

# Projecting the Effects of Climate Change on European Fisheries: From Physics to Fish Prices

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North Western Waters Advisory Council

Thursday November 26, 2020

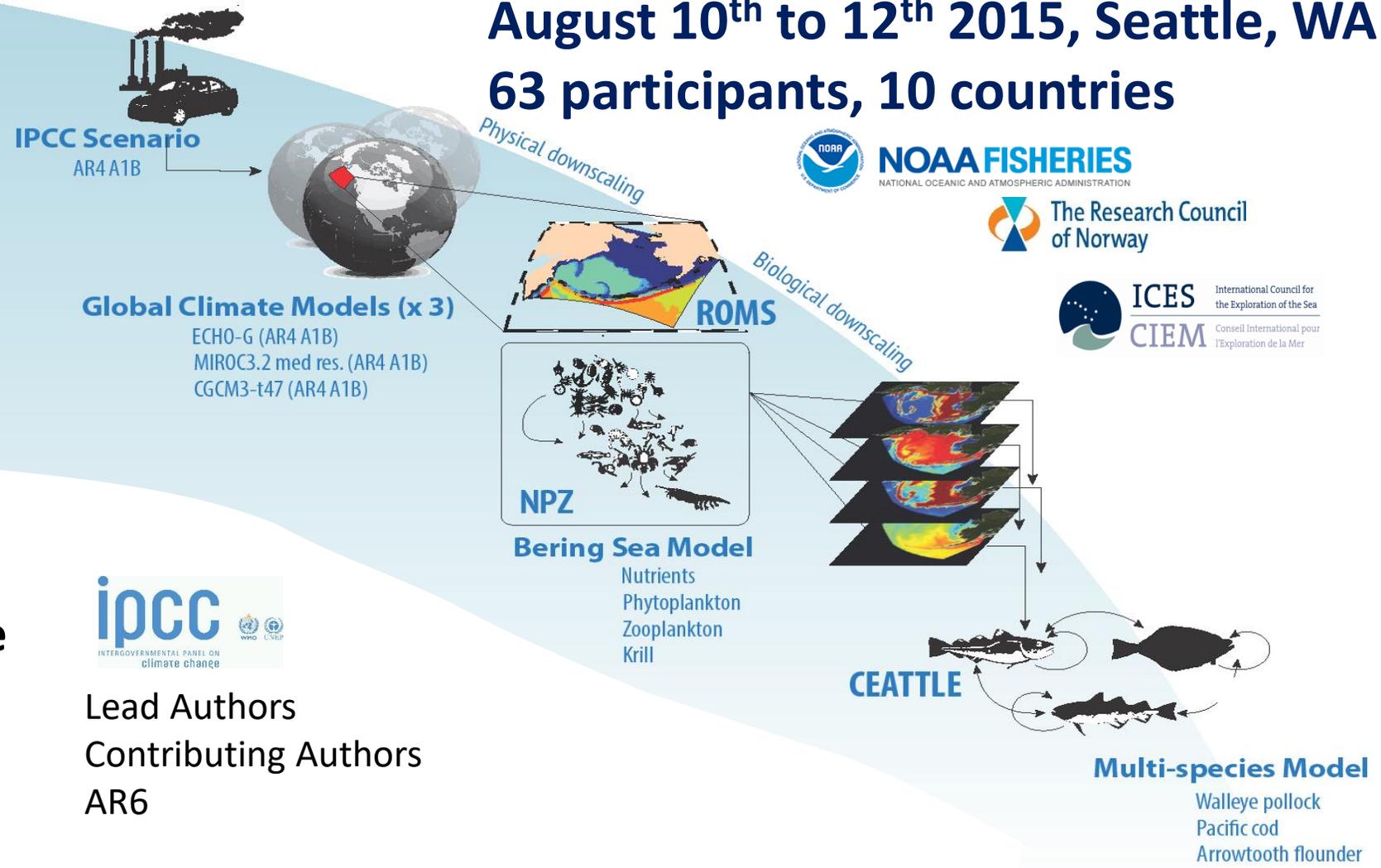


# SICCME Workshop: Coordinating Regional Activities & Future Scenarios



**August 10<sup>th</sup> to 12<sup>th</sup> 2015, Seattle, WA**  
**63 participants, 10 countries**

Convened by:  
*Anne Hollowed (U.S.A.),  
 Kirstin Holsman (U.S.A.),  
 Shin-ichi Ito (Japan),  
 Michio Kawamiya (Japan),  
 Trond Kristiansen (Norway),  
 Myron Peck (Germany),  
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 Cisco Werner (U.S.A.).*



## ICES-PICES SICCME (Strategic Initiative on Climate Change Impacts on Marine Ecosystems)



Lead Authors  
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 AR6

# Large Marine Ecosystems of the World and Linked Watersheds

SICCME Regional  
Modelling Nodes

## ICES-PICES SICCME (Strategic Initiative on Climate Change Impacts on Marine Ecosystems)



ICES  
CIEM

International Council for  
the Exploration of the Sea

Conseil International pour  
l'Exploration de la Mer

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Jackie King (Canada)

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**N. Atlantic**

Mark Payne (Denmark)

Christian Möllmann (Germany)

# Large Marine Ecosystems of the World and Linked Watersheds

SICCME Regional  
Modelling Nodes

ACLIM

CERES

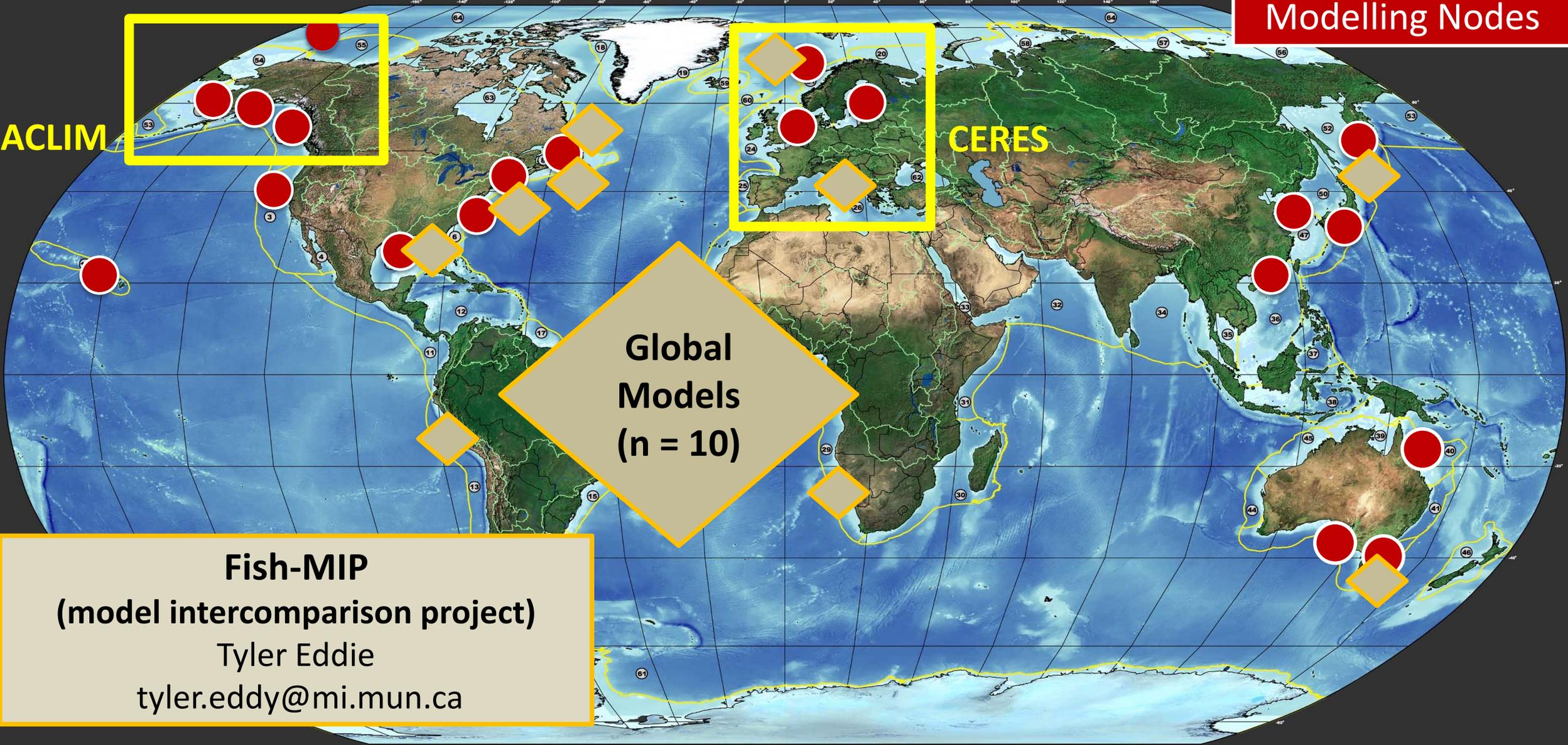
Global  
Models  
(n = 10)

**Fish-MIP**

**(model intercomparison project)**

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**CERES** 2016 – 2020  
26 partners  
12 nations



# CERES Storylines [\(ceresproject.eu\)](http://ceresproject.eu)



#1 Rainbow trout in north-east Europe



#2 Rainbow trout in the eastern Mediterranean



#3 Carp in north-east Europe



#4 Pike-perch in south-east Europe



#5 Mussels in the North Sea



#6 Oysters in the North Sea



#7 Mussels in the Atlantic coast



#8 Oysters and clams in the Atlantic coast



#9 Mussels in the Mediterranean



#10 Salmon in the north-east Atlantic



#11 Meagre at the Atlantic coast



#12 Seabass and seabream in West Med and European south Atlantic



#13 Seabass and seabream in the eastern Mediterranean



#14 Herring, capelin, and cod in the Barents and Norwegian Seas



#15 Herring, sprat and cod in the Baltic Sea



#16 Herring in the North Sea



#17 Gadoids in the North Sea



#18 Mackerel in the north-east Atlantic



#19 Flatfish in the North Sea and north-east Atlantic



#20 Dolphinfish in the north-west Mediterranean



#21 Sardines and anchovies in the Bay of Biscay



#22 Sardines and anchovies in the north-west Mediterranean



#23 Hake in the Aegean Sea and eastern Mediterranean



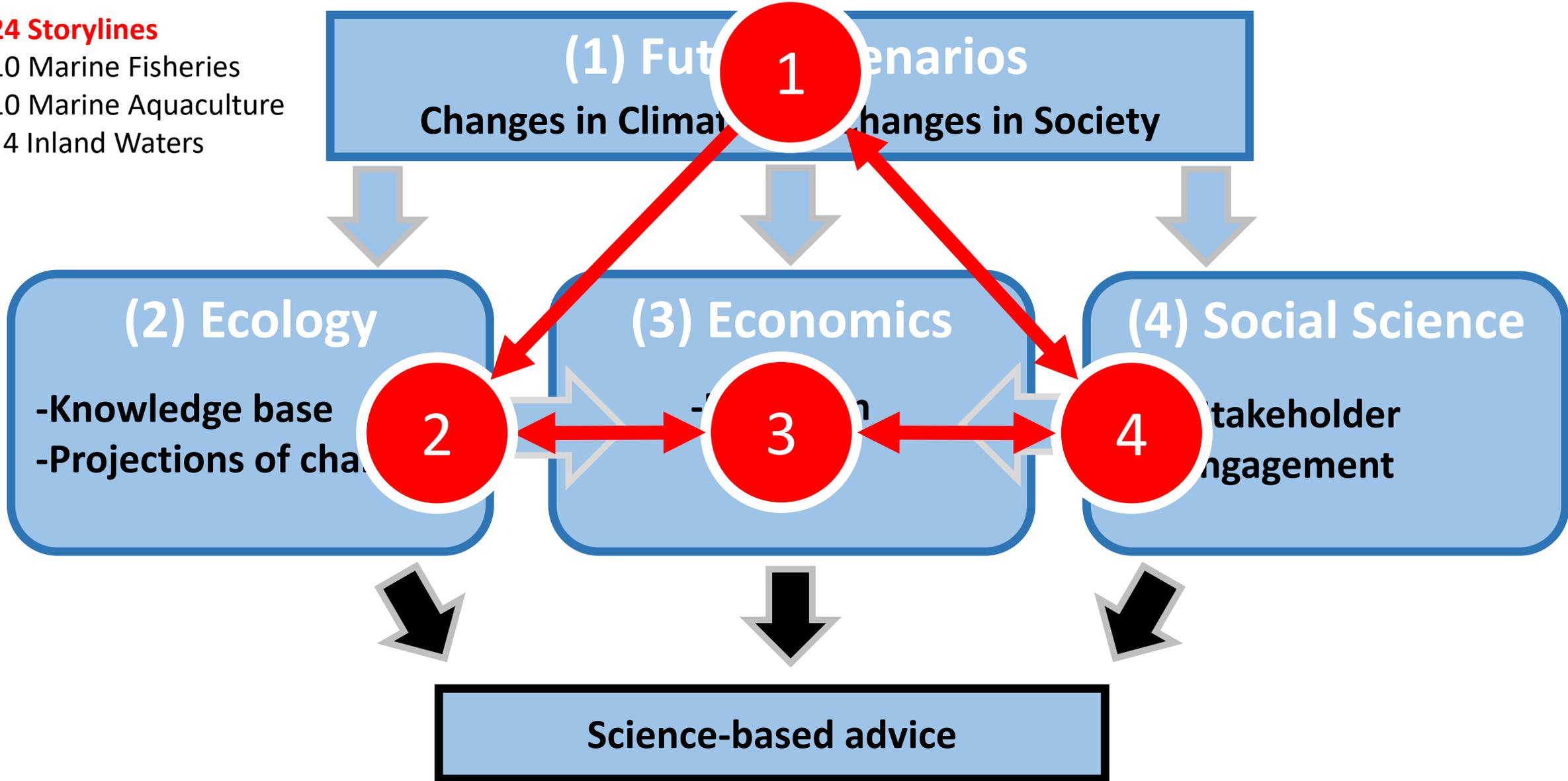
#24 Bluefin Tuna in the north-west Mediterranean

