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Listen to the ocean

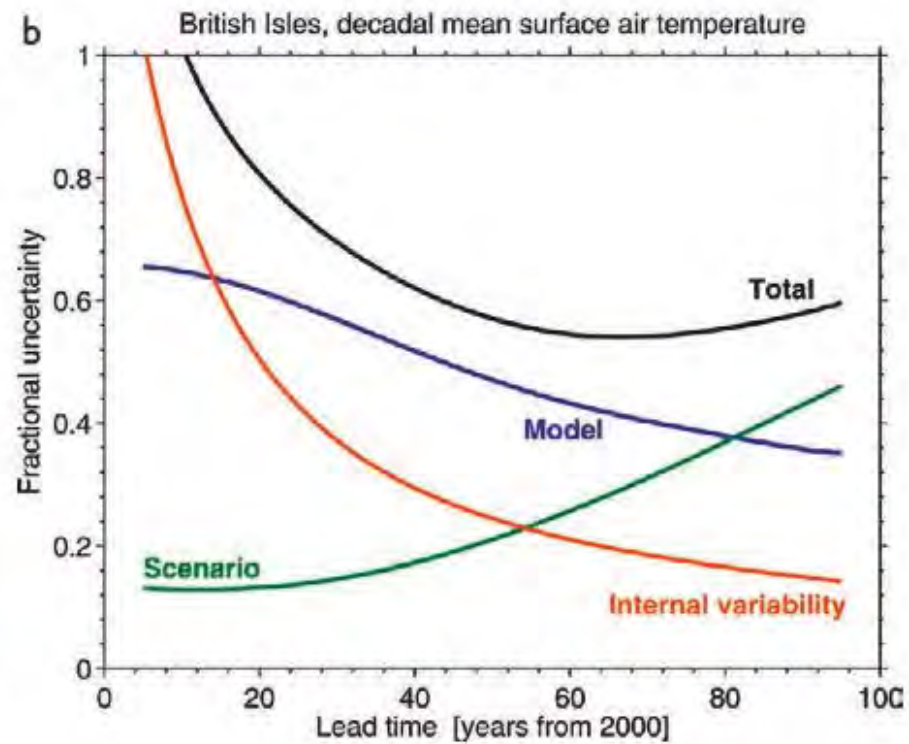
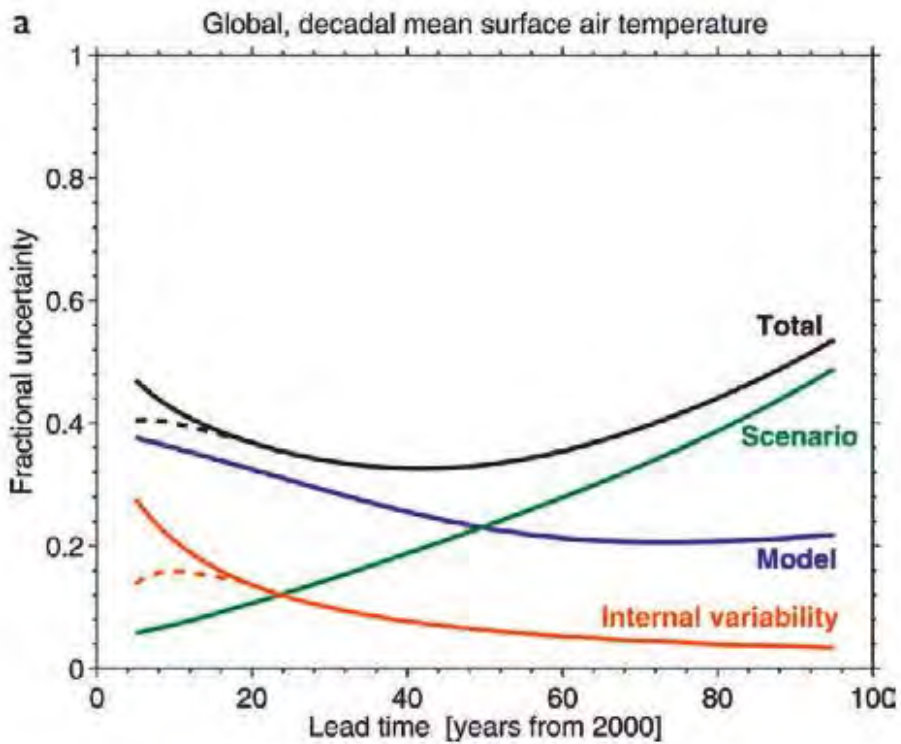
Dealing with uncertainty when developing socio-economic scenarios for North Atlantic fisheries futures

Manuel Barange, Plymouth Marine Laboratory, UK

and C. Mullon (IRD, France) J.A. Fernandes (PML), G. Merino (AZTI, Spain), W.W.L. Cheung, (UBC, Canada)

