- A review-

The Effects of Anthropogenic Global Warming on the Marine Ecosystem

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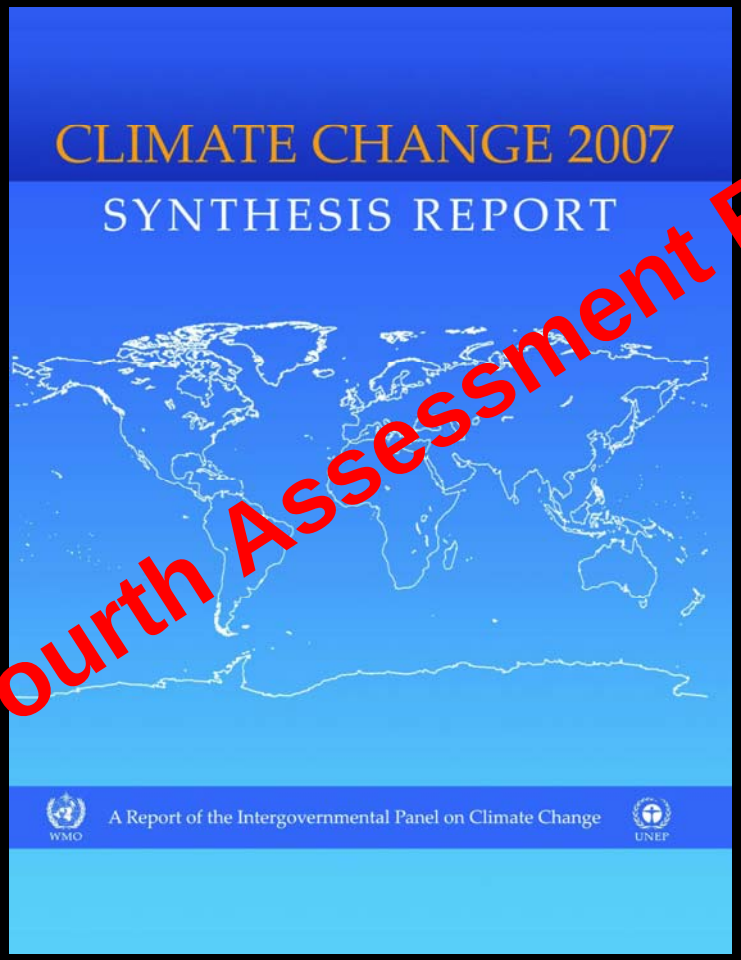
*Tohoku National Fisheries Research Institute



IPCC Fourth Assessment Report

Motivation

Schematic of the observed change in Ocean state.

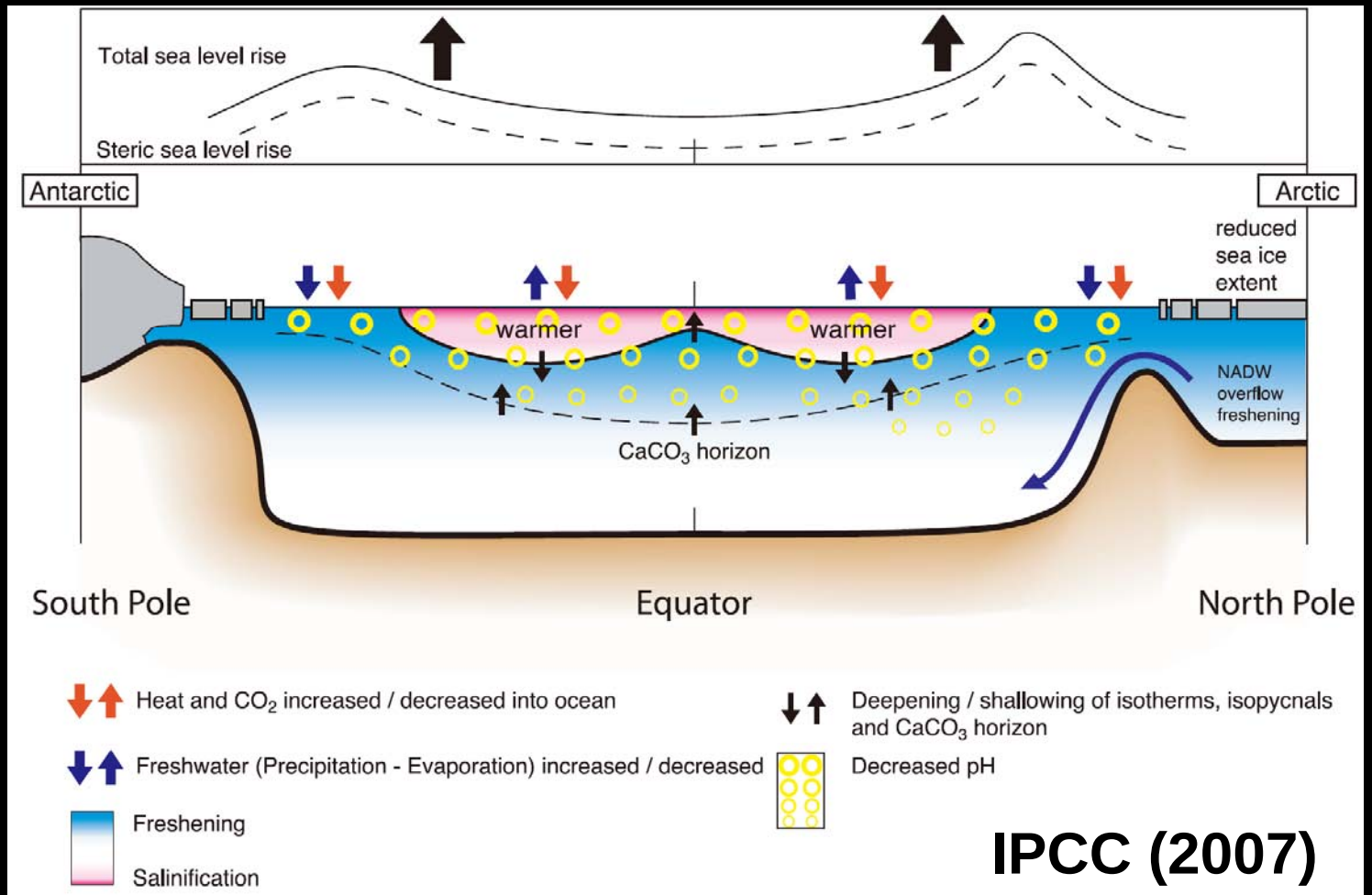
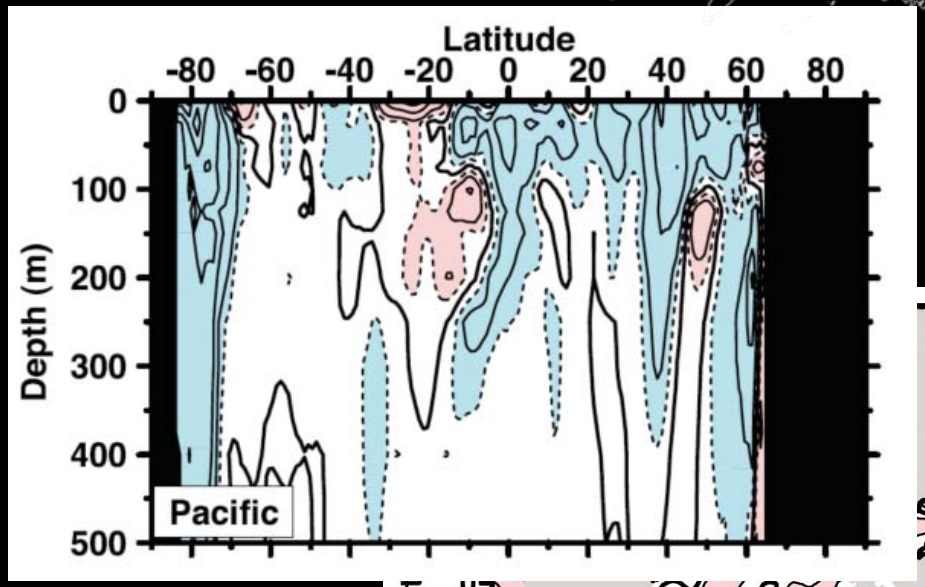


Figure 5.23. *Schematic of the observed changes in the ocean state, including ocean temperature, ocean salinity, sea level, sea ice and biogeochemical cycles. The legend identifies the direction of the changes in these variables.*

Contents

North Pacific

Salinity change



Temperature change (1955-2003)

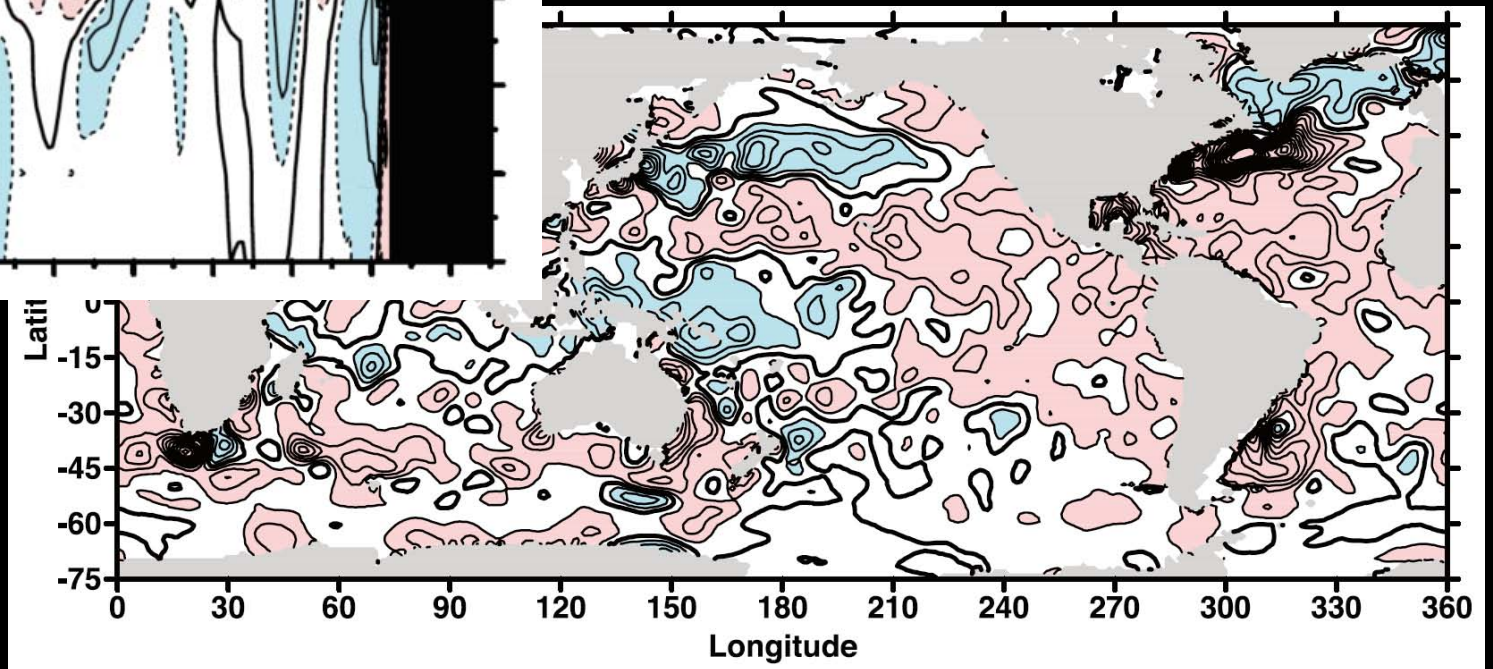
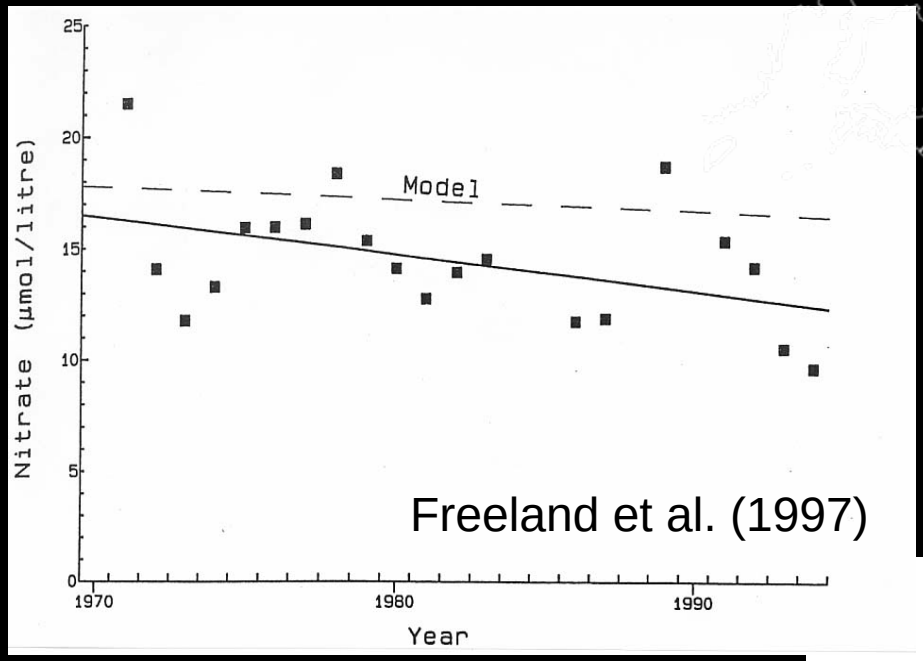


