

Projections of climate change impacts in regional marine ecosystems: requirements and challenges

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Those who have
knowledge, don't predict.
Those who predict, don't
have knowledge.

Lao Tzu, *6th Century BC Chinese Poet*

Forecasting is the art of saying what will
happen,
and then explaining why it didn't!

-Anonymous



Prediction is difficult,
especially if it involves
the future.

Nils Bohr

Prediction is easy, getting it right is
the difficult part!

Prediction is easy, getting it right is the difficult part!

What does “right” imply?

-Some quantifiable measure of how well the model fits the observations

-For future projections where we won't have observations need some quantifiable measure of the **uncertainty**.

Nomenclature (from 2001 IPCC)

Projection – IPCC uses this to refer to model-derived estimates of future climate.

Forecast/Prediction - When a projection is branded "most likely" it becomes a forecast or prediction.

Scenario - A scenario is a coherent, internally consistent and plausible description of a possible future state of the world. It is not a forecast; rather, each scenario is one alternative image of how the future can unfold.

What kind of Models?

Models are simplification of our world-
Cannot expect to them to produce results that explain everything.

Types of models vary greatly in complexity:
conceptual, analytical, statistical, size spectra,
food-web models, end-to-end dynamical models.

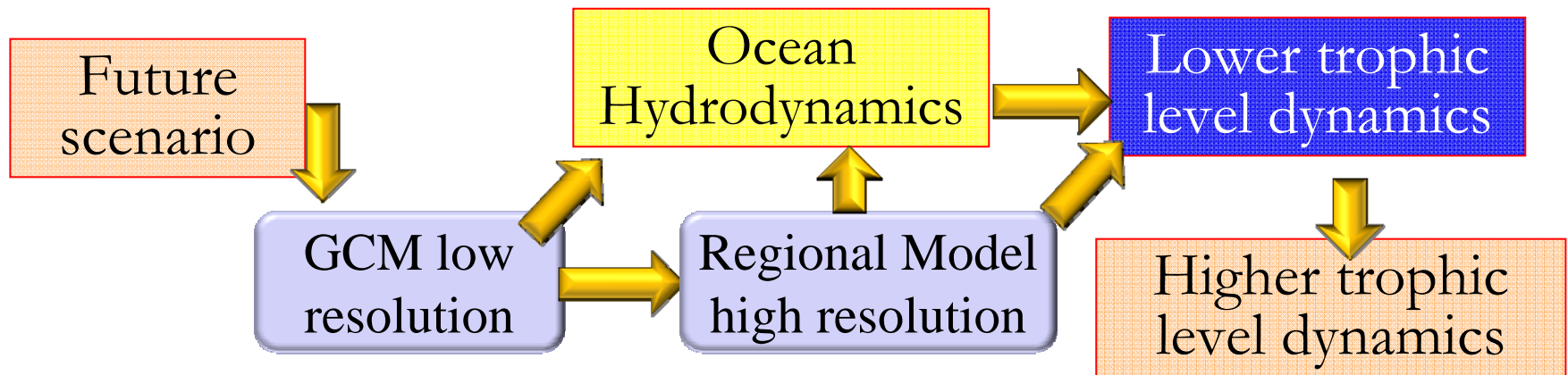
Need all kinds!

A good forecaster (modeller) is not smarter than everyone else, he merely has his ignorance better organised.

-Anonymous

Developing Regional Impacts of Global Change

- Need Regional Models
- IPCC provides Climate Change scenarios from GCMs
- Use IPCC scenario's for '**downscaling**' GCMs output by regional models for hydrodynamics (and biota) in regional seas



Sounds relatively simple but

Some Present IPCC GCMs Limitations

- CO₂ scenarios highly uncertain
- Small to large (1-3°) scales: mixing and turbulence, friction, waves, clouds, marine optics
- Arctic sea ice conditions not well represented
- Generally poor representation of ENSO, NAO, etc.
- Tides, tidal variability has the potential to impact significantly on climate: e.g. (W.Munk et al., 2001)
- No variability considered (temporal, spatial) in tidal forcing (IPCC, 2007)

IPCC GCMs: Limitations

→ No initialization to the present state (particular problematic for the ocean)