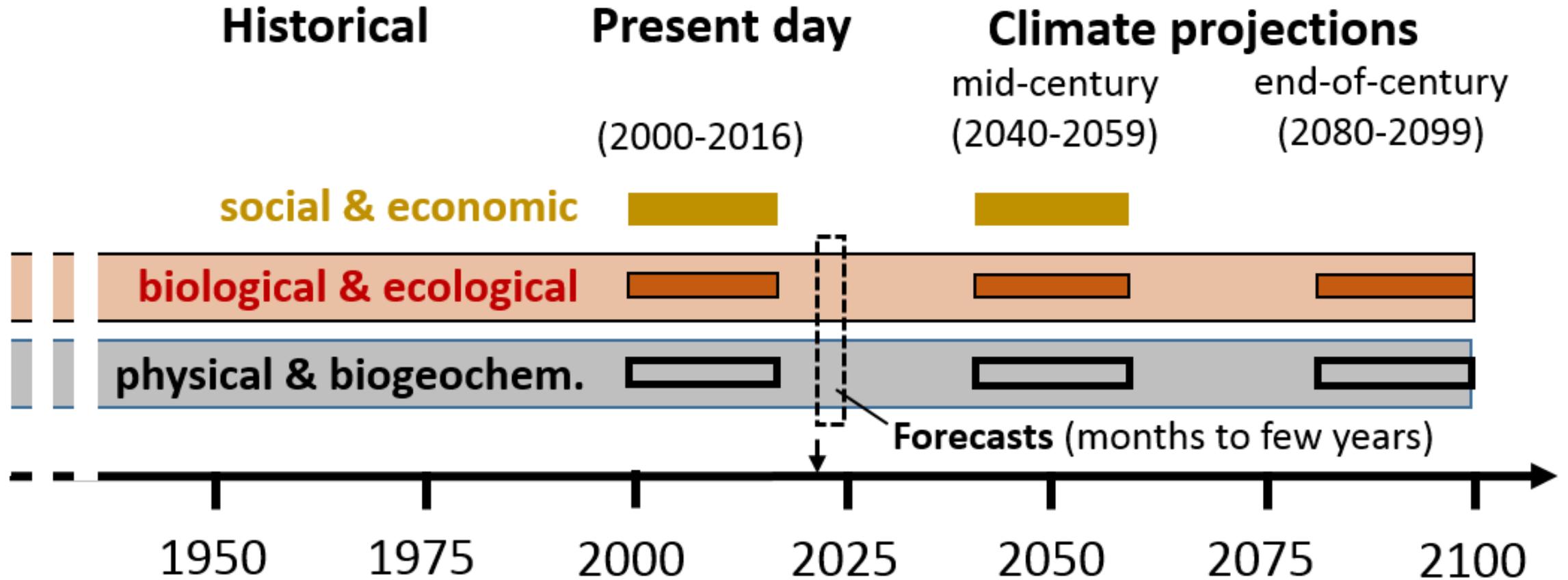
**Physics / biogeochemistry**  $\longleftrightarrow$  **Ecology**  $\longleftrightarrow$  **Economics**  $\longleftrightarrow$  **Sociology**

# Projecting Impacts of Climate Change

**24 Storylines**

- 10 Marine Fisheries
- 10 Marine Aquaculture
- 4 Inland Waters





# Projecting Impacts of Climate Change

**(1) Future Scenarios**  
Changes in Climate and Changes in Society

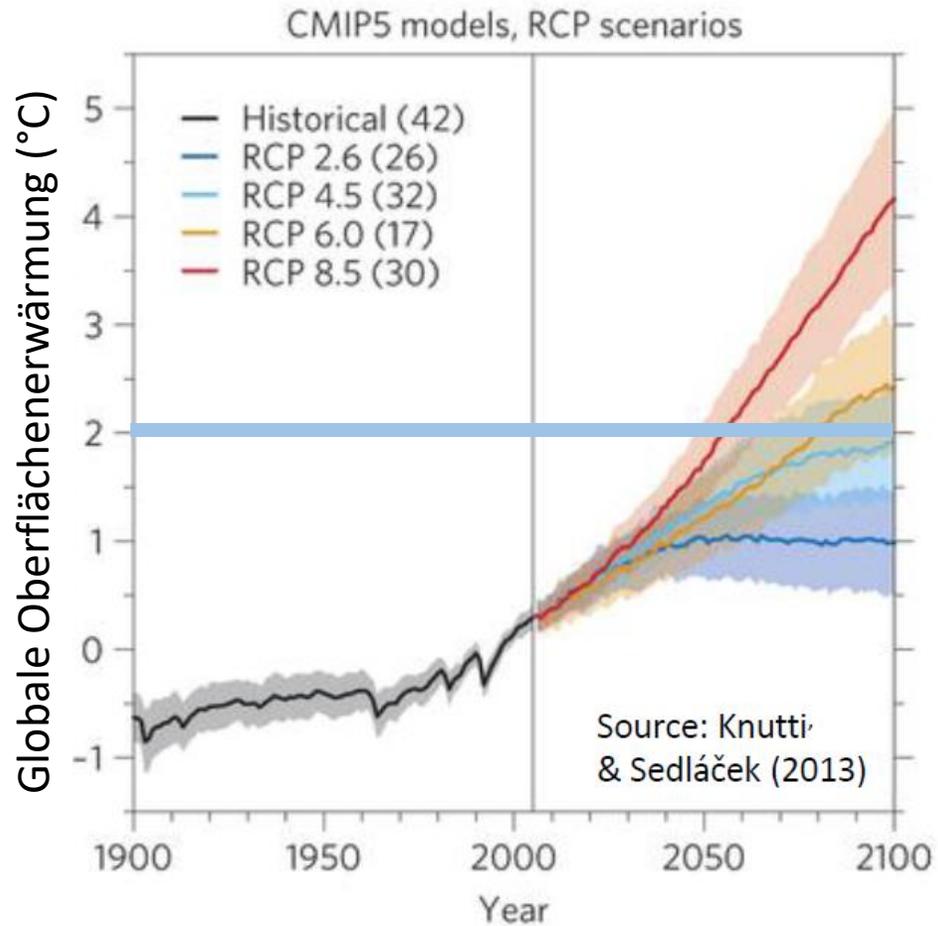
**(2) Ecology**  
-Knowledge base  
-Projections of change

**(3) Economics**  
-European Fleets

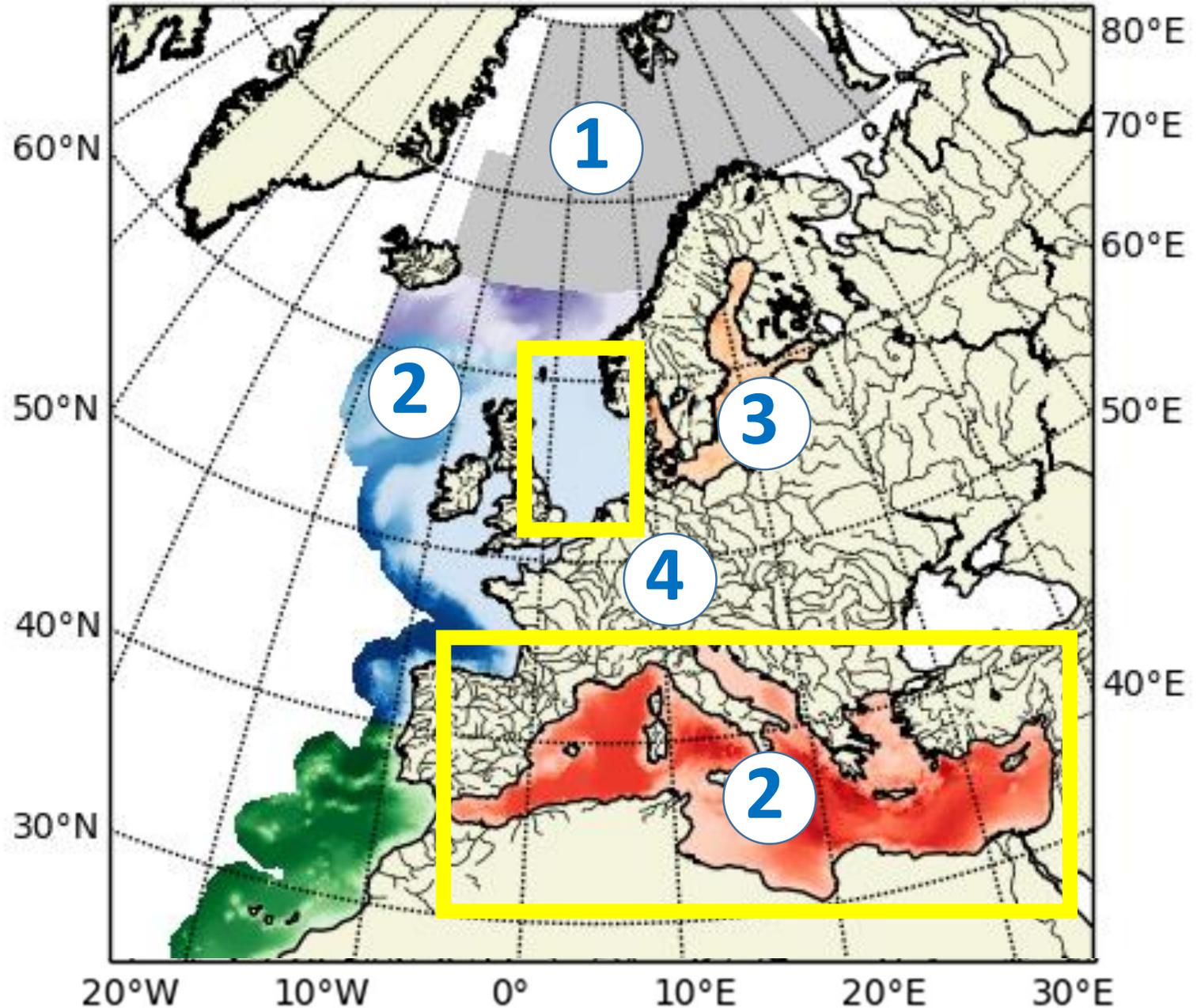
**(4) Social Science**  
-Stakeholder Engagement