Figure 5.2. *Linear trends (1955–2003) of change in ocean heat content per unit surface area (W m^{-2}) for the 0 to 700 m layer, based on the work of Levitus et al. (2005a). The linear trend is computed at each grid point using a least squares fit to the time series at each grid point. The contour interval is 0.25 W m^{-2}. Red shading indicates values equal to or greater than 0.25 W m^{-2} and blue shading indicates values equal to or less than –0.25 W m^{-2}.*

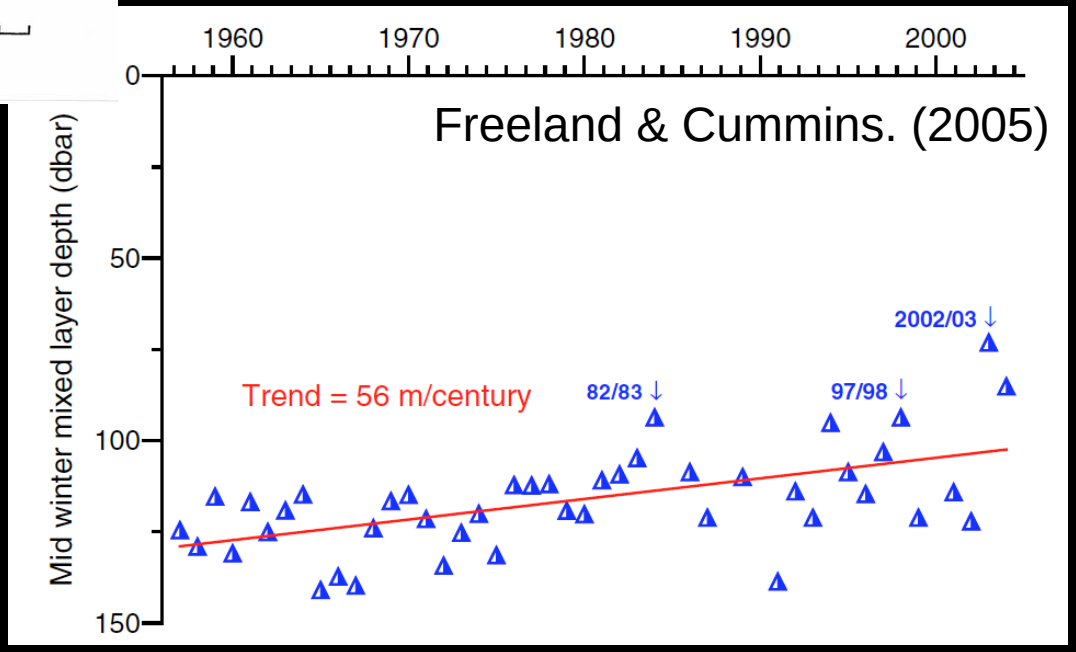
IPCC (2007)

North Pacific



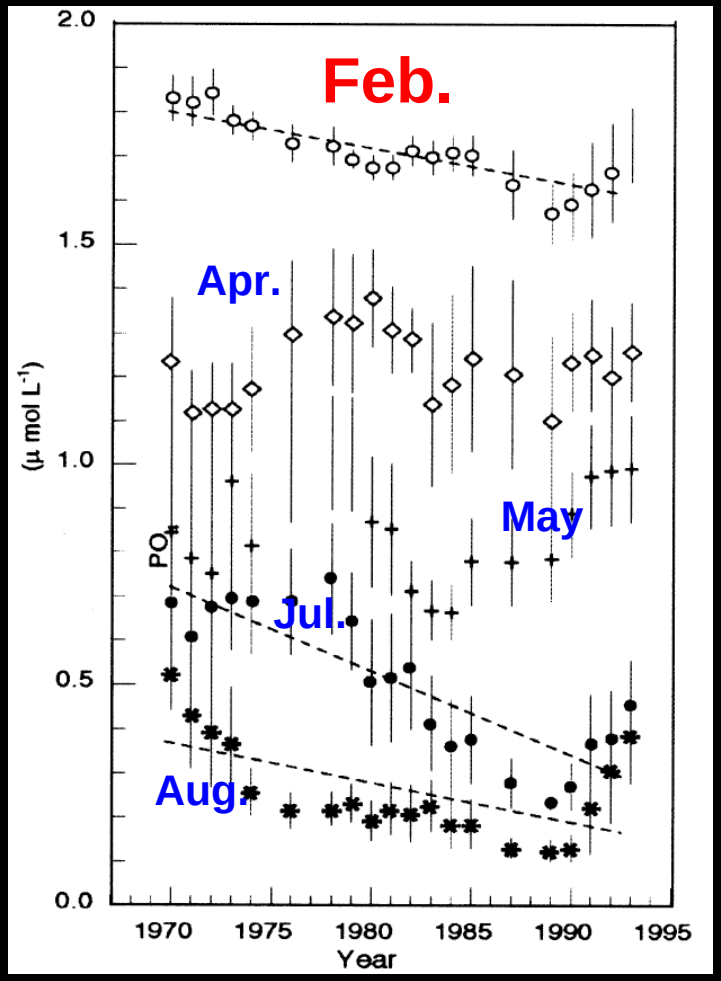
Winter NO_3 in surface layer

The max. MLD in the winter

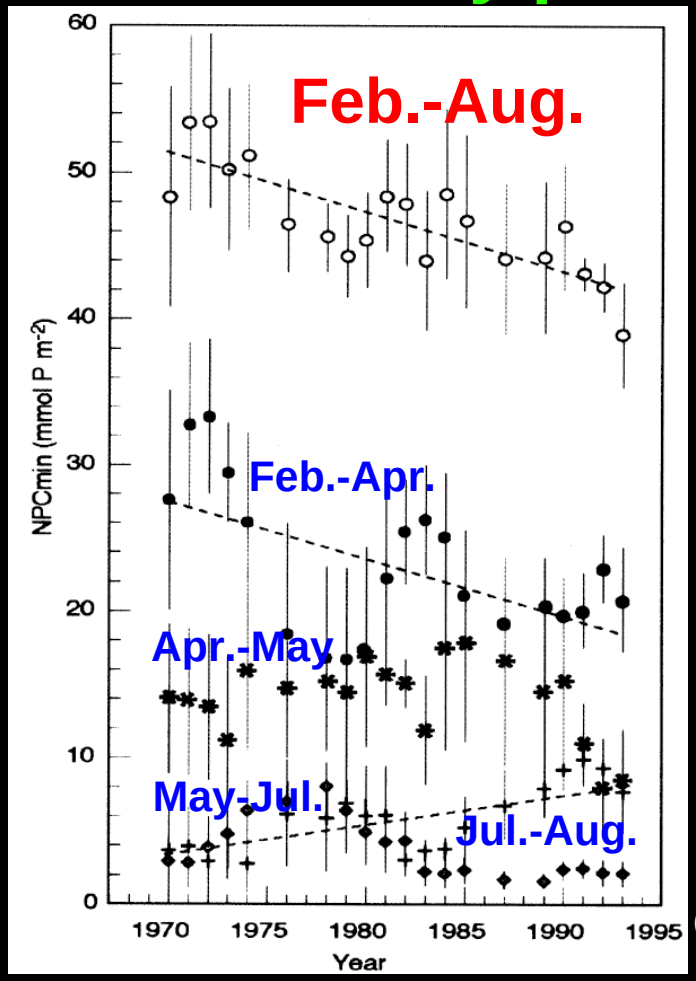


North Pacific

PO_4



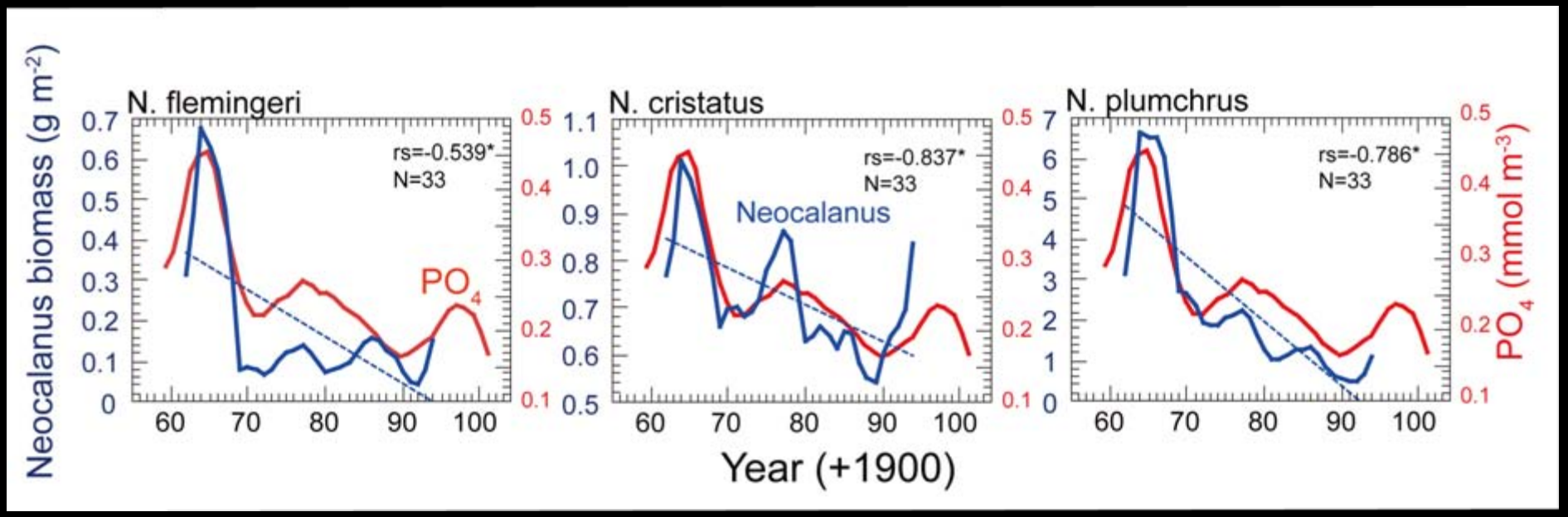
Net community production



Ono et al. (2002)