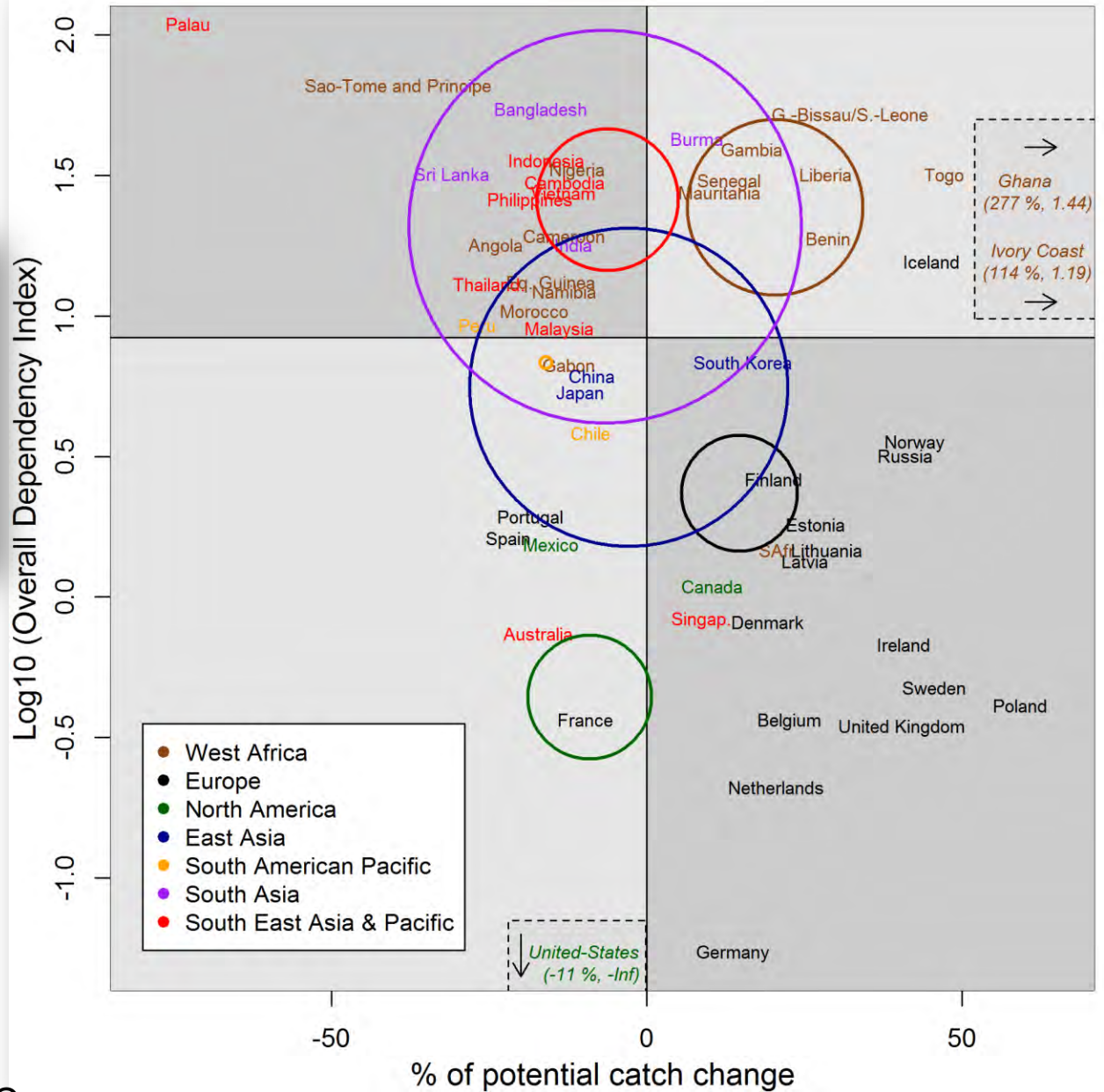
www.pml.ac.uk
m.barange@pml.ac.uk

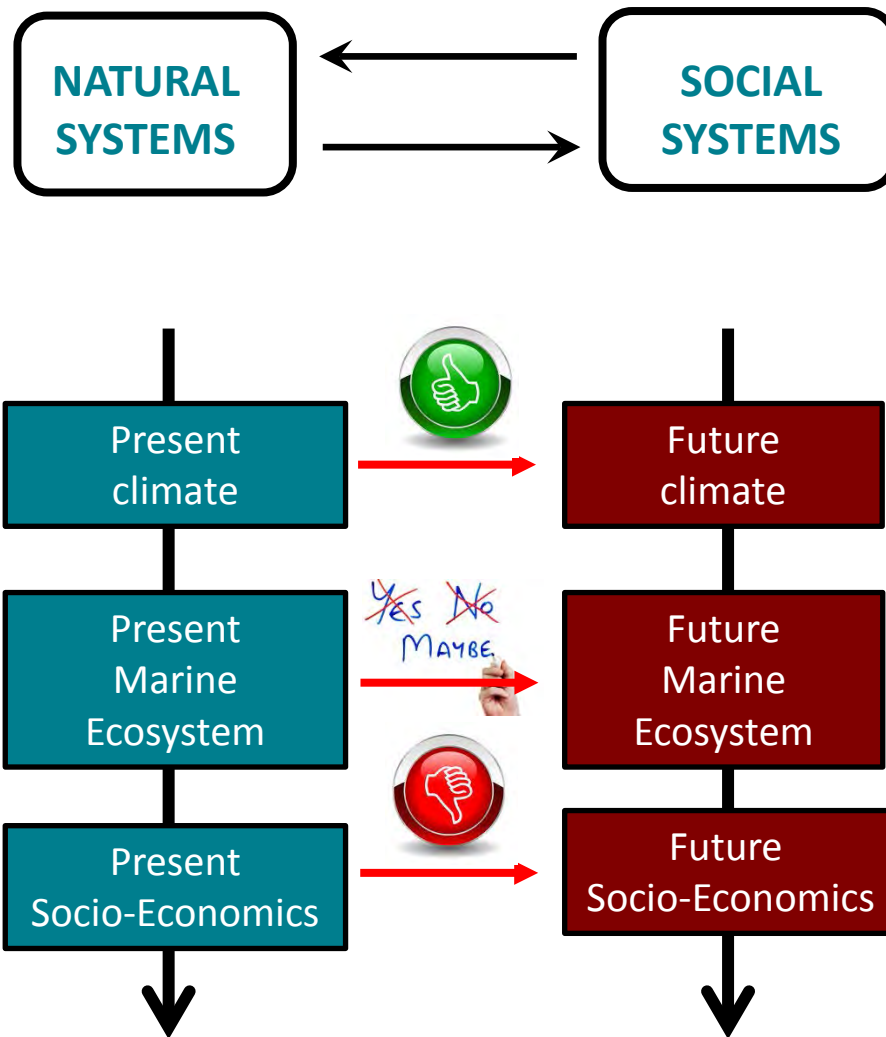


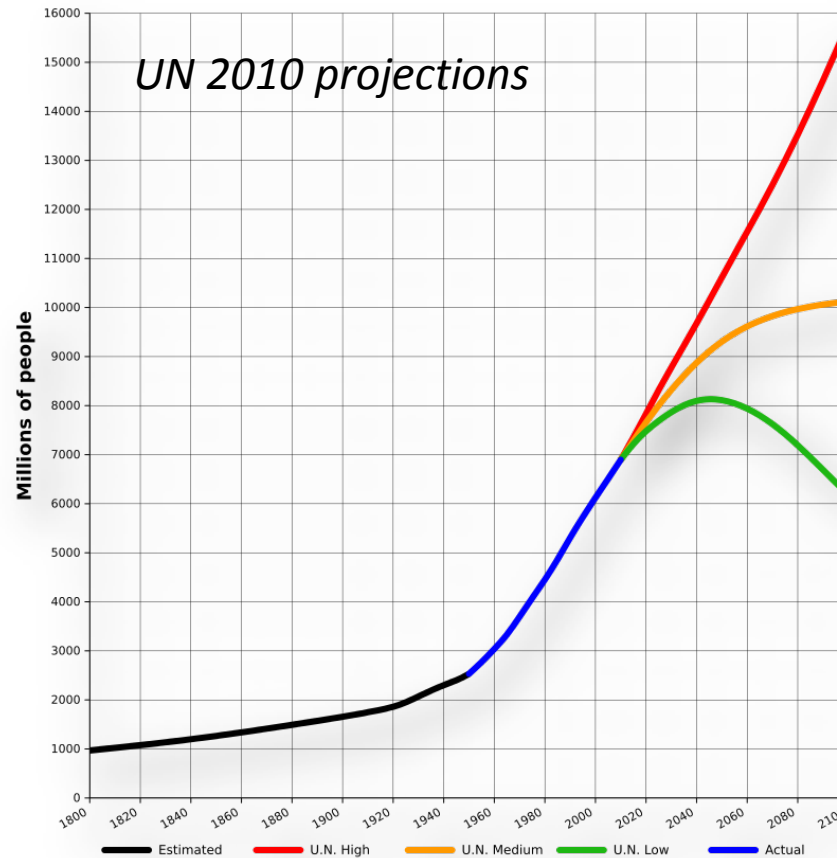




Responses (Social, political, economic, behavioural)







