Decadal changes in North Atlantic phytoplankton blooms

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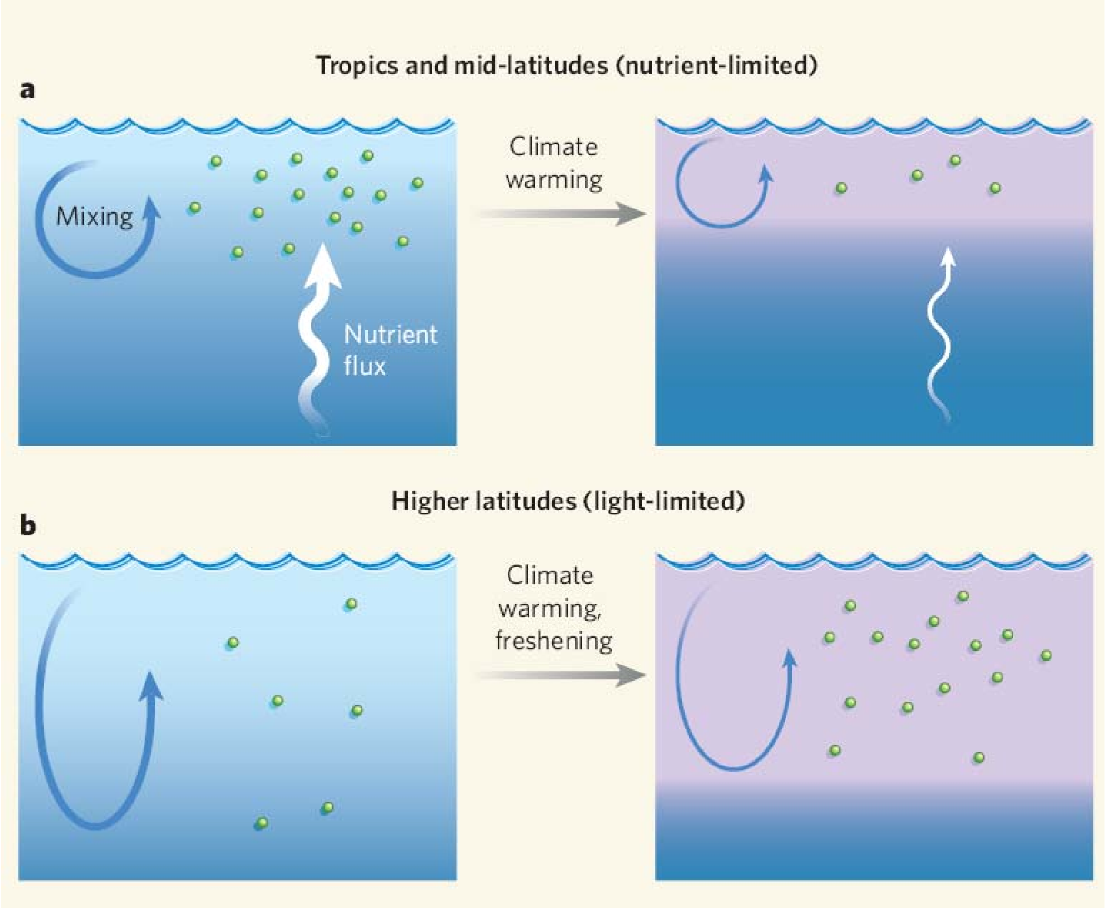
Response of primary production to changing forcing

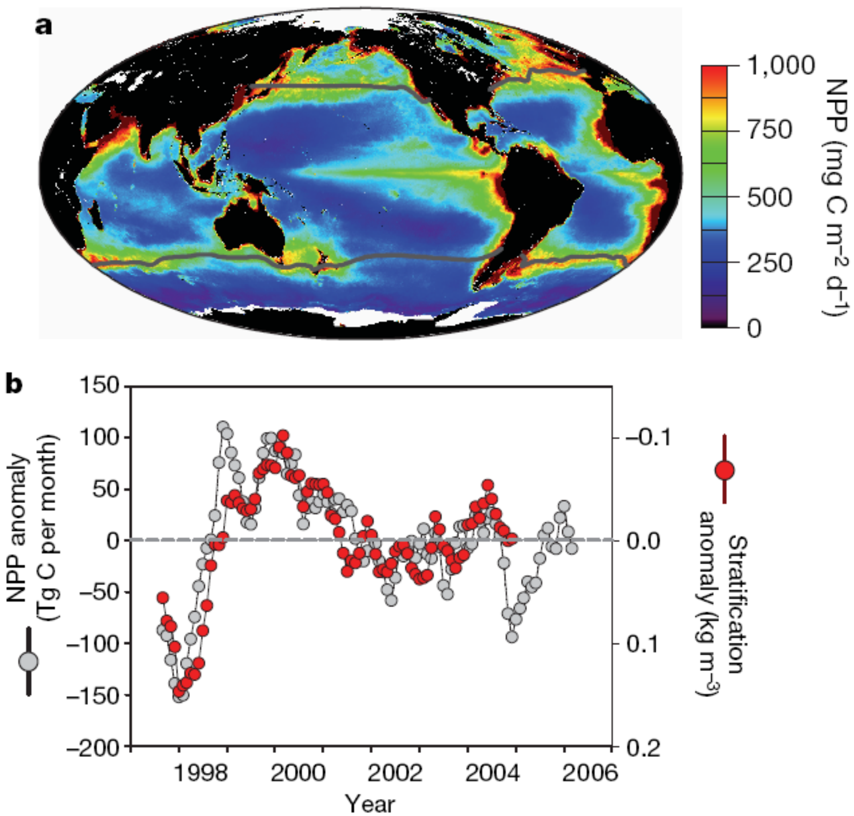


Reduced mixing + nutrient limitation -> lower PP

Reduced mixing + light limitation -> higher PP & earlier blooms

Doney, 2006

Response of primary production to changing forcing



Behrenfeld et al., 2006

In sub-tropics increasing stratification reflected in lower SeaWiFS NPP

Downward trend in NPP since 1999 - is this just normal interannual variability, a response to ENSO, or unprecedented change?