North Pacific

PO_4 concentration & *Neocalanus* biomass

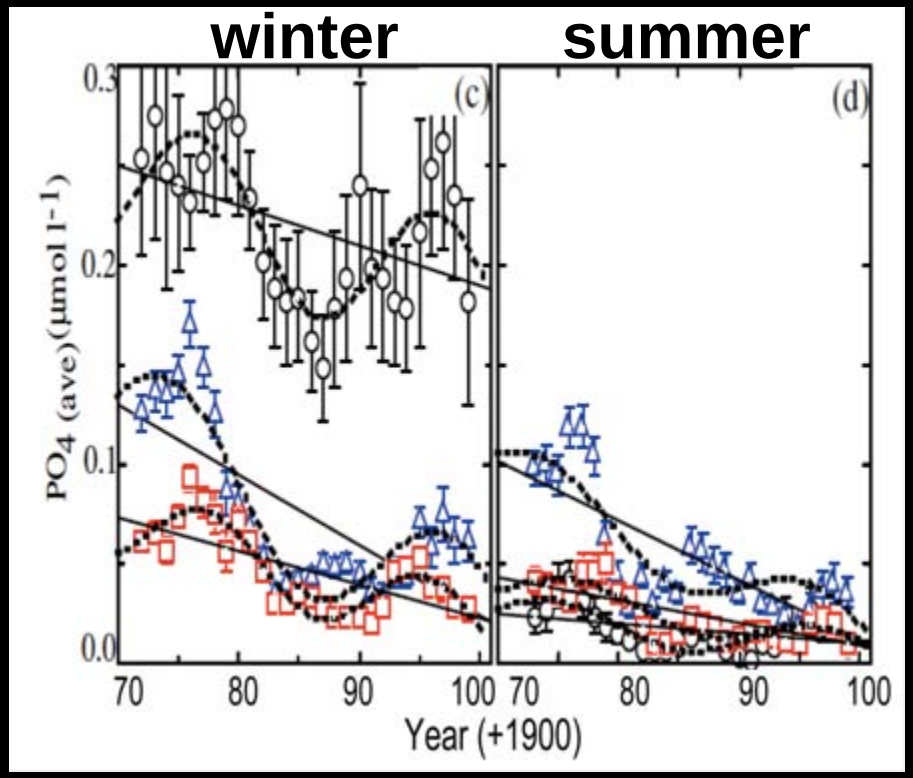


Tadokoro et al. (submitted)

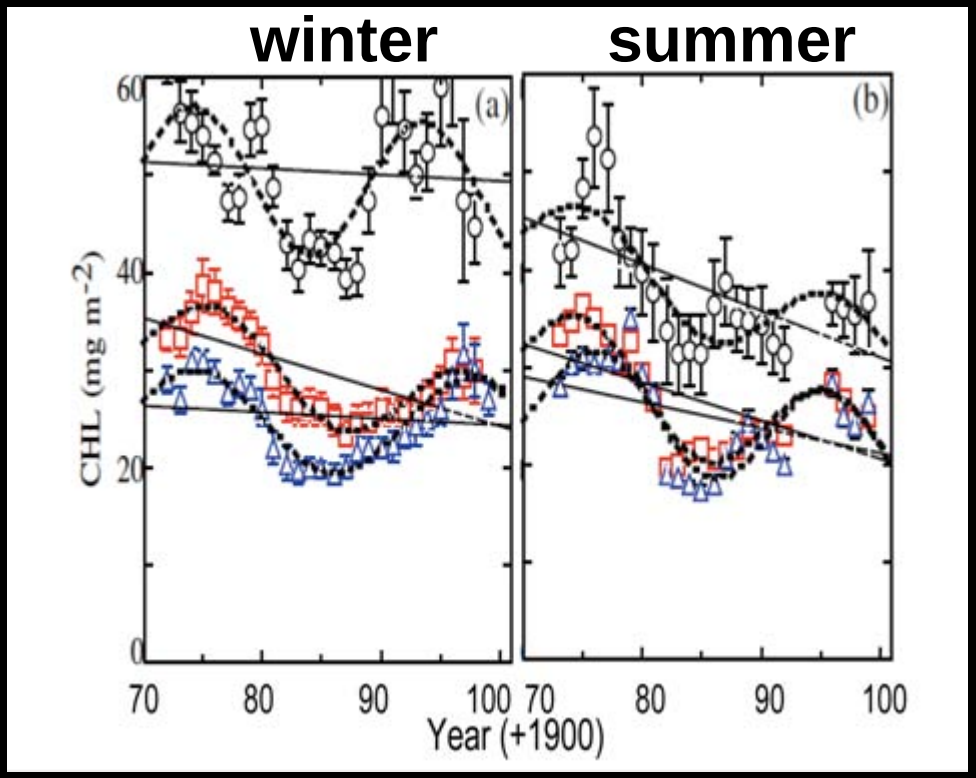
North Pacific

Subtropical

PO_4



Chl-a

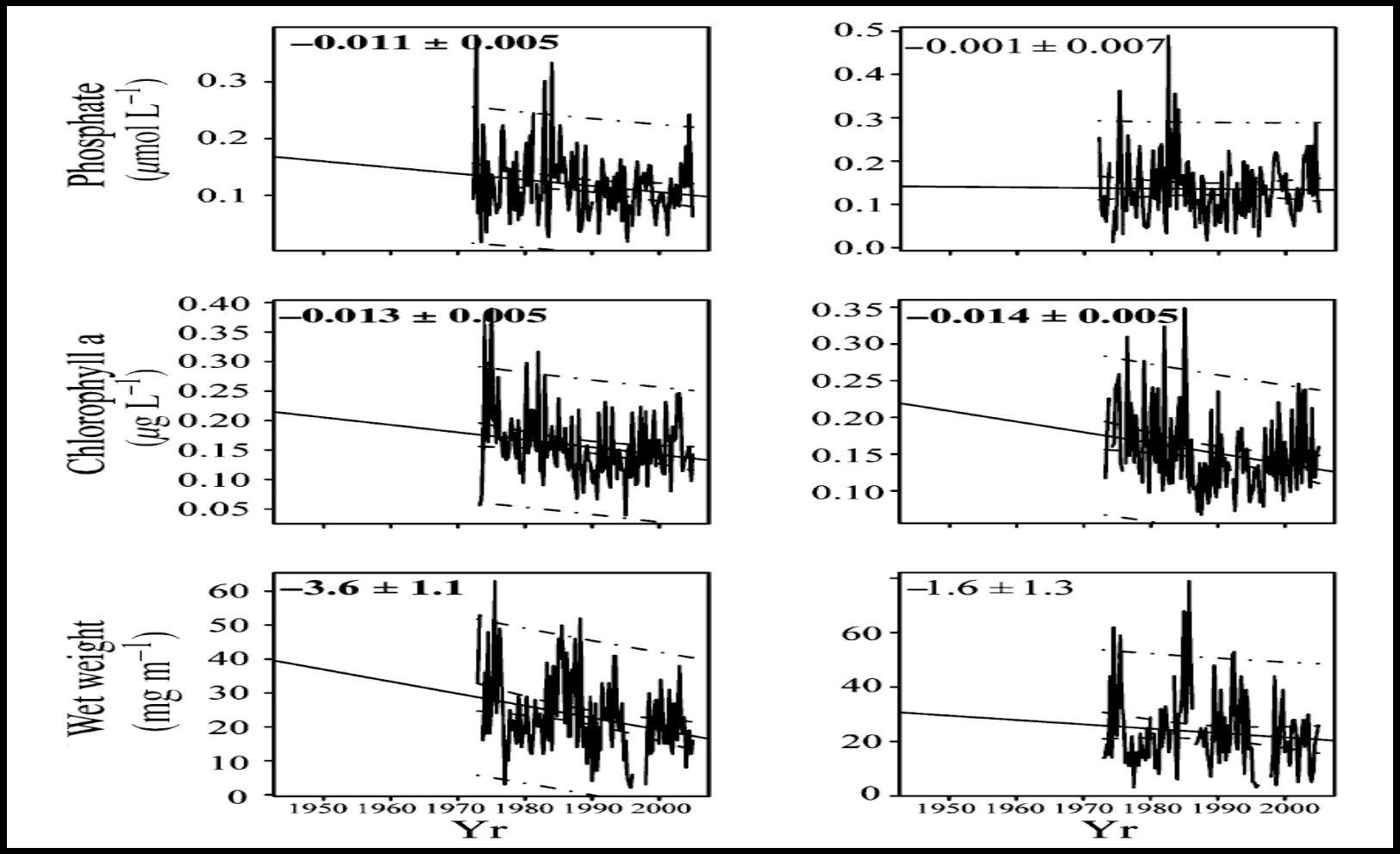


Watanabe et al. (2005)

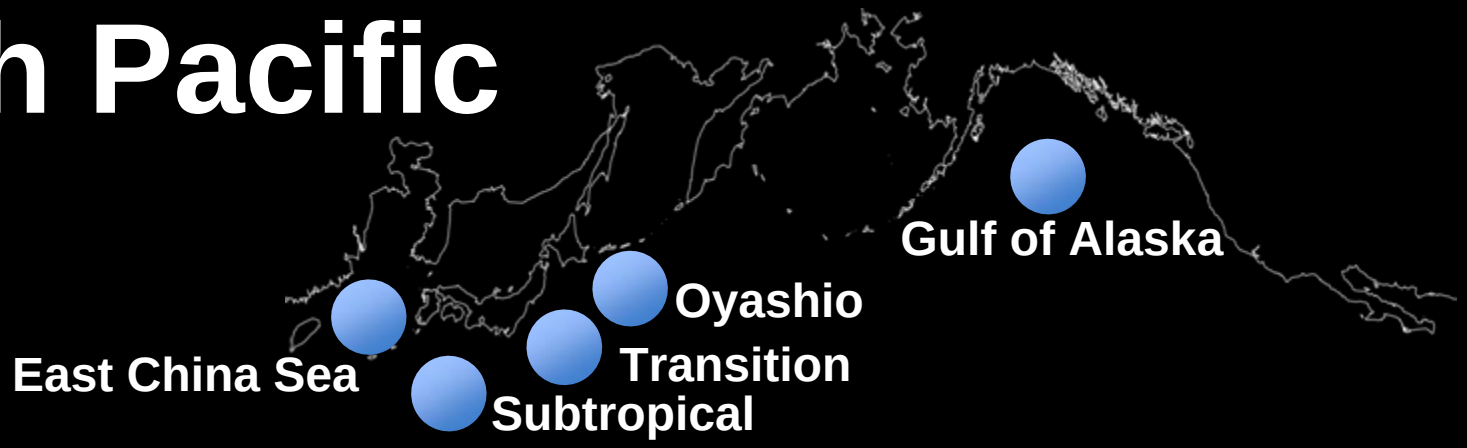
North Pacific

East China Sea

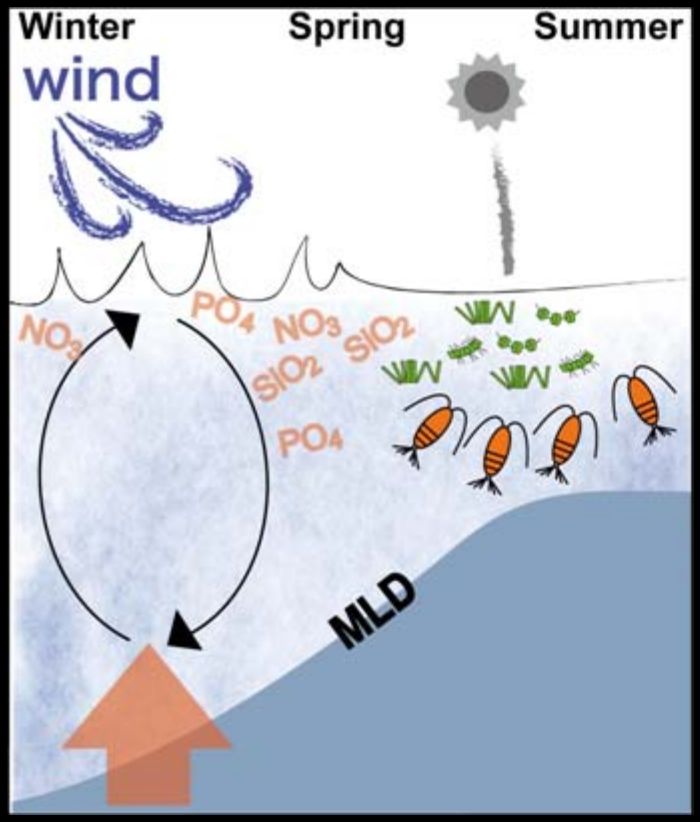
Aoyama et al. (2008)



