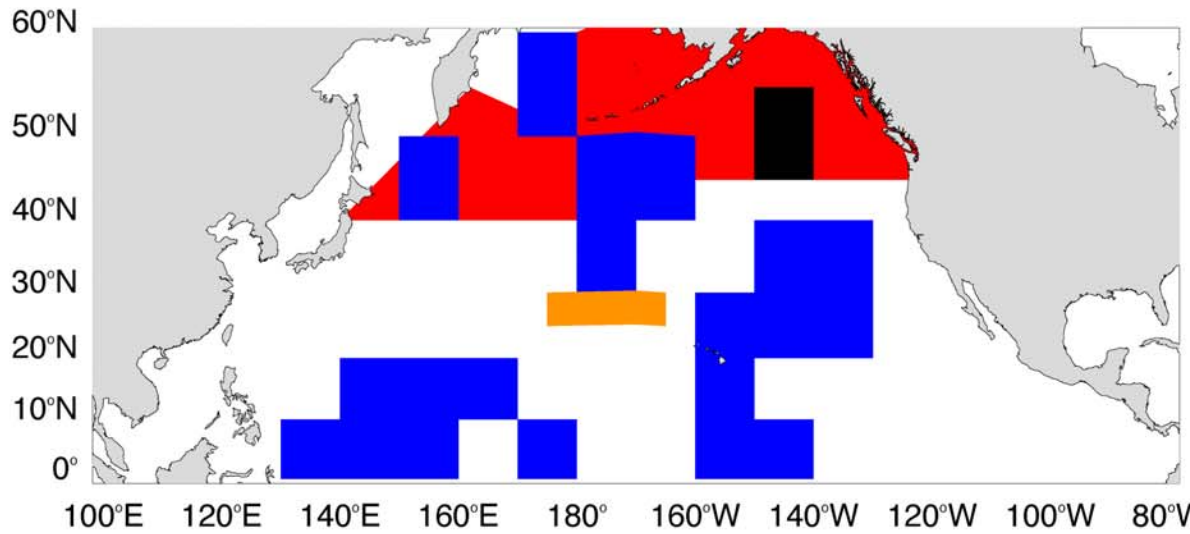
Venrick et al. [1987]

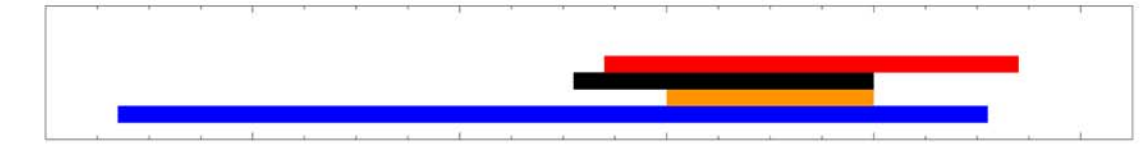
Falkowski & Wilson [1992]

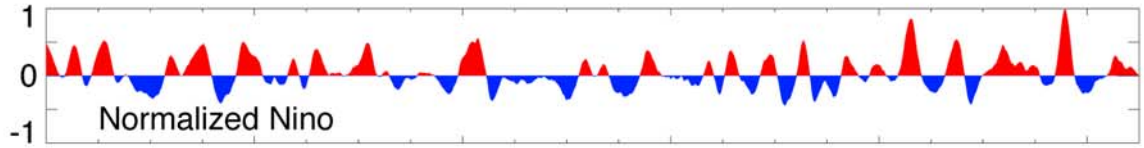
Polovina et al. [1995]

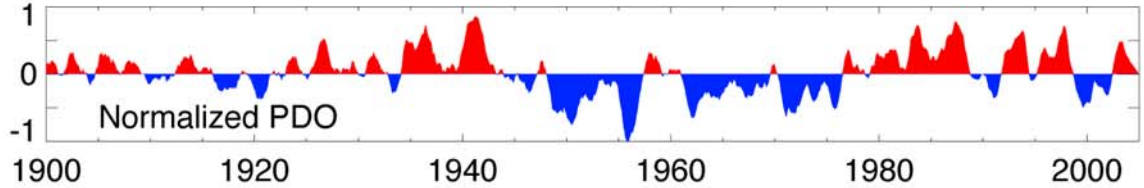


No Chlorophyll trend…









Falkowski & Wilson [1992]

Polovina et al. [1995]

McClain et al. [1996]

Sugimoto & Kazuaki [1997]