Regional Study - North Atlantic

• Regional response to changing physical forcing

• Set the 10-yr SeaWiFS record in longer-term context

• Fully prognostic physical-biogeochemical model (MOM4-TOPAZ, CORE forcing). No data assimilation. 1959-2004

• Variability in **bloom timing** is important to:

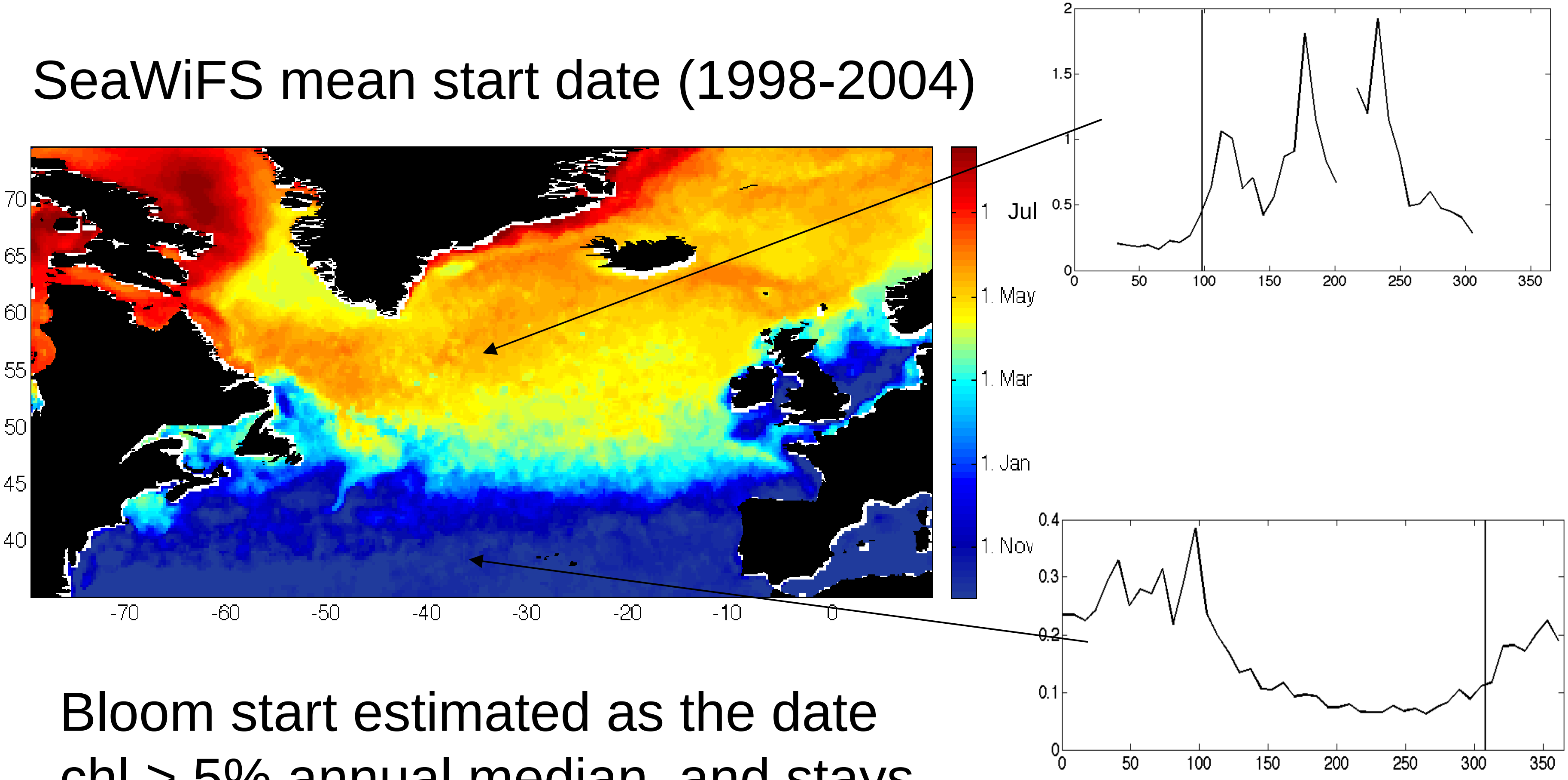
Higher trophic levels

Export flux

Reflects changes in underlying physical forcing

