

# PML

Plymouth Marine  
Laboratory

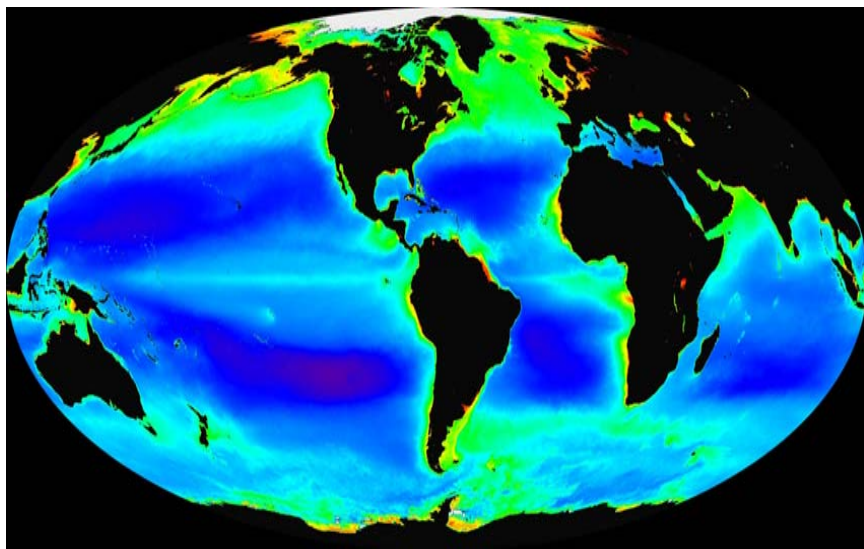
Marine Matters

## Shelf Seas Ecosystems: Modelling Challenges for Past Present & Future States



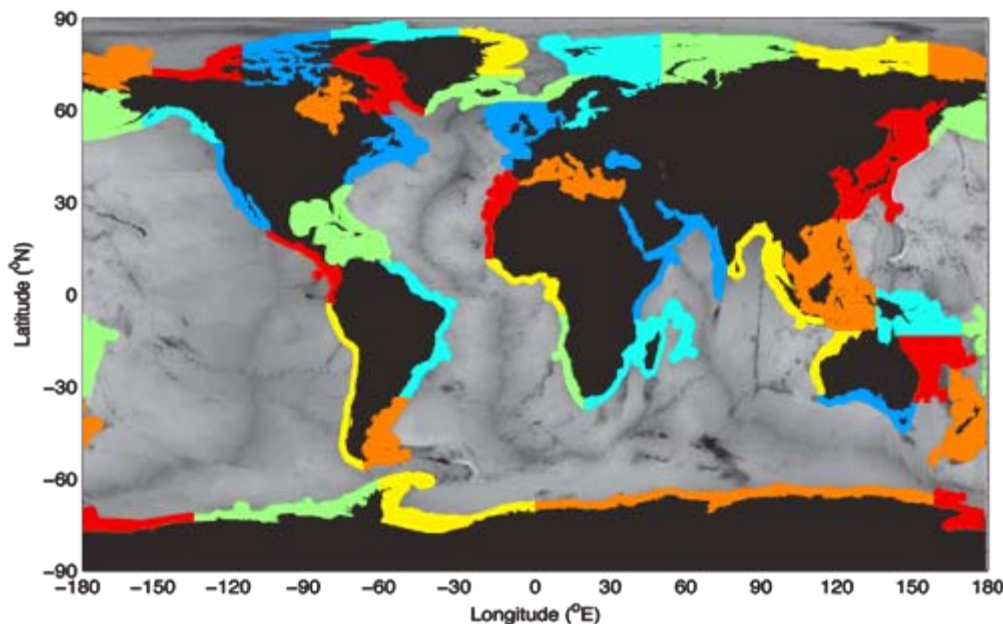
Icarus Allen

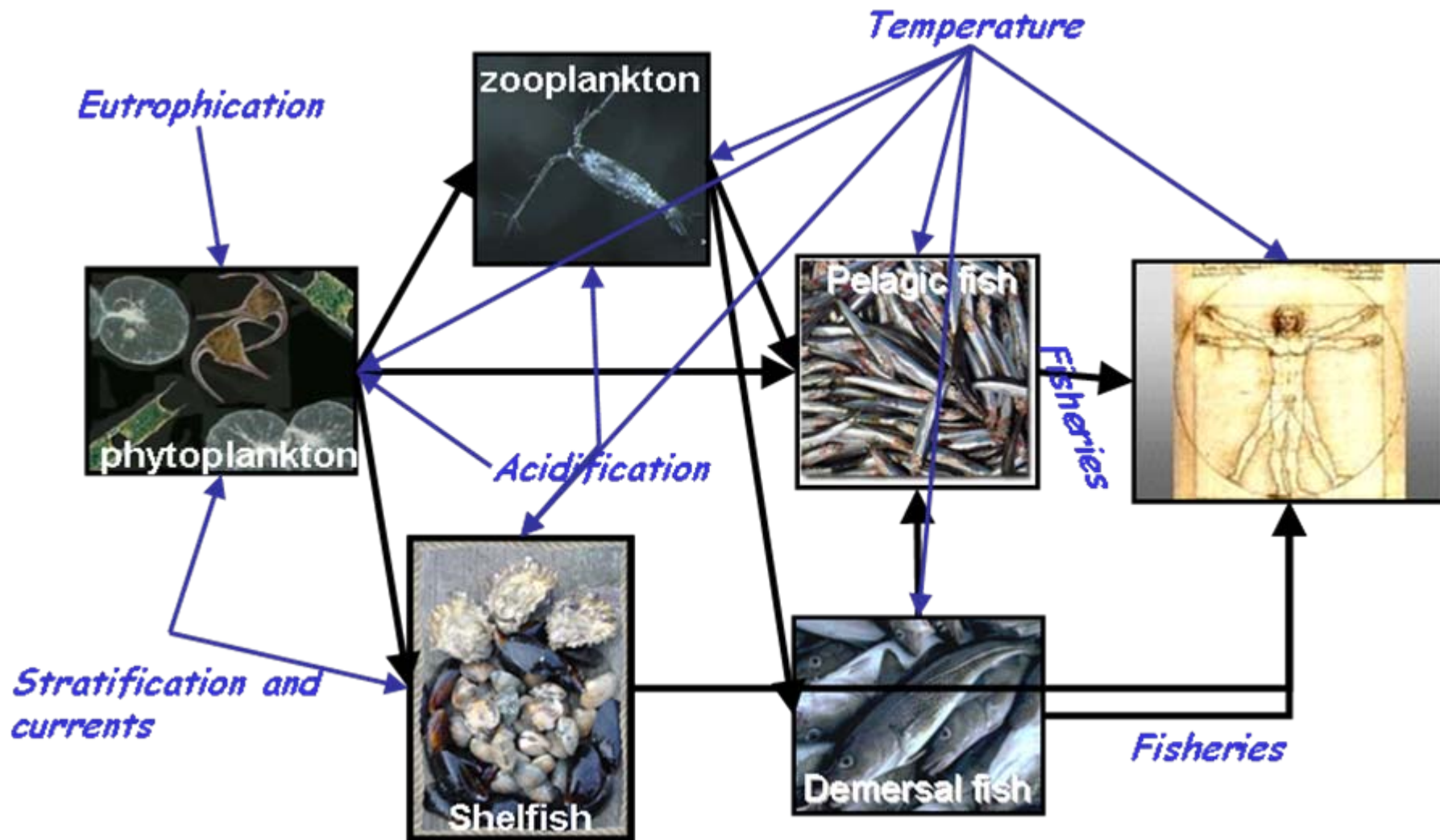




**Interface with the land**  
**Eutrophication and pollution**  
**30% primary production**  
**Focal point for biogases**  
**and nutrient cycling**  
**60% of commercial fisheries**  
**Sensitive to ocean**  
**acidification**

