WG137

Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Utilizing long-term data to distinguish human from climatic drivers of ecological change

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and many others

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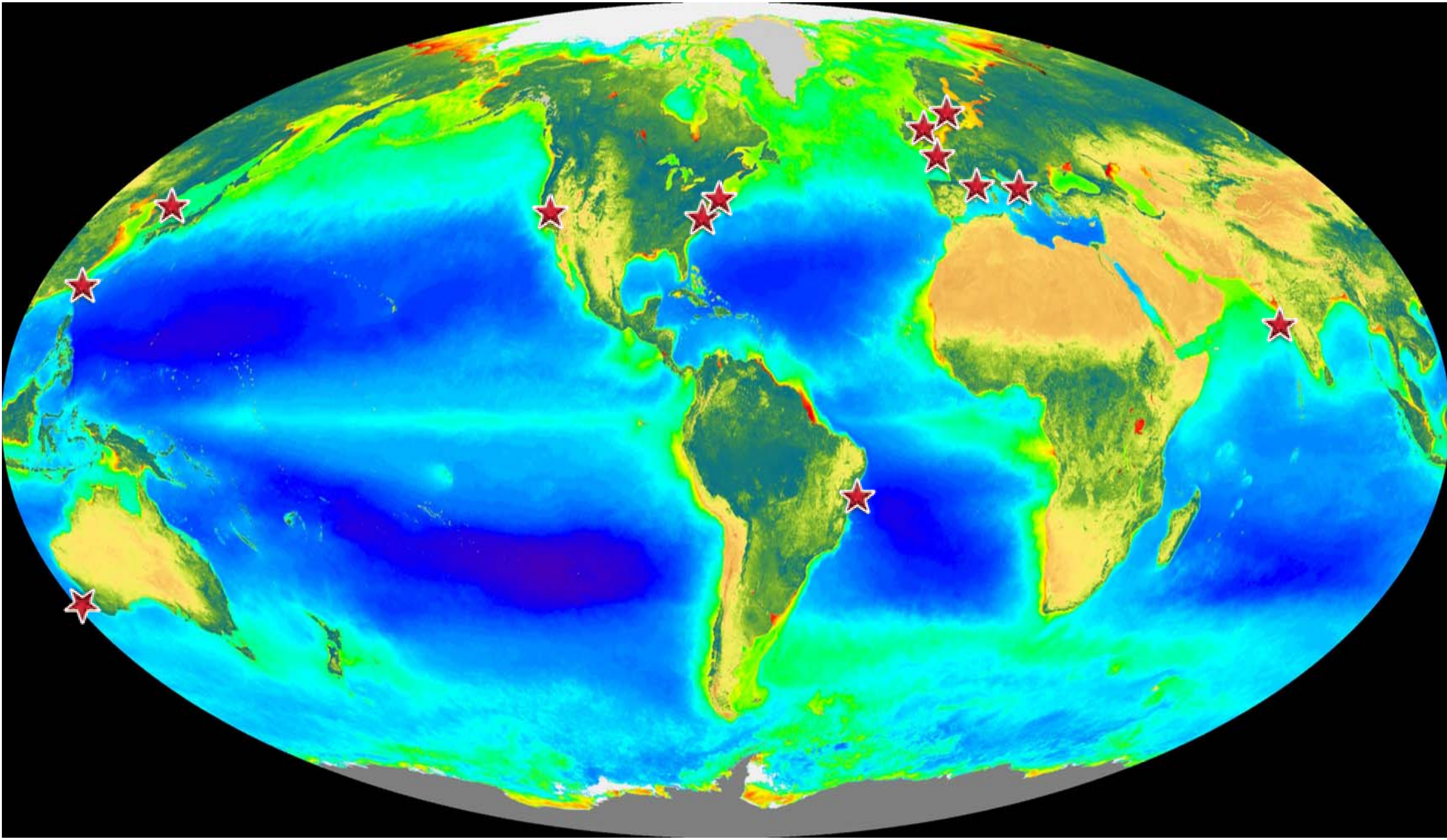
(http://wg137.net)

SCOR WG 137 Long-term Comparative Study Sites ★



Coastal Ocean: <10% of worlds ocean >30% of global marine primary production

Environmental Factors Impacting Coastal Phytoplankton Communities

Positive

- Adequate N & P (low N:P for N_2 fixing taxa)
- Low turbulence (benefits mobile/buoyant taxa, e.g., flagellates, cyanobacteria)
- High (adequate) light
- Elevated temperature (except for low temperature adapted diatoms, chlorophytes)
- Long residence time

  (benefits slow-growers)
- High DOM high DIC
- Sufficient Fe (+ traces)?
- Low grazing rates (although some fast growers might benefit due to nutrient recycling)?

rates

rates

Diversity

Negative

- Low N & P (except for N_2 fixers)
- High turbulence (takes away advantage for motile taxa, benefits diatoms)
- Low temperatures
- Low light (for most taxa)
- Short residence time
- Low DOM
- Low Fe (+ trace metals)?
- High grazing rates? (although fast growers will benefit from enhanced nutrient recycling)?

Modulating Factors

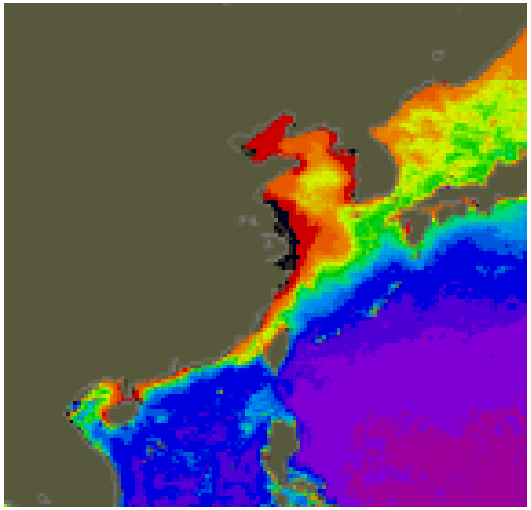
- Strong Biogeochemical Gradients, e.g. persistent stratification, stable benthos
- Heterogeneous and diverse habitats (e.g. reefs, seagrasses, marshes, sediments, aggregates)
- Selective grazing
- Eutrophication
- “Toxins”??

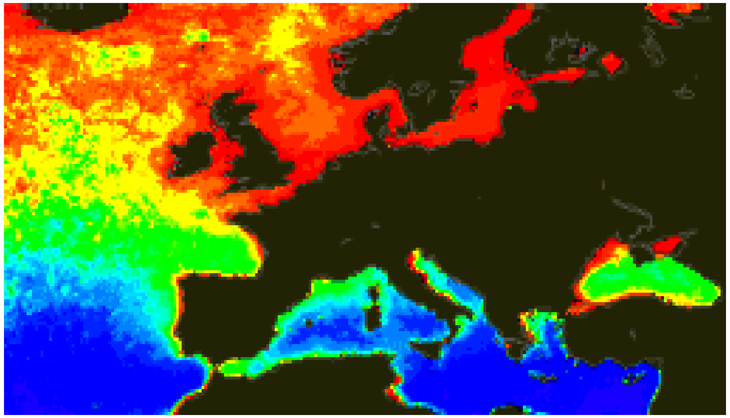
The challenge: Use long-term comparative phytoplankton community structure/function and environmental data sets to identify and "tease apart" key anthropogenic & climatic drivers of ecological change

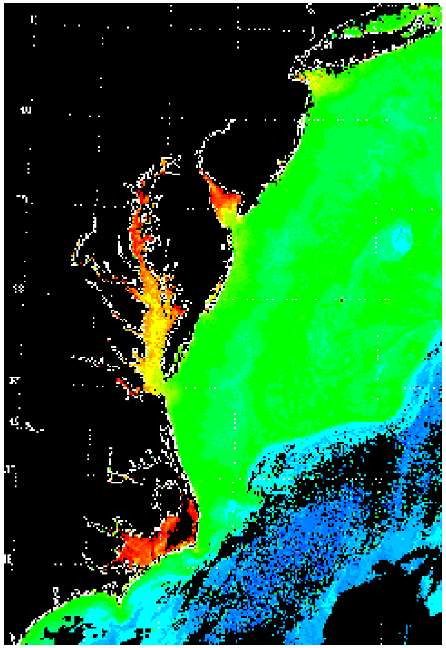
Key interactive drivers discussed here

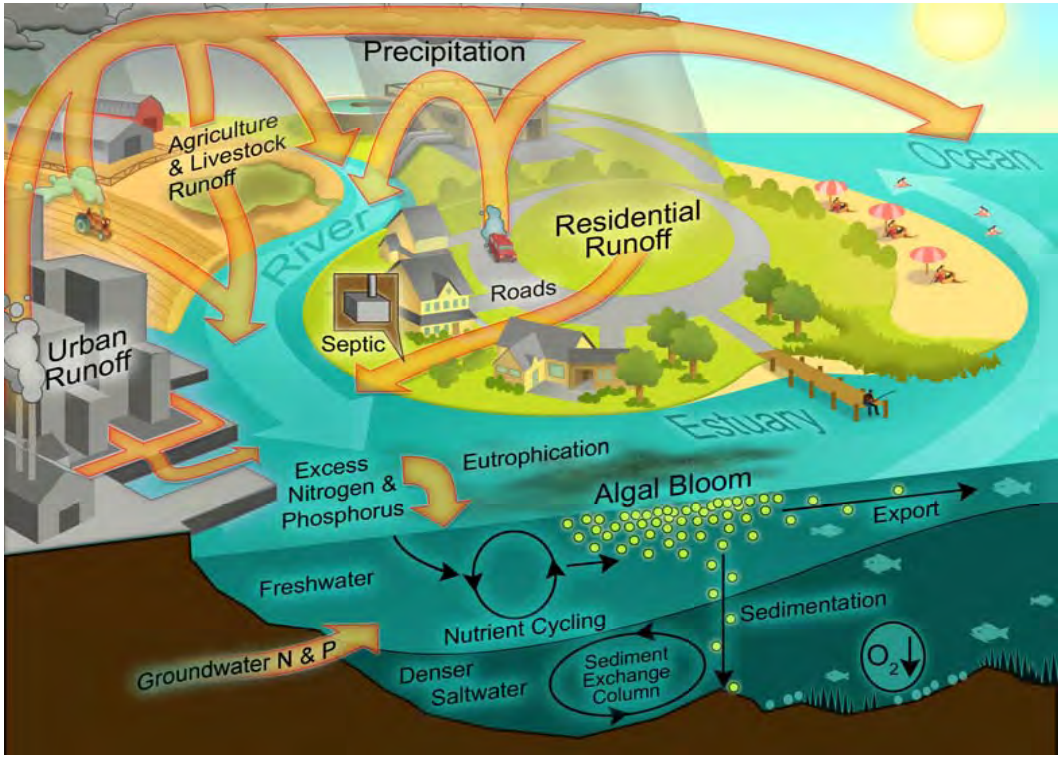
- Nutrients: N, P, Si, Fe
- Climatic: temperature, precipitation/FW discharge, circulation/stratification
- Light (transparency, color)
- Top-down: Grazing, predation, trophic interactions

Nutrient-Coastal Eutrophication Dynamics

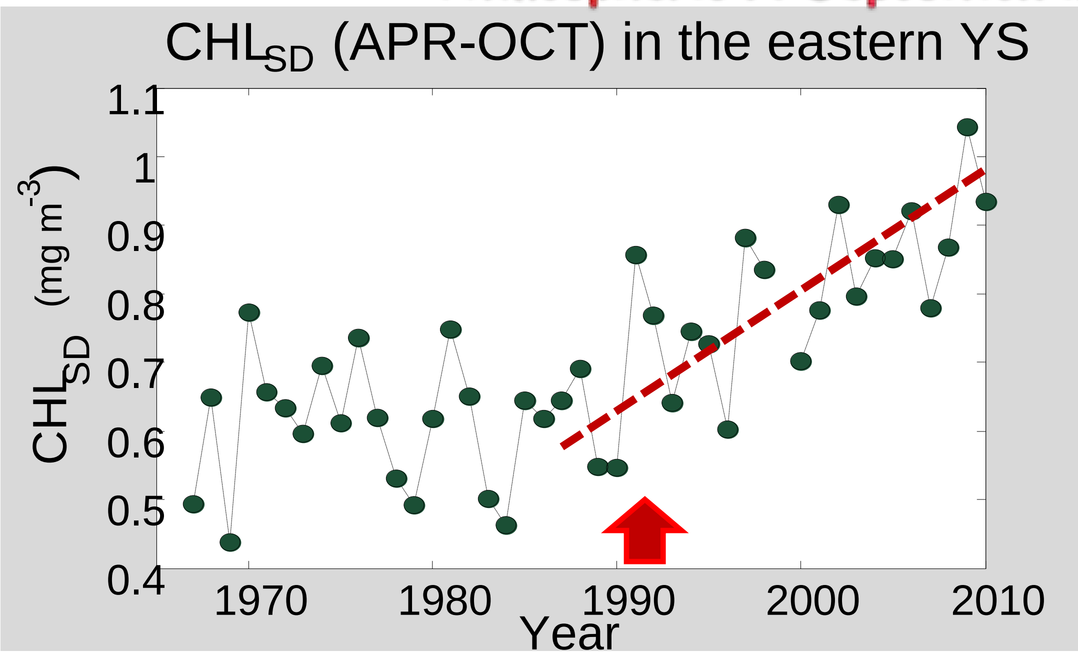








Anthropogenic nutrient (N) inputs & Eutrophication: Atmospheric N Deposition in the Yellow Sea



(Yoo, *in preparation*)

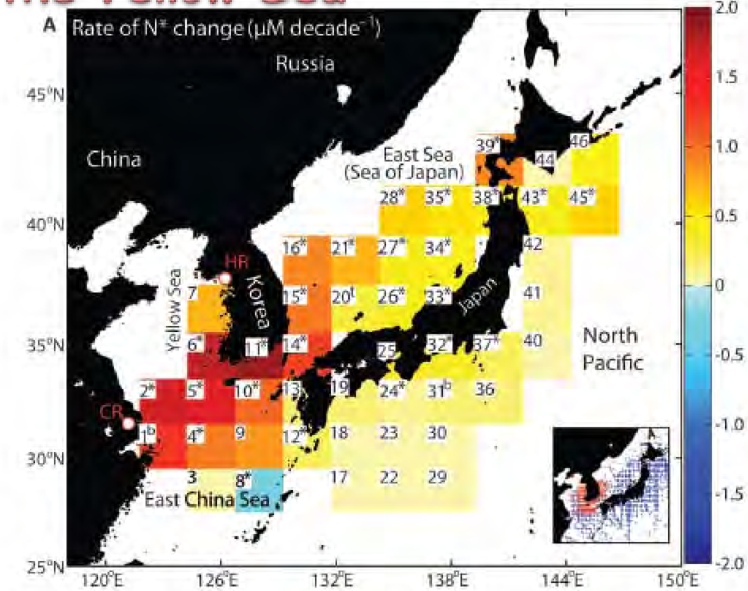


Fig. 1. **(A)** Rate of change (μM decade^{-1}) of N* in surface waters (≤50 m) of the study area. The red and yellow boxes indicate regions in which the N* values tended to increase, and the blue box indicates a region in which N* decreased. Boxes with statistically significant N* trends are marked with an

and Han ri… pled over th… Research ar… (blue). **(B)** T…

(Kim *et al.*, 2011)

