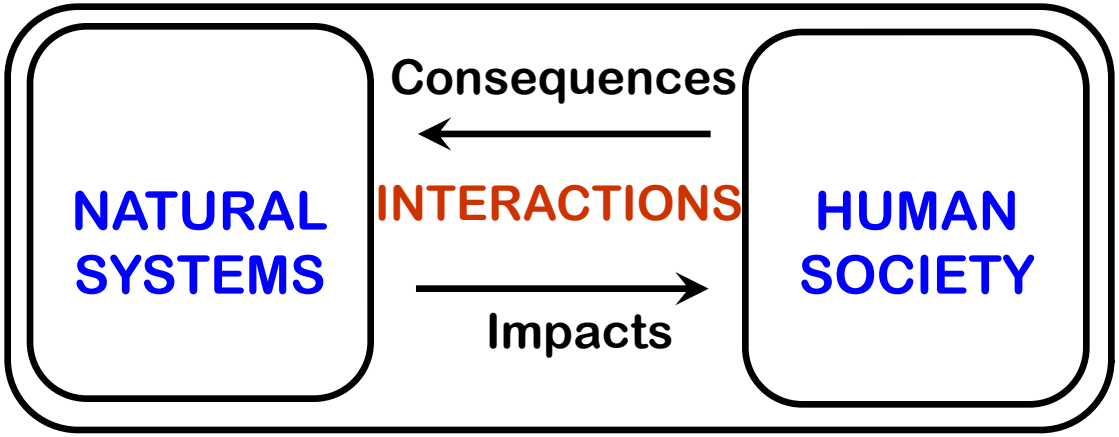
WP 7 - Bioeconomic modelling of N.Atlantic fish resources



Partners

- PML, UK (Manuel Barange, Gorka Merino)
- IRD, France (Christian Mullon)
- UEA, UK (William Cheung)
- CEFAS, UK (Simon Jennings)

The QUEST_Fish model

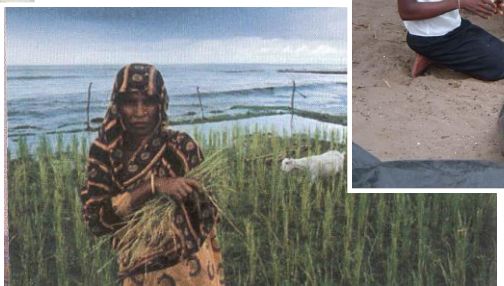
GCMs

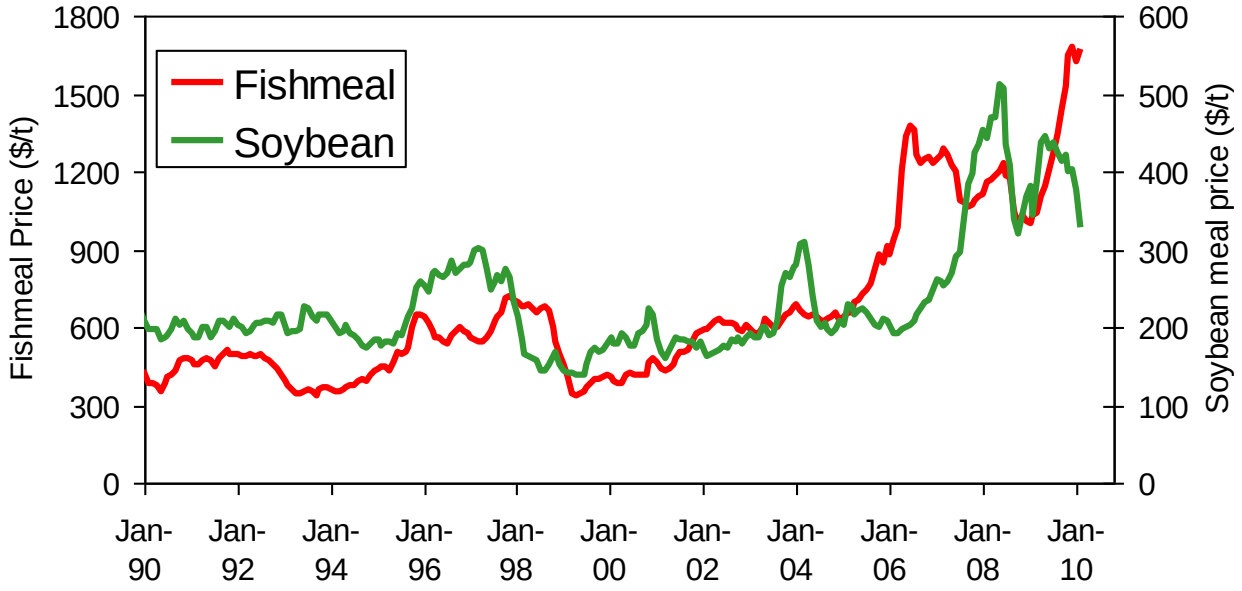
Regional Physical-Biological Shelf-Sea Models