Global protein supply (kg/cap/yr)

	1969	1979	1989	1999	2009
Meat (kg/cap)	26.6	30.1	33.1	38.1	41.8
Fish (kg/cap)	10.7	11.4	13.4	15.6	18.2
Total (kg/cap)	37.3	41.5	46.5	53.7	60

Present
Socio-economics



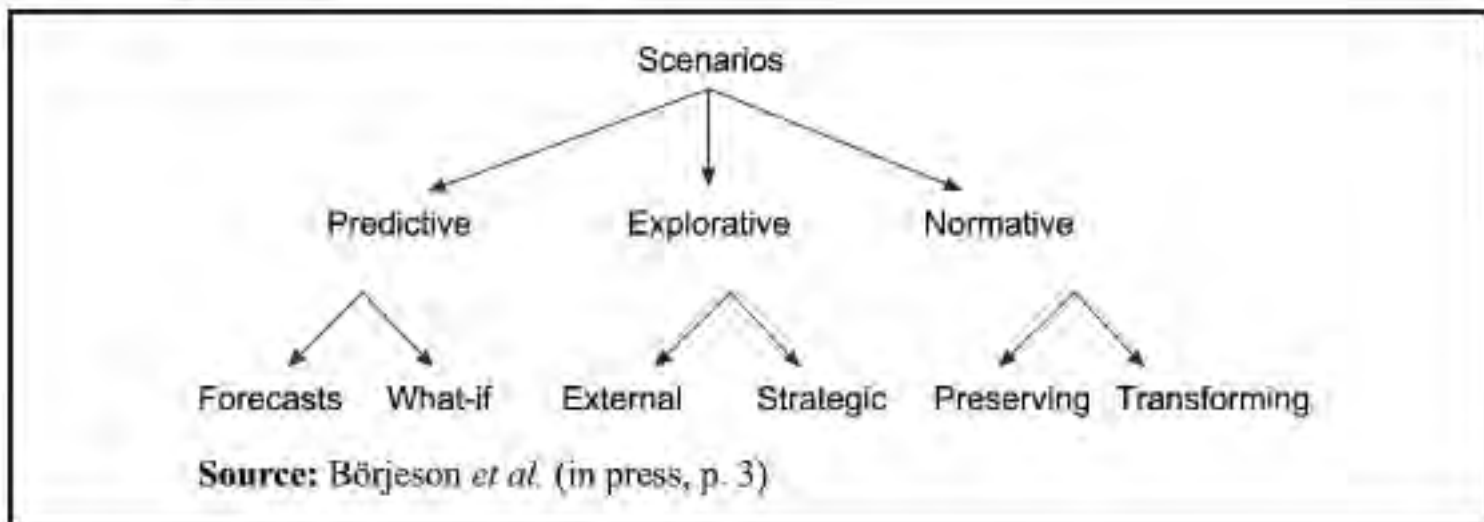
Future
Socio-economics

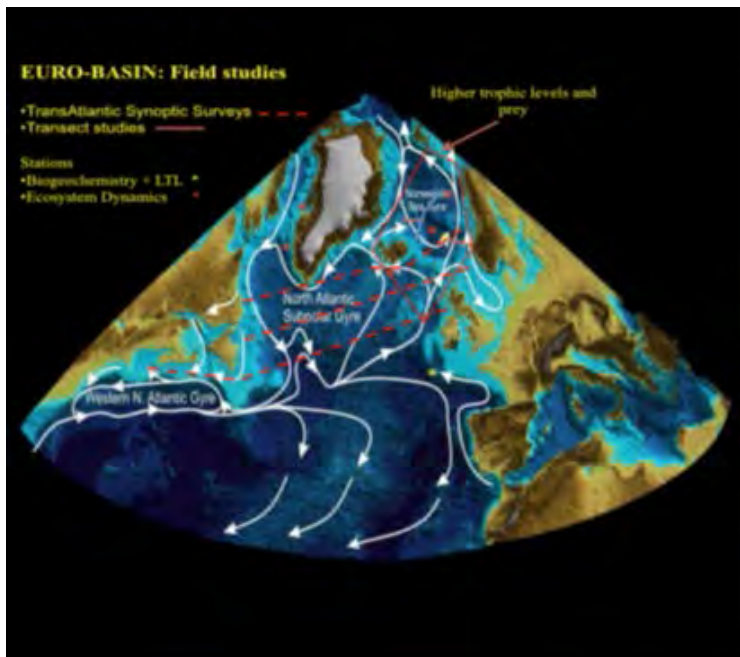
- Generic scenarios
- Data-driven scenarios