Part IV

Climate-scale variability in biological data

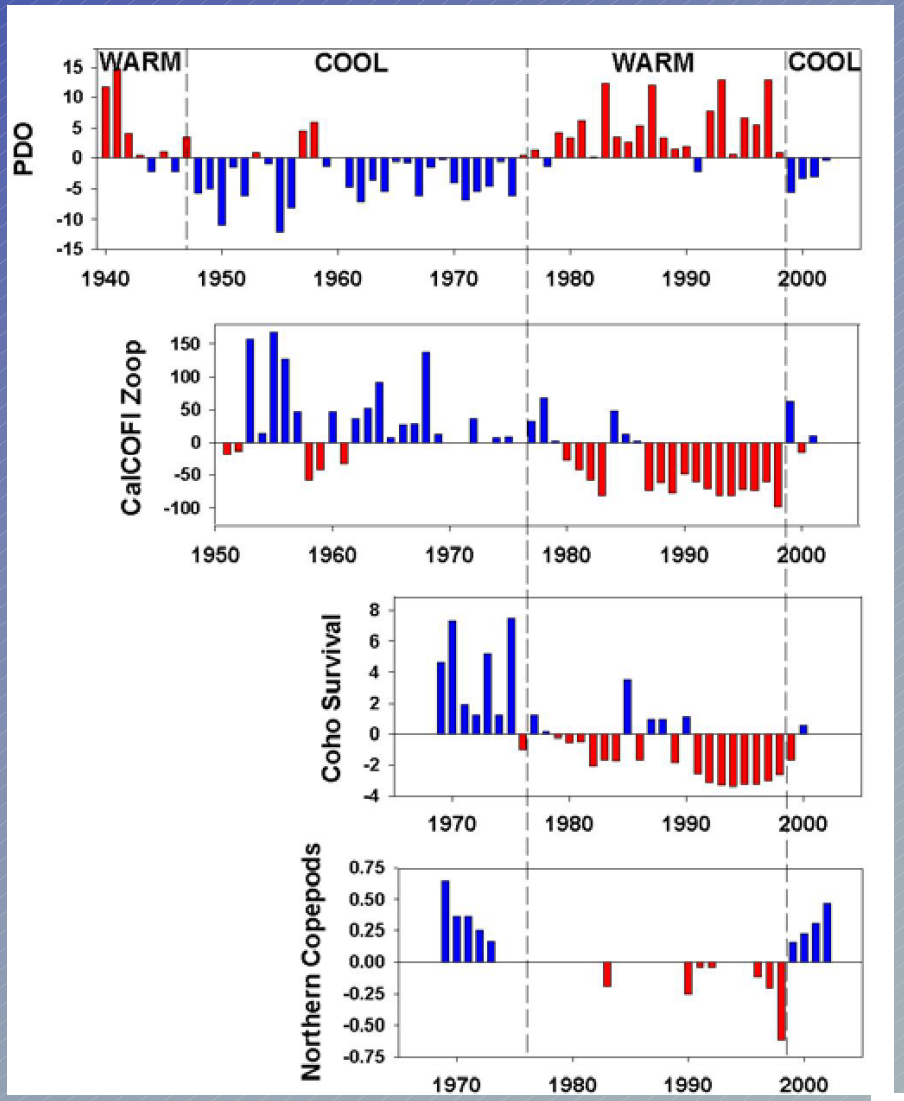
from Peterson & Schwing [2003]