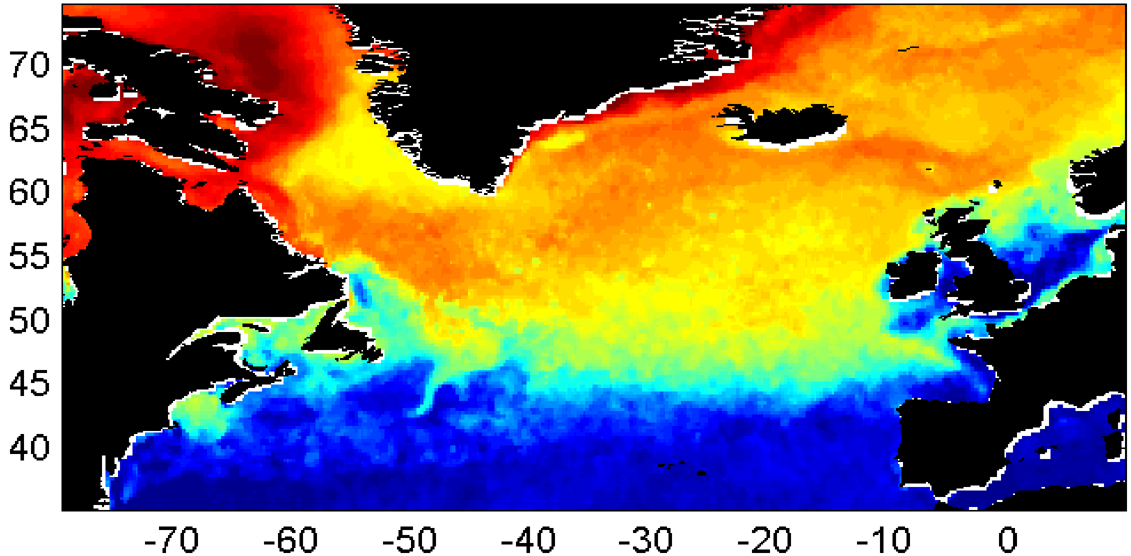
Bloom timing from SeaWiFS

SeaWiFS mean start date (1998-2004)

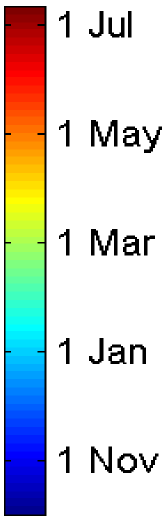


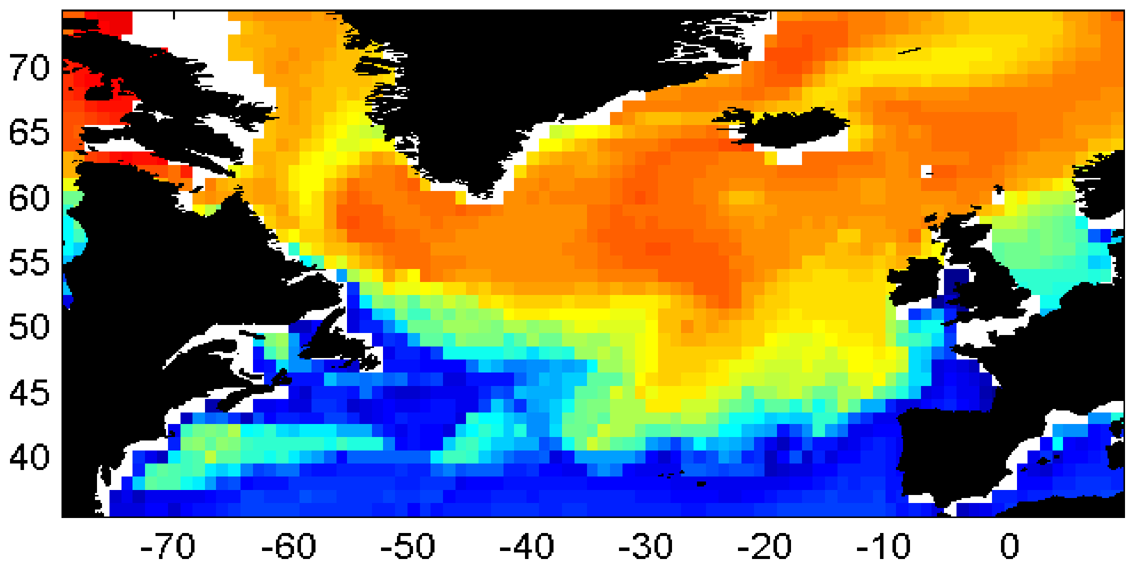
Bloom start estimated as the date chl > 5% annual median, and stays elevated (Siegel et al., 2000; Henson et al., 2006)

An alternative measure of model skill



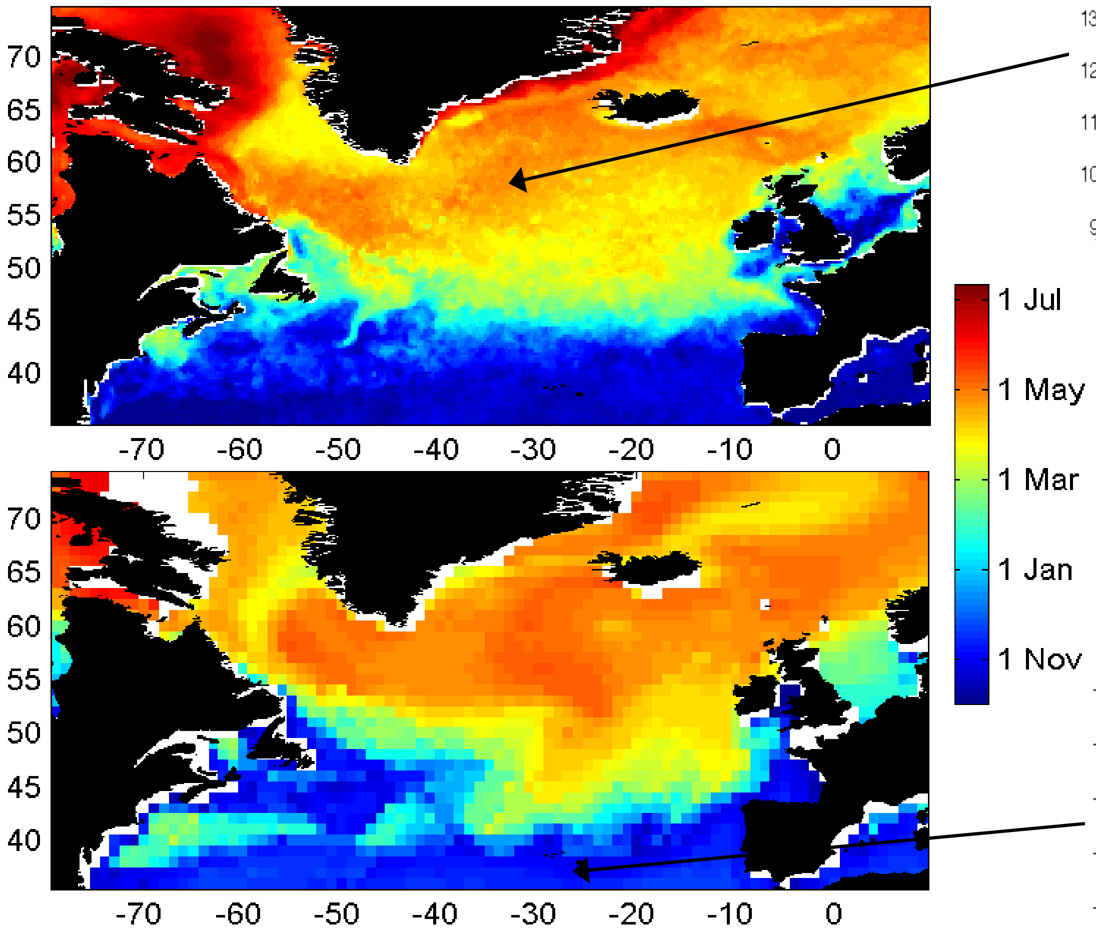
SeaWiFS mean start date (1998-2004)