Science-based advice

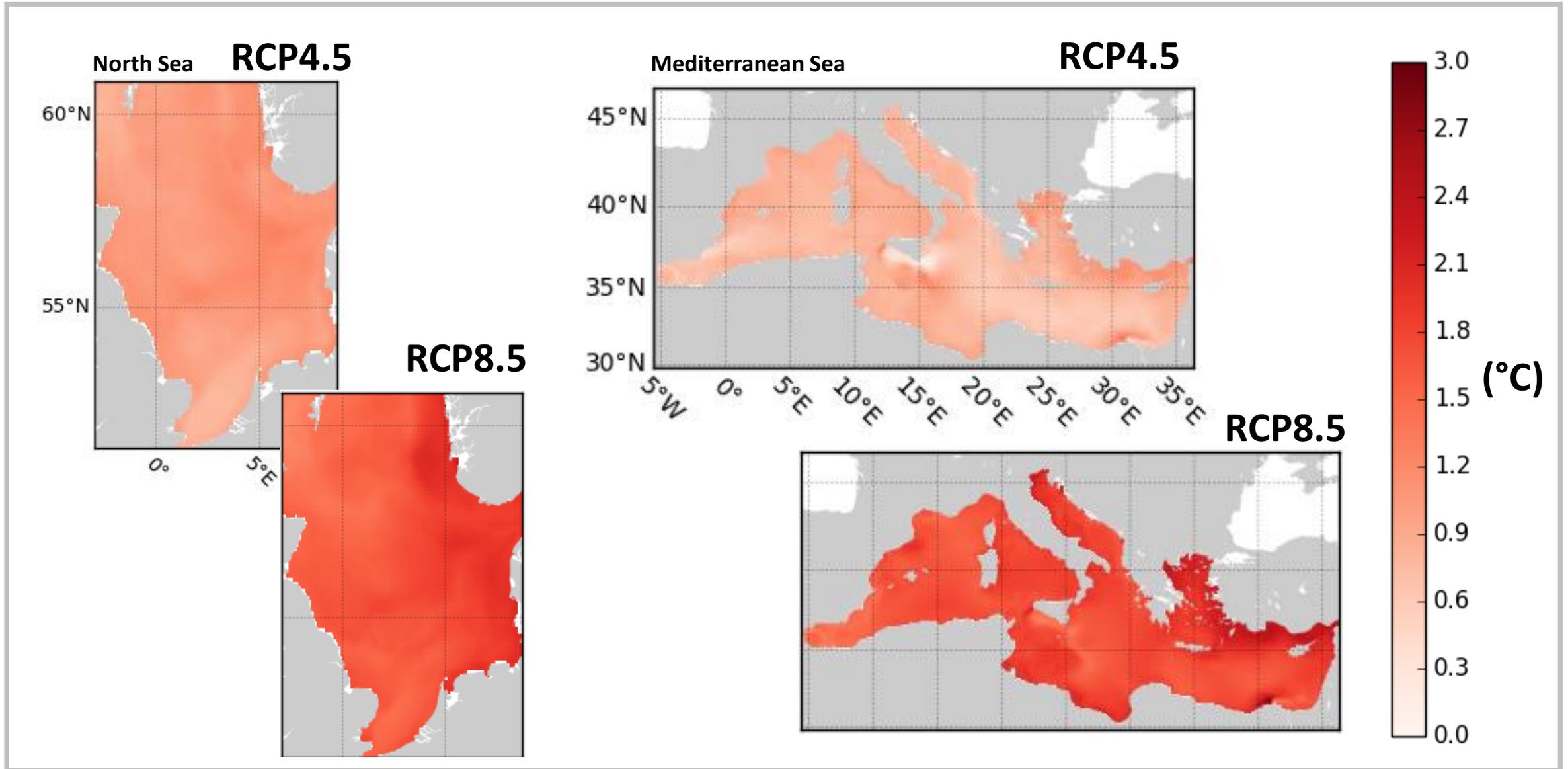
# Physical / biogeochemical projections



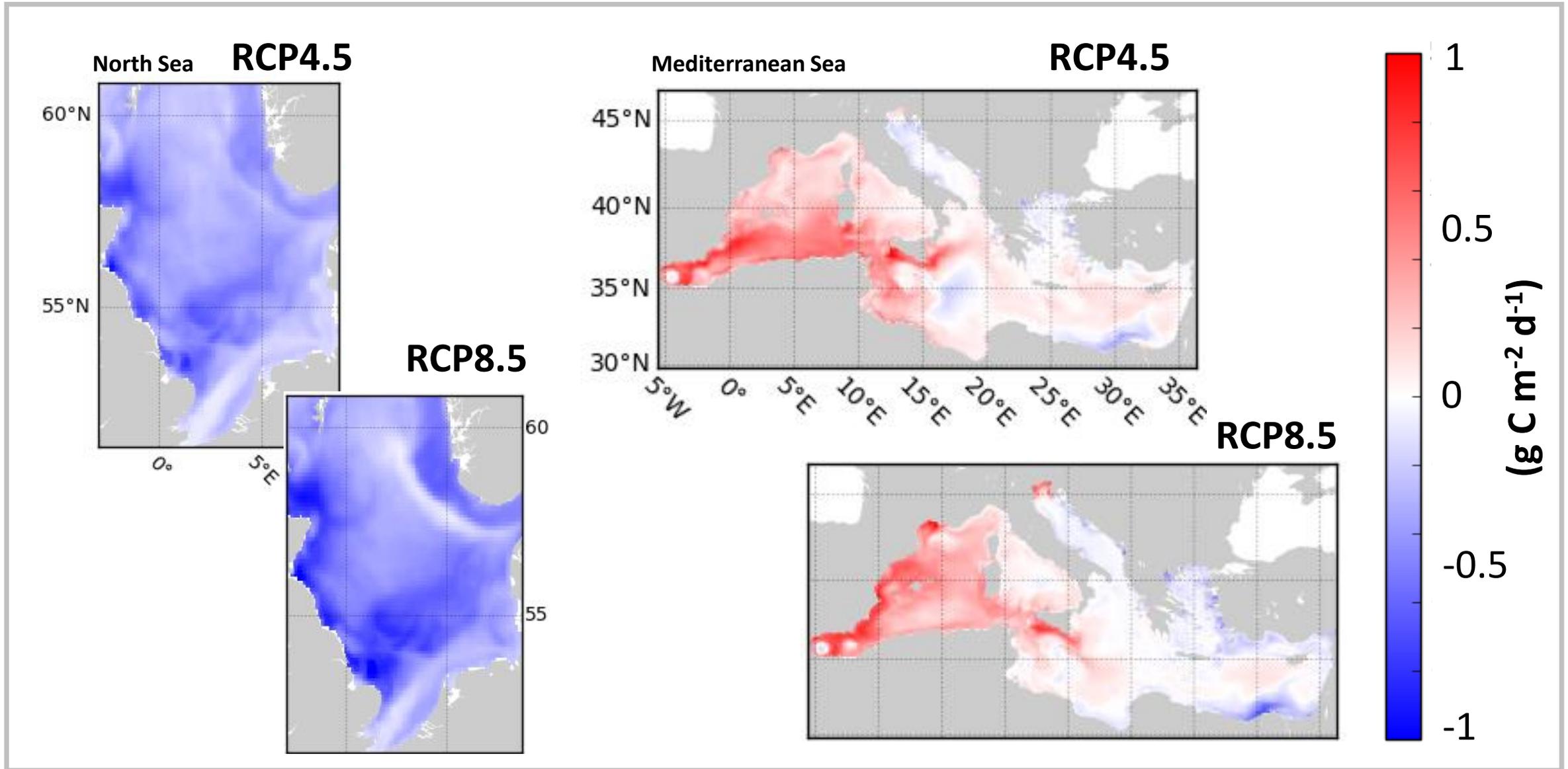
Representative Concentration Pathways (RCPs) 4.5 & 8.5 to 2070 or 2100



# Projected Change in Sea Surface Temperature in 50 years



# Projected Changes in Primary Productivity in 50 Years



# Fishers want to know about future storminess...

Winter of 2013/14 was stormiest in last 66-years and strong storms had devastating consequences for the inshore UK fishing industry.

Vessels tied up in port for > 5 months, with implications for revenues, profits and local economies and damage to both onshore infrastructure and to the fishing vessels themselves.

Projections of future storminess are very uncertain, but generally we expect more frequent, larger storms in the North Sea

From John Pinnegar (CEFAS)



Prices of fish have been pushed up by the storms

Fishermen who have been trapped on land as ferocious storms batter Cornwall's coast may risk sailing in dangerous conditions, a leading fishing organisation has warned.

Dwindling fish market stocks have led to soaring prices and the Cornish Fish Producers Organisation (CFPO) said that could tempt skippers to take risks.

Most of the Cornish fleet has been docked for at least six weeks.

As a result some wholesale prices have nearly doubled.



Many fisherman have been unable to get out to sea for several weeks

Relentless storms have left many fishermen facing desperate financial crisis, with some unable to work since Christmas, a charity has said.

Weeks of ferocious weather have forced many boats from the sea, particularly the inshore fleets in the South West.

The Fishermen's Mission, which provides emergency grants, said it was giving out "thousands of pounds every day".

The charity said the crisis was unprecedented and it has launched a new

#### Related Stories

Market closed as storms hit fishing  
Money 'no object' for flood relief

Fishermen count the costs of storms

#### Related Stories

Storms 'destroyed' £25k of crab pots'