Potential Fish Production Estimates

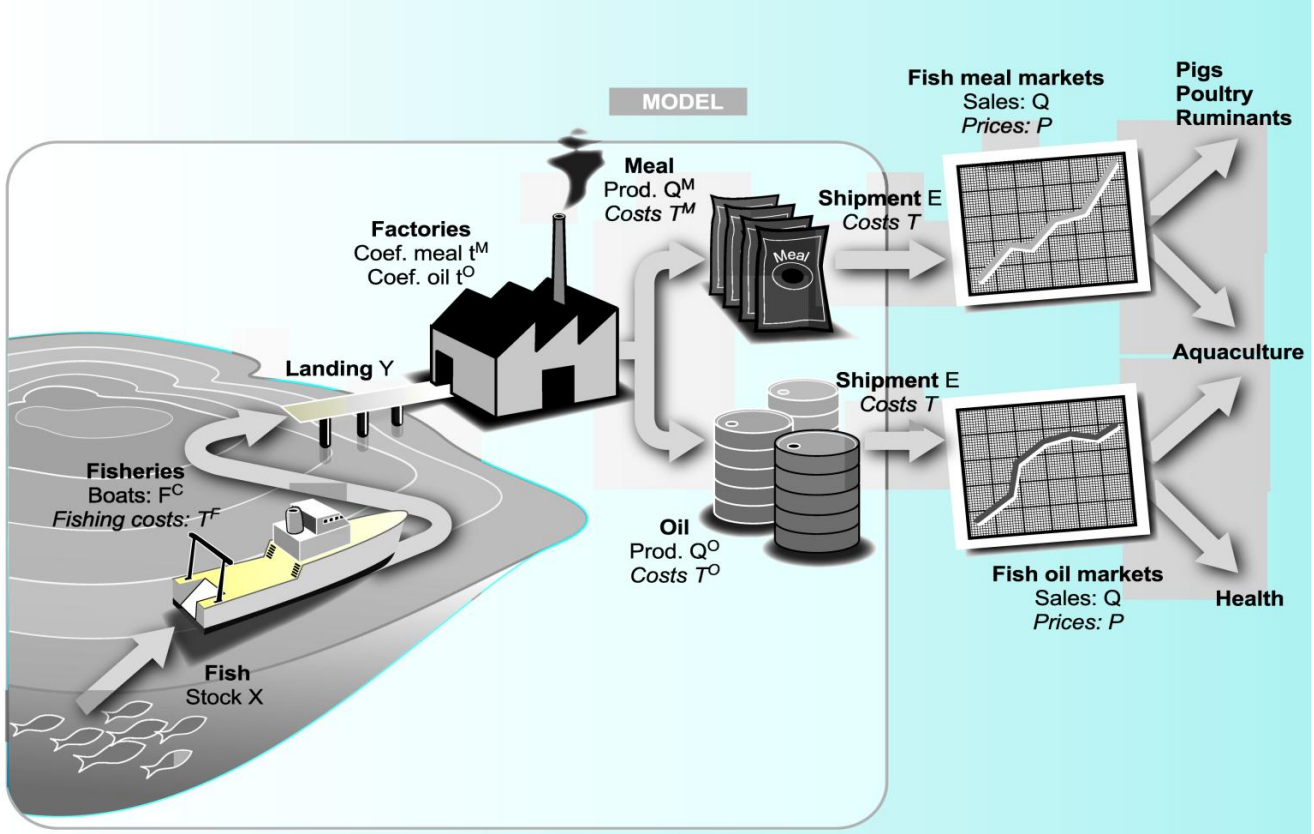
Bio-economic marine commodity models

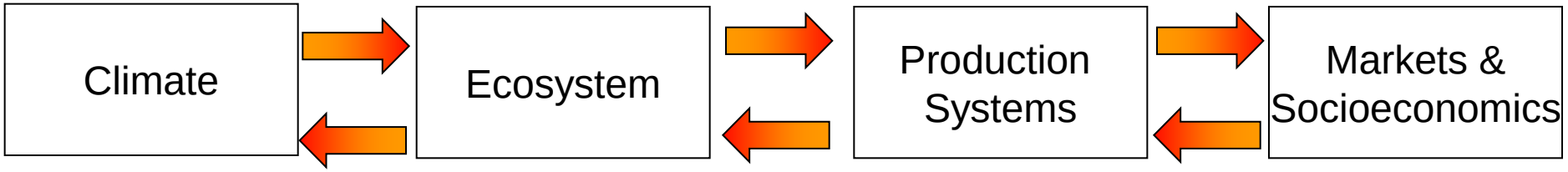
Vulnerability Assessments

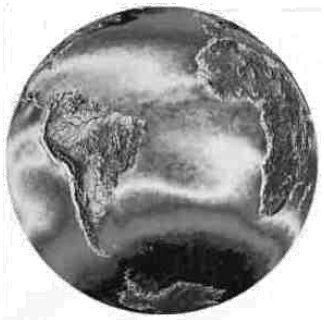


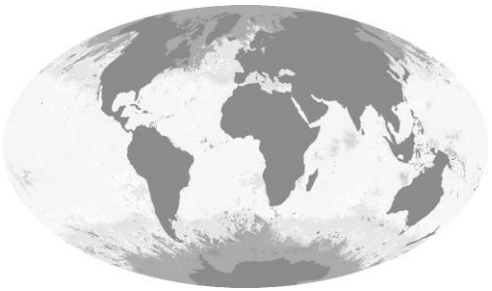


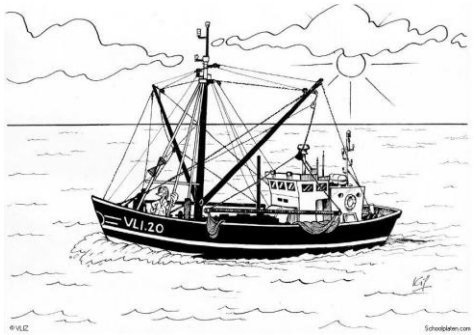
6Mt Fishmeal + 1.2 Mt Fish oil

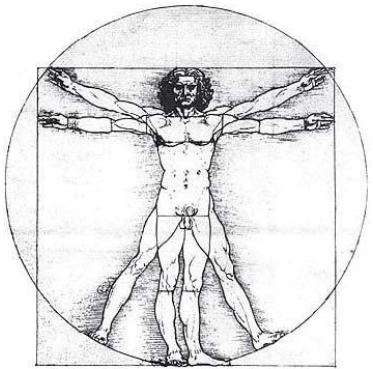

MODEL
Fish meal markets
Sales: Q
Prices: P
Pigs
Poultry
Ruminants
Meal
Prod. Q^M
Costs T^M
Factories
Coef. meal t^M
Coef. oil t^O
Shipment E
Costs T
Meal
Landing Y
Shipment E
Costs T
Aquaculture
Fisheries
Boats: F^C
Fishing costs: T^F
Oil
Prod. Q^O
Costs T^O
Fish oil markets
Sales: Q
Prices: P
Health
Fish
Stock X

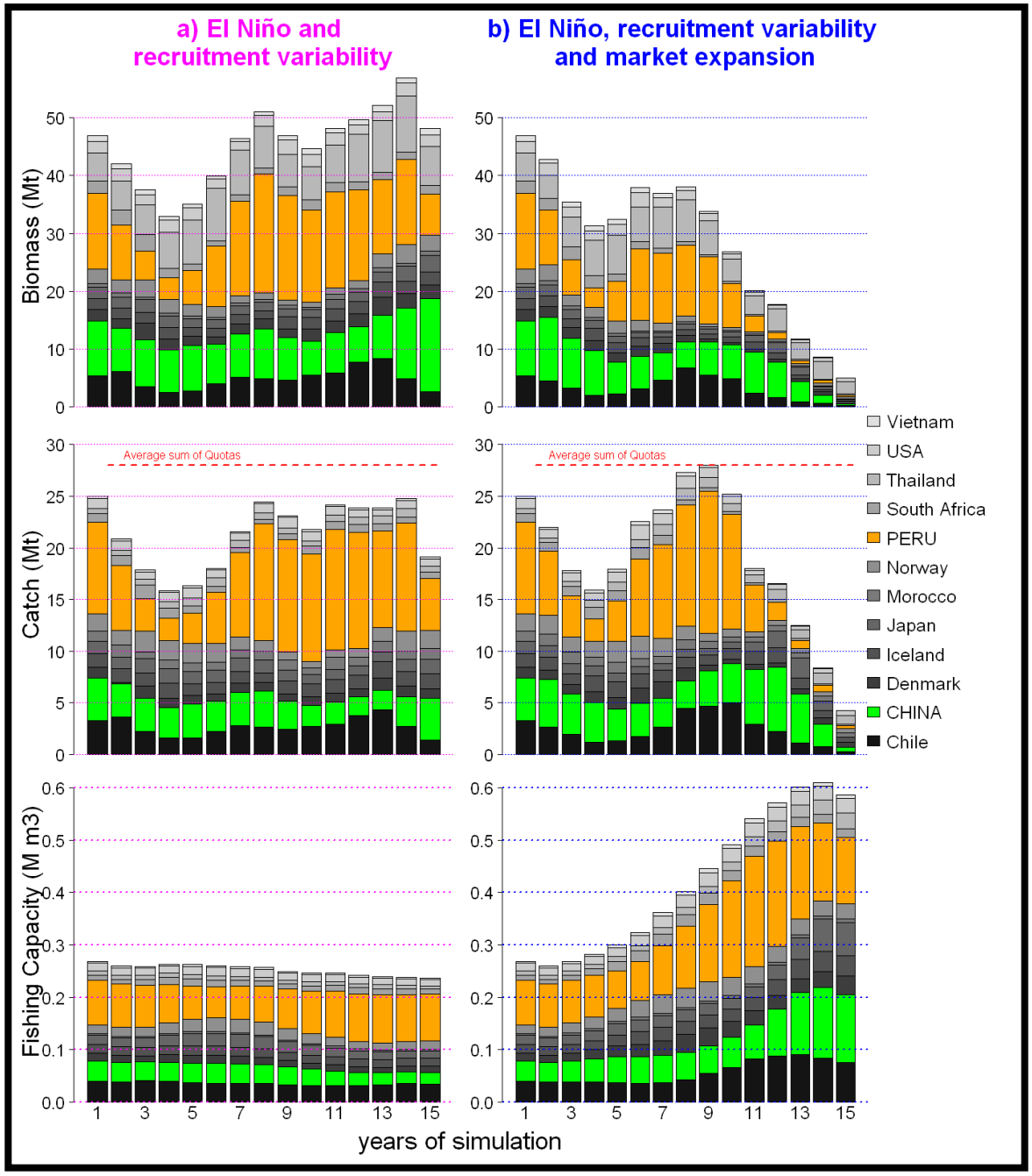

Climate
Ecosystem
Production Systems
Markets & Socioeconomics



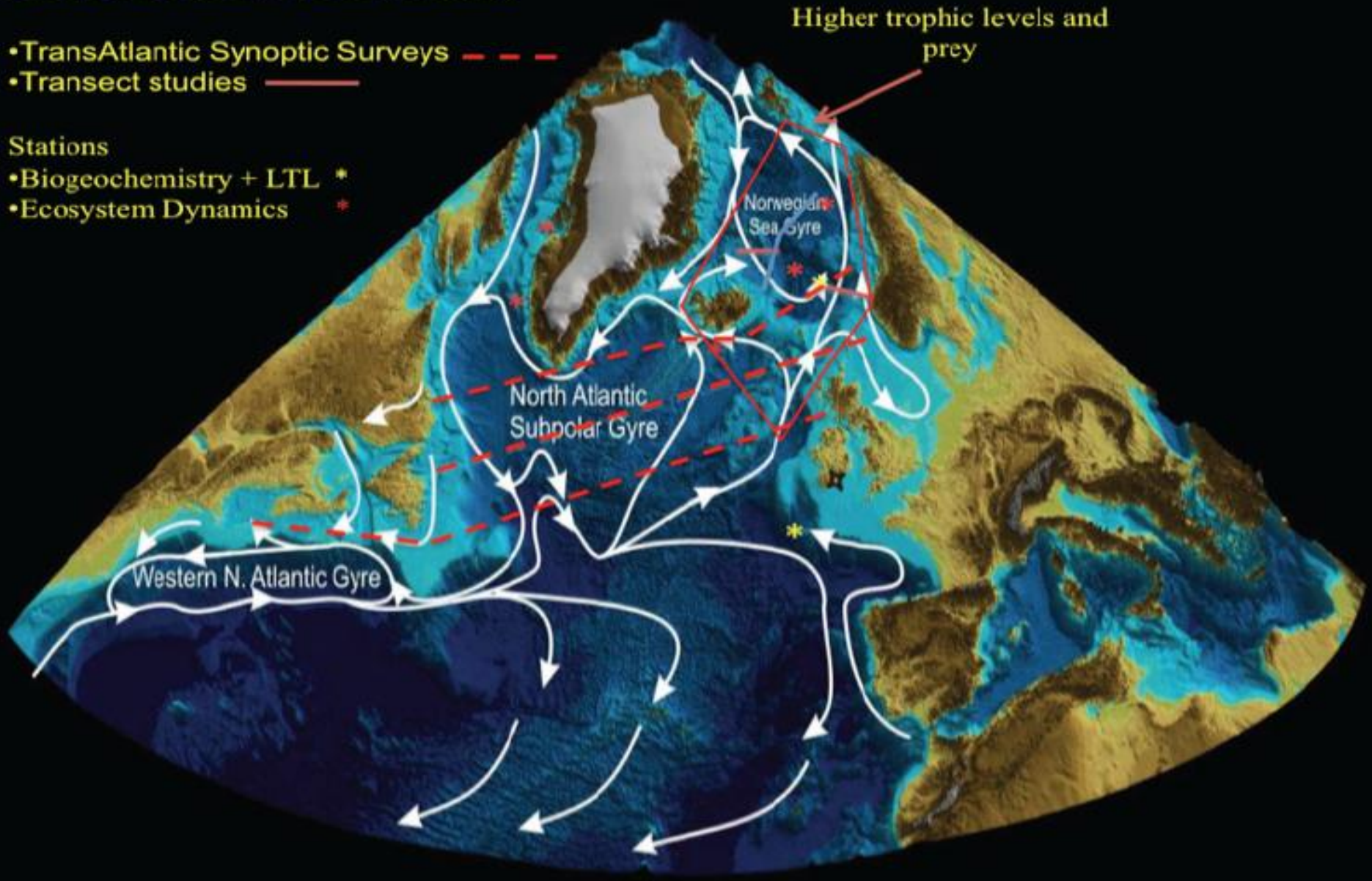



VLI.20




a) El Niño and recruitment variability
b) El Niño, recruitment variability and market expansion
Biomass (Mt)
Catch (Mt)
Fishing Capacity (M m3)
Average sum of Quotas
Average sum of Quotas
years of simulation
Vietnam
USA
Thailand
South Africa
PERU
Norway
Morocco
Japan
Iceland
Denmark
CHINA
Chile