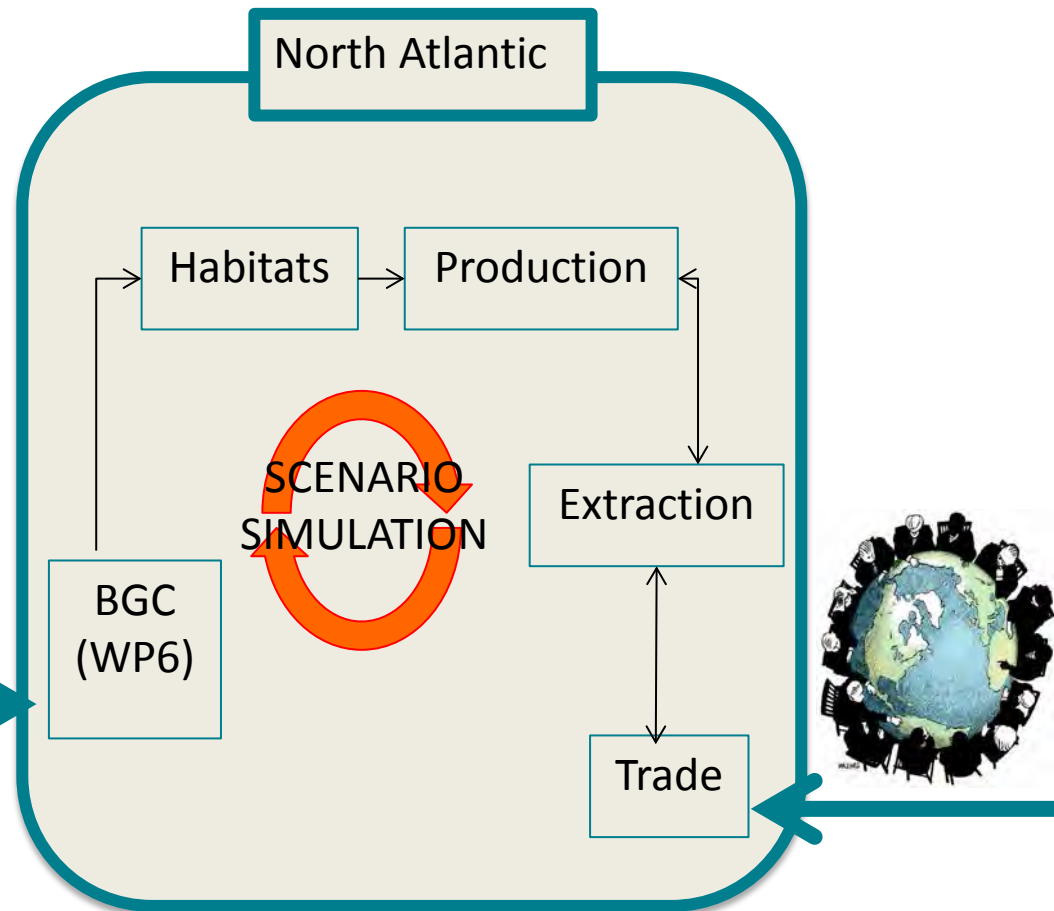
Figure 1 Borjeson scenario typology



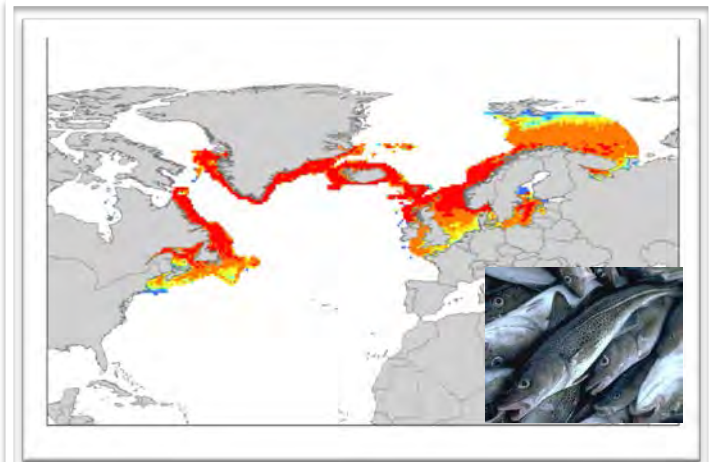


EURO-BASIN

BASIN SCALE ANALYSIS, SYNTHESIS AND INTEGRATION



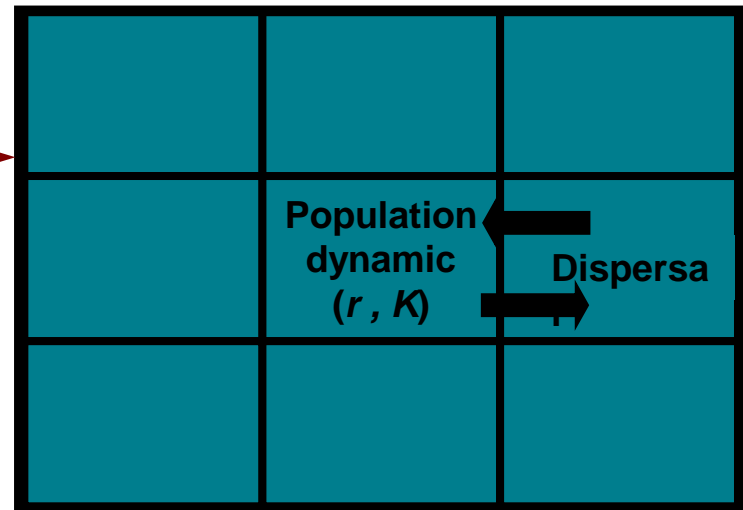
Step 1. Predict the distribution and production of key fish stocks based on climate change projections



- P(occurrence) by:
- Temperature
- Depth limits
- Habitats
- Distance from sea-ice

Global climate change ocean projections

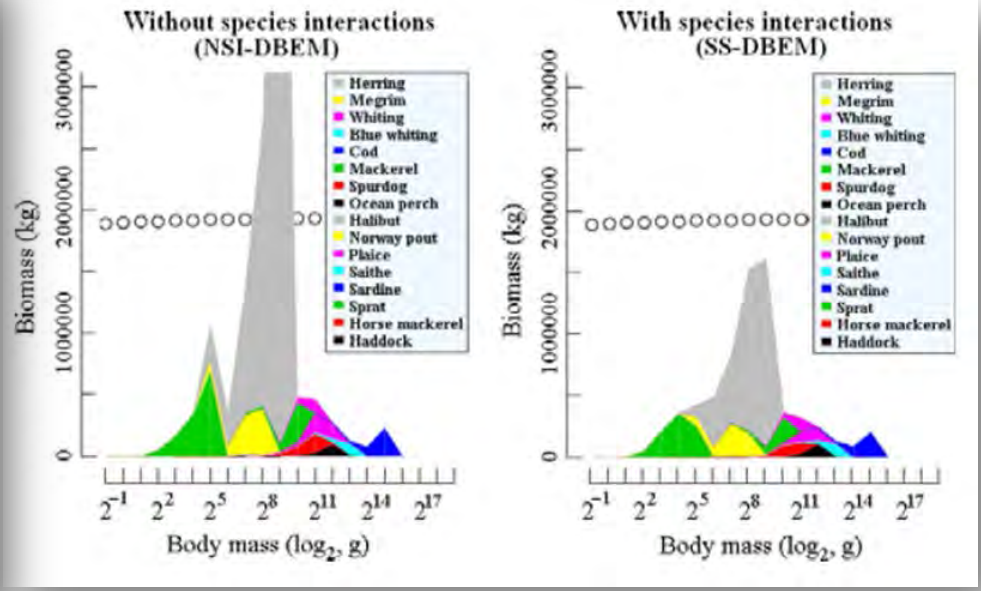
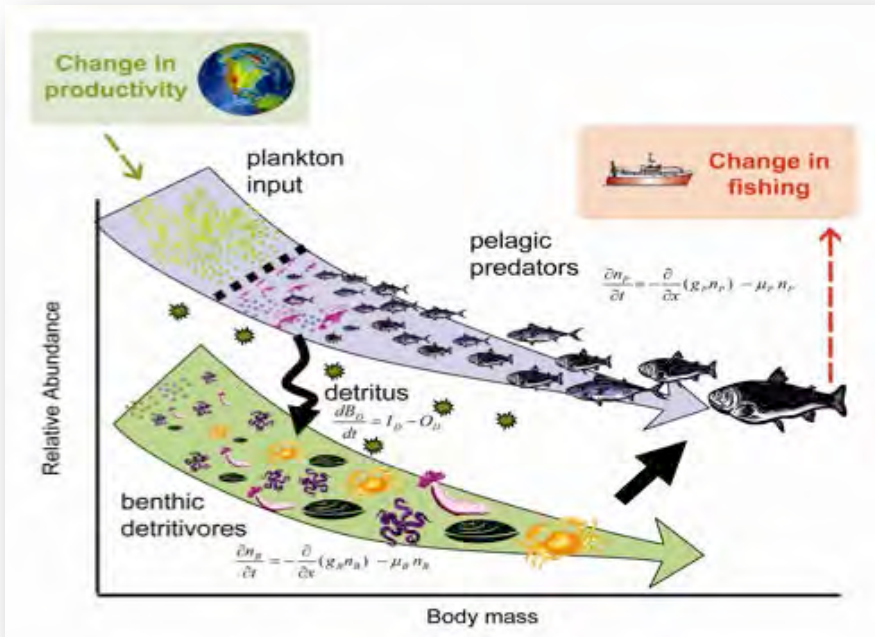
Population Dynamics