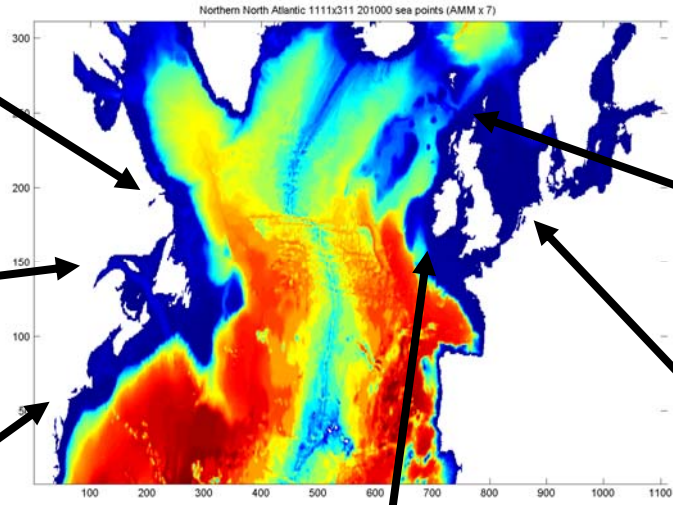
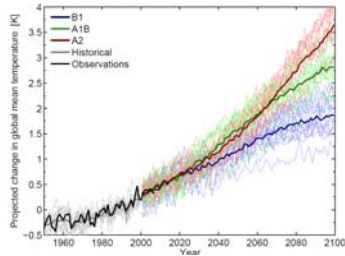
**Projected Increase in  
Human Population**





## Biogeochemical Cycling

## Climate



## Basin Scale Connectivity

## Ocean Acidification



Observed changes  
In plankton distributions

Observed reduction in  
CO2 sink

## Fisheries

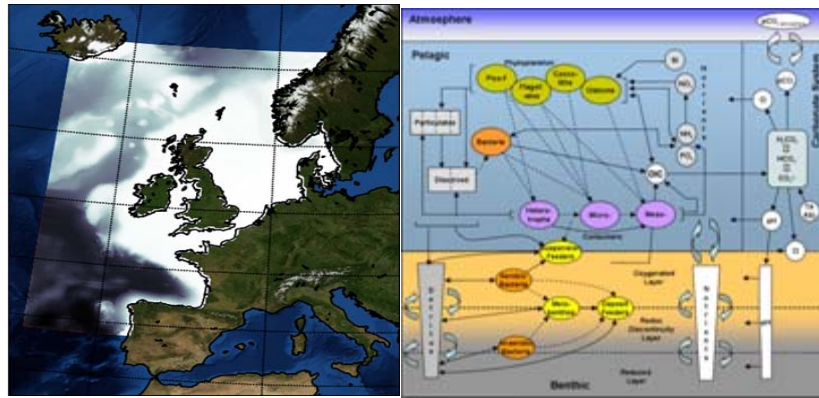


## Eutrophication





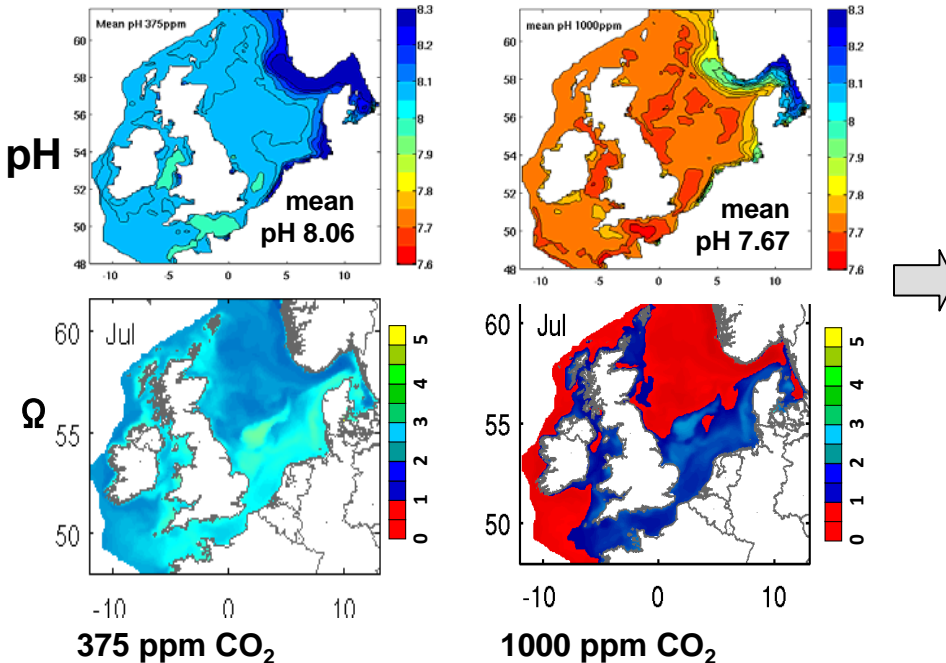
## Coupled model system



## Ecosystem Impacts

Calcification  
 Primary Production  
 Nitrogen Cycle  
 Stoichiometry  
 Organism health

## Predict future states & heterogeneity

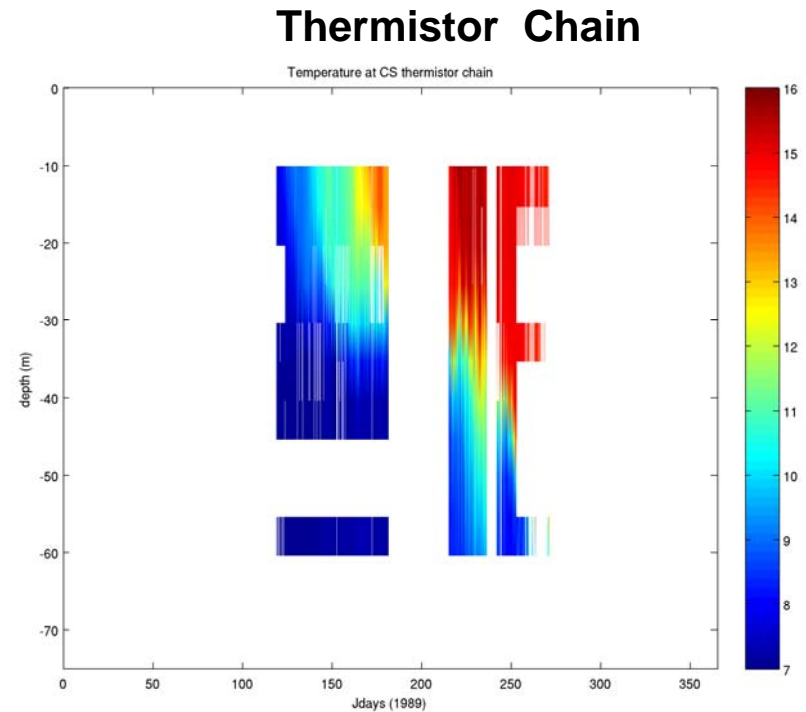
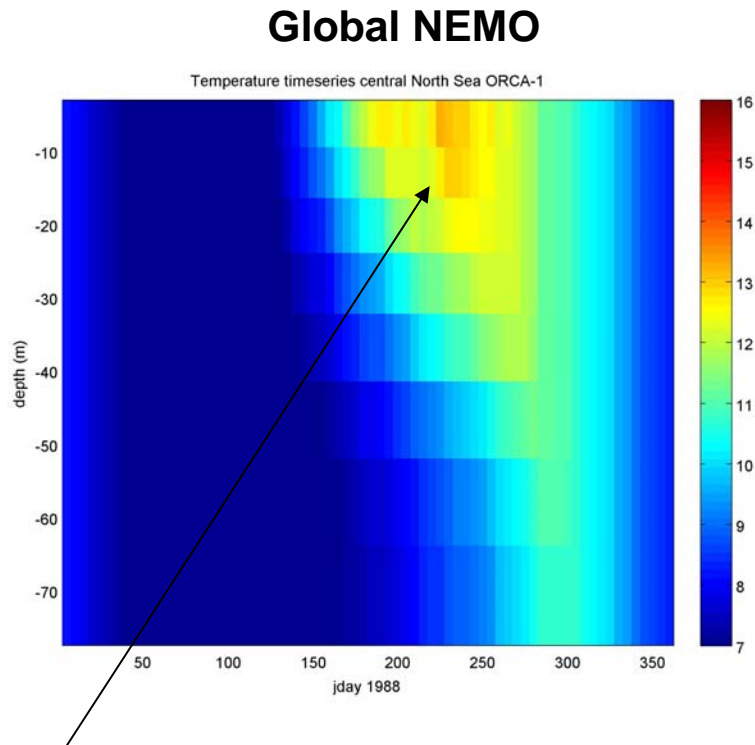


## Social - economic Impacts

Community structure  
 Biodiversity (indicators)  
 Trophic transfer

# Why downscale?

- Coupled OGCM's just don't do the job...