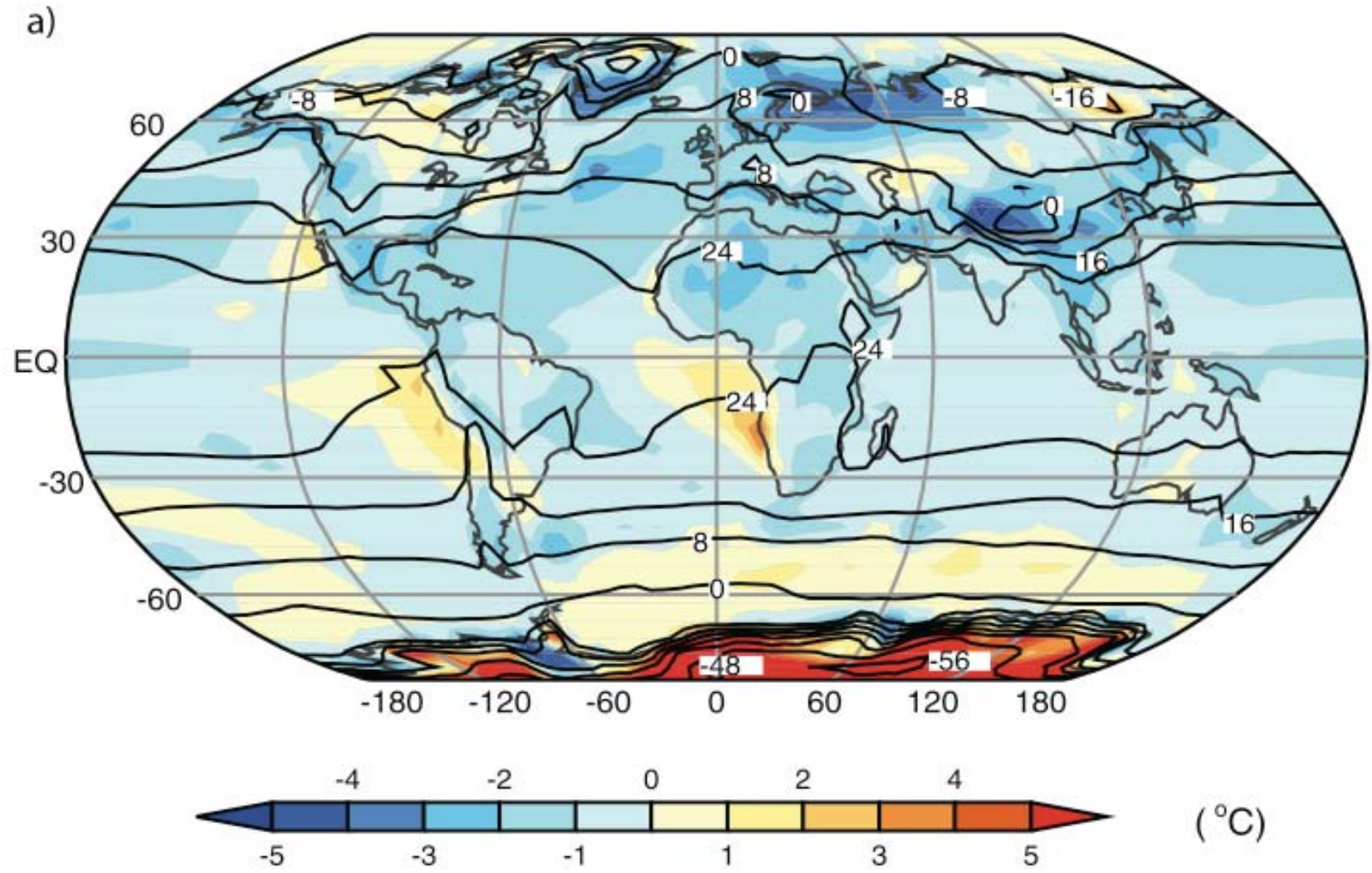
- Dr. Kevin Trenberth (*head of Climate Analysis Section, NCAR*) states:

(...) None of the models used by IPCC are initialized to the observed state and none of the climate states in the models correspond even remotely to the current observed climate. In particular, the starting state of the oceans, sea ice, and soil moisture has no relationship to the observed state at any recent time in any of the IPCC models.(...)

(...) I postulate that regional climate change is impossible to deal with properly unless the (global climate) models are initialized (to the current state).

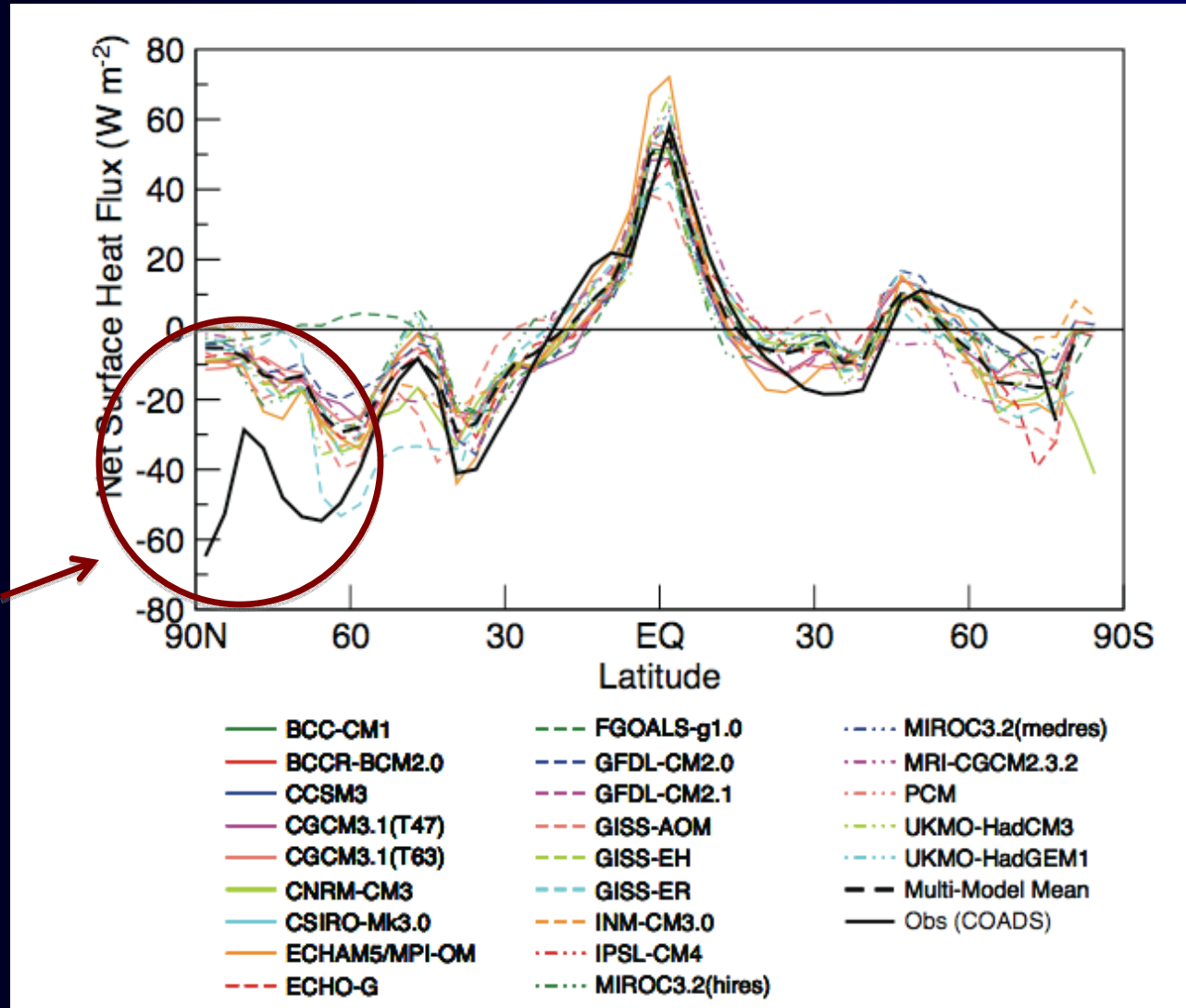
http://blogs.nature.com/climatefeedback/2007/06/predictions_of_climate.html