EURO-BASIN: Field studies



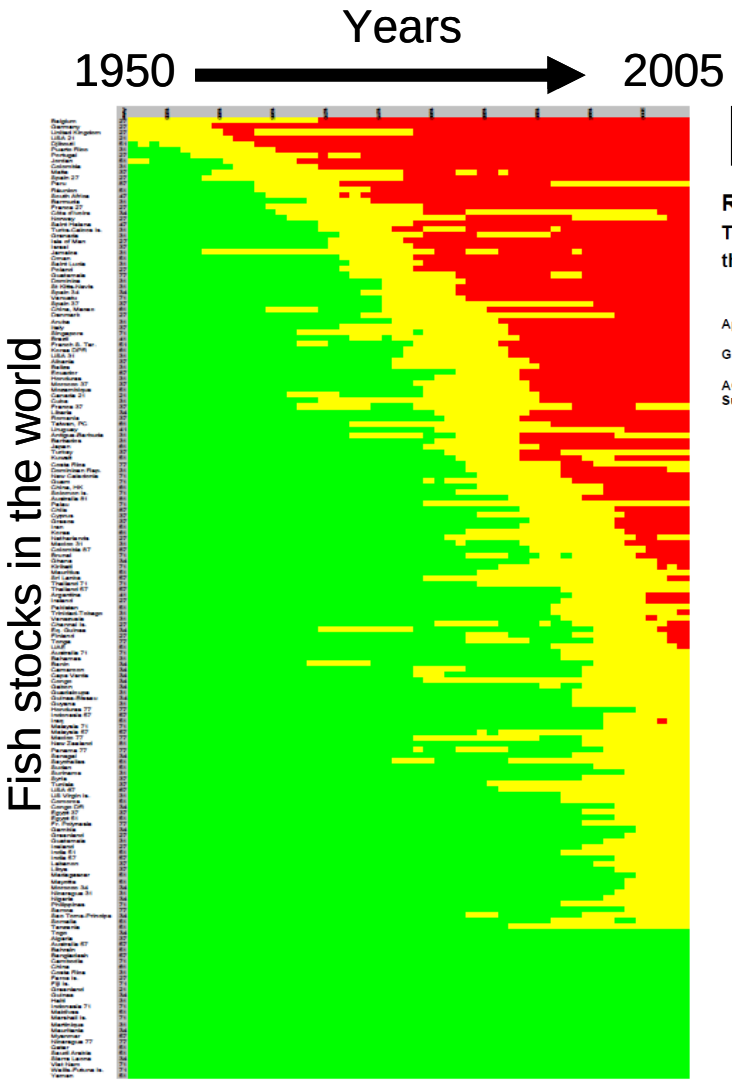
WP 7 - Bioeconomic modelling of N.Atlantic fish resources

Objectives

To "assess the impacts of Global Environmental Change (GEC), including climate change, fisheries management and market developments, on the productivity, dynamics and services of North Atlantic fish commodities. Specifically we will:

- **Estimate the economic cost of sub-optimal fisheries management (hindcast) – Task 7.1**
- **Predict the distribution and production of key fish stocks based on climate change projections – Task 7.2**
- **Develop and apply a bio-economic model of fish commodities in the North Atlantic – Task 7.3**
- **Investigate the consequences of climate change and economic globalisation on the basin-wide fish production system – Task 7.3**

Task 7.1 Estimating the economic loss of sub-optimal fisheries management in the North Atlantic



THE WORLD BANK
Washington DC

Rising to Depletion?
Towards a dialogue on
the state of national marine fisheries

April 2009

Global Program on Fisheries (PROFISH)

AGRICULTURE AND RURAL DEVELOPMENT
Sustainable Development Network

Figure 18: Total Fishes - Synoptic qualitative representation of the state of development of the assessed Home Areas. See text for the indicator used and the colour coding. Rows are ranked in relation to the decade in which the average maximum landing has been reached.

Intro:

1) Nearly 70% of world's fisheries are misusing the potential of food and economic production (50% due to over and 20% due to subexploitation).

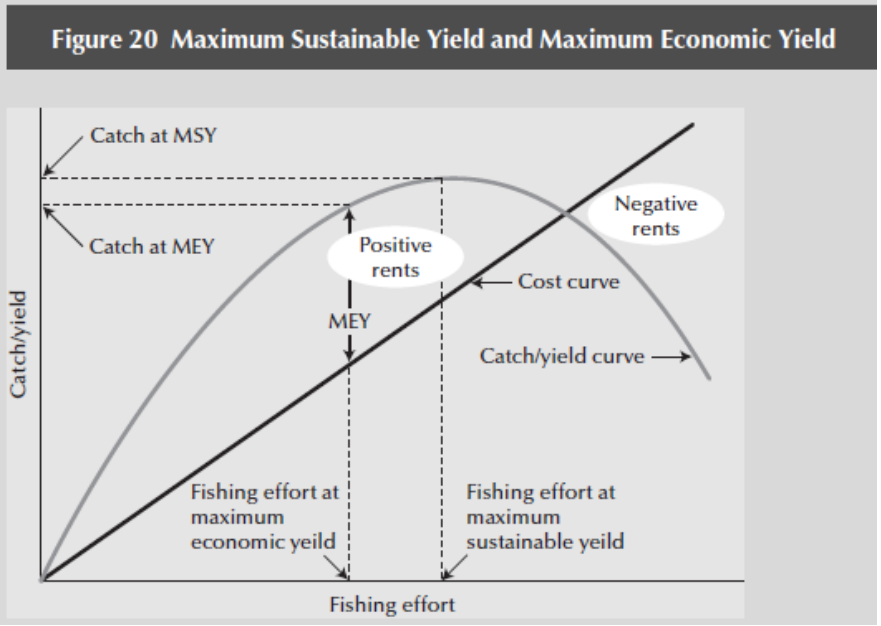
2) NA has been one of the firstly exploited and overexploited oceanic areas.

3) Historical deviations from production and economic optima can be estimated:

1. Hindcasting

2. Comparing data with potential trends under alternative management options.

Objective: Estimate the loss of potential economic rent in the North Atlantic fisheries system during the last ca. 50 years. The loss is the difference between the potential and the actual net benefits.



Methodology

1) Estimate potential MSY and MEY equilibria using biological parameters, fisheries data, biological assessments and economic information.
2) Rebuild fish stocks population dynamics, compare estimated and observed landings to validate parameters.
3) Build dynamic supply and economic yield potential and compare with observed catch series and implemented regulation history.
4) Build management scenarios to see how deviations from optima might have been (and might be in the future) be avoided.

Example

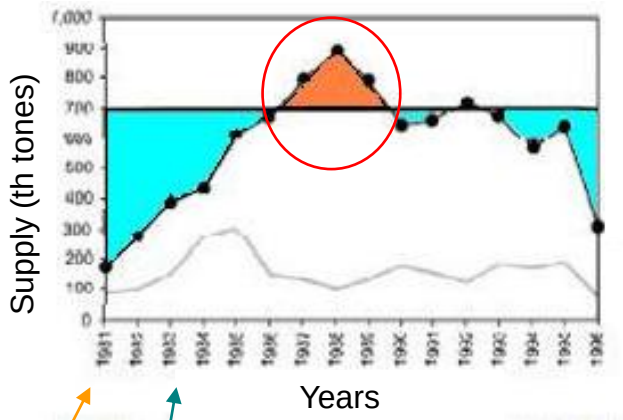
Marine Resource Economics, Volume 18, pp. 345–361
Printed in the U.S.A.

