# Ocean ecosystems and AMOC variability

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# Ecosystem variability plausibly tied to AMOC

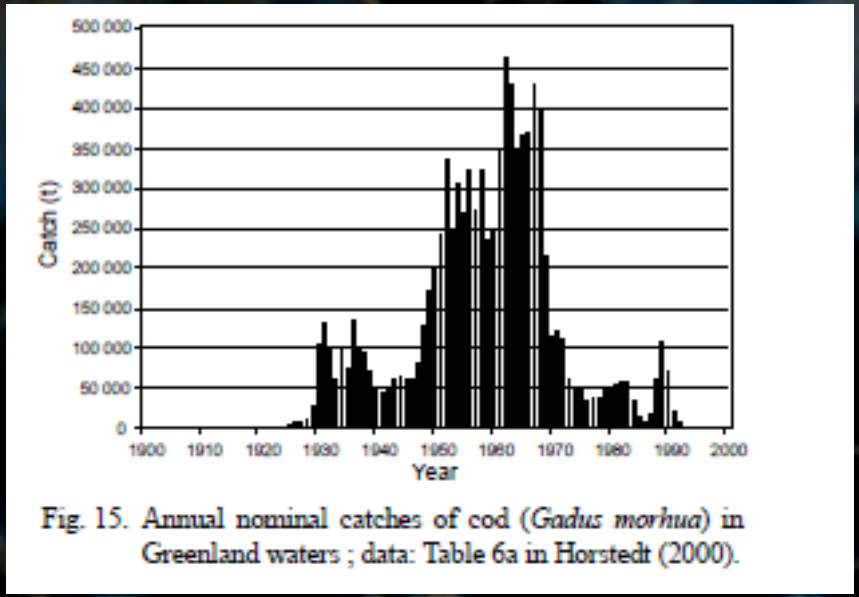
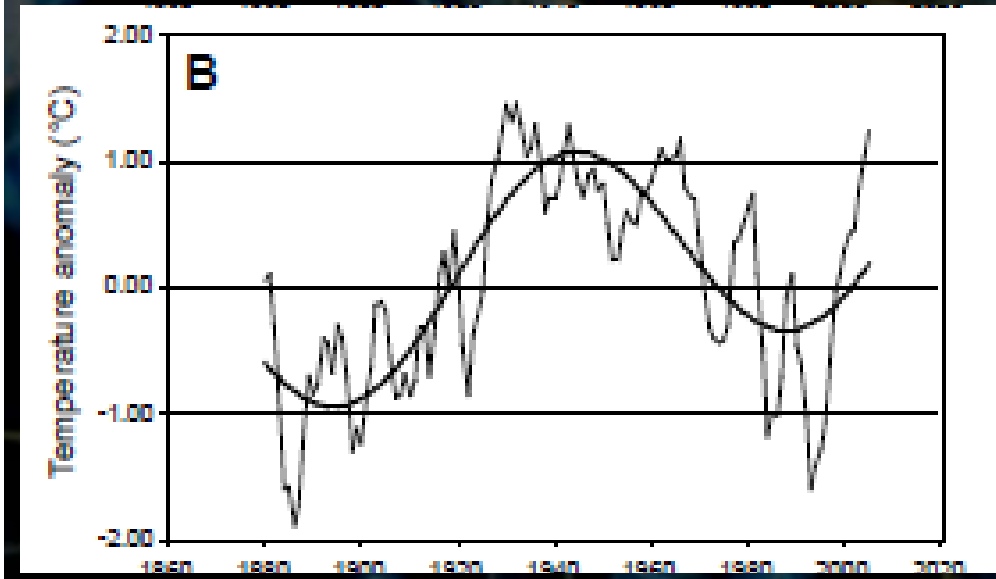



Fig. 15. Annual nominal catches of cod (*Gadus morhua*) in Greenland waters ; data: Table 6a in Horstedt (2000).

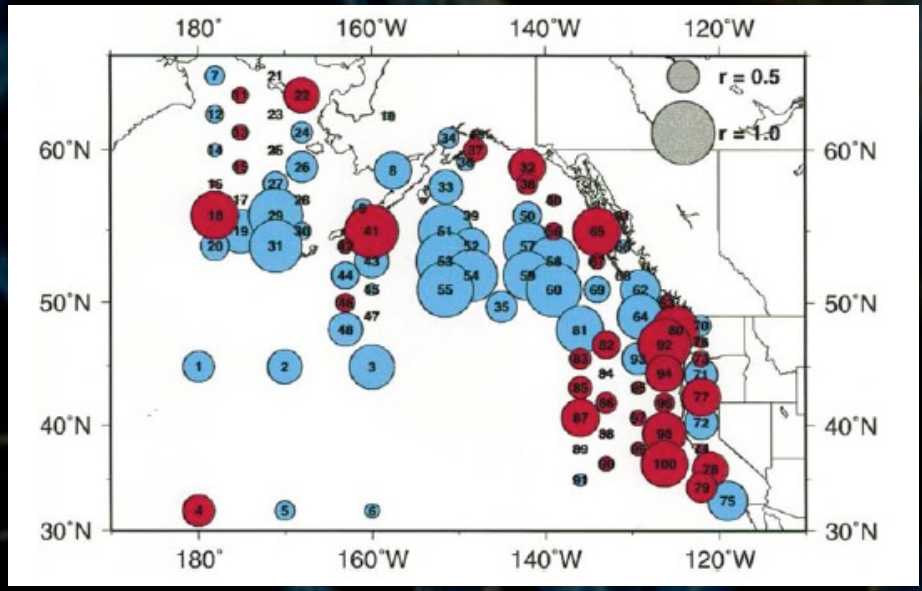



Stein, J. Northw. Atl. Fish. Sci., 2007

Suggests changes in mixing might be involved, with linkage to Atlantic Multidecadal Oscillation (AMO).