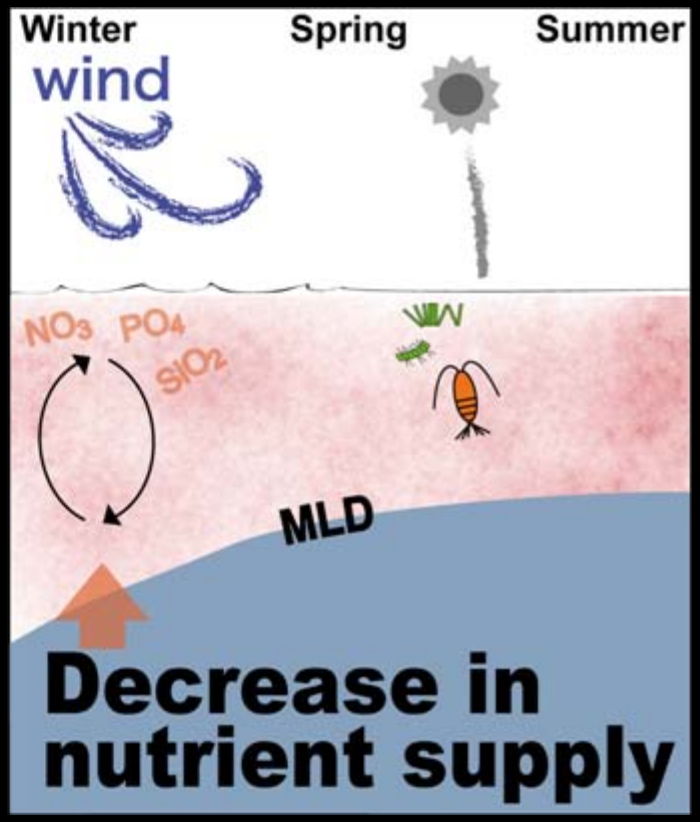
North Pacific



Process of ecosystem change

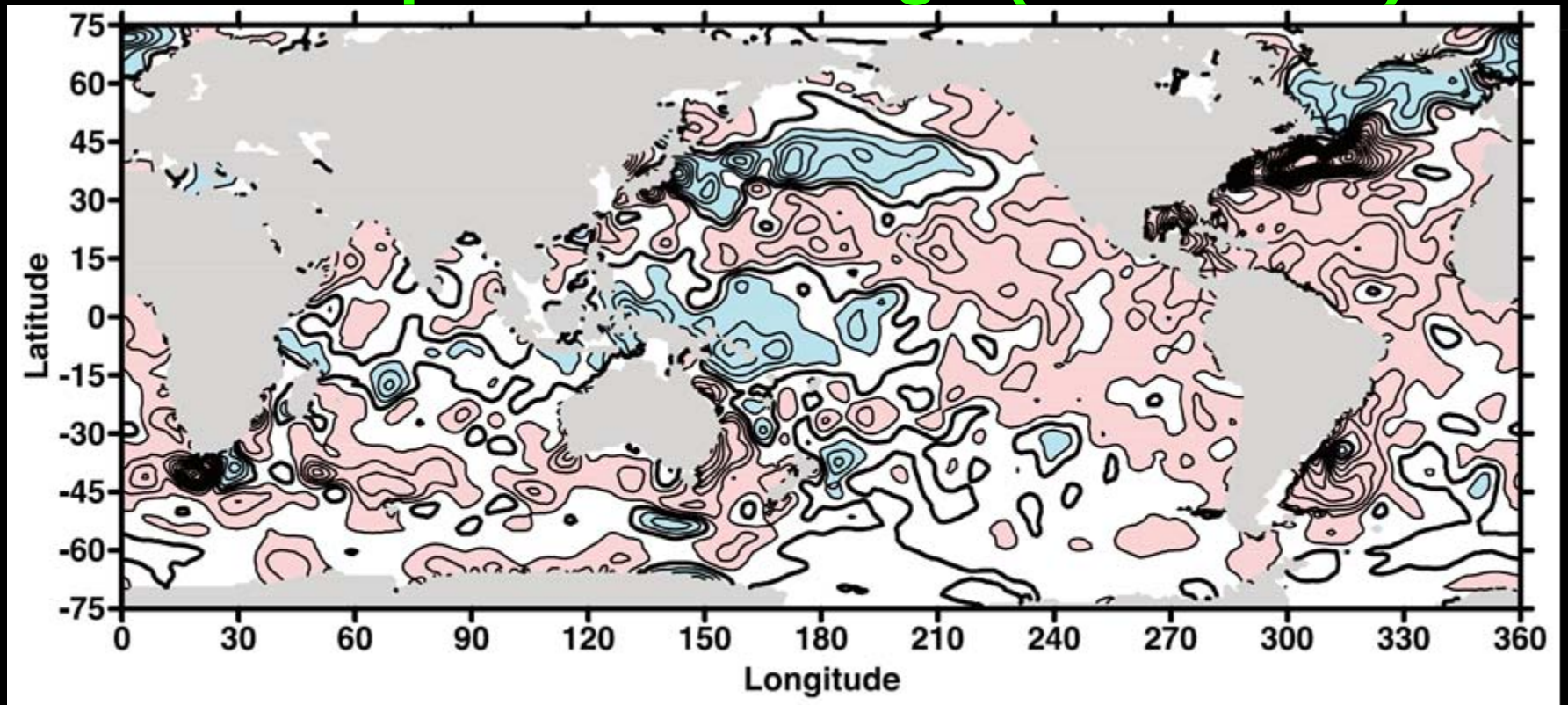


Sal. decrease
Temp. increase



North Atlantic

Temperature change (1955-2003)



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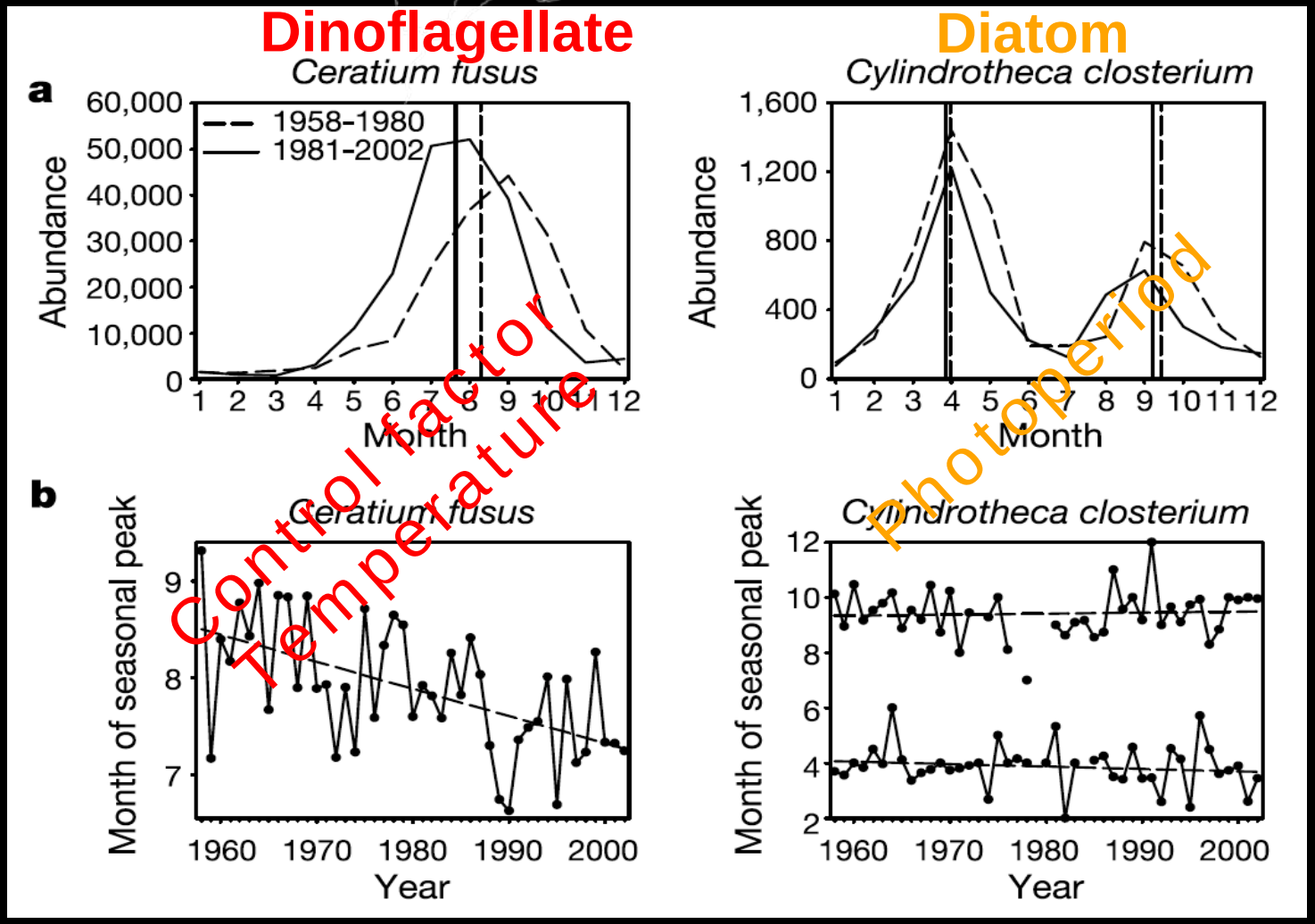
North Atlantic

Phenological change



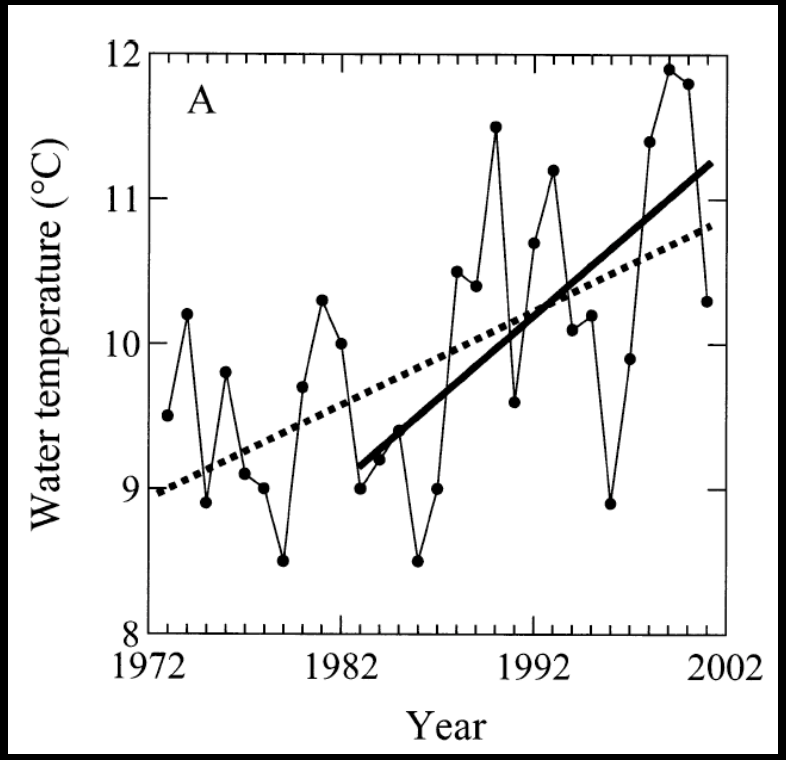
Edward & Richardson (2003)

North Atlantic

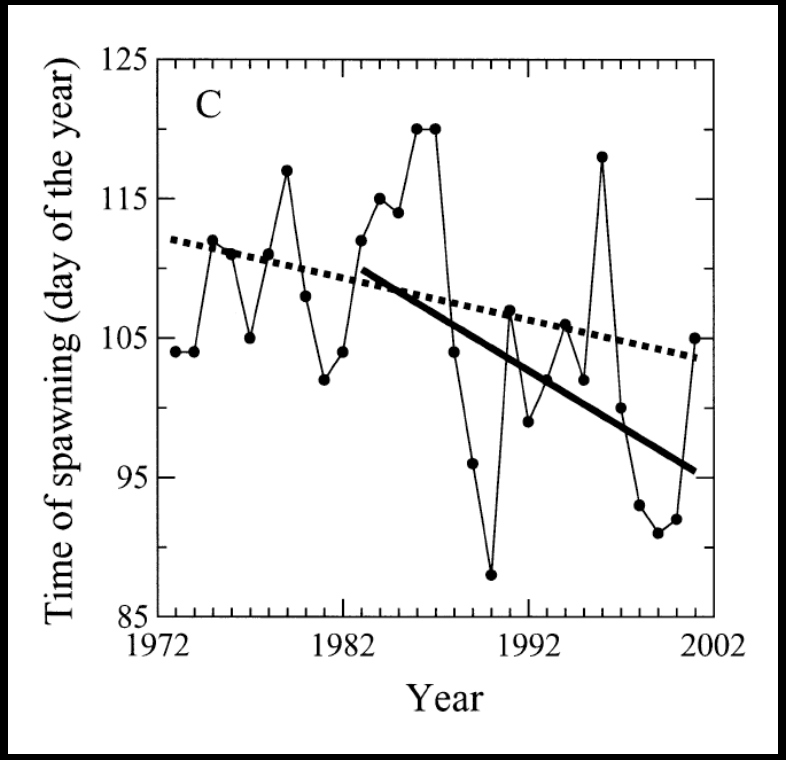
Clam
Macoma balthica

Phenological change

Temperature



Time of spawning



Philippart et al., (2003)