PDO

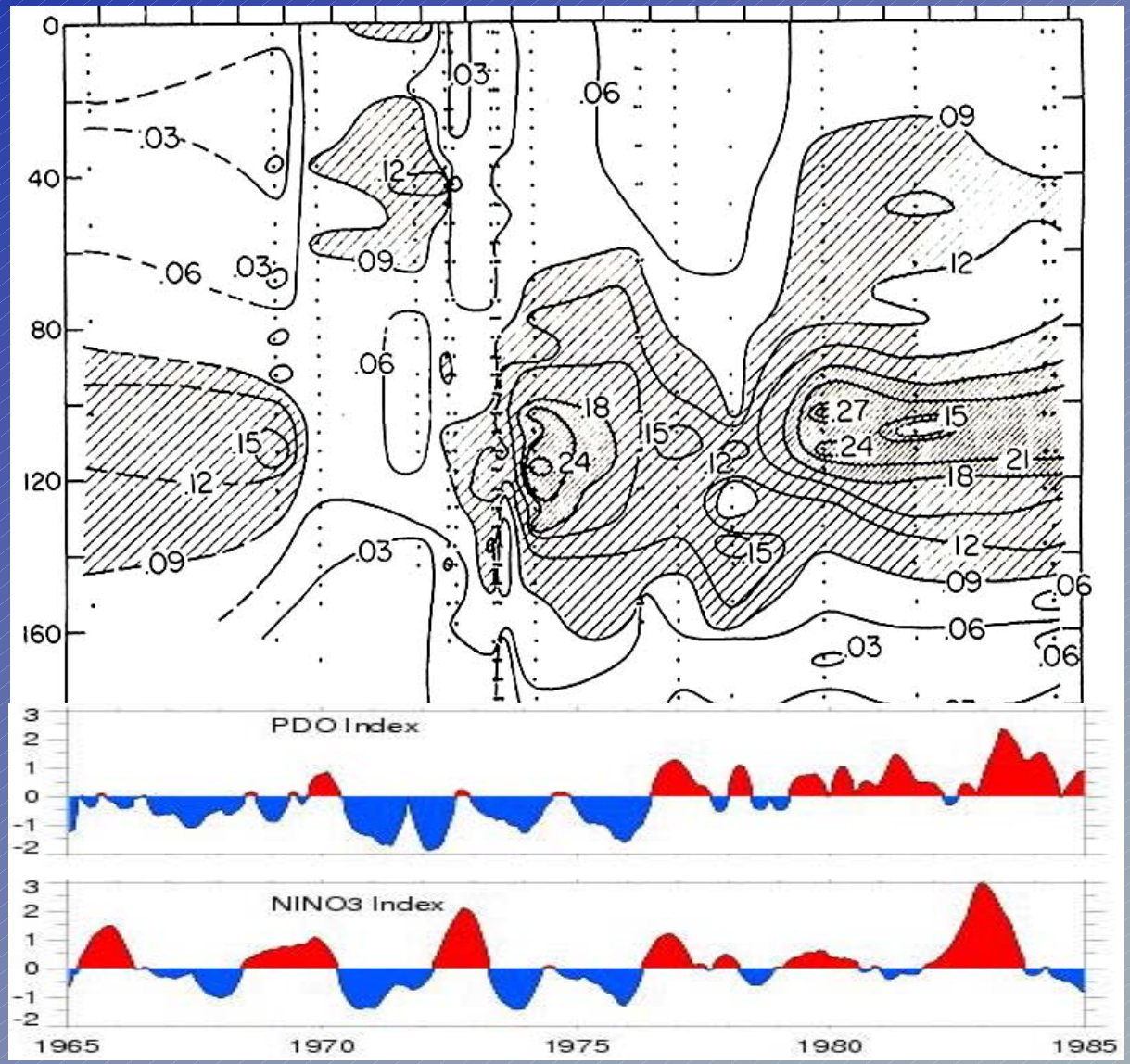
Zooplankton (CalCOFI)