Surface Temperature error IPCC model ensemble



Validation of global climate models

Drift problems?
Sea-ice problems?



Regional Climate Models

Climatic Change (2007) 81:31–52
DOI 10.1007/s10584-006-9213-4

An inter-comparison of regional climate models for Europe: model performance in present-day climate

**Daniela Jacob • Lars Bärring • Ole Bøssing Christensen •
Jens Hesselbjerg Christensen • Manuel de Castro •
Michel Déqué • Filippo Giorgi • Stefan Hagemann •
Martin Hirschi • Richard Jones • Erik Kjellström •
Geert Lenderink • Burkhardt Rockel • Enrique Sánchez •
Christoph Schär • Sonia I. Seneviratne • Samuel Somot •
Aad van Ulden • Bart van den Hurk**

**One main conclusion: → RegCM are critically affected by
the driving large-scale fields from GCM and are very similar
to GCM results**

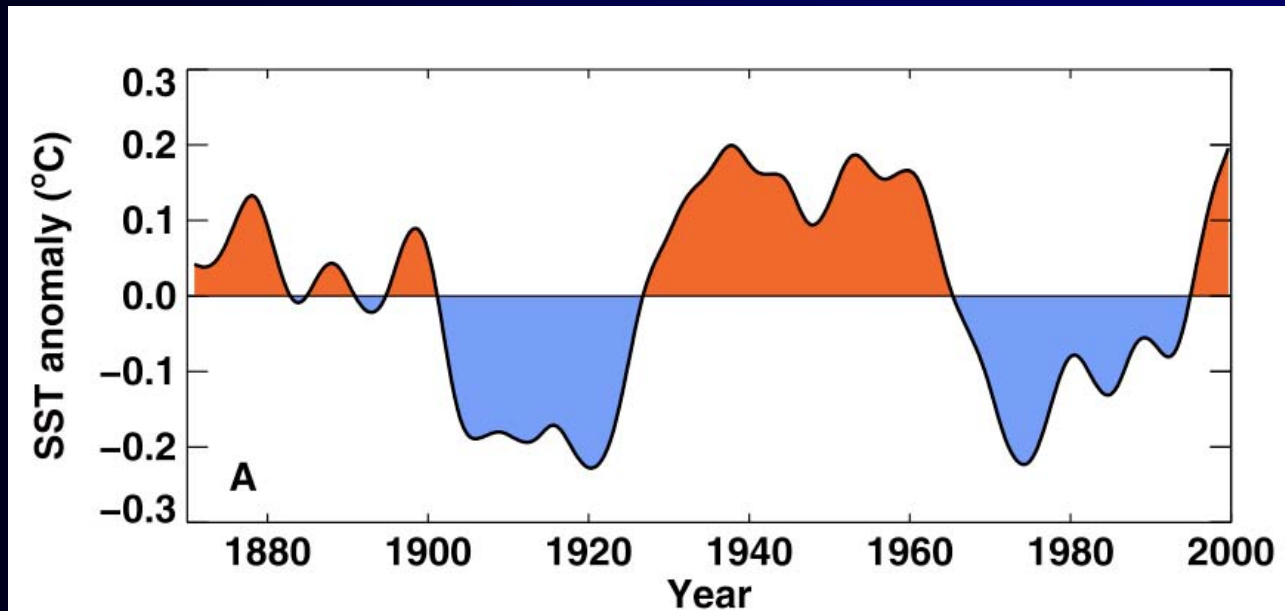
Regional downscaling

IPCC (2007) Chapter 11

- Few coupled ocean-atmosphere models on the regional scale
- Fewer models using different global models for downscaling
- Regional models that are available mostly use previous IPCC (2001) global model assessments
- No ecosystem models reported in the last IPCC report

Recently: Improved global decadal predictions by improving initialisation

- Doug Smith et al., 2007, Science
- Noel Keenlyside et al., 2008, nature



Related publications indicated the importance of AMO for the NA region - Knight et al. (2005) and Knight et al. (submitted)