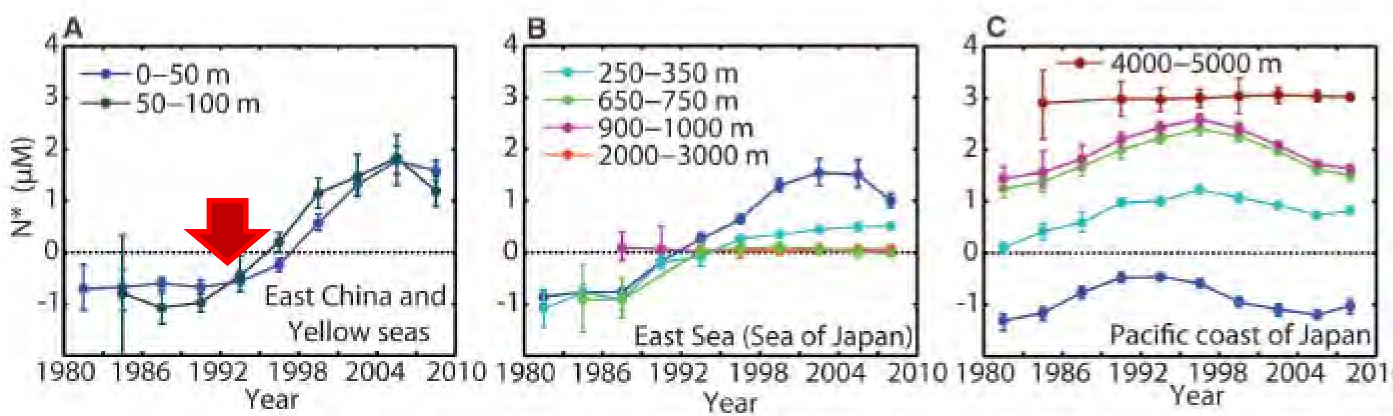
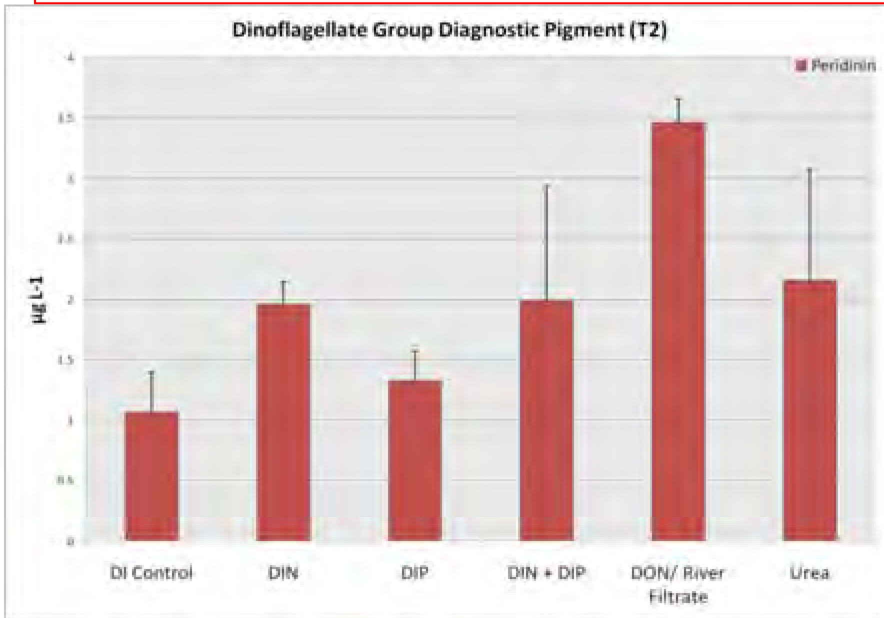
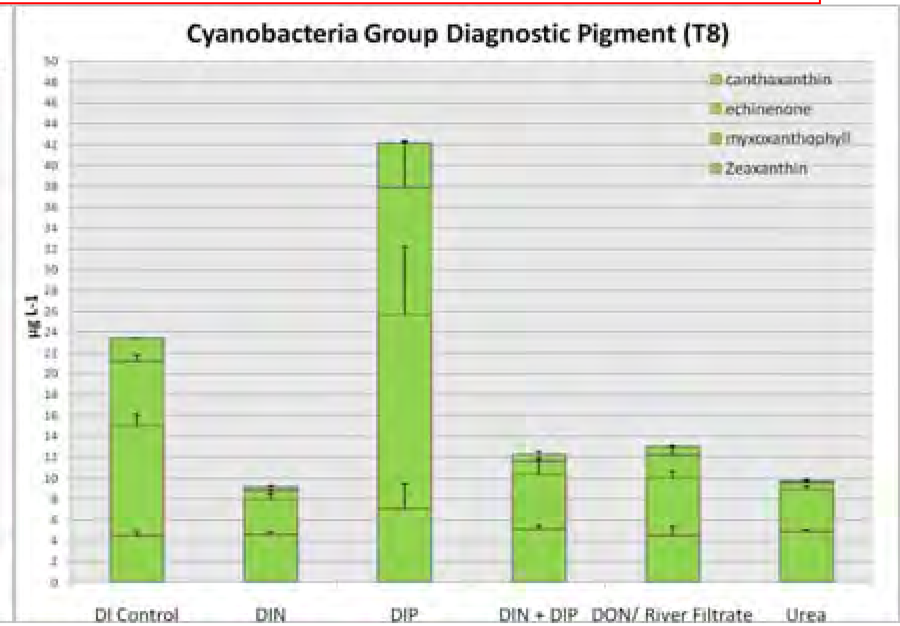


Fig. 4. Time series of the 3-year mean N* (μM) for various depth ranges in **(A)** the East China and Yellow seas, **(B)** the East Sea (Sea of Japan), and **(C)** the Pacific coast of Japan. The colors indicate the N* values derived from the data collected at the indicated depth ranges. The dotted lines correspond to N* = 0 μM. The error bars are the confidence intervals of the resulting N*, for $P = 0.05$. The colored lines in (C) not indicated in the legend correspond to the depths indicated in (A) and (B).

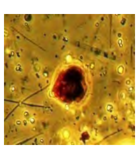
The forms of N and P enrichment matter: Effects of DIN, DON and P on HABs in the New River Estuary, NC



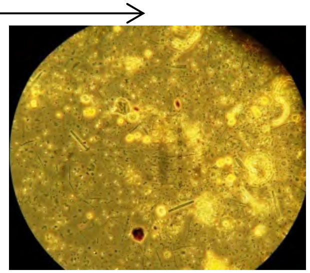


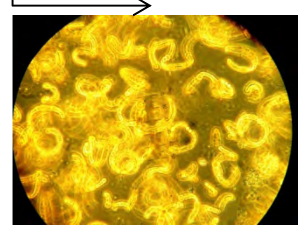
Dinoflagellate (Peridinin) biomass and Cyanobacteria (multiple) indicator pigment responses

Karlodinium sp



Scrippsiella trachoidea





Anabaenopsis sp

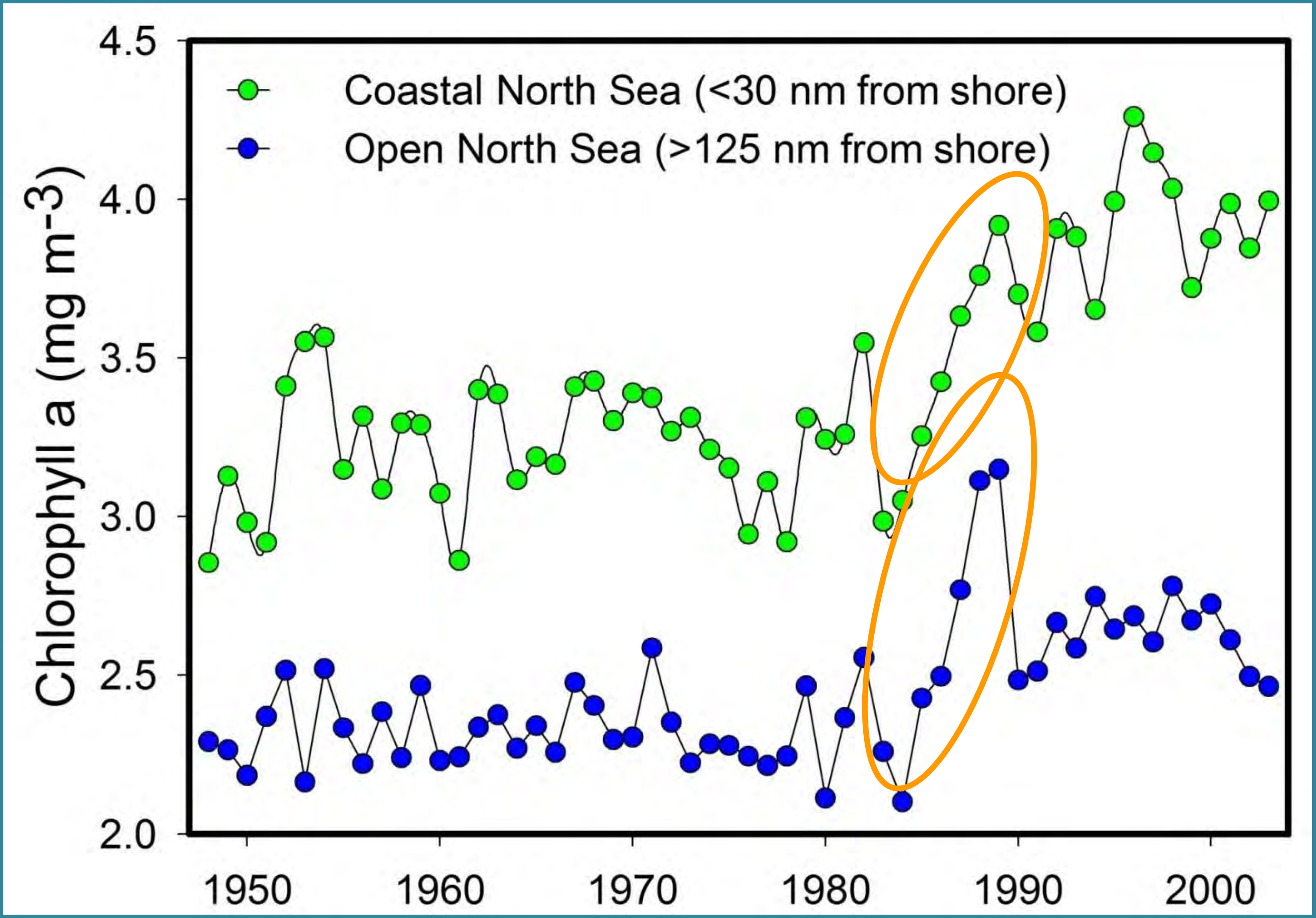
Heterocysts: site of N-fixation

Anabaenopsis sp

Altman & Paerl 2012.

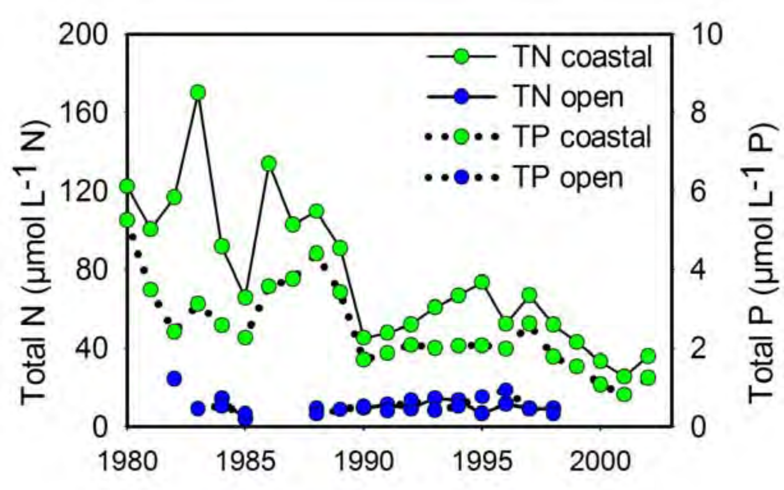
The Interactive effects of Climate Change (warming & hydrology) on phytoplankton communities

Increasing CPR-Chl-a in North Sea



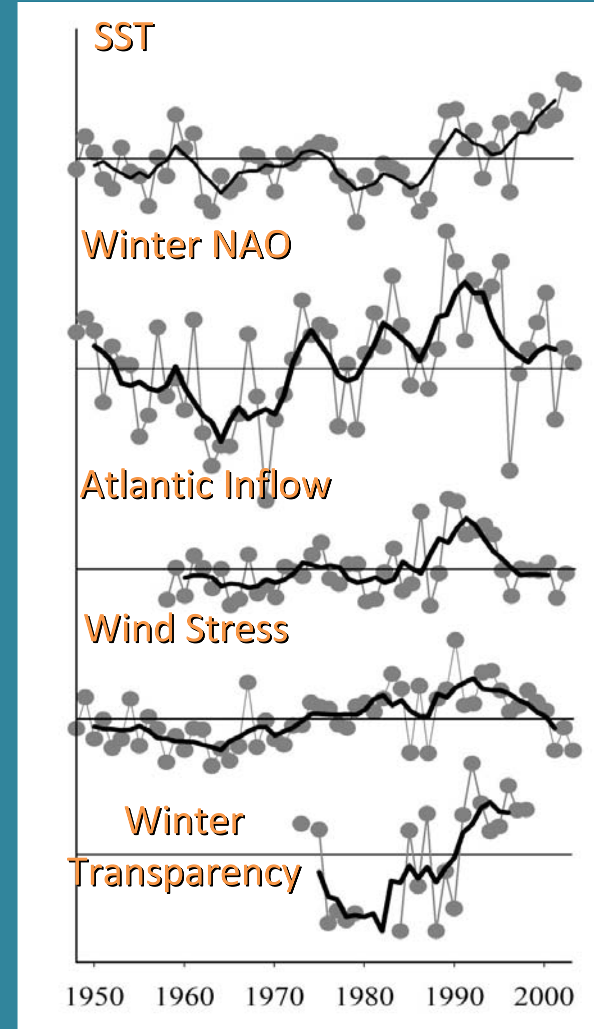
Eutrophication or climate?

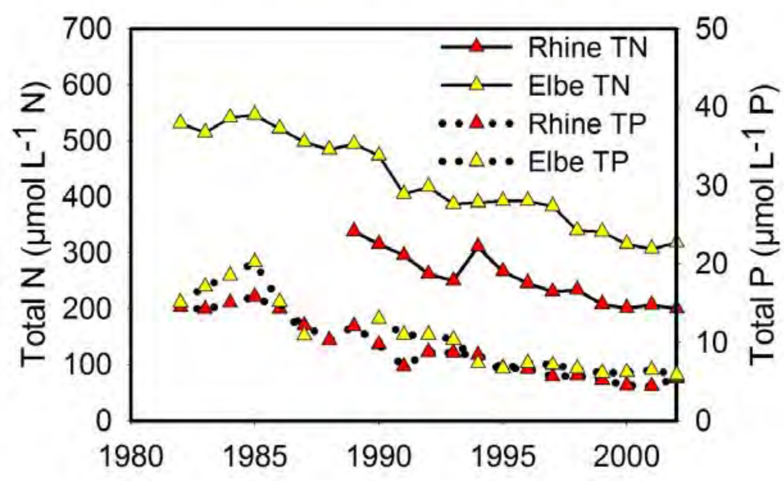
Data sources: Continuous plankton recorder (CPR), Europ. Environ. Agency



North Sea

(Data: CPR, Europ. Envir. Agency, Hadley Ctr., NCEP/NCAR, NORWECOM, J. Hurrell)