Fishermen count the costs of storms  
Storms send fish prices rocketing

# Projecting Impacts of Climate Change

**(1) Future Scenarios**  
Changes in Climate and Changes in Society

**(2) Ecology**  
-Knowledge base  
-Projections of change

**(3) Economics**  
-Fleets

**(4) Social Science**  
-Stakeholder Engagement

Science-based advice

# Gap Analysis

Web of science n = 21,714 studies,  
344 met criteria for inclusion

## Marine fisheries



7 pelagics, 6 demersals, 1 squid, 1 shrimp

## Marine aquaculture

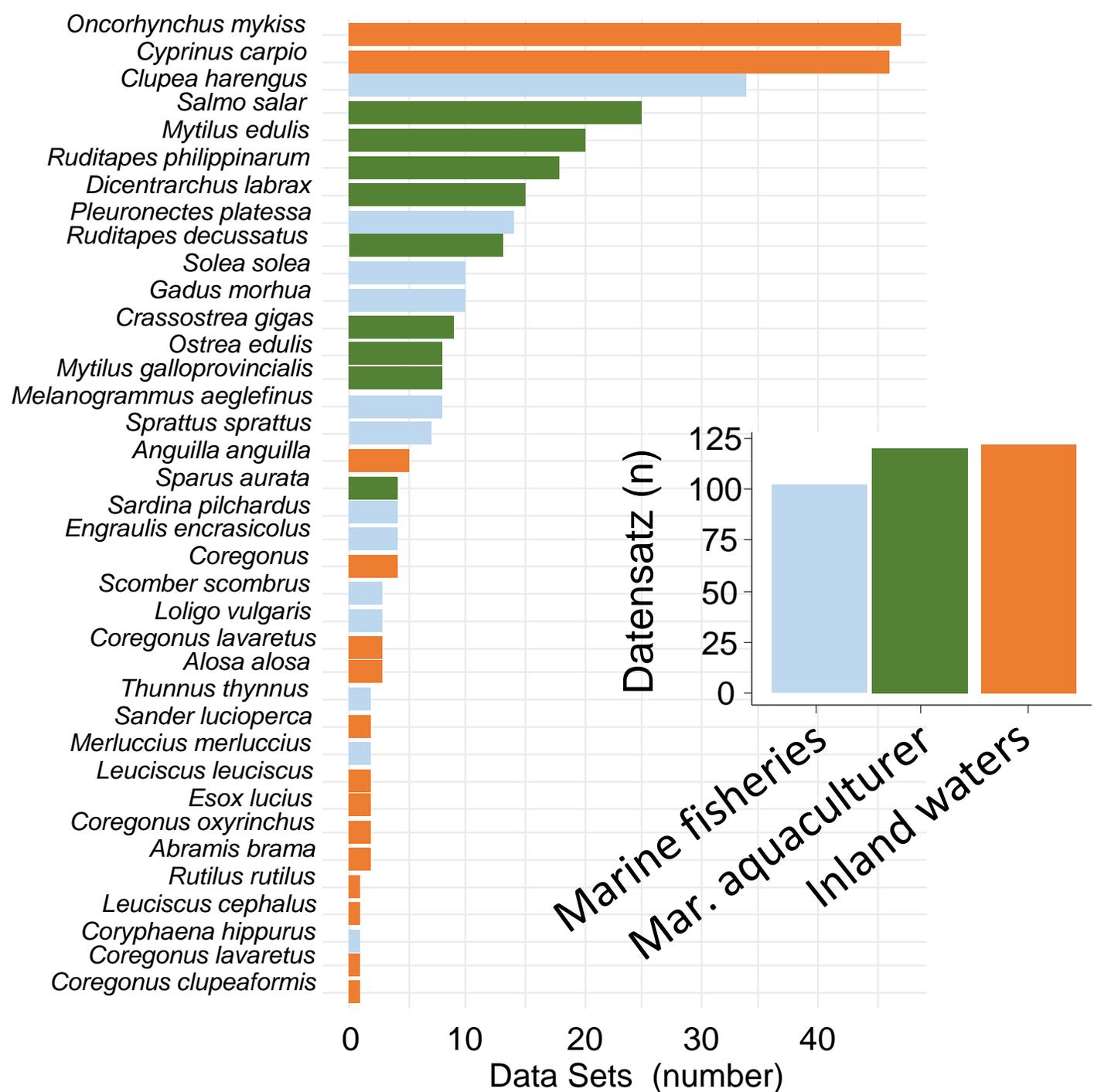


3 finfish, 6 bivalves

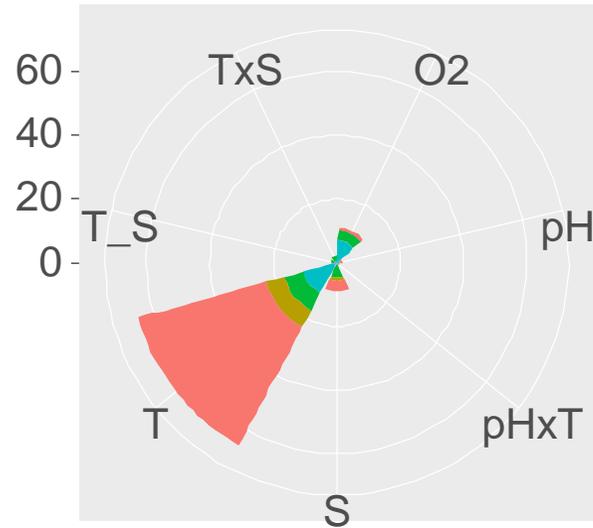
## Inland waters



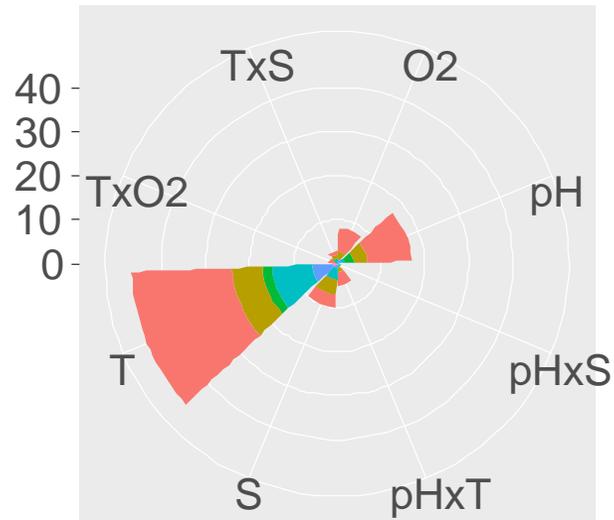
2 cultured fish, >15 fished species



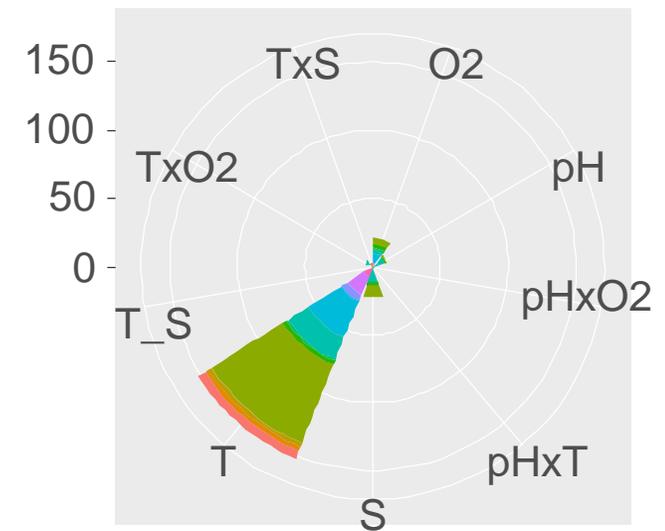
## Marine Fisheries



## Marine Aquaculture



## Freshwater



### Effekt studiert

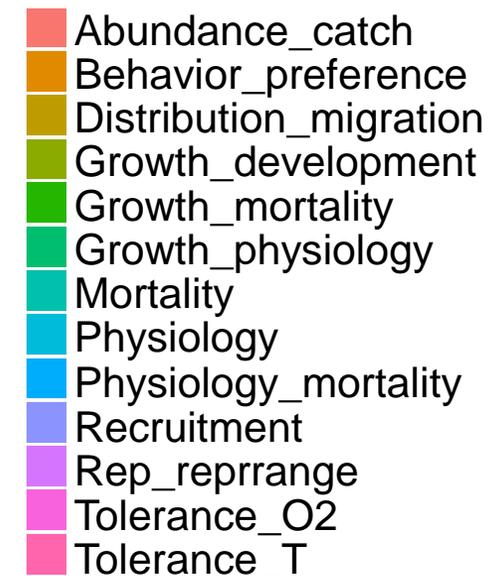
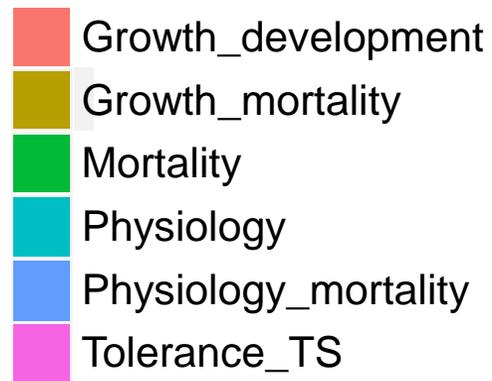
### Abiotic Factor

T = Temperature

S = Salinity

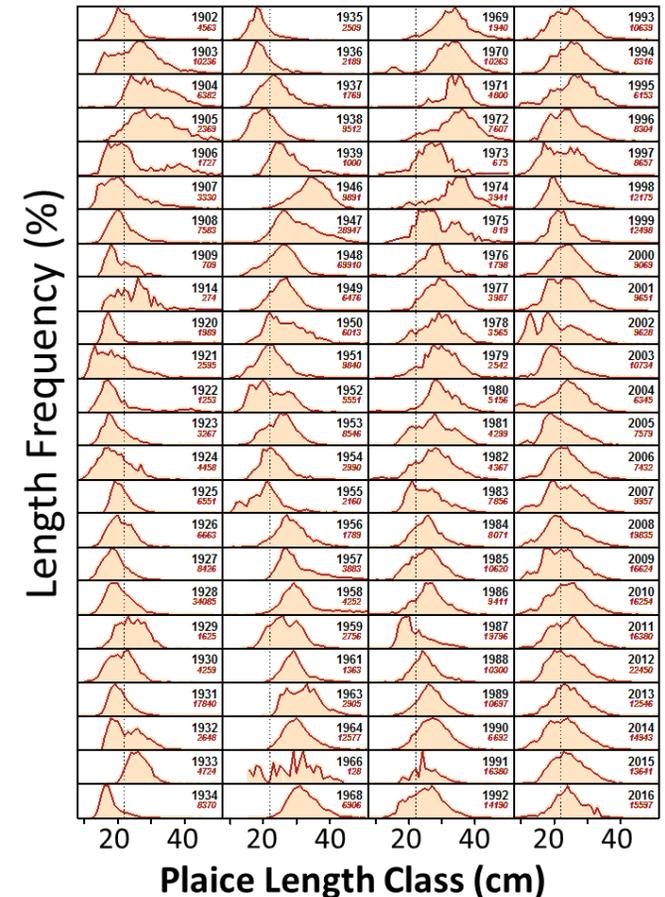
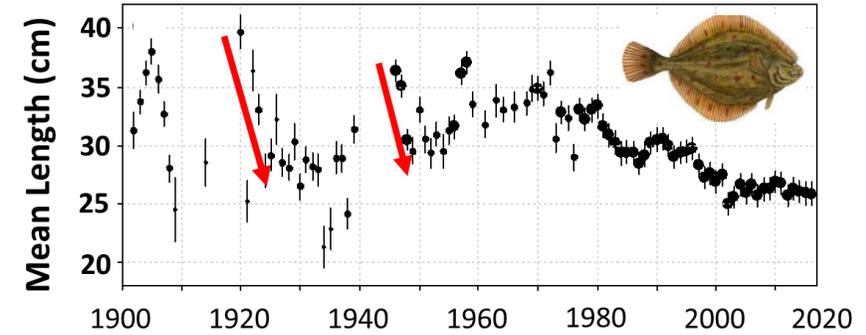
O<sub>2</sub> = dissolved O<sub>2</sub>

pH = pH



# Attribution - Importance of Biological Time Series

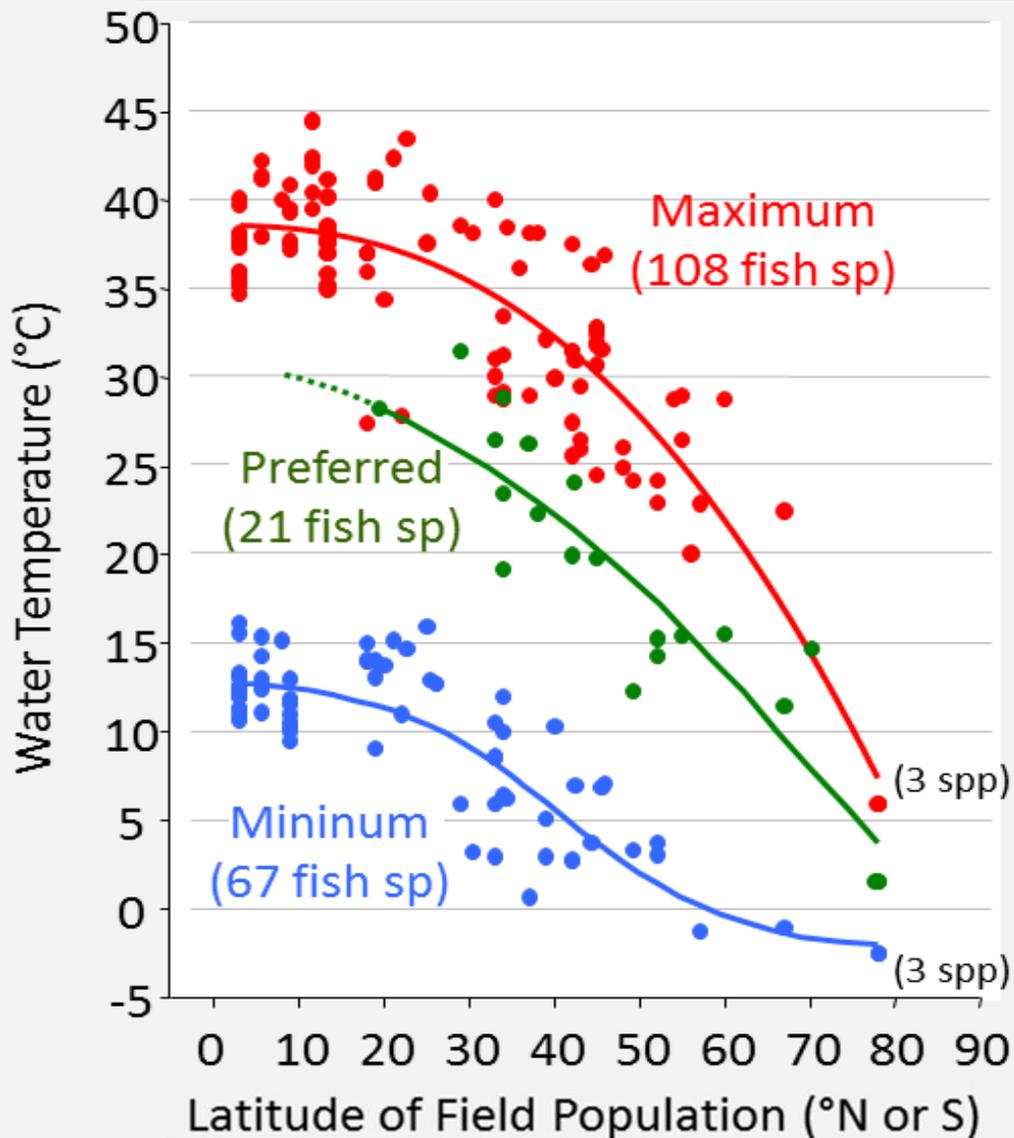
- Time series analyses (11 applications) of single or multiple species within 8 European regions.
- Historical changes in stocks mainly driven by fishing but **climate variability has triggered (amplified or weakened) observed responses.**
- Capacity to build reliable projection models requires robust (long, continuous, data-rich) time series for the main European Seas and inland waters. Such **time series are scarce and in only a few areas.**
- Healthy stocks will display less climate-driven variation (until physiological thresholds are passed) underscoring **importance of sustainable, ecosystem-based management for climate adaptation**



Cefas (Engelhard, Pinnegar et al.)

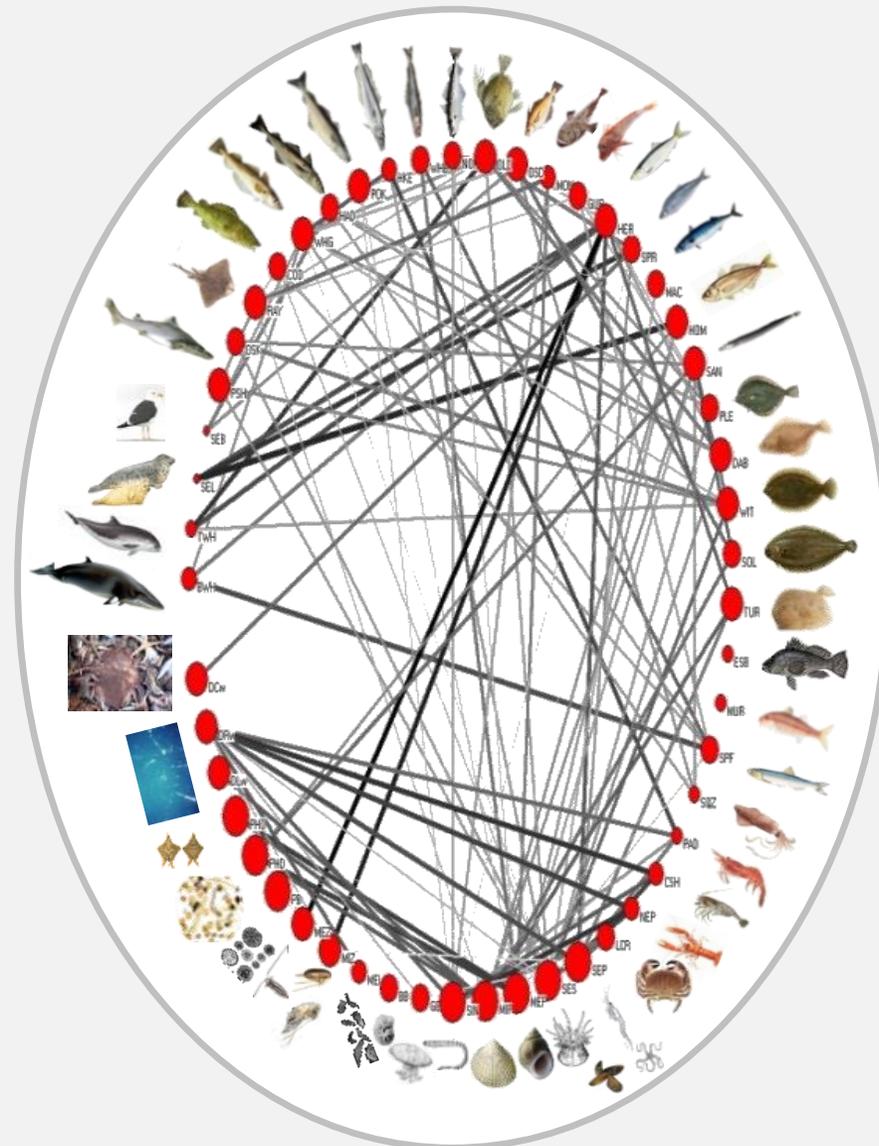
# Models created from ecological knowledge