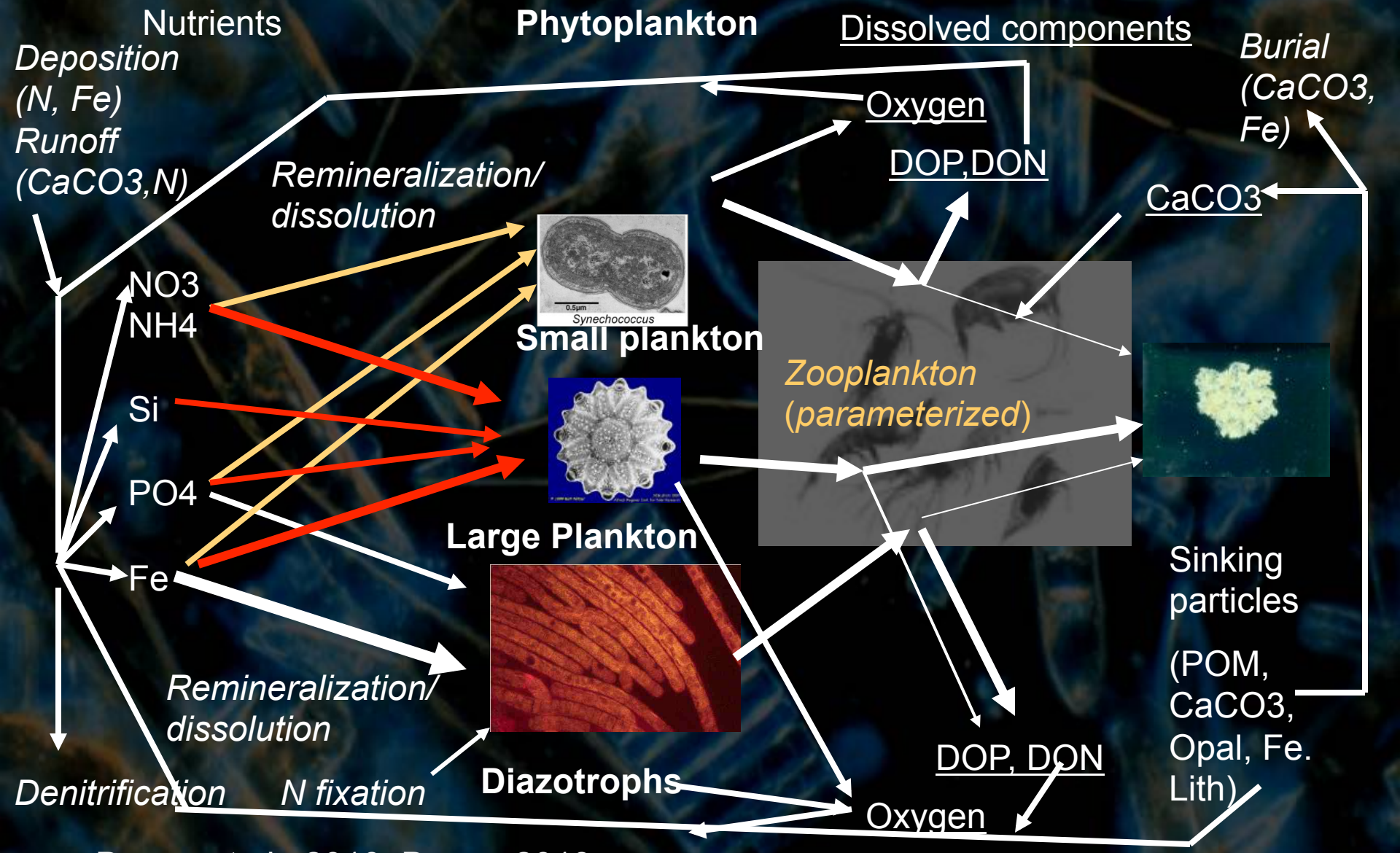
# Paradigmatic regime shift: North Pacific

- Regionally coherent
- Temporally closely spaced
- Results seen across multiple trophic levels.
  - Turtles
  - Salmon
  - Pacific halibut
  - CalCOFI zooplankton



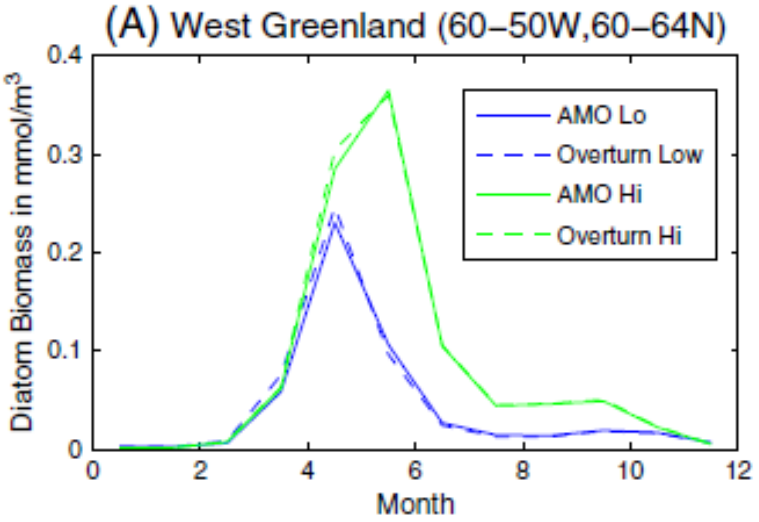

Hare and Mantua, Progr. Oceanog. 2000

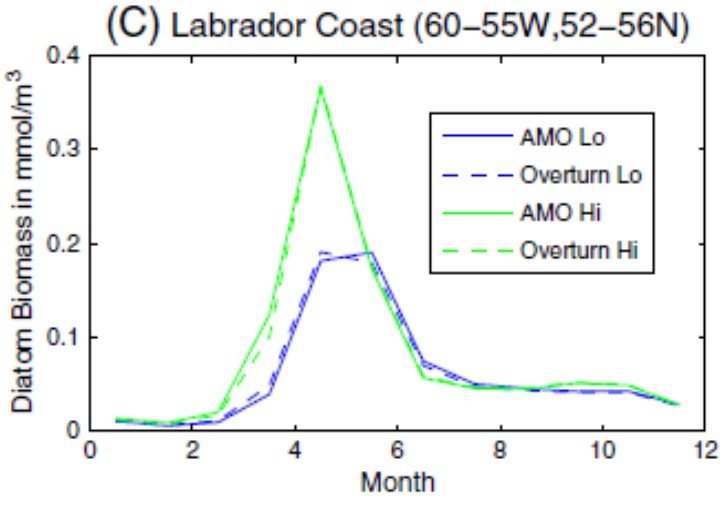
# GFDL's Ocean BGC model (TOPAZ)




Dunne et al., 2010, Dunne 2013.

# West Greenland vs. Labrador




Higher biomass throughout spring/fall
Similar signal for overturning, AMOI.