North Atlantic

Distribution change

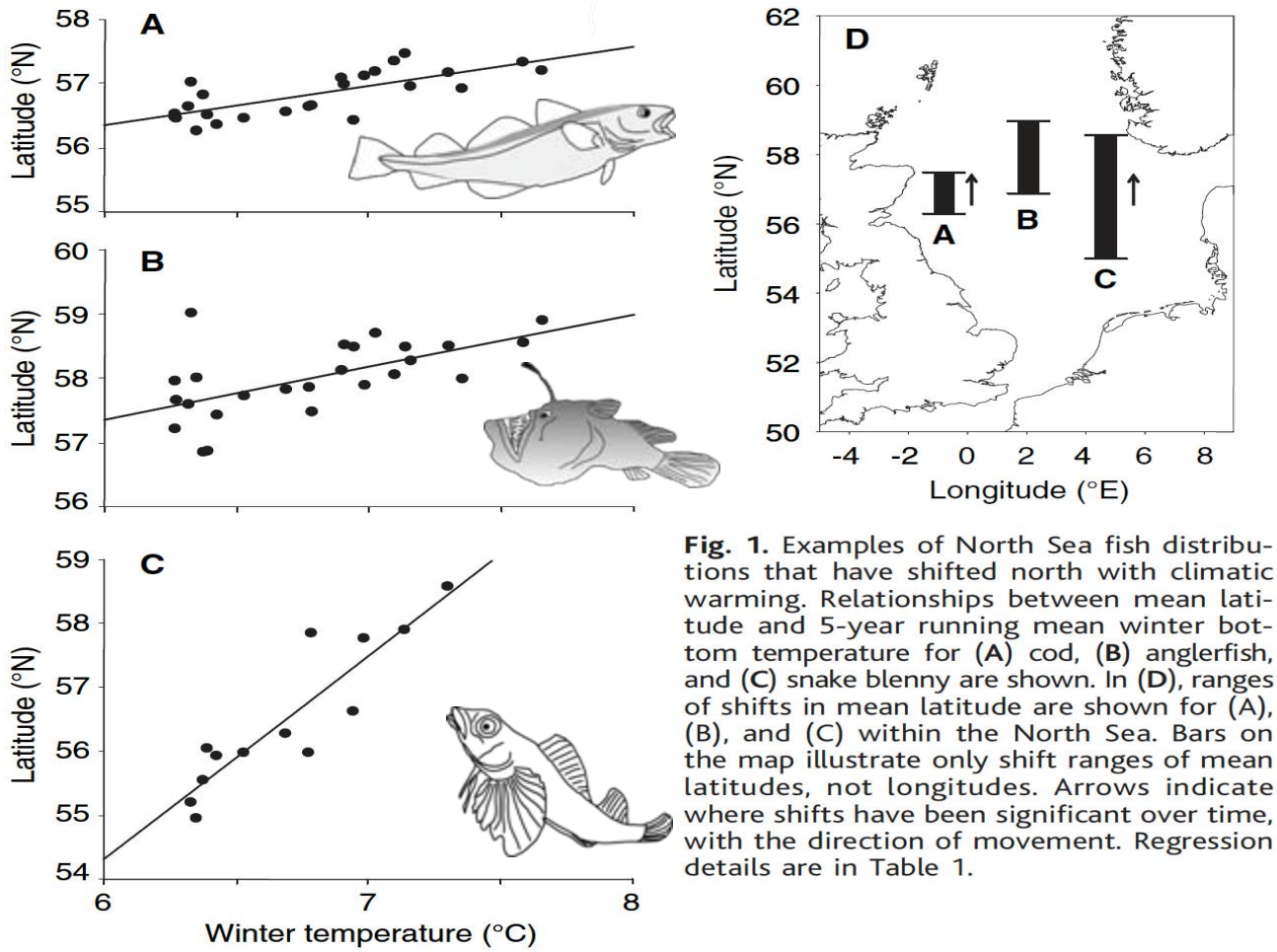


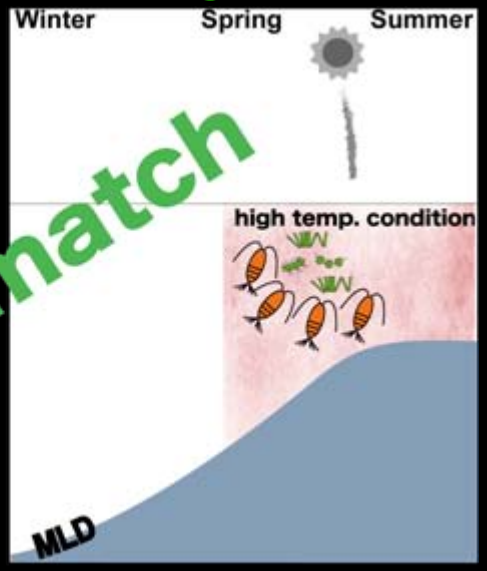
Fig. 1. Examples of North Sea fish distributions that have shifted north with climatic warming. Relationships between mean latitude and 5-year running mean winter bottom temperature for (**A**) cod, (**B**) anglerfish, and (**C**) snake blenny are shown. In (**D**), ranges of shifts in mean latitude are shown for (A), (B), and (C) within the North Sea. Bars on the map illustrate only shift ranges of mean latitudes, not longitudes. Arrows indicate where shifts have been significant over time, with the direction of movement. Regression details are in Table 1.

Perry et al., (2005)