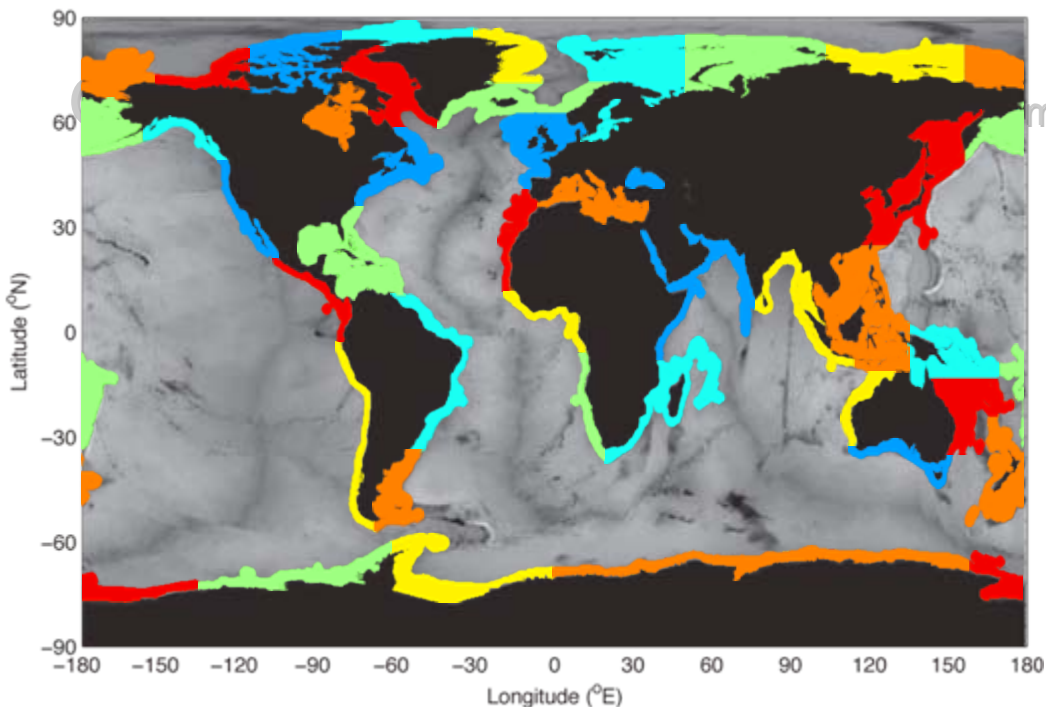


T to low, mixed later  
depth to shallow

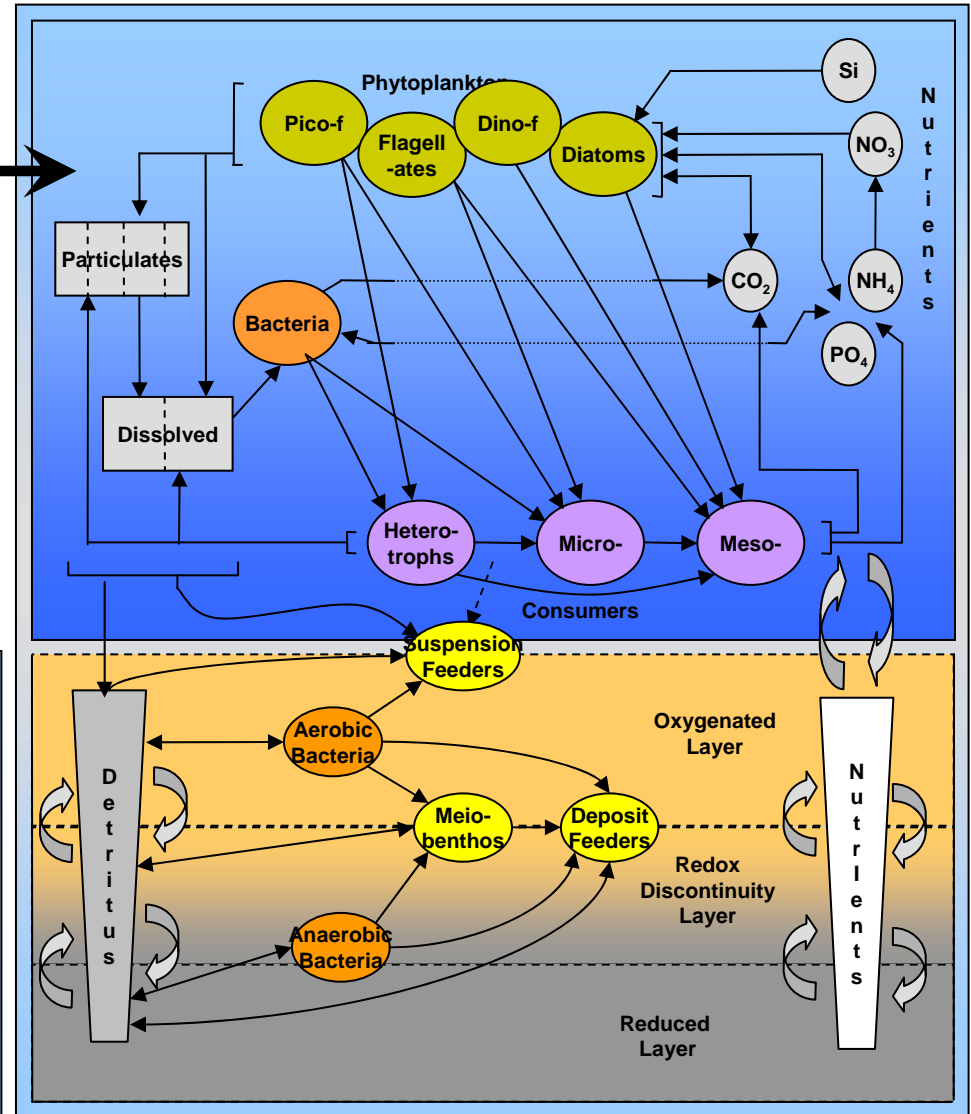
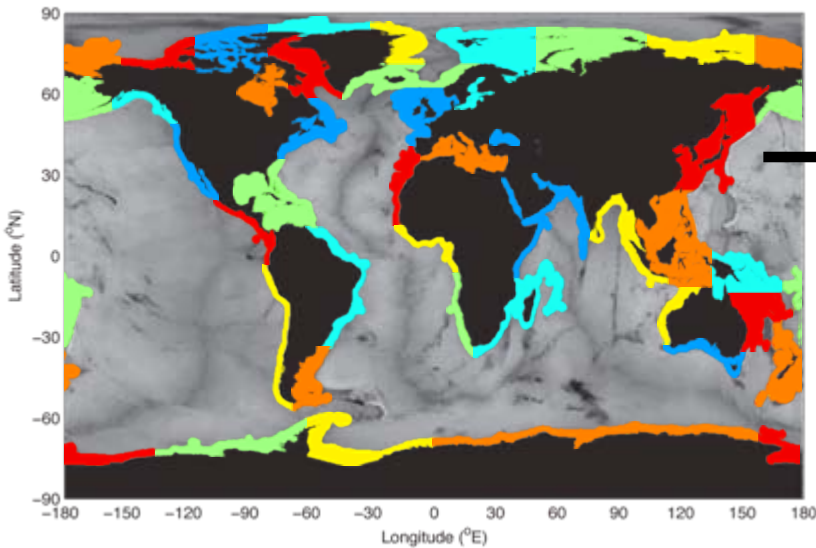
North Sea station CS