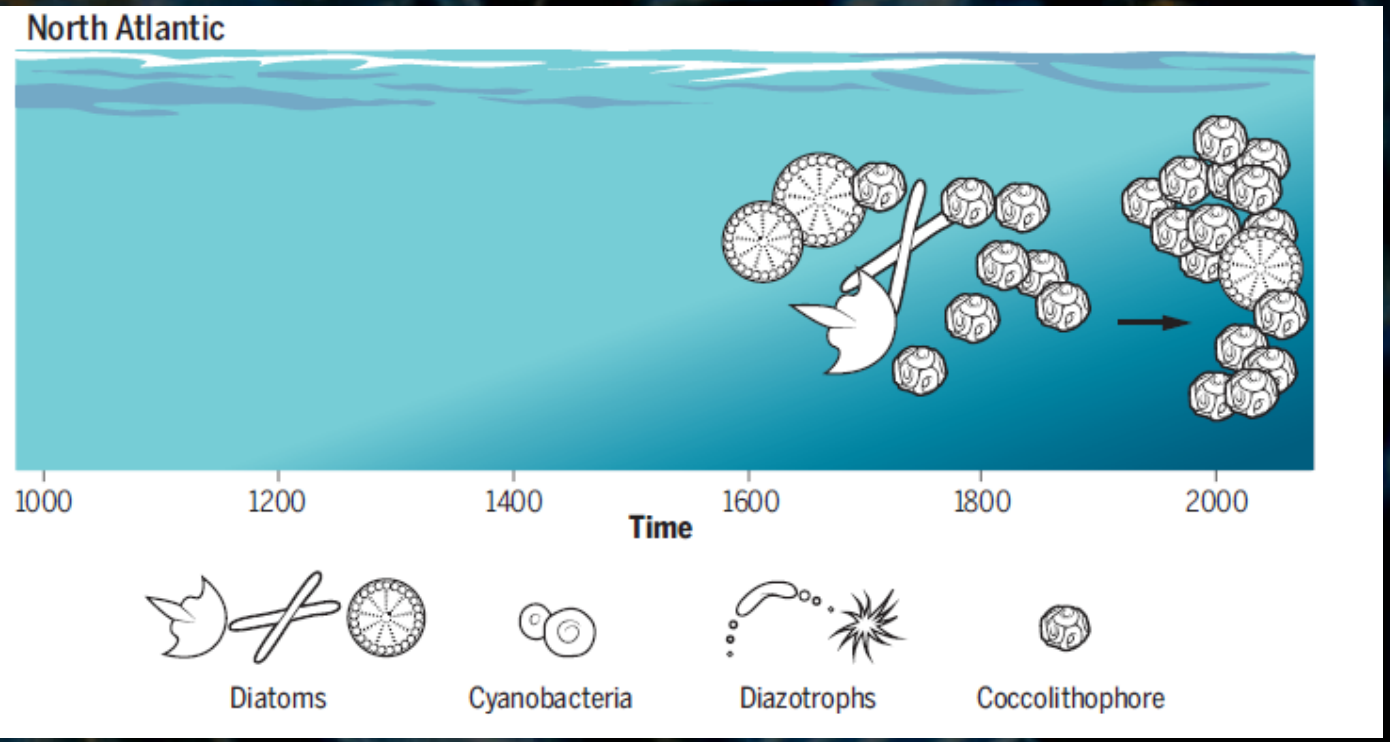
Driven by higher nutrients associated with deep convection.

Higher biomass during spring
Similar signal for overturning, AMOI.

Driven by higher light associated with warming.

Gnanadesikan, Dunne and Msadek, J. Mar. Sys., 2014

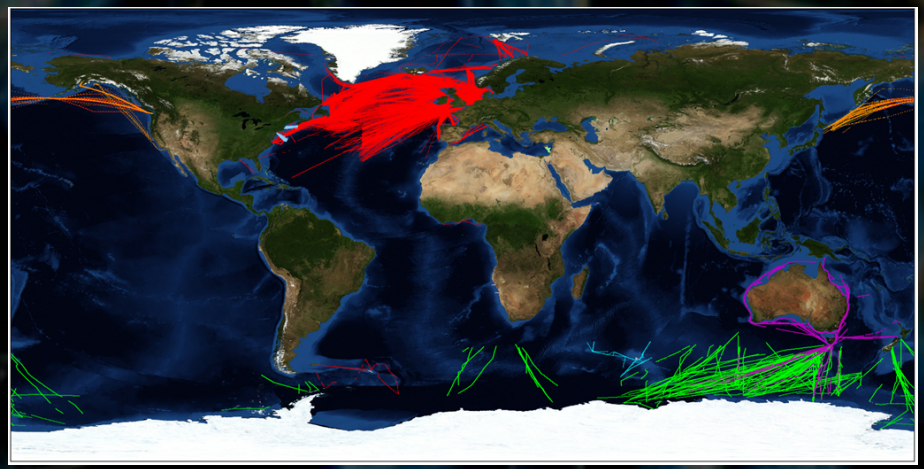
# What do observations show?



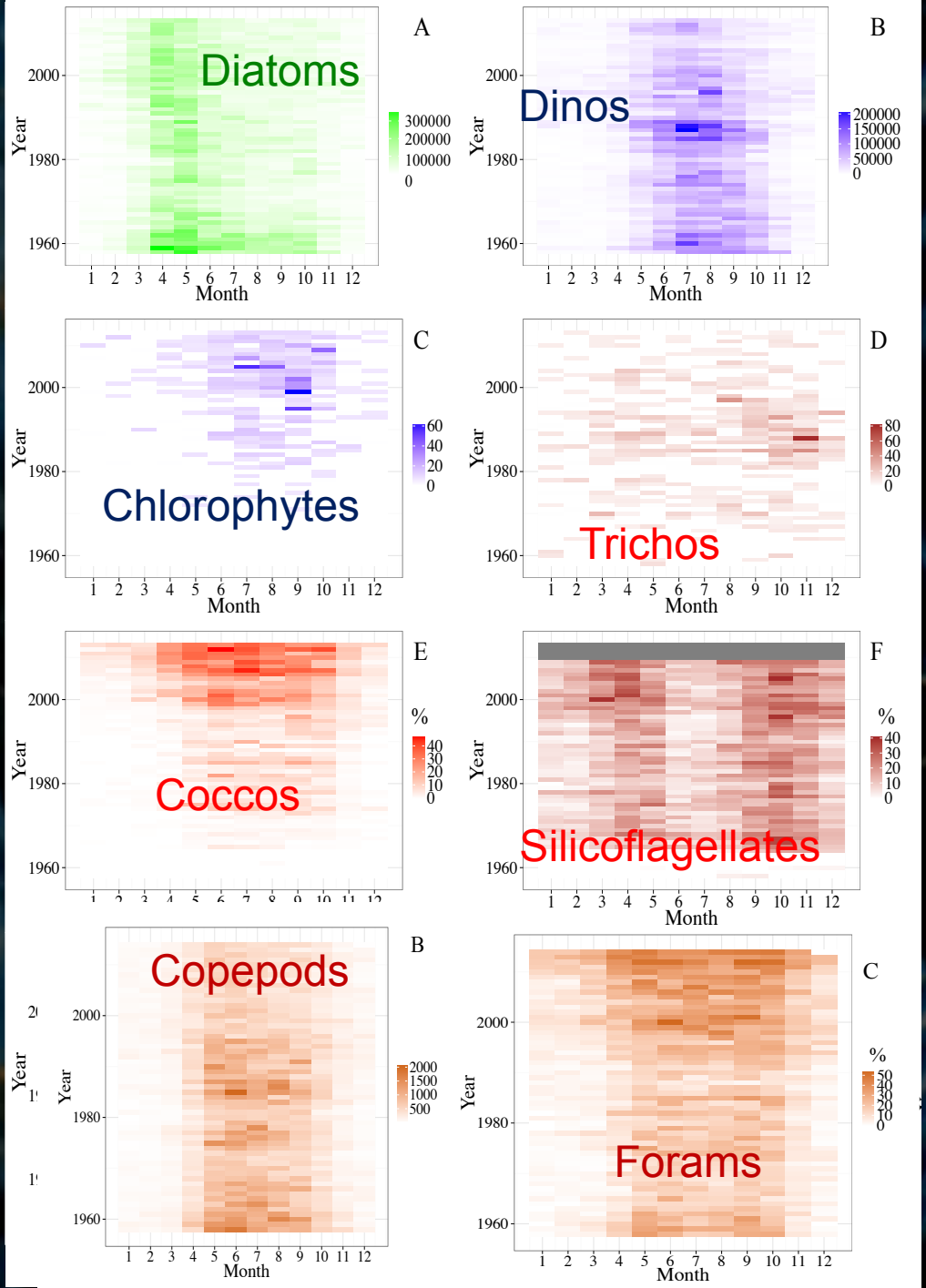

How are functional groups of phytoplankton changing over N. Atlantic?