0738-1360/00 $3.00 + .00

Supply Functions for North Sea Herring

LINDA NØSTBAKKEN
Norwegian School of Economics and Business Administration

TROND BJØRNDAL
University of Portsmouth



MSY Optima

Actual

Unregulated

1981. Fishery reopened after a moratorium in S-NS

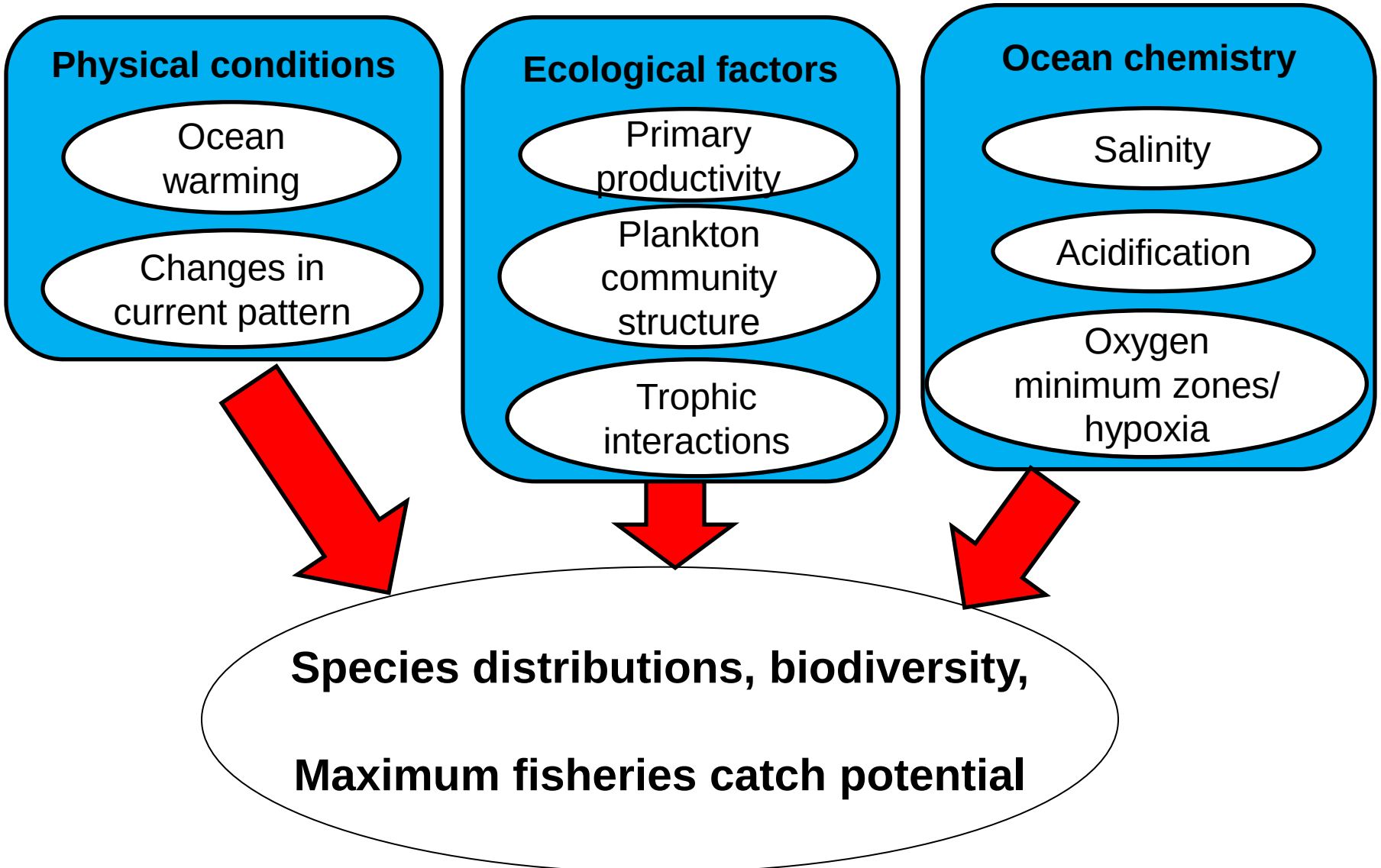
1981. Fishery reopened in C and N-NS

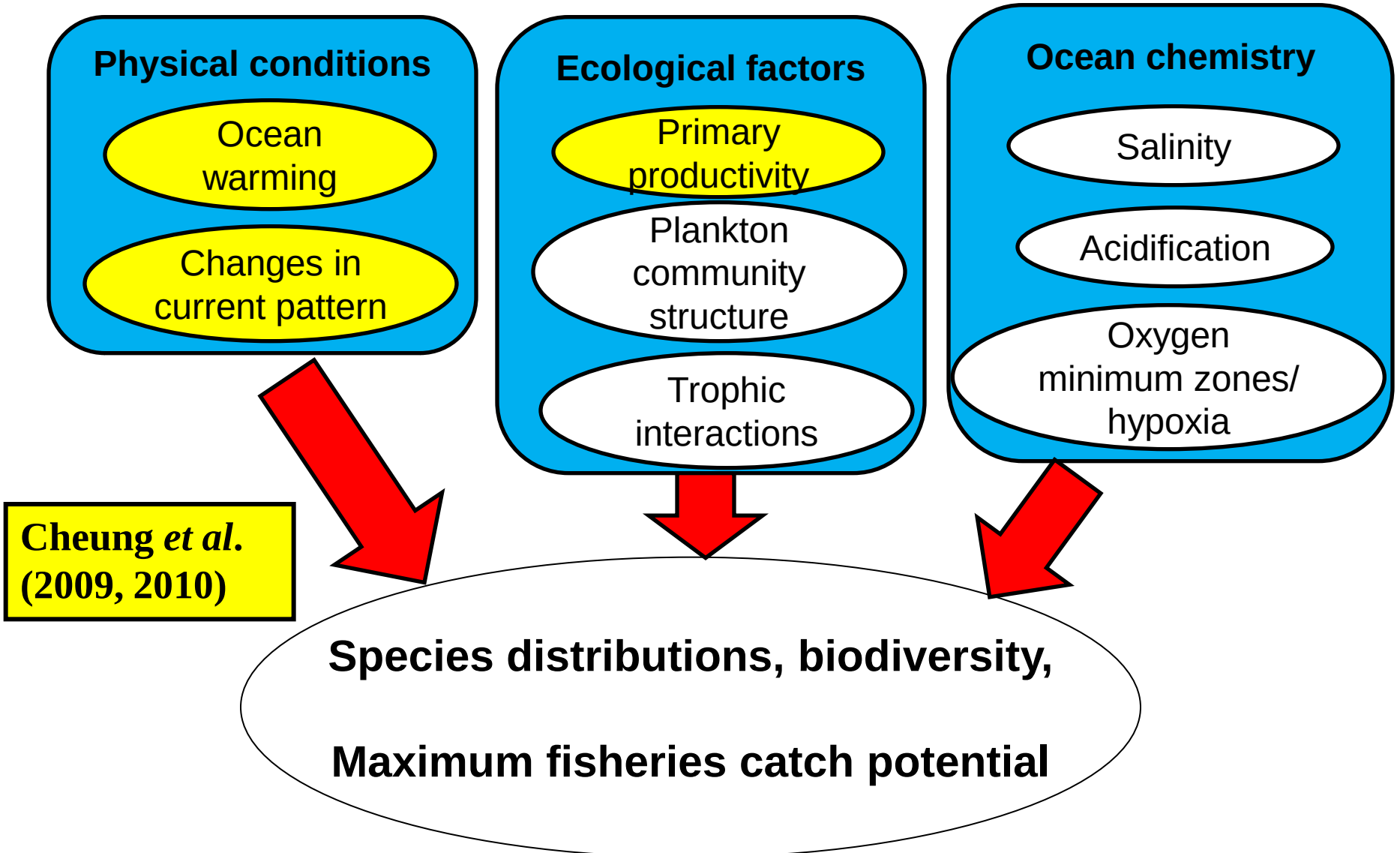
1983-1988. Non sustainable catch

Over MSY

1981-1996: Regulated Open Access, avoided OA but underused ecosystems potential

Task 7.2 Predict the distribution and production of key fish stocks based on climate change projections.




Physical conditions
Ocean warming
Changes in current pattern
Ecological factors
Primary productivity
Plankton community structure
Trophic interactions
Ocean chemistry
Salinity
Acidification
Oxygen minimum zones/ hypoxia
Cheung et al. (2009, 2010)
Species distributions, biodiversity,
Maximum fisheries catch potential

Global climate change projections

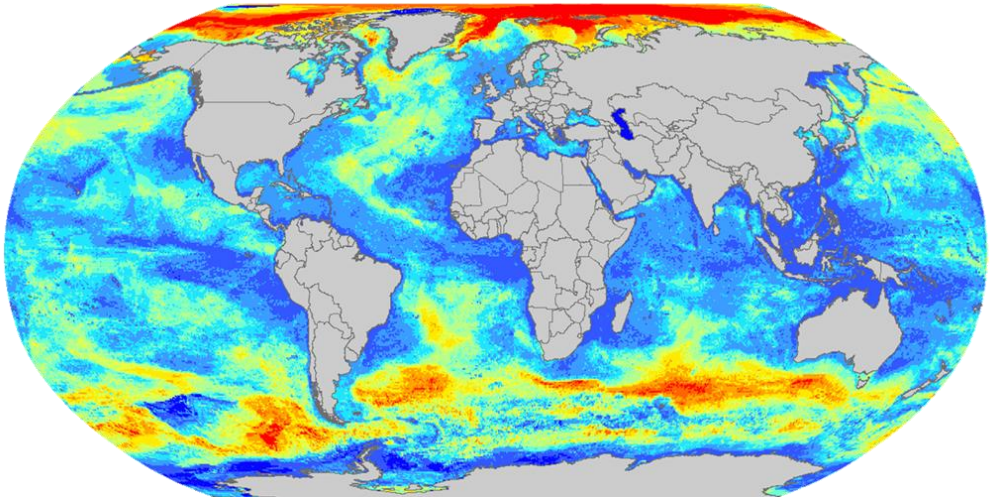
Current species distribution

Population dynamics

Probability of occurrence by:
- Temperature
- Depth limits
- Habitats
- Distance from sea-ice