Predicted future species distribution

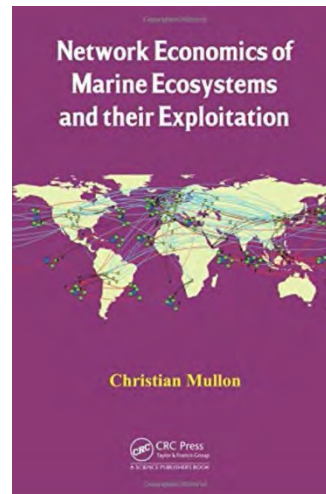
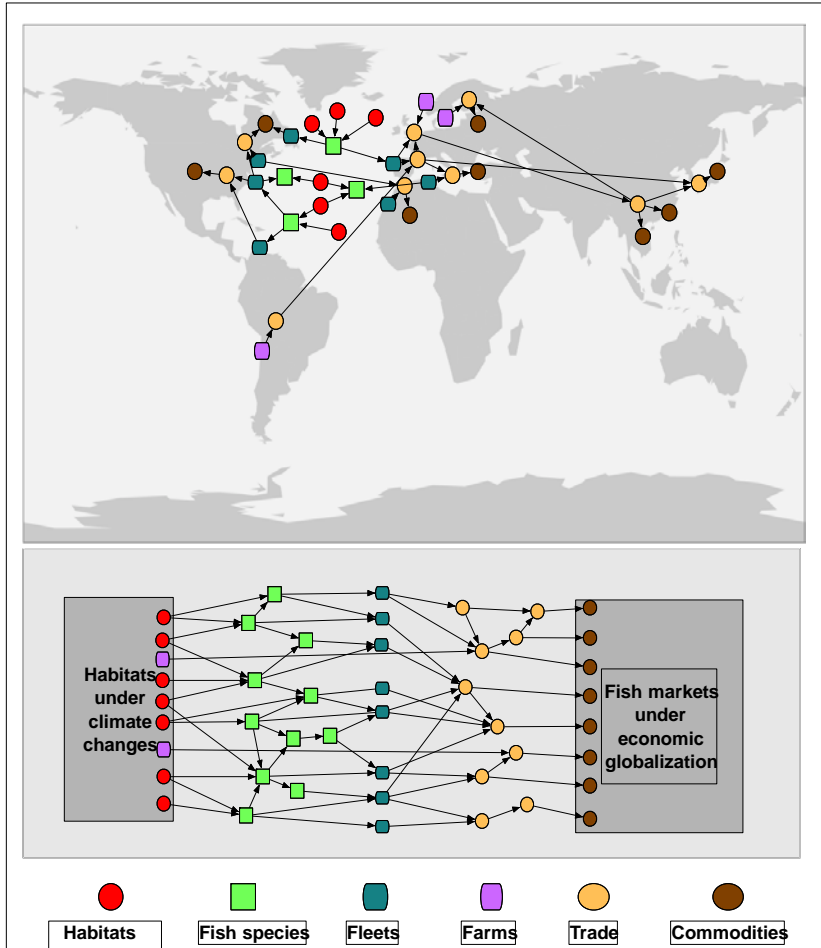
Catch potential (t)

Step 1. Predict the distribution and production of key fish stocks based on climate change projections



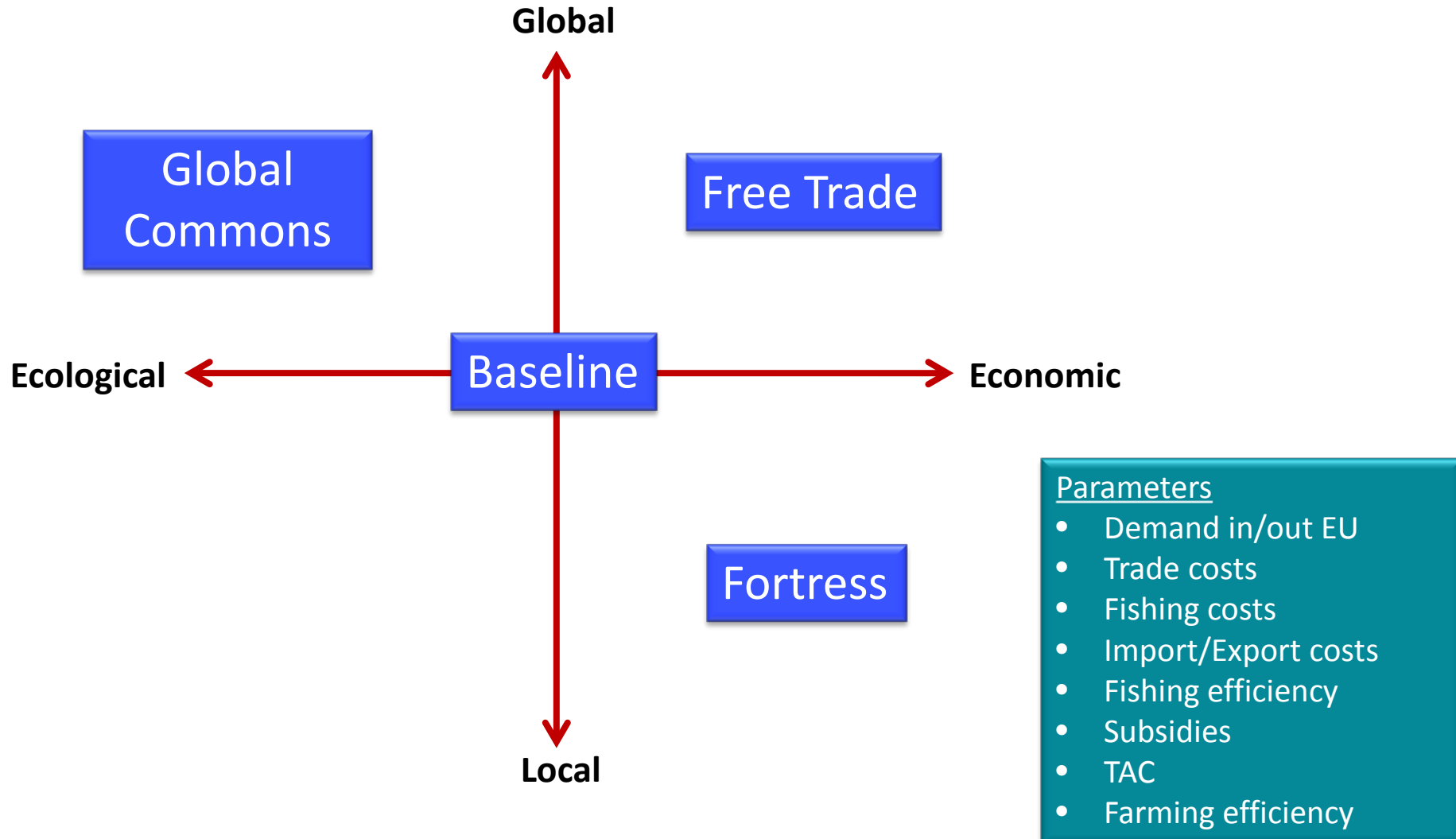
Fernandes, J., W. Cheung, S. Jennings, M. Butenschon, L. de Mora, T. Froelicher, M. Barange, A. Grant (2013). Modelling the effects of climate change on the distribution and production of marine fishes: accounting for trophic interactions in a dynamic bioclimate envelope model. *Global Change Biology* 19: 2596–2607