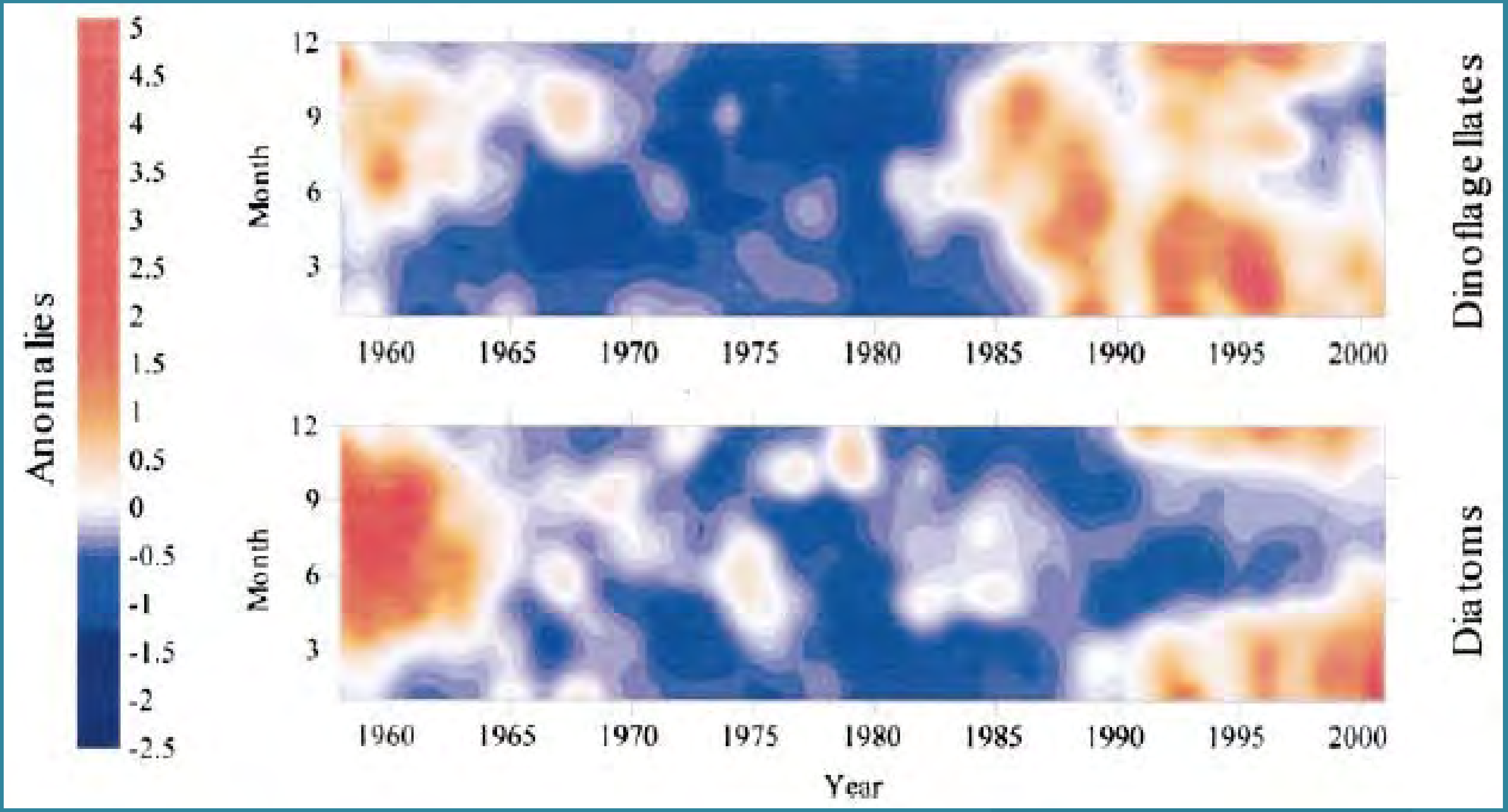
Nutrients

- Signif. decrease of nutrients in coastal waters and rivers
- Coastal nutrients decrease significantly and negatively correlated with Chl-a
- Open nutrients not correlated with Chl-a

Climate

- SST, wind & winter water trans correlated with Chl a
- Open Chl a correlated with SST, NAO, inflow, wind = climate driving phyto-biomass

Phyto. Community changes

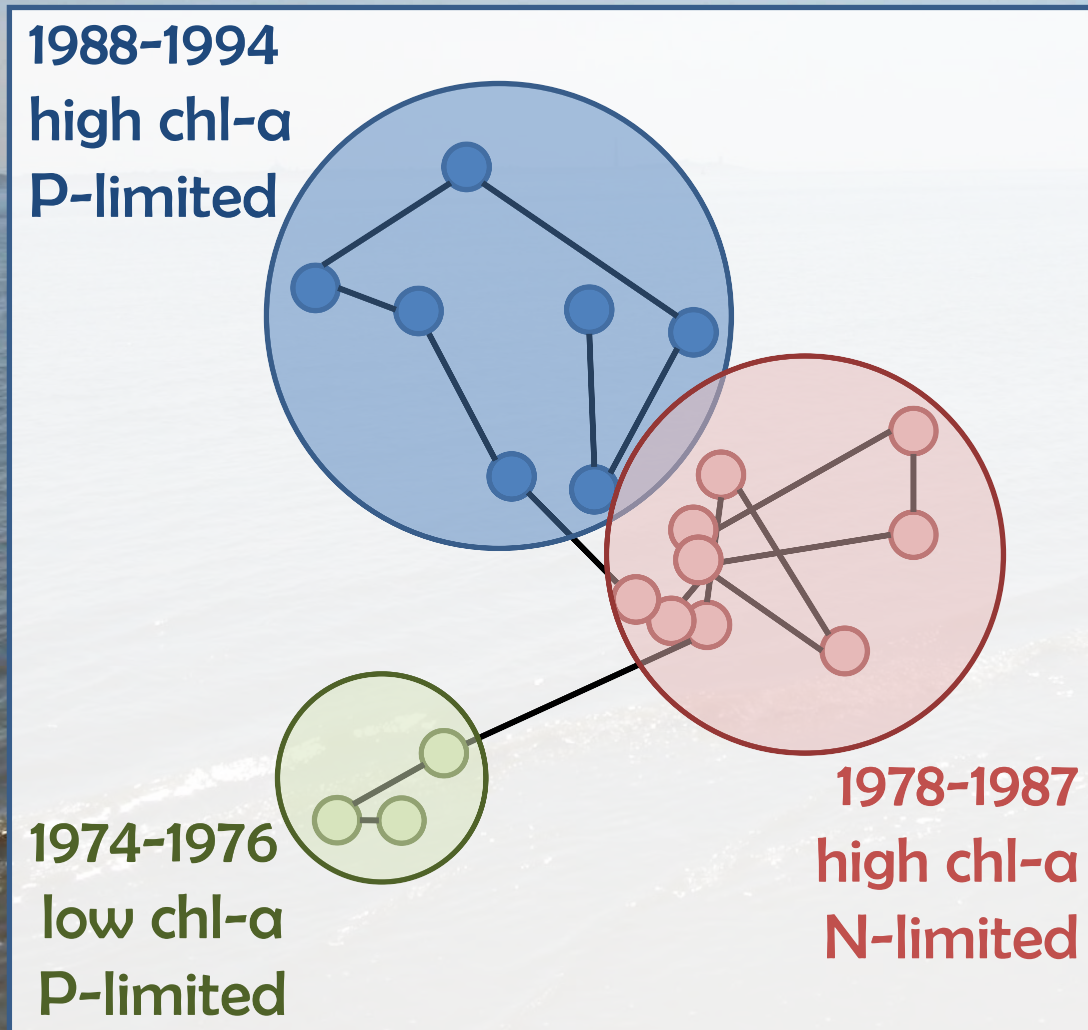


'87-88 "shift"

Edwards et al (2006) L&O

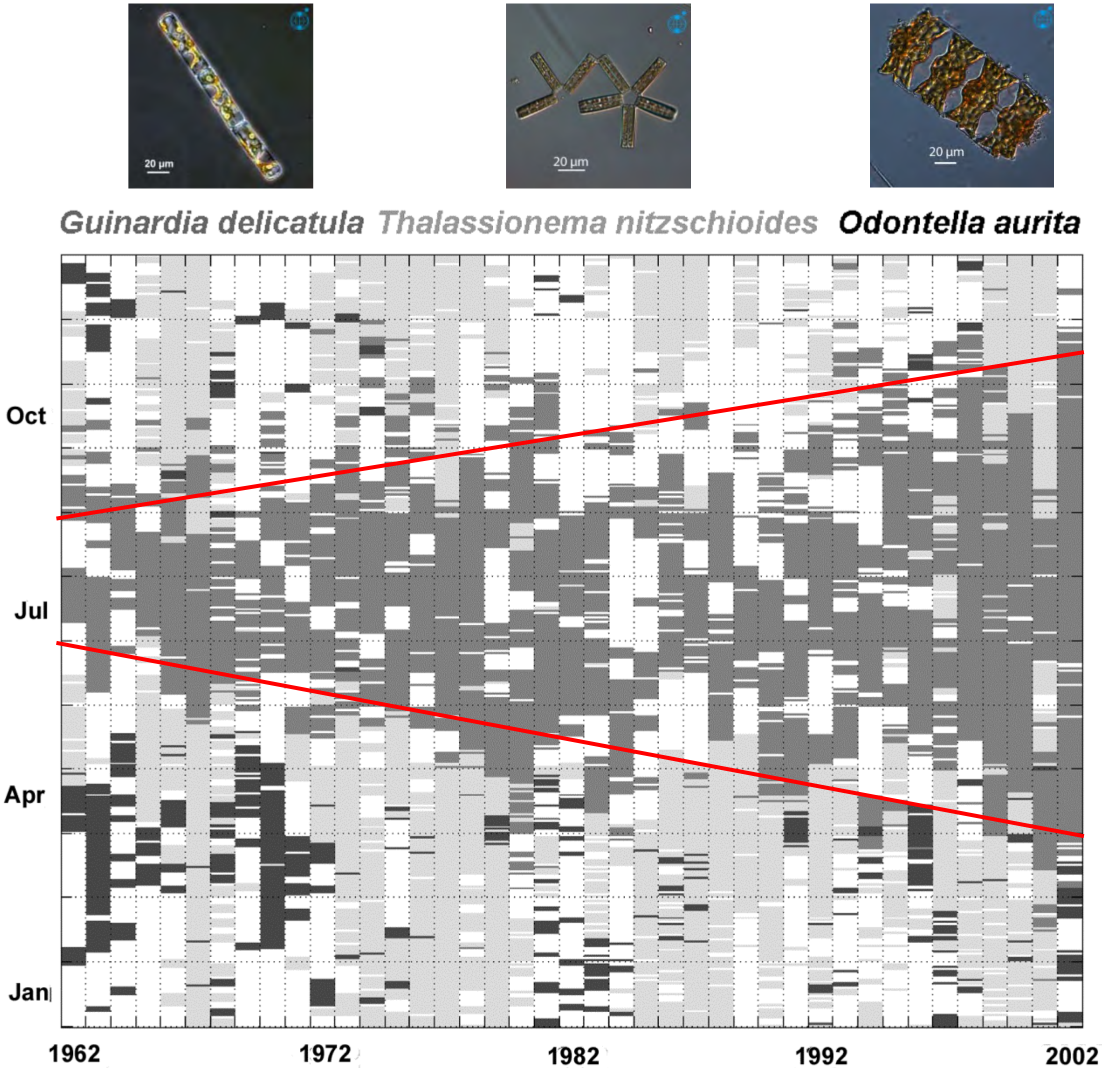
Marsdiep tidal inlet (southern North Sea). Sudden Shifts in Phytoplankton Species Composition (1977/1978 & 1987/1988)

This is coincident with climatic (precipitation/FW discharge) changes
Timing is remarkably "in tune" with larger-scale (North Atlantic) shifts in phytoplankton dynamics



Philippart et al. (2000) Limnol. Oceanography 45: 131–144.

Changes in abundance/seasonality



Helgoland Roads, Germany

Guinardia delicatula is broadening its range

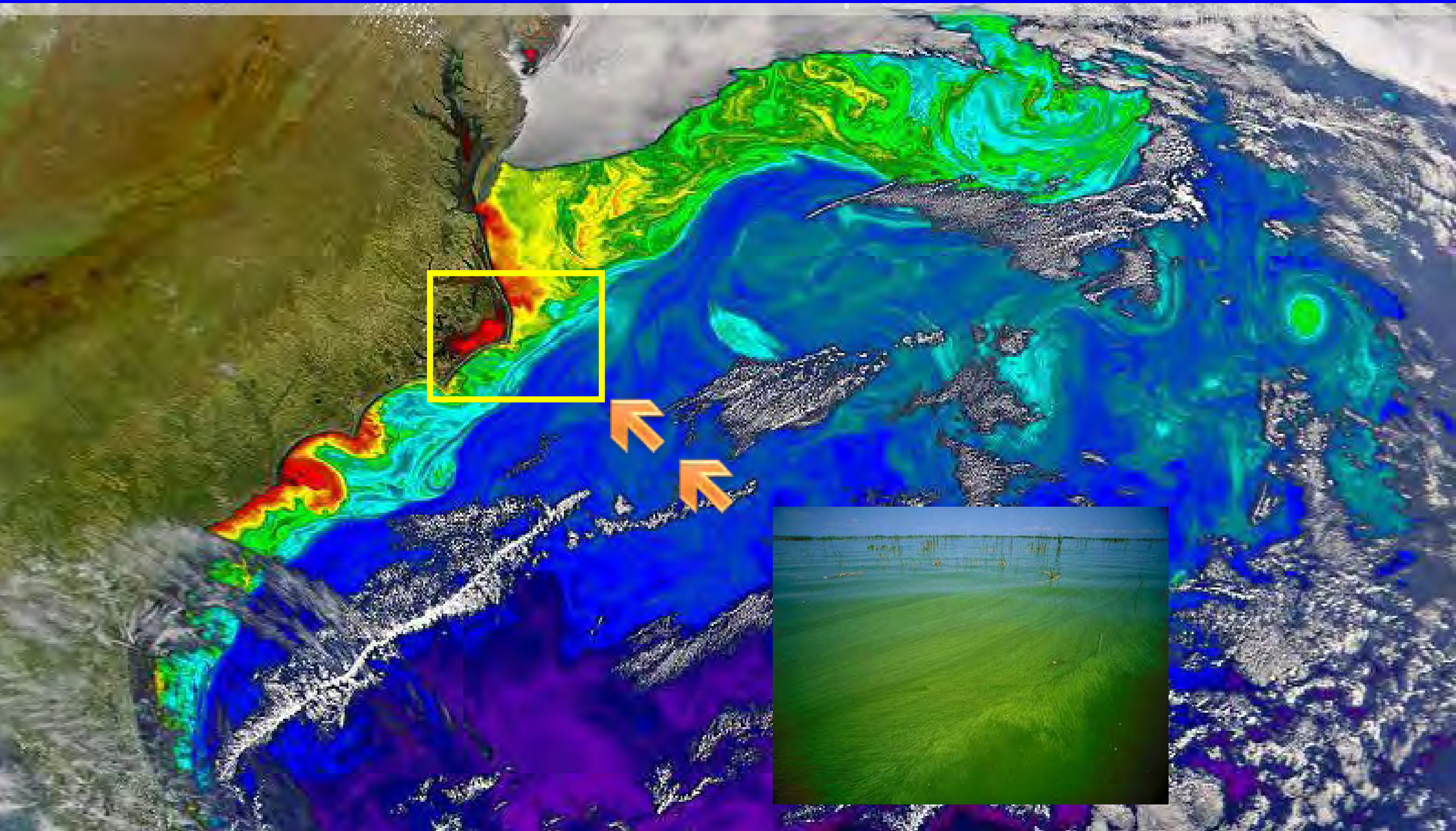
O. aurita: cell numbers decreasing

Wiltshire et al. 2010

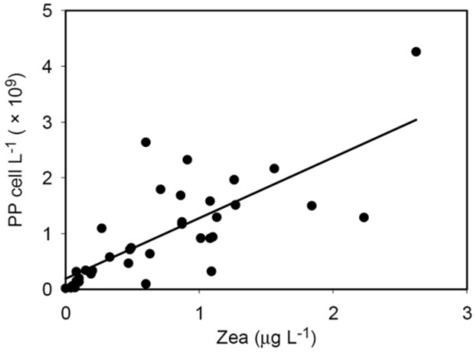
Reason? In the case of *Guinardia*, preference for warmer temperatures

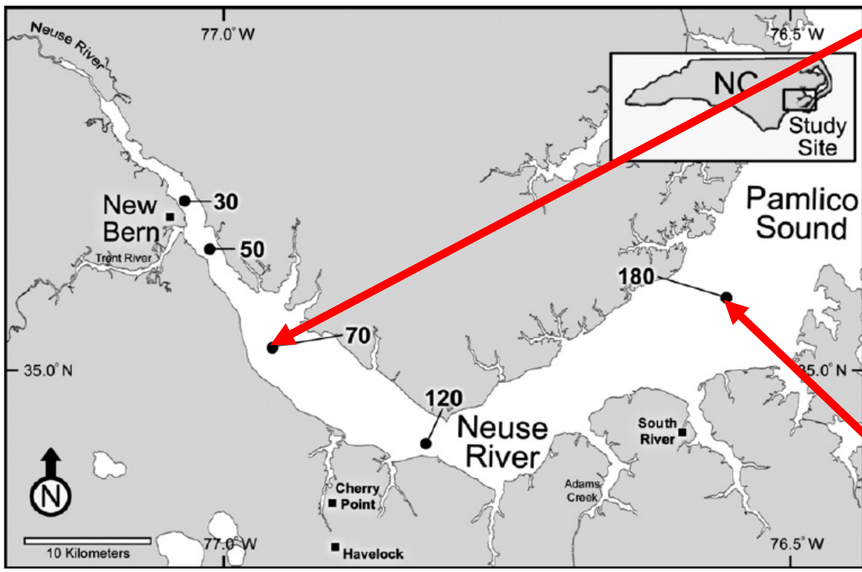
US Mid-Atlantic Coastal Waters: The Neuse-Pamlico Sound System, The US's Largest Lagoon/Key Fishery: Recent increase in cyanobacterial dominance