Keenlyside et al., 2008

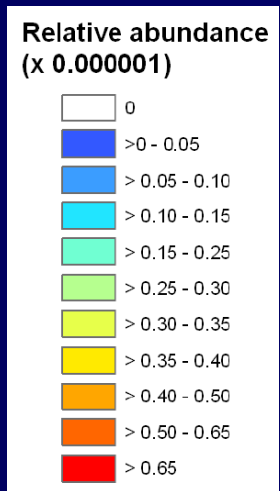
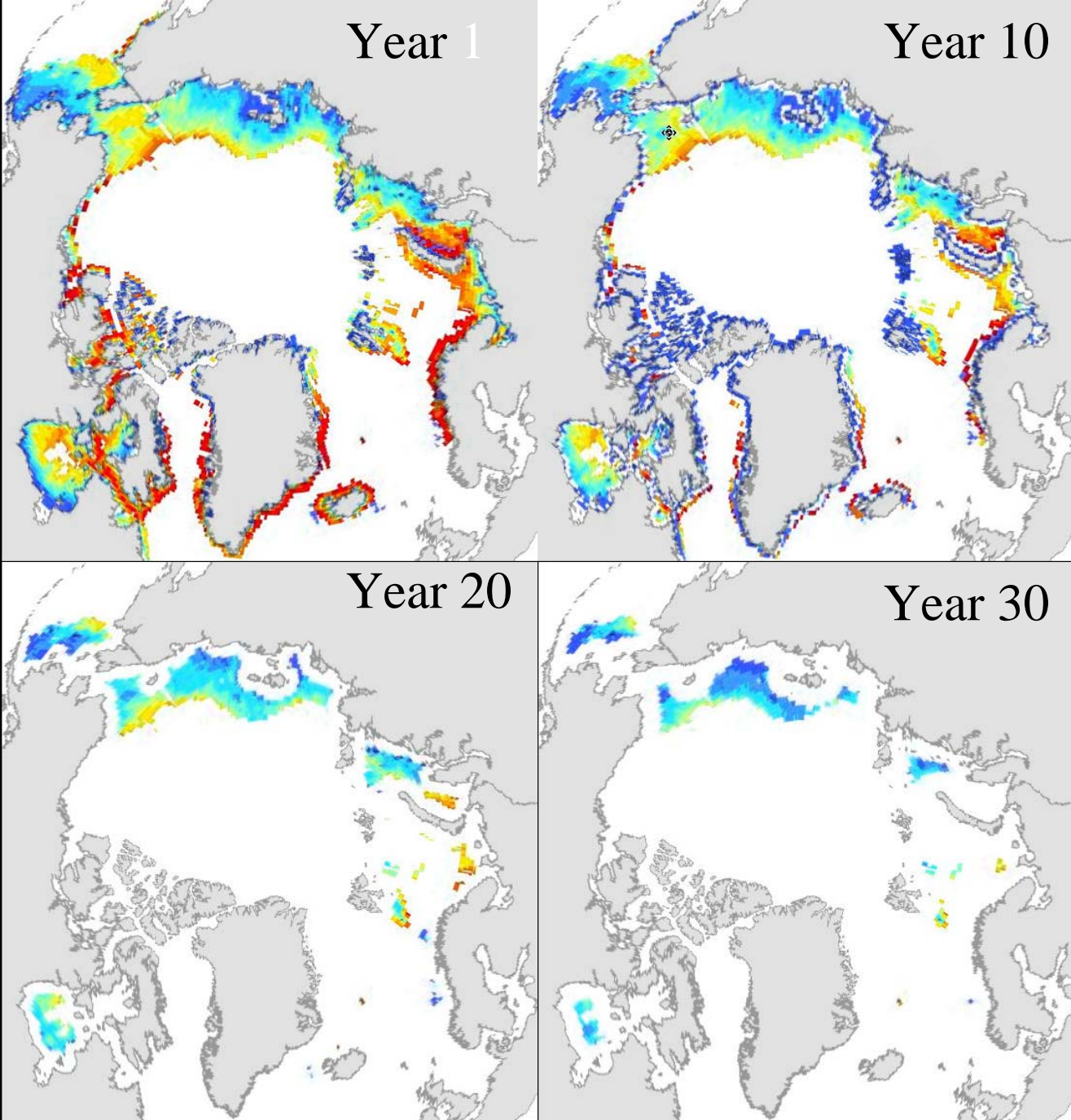
To investigate the sensitivity of the predictions to greenhouse gas forcing only, the two forecasts were repeated assuming that greenhouse gases were stabilized at year 2000 values. The predictions for the MOC and surface temperature remain basically unchanged. Thus, in the near future, natural decadal variability in the Atlantic and Pacific may not only override the regional effects of global warming, but temporarily weaken it. Thus, a joint initial/boundary value problem has to be considered when forecasting North Atlantic sector and global climate variability for the coming decades.

Regional Ecosystem Models

- Most only up to zooplankton
- Few include fish but are being developed (e.g. NEMURO, ATLANTIS)
- Usually not looking into future yet
- Some methods that have been used....