Step 2. Develop a bio-economic model of fish commodities in the North Atlantic



- 19 fish stocks
- 11 fishing systems
- 4 aquaculture systems
- 12 fish commodities
- 11 geographical areas
- 22 political nodes
- 23 trade systems
- 67 markets

Step 3. Simulations will be run for 30 to 50 years in a scenario-oriented perspective



MSY-based exploitation scenarios

Dynamic Bioclimate Envelope (DBEM) + Size Spectrum Model (SS)
Fernandes et al. 2013, GCB

Phys./ biol. Models
ERSEM-MEDUSA

Global Climate Models (2050)

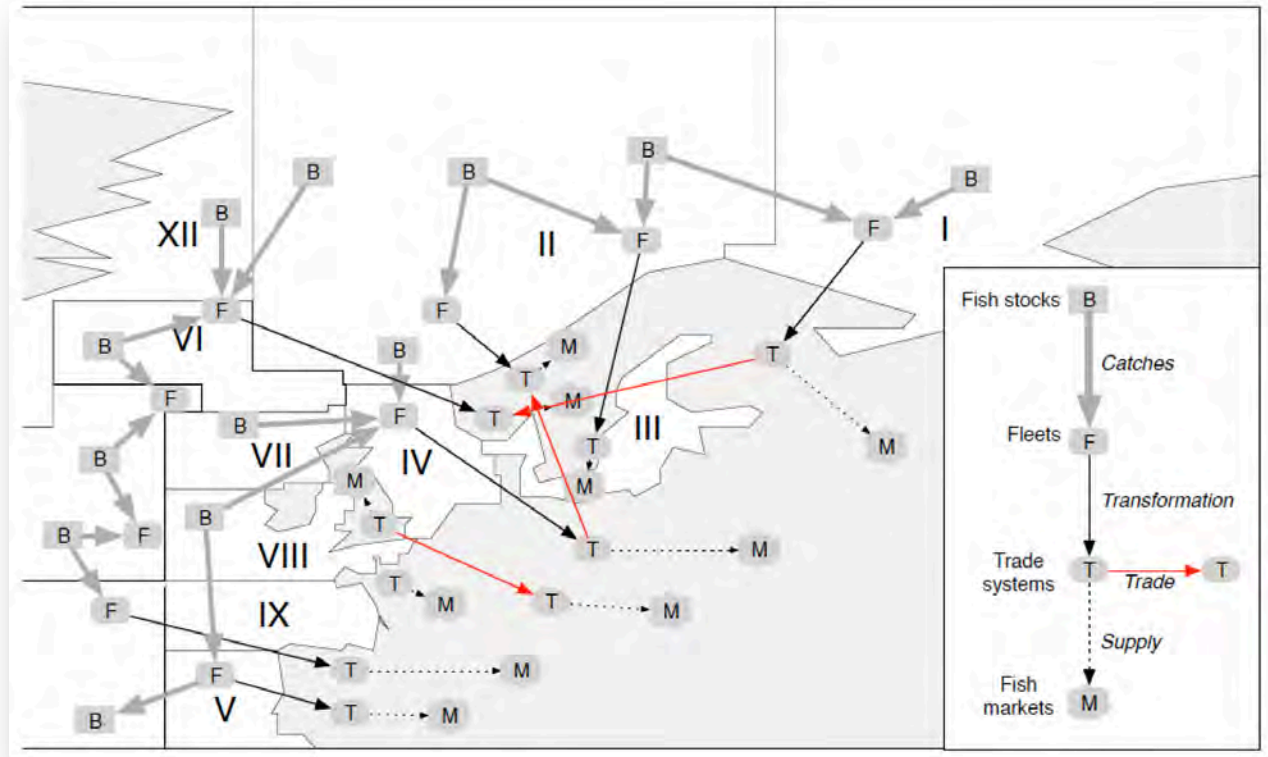
IPCC 4 A1B
IPCC 5 RCP 2.6
IPCC 5 RCP 8.5

X

Global Commons

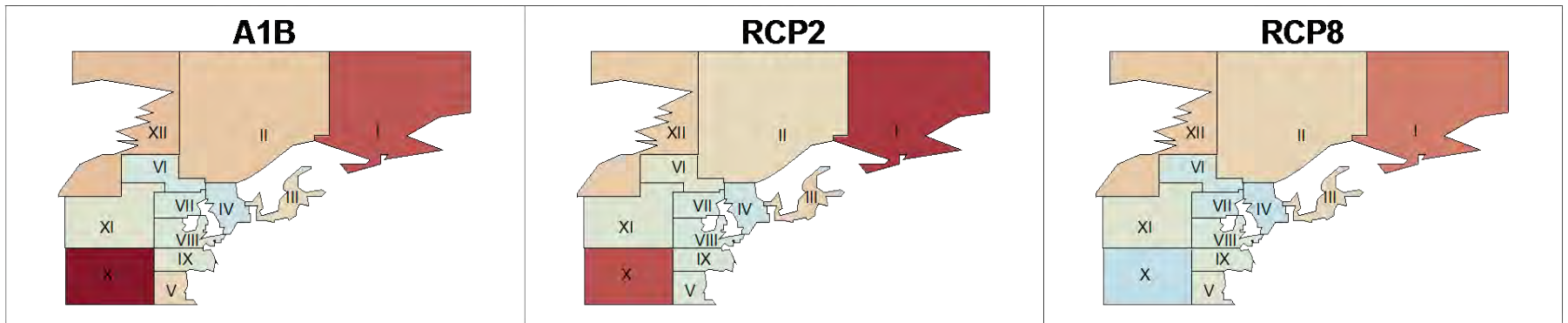
Free Trade

Fortress



(Carrying Capacity 2030s ref. to 2010s)

BioClim



0.