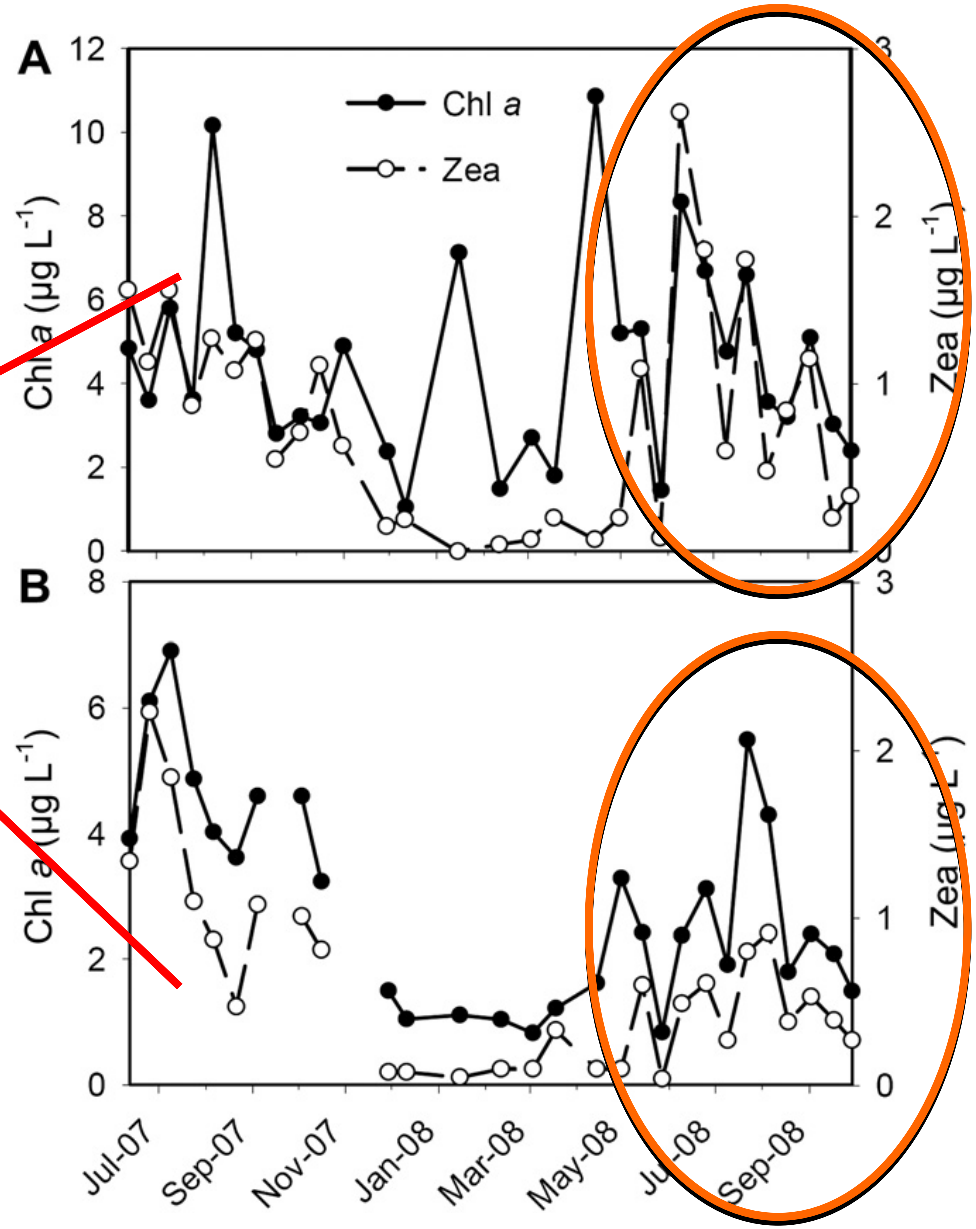
Is it solely due to eutrophication????



Seasonal patterns of Chl *a* and cyanobacterial biomass (zeaxanthin) in the Neuse River Estuary, NC

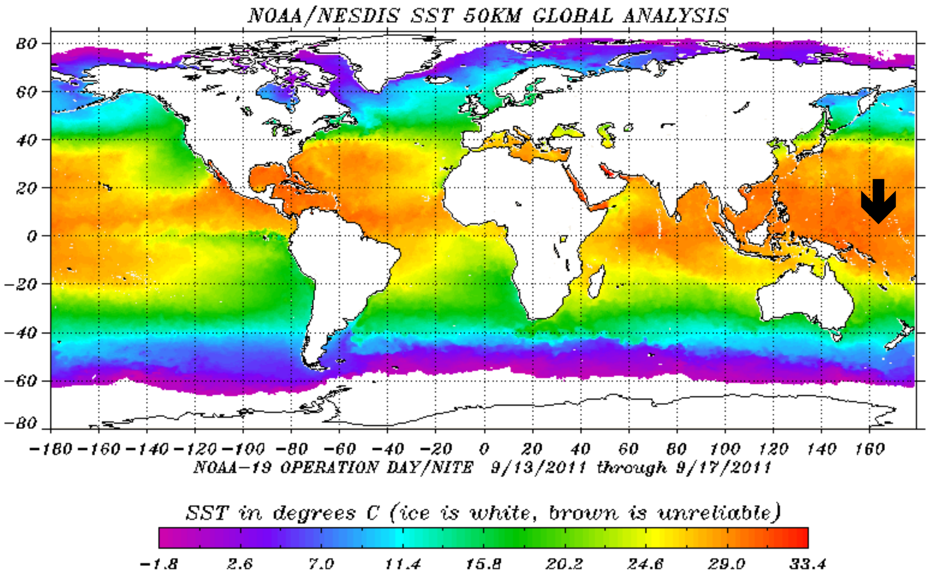


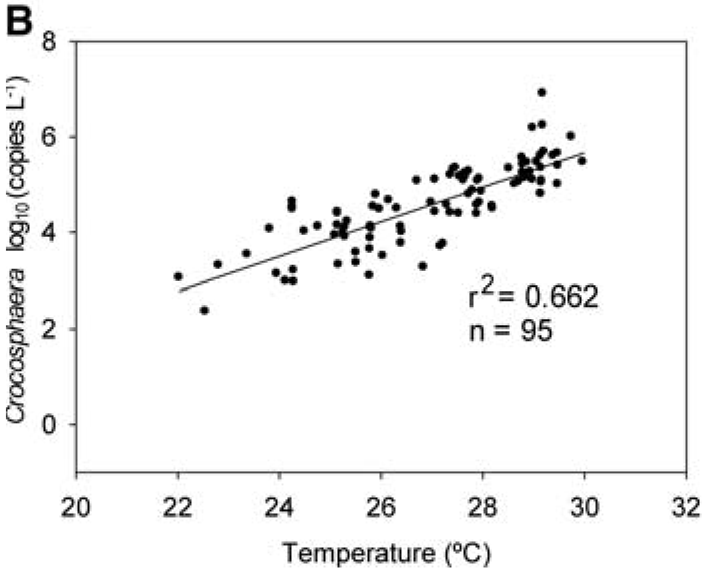




Gaulke et al. 2010

Pelagic N_2 fixing picocyanobacterial abundance vs. temperature



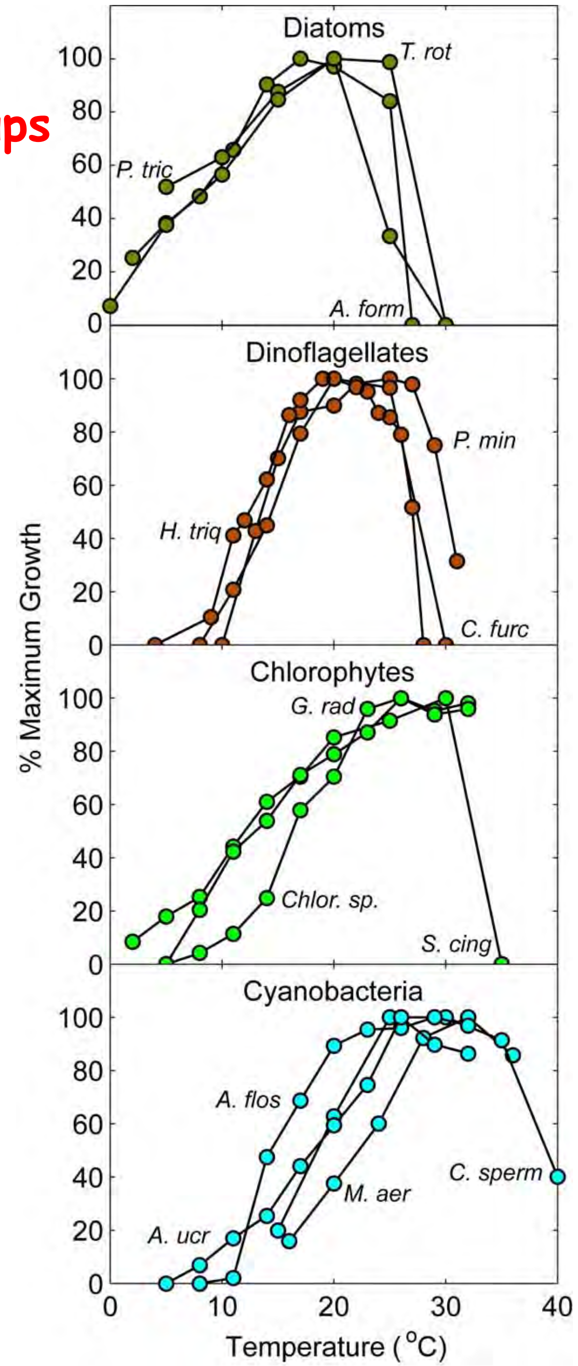


Relationship of unicellular diazotroph abundances [log10 (nifH copies per liter)] and temperature for *Crocosphaera*. f = 5.13 – 0.1754x + 0.0638x2 – 0.0124x3..

Moisander et al. 2010 (Science 327: 1512-114).

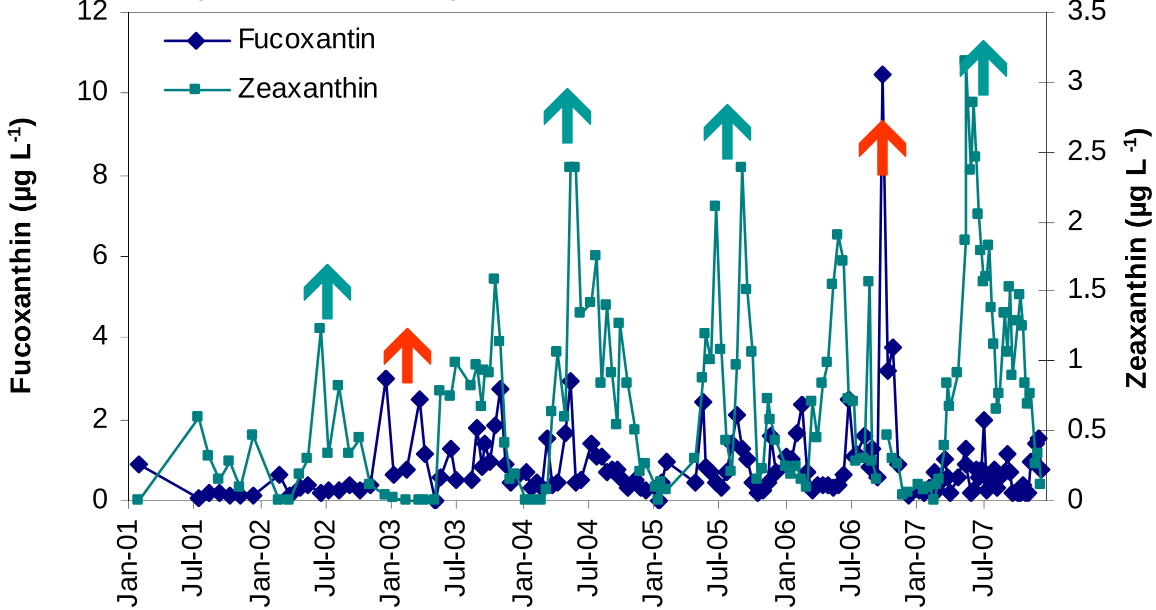
Temperature affects growth rates

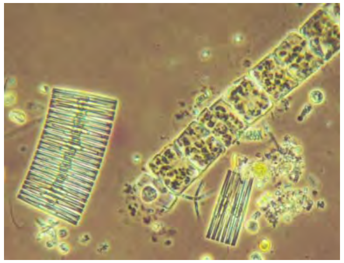
influences dominance by various phytoplankton groups



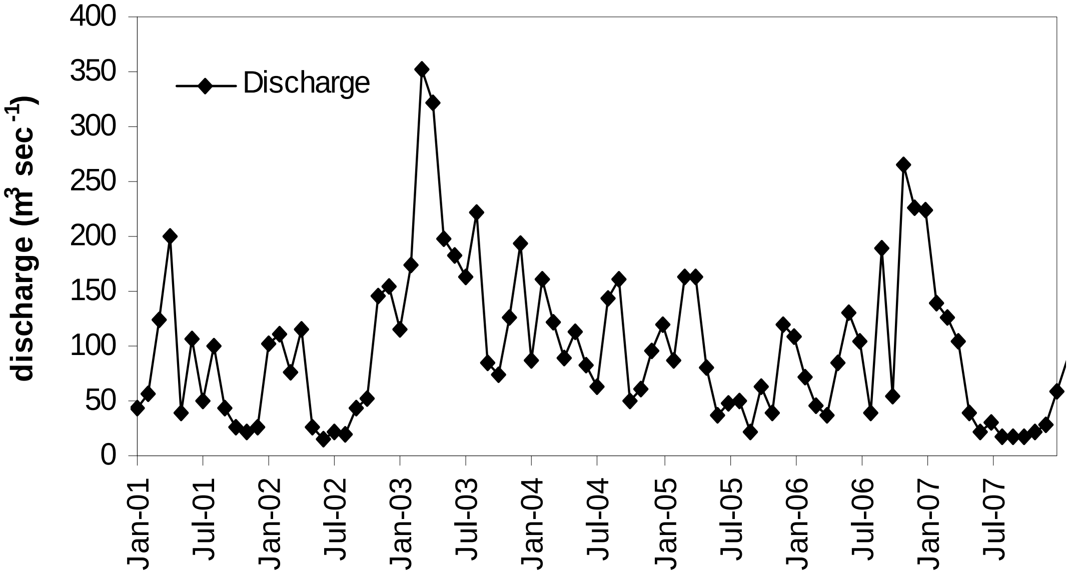
Refs.: Kraweik 1982, Grzebyk & Berland 1996; Kudo et al., 2000, Litaker et al., 2002, Briand et al., 2004, Butterwick et al., 2005, Yamamoto & Nakahara 2005, Reynolds 2006

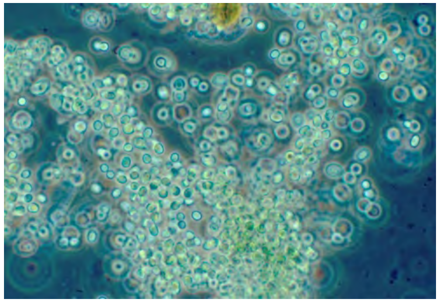
Freshwater discharge (flushing) interacts with temperature to impact phytoplankton composition: Effects on diatom (fucoxanthin) & cyanobacterial (zeaxanthin) dominance in the Neuse R. Estuary, NC