North Atlantic

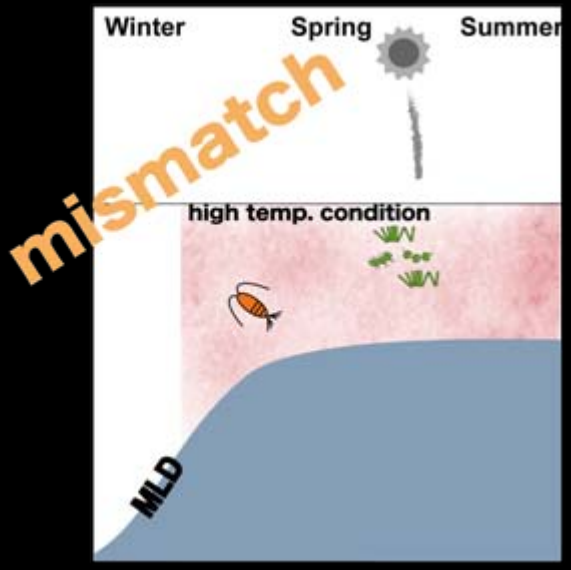
Distribution change

Phenological change

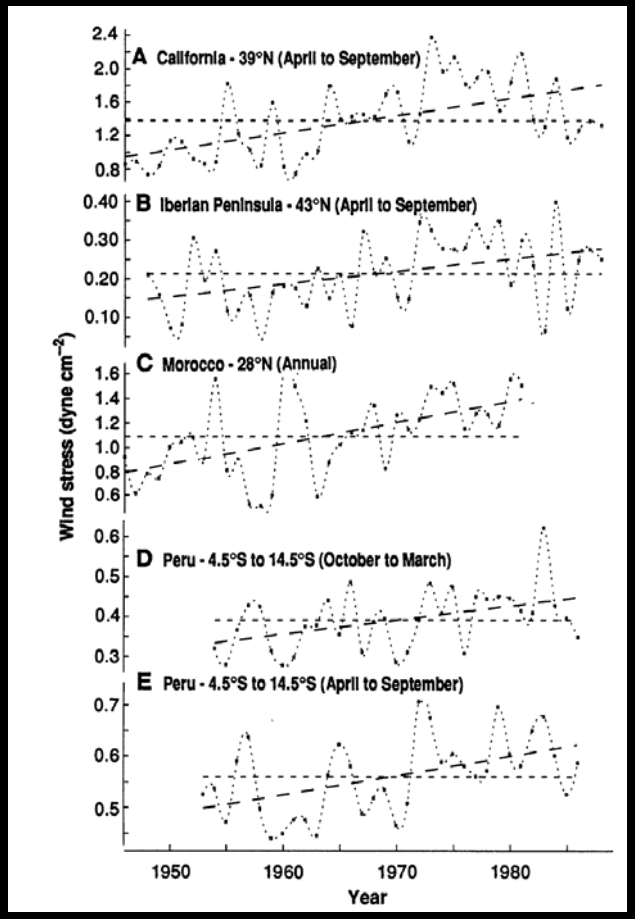


Cool Phase

Warm Phase

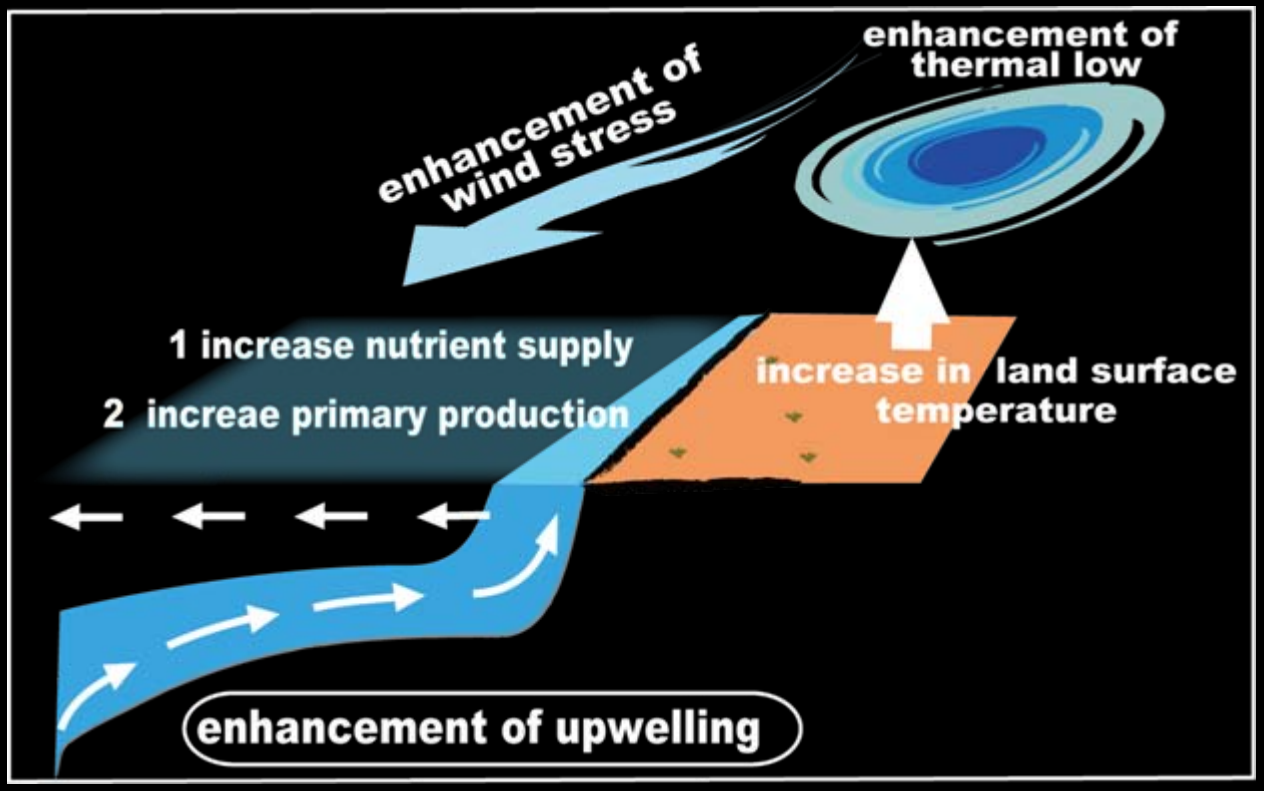


Coastal Upwelling



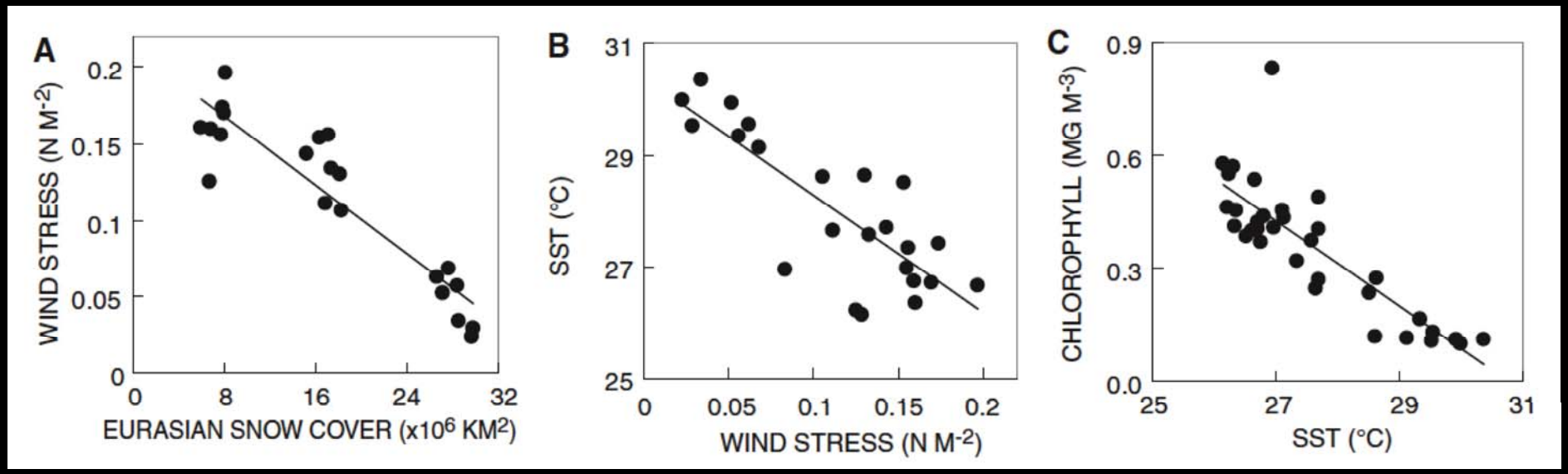
Bakun (1990)

Enhancement of upwelling



Coastal Upwelling

Monsoon current system



Goes et al., (2005)

Snow cover decrease

↓

Summer monsoon wind increased

↓

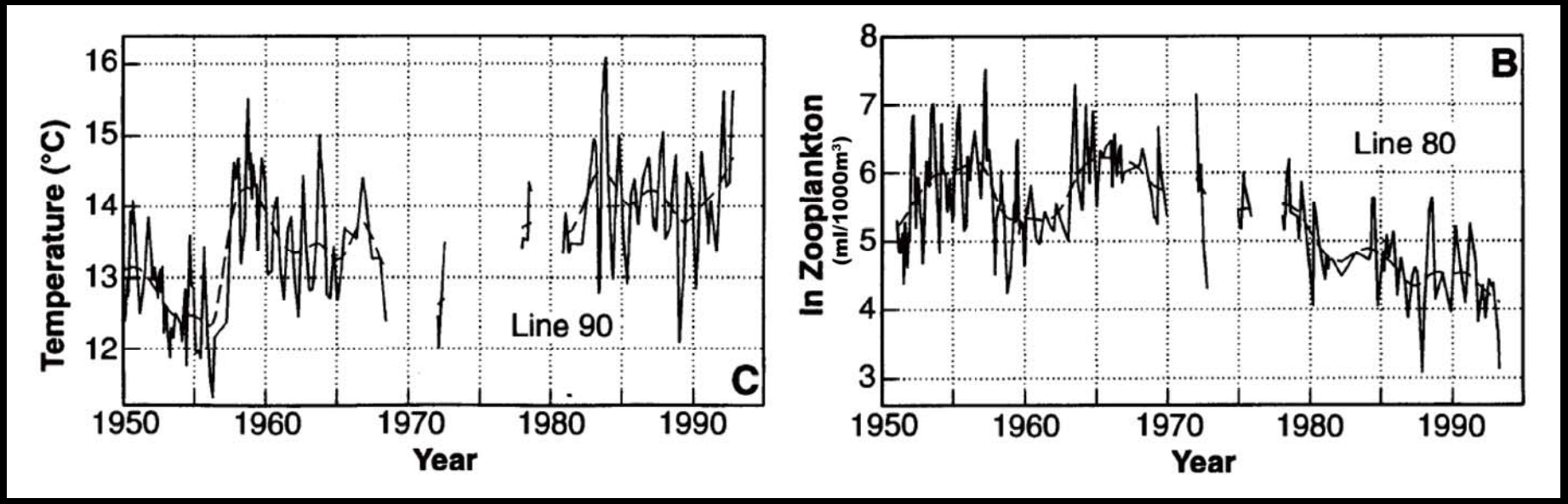
Coastal upwelling enhance

↓

Primary productivity increase

Coastal Upwelling

California current system

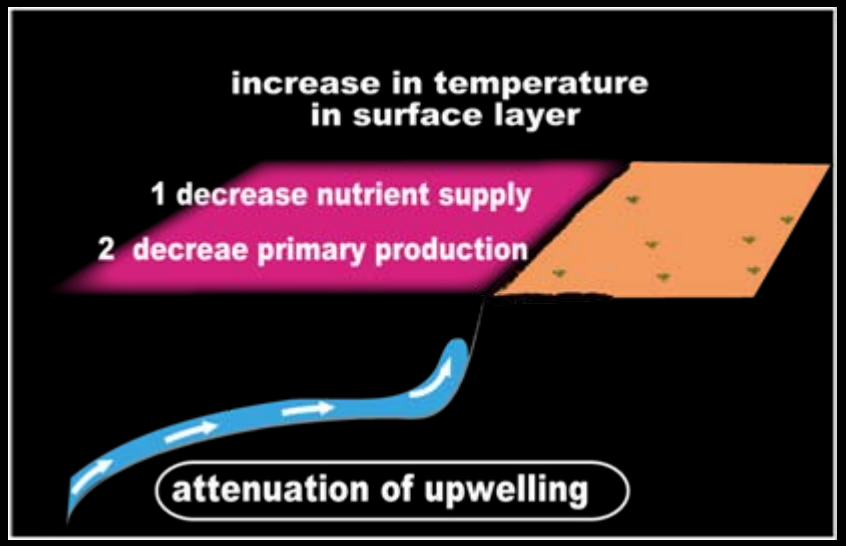


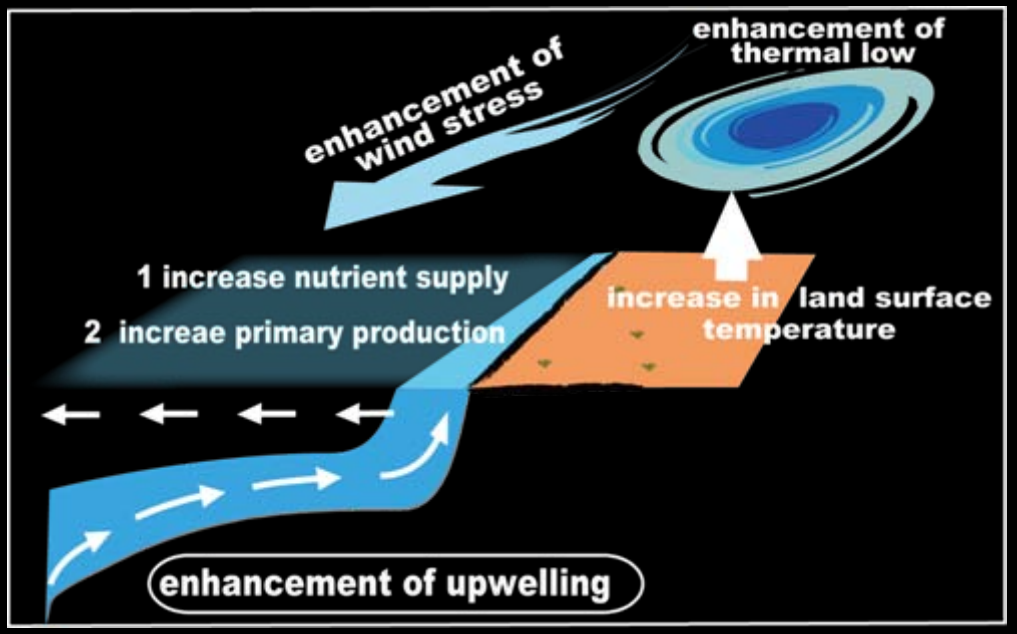
Roemmich & McGowan(1995)