Coho Survival

Northern Copepods

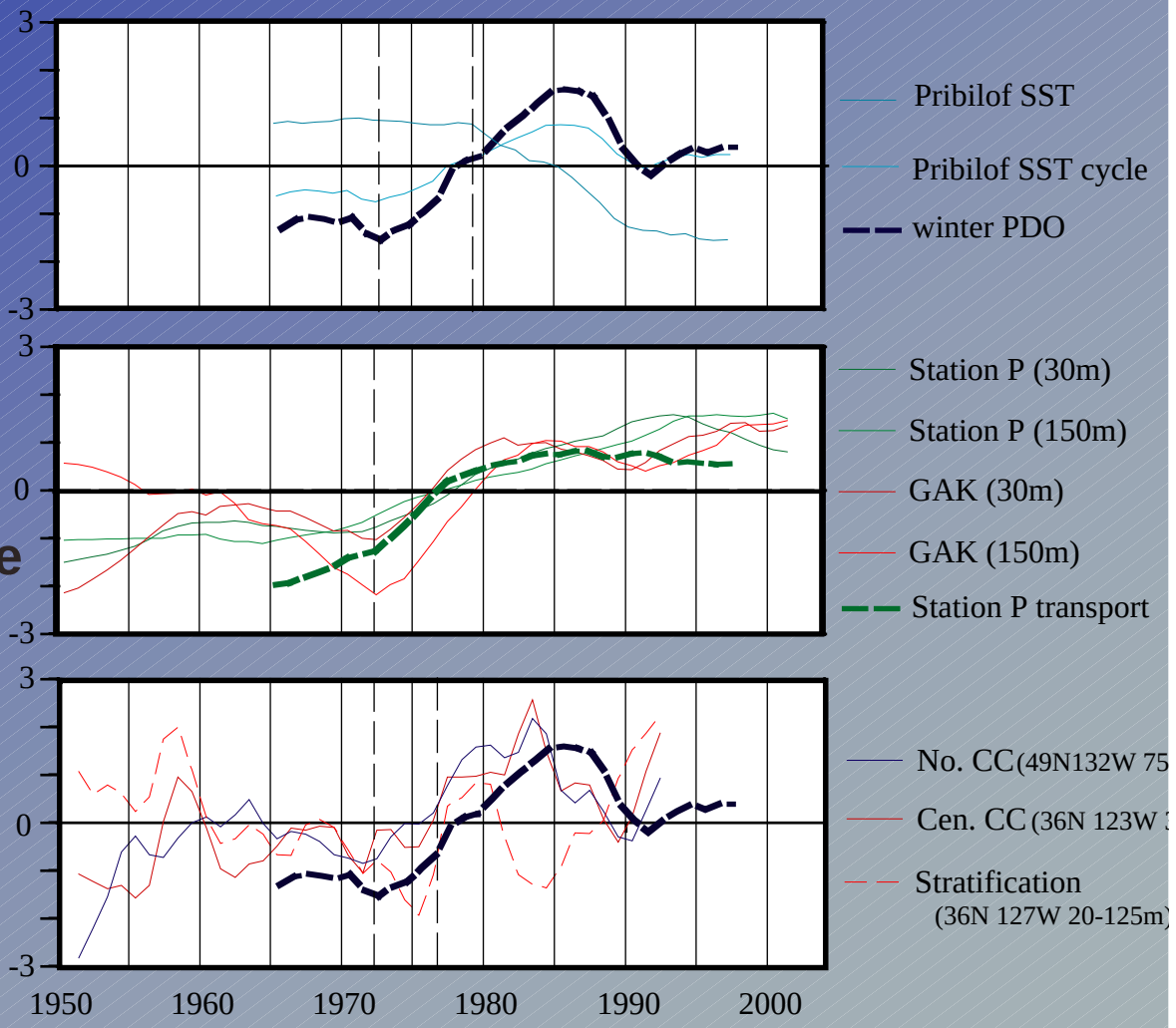


from Venrick et al. [1987]



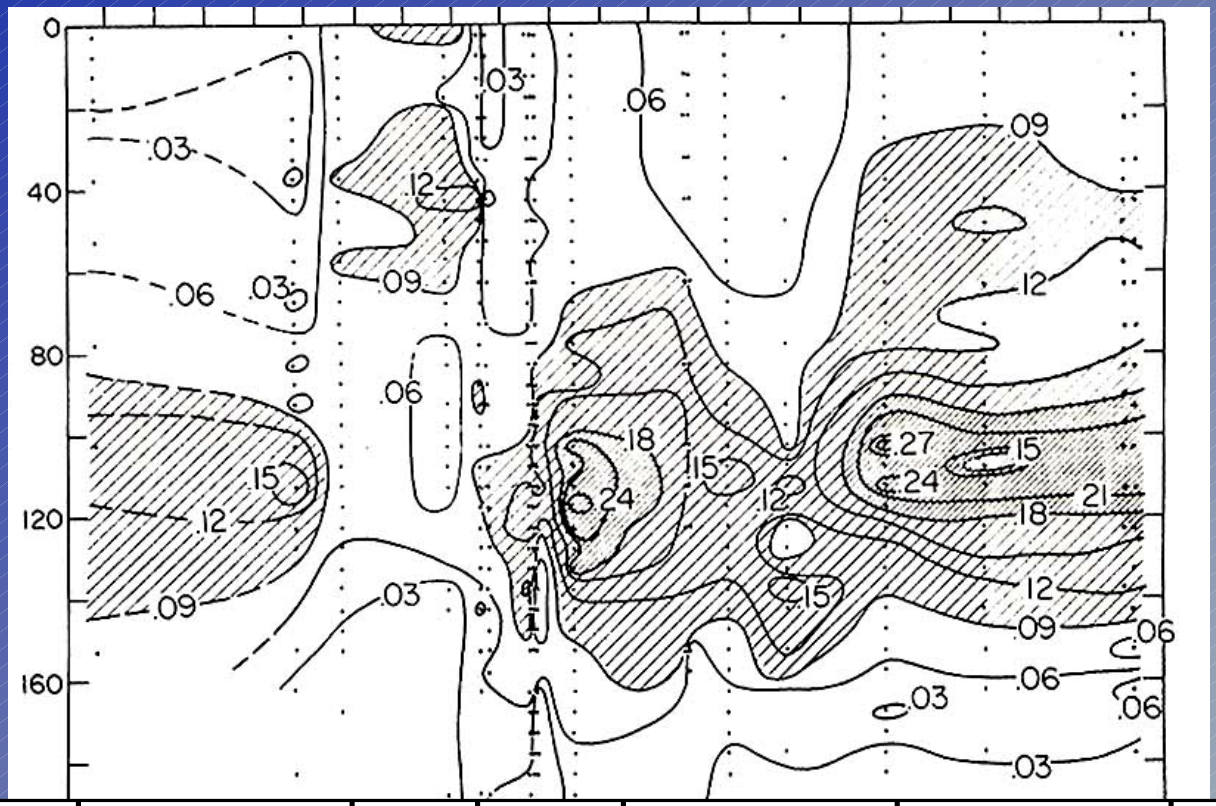
Ocean Temperature Changes

- **Bering Sea**
  - cooling begins in 1979
  - cyclic warming in 1972
  - includes PDO signal
- **Gulf of Alaska**
  - warming begins in 1972
  - no clear change in 1976
  - reflects transport increase
- **California Current**
  - warming begins in 1972
  - accelerates in 1976
    greater signal in south
  - stratification may differ