Diatoms like it cool & fast

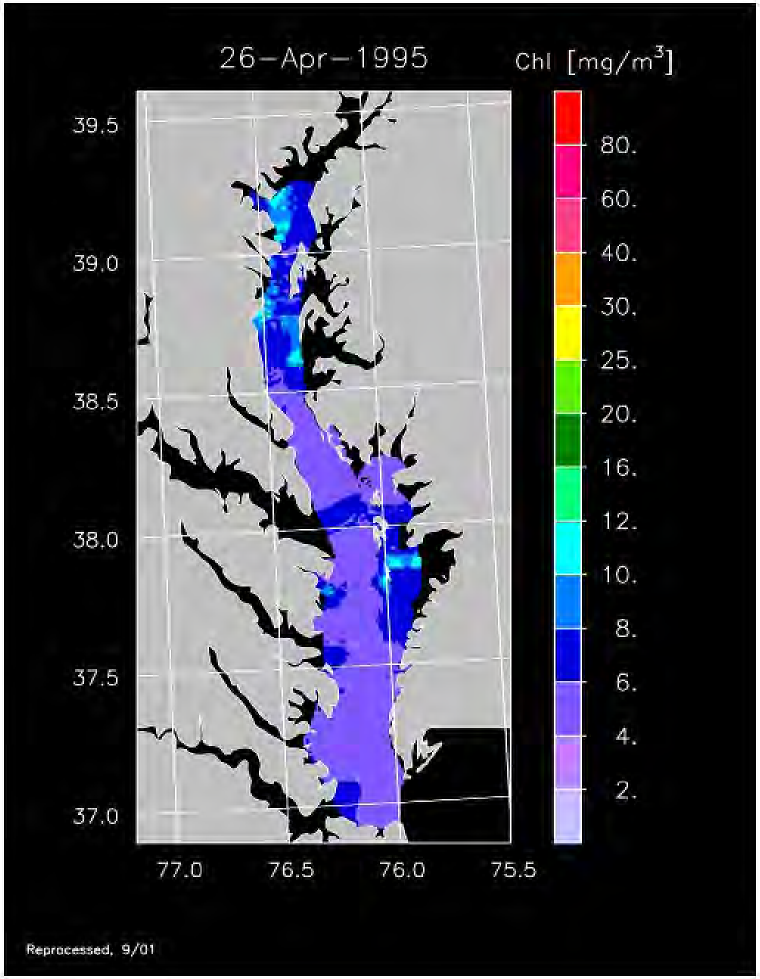


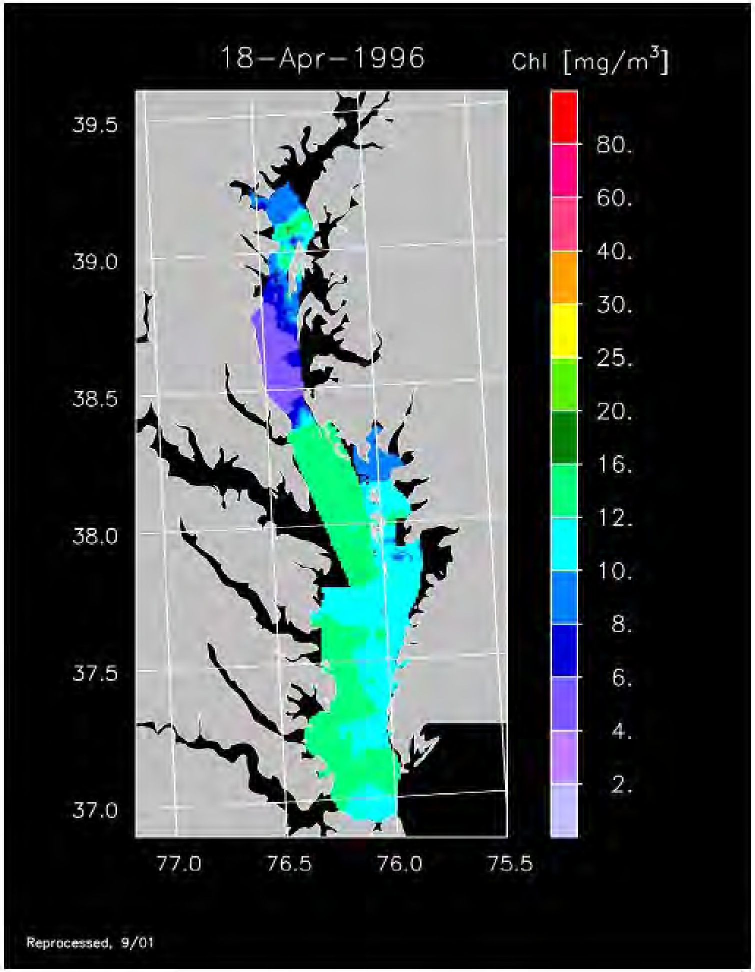


Cyanos like it hot & slow

Paerl et al. 2011

Chesapeake Bay: Remotely sensed chl-a from SeaWiFS Aircraft Simulator (SAS II) during low flow ('95) and high flow ('96) years



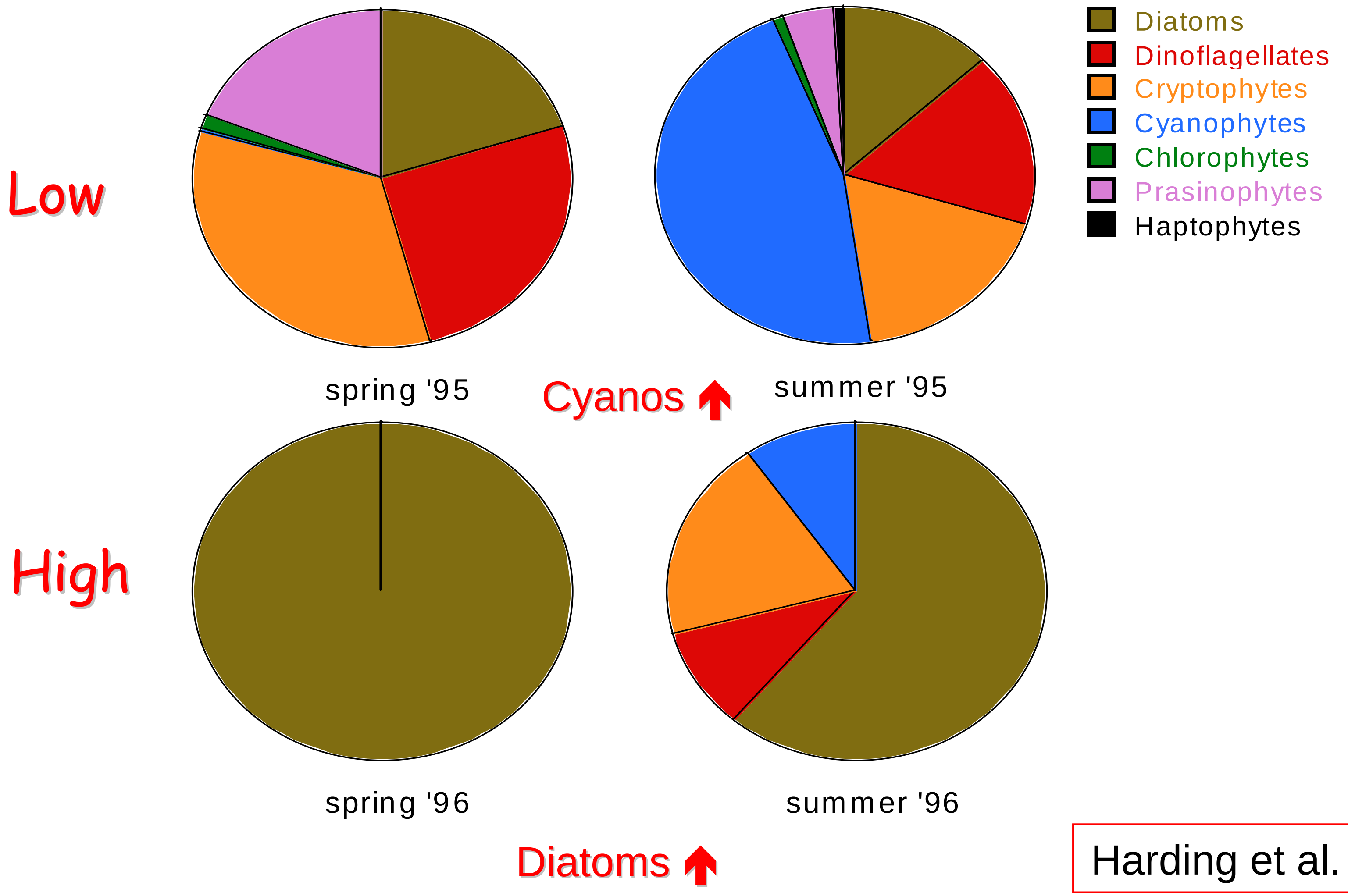


spring '95, low flow

spring '96, high flow

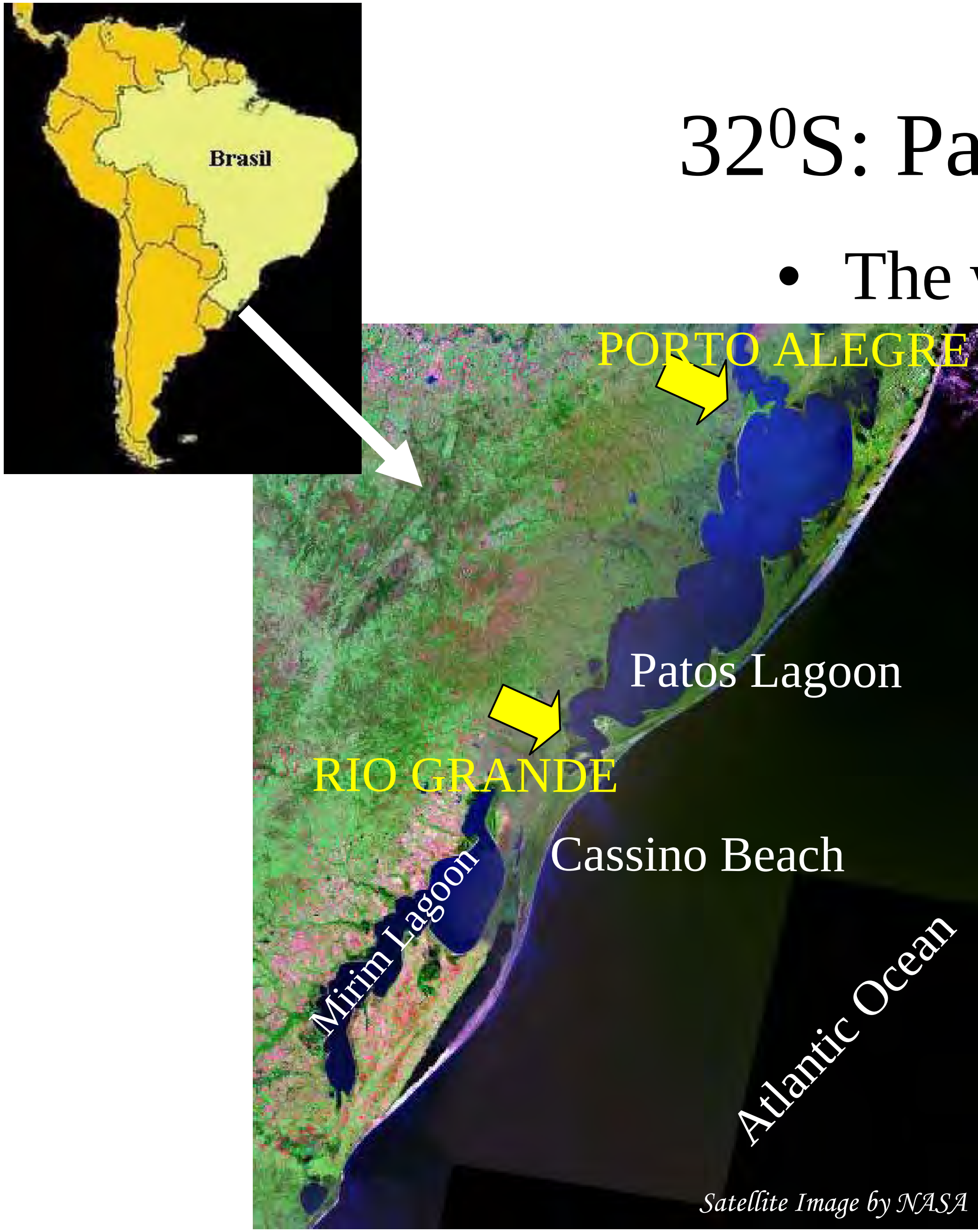
Harding et al. 2009

Chesapeake Bay CHEMTAX – contrasting flow years



Harding et al. 2009

32^0S: Patos Lagoon, Brazil



- The world largest choked lagoon

Area:

10.227 km^2

Hydrographic basin:

- 201.626 km^2

- Main Cities

North:

Porto Alegre Pop.: 1.5 million.

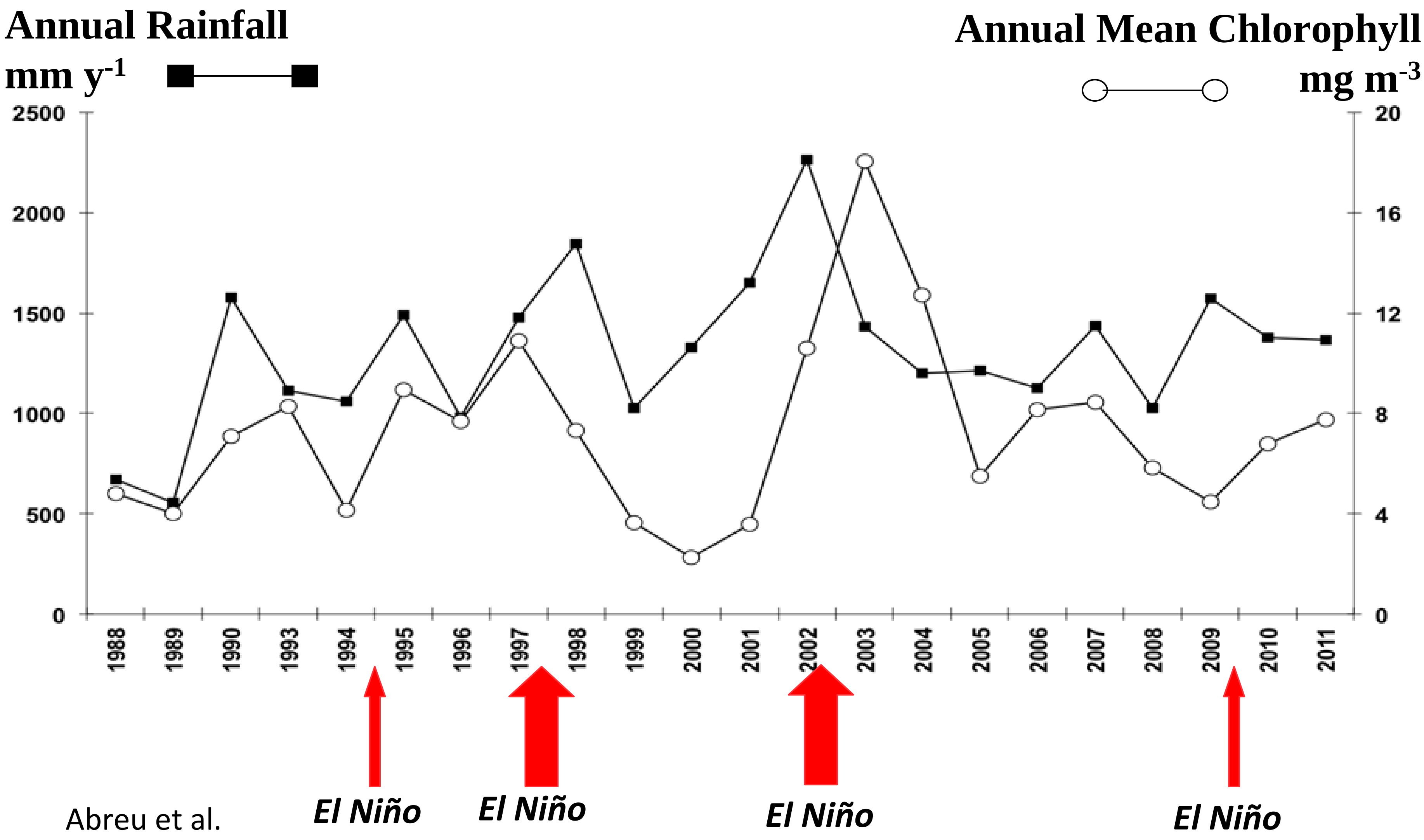
South:

Rio Grande+Pelotas Pop.:~ 400,000.