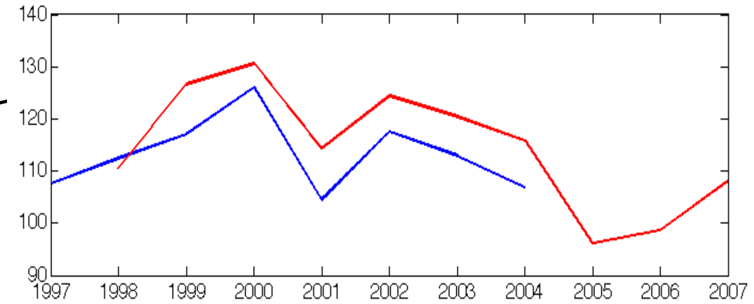




TOPAZ output mean start date (1998-2004)

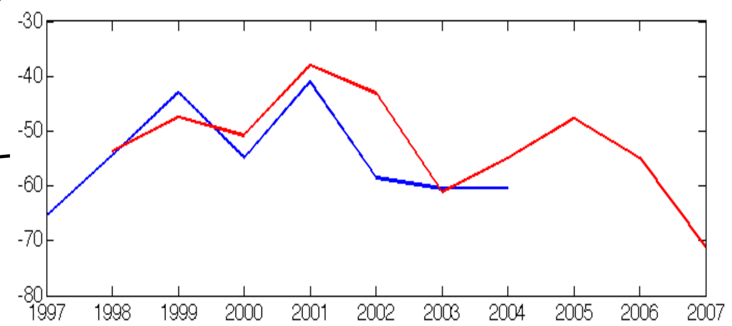
Interannual variability in bloom timing



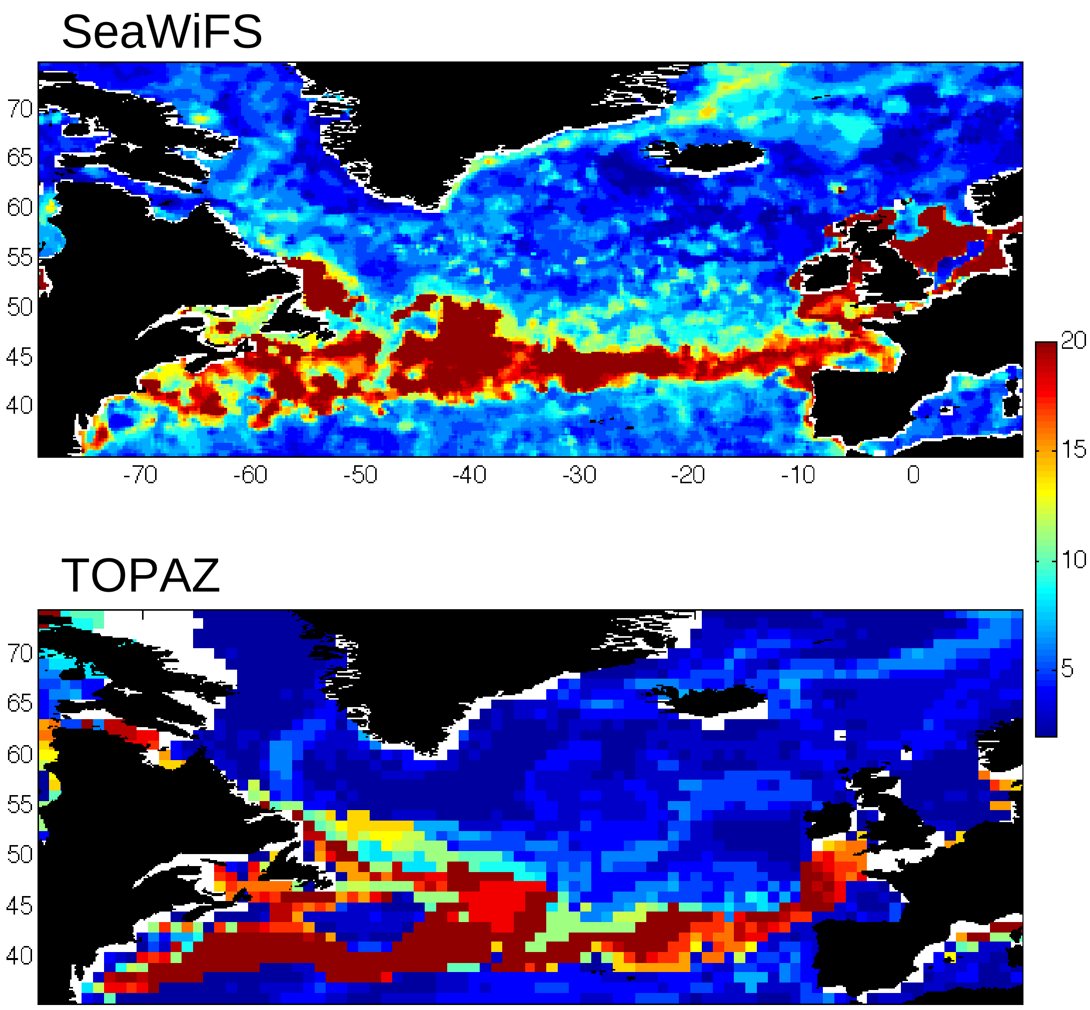


Blue: TOPAZ start date

Red: SeaWiFS start date



Range in bloom timing

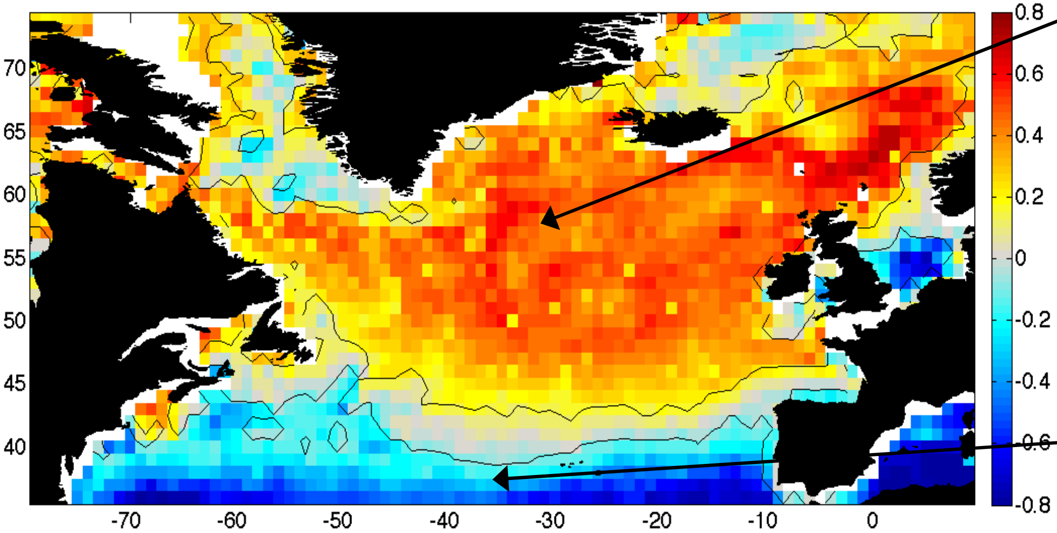


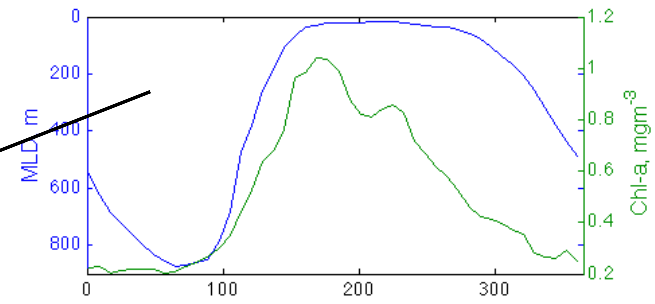
Number of weeks difference between earliest and latest bloom start (98-04)