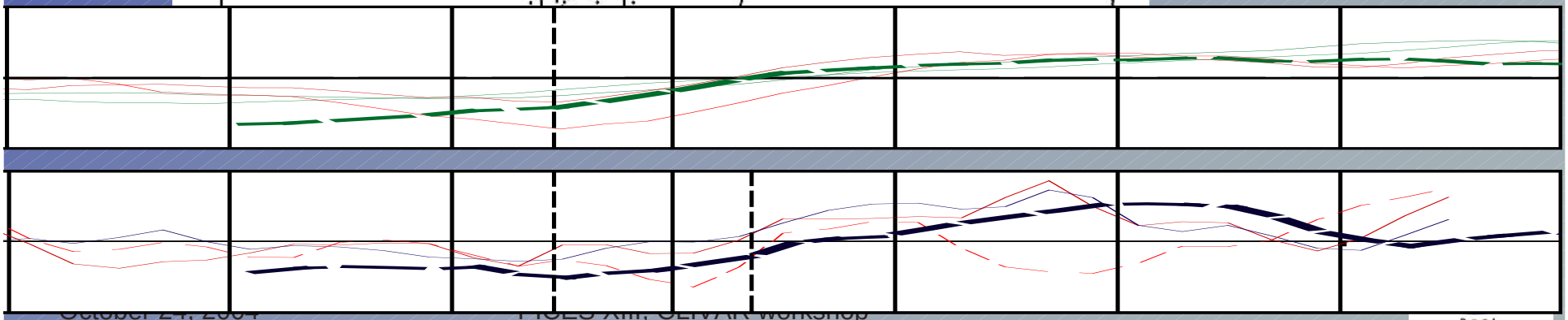


From Schwing et al, S1-2096

from Venrick et al. [1987]



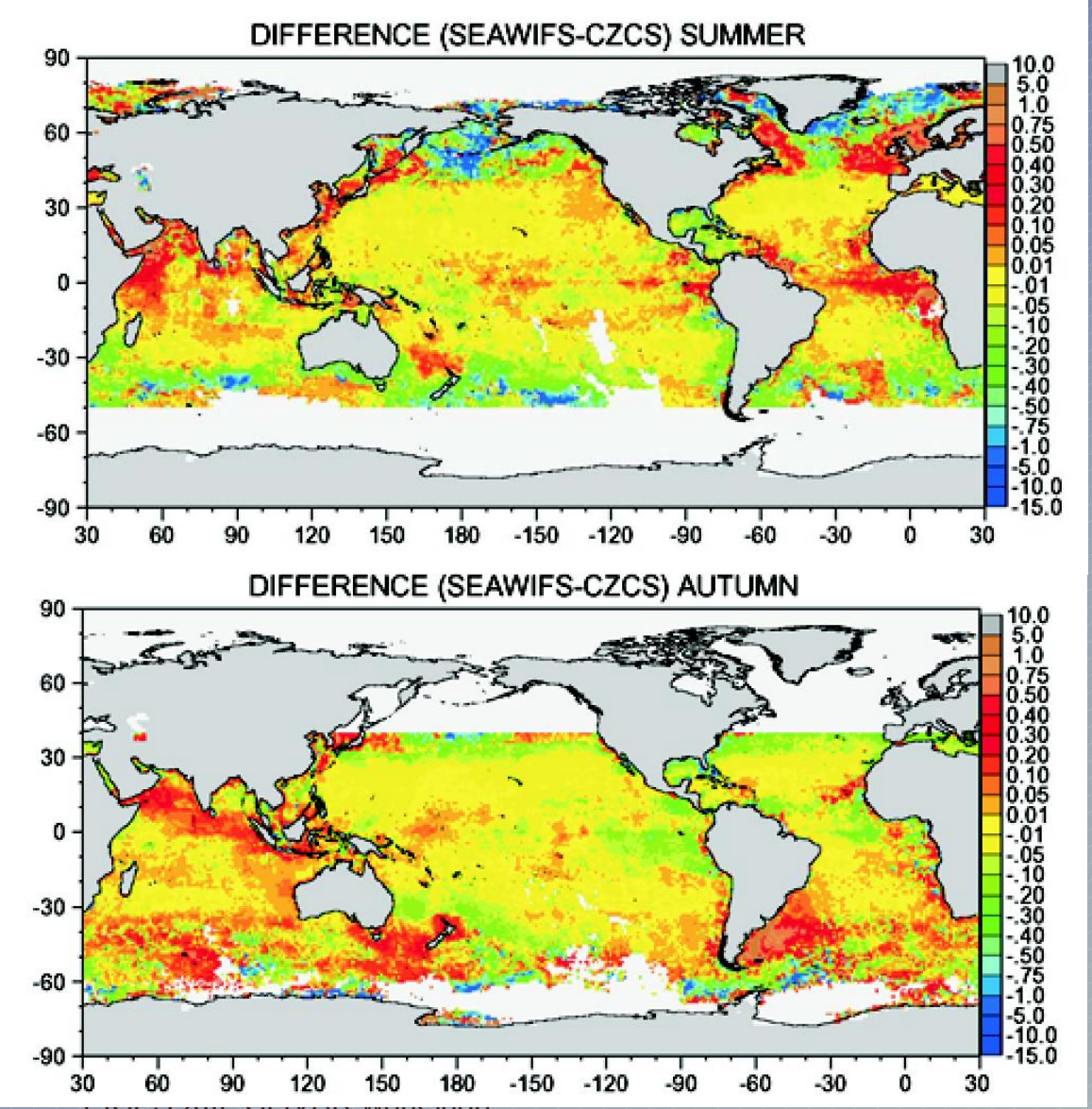
Temperature trends, from Schwing et al, S1-2096