Vogt, Science, 2015

# Dataset- Continuous Plankton Recorder dataset

www.safhos.ac.uk




# Seasonal Dependence

Different seasonal cycles match standard picture of North Atlantic bloom.

Overall magnitudes change… but at different times.

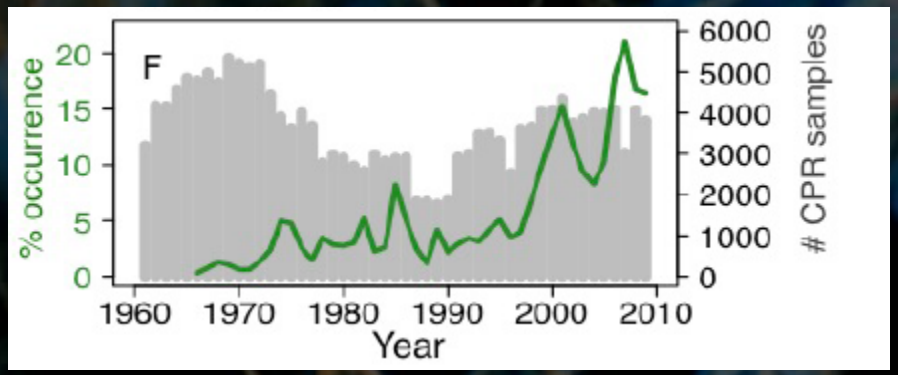
-Diatoms high at beginning, drop by 1970s.

-Dinos also drop but return in 1990s

-Copepods drop around 2000

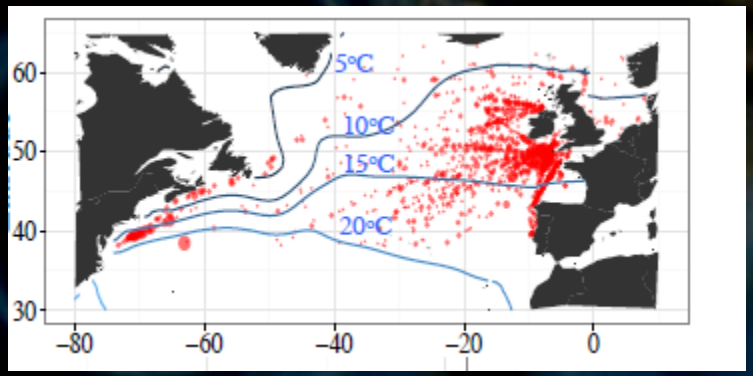
-Forams increase around 2000

# Large-scale summary




Rivero-Calle et al., Science, 2015

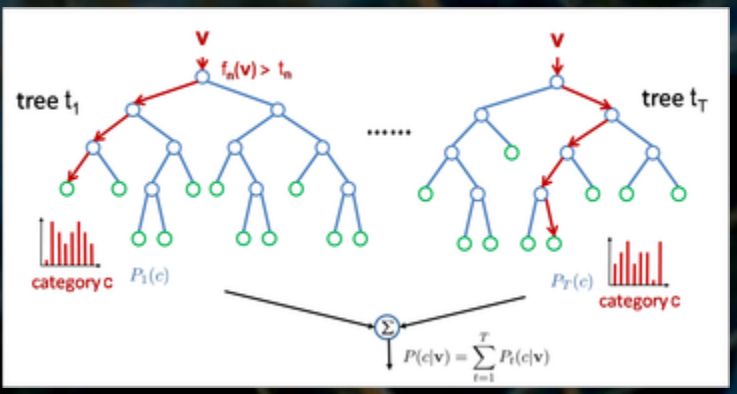
Probability of finding coccolithophores In N. Atlantic increases by an order of magnitude!

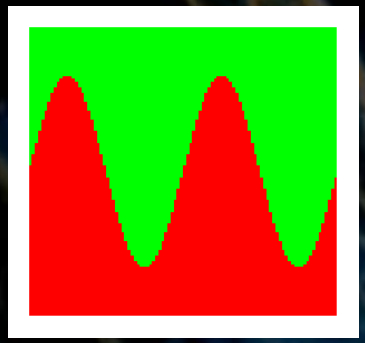


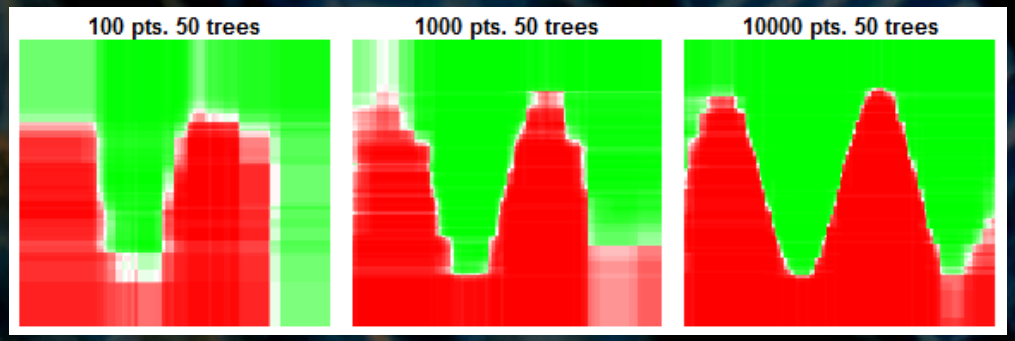

Rivero-Calle et al., GBC., 2016

Interdecadal variability of Trichodesmium in Bay of Biscay (high during the 1980s).