BioEnvelope Models

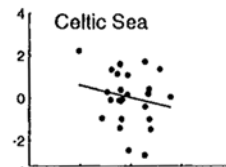
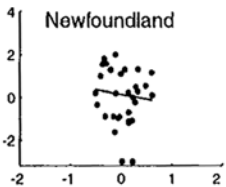
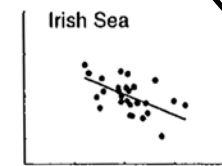
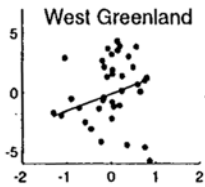
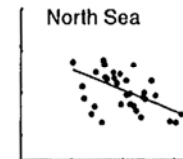
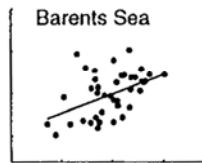
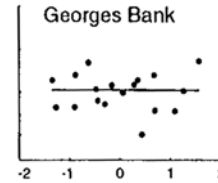
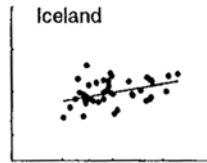
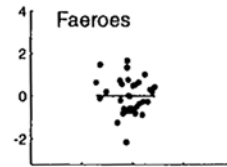
Polar cod



Cod Recruitment and Temperature

**Warm Temperatures
increases Recruitment**

**Warm Temperatures
decreases Recruitment**

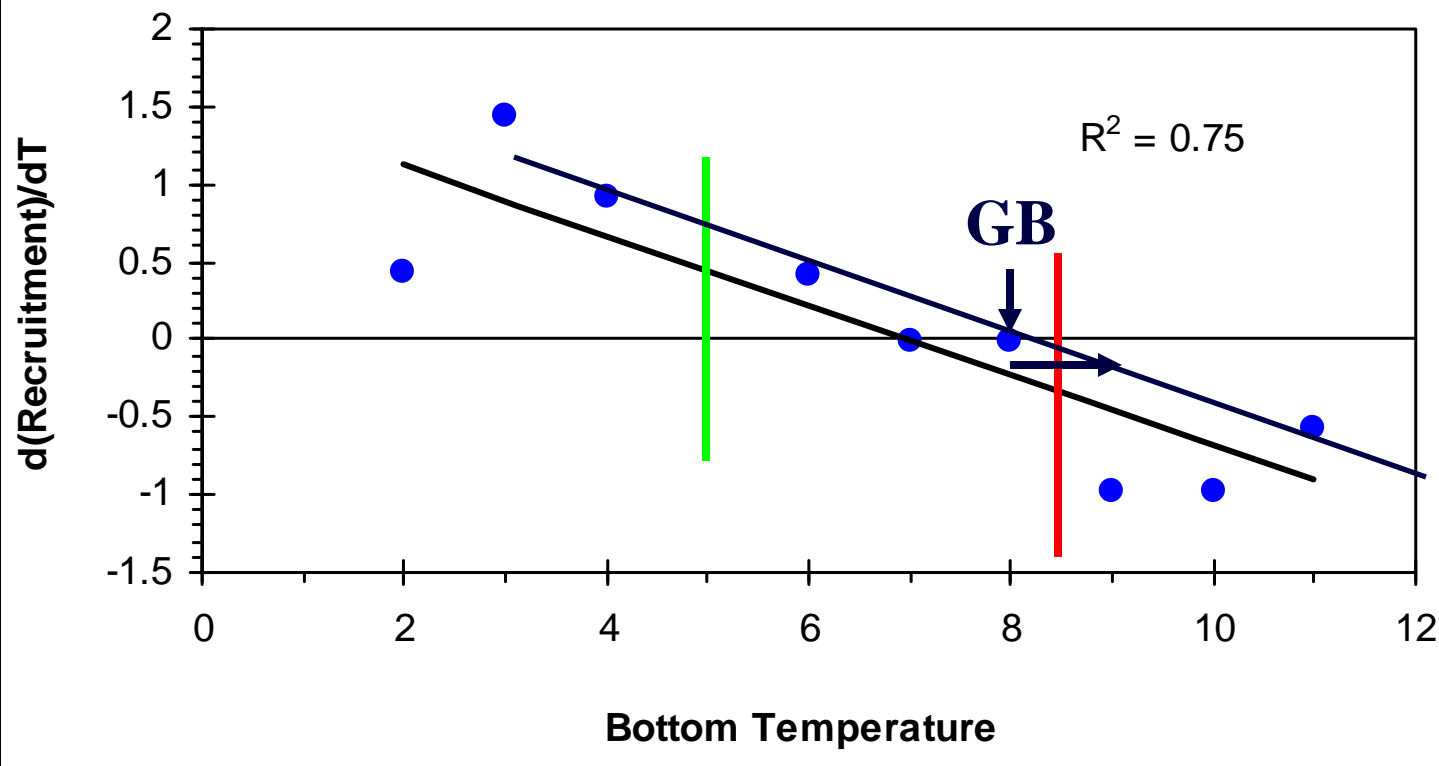


Recruits

Temp

Mean Annual Bottom Temperature

Planque and Fredou (1999)