See talk by Jason Holt later today

- GCOMS (Global Coastal Ocean Modelling System).
- Model components:
  - POL-Coastal Ocean Modelling System
  - ERSEM (European Regional Seas Ecosystem Model)



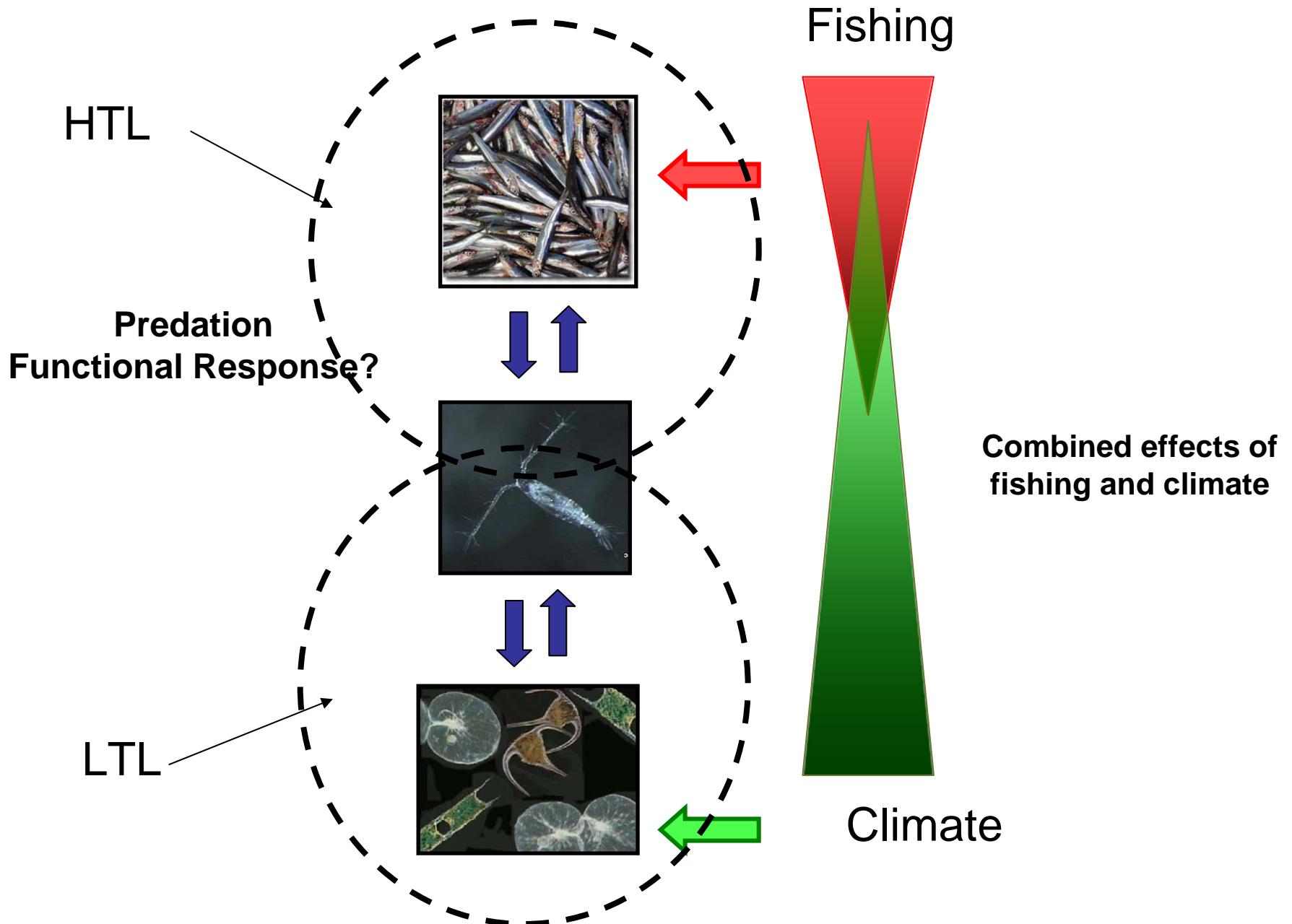
- 1/10° resolution
- Includes important shelf processes: Tides, upwelling, Benthic/pelagic recycling
- Geographically linked to LME : ocean governance scale
- Although global, the models are regional



## ERSEM

- Resolves functional groups
- Inclusion of benthic system
- Explicit decoupled cycling of C, N, P, Si and Chl.
- Consequently flexible and adaptable to a wide range of global ecosystems.





## Aims

- Code the model only once (in FORTRAN)
- Run within various circulation models
  - GOTM, GETM, MOM4, ...
- Allow two-way biogeochemical coupling
  - carbonate chemistry, NPZD, higher trophic levels
- Allow run-time configuration
  - model selection, parameterization, and coupling
- Minimize code redundancy
- Aim for speed, but prioritize portability

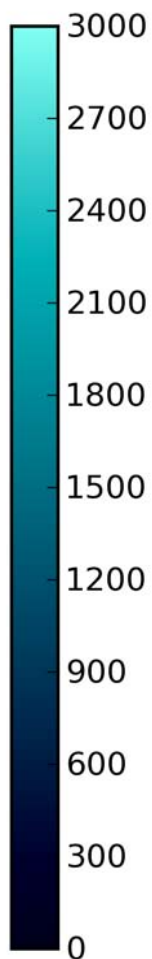
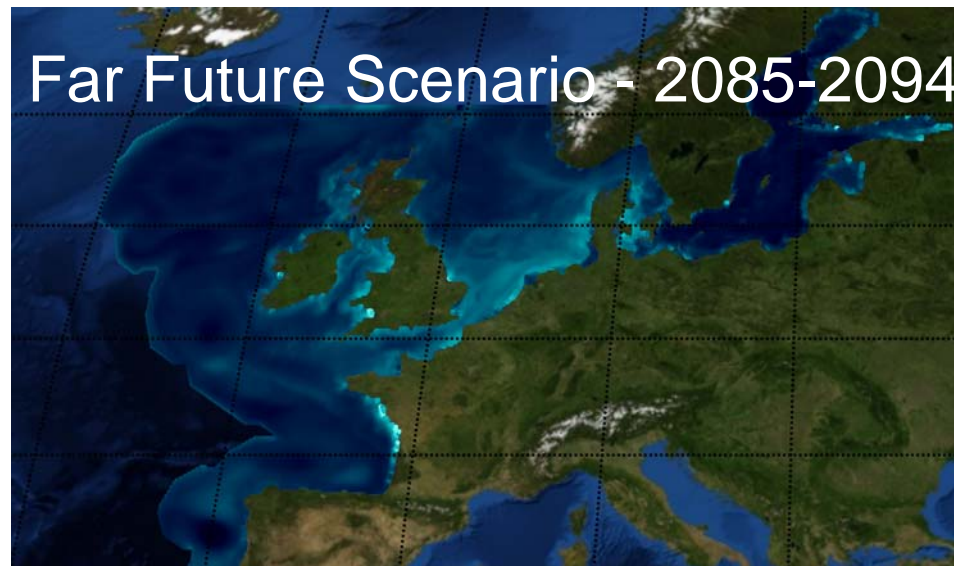
## Net Primary Production

- general increase
- Is there an impact?
- Is the change significant?