# Random forest

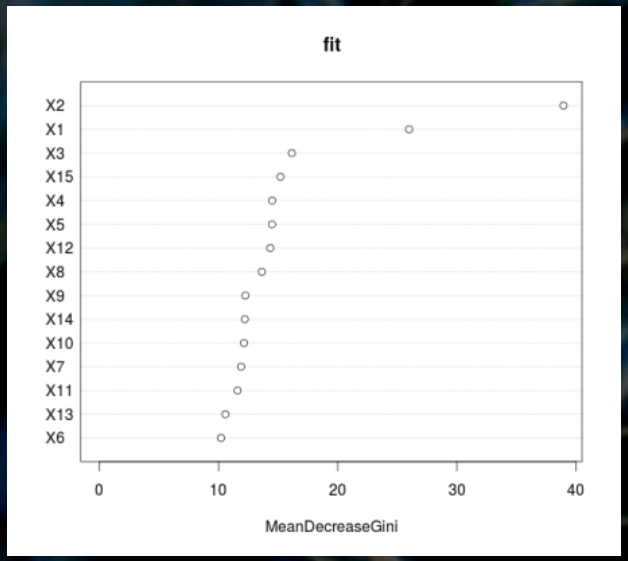


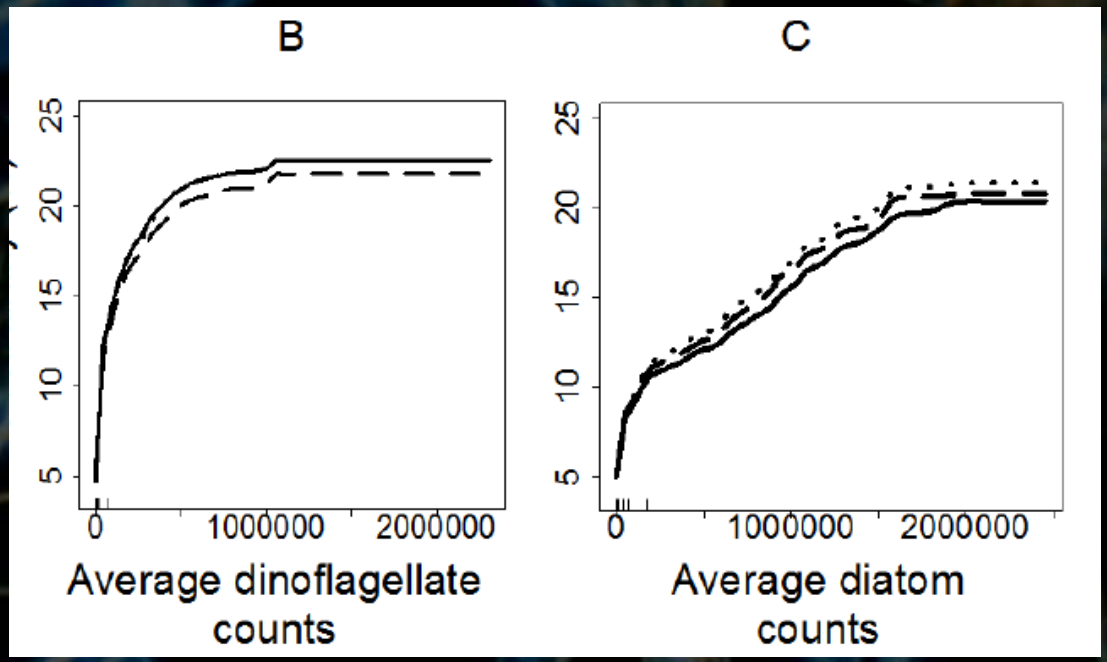






- Take a random subset of variables, data.
- Build a regression tree-subsetting data one variable at a time.
- Examine error in predicting points not included.
- Repeat over many trees.
- Aggregate results