‘Inter-gyre’ region may have either autumn or spring bloom

Chl response to changing MLD

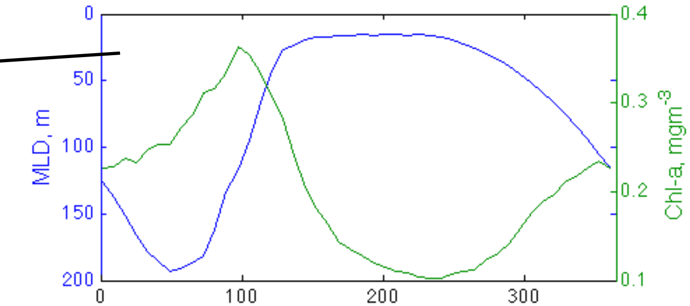
Linear correlation MLD and chl





Green: SeaWiFS mean chl

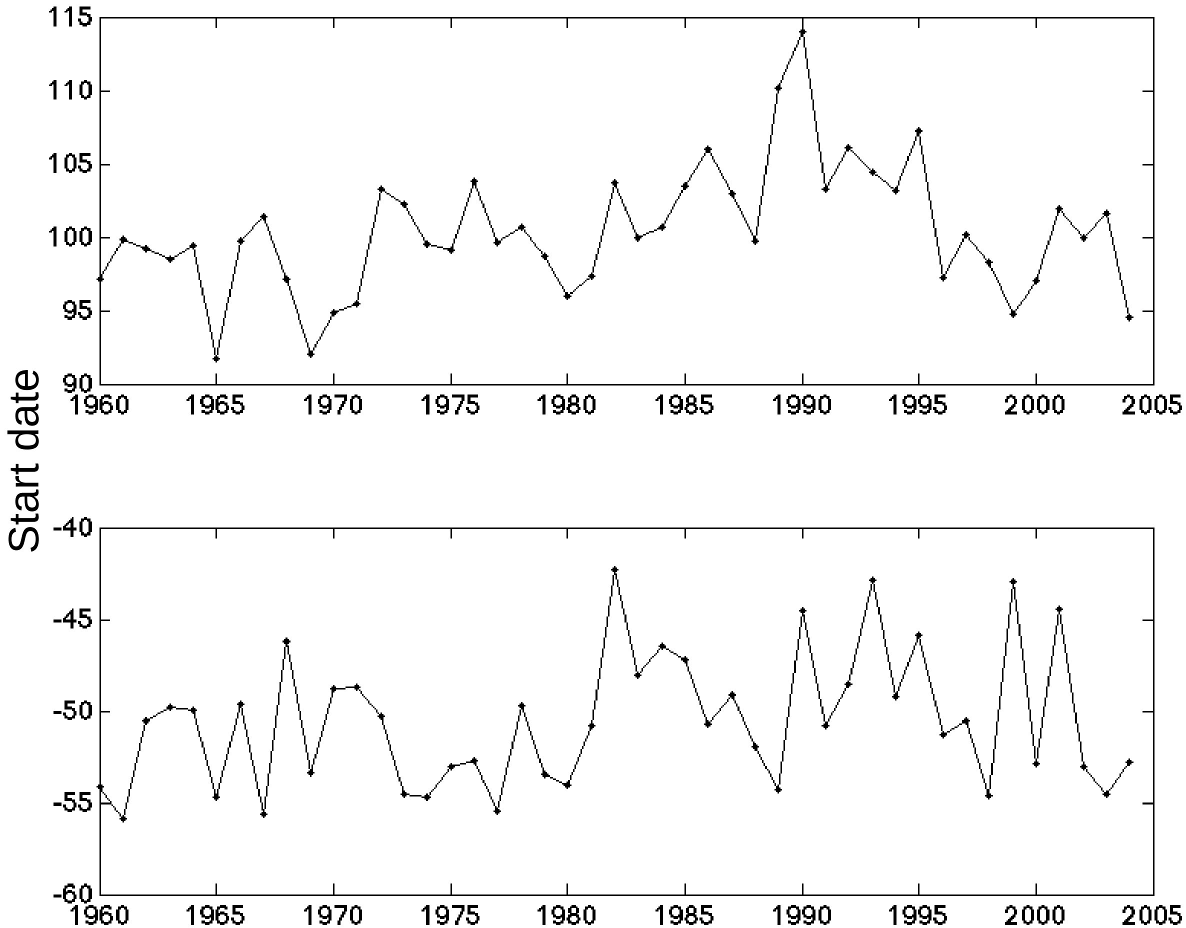
Blue: TOPAZ mean MLD



Sub-polar: Chl increases when MLD shallows -> light limited

Sub-tropical: Chl increases when MLD deepens -> nutrient limited

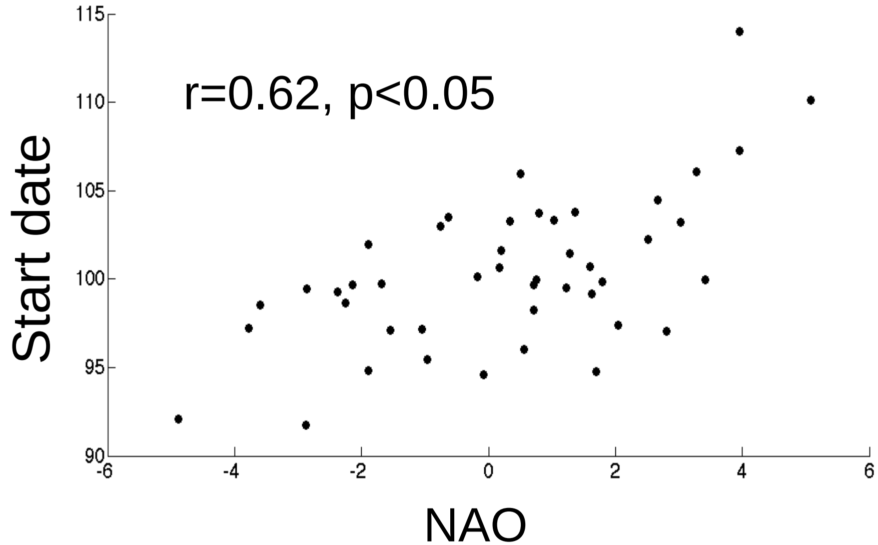
Decadal variability in bloom timing

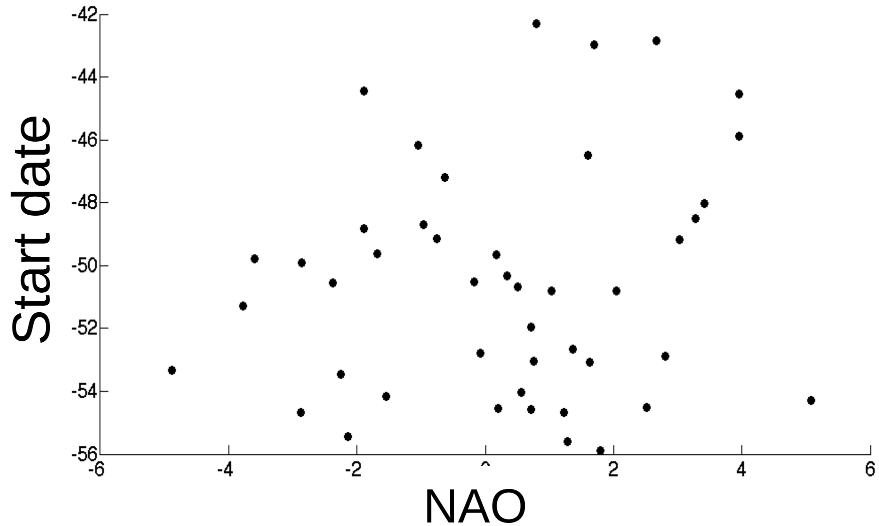


Sub-polar, no trend, but patterns of variability?