0.33



0.66



1.



1.33

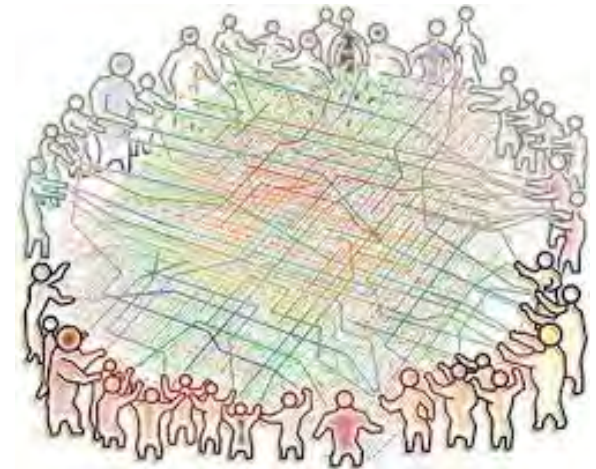
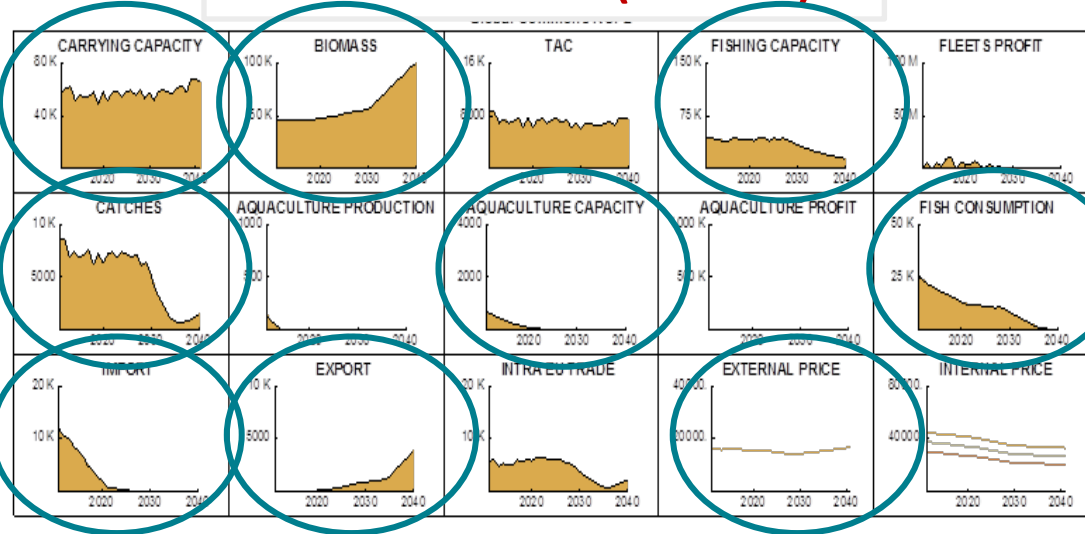


1.66



2.

Global Commons (RCP 2.6)



Global



Local

Ecological



Economic

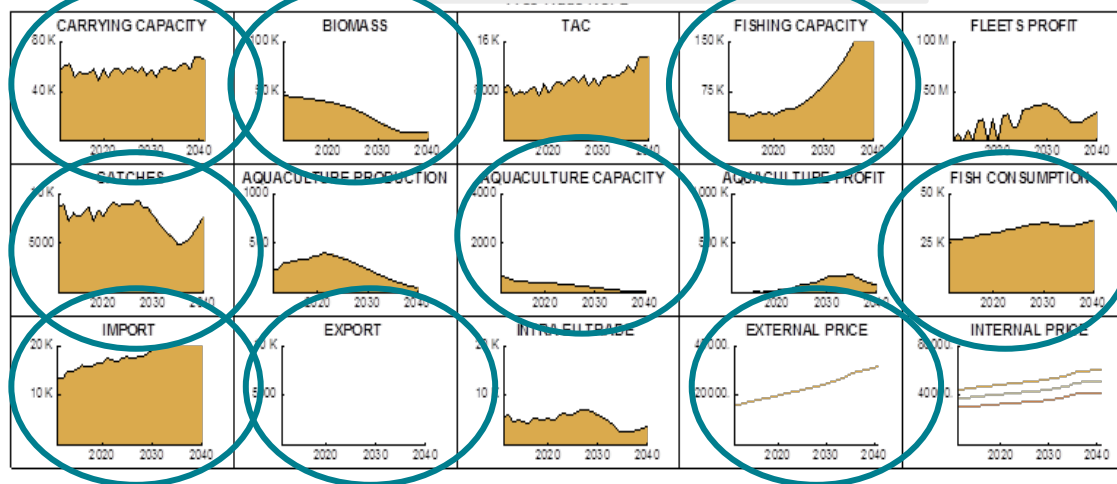


Under the **Global Commons scenario** the environment is protected. This could lead the rebuilding of fish stocks or the development of export industries. Ecological sustainability is achieved, but socio-economic sustainability is not secured.



Global

Free Trade (RCP 2.6)



Ecological

Economic

Under the **Free Trade scenario** the opening of international trade could lead the system to an unpredictable state. There is endangering of local stocks and fleets due to the high increase of the demand for fish. Economic indicators are positive but no long-term sustainability is assured.

Local

Global



Under the **Fortress scenario** there is overfishing, endangering of stocks, development of aquaculture. Development of aquaculture is artificial and due to subsidies despite marine fisheries do not meet the demand for fish products. Industrial structures are supported, but do not achieve long-term stability.