# Output of analysis

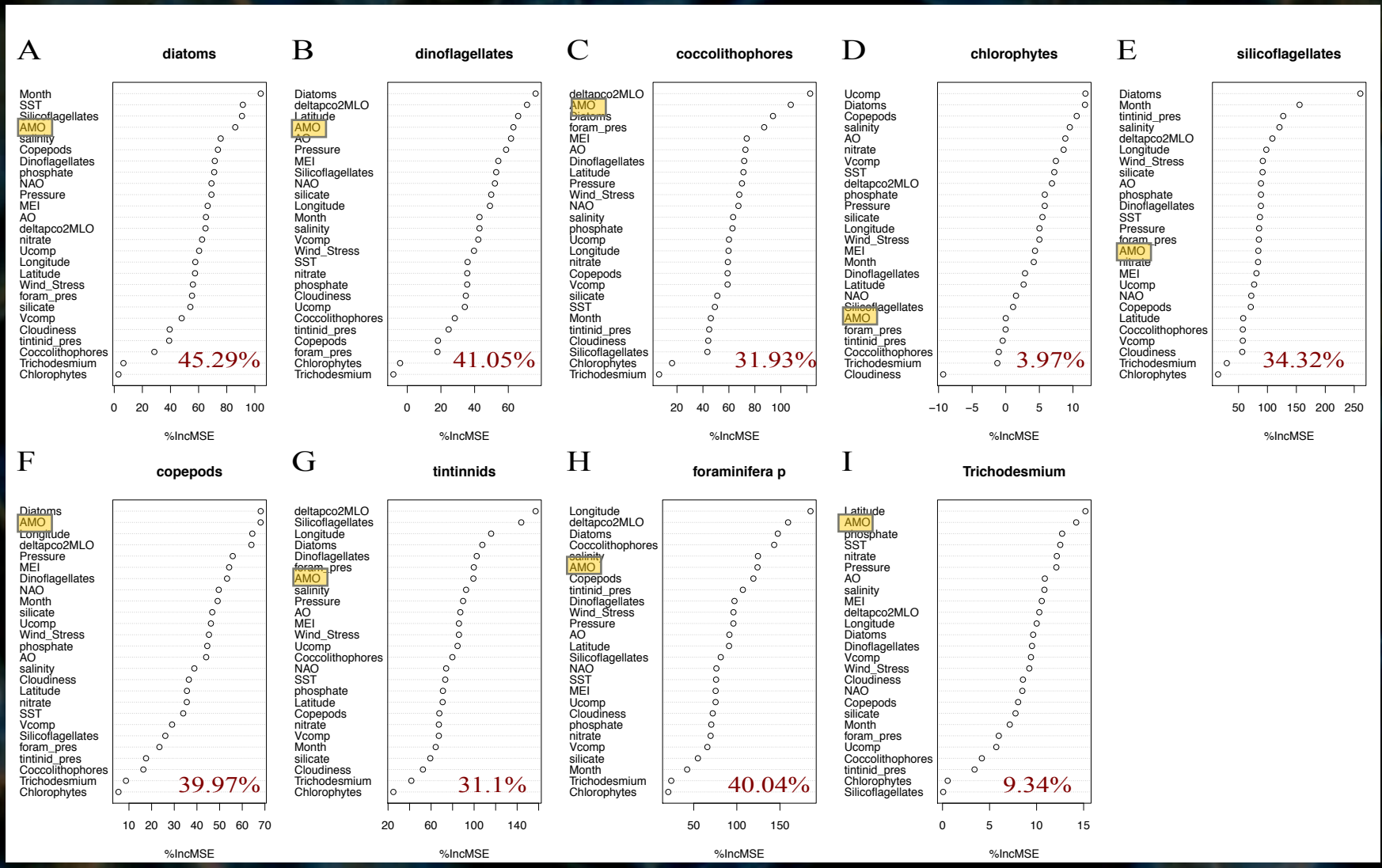


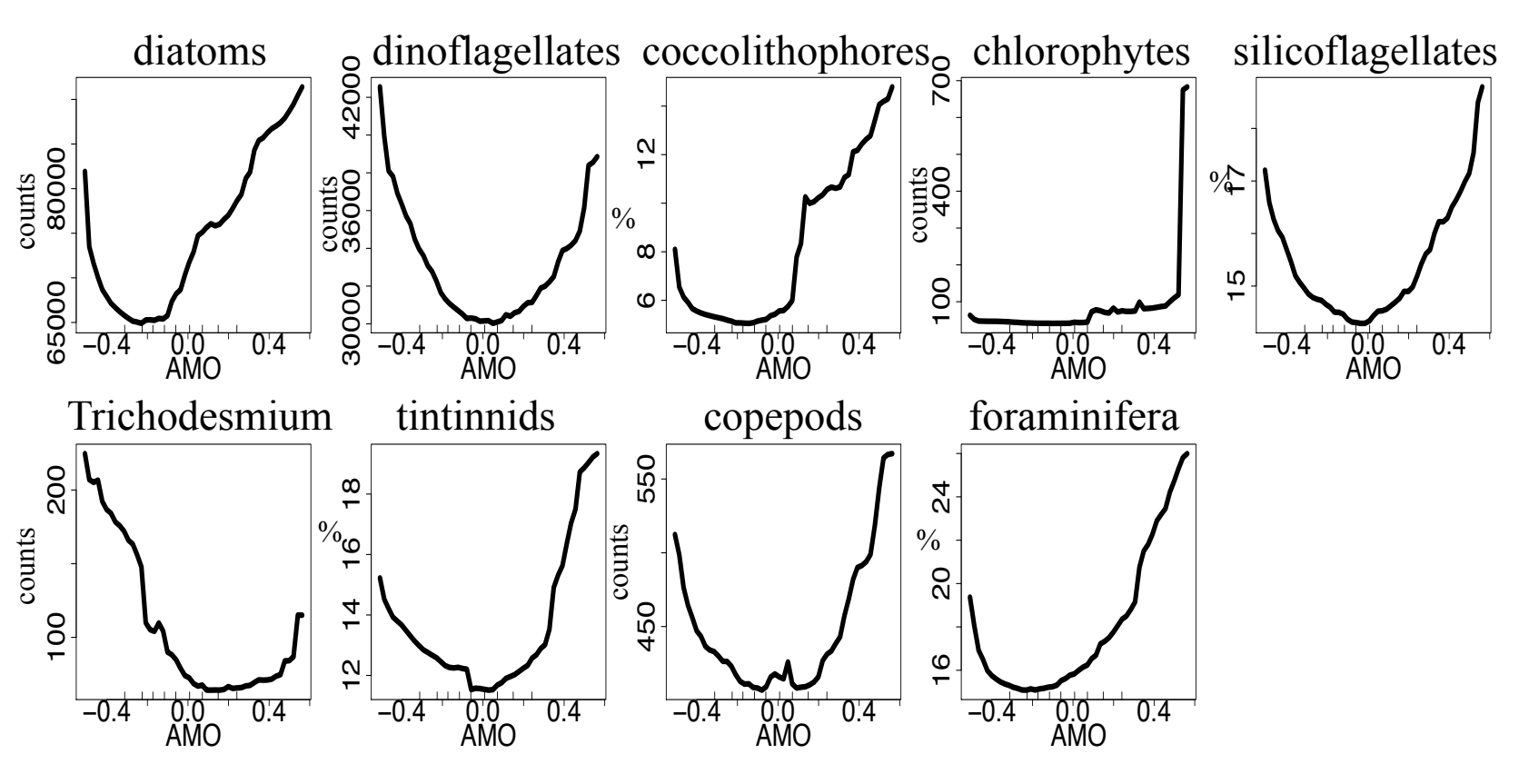

Variable importance plots show how often a variable is included/how much error eliminating it from the analysis causes

Partial dependence plots show nonlinear relationship between predictor and predictand.

# Overall dependence



# AMO partial dependence

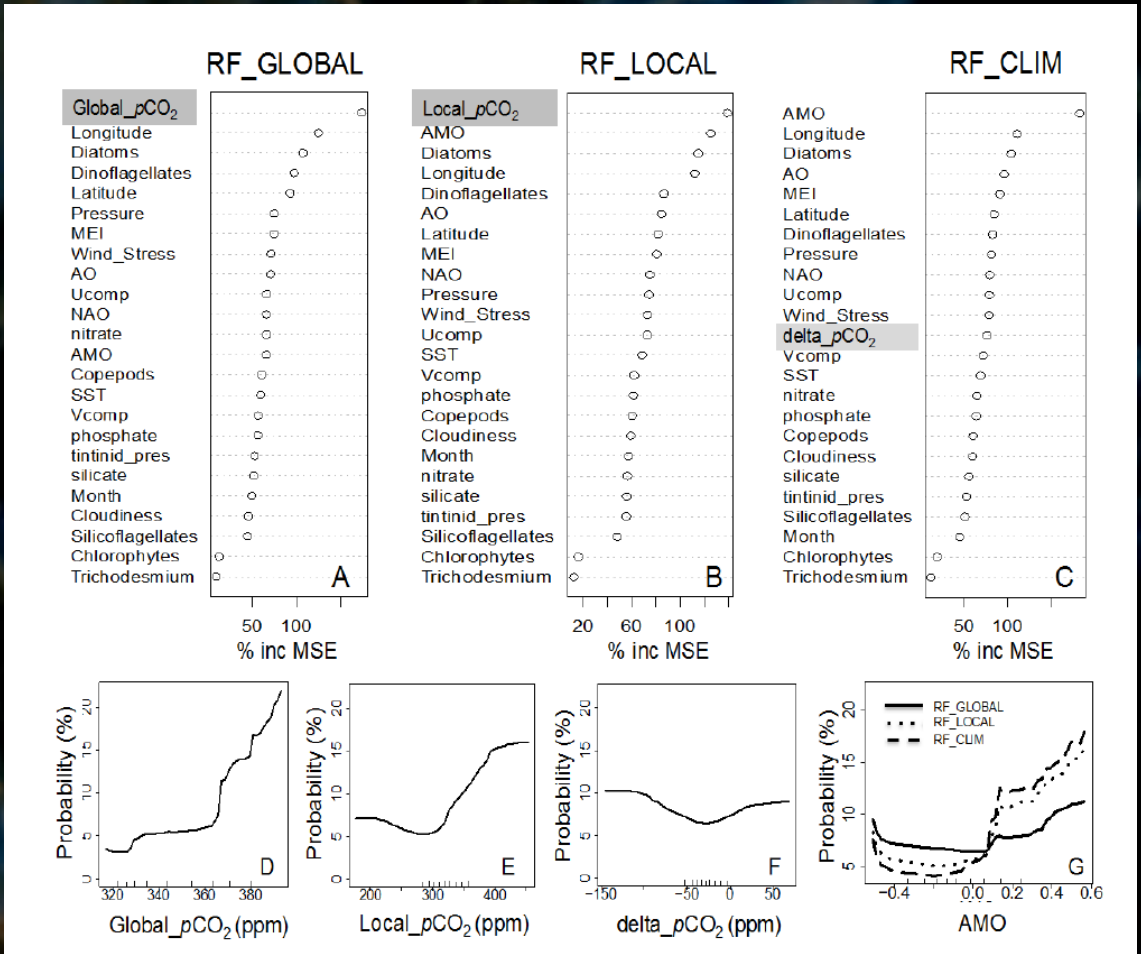



High values often at high *and* low values of AMO

# Conclusions

- Both models and observations link biological variability to the AMO… and thus implicitly to AMOC…
- But in some cases the key is convection, in others it's temperature.
- Linkages are likely to be dependent on region and functional group.
- No evidence at presence for a "regime shift" as has been seen in the Pacific.