Early industrial age - 1864-1873

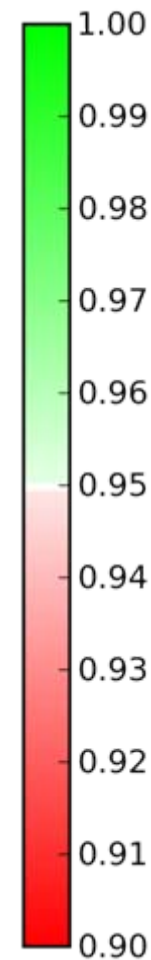
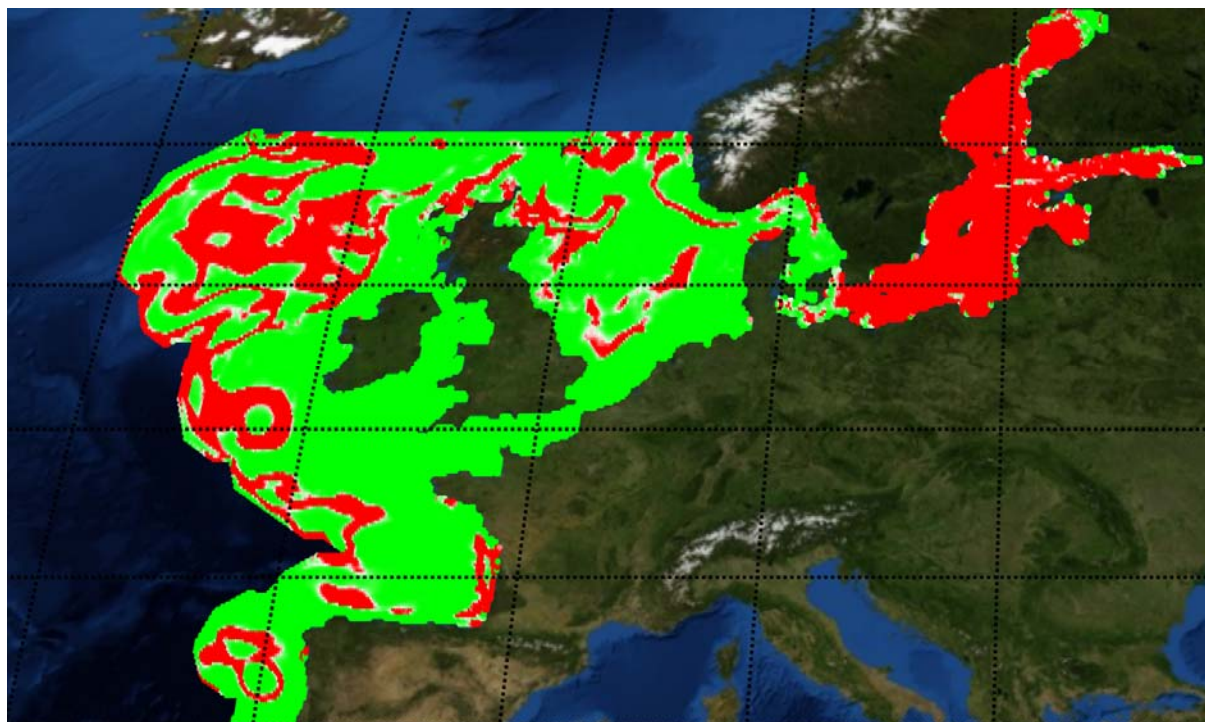


Far Future Scenario - 2085-2094



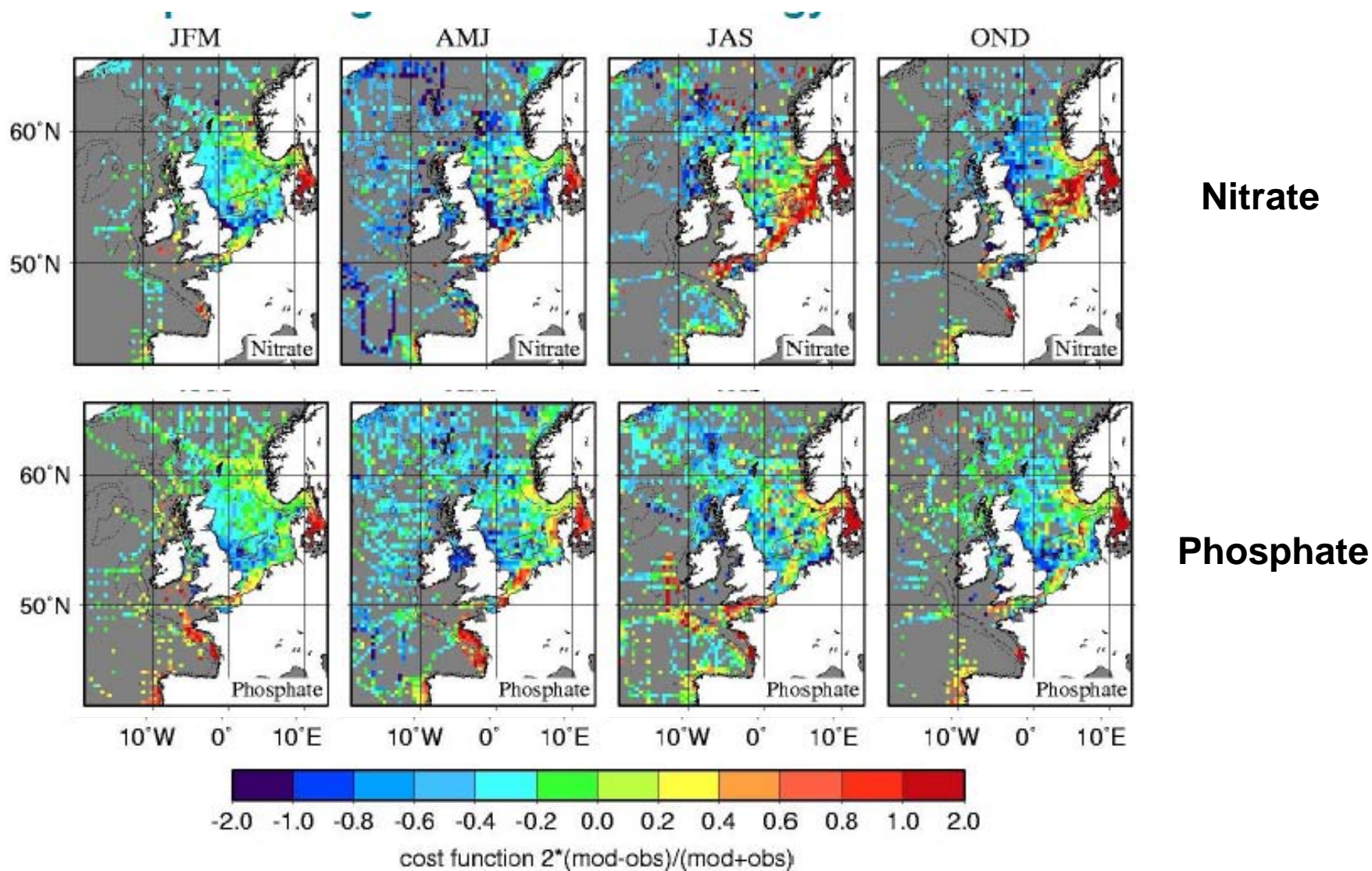
T-test of statistical significance of change in net primary-production

