ECONOMIC IMPACTS OF CLIMATE CHANGE ON MARINE FISHERIES IN THE ARCTIC

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NAAFE 2017
LA PAZ

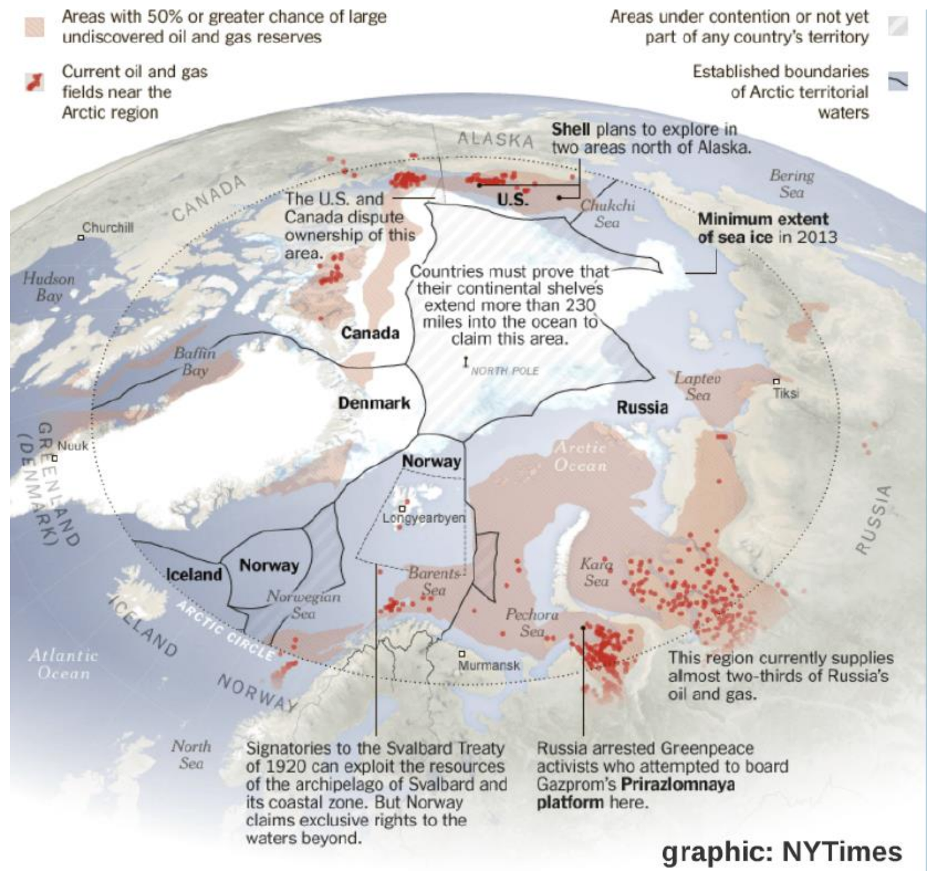
REGIMES – *PREDICTION*

REGIMES: *Interdisciplinaray investigations of ecosystem services and scenarios in the Svalbard Zone under a changing climate in the Arctic.*

- To investigate the effects of climate change on the Arctic marine ecosystem services
- To study how this will affect the potential for escalating conflicts over the Svalbard Fisheries Protection Zone.

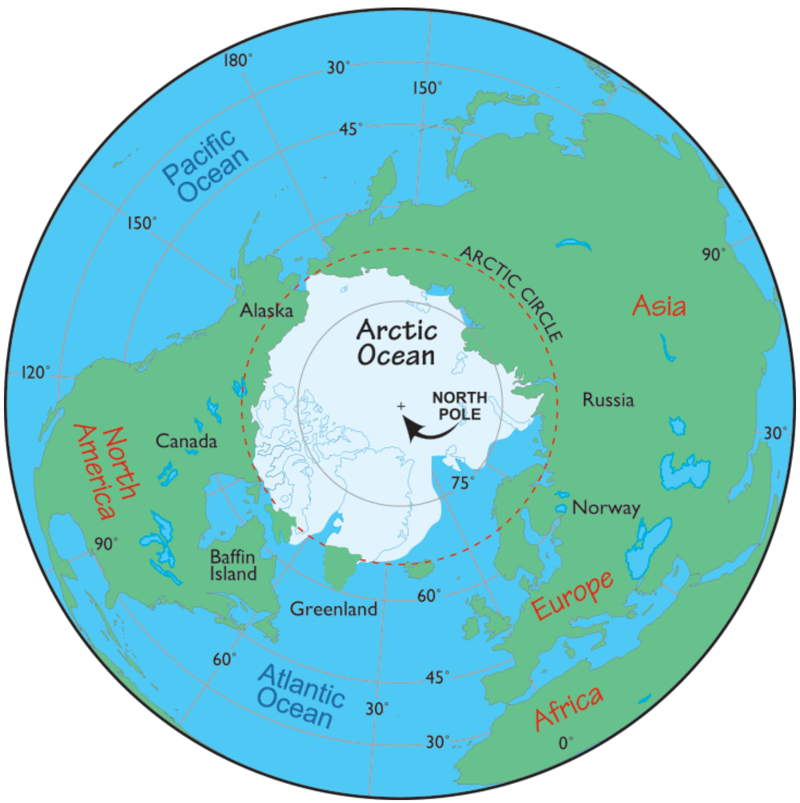
REGIMES

An interdisciplinary investigation into scenarios of national and international conflicts of ecosystem services in the Svalbard zone under a changing climate in the Arctic



The Arctic

- **Area:** 14.056 million sq. km (5.4 million sq. mi.), largely frozen ocean.
- **Top fishing countries** Norway, Iceland, Greenland, Russia & Faeroe Island (based on landed values);
- Norway – largest current landed value* (**US$ 929 million**);



Climate is Changing

Gattuso, Magnan, Billé, Cheung, Howes, Joos, et al. 2015 *Science*

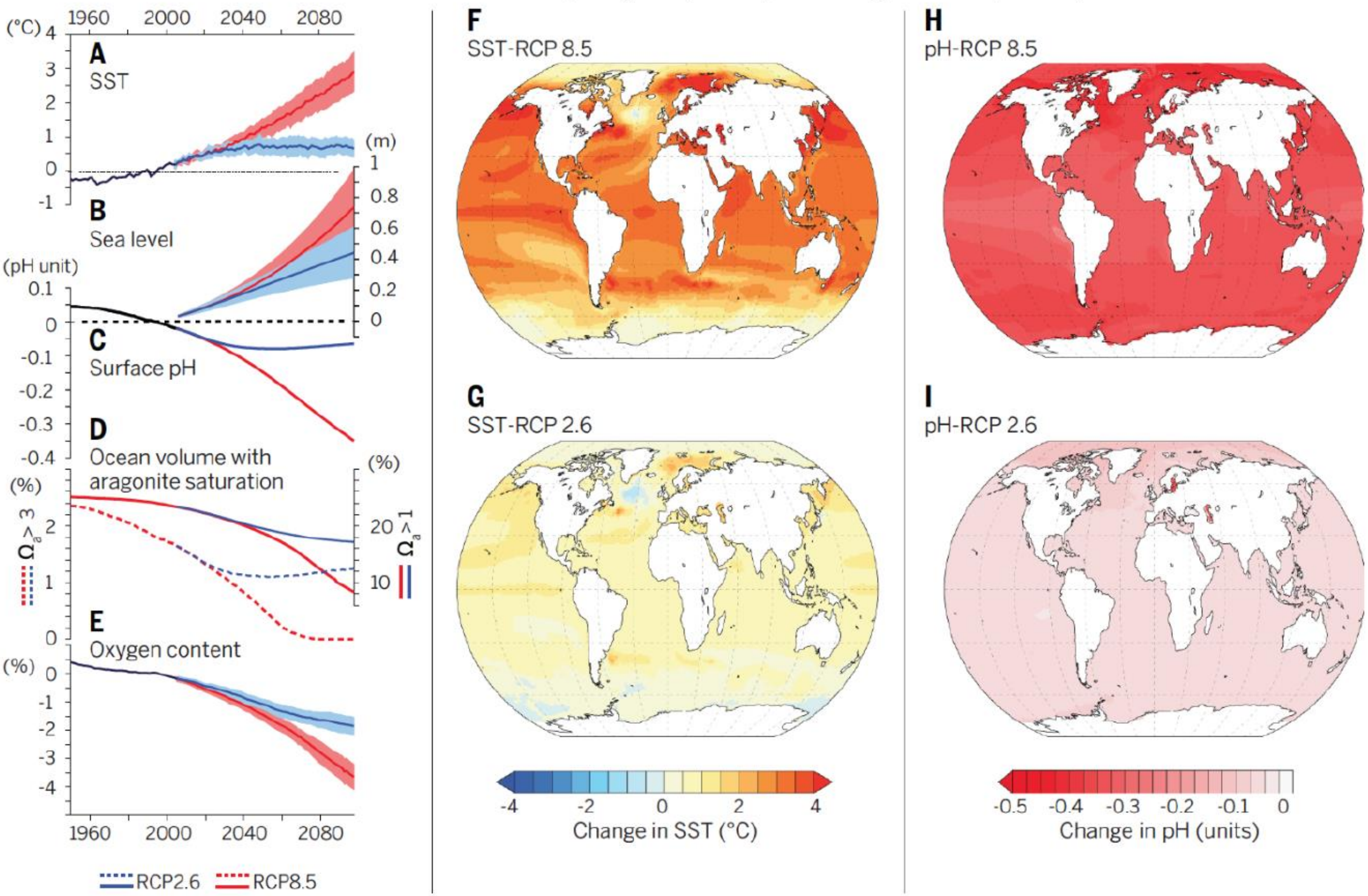


Fig. 1. Environmental changes over the industrial period and the 21st century for a business-as-usual scenario and a stringent emissions scenario consistent with the UNFCCC target of increase in global surface temperature by 2°C. (**A** to **E**) Changes in globally averaged (A) SST, (B) sea level, (C) sea surface pH (total pH scale), (D) ocean volume (in % of total ocean volume) with saturation state of calcium carbonate in aragonitic form (Ω_a) above 1 and above 3, and (E) dissolved oxygen. RCP8.5, red lines; RCP2.6, blue lines. Maps show the 21st century changes in SST (**F** and **G**) and in sea surface pH (**H** and **I**) for RCP8.5 (top) and RCP2.6 (bottom), respectively. All projected values represent ensemble mean values from the Coupled Model Intercomparison Project 5 [CMIP5 (*23*)].

Climate change impact on marine resources

Physical change in the ocean

- ↑ Sea temperature;
- ↑ Acidification;
- Δ Ocean current pattern;
- Δ Salinity;
- Retreat of sea ice;
- ↑ Coastal hypoxic & oxygen min. zone;
- ↑ Sea level.