Coastal Upwelling

Enhancement of upwelling

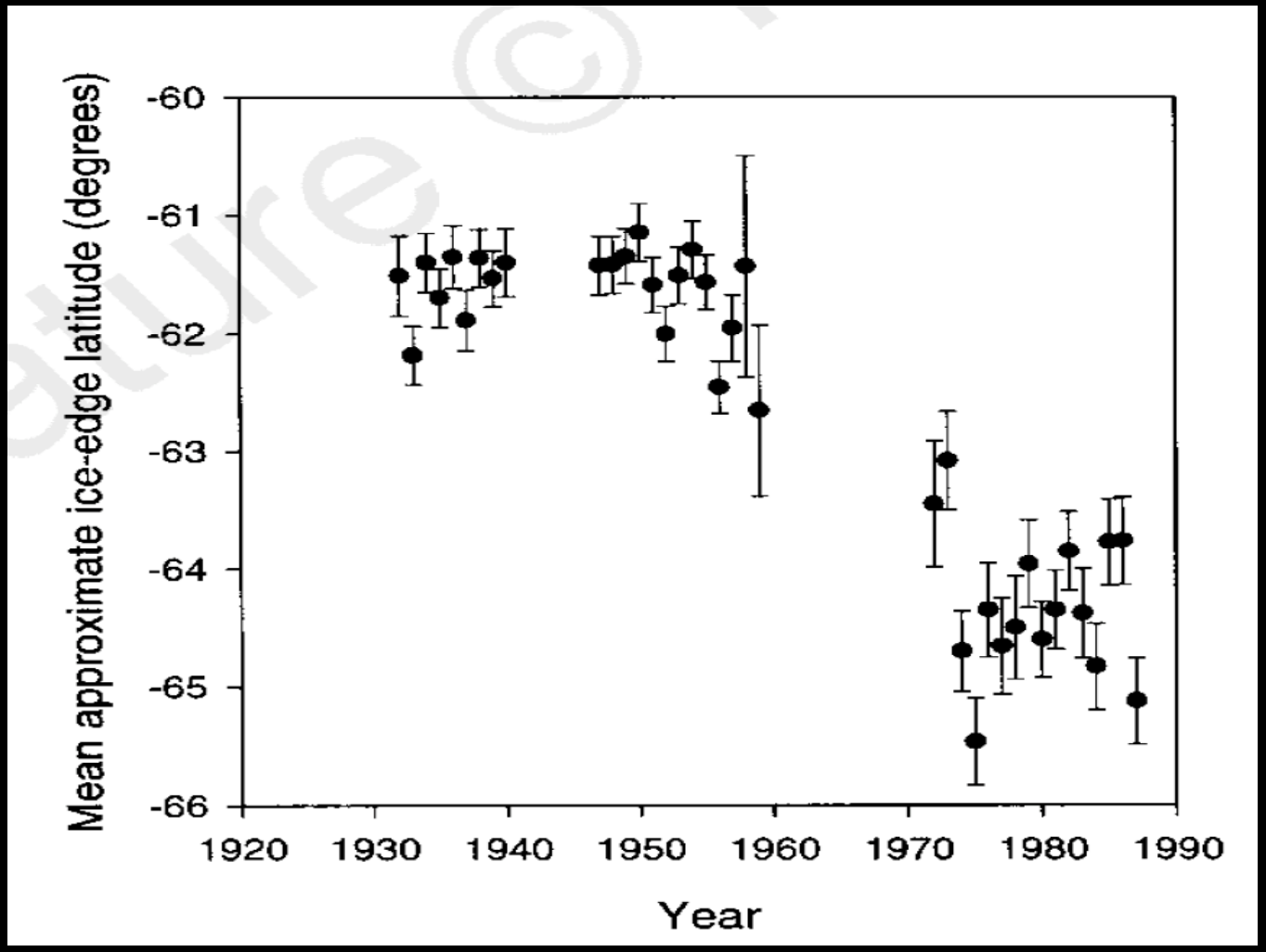
Attenuation of upwelling





Polar region

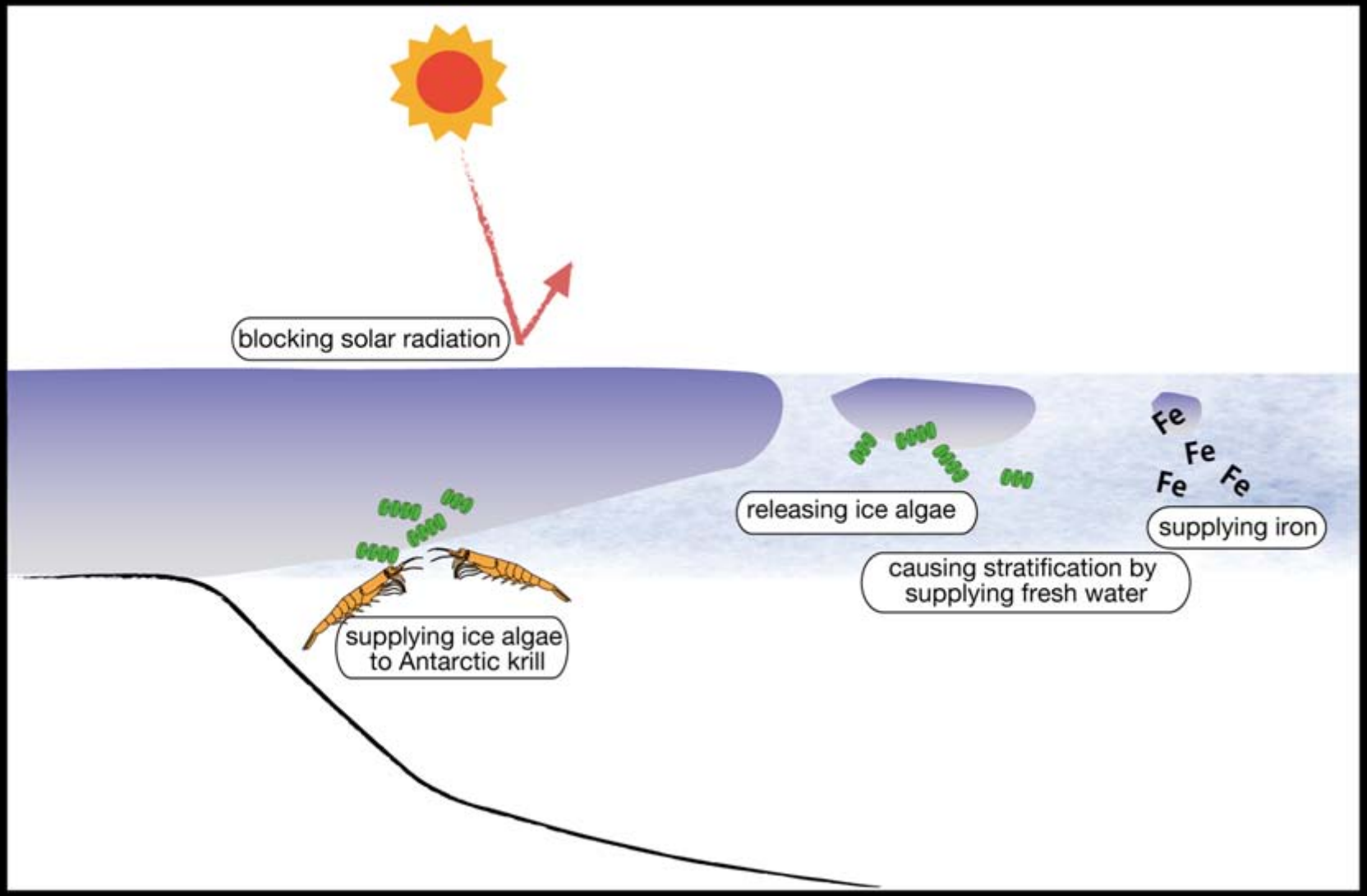
Decrease in sea ice in Antarctic



de la Mare (1997)

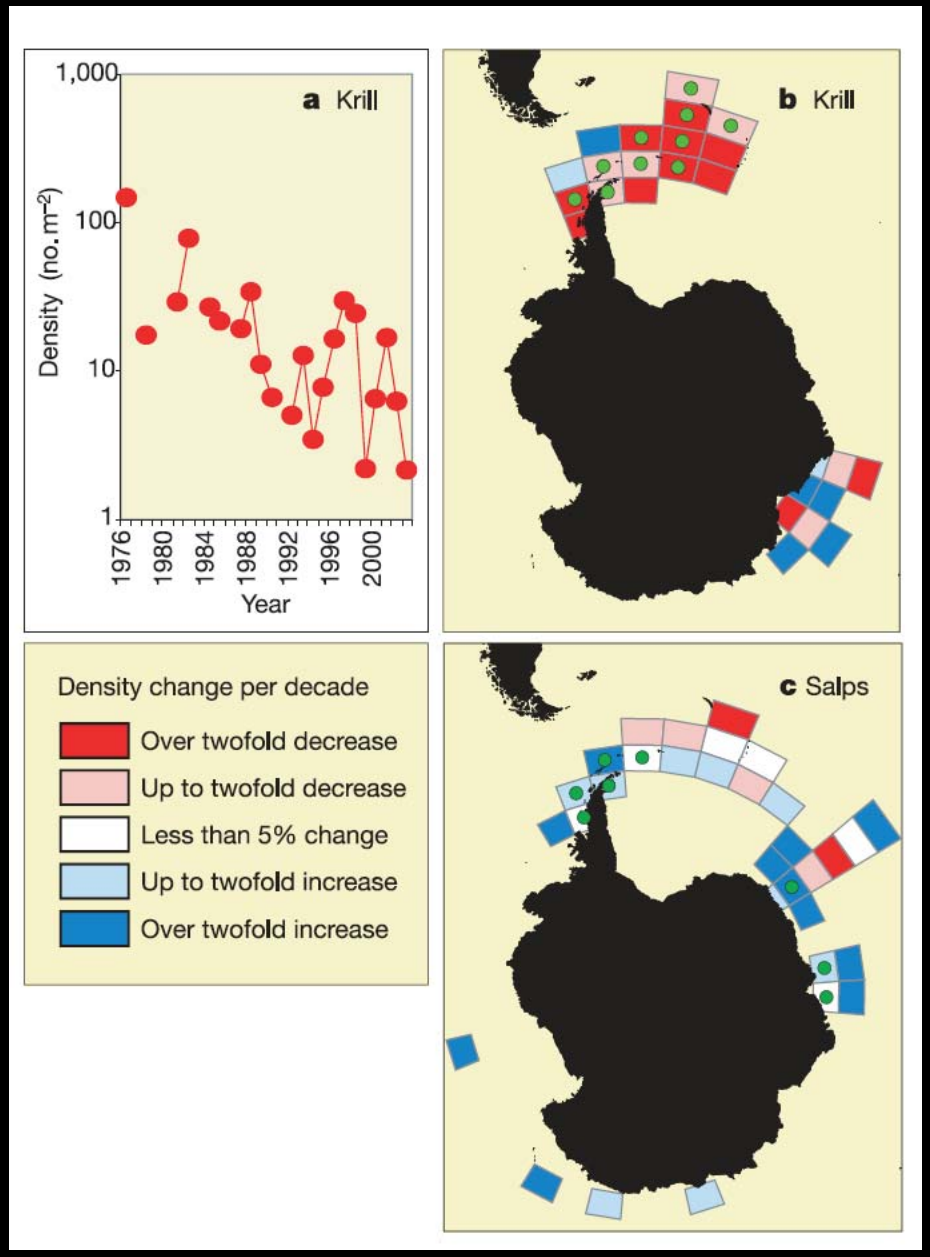
Polar region

Role of sea ice



Antarctic Krill decrease

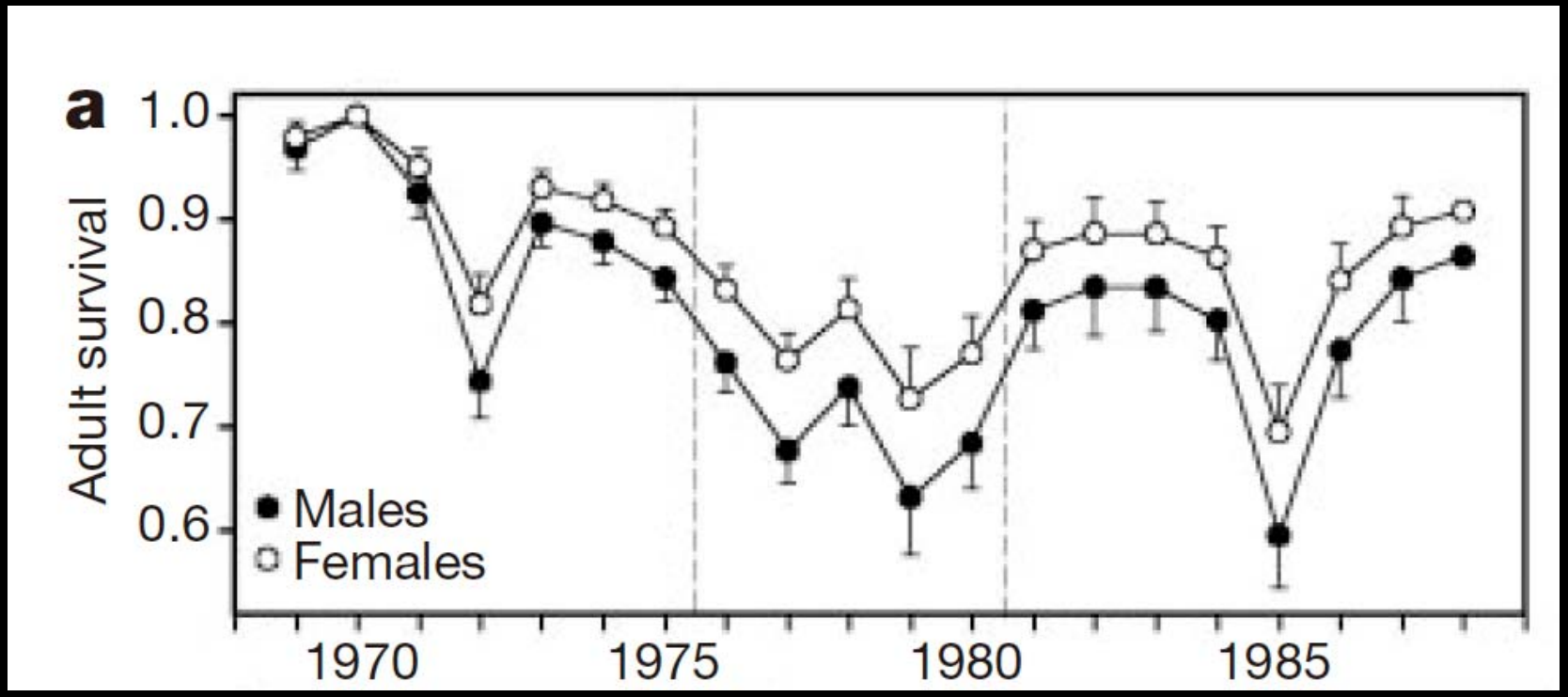
Polar region



Atkinson et al., (2004)

Polar region

Emperor penguin decrease



Barbraud & Weimerskirch (2001)

Acidification

Many experimental studies suggested that the acidification by increasing atmospheric CO_2 impact on calcareous organisms.