from Gregg & Conkright [2002]

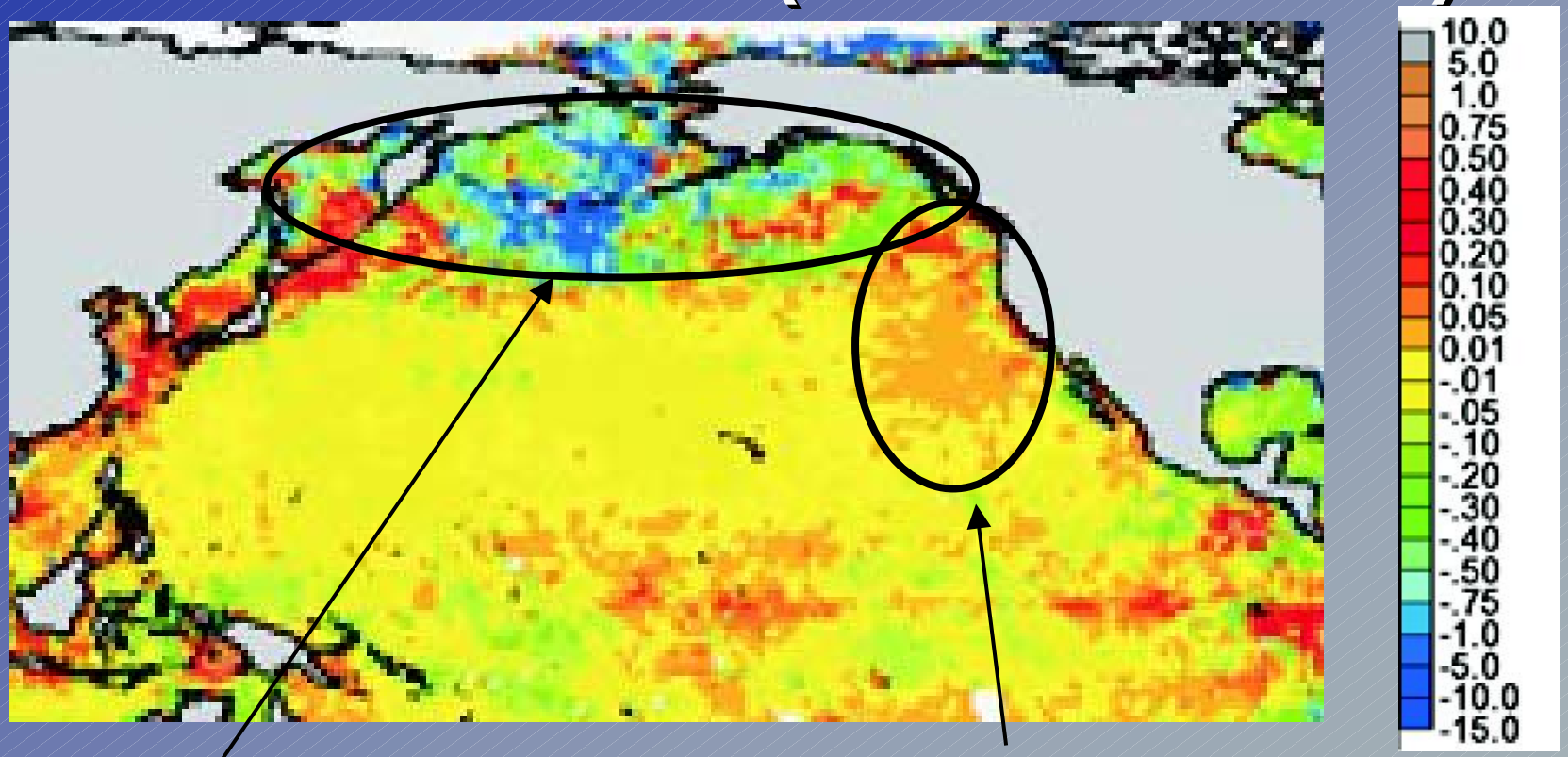
Summer Difference

Autumn Difference



from Gregg & Conkright [2002]

Summer Difference (SeaWiFS - CZCS)