... on physiological tolerance



(Pörtner & Peck, 2010)

... on food webs



North Sea  
food web in 'Atlantis'

# Lots of tools...

- 1 Atlantis
- 2 FishRent
- 3 SIMFISH/RUM
- 4 ISISFISH
- 5 FLBEIA
- 6 MEFISTO

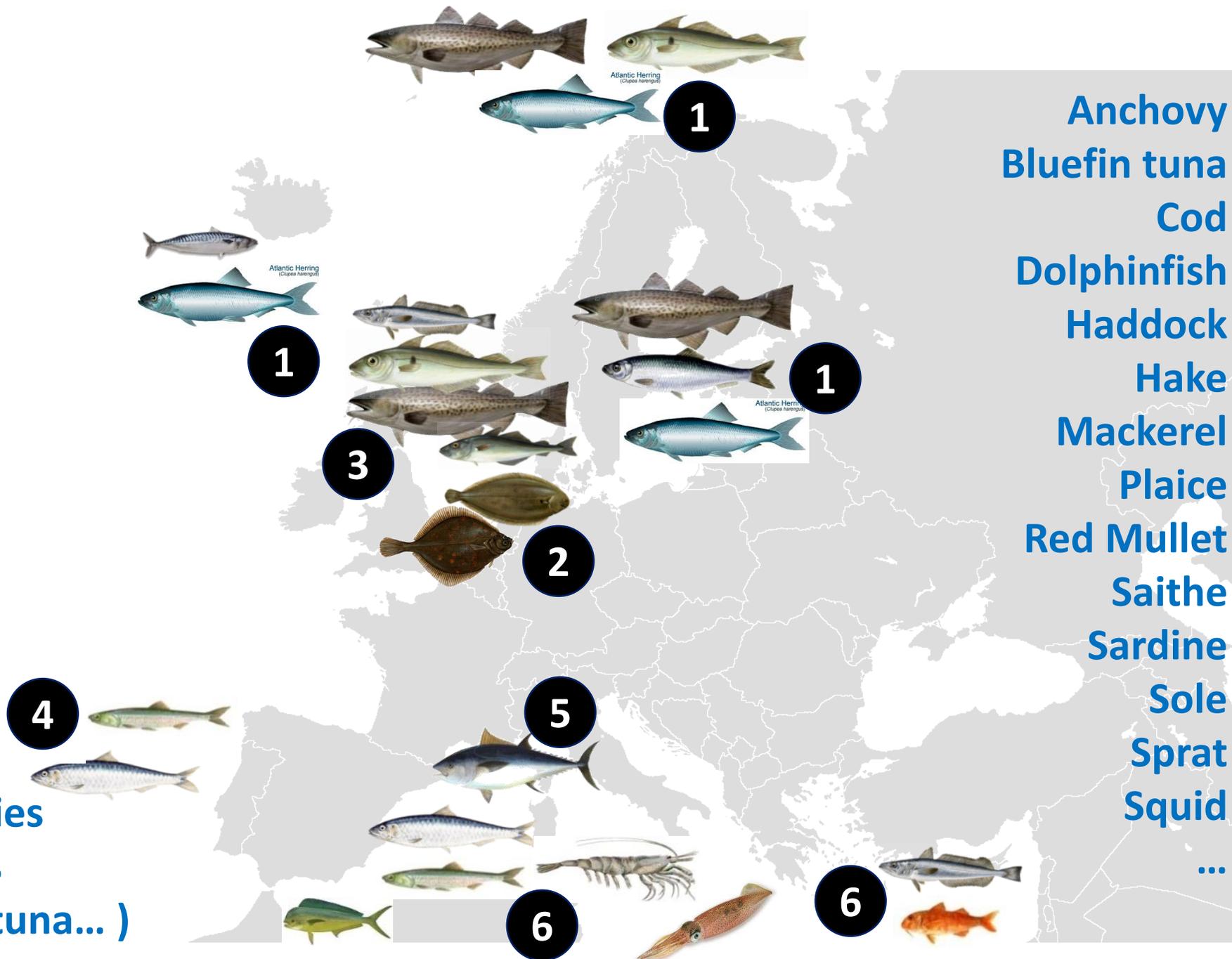
-DBEM (all areas)

-Statistical models

Mixed demersal fisheries

Mixed pelagic fisheries

Single species (bluefin tuna... )



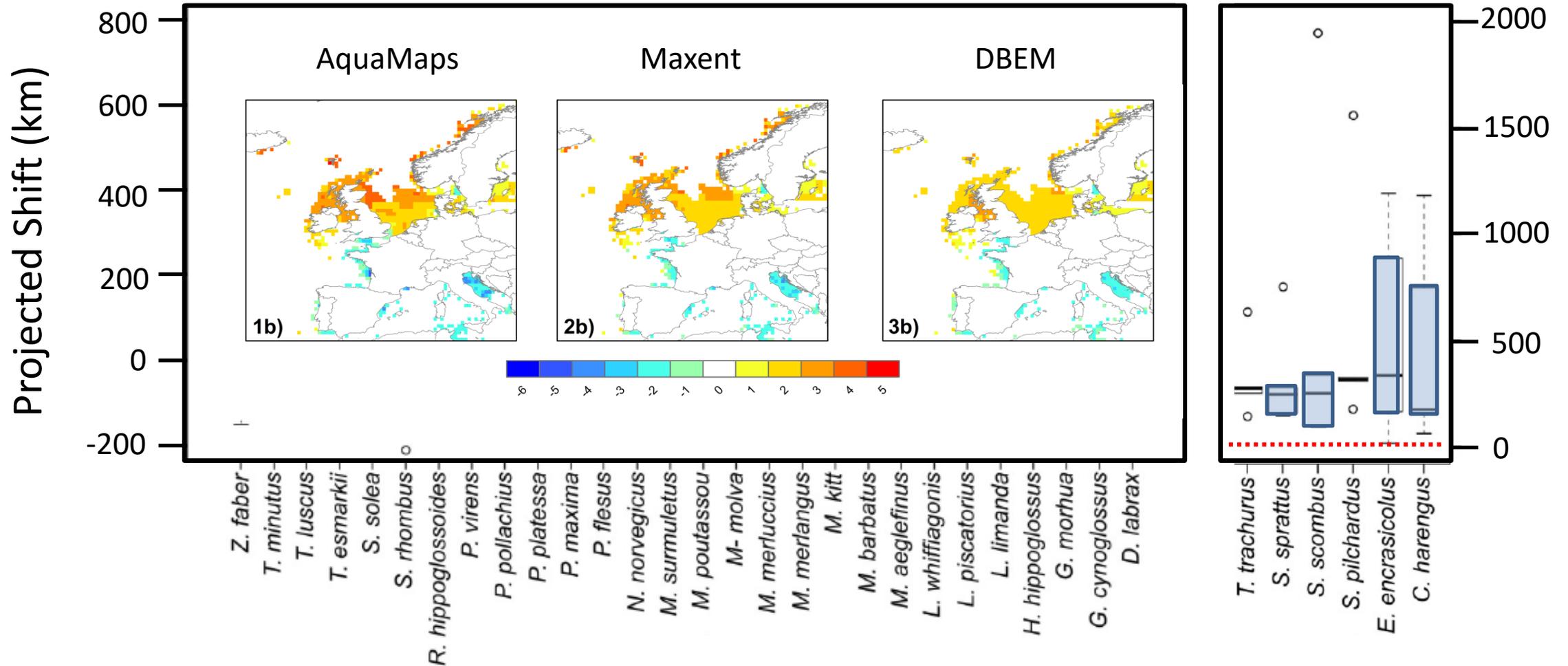
- Anchovy
- Bluefin tuna
- Cod
- Dolphinfish
- Haddock
- Hake
- Mackerel
- Plaice
- Red Mullet
- Saithe
- Sardine
- Sole
- Sprat
- Squid
- ...

# Projected Change in Distribution of North Sea Fish by 2050

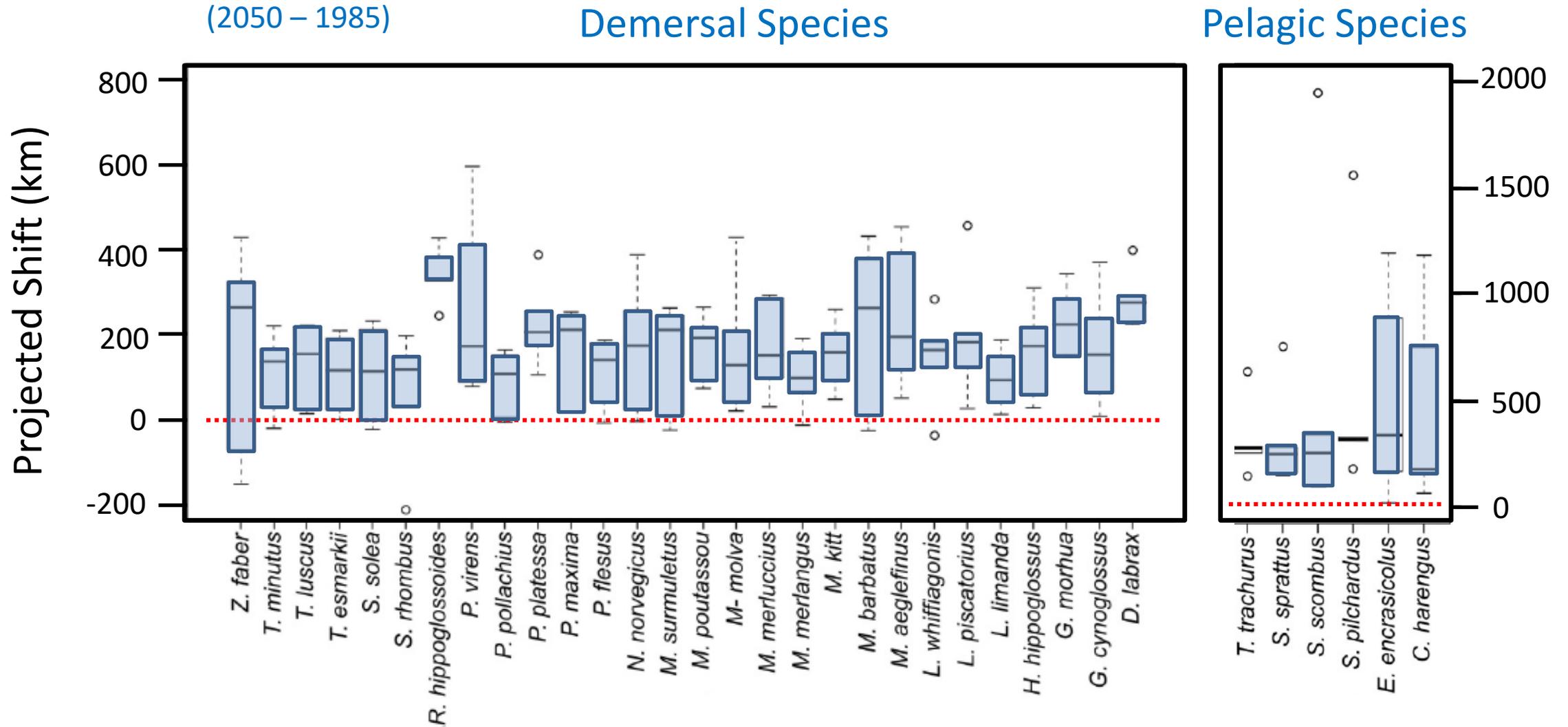
(2050 – 1985)