Biological / ecological change in the ocean

INDIVIDUAL

- Physiology
- Growth; &
- Body size.

POPULATION

- Recruitment
- Abundance
- Distribution

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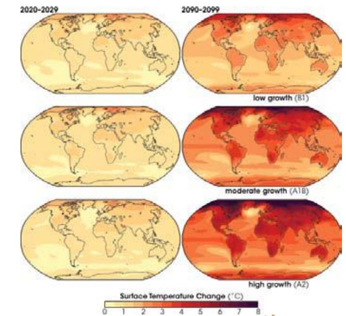
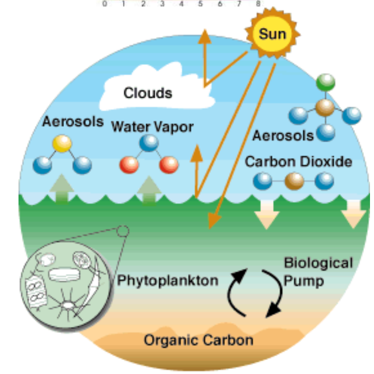
COMMUNITY

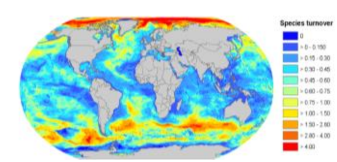
- Species composition;
- Invasion/extinction.

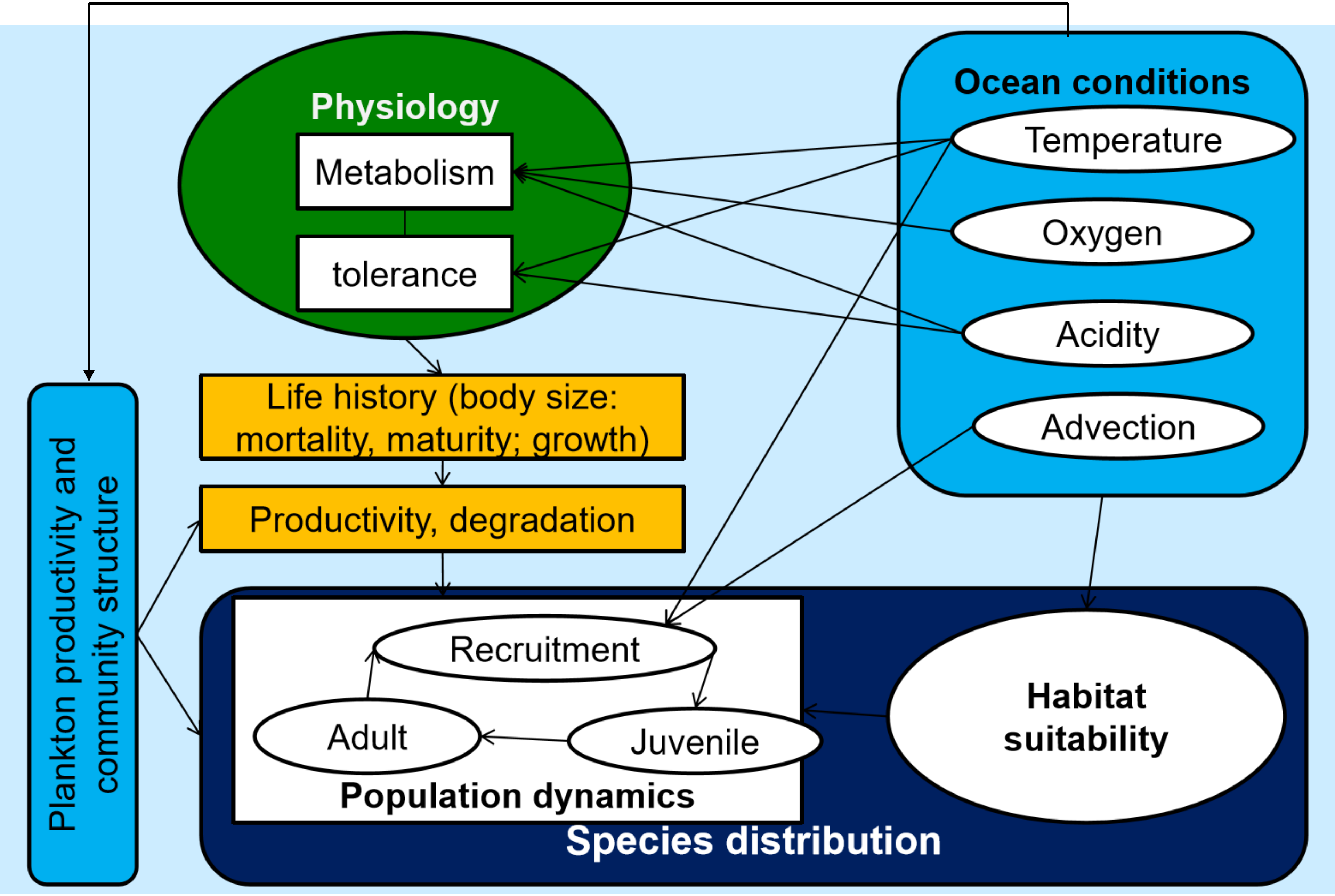
ECOSYSTEM

- Productivity;
- Species interaction.



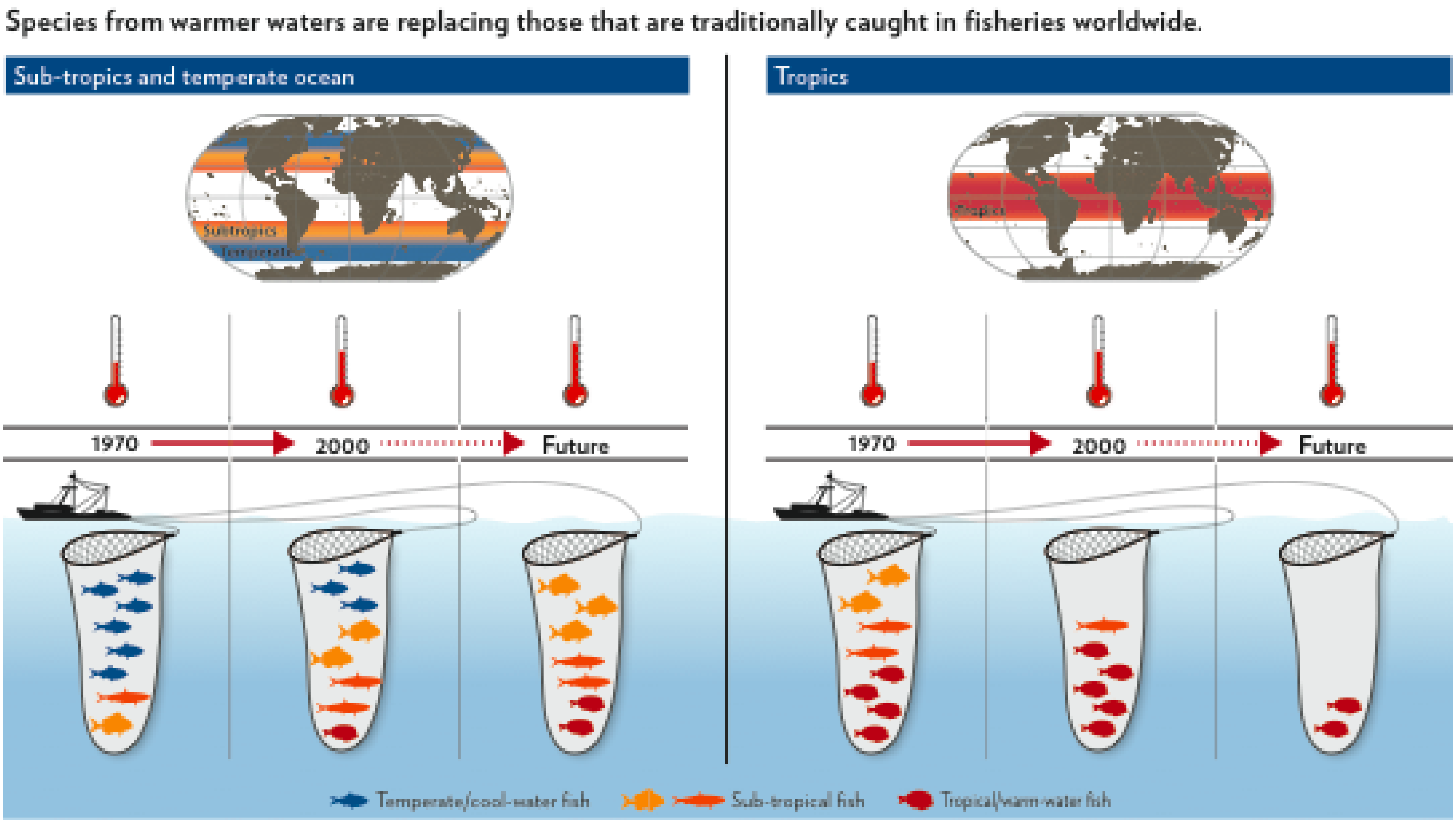





Physiology
Metabolism
tolerance
Ocean conditions
Temperature
Oxygen
Acidity
Advection
Life history (body size: mortality, maturity; growth)
Productivity, degradation
Plankton productivity and community structure
Recruitment
Adult
Juvenile
Population dynamics
Habitat suitability
Species distribution