Predicted future species distribution

Spp invasion rates



Cheung *et al*. (2009) Fish and Fisheries

Global climate change projections

Current species distribution

Population dynamics

Probability of occurrence by:
- Temperature
- Depth limits
- Habitats
- Distance from sea-ice

Predicted future species distribution

Catch potential (t)

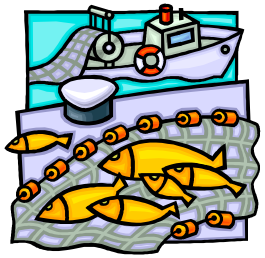
Cheung *et al.* (2009) Fish and Fisheries

Predicting catch from macroecology

Projected from Earth System model/empirical algorithms

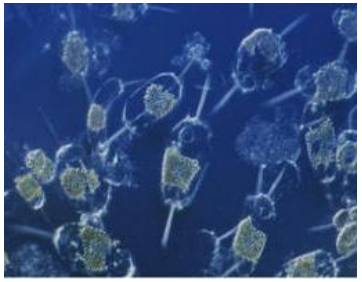
●

Projected from dynamic bioclimatic envelope model

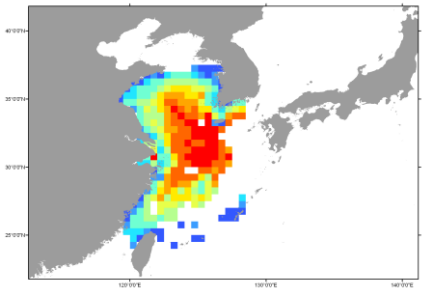


Catch potential

$\propto$



Primary production



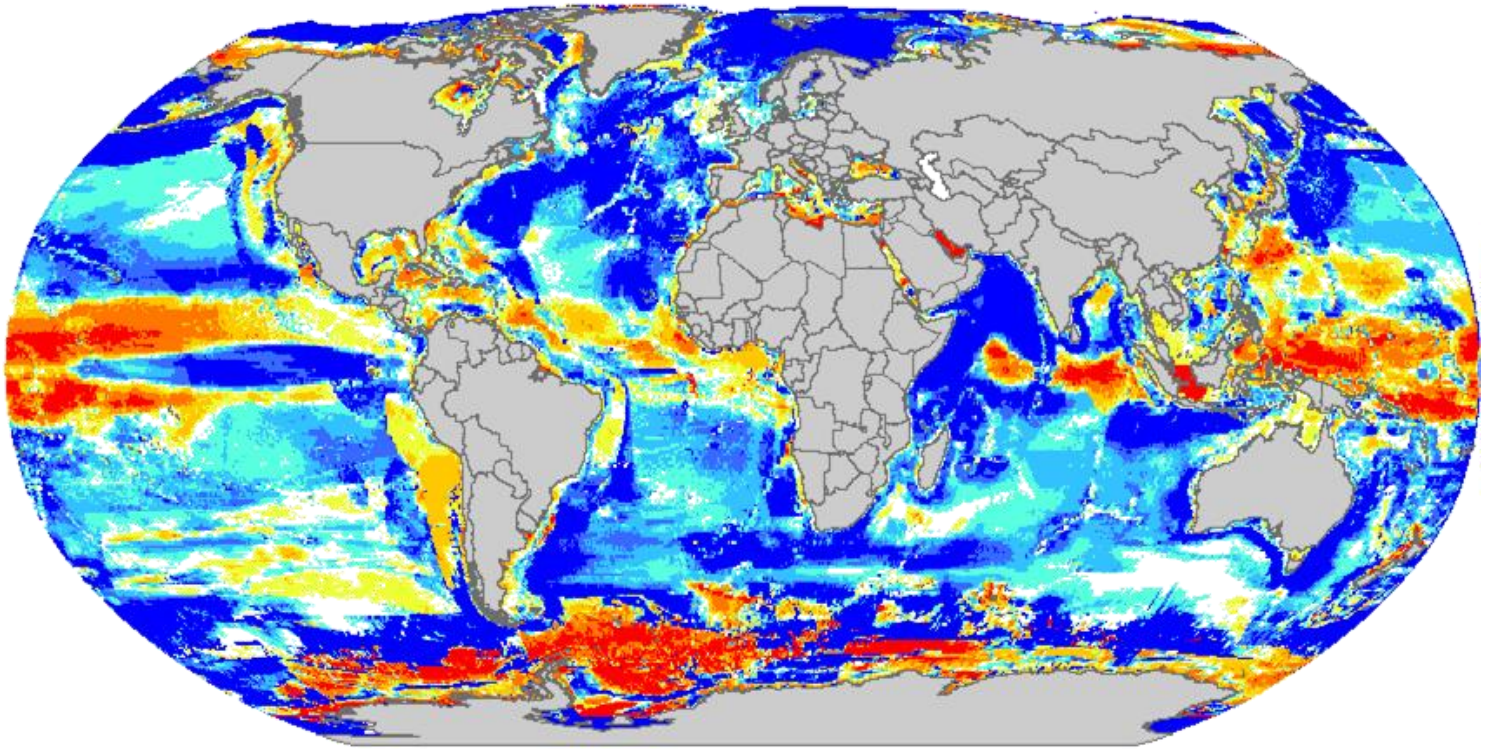
Range area

$$\log_{10}\mathrm{MSY}' = -2.881 + 0.826 \times \log_{10} P' - 0.505 \times \log_{10}(A) - 0.152 \times \lambda + 1.887 \times \log_{10}\mathrm{CT} + 0.112 \times \log_{10}\mathrm{HTC}' + \varepsilon$$

Cheung *et al*. (2008) Mar. Ecol. Prog. Ser. 365: 187-197.

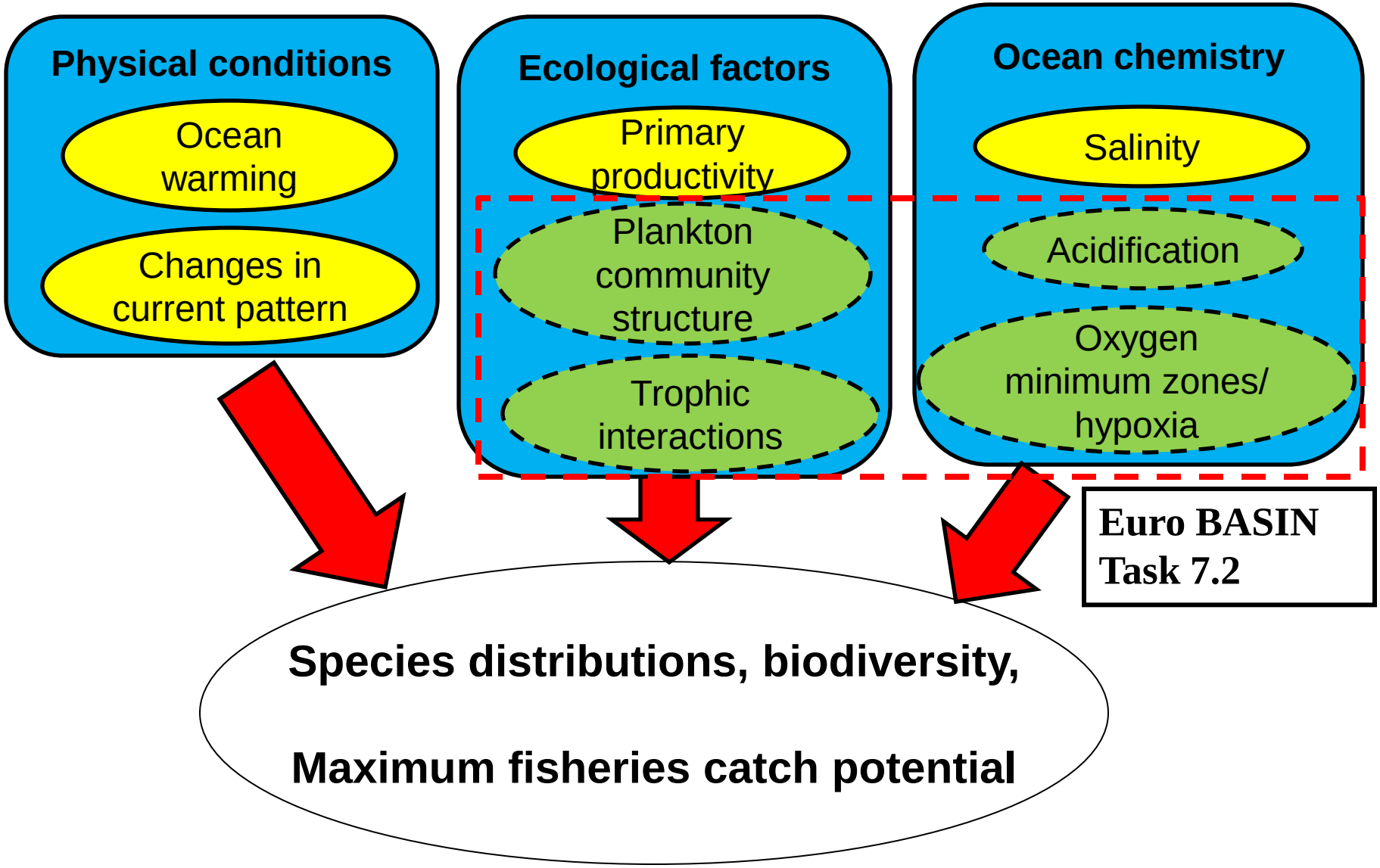
Projecting effects of changes in physical conditions on species distributions and potential catch