Demersal Species

Pelagic Species

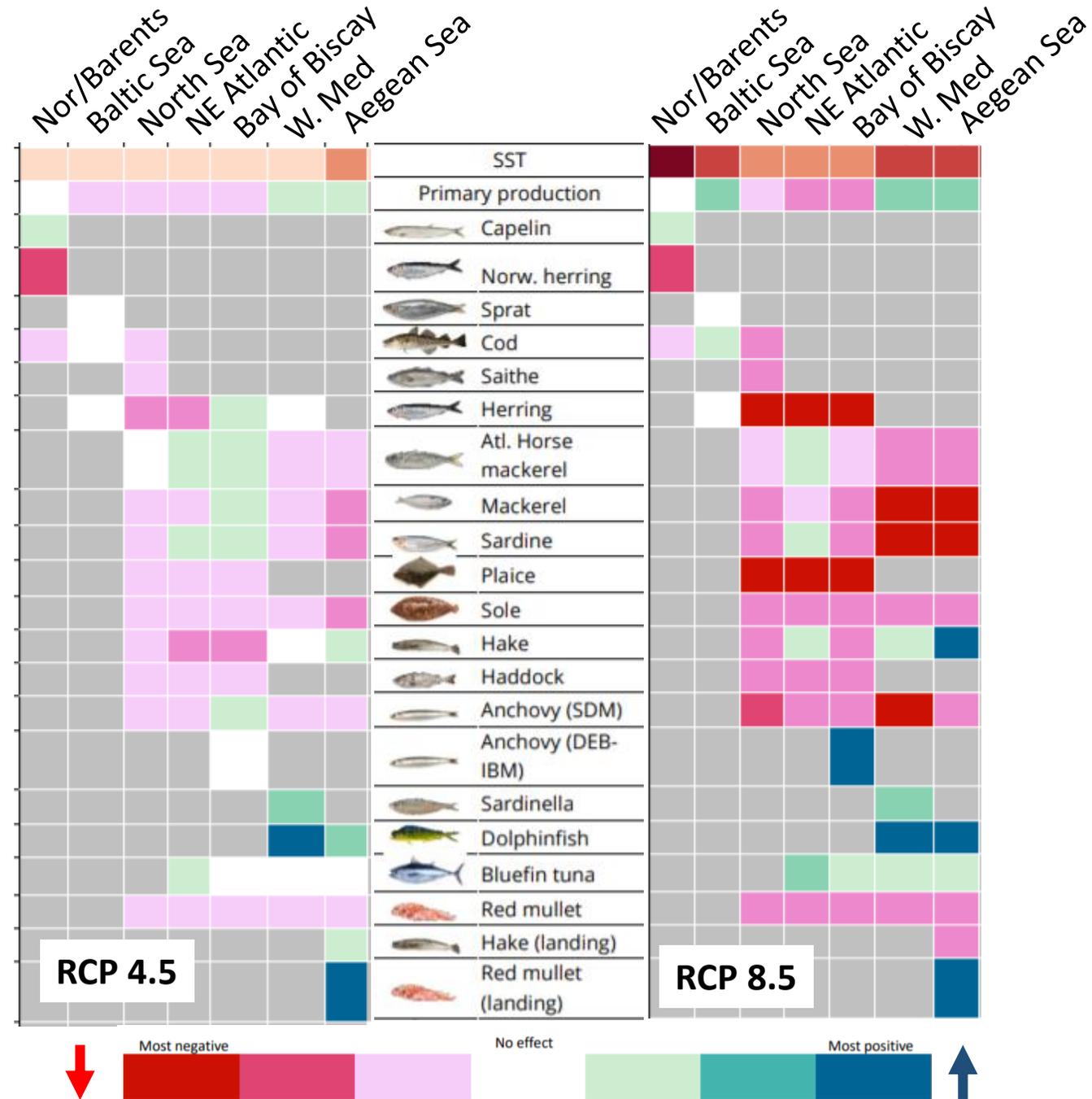


# Projected Change in Distribution of North Sea Fish by 2050

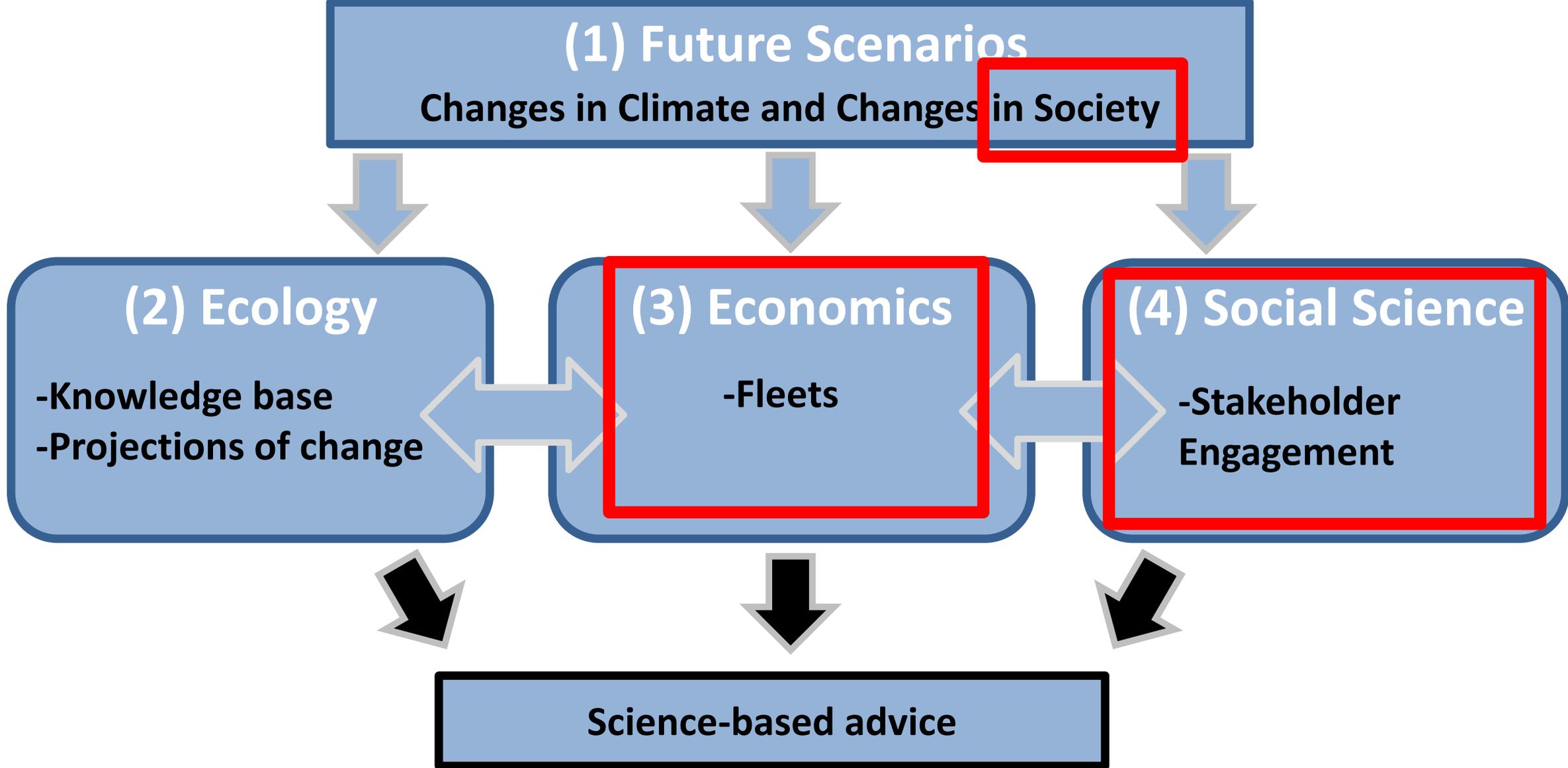


# Projected Climate Change Effects on Marine Fishery Targets

- Applied 12 state-of-the-art biological projection models (often 2 models per region).
- Projections of shift are consistent across different types of models – shown is % change by 2050
- Markedly stronger effects of RCP8.5 (right) compared to RCP4.5 (left)
- Winners and losers (e.g. also when comparing stocks of same species)
- Models projected change for species currently in region – not for novel species entering in future

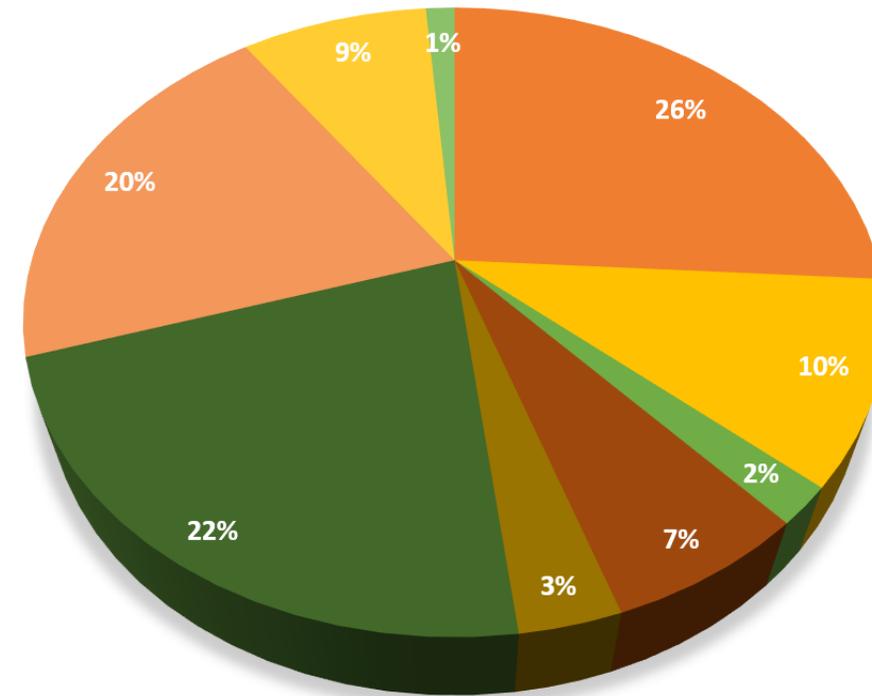


# Projecting Impacts of Climate Change



# Workshops, Interviews, Advisory meetings, Questionnaire, Focus groups, mind-mapping, Scenario Development

- Aquaculture industry
- Aquaculture/fisheries industry
- Aquaculture/ NGO or Policy
- Research/science
- Others
- Fisheries industry
- Food processing/trading
- Government/policy
- Umbrella association



<http://ceresproject.eu>



# (RCP8.5, SSP5) World Markets

*"Growth is good!"*



population growth highest,  
fossil fuel use is highest, profit driven

a sustainable alternative to WM but 14%  
growth rates

*"We've got the whole world in our hands!"*



# (RCP4.5, SSP1) Global Sustainability

# (RCP8.5, SSP3) National Enterprise



*"Pull up the drawbridge"*

more fossil fuel use but increased national  
economy, less thriving economy

more local resources / strategies, renewable  
use less compared to GS



Note: Working together for a harmonious existence.

*"Think local, act local"*

# (RCP6.0, SSP2) Local Stewardship

**CERES** Climate change and European aquatic REsources

**Socio-political scenarios for the fishery and aquaculture sectors in Europe**

Short-, medium- and long-term developments in socioeconomic, technological and economic drivers may be just as important to fisheries and aquaculture as climate driven changes in habitats and species.

Here we propose a suite of exploratory future socio-political scenarios that will be used throughout the CERES project in modeling exercises and serve as the basis for discussions in engagement with the wider stakeholder community.

- Scenarios are imagined 'futures'
- They do not come individually, as a forecast world, but in sets of alternatives.
- They describe both optimistic and problematic futures.
- For scenarios to be a useful tool, they must all be reasonably plausible and credible.

www.ceresproject.eu

ceresproject.eu

# Economic Impacts on Fleets

- Profitability at 2050 tested under four, contrasting scenarios (i.e. linked environmental, economic, legal, technological and political changes)
- Changes in policy (e.g. access rights, discard ban) and economics (future changes in fuel / fish price) more important than direct, biological effects of climate change.
- Shifts in profitability between fleet segments projected in Norwegian / Barents Sea.