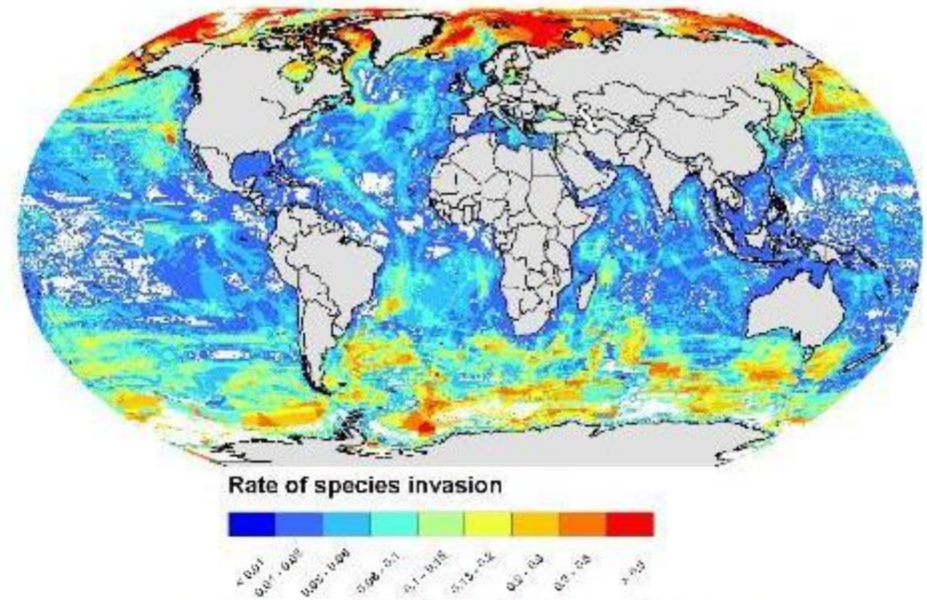
Source: ICES

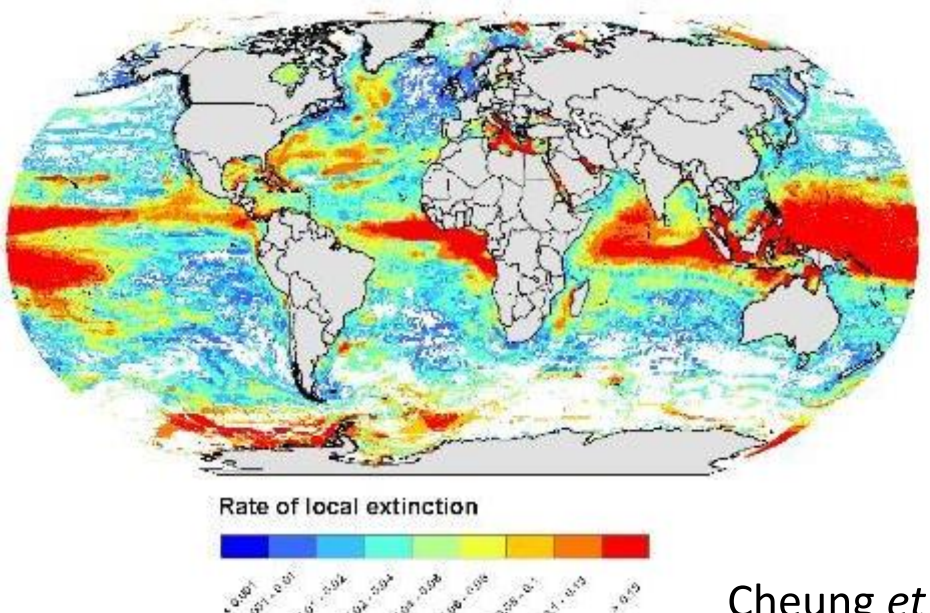
Ocean warming drives changes in species composition



Credit: Pew Charitable Trust; Based on Cheung *et al*. (2013) Nature

Species gain and local extinction





- Range shifts lead to species gain and local extinction;
- 1000 species;
- 2050s relative to 2000s, RCP 8.5

E.g., Snow crab in Norway;

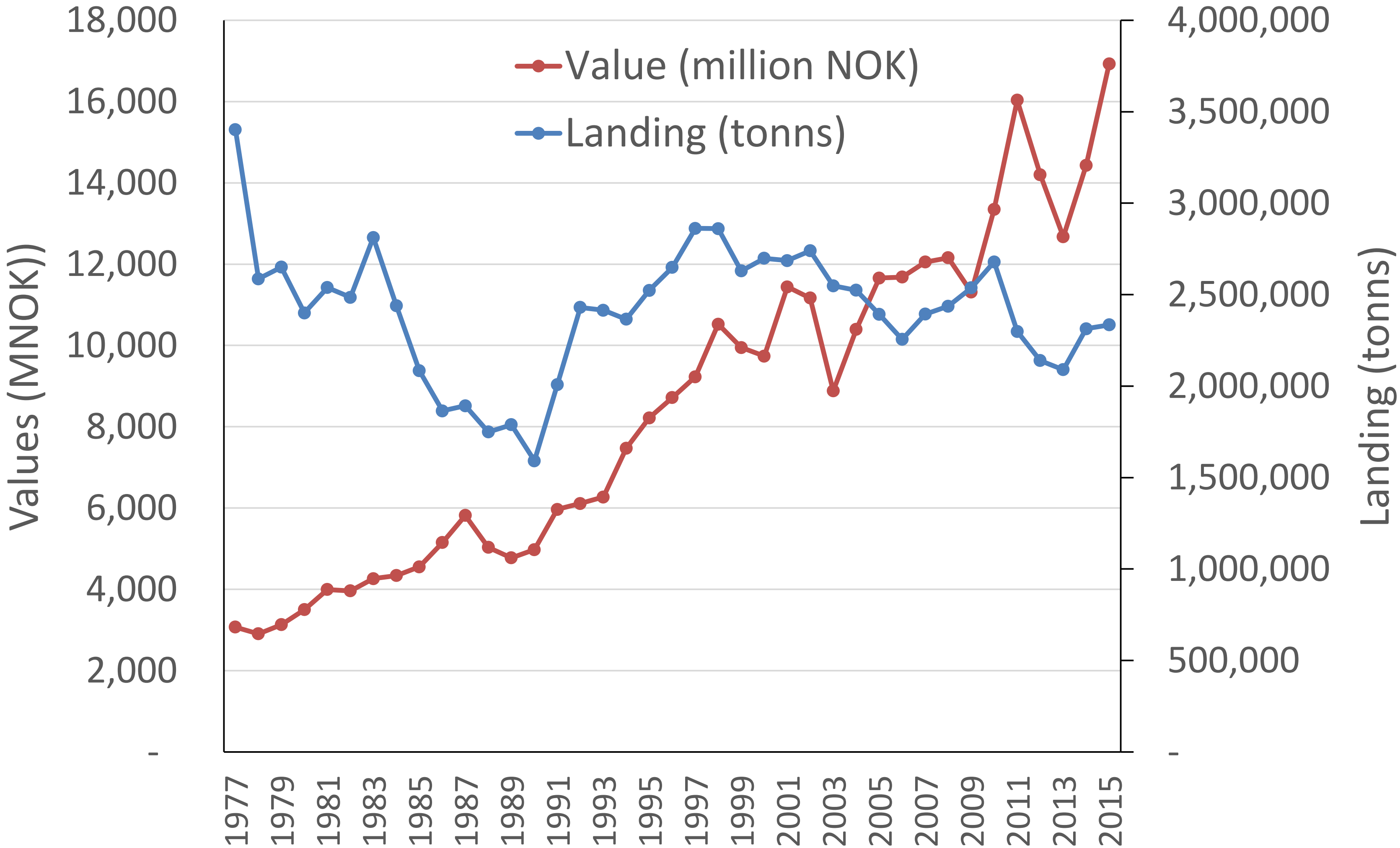
Cheung *et al*. (2009); Jones and Cheung (2015)

Climate Change Impact on Fishing Sector

<u>Expected in the Arctic</u>:

- Ocean warming has positive impacts on fisheries;
- Ocean acidification has negative impacts on fisheries;
- Impacts on: catches, costs, prices, revenues and jobs;
- Impacts on fishing sector and society.

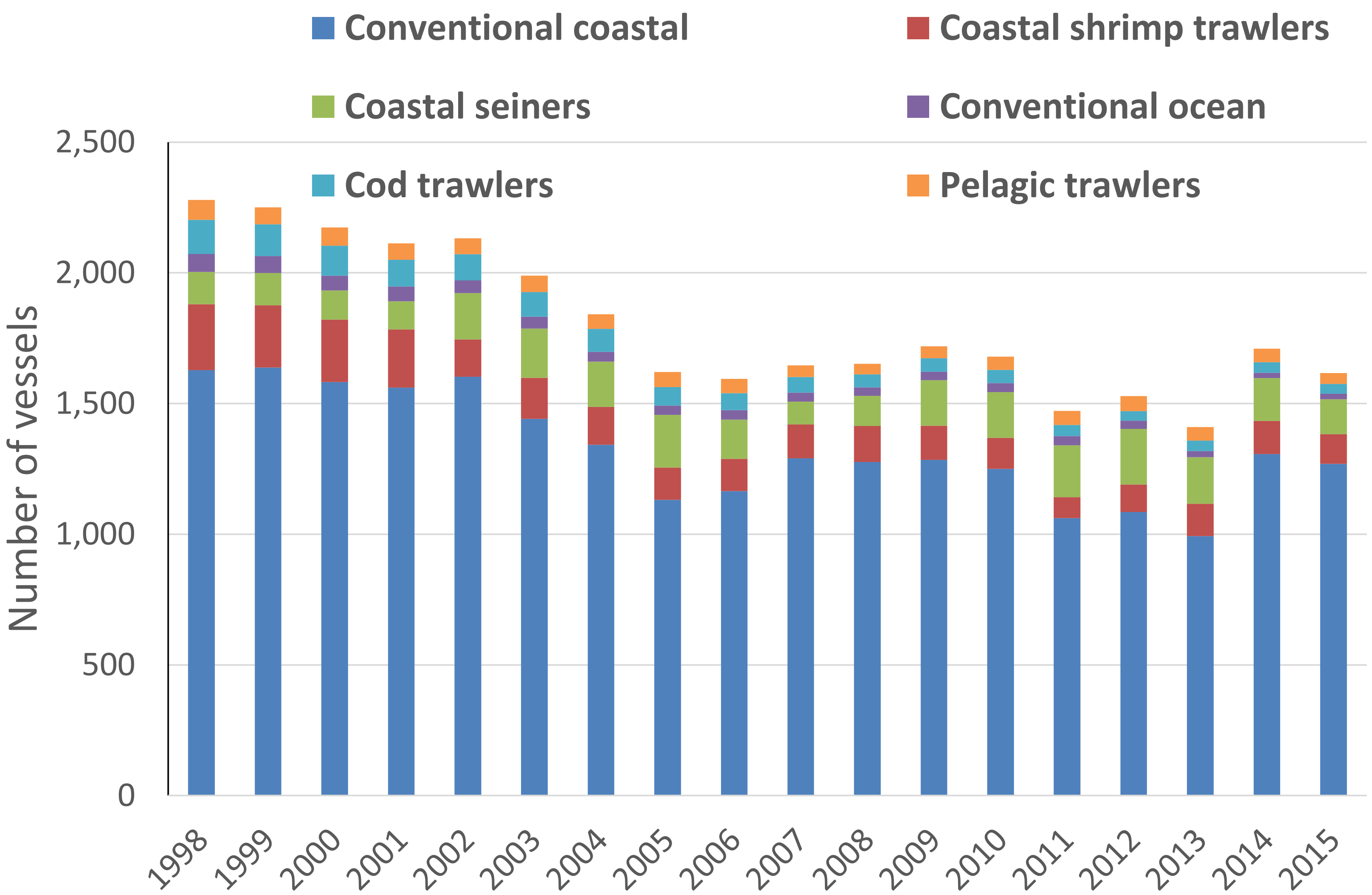
Norwegian Fisheries



Fish Species and fisheries in Norway

- **Pelagic species**: herring, mackerel, capelin, brisling (sprat), sandeel, Norway pout, blue whiting, etc.
- **Demersal species**: cod, saithe, haddock, pollack, ling, tusk, halibut, etc.
- **Coastal fisheries:** Conventional, coastal seiners, shrimp trawler.
- **Ocean fisheries:** Conventional, cod trawler, pelagic trawlers.