Rio Grande Harbor

Patos Lagoon Estuary, Brazil

Rainfall x Phytoplankton Chlorophyll

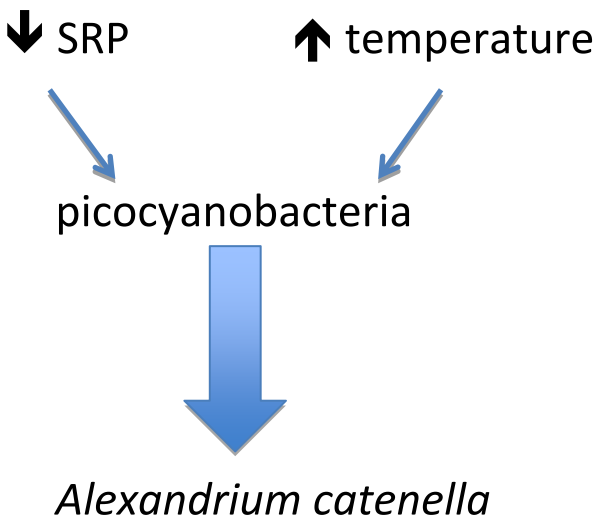


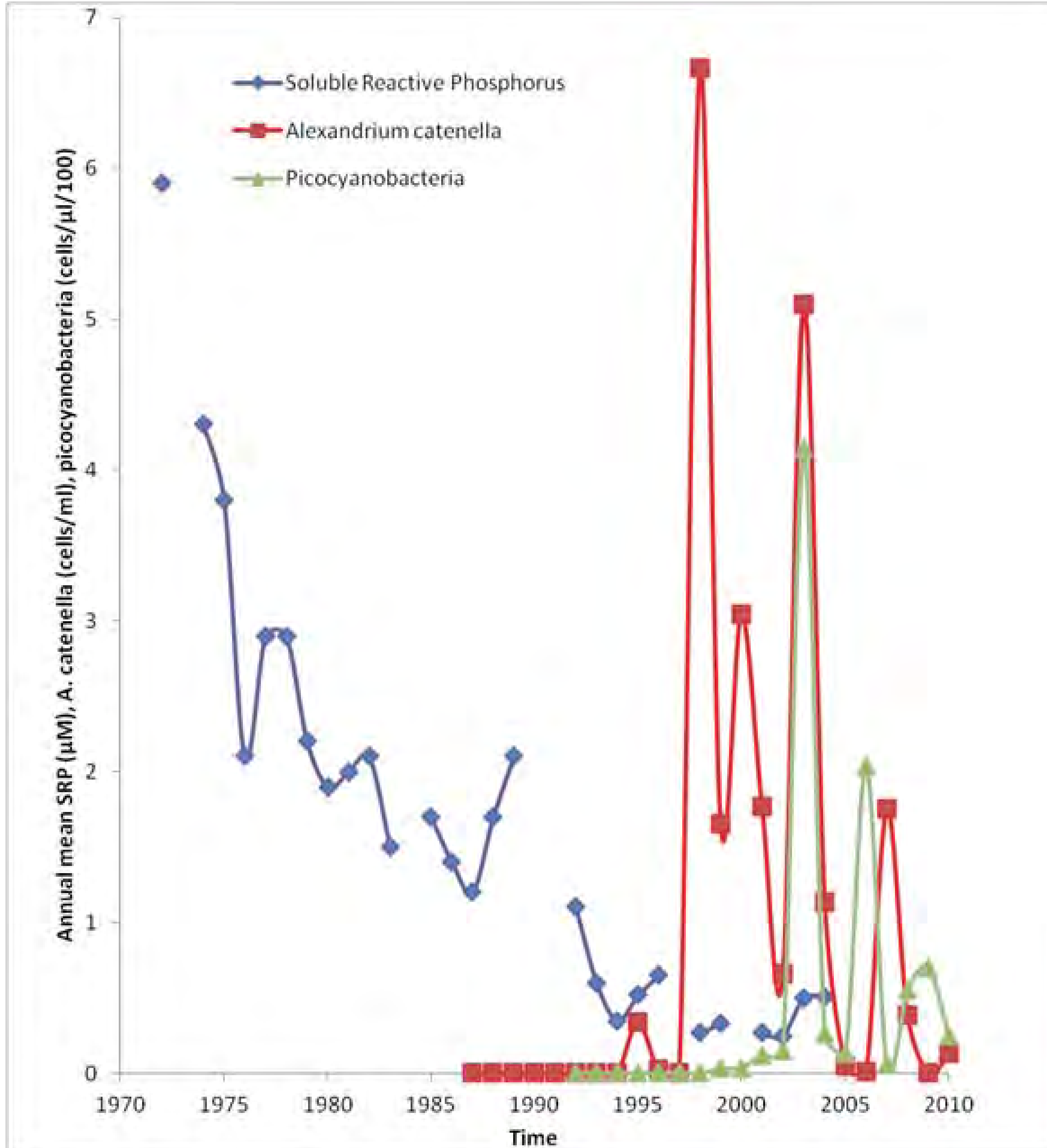
Abreu et al.

Anthropogenic (Nutrient)- climatic interactions determine phytoplankton community composition and function

Thau Lagoon, Mediterranean Coast, France

Climate change and oligotrophication: Thau lagoon, France





Decadal-Scale Changes of Dinoflagellates and Diatoms in the Anomalous Baltic Sea Spring Bloom

Riina Klais[1]*, Timo Tamminen[2], Anke Kremp[2], Kristian Spilling[2], Kalle Olli[1]

1 Institute of Ecology and Earth Sciences, University of Tartu, Tartu, Estonia, 2 Marine Research Centre, Finnish Environment Institute, Helsinki, Finland

- From 1995-2004, dinoflagellates have increased in the northern and eastern Baltic Sea.
- Shift has mostly been linked to climate variability and changes in the physical environment, since nutrients are not limiting at the beginning of the spring bloom.
- Wintertime mixing and resuspension of benthic cysts, followed by proliferation in stratified thin layers under melting ice favors motile dinoflagelates over sinking diatoms. Motility enables dinoflagellates compete with faster growing, but sinking diatoms.
- Shifts in dominant spring bloom algal groups can have significant effects on ecosystem biogeochemical cycling and trophodynamics.

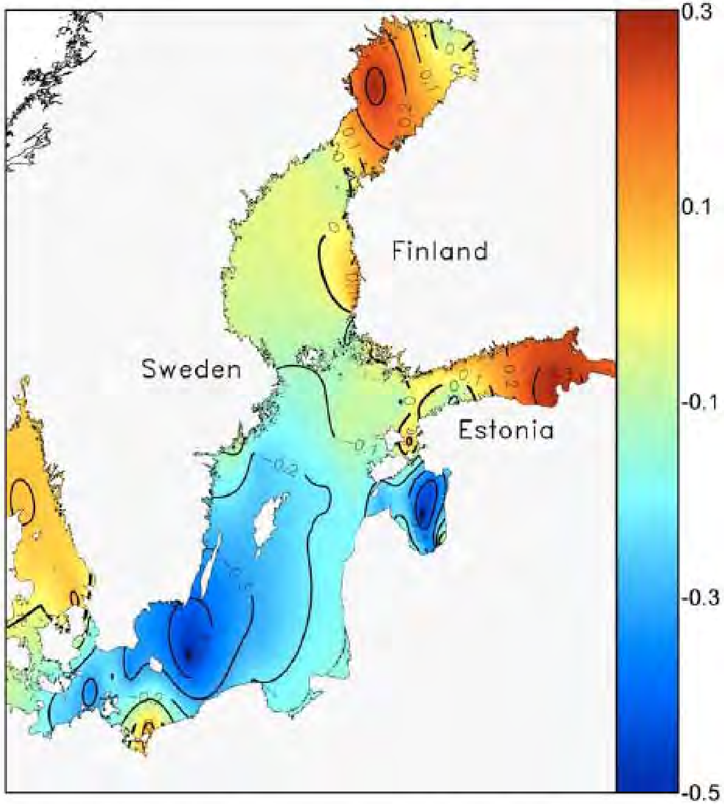
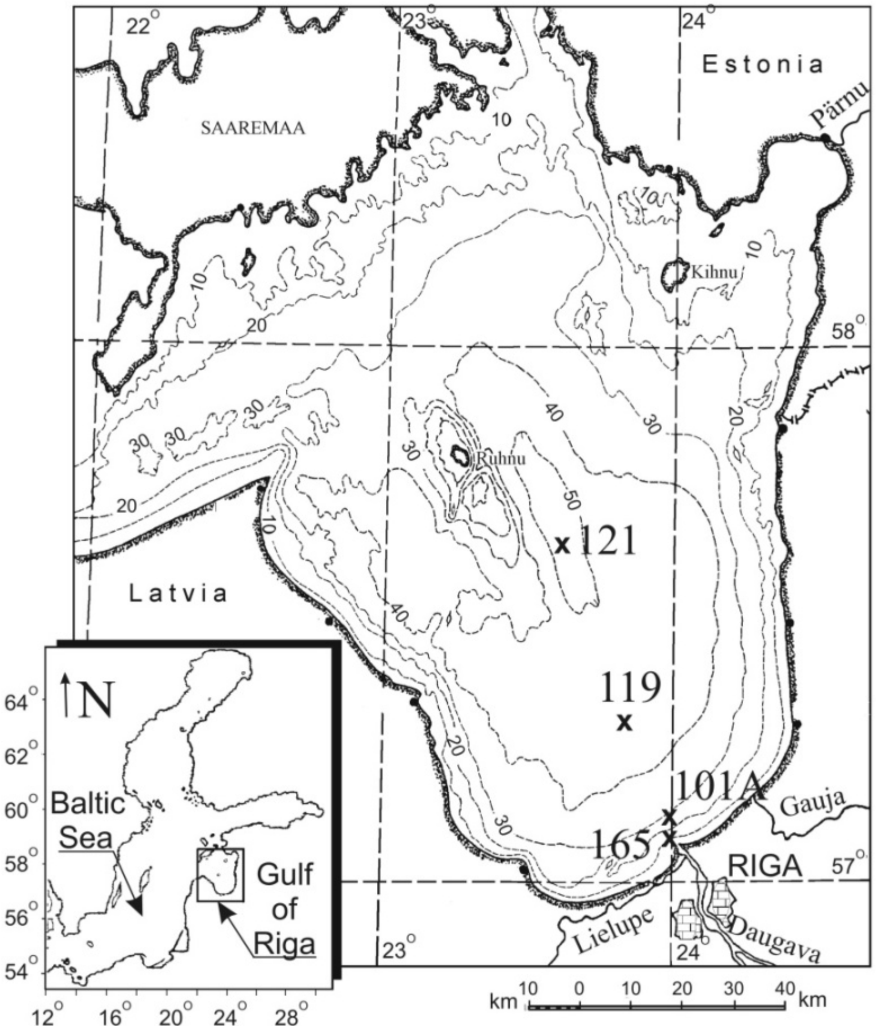
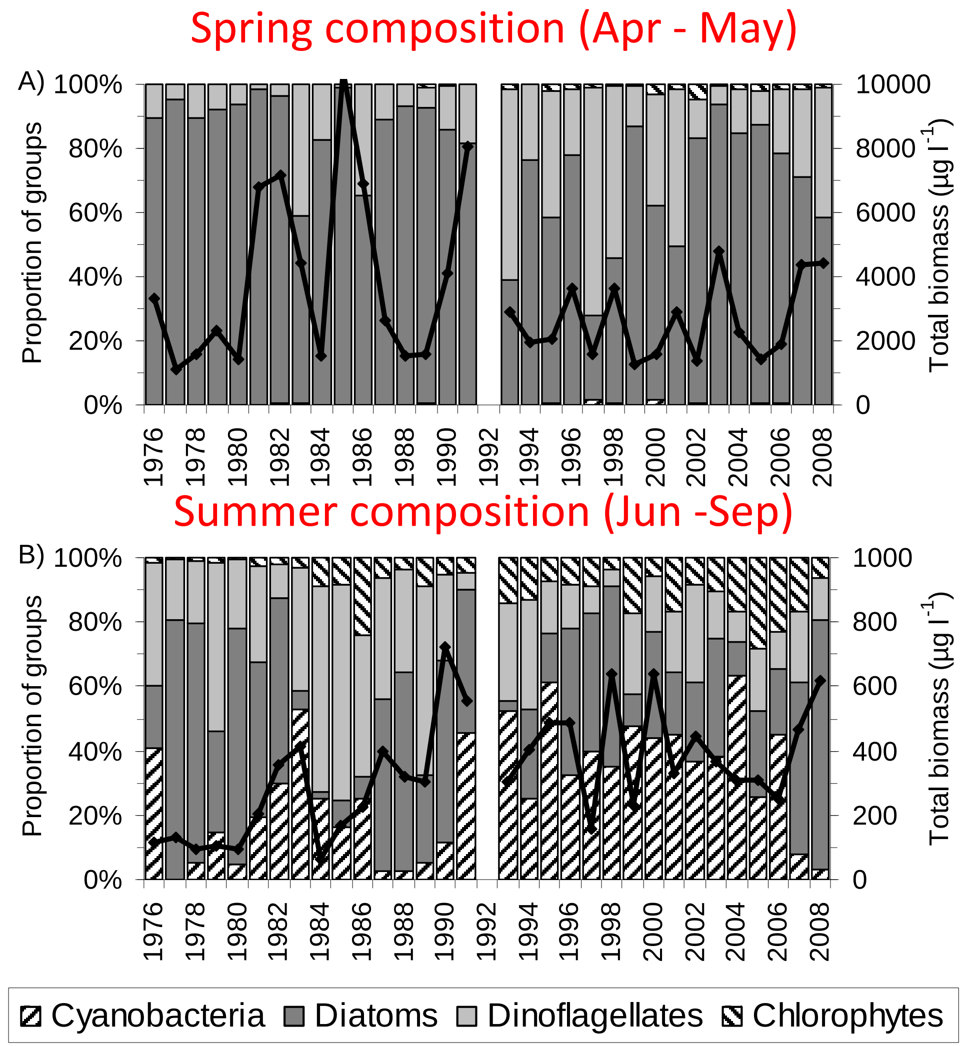


Figure 5. Shifts in the proportion of dinoflagellates over the period of ten years (1995 to 2004). The predictions were made by geographically weighted linear regression and interpolated with ordinary kriging. Positive and negative values represent the areas of increasing and decreasing dinoflagellate proportion, respectively. Thick contour lines denote boundary between areas of increasing and decreasing trend.

doi:10.1371/journal.pone.0021567.g005

Long-term changes in phytoplankton composition in the Gulf of Riga (1976-2008)