Maximum catch potential changes

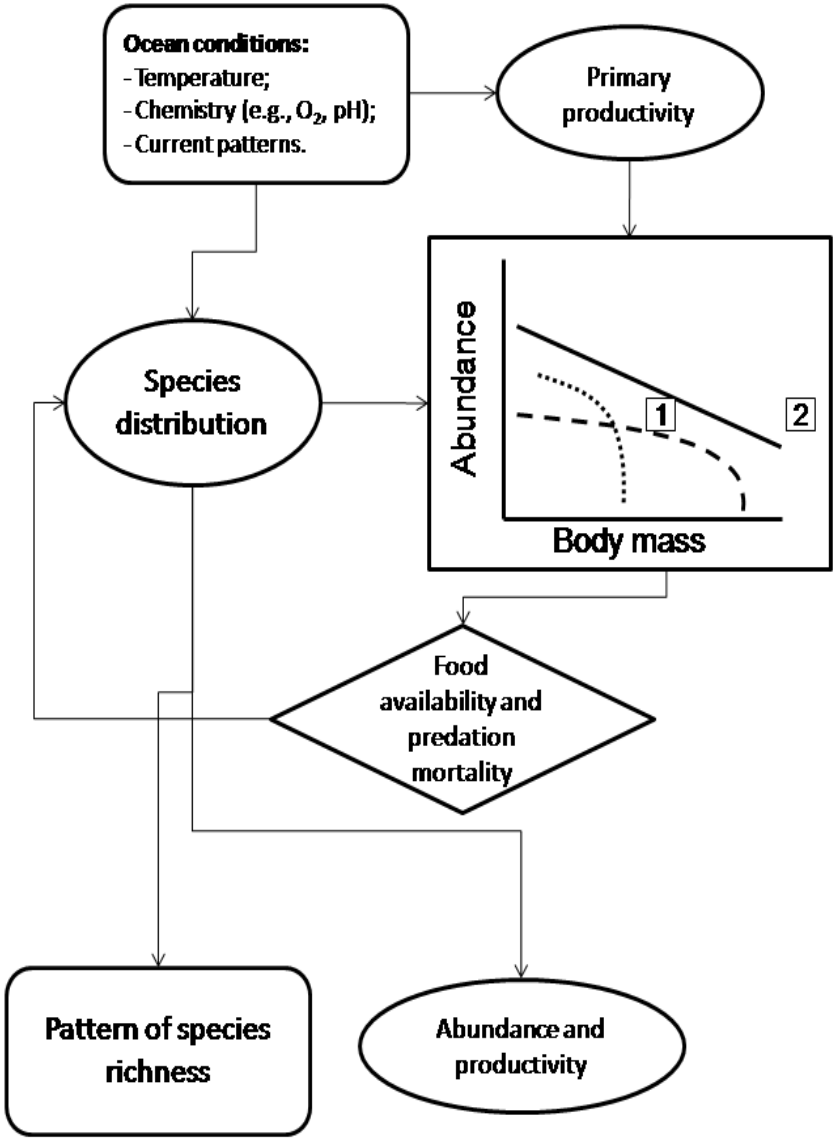


Cheung et al. (2010) Global Change Biology

EuroBASIN - Incorporate full range of ecological and biogeochemical factors



Integrated size-species based approaches



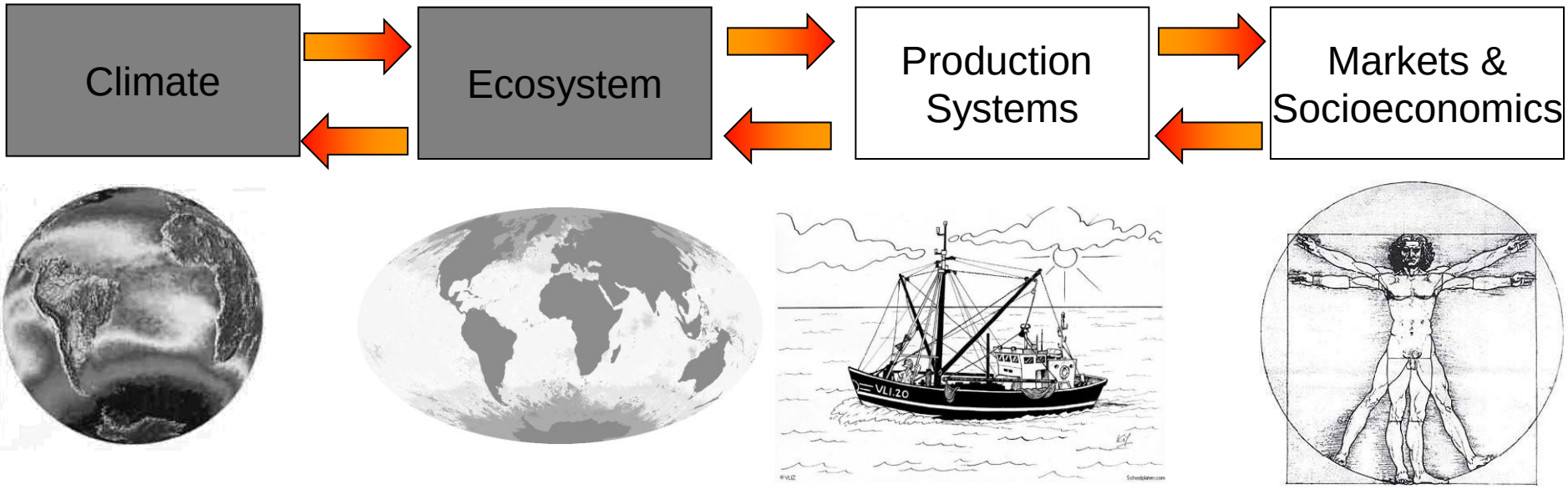
- Explicitly model the dynamic linkages between changes in ocean conditions, physiology, life history traits, recruitment, population dynamics and community size-structure;

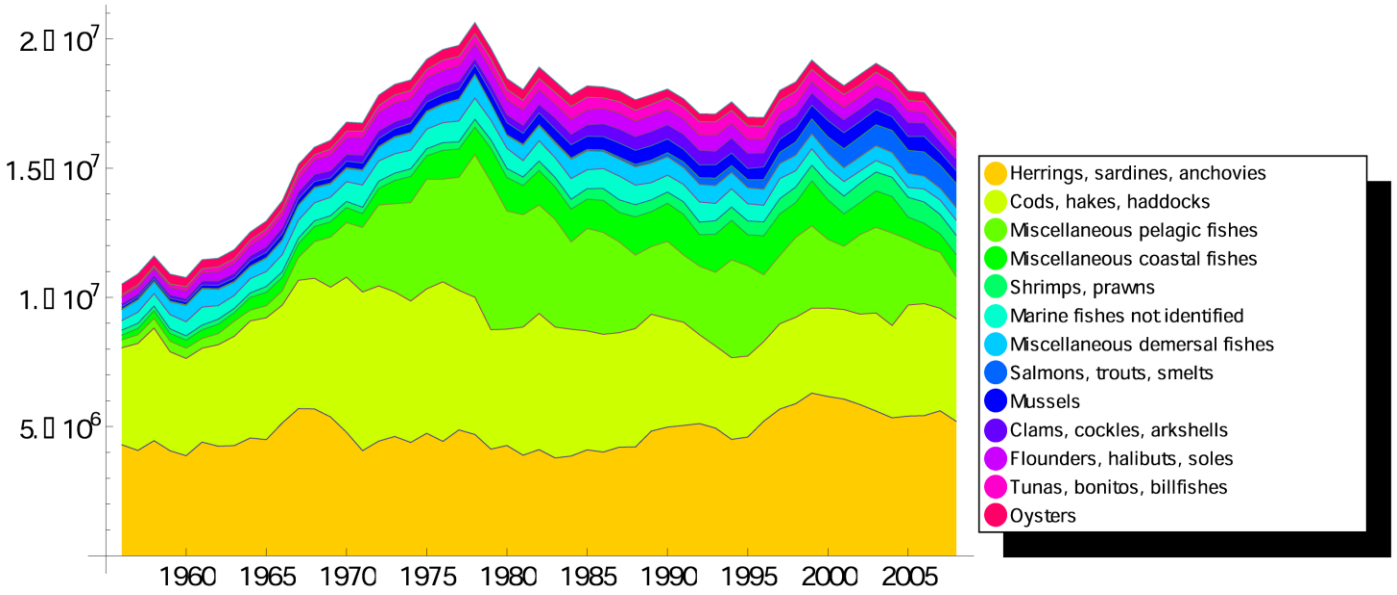
- Using community size-spectrum to estimate ecological constrains on changes in species' distributions, abundance and productivity under climate change scenarios.