Norwegian Fishing vessels



Changes in Catch

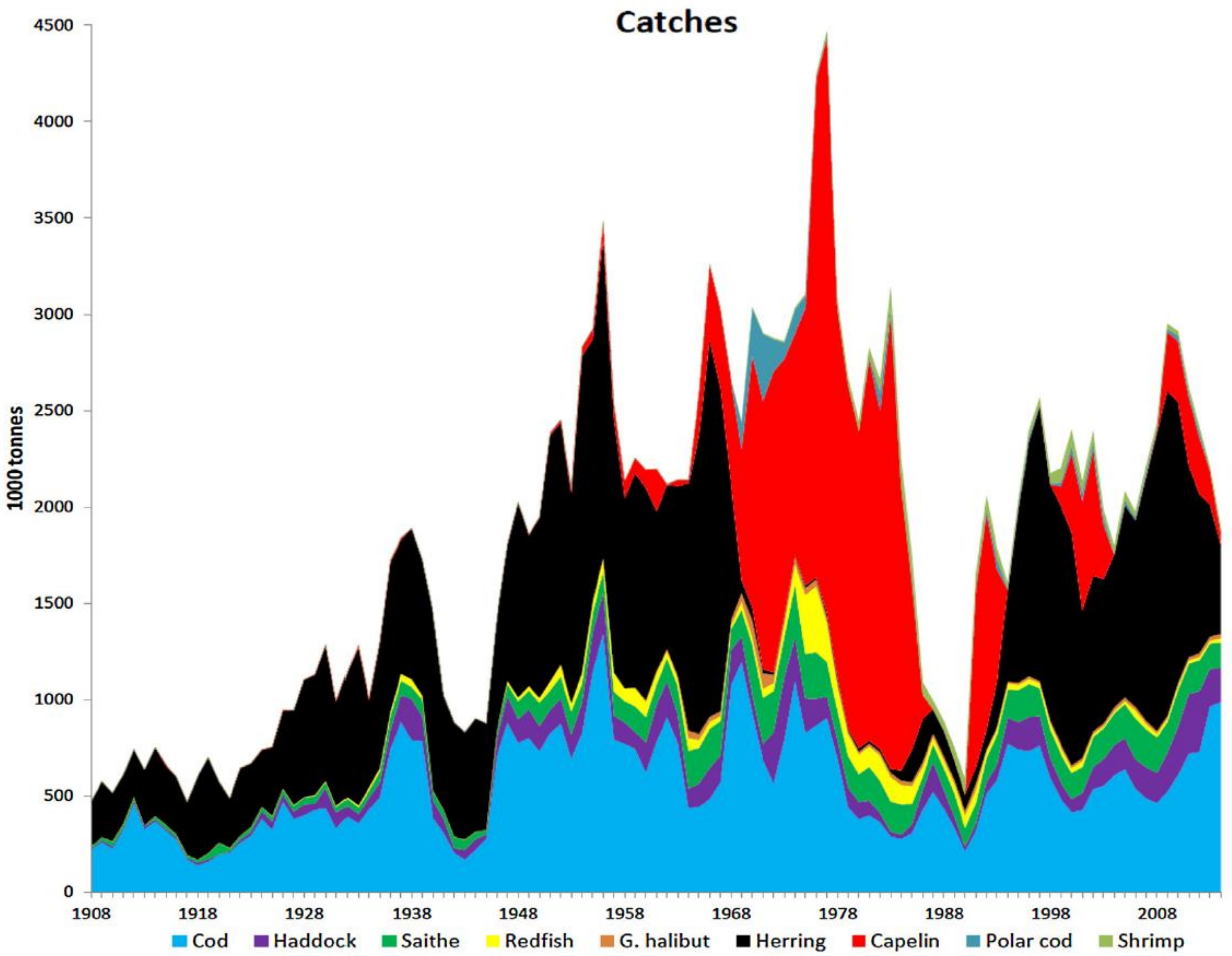
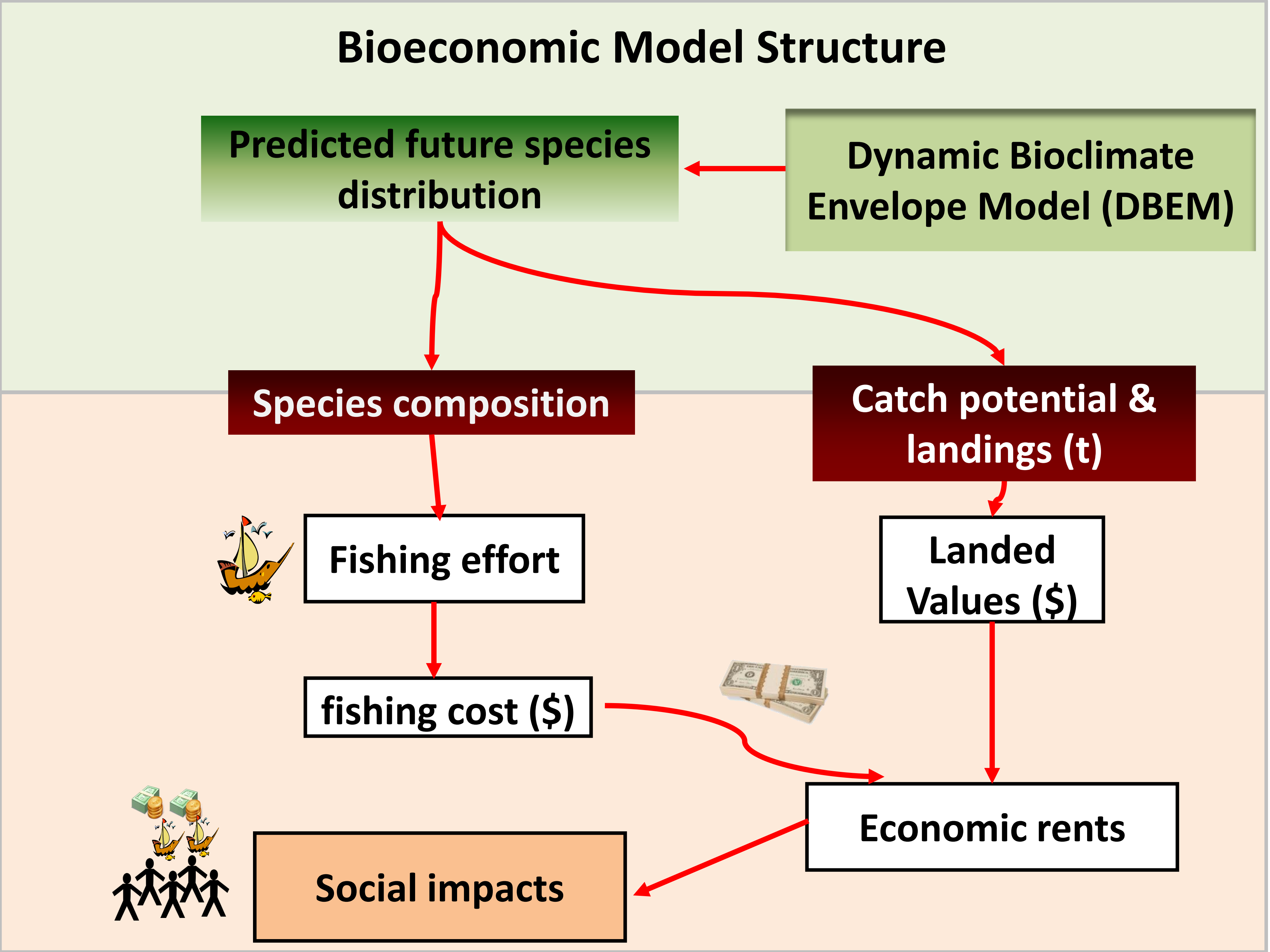


Fig. 3. Catches of main stocks in the Barents and Norwegian Seas 1908–2014. Historically, the catch reached a level between 2 and 3 million tonnes in the 1950s and has since mostly been within this range. A peak in the 1970s was due to large capelin catches, and a dip in the late 1980s was caused by low catches of all stocks. Data are taken from ICES (ICES, 2015a,b,c; Lassen et al., 2012). The catches include all catches of the species in ICES areas I, IIa and IIb (Fig. 1 for ICES areas). For herring, all catches of Norwegian spring-spawning herring are included, also those outside the mentioned ICES areas.

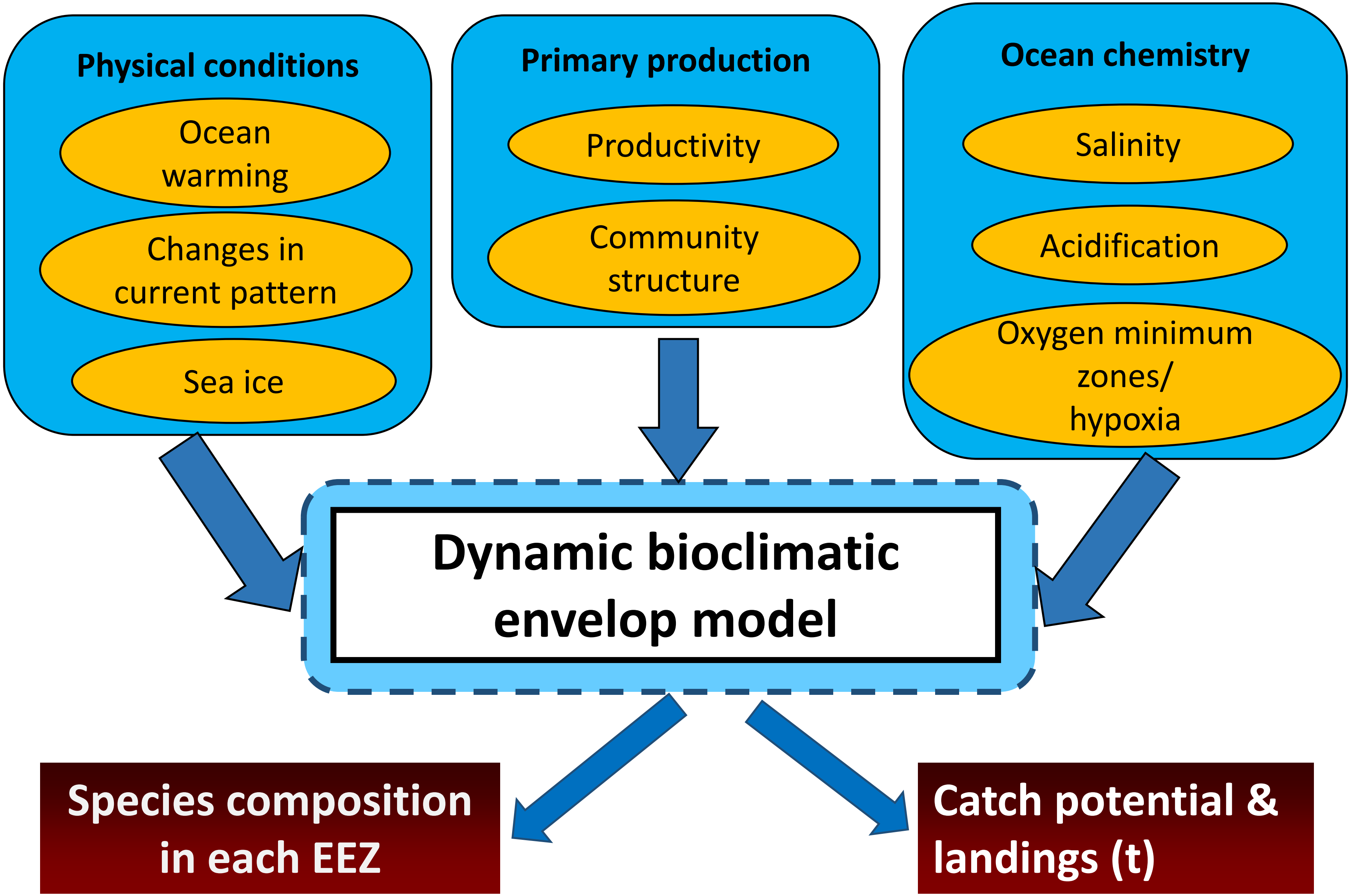
Haug *et al*. Fisheries Research (2017)