High - probability of significant change

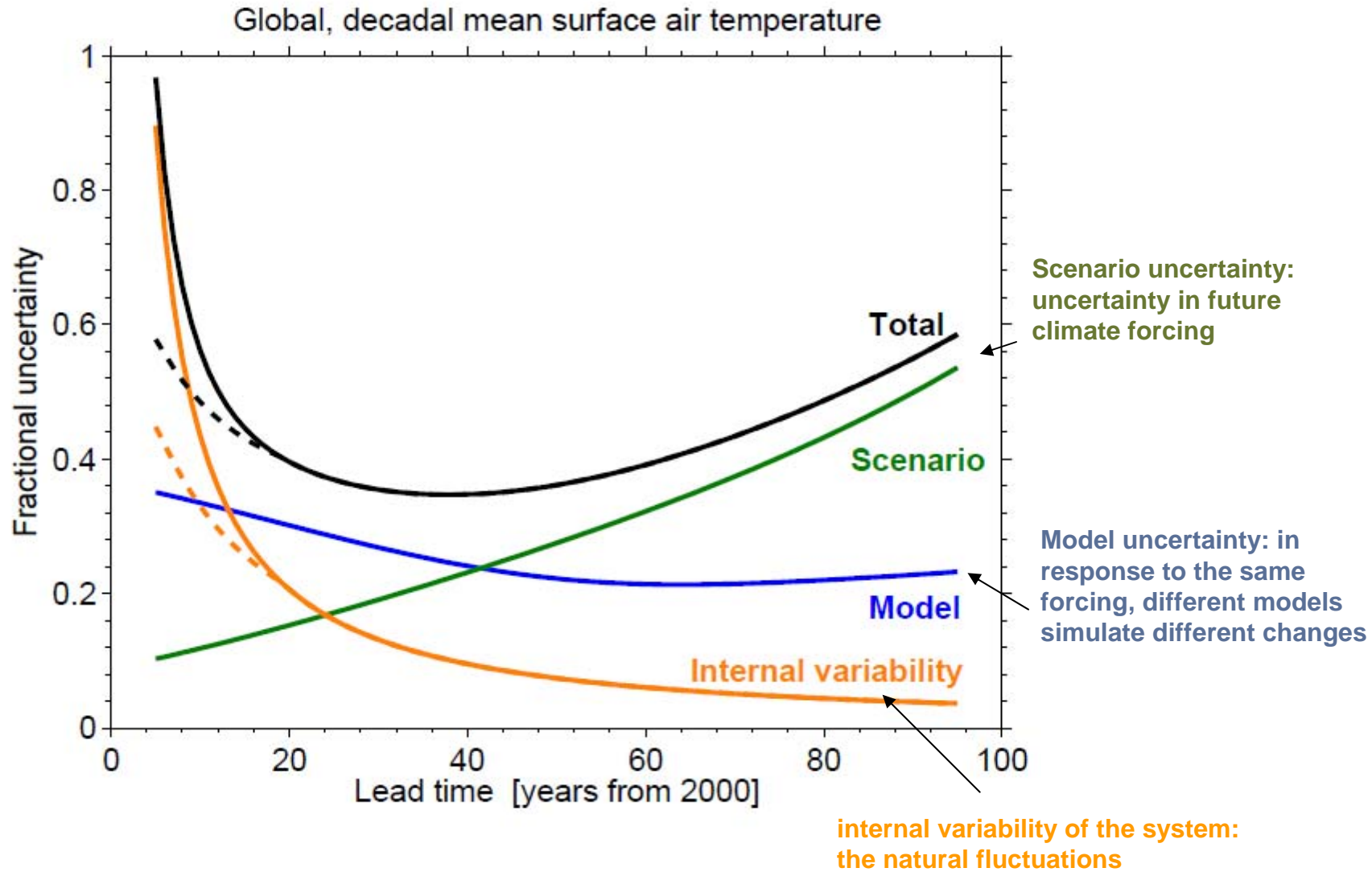




## Comparison with World Ocean atlas

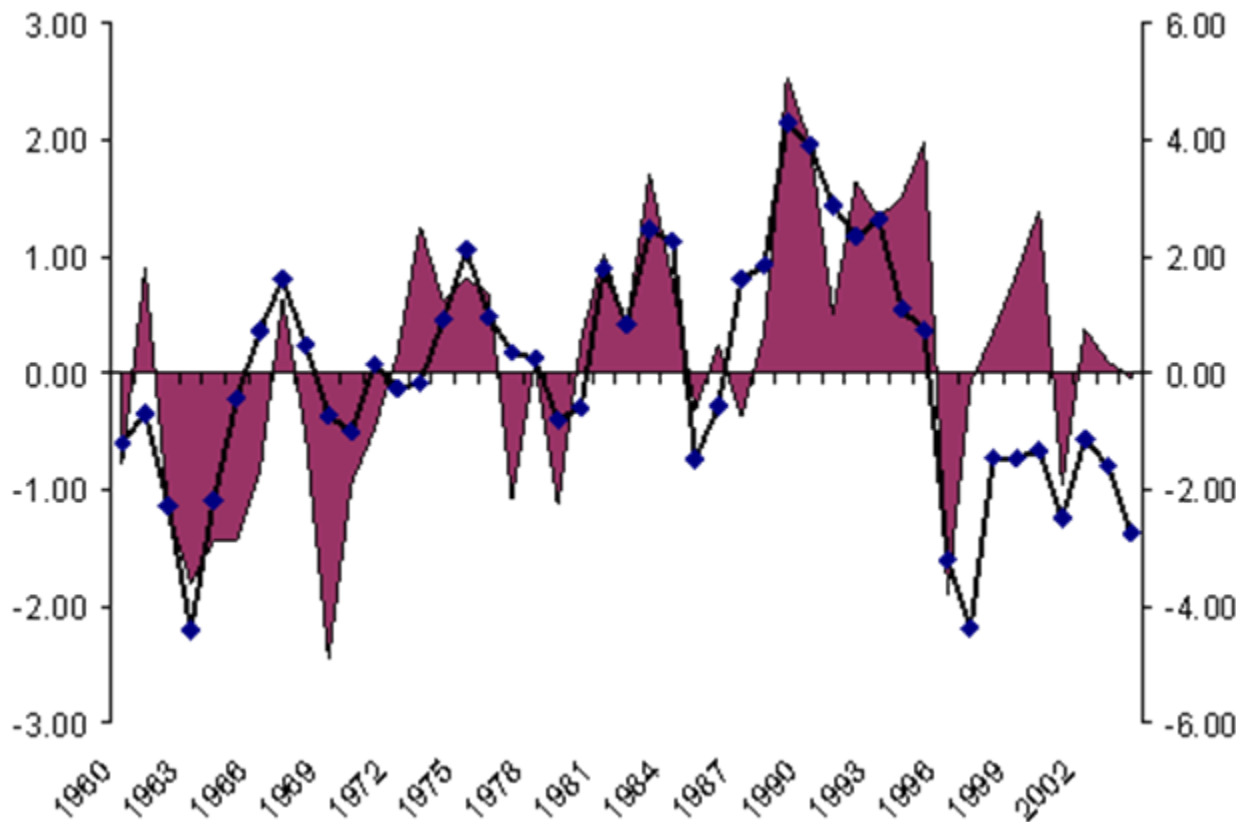


# What are the major sources of Uncertainty



## Climate signals - NAO

Relation of the NAO signal to model winter nutrients

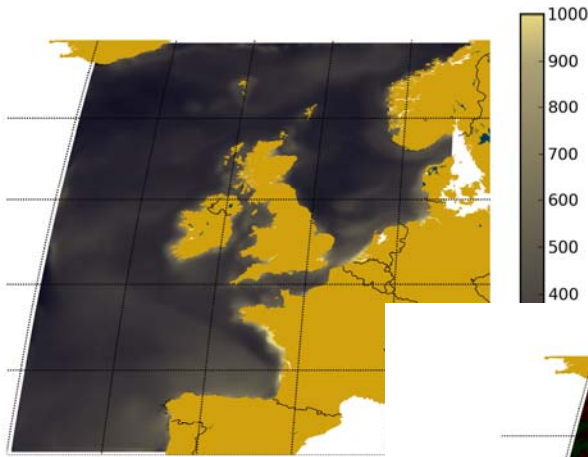


- Model transmits the signal from atmospheric forcing over ocean dynamics to the ecosystem.