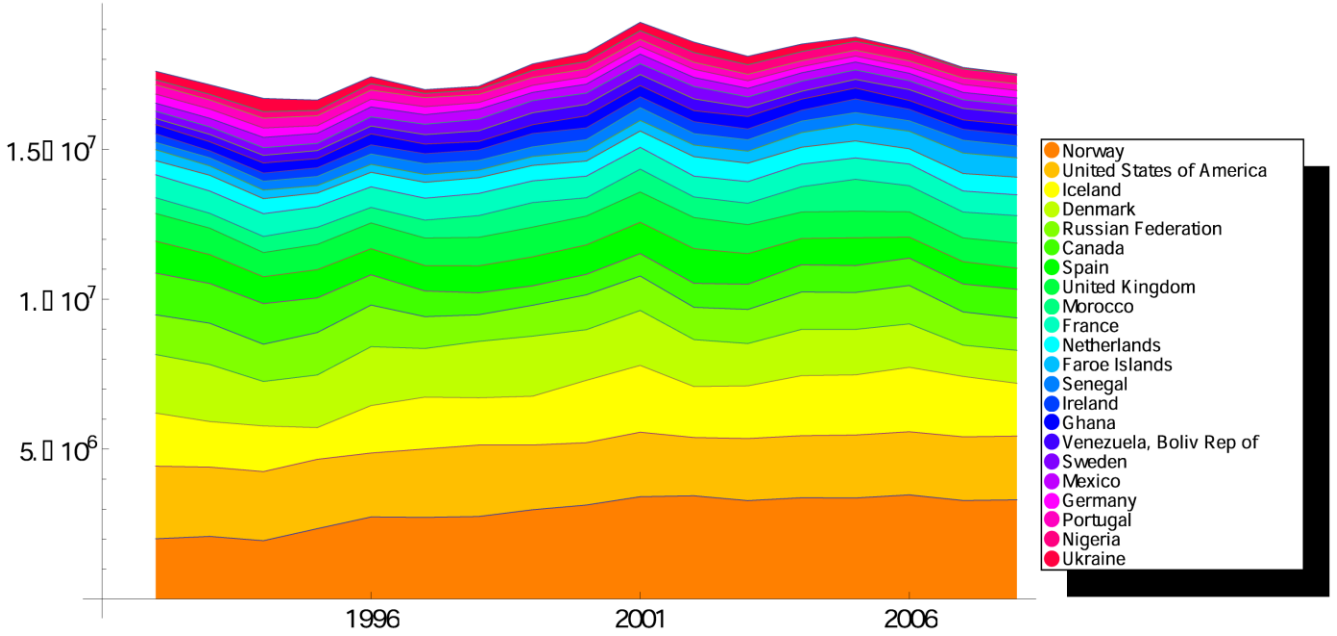
Expected outputs

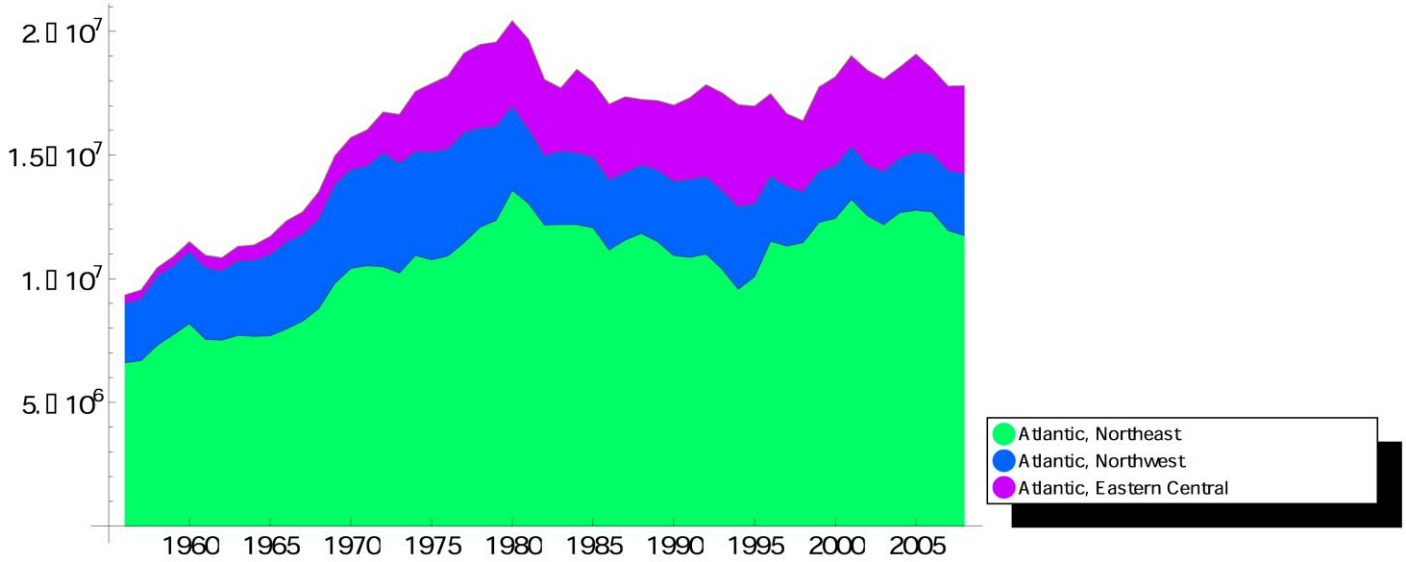
- An improved dynamic bioclimatic envelope models that account for projected changes in biogeochemistry and species interactions;
- Projected changes in fisheries catch potential of major commercial fishes and invertebrates in N. Atlantic on 30’ x 30’ grid from ecological models;
- The model outputs are then used to develop scenarios of changes in fisheries resources for economic analysis.

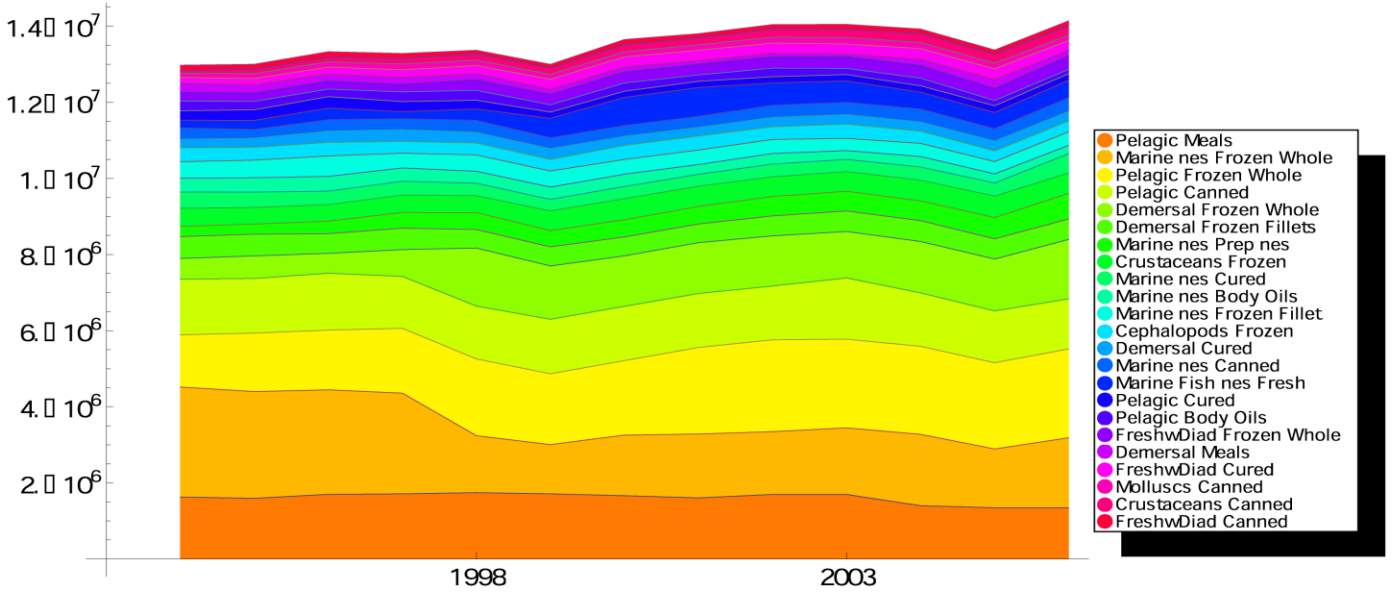
Task 7.3. Develop a bio-economic model of fish commodities in the North Atlantic