Methods

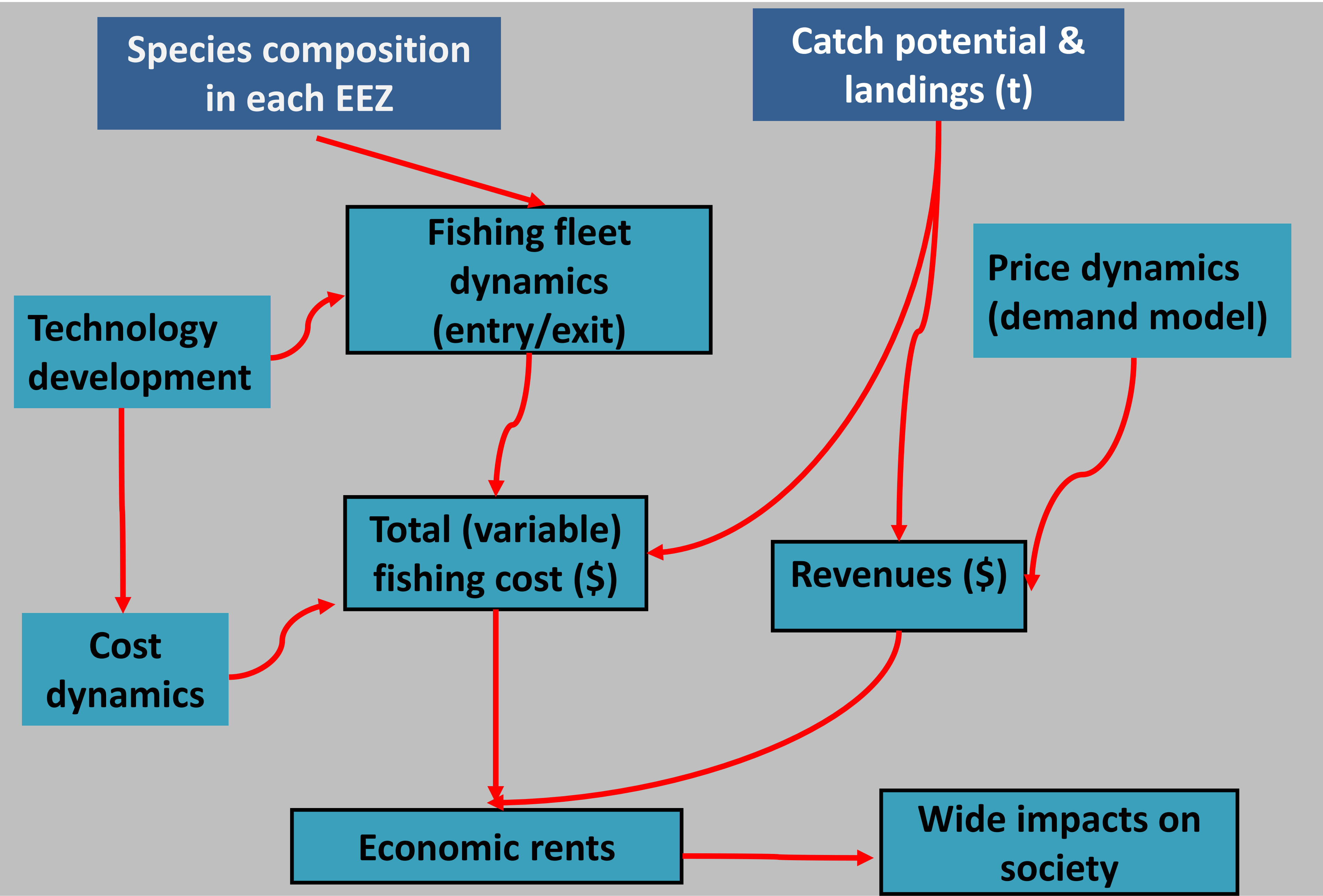
- **Ecological: Dynamic Bioclimatic Envelop model;**
  - Multi-model ensemble (GFDL, IPSL, CSM 1.4, CCSM3) under IPCC SRES A2 scenario to explore uncertainty of the assessment;
  - OA scenarios (based on Kroeker *et al.* 2010);
  - Monte Carlo method to determine the level of uncertainty;
  - Major species of exploited Arctic marine fishes and invertebrates are included;
- **Economic: production, cost, benefit**
  - Projected catches – production function
  - Costs – variable and fixed costs
  - Prices (supply/demand)


Bioeconomic Model Structure
Predicted future species distribution
Dynamic Bioclimate Envelope Model (DBEM)
Species composition
Catch potential & landings (t)
Fishing effort
Landed Values ($)
fishing cost ($)
Economic rents
Social impacts

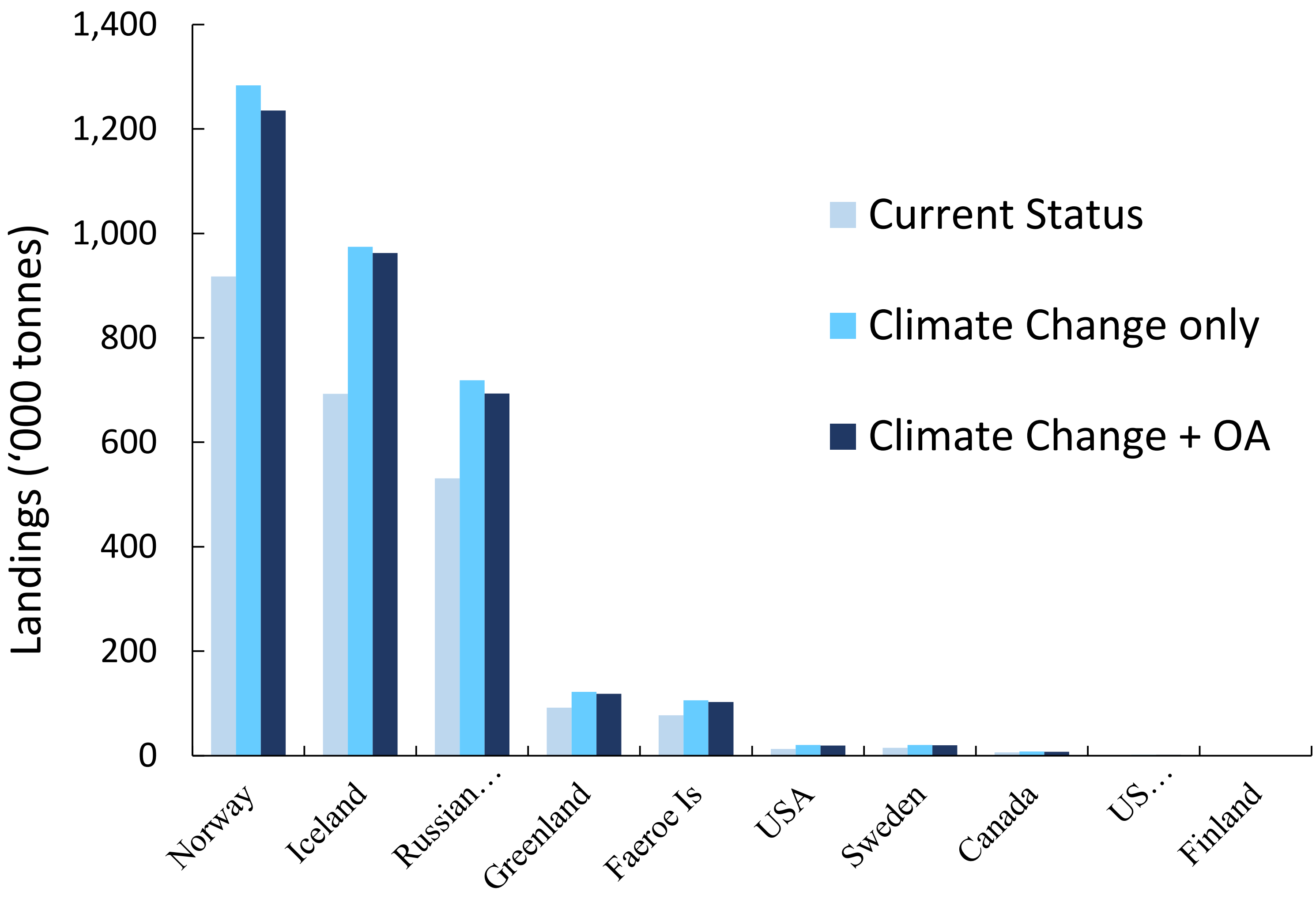
Dynamic Bioclimatic Envelop Model (EBEM)