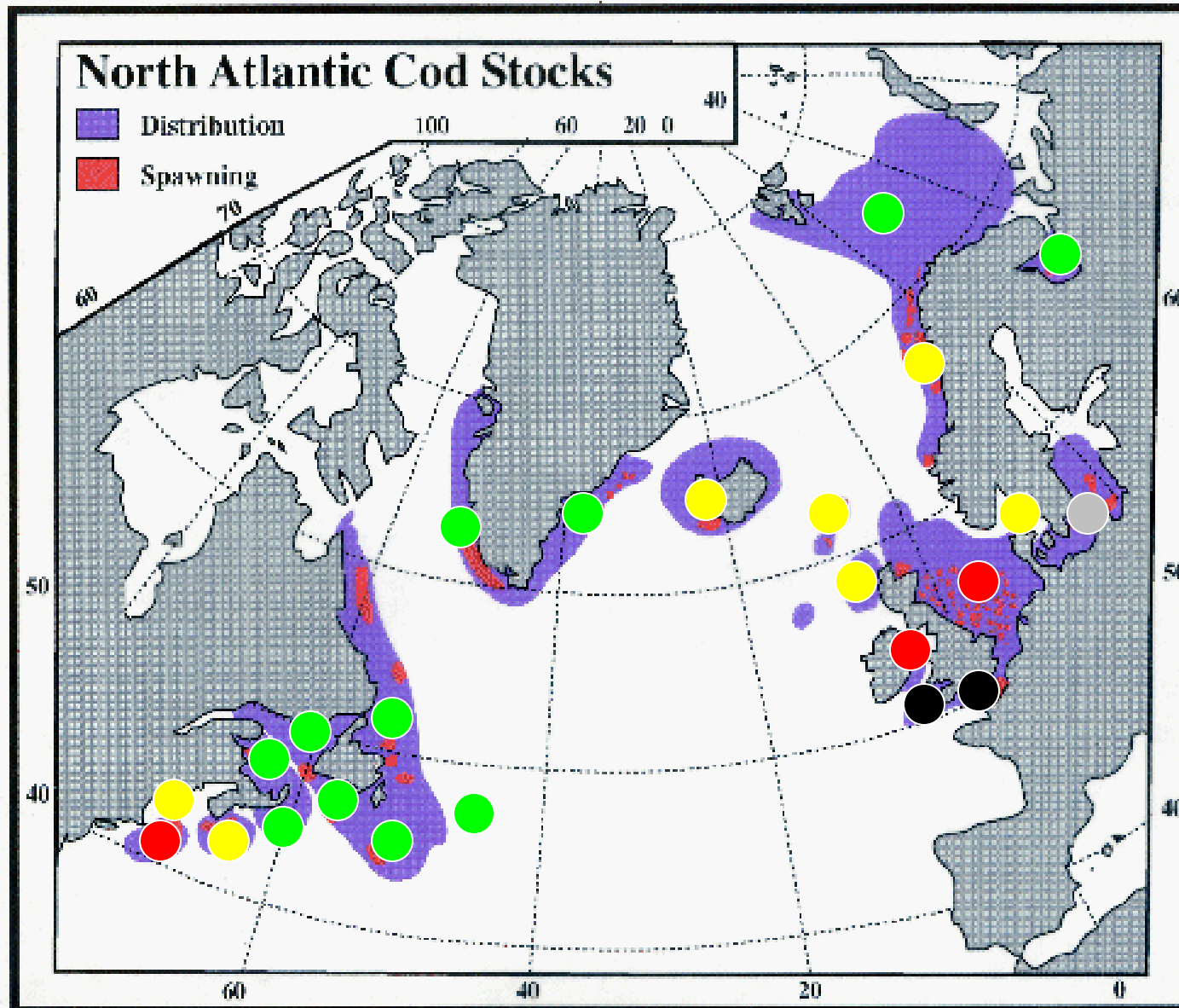
If $BT < 5^\circ$ and T warms stock recruitment generally increase