# Carbon dioxide dependence




Trend is relatively robust.

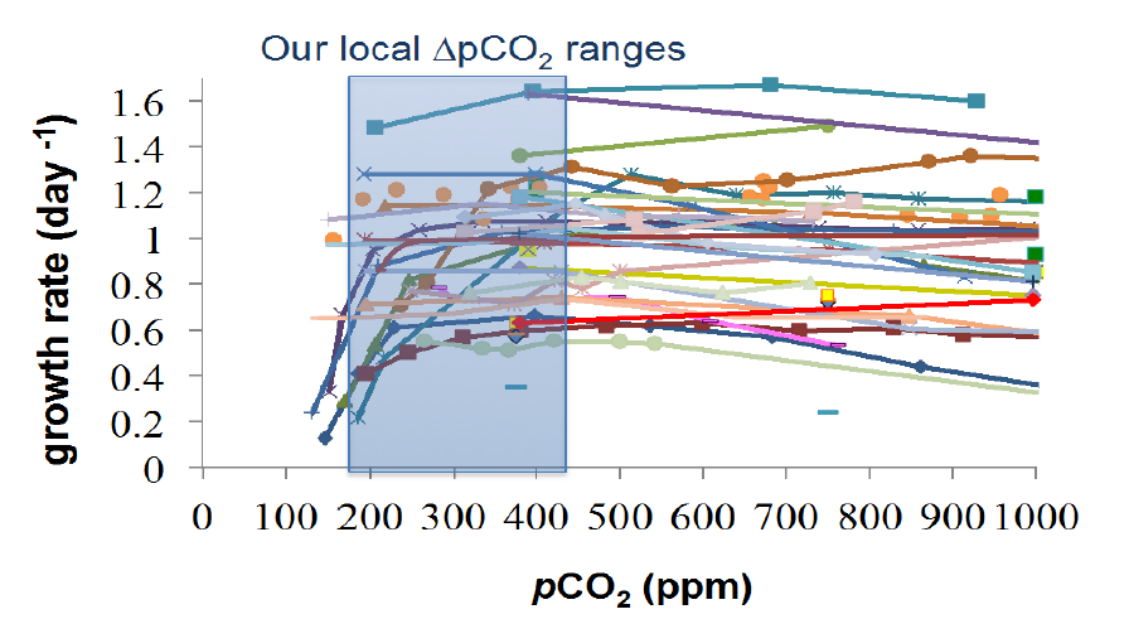
Local CO2 is a top predictor.

Roughly a factor of 3 increase attributable to increase in CO2 over fifty years.

Rivero-Calle et al., Science, 2015

# Compilation of laboratory datasets…

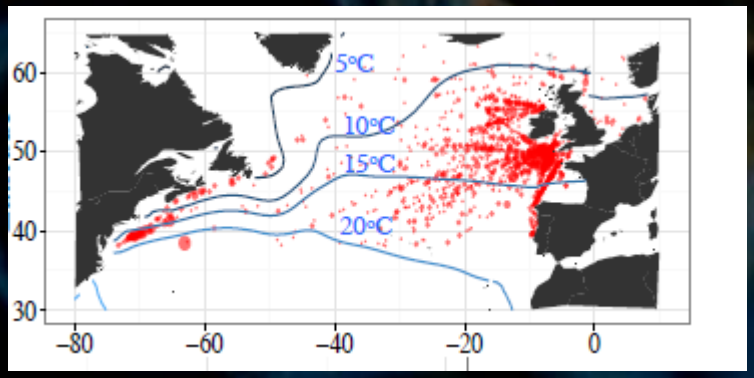
- Over pCO2 ranges seen in last 50 years over North Atlantic..