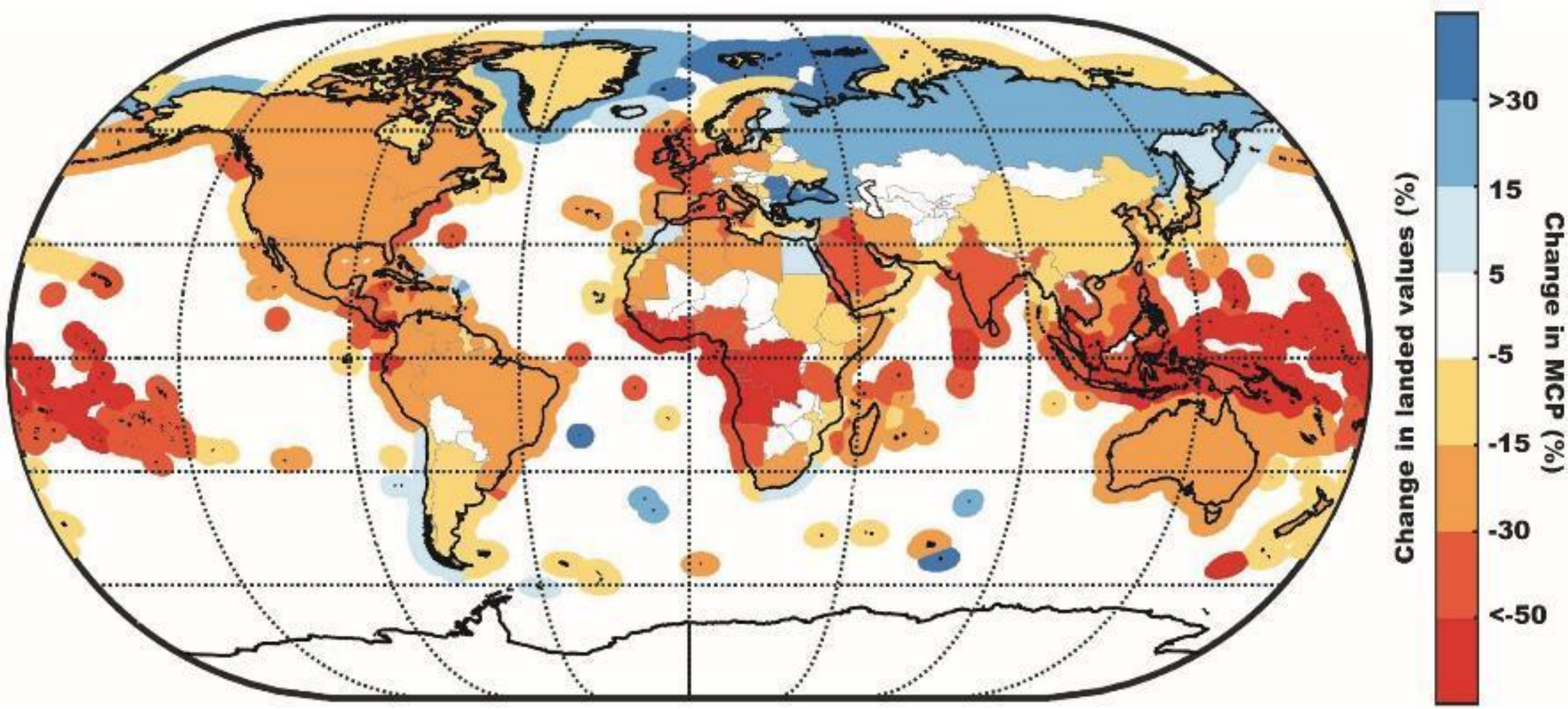
Economic Model Structure



Projected landing under climate scenarios



Mean percentage change in maximum catch potential (MCP) and revenues in the 2050s relative to current status under RCP 8.5 scenario



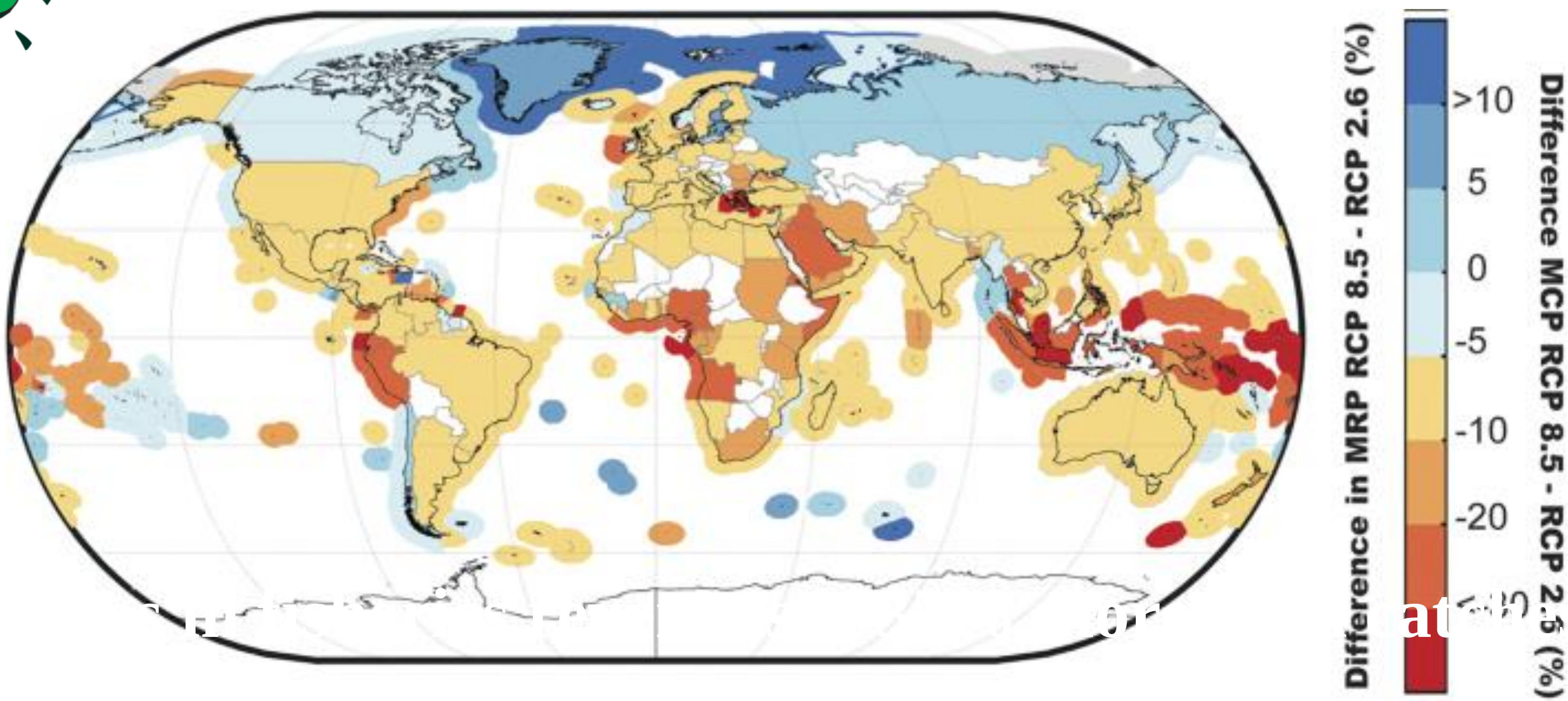
The map is created using MATLAB R2012b, http://www.mathworks.com

	Mean	Standard deviation
% change in MCP	-7.71	4.36
% change in revenues	-10.37	4.20

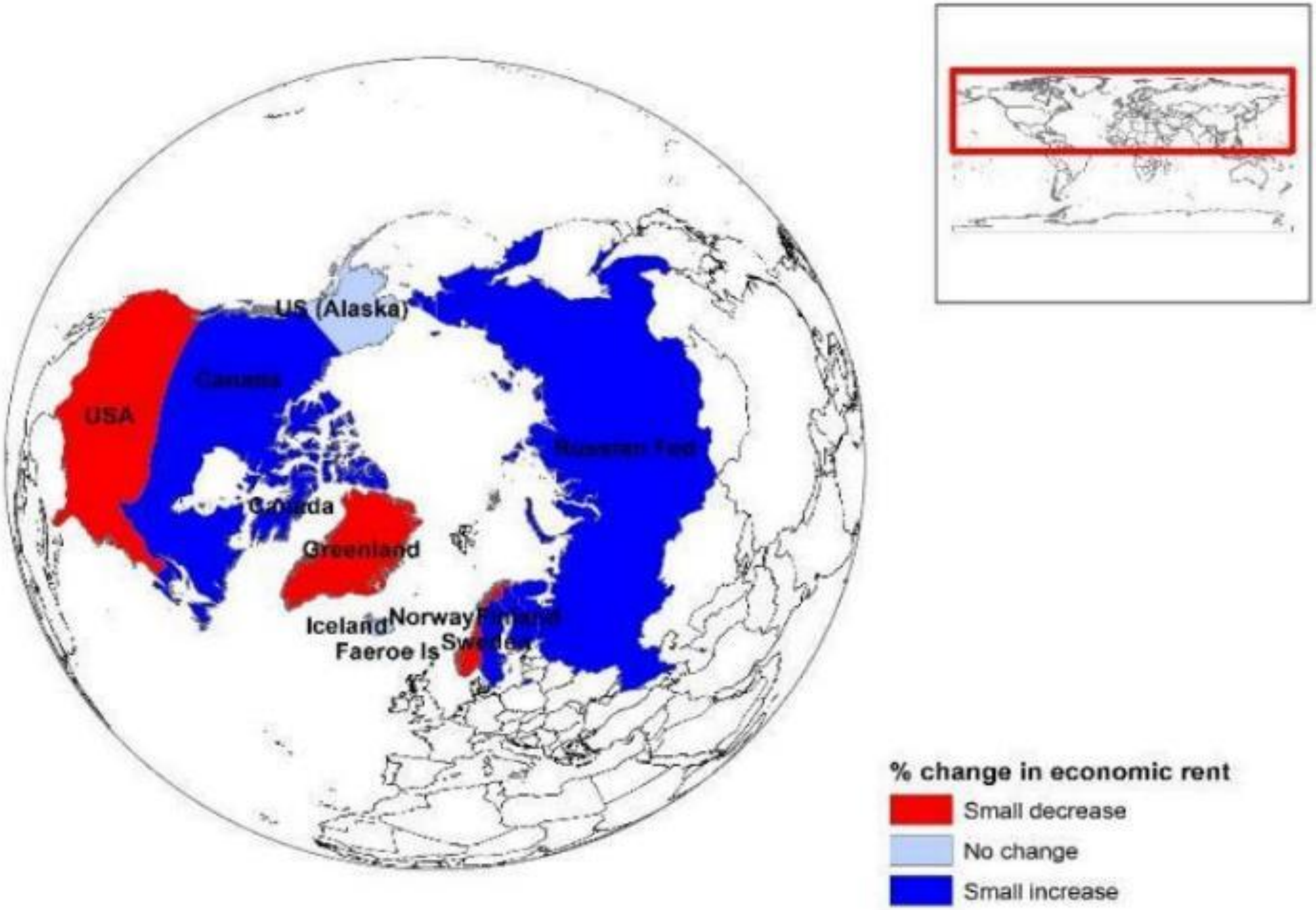
% change in revenues is 35% more than % change in MCP

Lam et al. (2016)