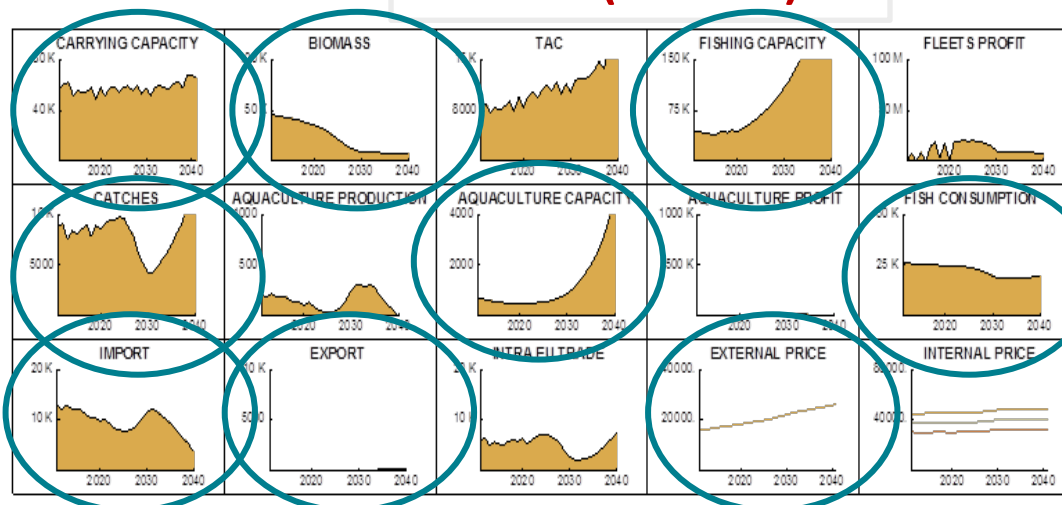
Ecological



Economic



Fortress (RCP 2.6)



Local



Conclusions

- The system is **more sensitive to governance changes than to climatic change**, at least at the horizon of 2040.
- Climate changes tend to result in a latitudinal drift of populations towards northern parts of the basin.
- An important driver of change for the future of the North Atlantic and the European fishing fleet appears to be the **interplay between wild fisheries and aquaculture**.
- Restrictions to **international trade are not as important as are relaxations of protection** means such as total allowable catch limits.
- The scenarios demonstrate that the **viability and profit of fisheries industries is highly volatile** across scenarios.
- Our conclusion is thus that this modelling experiment has resulted in a coordinated assessment of bio-economic modelling tools towards the development of objectives for future basin scale governance of the North Atlantic with stakeholders

Mullon, C., F. Steinmetz, G. Merino, J. Fernandes, W. Cheung, M. Butenschon, M. Barange (submitted). Quantitative pathways for North-East Atlantic fisheries based on climate and bio-economic modelling scenarios.

SUSTAINABILITY

Prediction, precaution, and policy under global change

Emphasize robustness, monitoring, and flexibility

By David E. Schindler* and Ray Hilborn

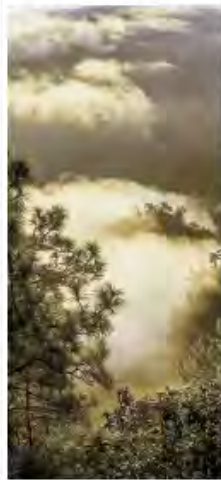
A great deal of research to inform environmental conservation and management takes a predict-and-prescribe strategy in which improving forecasts about future states of ecosystems is the primary goal. But sufficiently thorough understanding of ecosystems needed to reduce deep uncertainties is probably not achievable, seriously limiting the potential effectiveness of the predict-and-prescribe approach. Instead, research should integrate more closely with policy development to identify the range of a realistic plausible future and develop strategies that are robust across those scenarios and responsive to unpredictable ecosystem dynamics.

Calls for improving forecasts of future ecosystems states are common [e.g., (1)]. It is often assumed that poor performance of forecasting models (2) derives from weak understanding of ecological complexity and that developing richer mechanistic approximations of ecological interactions

POLICY will improve forecasts (3). There is also belief that statistical downscaling of global climate models will improve the accuracy of coupled climate-ecosystem models [e.g., (4)]. The utility of this information for improving forecasts of ecosystems is likely small; it is most useful for explaining observed ecological dynamics post hoc. The primary value of ecosystem models are as heuristic tools for communication and for developing scenarios to express uncertainties and test policies; reliable forecasts will remain elusive.

Scenario planning is used in many disciplines to assist policy development in situations with deep and intractable uncertainties (5–7). A range of information sources, which can include models, is used to develop alternative plausible trajectories of ecosystems; uncertainties about the future are represented by the range of conditions captured by the ensemble of scenarios. In contrast, forecasts narrowly limit uncertainties to those associated with a single potential

outcome that is assumed to be predictable; policy developed under this premise will prepare us poorly for the unpredictable (7).



change. Thus, environmental management will always operate in a realm where uncertainty dominates (8). Although more detailed knowledge about ecological processes will certainly be produced, reliable forecasts will likely accumulate much slower than will be useful for contributing to effective policy for sustainability or conservation, and ecosystems will likely change faster than knowledge accumulates.

A wide range of modeling approaches is used to explore and forecast ecosystem dynamics. However, models are prone to errors that can mislead policy if not treated with appropriate skepticism (11). For example, in statistical models, historical time series are often compared to quantify cause-and-effect relationships between resources and environmental variables. Without controlled manipulations and appropriate reference systems, such comparisons can lead to false conclusions, based on spurious correlations, about cause-and-effect relationships. For example, a reanalysis of 47 previously published relationships between environmental variables and recruitment in marine fish—after including an additional decade of new data—revealed that only one of the previously statistically determined relationships was still used in management because the initial correlations failed to persist through time (12).

Nonstationarity in ecosystem relationships (i.e., evolution of parameters that quantify them) adds substantial uncertainty to models, even if statistical relationships are based on real interactions in ecosystems. For example, changing climate and land-use are fundamentally changing the statistical relationships (e.g., between precipitation and river flow) that provide the foundation for water resource planning (13). Retrospective analyses of relationships between interacting variables are often used as the basis for forecasting tasks. However, in ecological models, statistical parsimony often selects retrospective models that have more mechanistic detail than can be supported when evaluating their forecast performance; the best forecast models are typically mechanism-free, relying on emergent statistical properties of data to make short-term projections (2, 14).

It is typical to validate or verify a numerical model by assessing its ability to accurately simulate observed changes in an ecosystem. However, in even modestly complicated models, simulations can recapture observed dynamics, but for entirely wrong mechanistic reasons (11, 16). Thus, current approaches to verification and validation of ecosystem models. Early produce overly optimistic impressions of the reliability of forecasts underlying management and conservation prescriptions.

School of Aquatic and Terrestrial Sciences, University of Washington, Seattle, WA 98195, USA
*E-mail: dschindler@u.washington.edu

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Present
Socio-Economics



Future
Socio-Economics

“Scenario planning is used in many disciplines to assist policy development in situations with deep and irreducible uncertainties”

“In contrast, forecasts narrowly limit uncertainties to those associated with a single potential outcome that is assumed to be predictable; policy developed under this premise will prepare us poorly for the unpredictable”



Schindler and Hilborn 2015. Science 347

Thank you