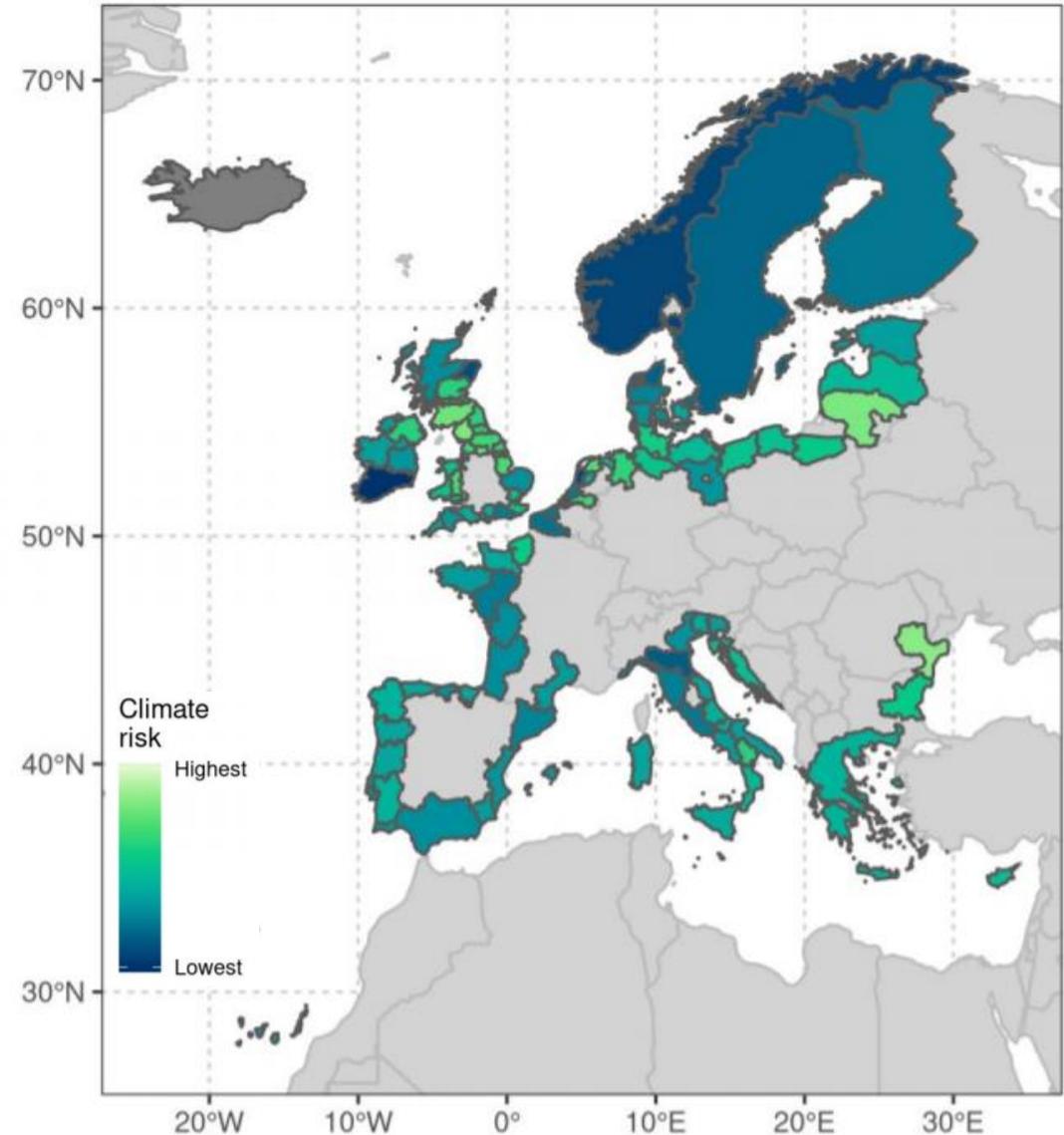
Regions	Pelagic Fleets				Demersal Fleets			
	WM	NE	GS	LS	WM	NE	GS	LS
Norwegian and Barents Sea*	Red	Pink	Dark Red	Purple	Teal	Dark Blue	Light Green	Dark Blue
Baltic Sea	Teal	Light Green	Dark Blue	Teal	Light Green	+/-	Teal	Light Green
North Sea/ North East Atlantic	+/-	++/--	Teal	++/--	Dark Blue	Light Green	Teal	Teal
Western Mediterranean Sea	Teal	Teal	Light Green	Grey	Grey	Grey	Grey	Grey
Aegean Sea	Grey	Grey	Grey	Grey	Teal	+/-	Teal	Teal

Most negative			No effect			Most positive	No data
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# Climate Change Risk Analysis

- **Regions in SE Europe and UK have highest risk** to both fleets and communities (low GDP, few targeted species)
- In other regions, risk is greatest at fleet or community level but **considerable differences exist, even within a country**
- **Smallest vessels (less than 6m) had much higher risk** than other size classes (Mediterranean - Croatia, Bulgaria, France, Malta and Greece)
- In some regions (e.g. SE Baltic) increasing resilience needed (e.g. creating **alternative employment opportunities** in community)
- In regions where fleet risks dominate, **prioritize increasing fleet efficiency / diversity.**





# Climate Change and European Fisheries and Aquaculture



CERES Project Synthesis Report

## CERES Synthesis Report



## CERES in 2020 Report

[ceresproject.eu](http://ceresproject.eu)



**WATER: Where can Aquaculture Thrive in EuRope**

Use WATER to map depth, wave height, oxygen, and other parameters in regional seas. You can also use it to find out how well a particular species will grow in marine waters.

**MET Database**

Get data on the cultivation thresholds of aquatic animals and plants on the Maritime and Environmental Thresholds for Aquaculture database



# CERES Consortium and Research Advisory / Reference User Groups



Ingrid van Putten (CSIRO)



Selina Stead (Newcastle University)



Sandra Shumway (UCONN)



Greta Pecl (IMAS)



Anne Hollowed (NOAA/NMFS)



William Cheung (UBC)



Patrick Sorgeloos (U Ghent)



Steven Cooke (Carleton)



Johan Johansen (Salten AP)



Tyler Eddy (Memorial Univ.)



Derek Tittensor (Dalhousie)



Marta Carreras (MEDAC)



Mariló López (Culmarex)



Fabio Massa (GFCM)



Stefan Meyer (EATIP)

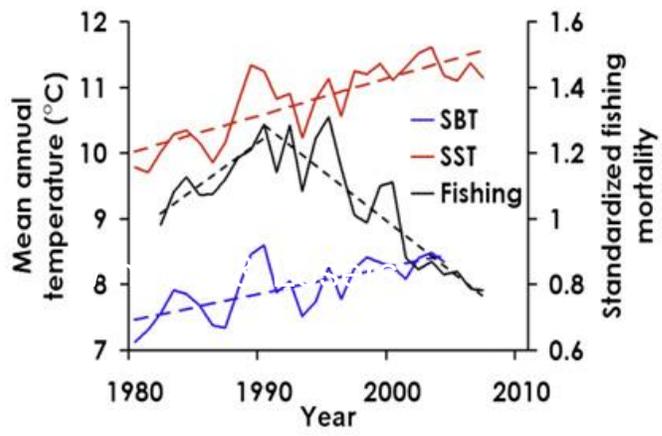


Ion Munteanu (DDBRA)