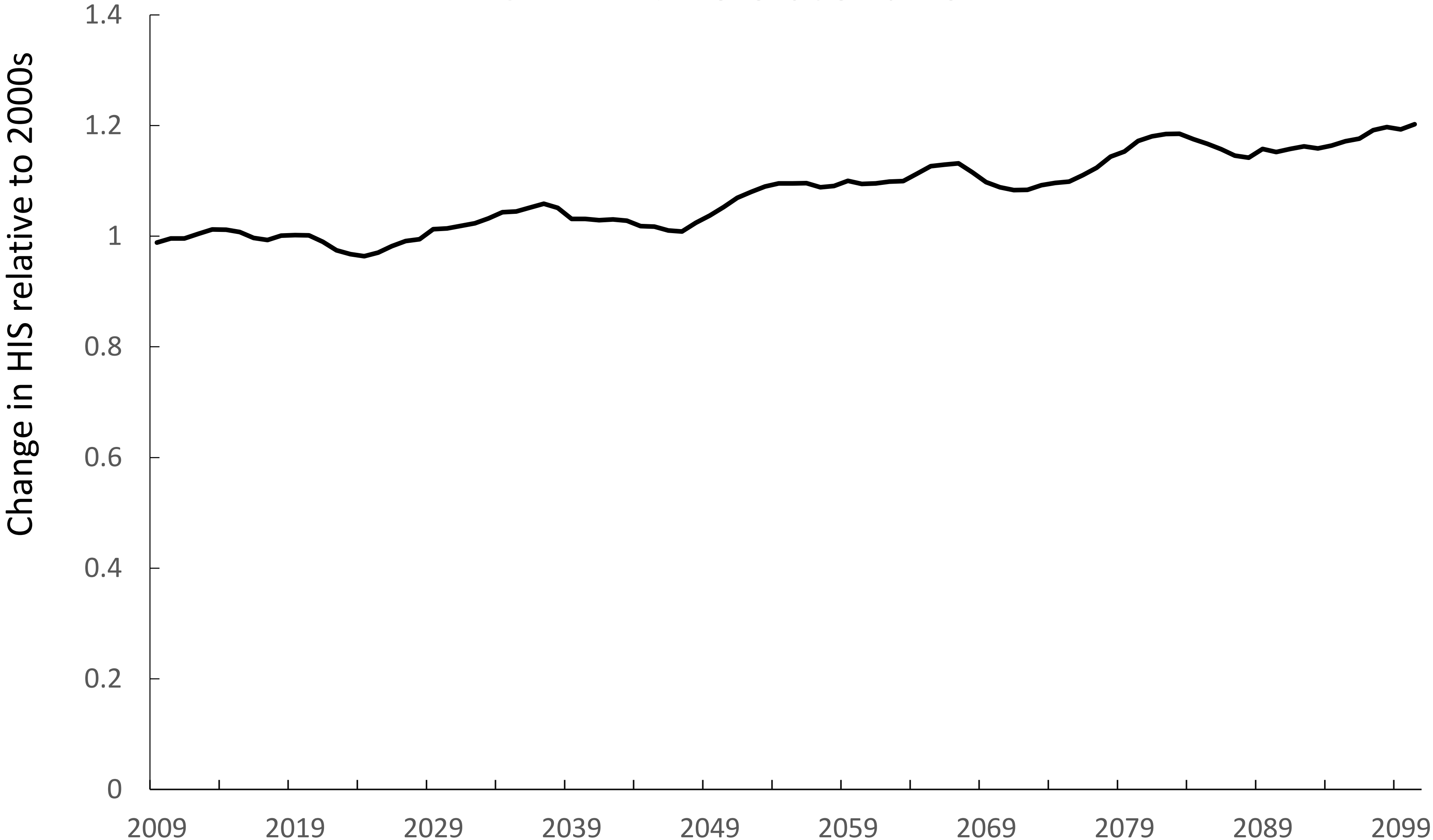
Difference maximum revenues (MRP) between RCP 8.5 and RCP 2.6