Sub-tropical, no trend

North Atlantic Oscillation correlated with sub-polar bloom timing



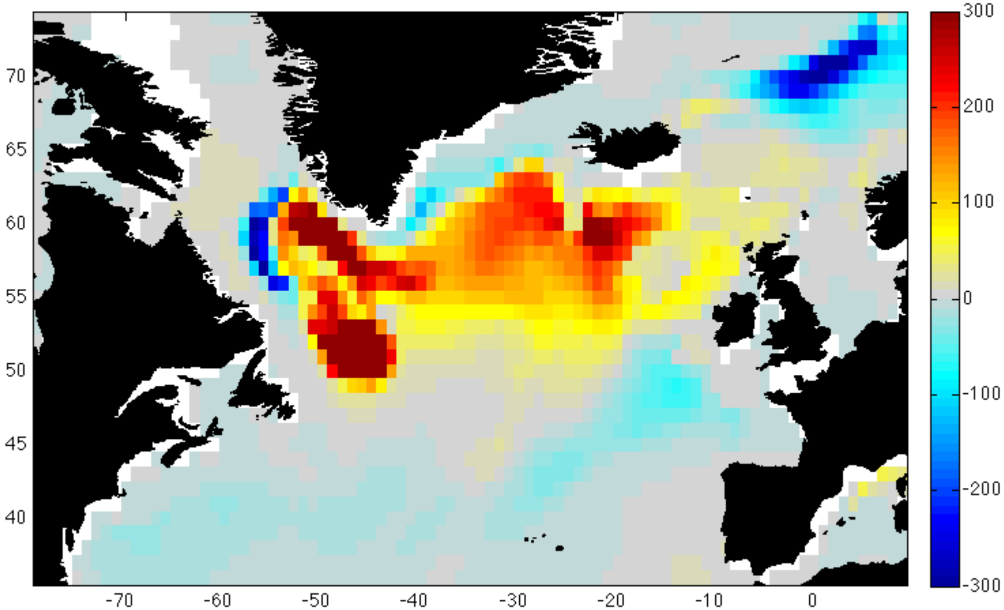


Sub-polar, later bloom start in positive NAO years

+ve NAO, more northerly storm track, deeper winter mixed layers in sub-polar region