If BT between 5° and 8.5°C little change in recruitment

If $BT > 8.5^\circ\text{C}$ recruitment generally decreases

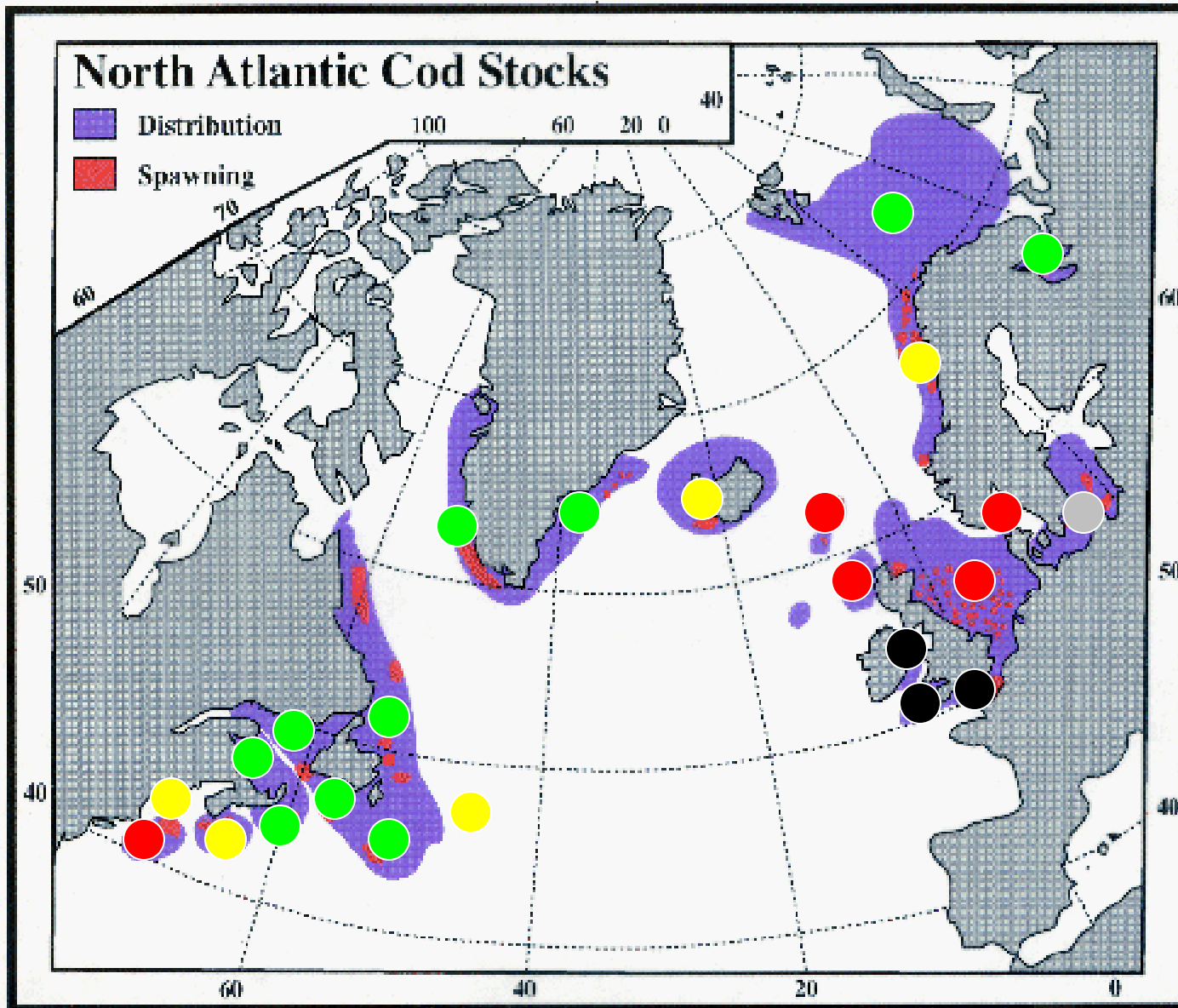
If BT 12°C we do not see any cod stocks

Effect on abundance of 1°C increase



- Increase
- No change
- Decrease
- Collapse
- ?