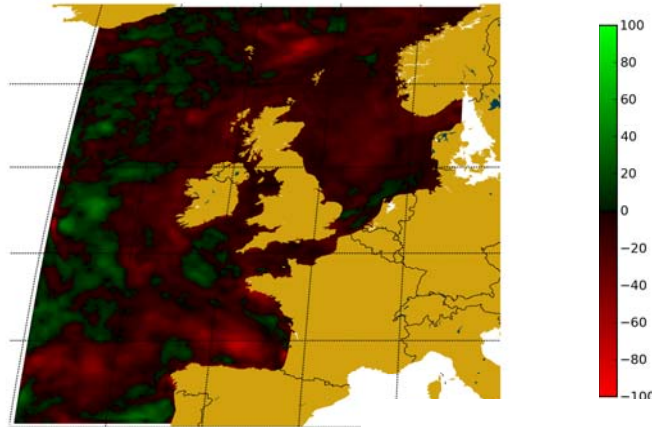
=> Indication of capability to model observed NAO-nutrient correlations

# Parameter Uncertainty



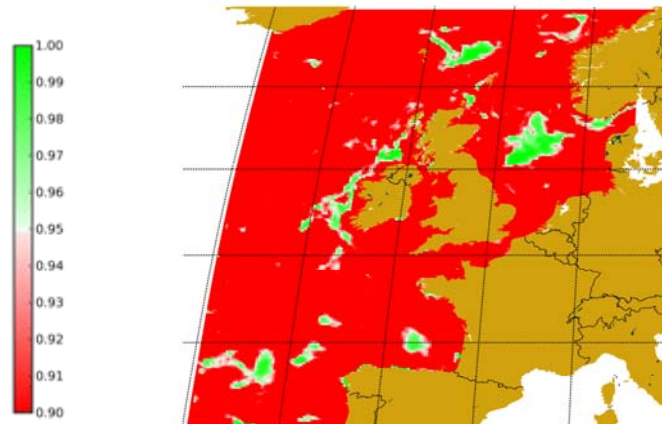
**Concentration**

**Phytoplankton**



**Difference**

Zooplankton shows a similar response



**Prob. of Significance**

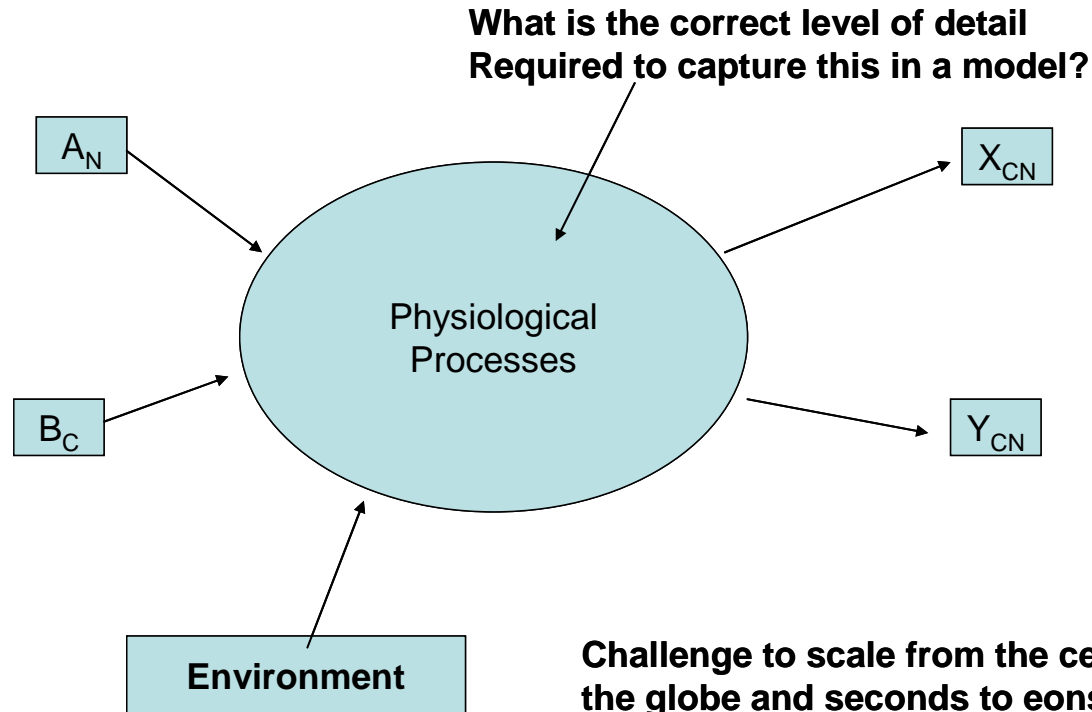


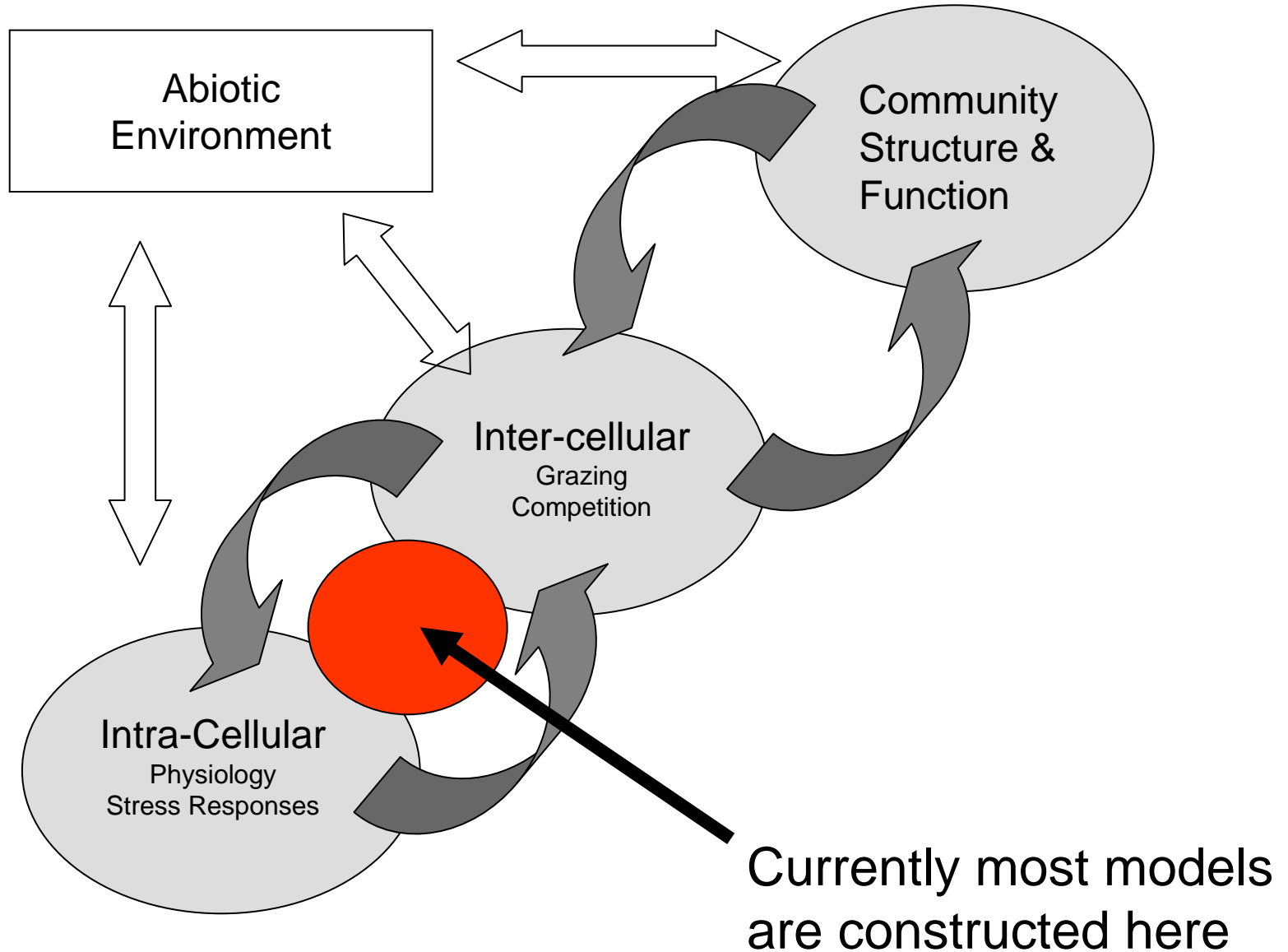
**Biogeochemical models treat the ecosystem as a set of chemical processes**

**Fine for physiological processes not so good for populations processes**

**The cell as a chemical factory**

Currency – elemental concentrations C, N, P, Si etc...