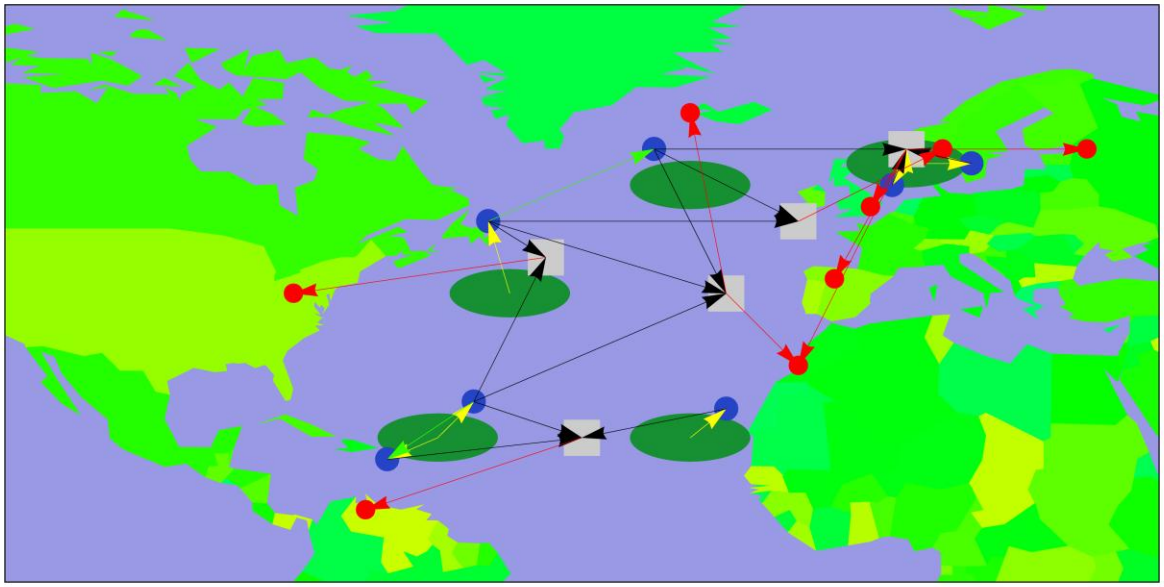

2.□ 10^7
1.5□ 10^7
1.□ 10^7
5.□ 10^6
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
Herrings, sardines, anchovies
Cods, hakes, haddocks
Miscellaneous pelagic fishes
Miscellaneous coastal fishes
Shrimps, prawns
Marine fishes not identified
Miscellaneous demersal fishes
Salmons, trouts, smelts
Mussels
Clams, cockles, arkshells
Flounders, halibuts, soles
Tunas, bonitos, billfishes
Oysters


1.5□ 10^7
1.□ 10^7
5.□ 10^6
1996
2001
2006
Norway
United States of America
Iceland
Denmark
Russian Federation
Canada
Spain
United Kingdom
Morocco
France
Netherlands
Faroe Islands
Senegal
Ireland
Ghana
Venezuela, Boliv Rep of
Sweden
Mexico
Germany
Portugal
Nigeria
Ukraine


2.□ 10^7
1.5□ 10^7
1.□ 10^7
5.□ 10^6
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
Atlantic, Northeast
Atlantic, Northwest
Atlantic, Eastern Central


1.4□ 10^7
1.2□ 10^7
1.□ 10^7
8.□ 10^6
6.□ 10^6
4.□ 10^6
2.□ 10^6
1998
2003
Pelagic Meals
Marine nes Frozen Whole
Pelagic Frozen Whole
Pelagic Canned
Demersal Frozen Whole
Demersal Frozen Fillets
Marine nes Prep nes
Crustaceans Frozen
Marine nes Cured
Marine nes Body Oils
Marine nes Frozen Fillet
Cephalopods Frozen
Demersal Cured
Marine nes Canned
Marine Fish nes Fresh
Pelagic Cured
Pelagic Body Oils
FreshwDiad Frozen Whole
Demersal Meals
FreshwDiad Cured
Molluscs Canned
Crustaceans Canned
FreshwDiad Canned

A modeling approach



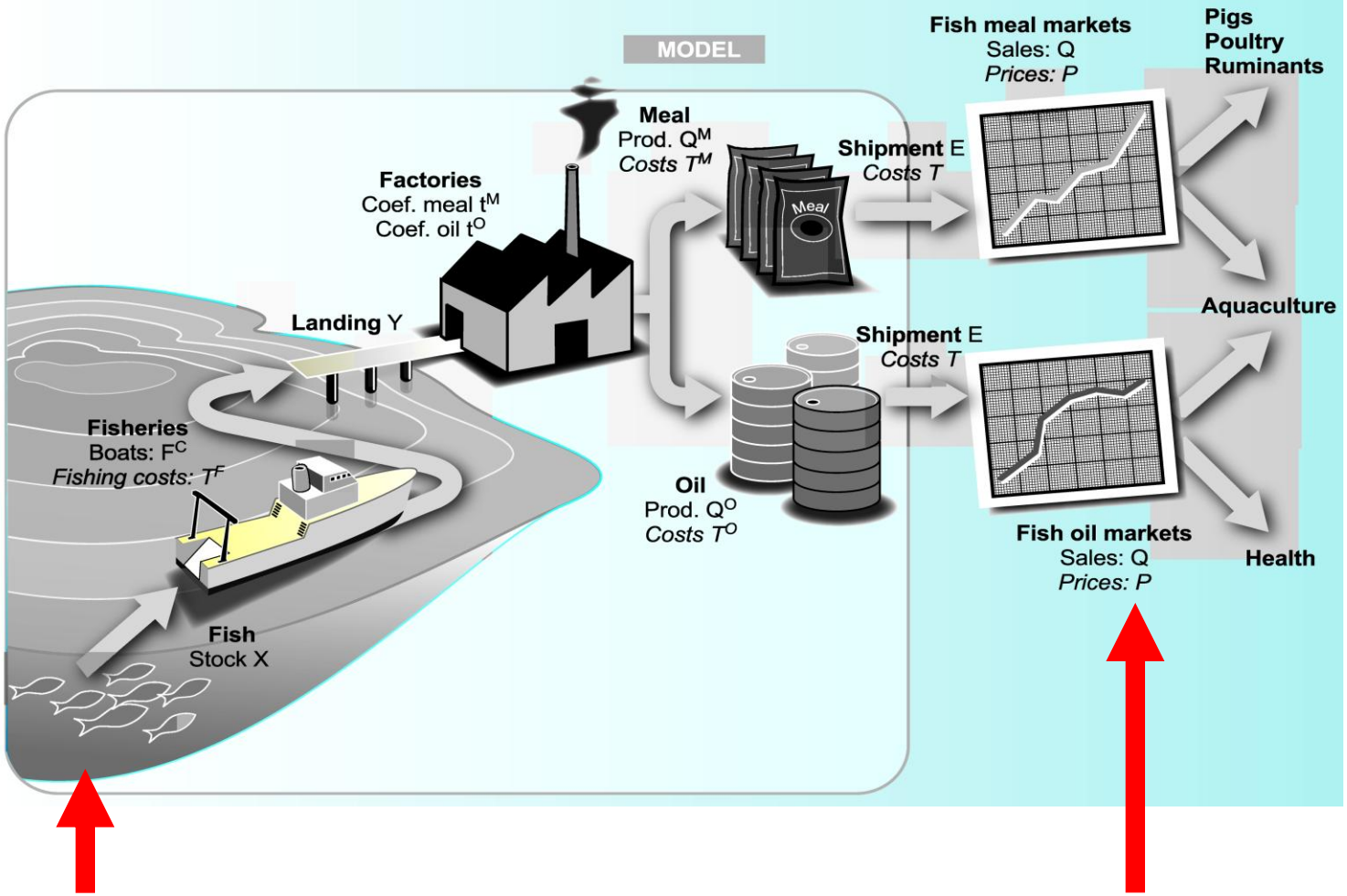
Processes

- Trophic production (WP7.2)
- Fishing/ Demand
- Fisheries investment

- **Scales**
- Spatial extension : Atlantic basin
- Spatial resolution : FAO areas or smaller
- Time horizon : 30-50 years
- Time step : year
- Granularity : 15 production areas, 50 fish populations, 50 fleets, 100 fish product markets

Networks Economics

Mullon C, Shin Y and Cury P (2009) *NEATS: A Network Economics Approach to Trophic Systems.* Ecological modelling. 220 (21) 3033-3045



Climate Change

Economic Globalization

DOUBLE EXPOSURE

Website: **http://www.pml-globalpelagic.org.uk**

Double exposure: Control parameters

- Climate change
- Climate variability
- Carrying capacity changes
- Renewal rate changes
- Latitudinal climate changes

- Economic globalization
- Demand changes
- Fishing capacity
- Depreciation rate
- Catchability changes
- Total allowable catches
- Fuel prices changes
- Fishing rights
- Import taxes

Data: Production areas (about 15)

Needed	Availability
Every year, production estimates	From other WPs
Every year, mixing estimates	From other WPs

Data: Fish Populations (about 50)

Needed	Availability
Every year, catches	Fishstat, ICES
Every year, stock estimates	ICES
Constant: biological parameters used in production functions (assimilation efficiency, trophic efficiency, carrying capacity, renewal rate, etc)	ICES, UCB-Sea Around Us

Data: catches; Fish species x fleets

Needed	Availability
Every year, catches	Fishstat, ICES

Data: Fleets (~50)

Needed	Availability
Every year, catches	Fishstat
Every year, fishing effort and fishing capacity estimates	ICES
Magnitude order of fishing costs, of vessel prices	Ifremer, …, XX Europe, US-Canada

Data: shipments: fleets x commodity markets

Needed	Availability
Every year, shipment flows	Eurostat, OCDE, WTO
Magnitude order of shipment costs	Ifremer, …, XX Europe, YY US-Canada

Data: Commodity markets (about 100)

Needed	Availability
Every year, production volumes	Fishstat, OCDE
Every year, production prices	Fishstat, Sea Around Us
Magnitude order of conversion factors, production costs, importation taxes	Ifremer, …, XX Europe, YY US-Canada