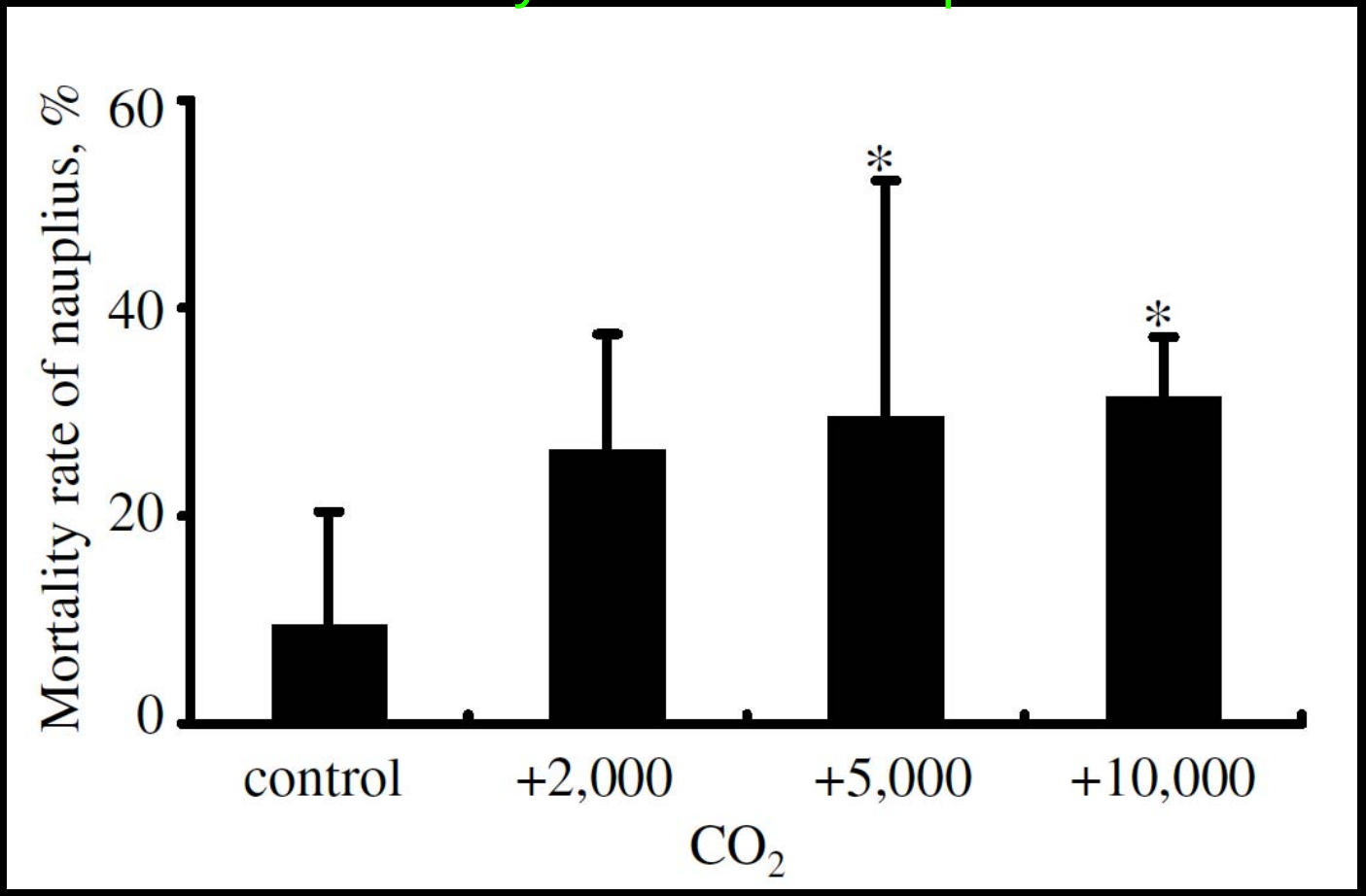
- Calcite organisms
  - Coloclith
  - Foram
- High magnesium calcite organisms
  - Echinodermata
  - Coralline algae
- Aragonite organisms
  - Coral
  - Pteropod

Some study reported that the acidification also affect reproduction of non calcareous organisms such as copepod.

Acidification

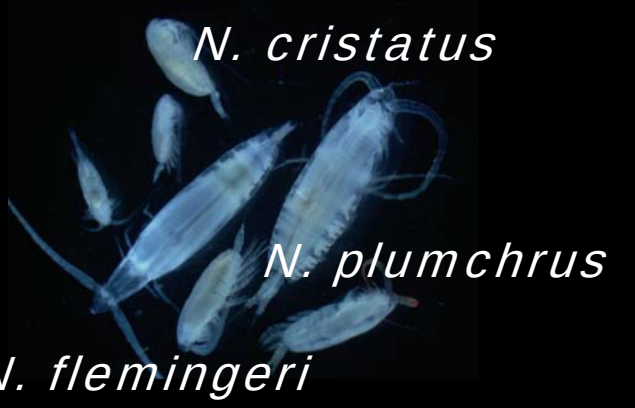
Copepod (*Acaria steueri*)

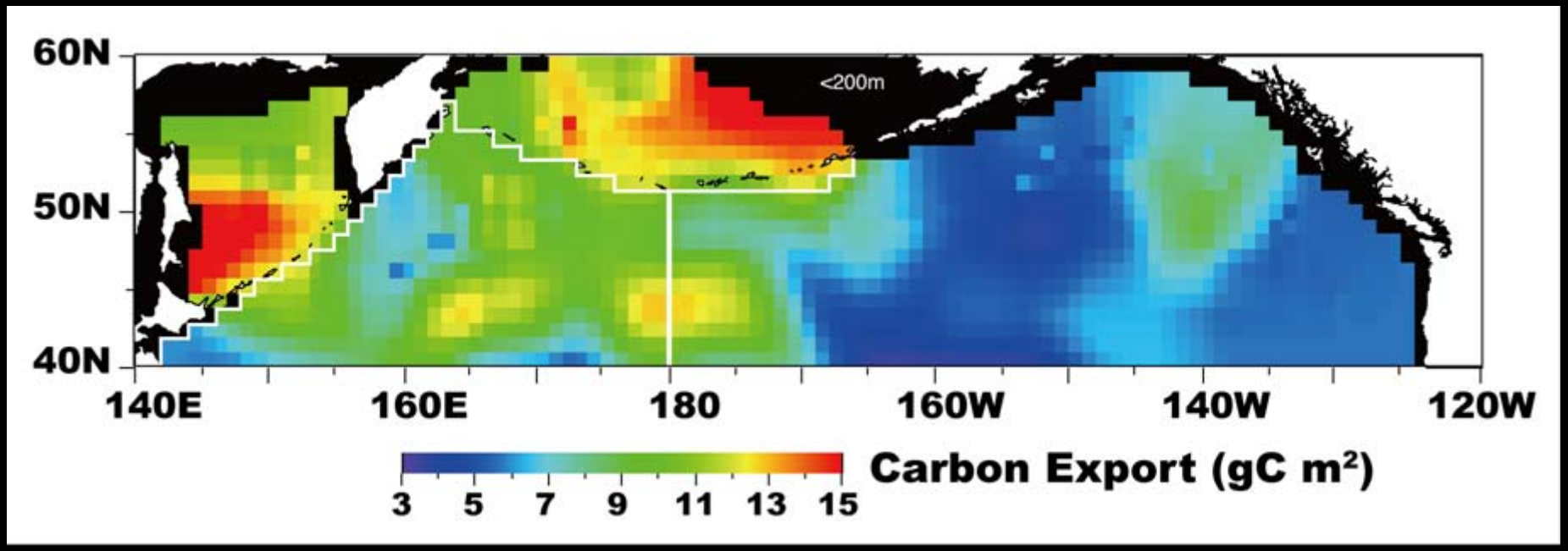
Mortality rate of nauplius



Kurihara et al. (2004)

Acidification





Harrison et al. (2004)

Neocalanus transport 0.1Gton C year $^{-1}$.
15% of new production in the area.
30% of CO_2 emission of Japanese.

Future Problems

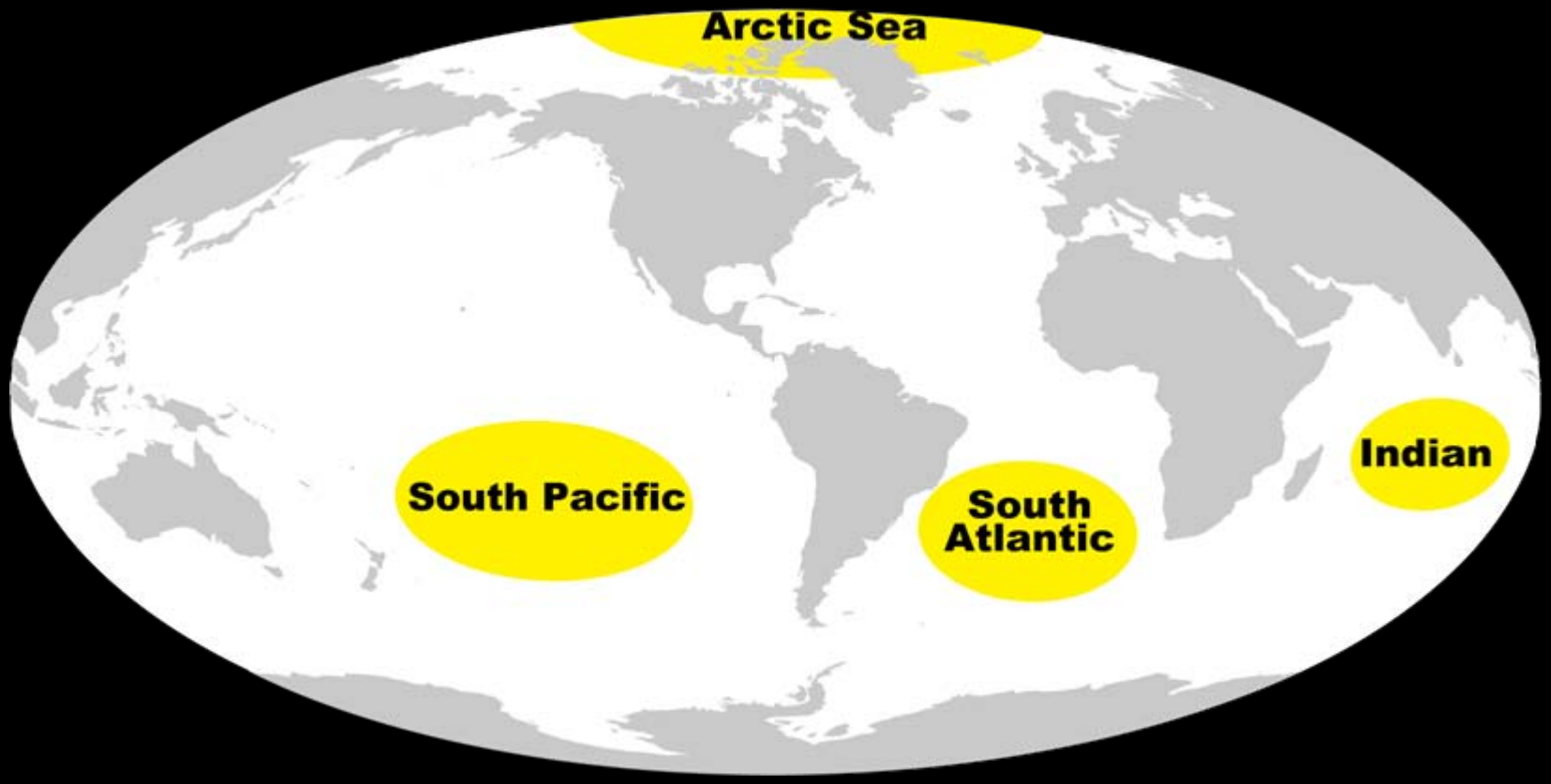
1 Primary productivity vs match/mismatch
(North Pacific) (North Atlantic)

2 Effect to the upwelling ecosystem.

3 Global scale monitoring.

Future Problems

Research of the yellow region is not so advanced.



Monitoring is need !