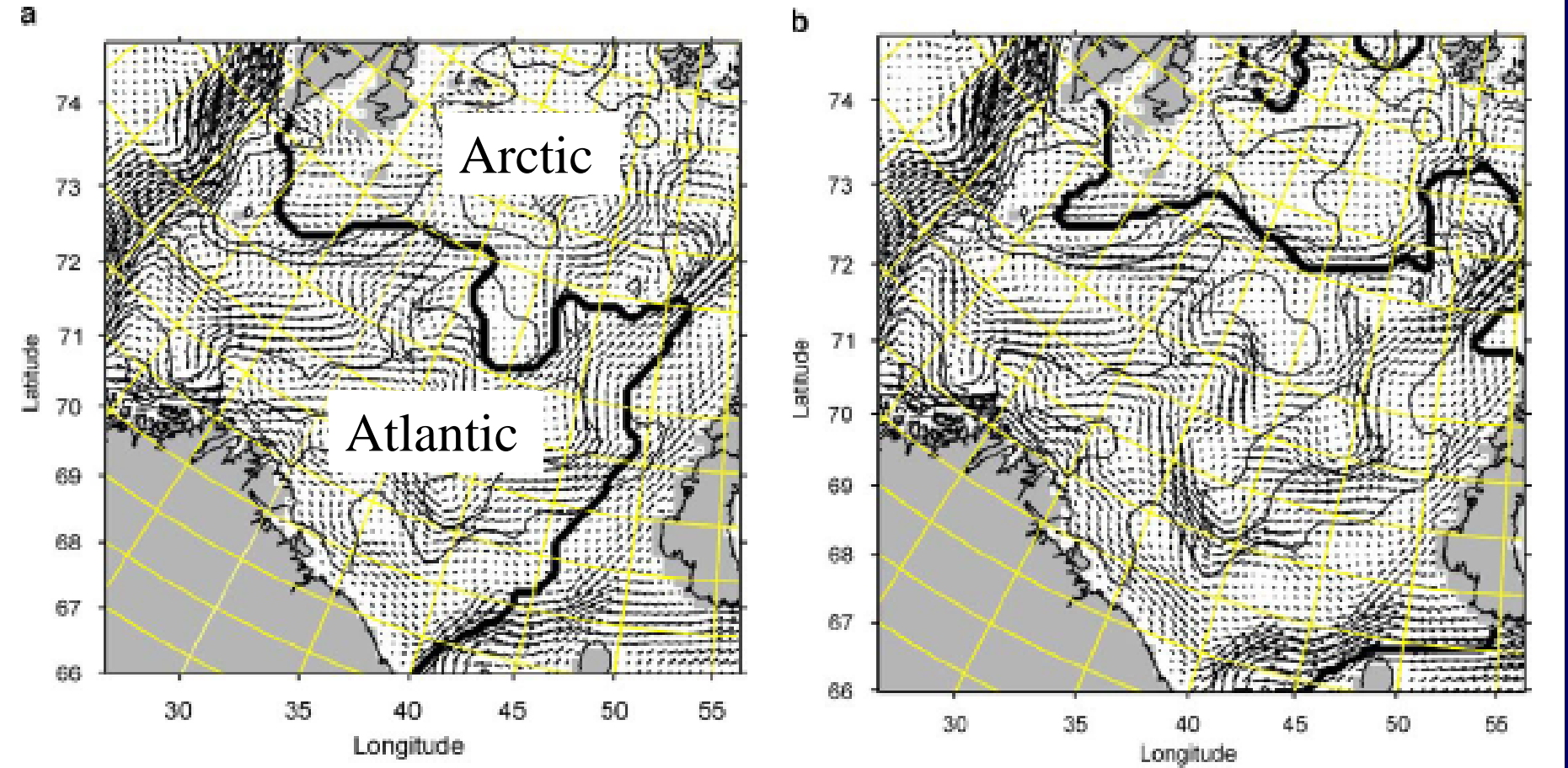
1 to 2°C Temperature Increase



Barents Sea

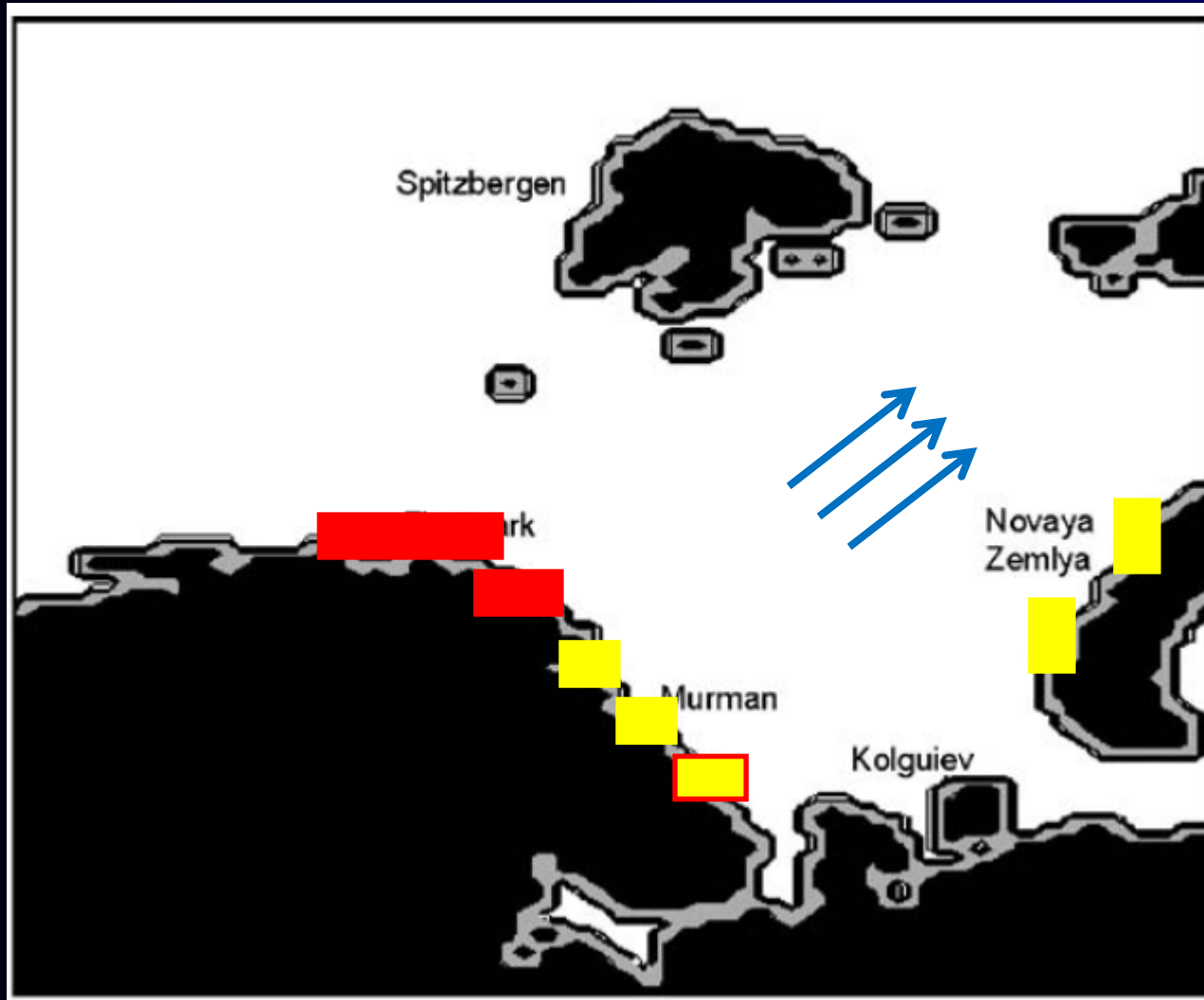
2000

2047



Modelled currents and Polar Front (thick black line).

Capelin Spawning in Response to Climate Change



Present Spawning

Future Spawning

Direction of distributional shift of adult feeding migration


Used Decision Theory

Huse and Ellingsen, 2008

Problems with these approaches

- Single species
- Does not take into account predators, prey or competitors
- Often does not consider thresholds
- Does not consider changes in light regimes

Need to include Fishing Effects

A photograph of a fishing boat on the ocean, viewed from a distance. The boat is blue and white, with a complex rigging system. The sea is covered with a massive flock of white birds, likely terns, flying and landing on the water's surface. The sky is overcast and grey.

Models need to be used to determine interaction between climate and fishing and explore effects of management strategies on stocks under climate change scenarios.

Next IPCC Runs

- Going to Earth System Models only
- Many of the models will be total new with increased number of parameterizations
- Will this lead to increased spread in model ensemble?
- Planning to initialize the fields

What do we need for Regional Impact Studies?

- Regional models (improved GCMs)
- Better understanding of the processes linking climate and food webs
- Improved parameterization of the models
- Measures of uncertainty

Conclusions 1

- Uncertainty due to global, regional and biological models is (much?) larger than the signal to study
- Need to develop uncertainty estimates of future scenarios
- Improved understanding of processes and better parameterization of the models
- Develop models that include fish and fisheries

Conclusions 2

- IPCC scenario model predictions (and consequently the RCMs based on these) are only of limited use for regional climate change assessment
- Presently might be able to learn as much performing controlled sensitivity tests with validated regional models
- Need to stress uncertainties when presenting results.
- Future projections from RCMs can be used to develop methodologies.
- Things are improving!



Thank you!