## Levels of Organisation

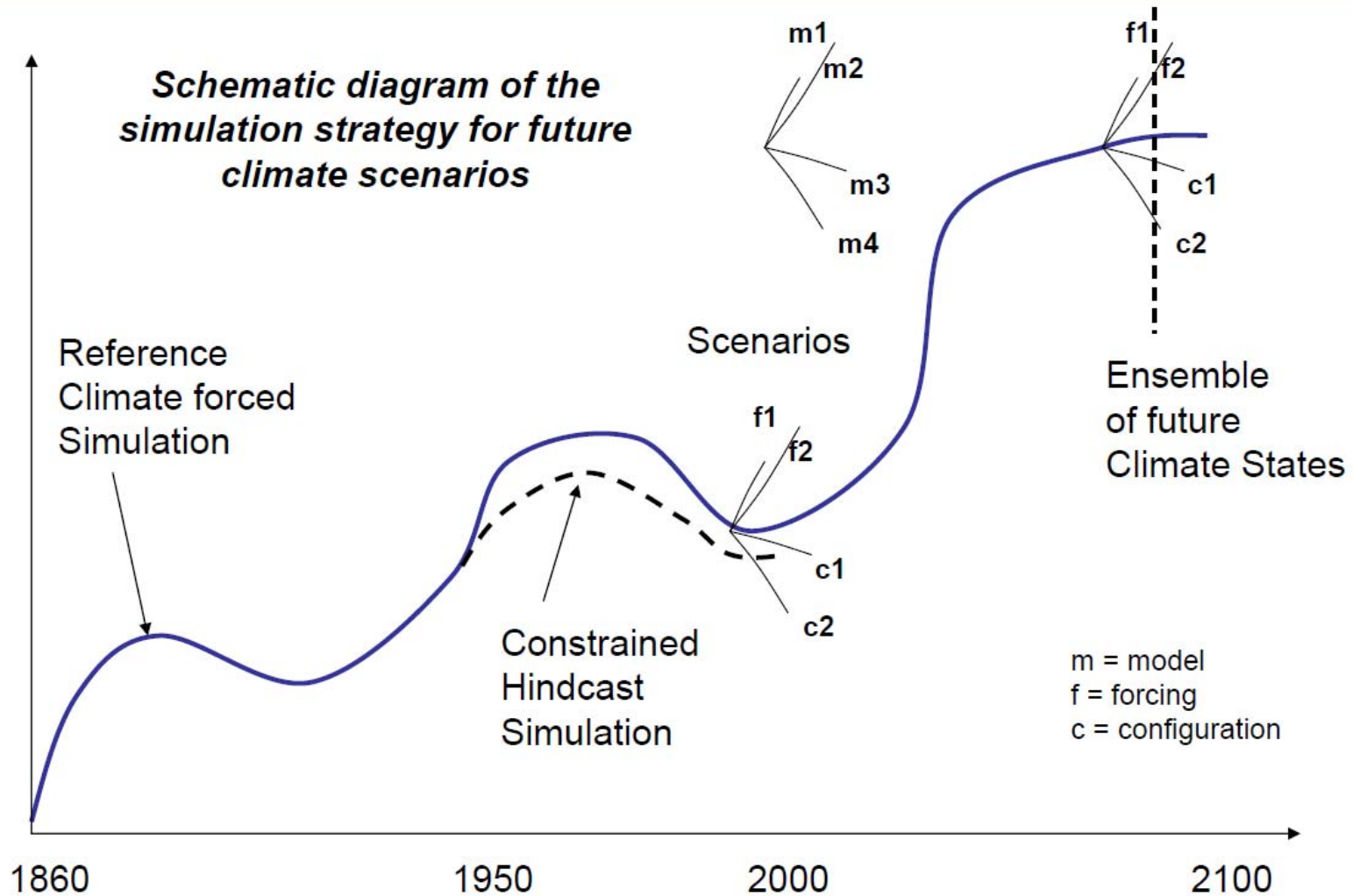
- The great unknown...
- Same biology (PLANKTOM) different physics

## **But what about same physics different biology?**

Requires

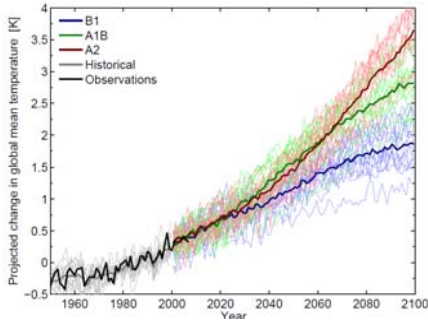
- a common physical framework
- Skill assessment metrics + data

This will allow us to build up a multi-model multi-scenario 'super-ensemble' using plankton models of different complexity



Force with a coupled ocean atmosphere model



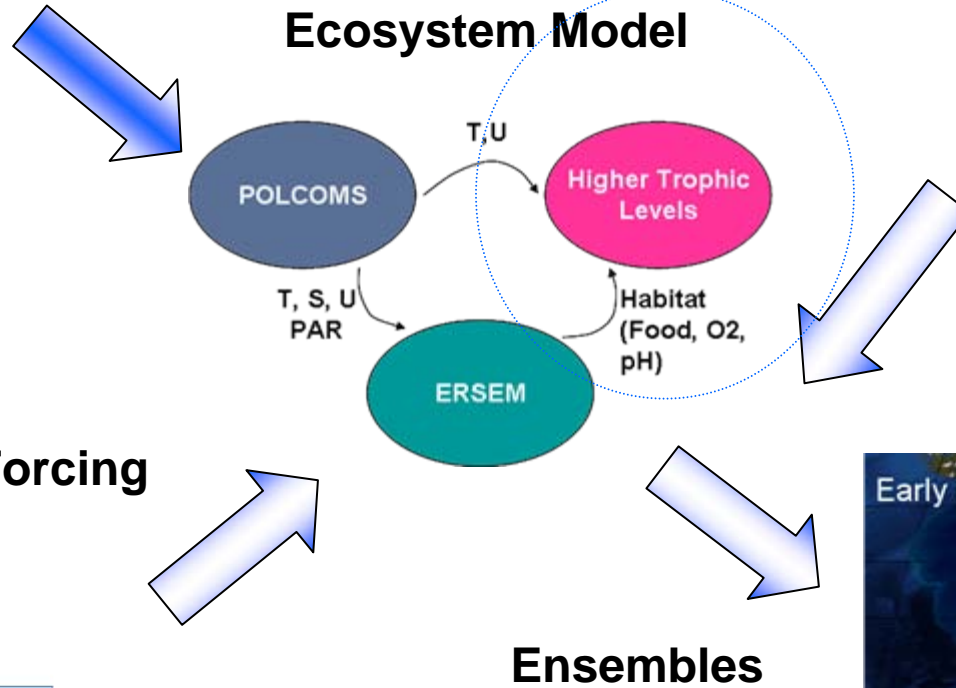
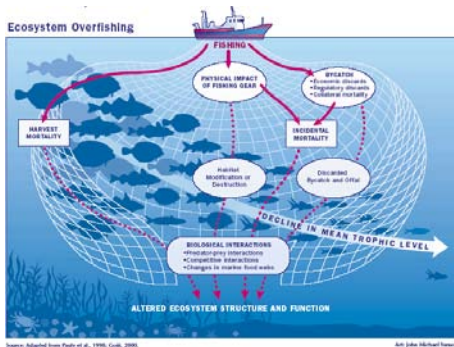


## Climate Forcing

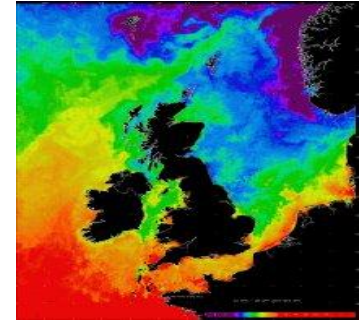
- Global
- Regional Downscale

## Anthropogenic Forcing

- Nutrient Loads
- Fishing pressure
- Pollution



## Observations



## Quantification of Uncertainty

## Ensembles



## Scenarios