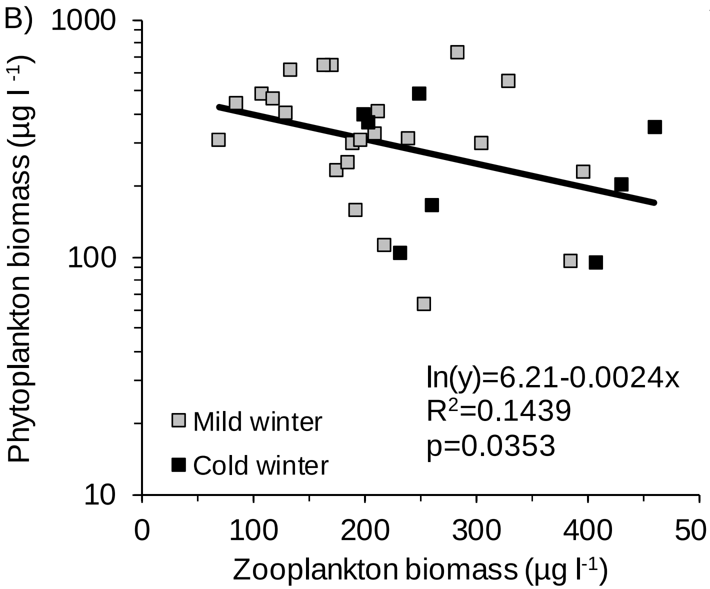




Jurgensone et al. (2011) Estuaries & Coasts

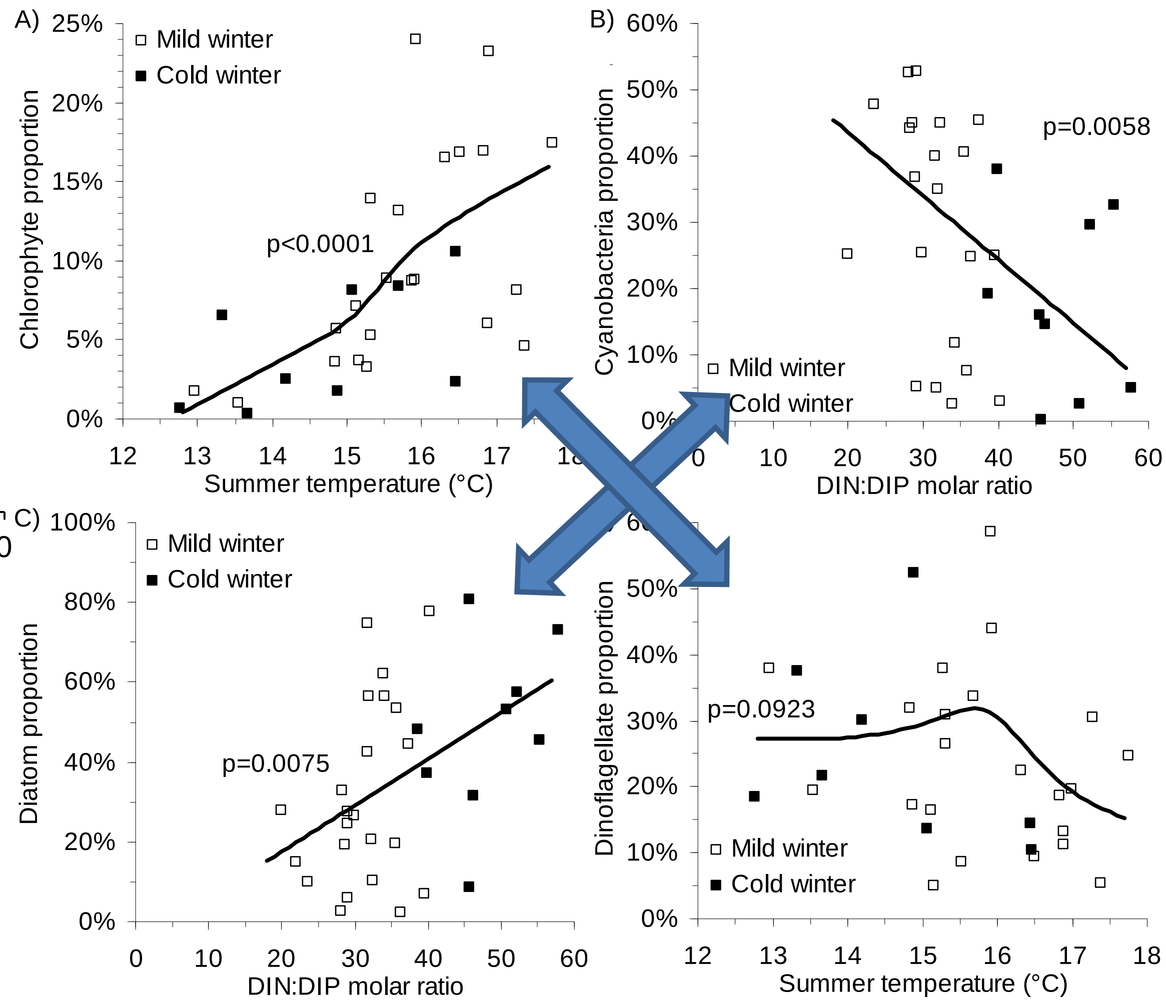
Summer phytoplankton community (Jun-Sep)

Biomass



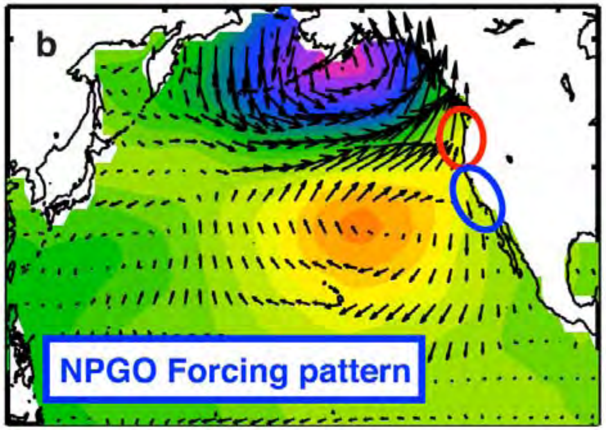
The ***biomass*** *of the summer phytoplankton community was mainly* ***controlled by pelagic grazing****,* ***which has declined over the period due to overfishing***

Composition



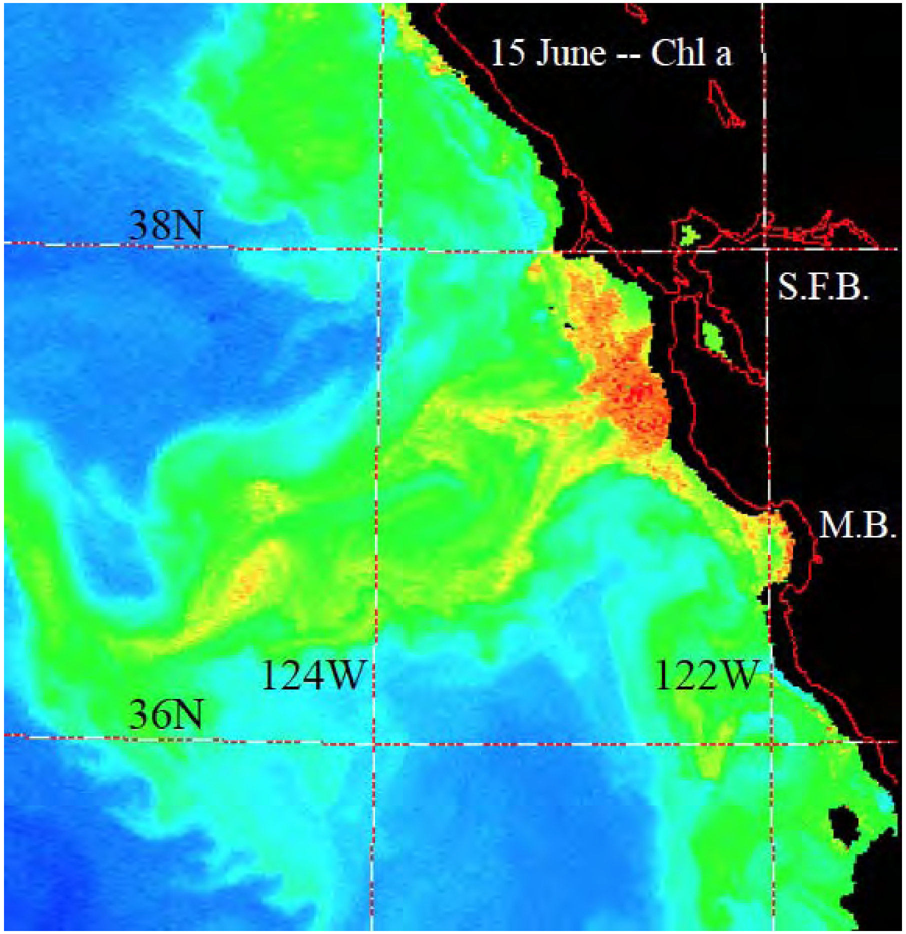
Low ***DIN:DIP ratios*** *favors cyanobacteria and* ***increasing temperatures*** *cause a shift from dinoflagellates to chlorophytes*

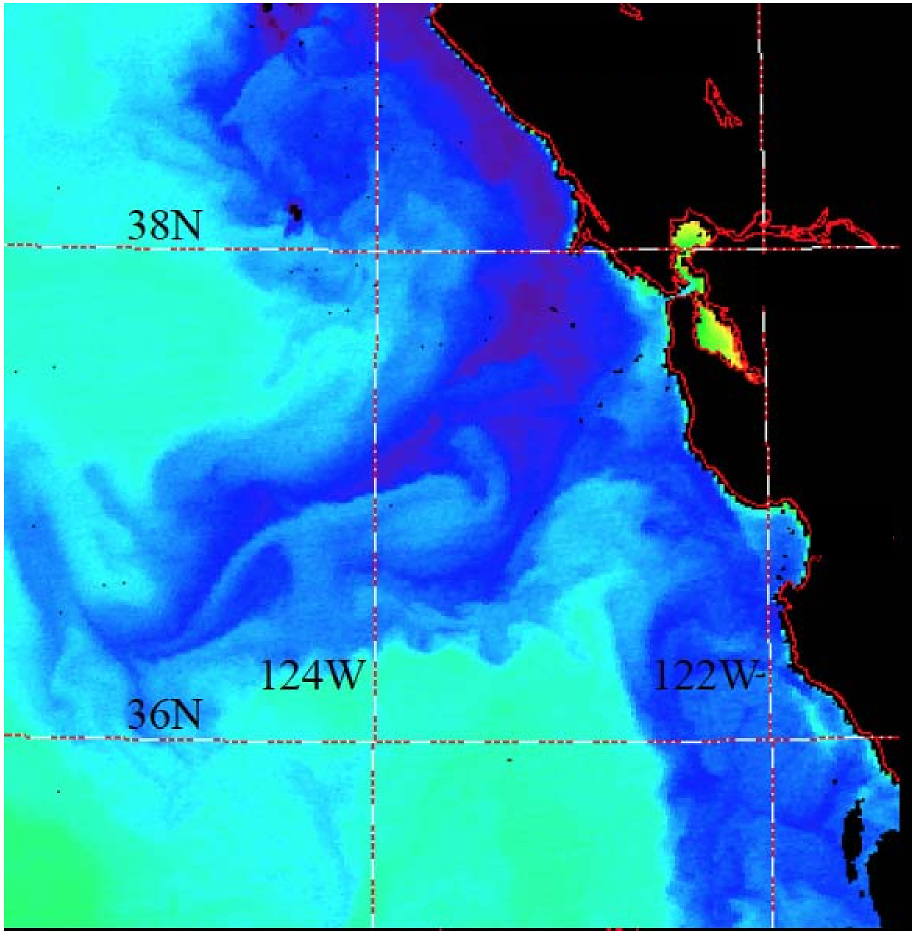
Jurgensone et al. (2011) Estuaries & Coasts



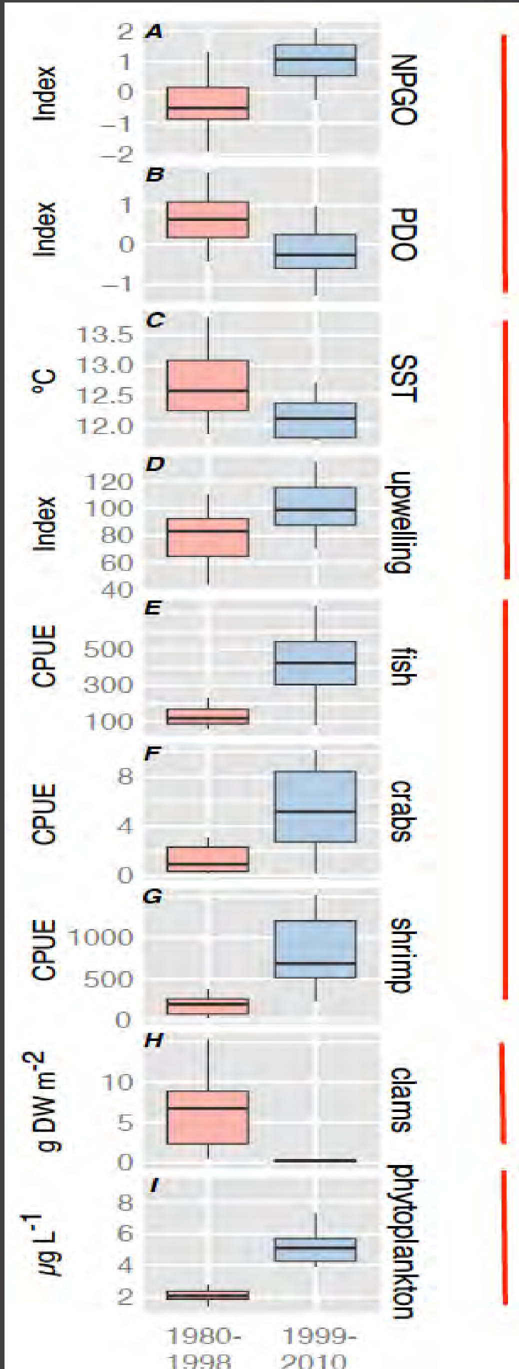
Climatically-driven Changes on Coastal Upwelling due to shifts in North Pacific Gyre Oscillation Effects on San Francisco Bay, CA

Biological ramifications?

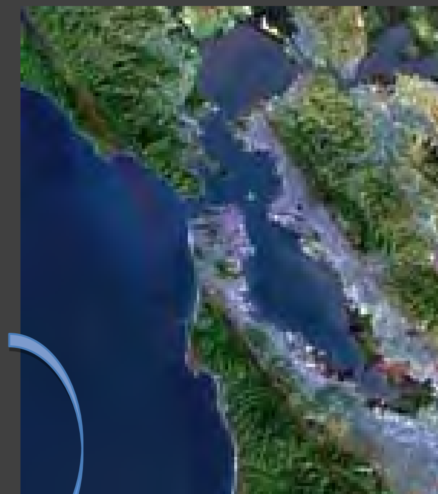




A Climate-Driven Trophic Cascade in San Francisco Bay



NE Pacific shifted to its cool phase (+NPGO/ -PDO) after 1998

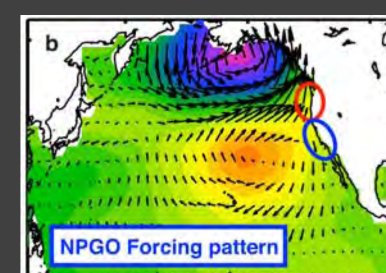


Intensified upwelling and primary productivity in coastal waters adjacent to SF Bay

Immigration of record-high numbers of marine shrimp, juvenile flatfish & crabs (benthivores)

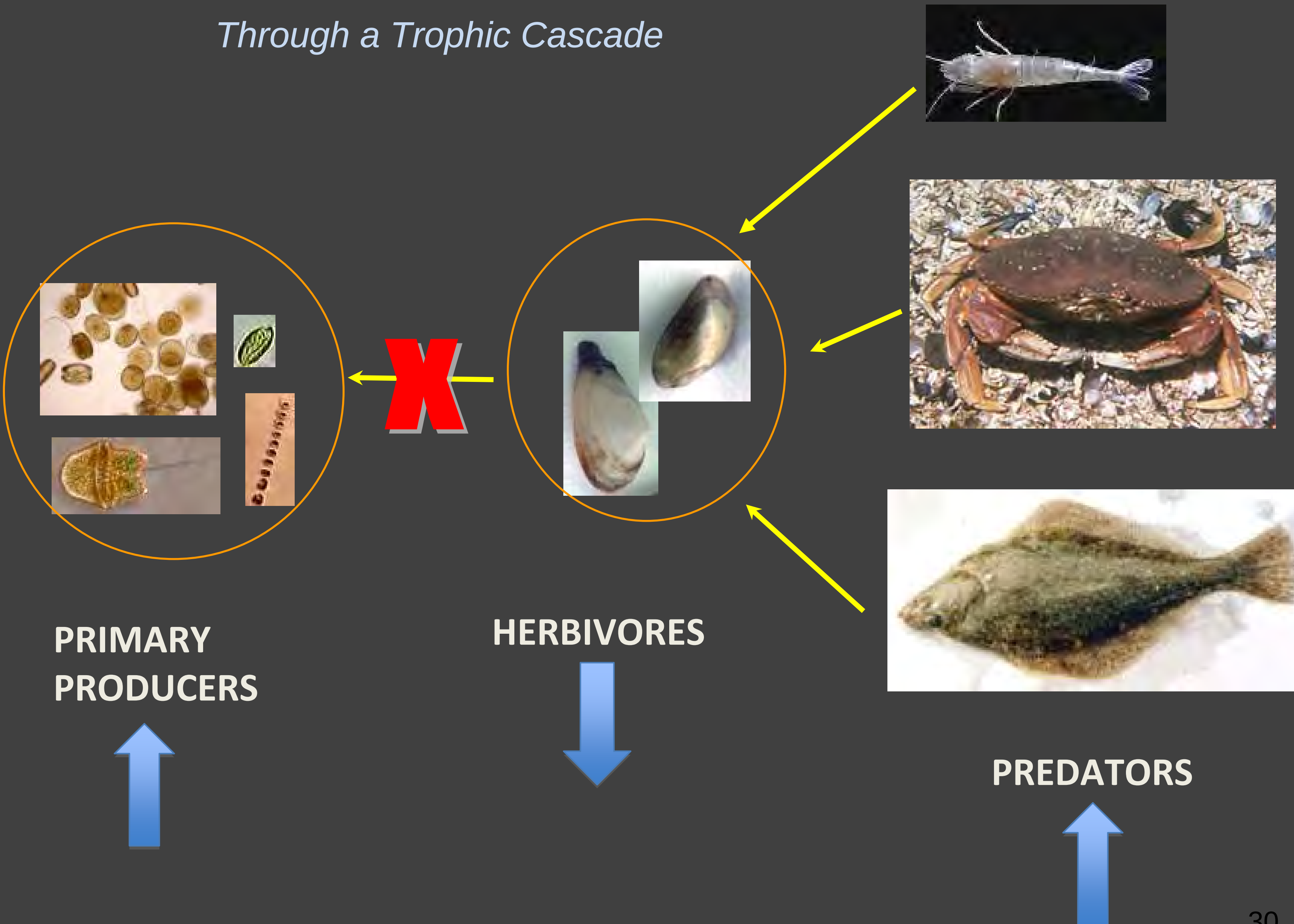
Disappearance of bivalve suspension feeders