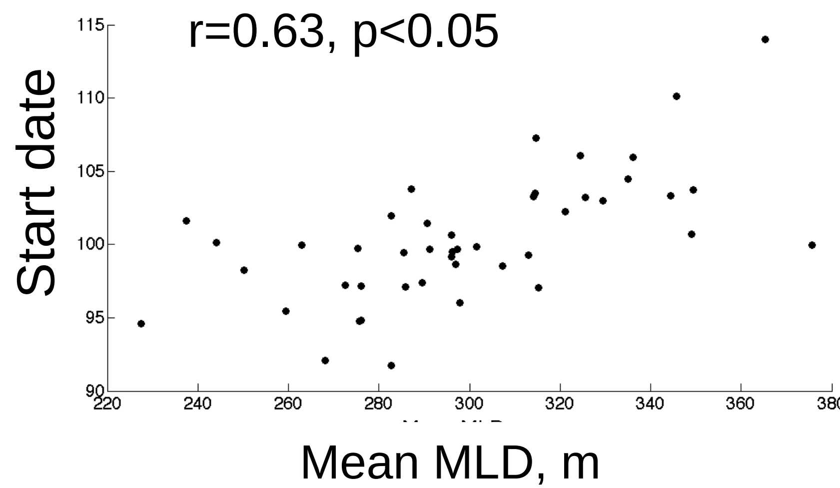
Sub-tropical, no correlation

Variability in MLD drives bloom timing

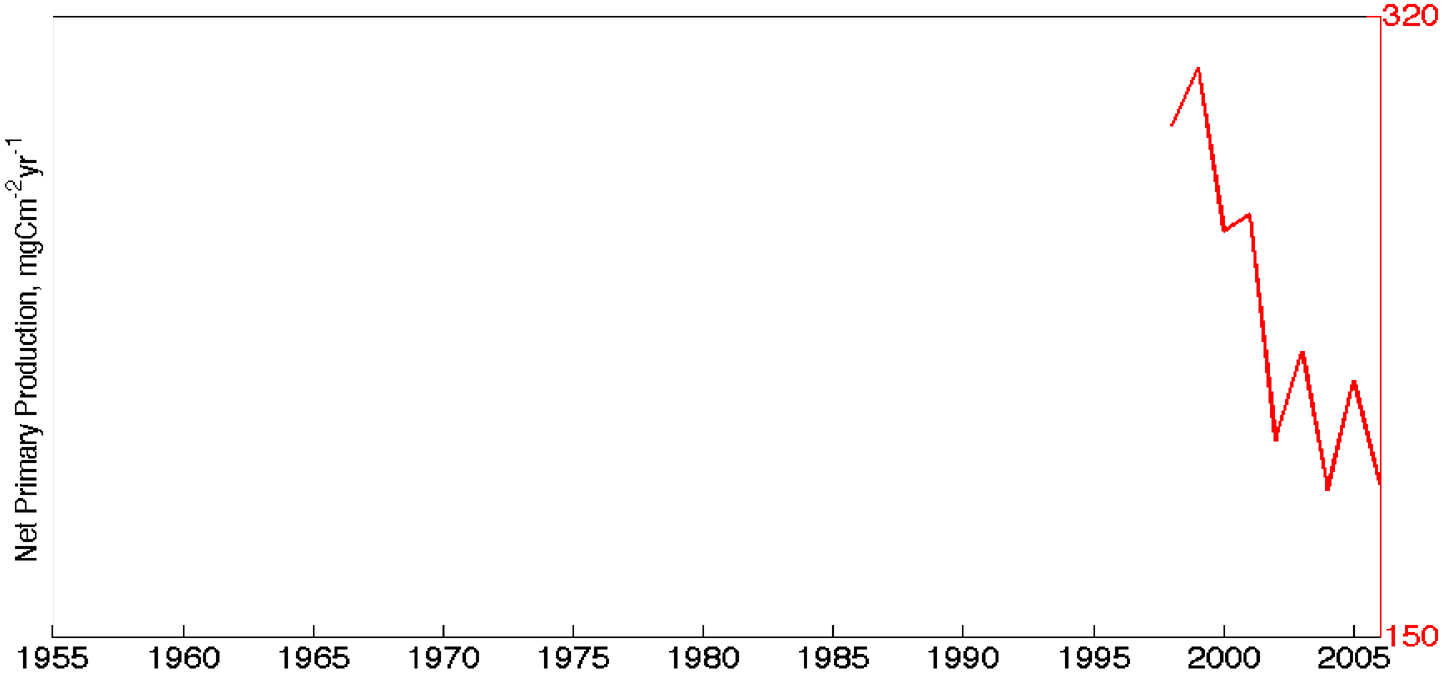


Difference in winter modelled MLD between 3 latest, and 3 earliest, blooming years

Deeper mixed layer results in later spring bloom in sub-polar region



Primary Production trend in SeaWiFS

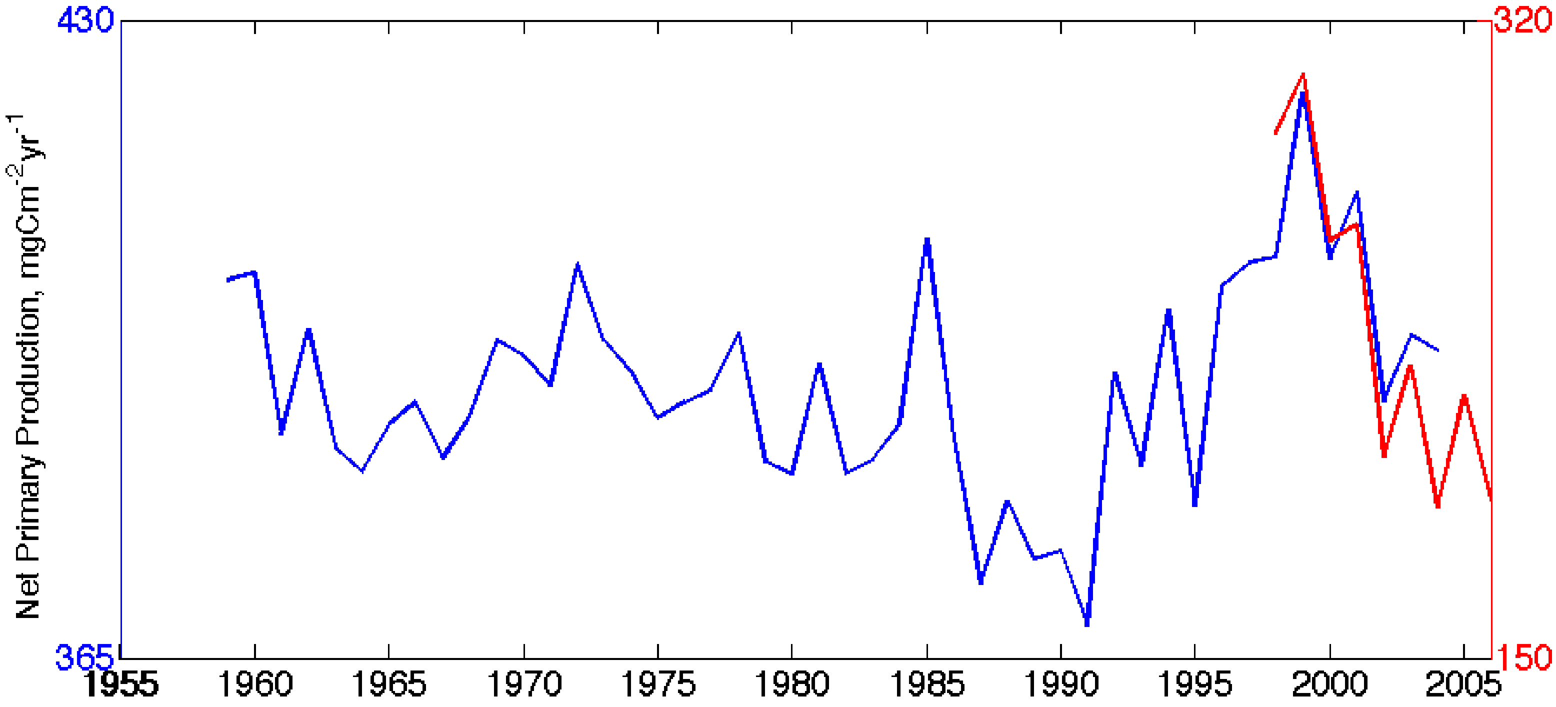


Sub-polar region SeaWiFS NPP shows decreasing trend since 1998

NPP estimated from CbPM, Behrenfeld et al. (2005)

Primary Production decadal trend

Red - SeaWiFS, Blue - TOPAZ model



NPP decrease in recent years consistent with decadal variability

Conclusions

- Bloom timing is a useful metric of model skill
- N. Atlantic split into 2 regions:
    - Sub-polar: bloom starts when ML shallows
    - Sub-tropical: bloom starts when ML deepens
- What controls the position of the front between the 2 regions interannually?
- No evidence of long-term trend in bloom timing
- Variability in sub-polar bloom timing correlated with NAO -> mechanism is variability in MLD
- Be careful interpreting variability in the 10-year SeaWiFS record