Decrease in Bering Sea

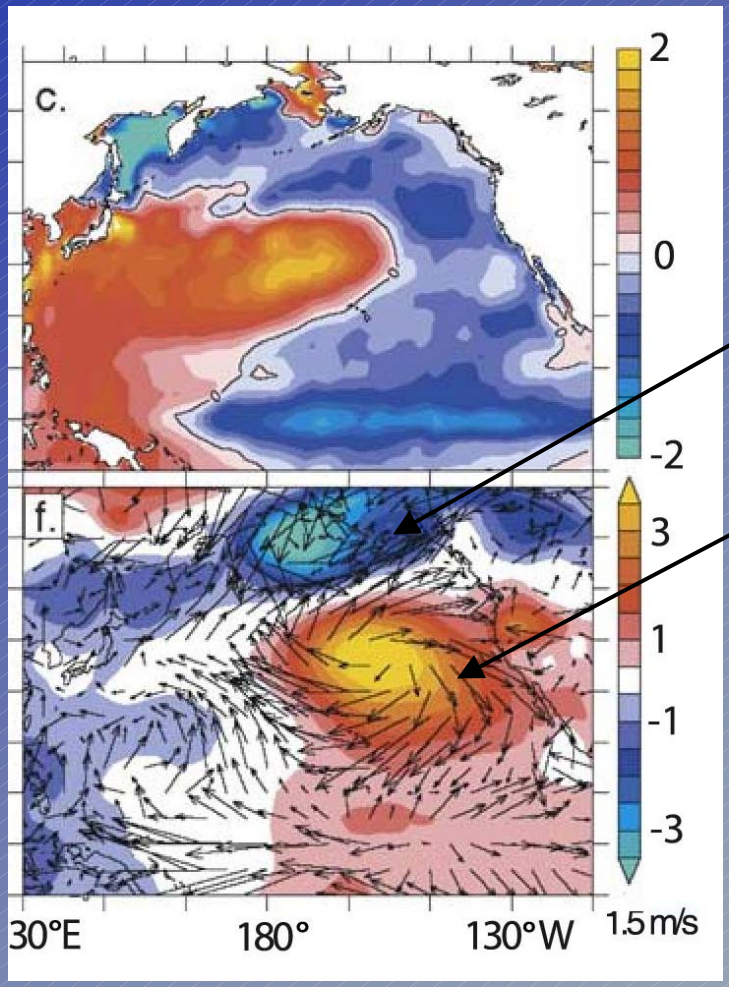
Increase off the west coast

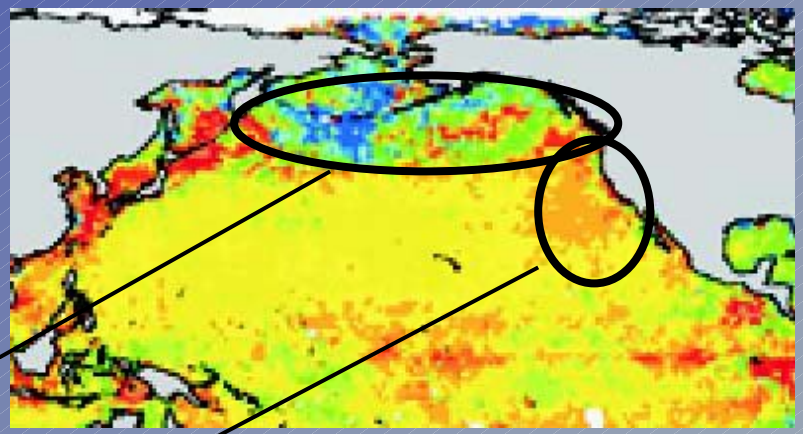
Decadal Differences

1999-2003

SST

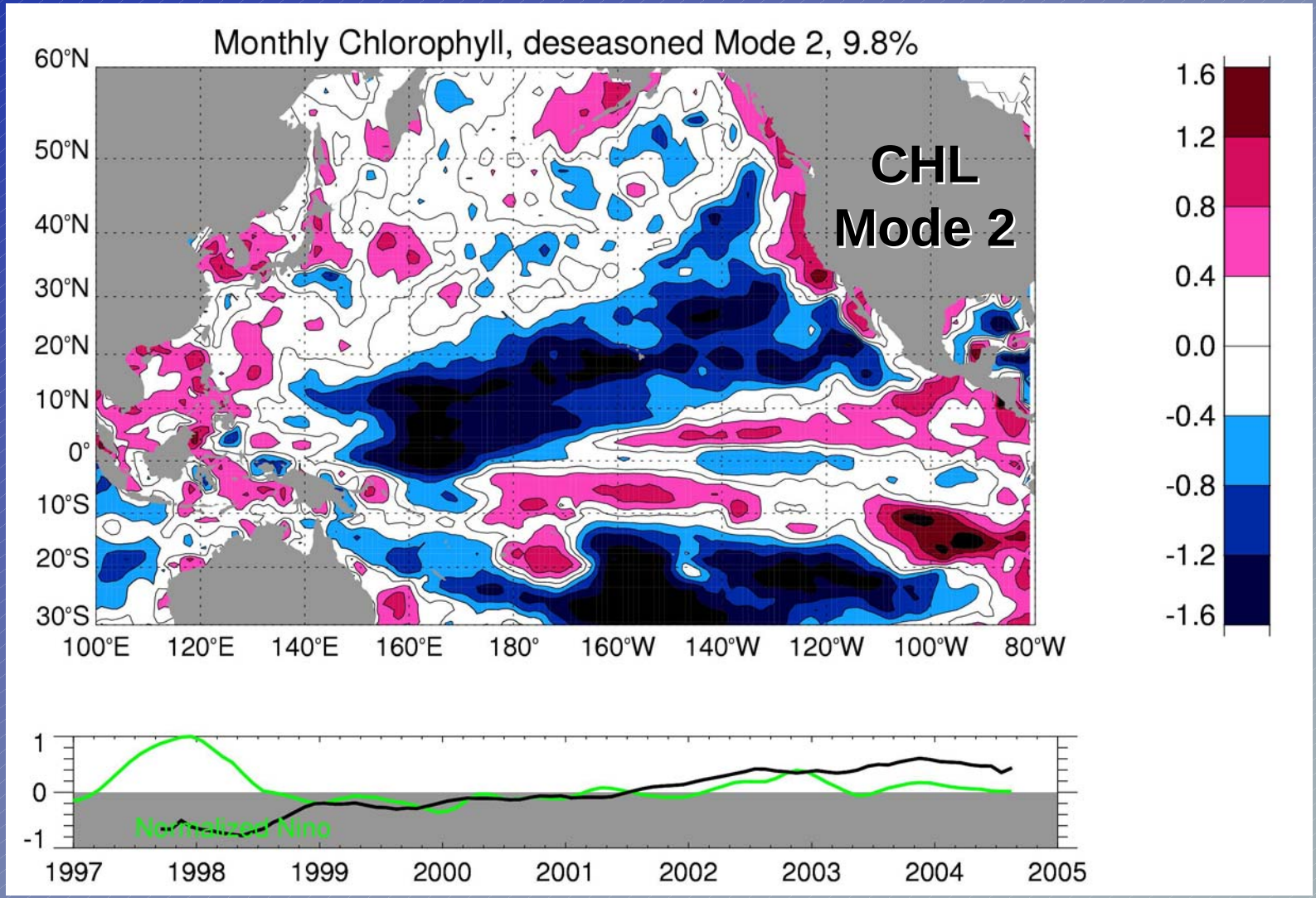
SLP





Chlorophyll
(1997/2004) - (1979/86)

Chlorophyll Variability - Long-term trend



Conclusions – specific

- **Overall El Niño related chlorophyll decreases are coupled with increases in SSH and SST, the off-equatorial and is tied to SSH (thermocline) changes.**
- **However, unlike SSH and SST, the timing of El Niño related chlorophyll changes are significantly different along the equator and in off-equatorial regions.**
- **The annual southern position of the TZCF is tied to decadal climate variability such as the PDO and the Victoria Pattern.**

Conclusions – general

- **Important to understand underlying bio-physical relationships before attempting to make sense of interannual (and longer) changes in biophysical coupling.**
- **Significant regional differences in the fundamental bio-physical dynamics.**
- **Basin-scale patterns show clear regional scale differences – emphasizing need for analyses on a spectrum of different scales.**


Thanks!