Increased phytoplankton biomass

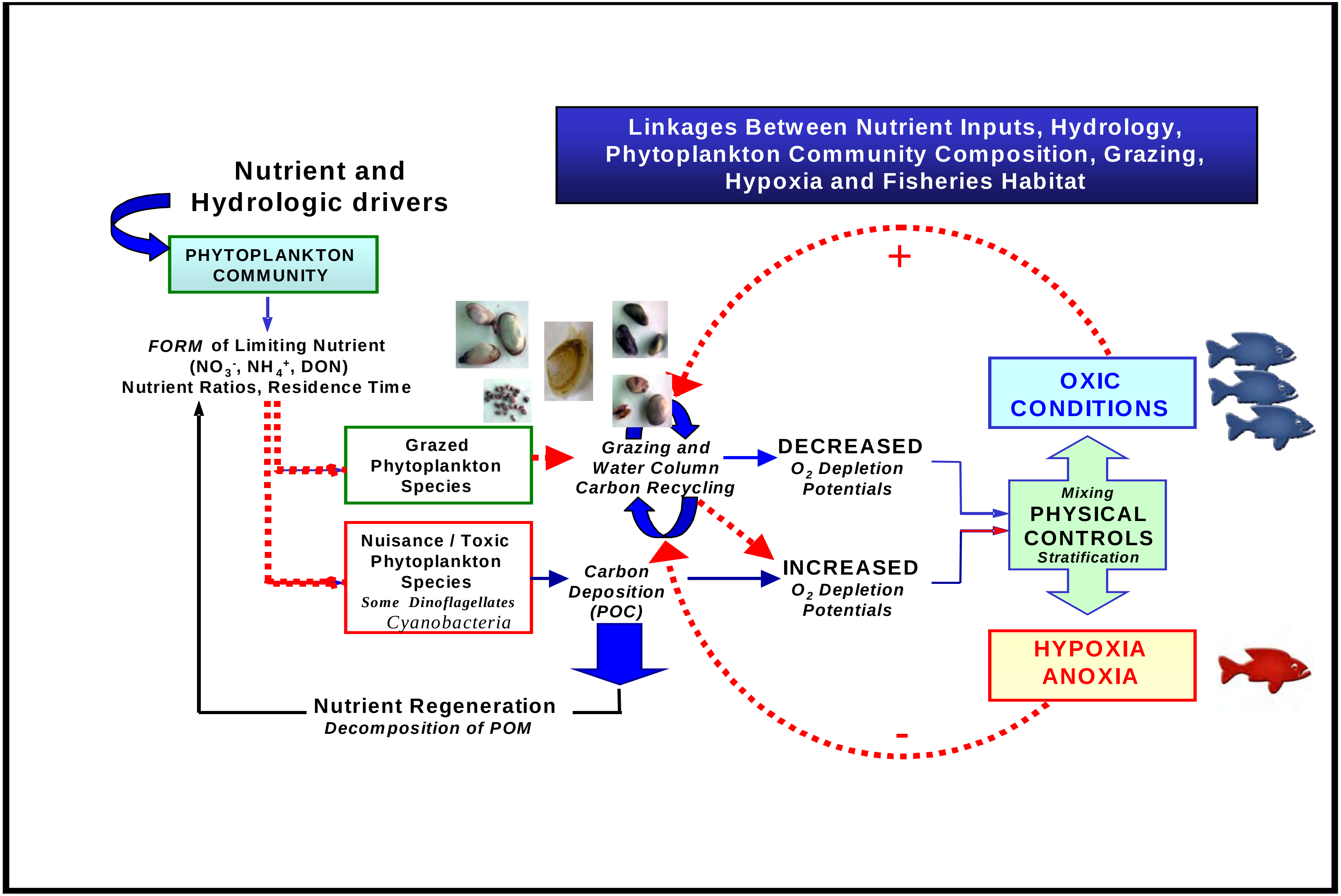


Cloern & Jassby 2012

Through a Trophic Cascade

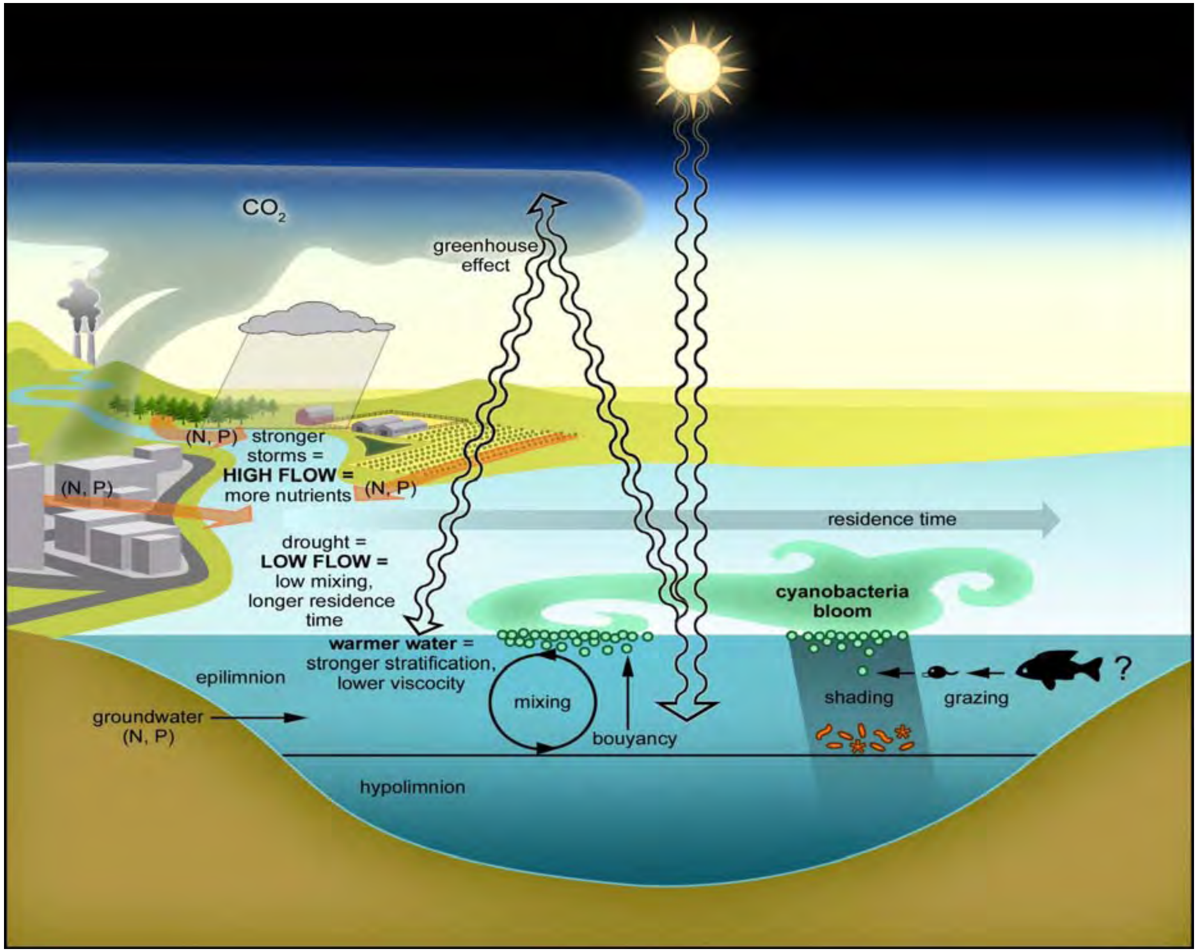


Scaling up to the Ecosystem



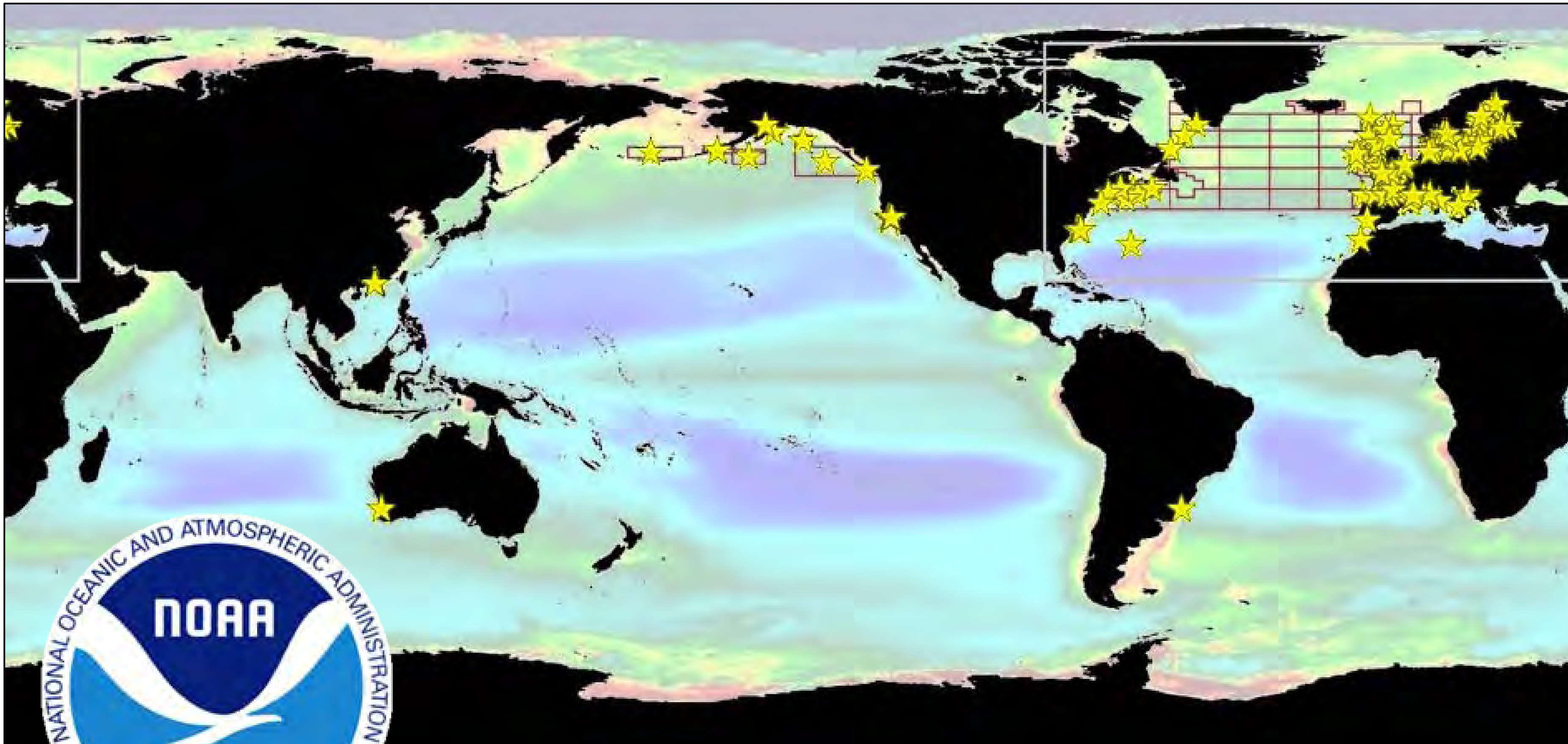
Conclusions (for now)

- Strong interactions between climatic, nutrient and "top down" factors control coastal ocean phytoplankton dynamics.
- Residence time and ocean-estuary exchange (flushing, transport) determines sensitivity to eutrophication, biogeochemical/trophic changes.
- Nutrient input-phytoplankton growth & bloom thresholds need to incorporate effects of climate change (warming, precip., stratification).

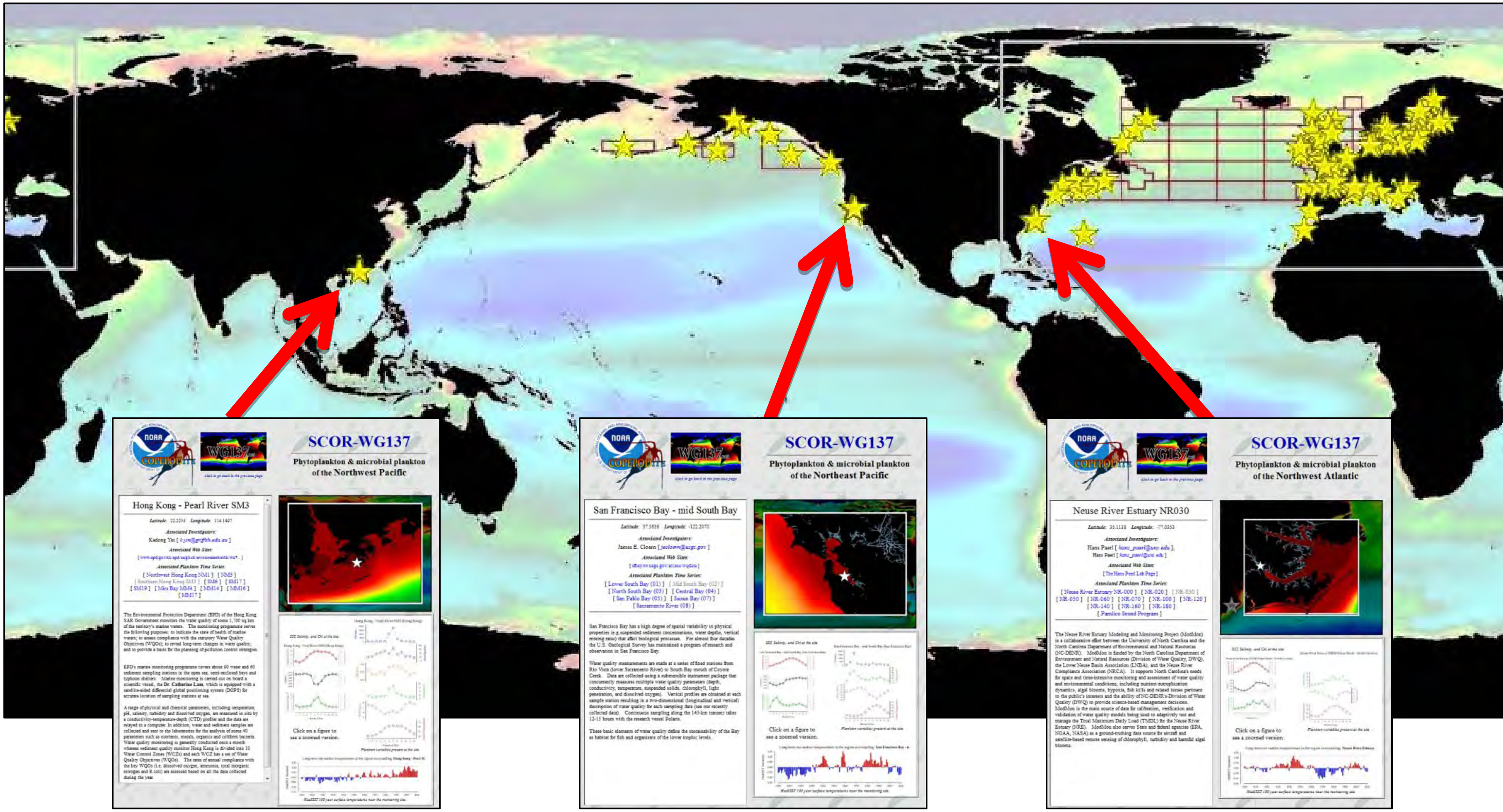


http://wg137.net/

WG 137 Data Management & Website



- The bulk of WG137's data is being managed with the *COPEPOD Interactive Time-series Explorer* (**COPEPODITE**) data system.
- The data handling process involves the transformation of hundreds of raw data files into a common format, common units, and indexing via a standardized variable identity set.
- WG137 (*in cooperation with ICES-WGPME*) has assembled a database of over 150 phytoplankton sites.



- The WG137 web site (http://WG137.net) features an interactive map and searching tool that provides data and site contact information as well as a detailed graphical and text summary for each site participating in the WG137 study.

- As they become available, this site will also link to research results and publications.