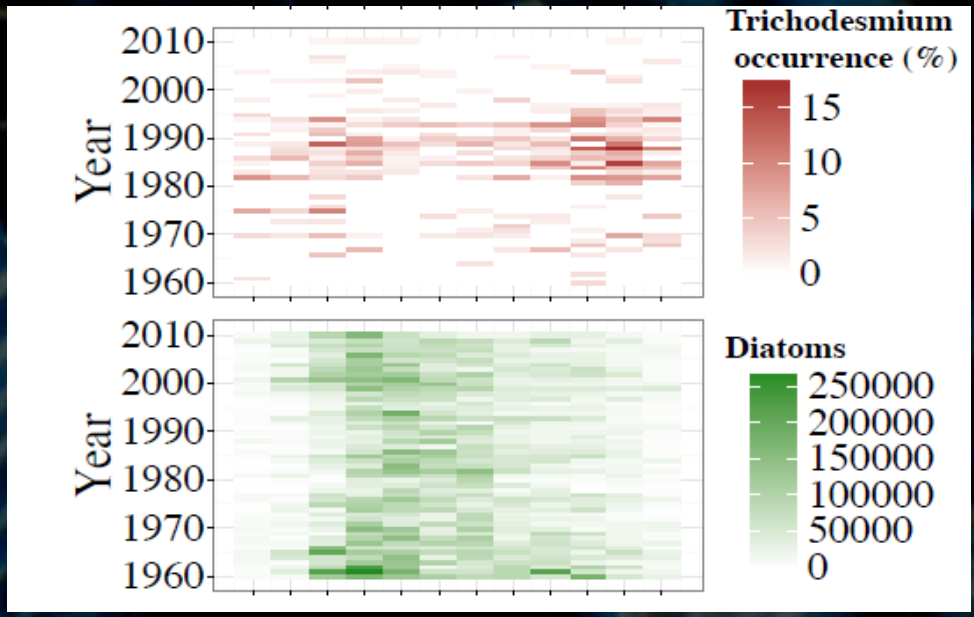


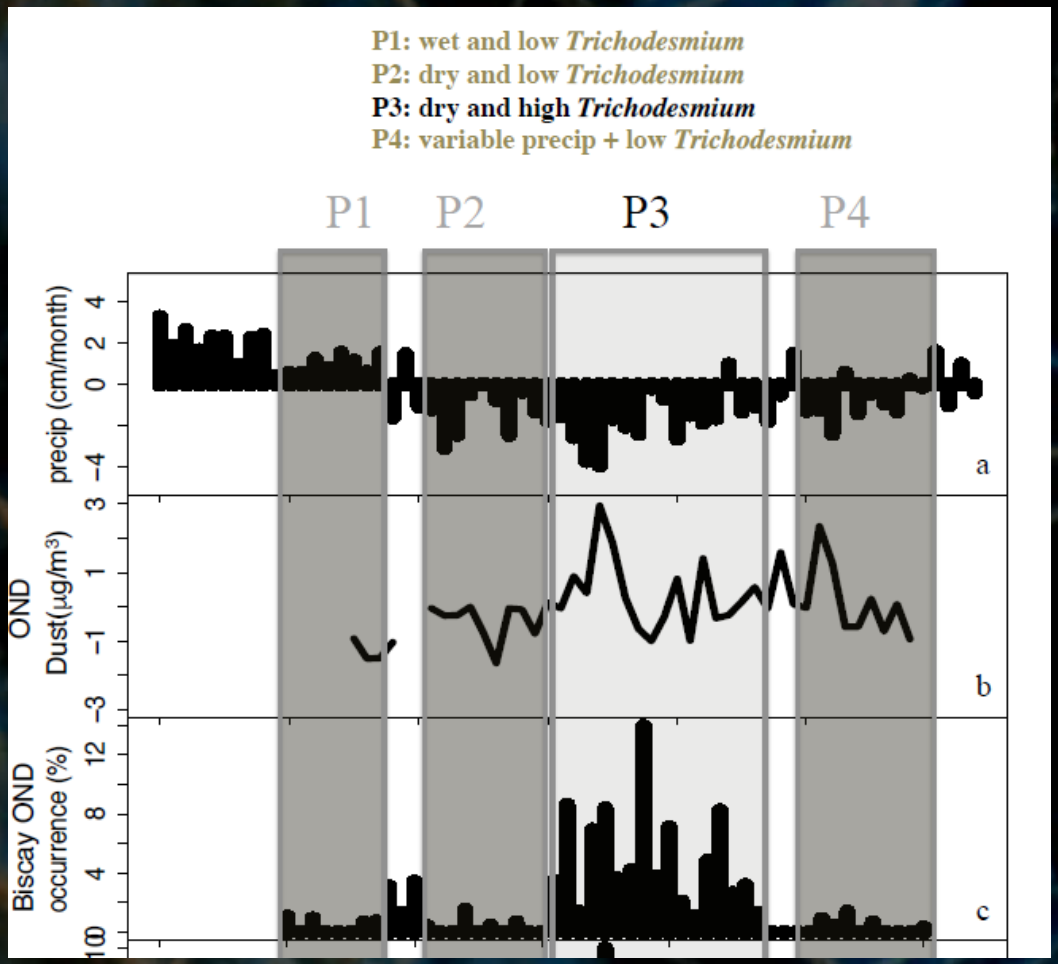

- A significant subset of laboratory measurements also show increase in growth

# Trichodesmium Variability

- Found in North Atlantic in relatively cold waters.
- Big increase in 1980s in Bay of Biscay- usually towards end of the year.
- Doesn't seem to correspond to changes in diatoms…



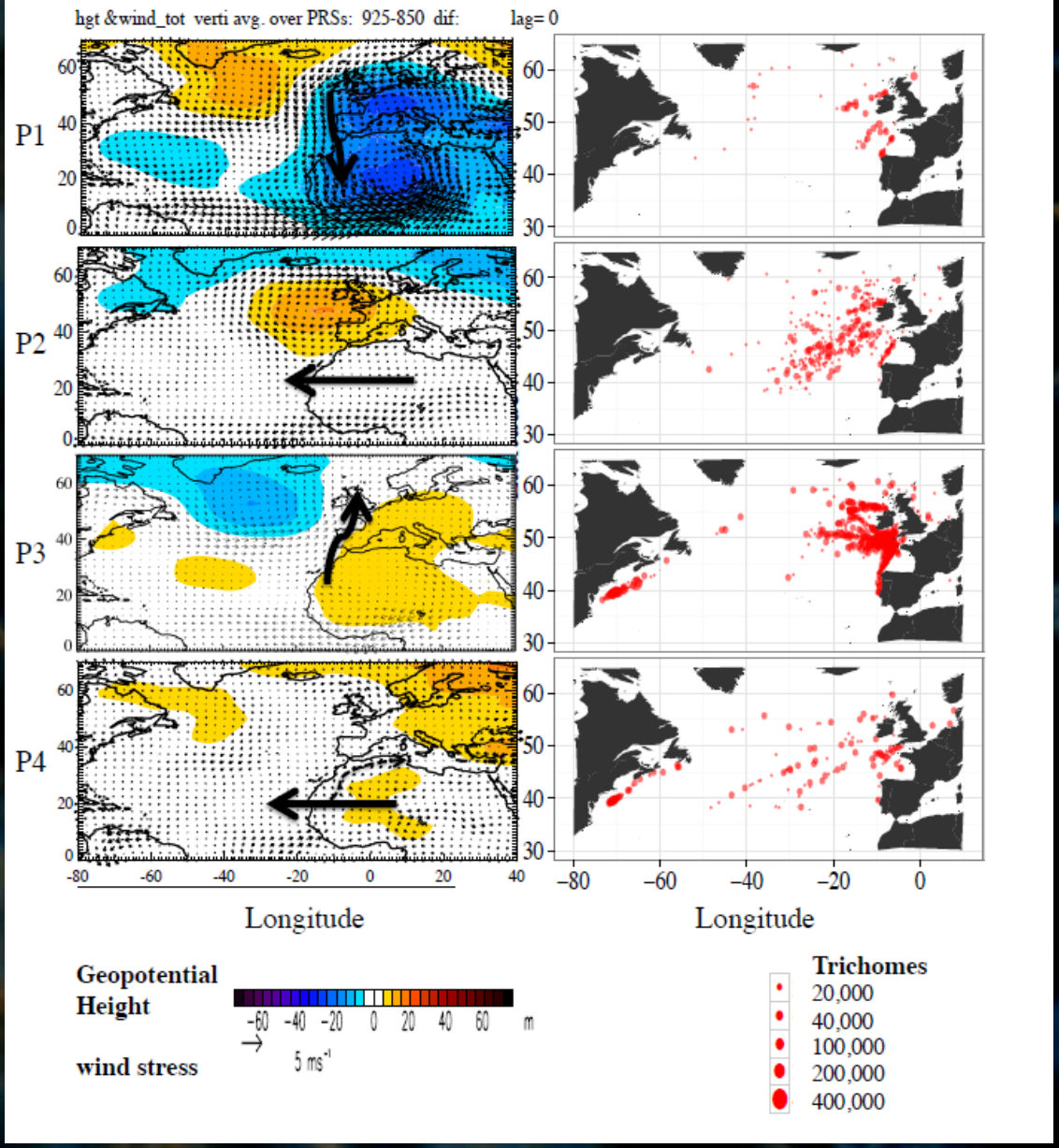






Rain in Sahel

Dust in Barbadoes

Trichodesmium in Bay of Biscay.




Speculation: Dust source+atmospheric pathway?

Evidence at present is circumstantial…

But if true would imply Trichodesmium in cold waters are sensitive to dust supply, while diatoms are not.

Does this imply nitrogen fixation (contrary to laboratory results)?