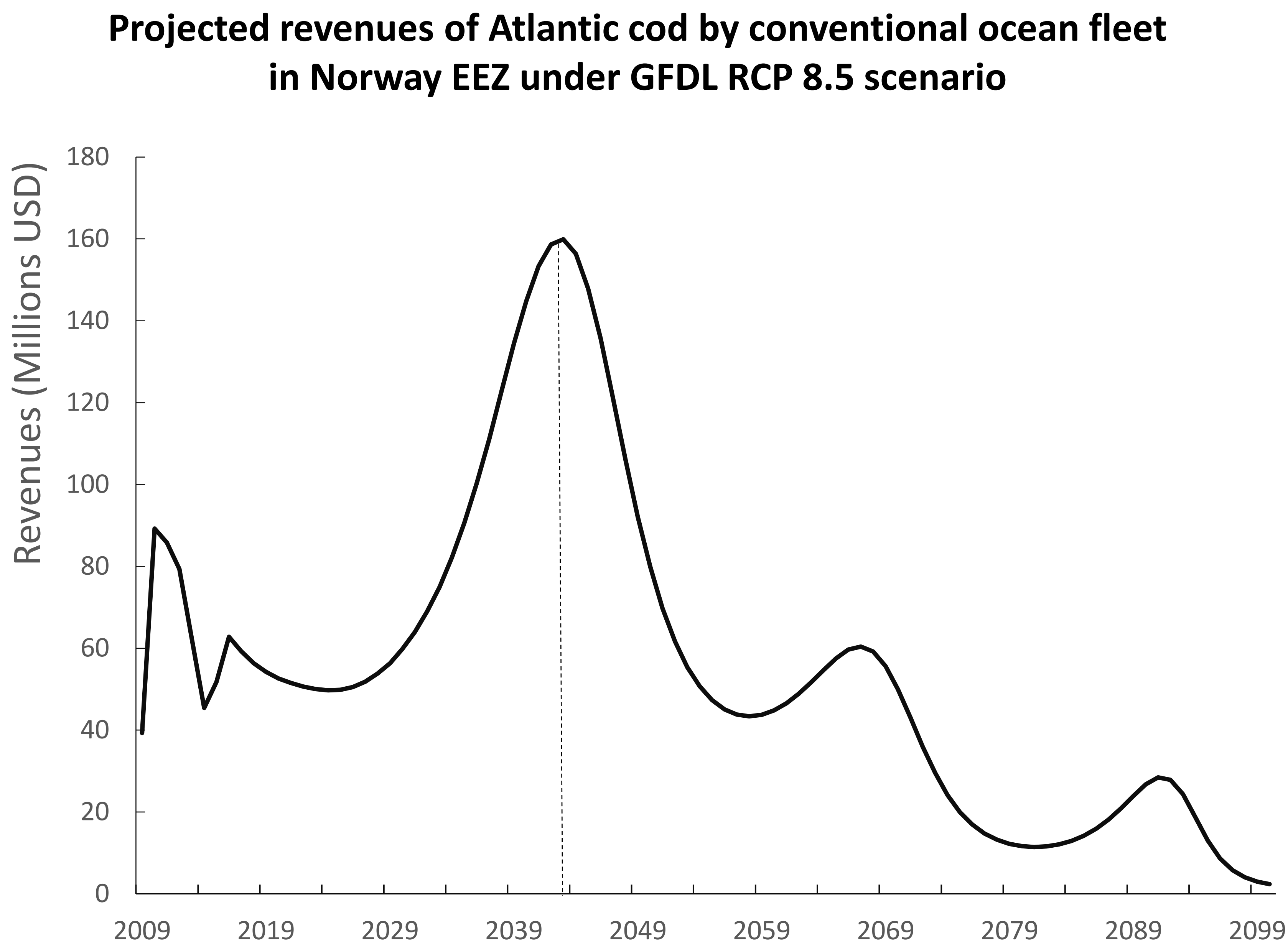


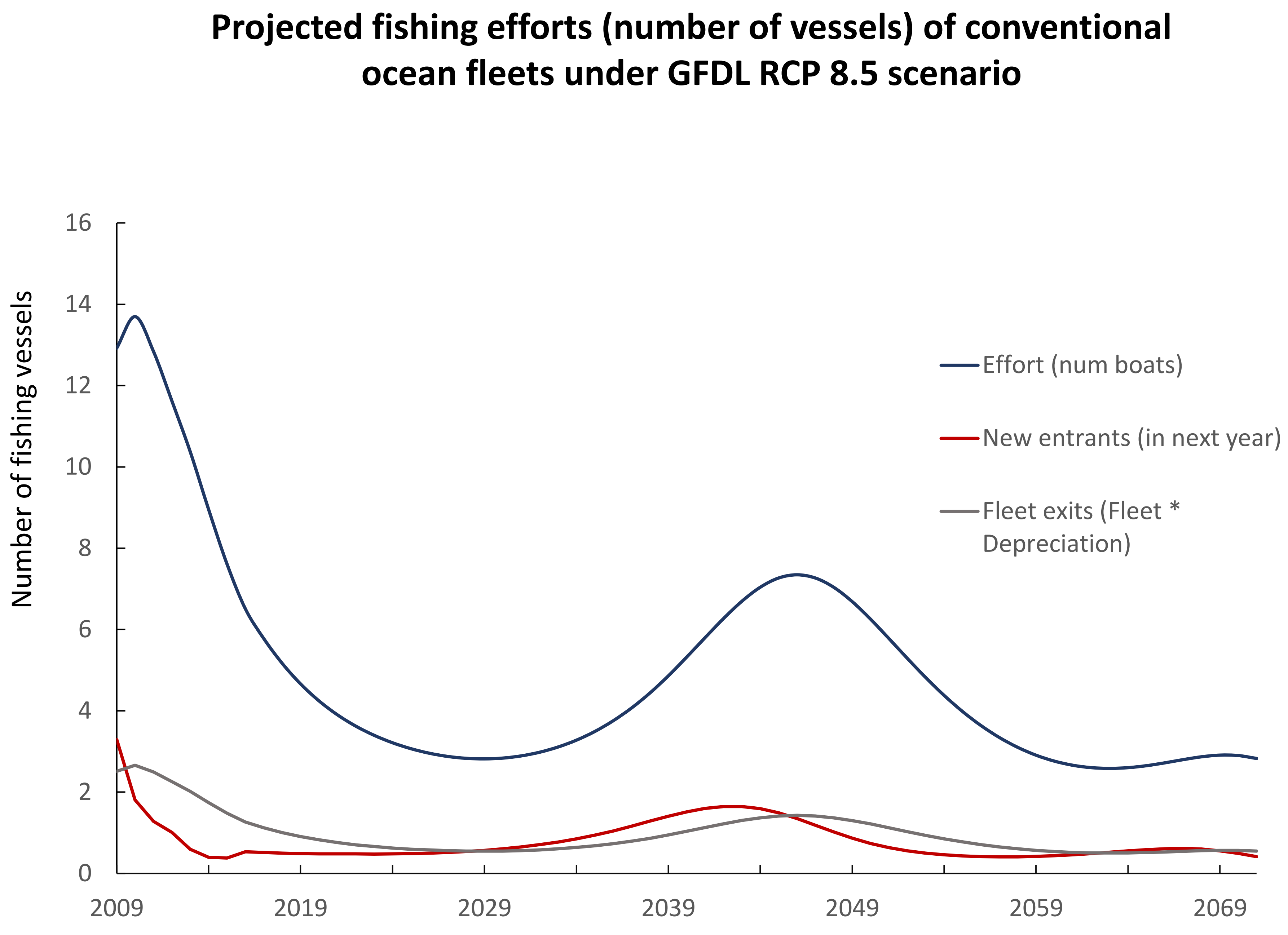
Revenues from Fisheries in the Arctic



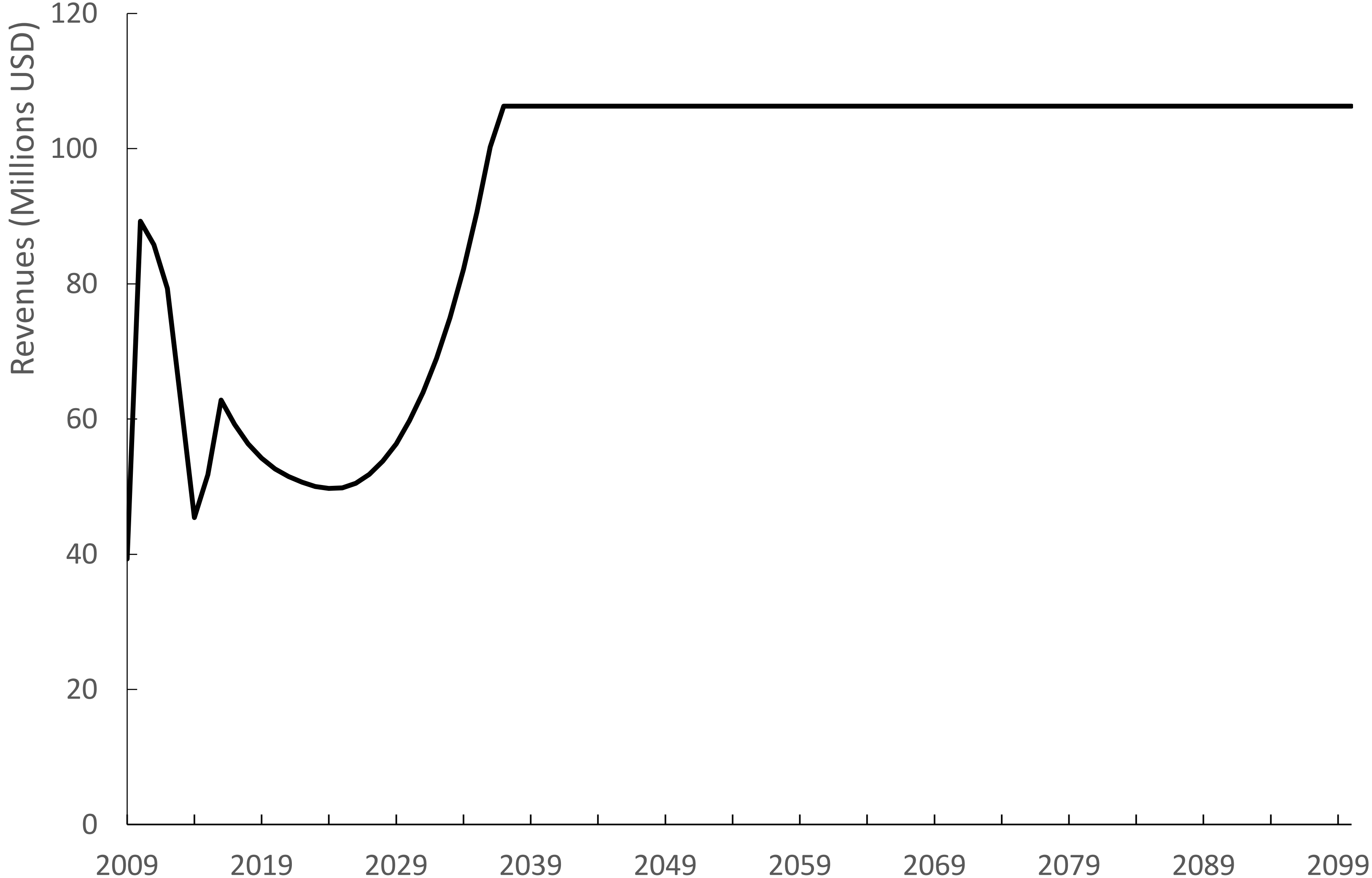
Change in Habitat Suitability Index (HIS) of Atlantic cod in Norway EEZ (area for ocean fisheries) relative to that in the 2000s under GFDL RCP 8.5 scenario

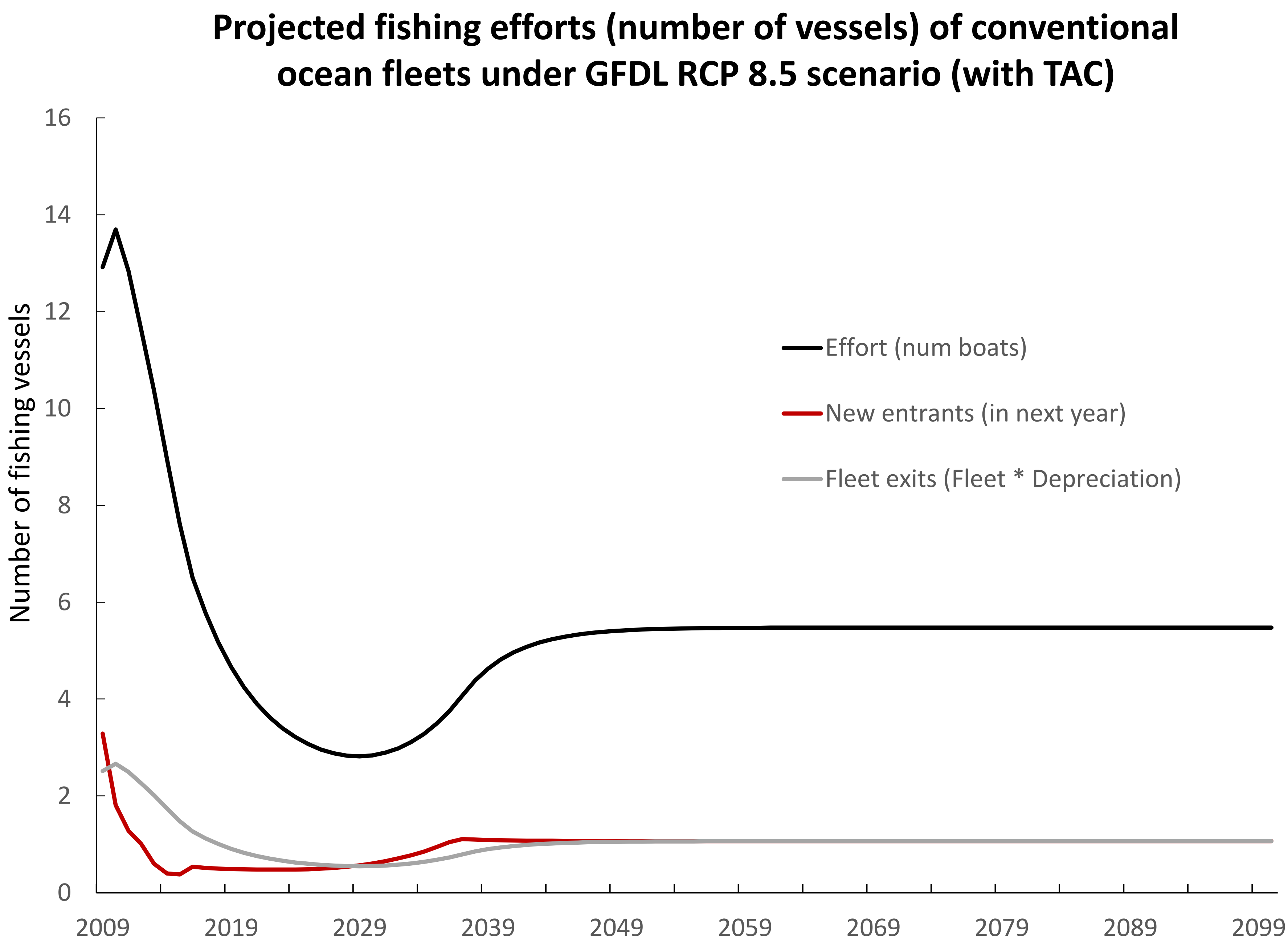



Projected revenues of Atlantic cod by conventional ocean fleet in Norway EEZ under GFDL RCP 8.5 scenario
Revenues (Millions USD)
0
20
40
60
80
100
120
140
160
180
2009
2019
2029
2039
2049
2059
2069
2079
2089
2099


Projected fishing efforts (number of vessels) of conventional ocean fleets under GFDL RCP 8.5 scenario
Number of fishing vessels
0
2
4
6
8
10
12
14
16
2009
2019
2029
2039
2049
2059
2069
Effort (num boats)
New entrants (in next year)
Fleet exits (Fleet * Depreciation)

Projected revenues of Atlantic cod by conventional ocean fleet in Norway EEZ under GFDL RCP 8.5 scenario (with TAC)





Projected fishing efforts (number of vessels) of conventional ocean fleets under GFDL RCP 8.5 scenario (with TAC)
Number of fishing vessels
16
14
12
10
8
6
4
2
0
2009
2019
2029
2039
2049
2059
2069
2079
2089
2099
Effort (num boats)
New entrants (in next year)
Fleet exits (Fleet * Depreciation)

Next,

- Add fishing fleet dynamics (effort);
- Cost dynamics (fishing & travel costs);
- Price function (demand);
- NPV;
- Different management scenarios;
- Winners vs. losers

Acknowledgement

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- REGIMES TEAM:
  - **Dorothy Dankle** from University of Bergen
  - **Rachel Tiller** from SINTEF OCEANS
  - **Yajie Liu** from Department of Economics, NTNU
  - **William Cheung and Vicky Lam** from University of British Columbia

REGIMES

An interdisciplinary investigation into scenarios of national and international conflicts of ecosystem services in the Svalbard zone under a changing climate in the Arctic

https://regimes.b.uib.no/

Thank you


DID YOU SEE THAT ARTICLE ONLINE ABOUT THE GLOBAL WARMING EMAILS? APPARENTLY, CLIMATE CHANGE IS A HOAX.
SHUT UP AND PADDLE.