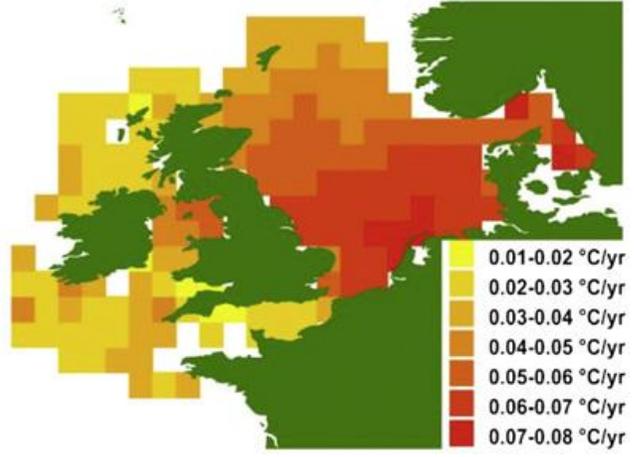
Extra slides for group

# Climate Change & Fish in the North Sea

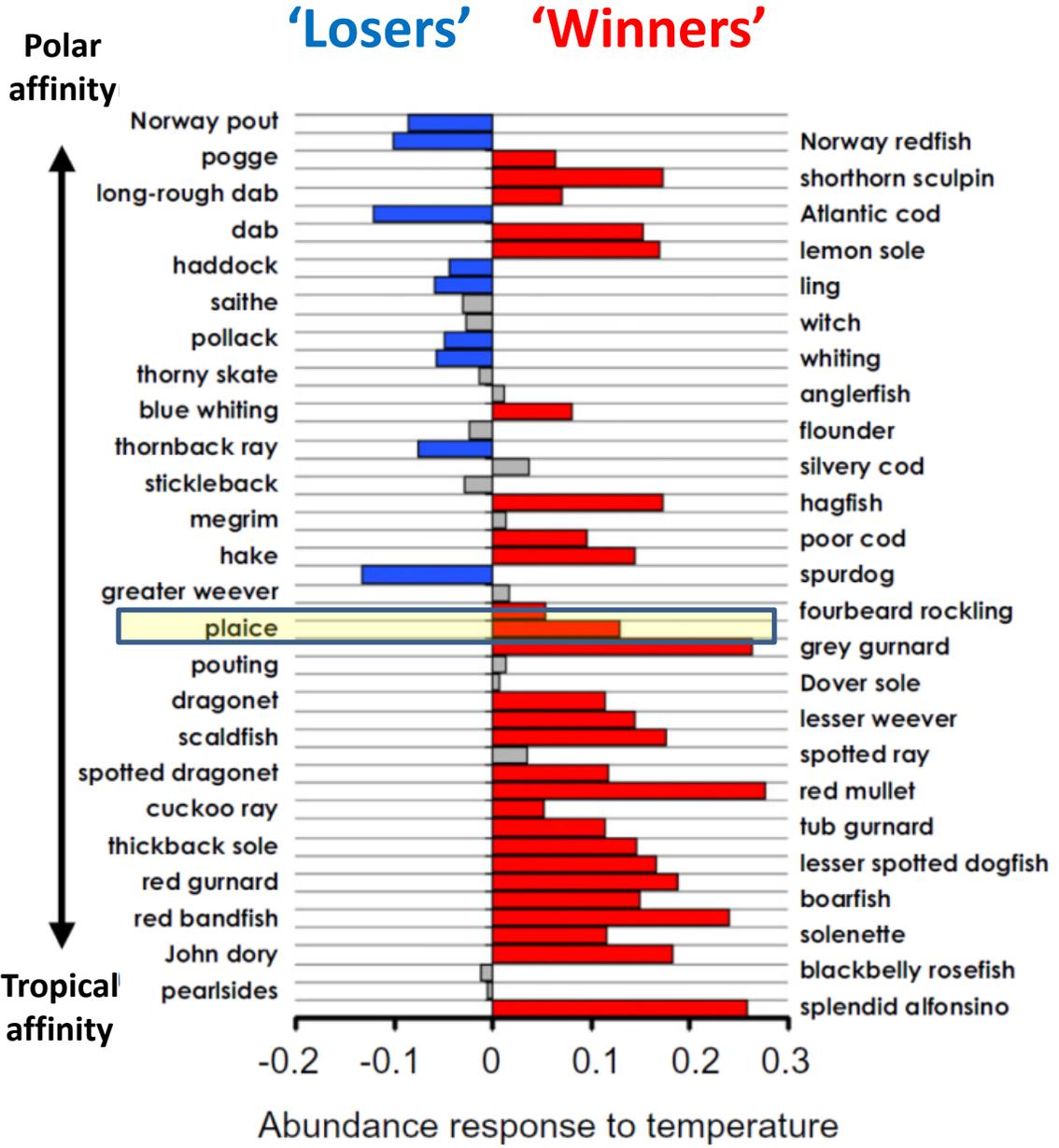
## Trends with time



## Spatial differences in warming

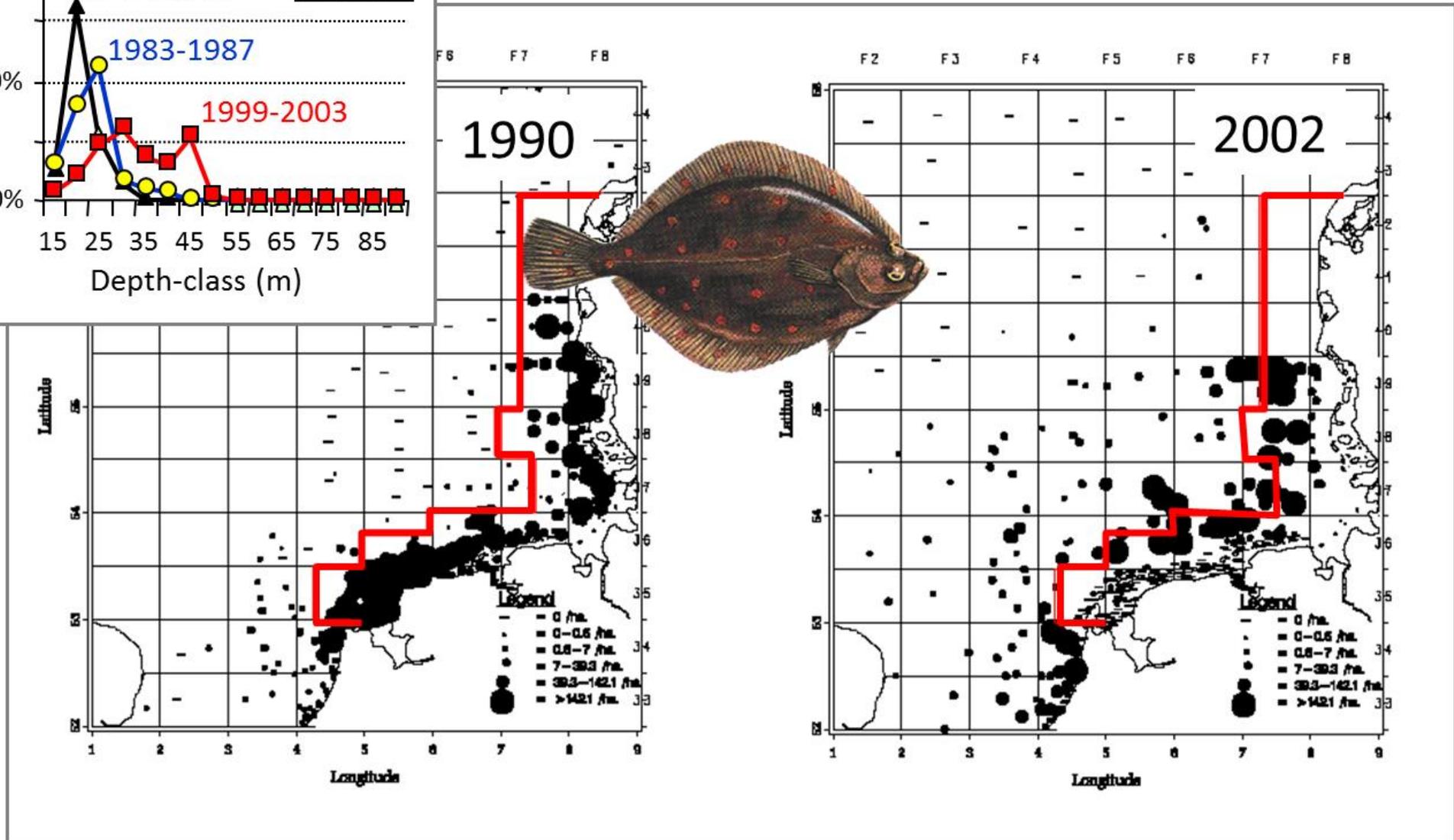
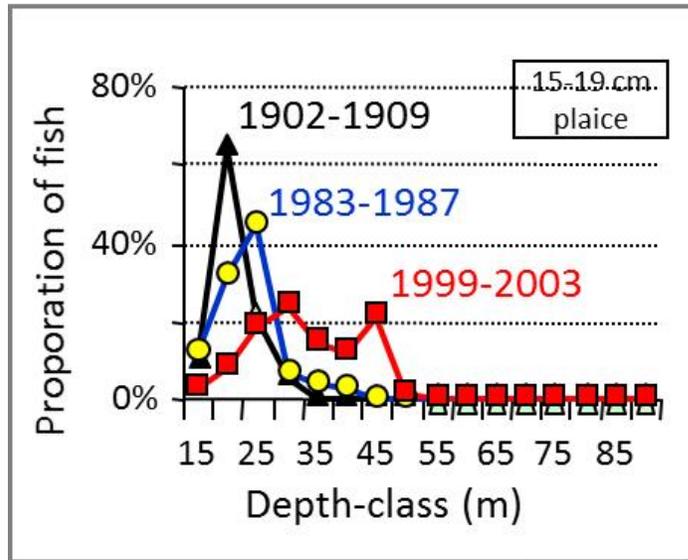


- **72% of fish species have responded** to warming by changing distribution and abundance
- Centers of distribution have generally shifted by **distances ranging from 48 to 403 km**
- Demersal fish assemblage **deepened by ~3.6 m per decade** between 1980 and 2004
- Catches (1913–2007) of cod, haddock, plaice and sole have shifted distribution but **not in a consistent way**



(Perry et al. 2005 ;Dulvy et al. 2008; Engelhard et al. 2011; Simpson et al. 2011).

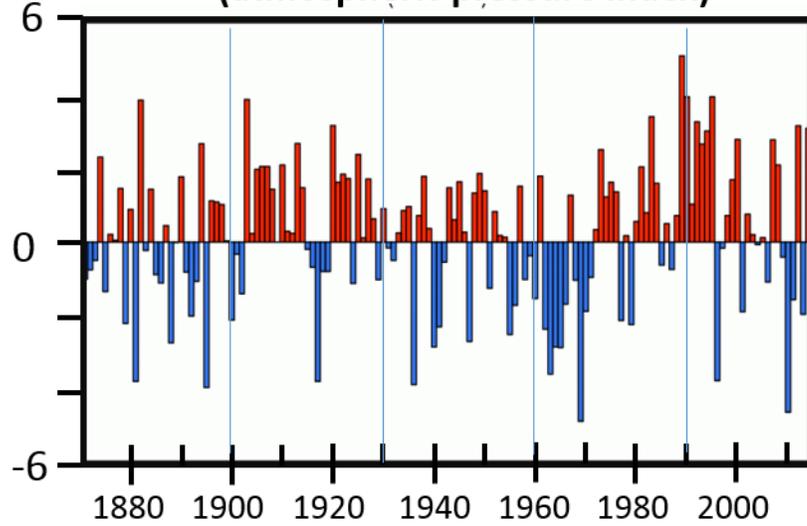
# „Plaice Box“: Closed Area for juveniles (red line)



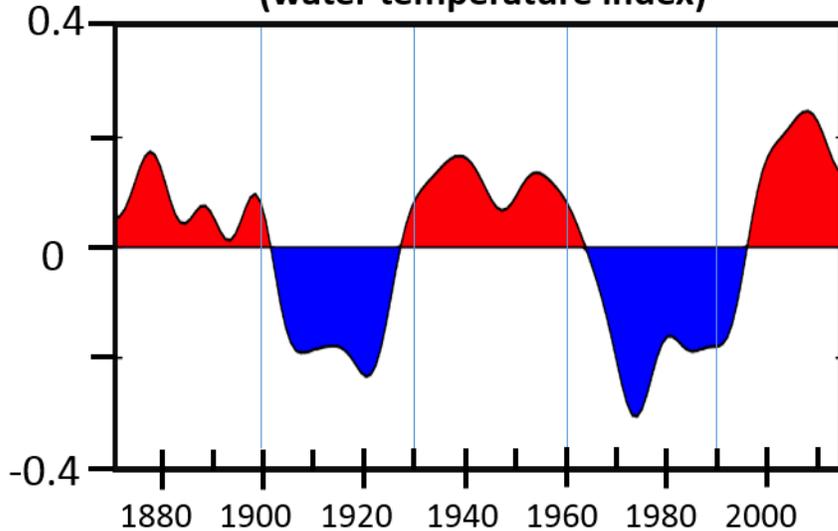
(From Adriaan Rijnsdorp, IMARES: *Van Keeken et al. 2007 Journal of Sea Research*)

# Climate Change?

North Atlantic Oscillation (NAO)  
(atmospheric pressure index)



Atlantic Multidecadal Oscillation (AMO)  
(water temperature index)

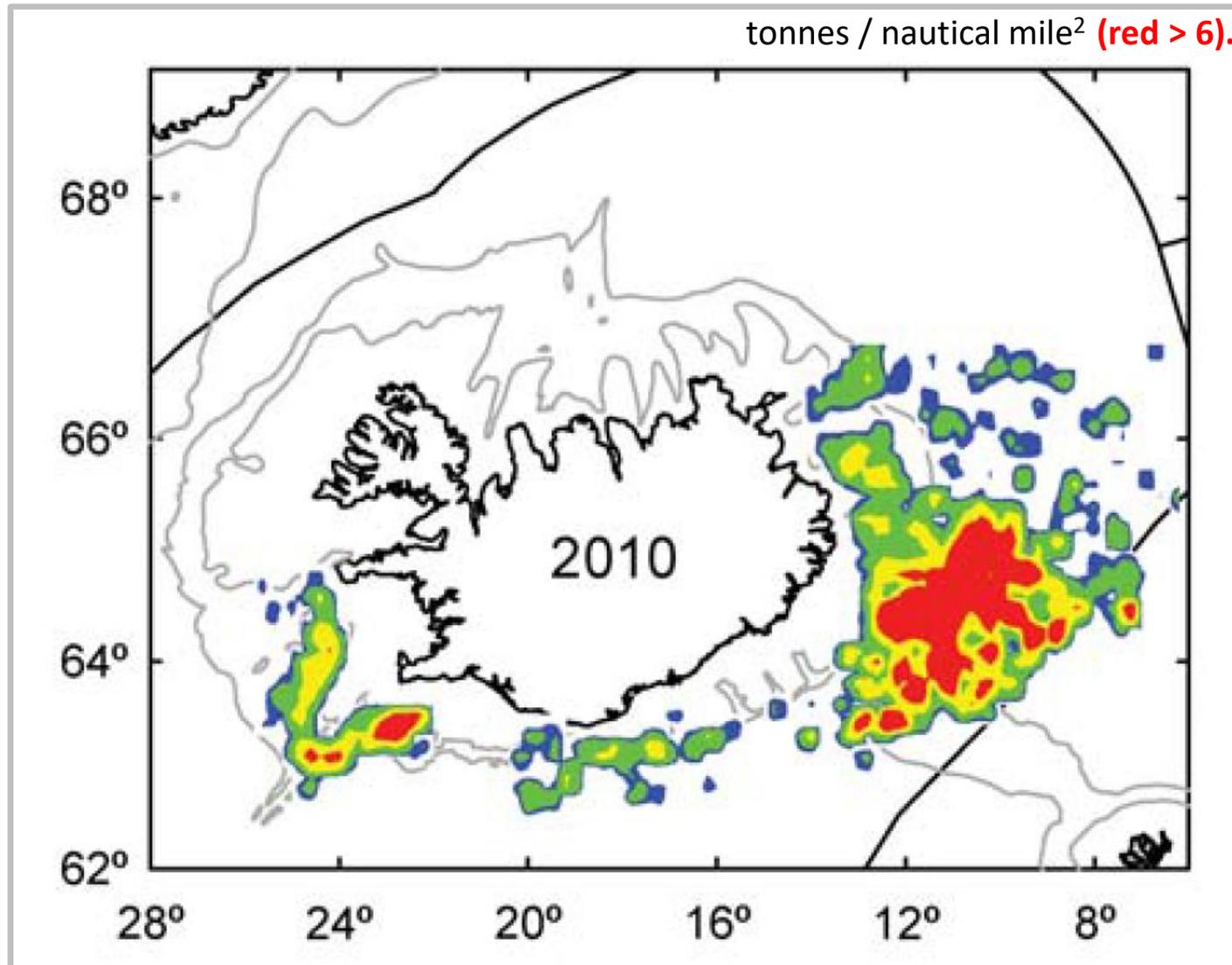


## Bluefin tuna return to North Sea waters after 50-year absence

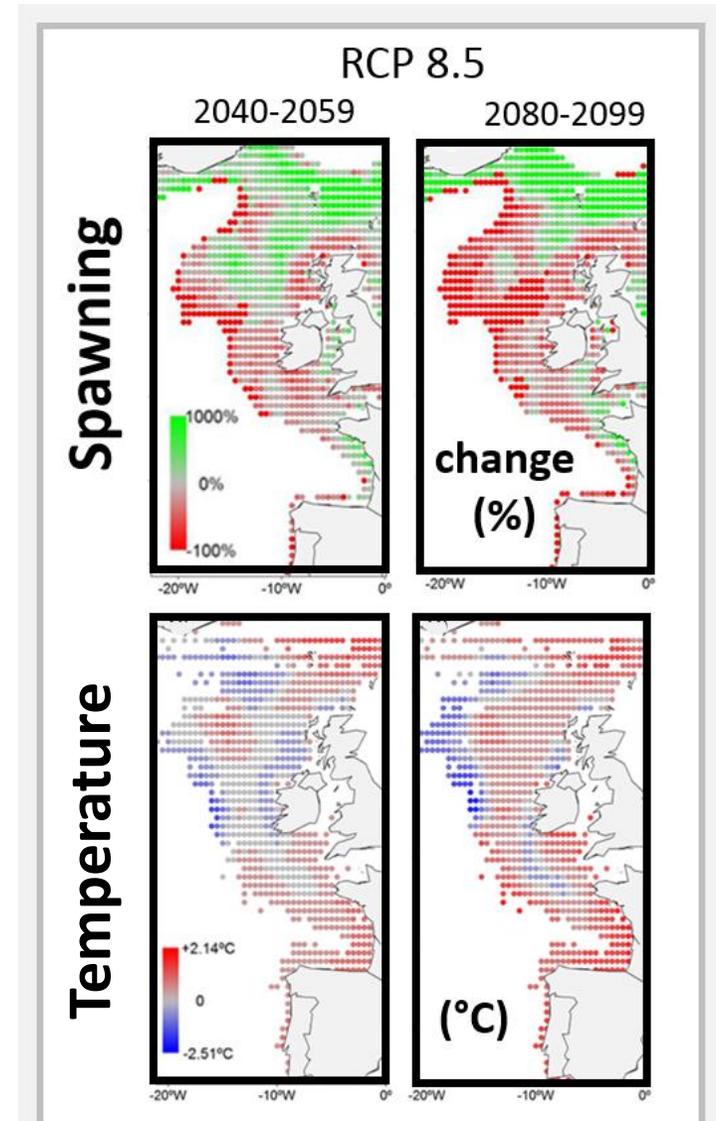
Tech & Media [f](#) [t](#) [in](#) [e](#) September 11, 2017



Sovereign rights will be tested:  
Shifts in mackerel from Norwegian to Icelandic waters...

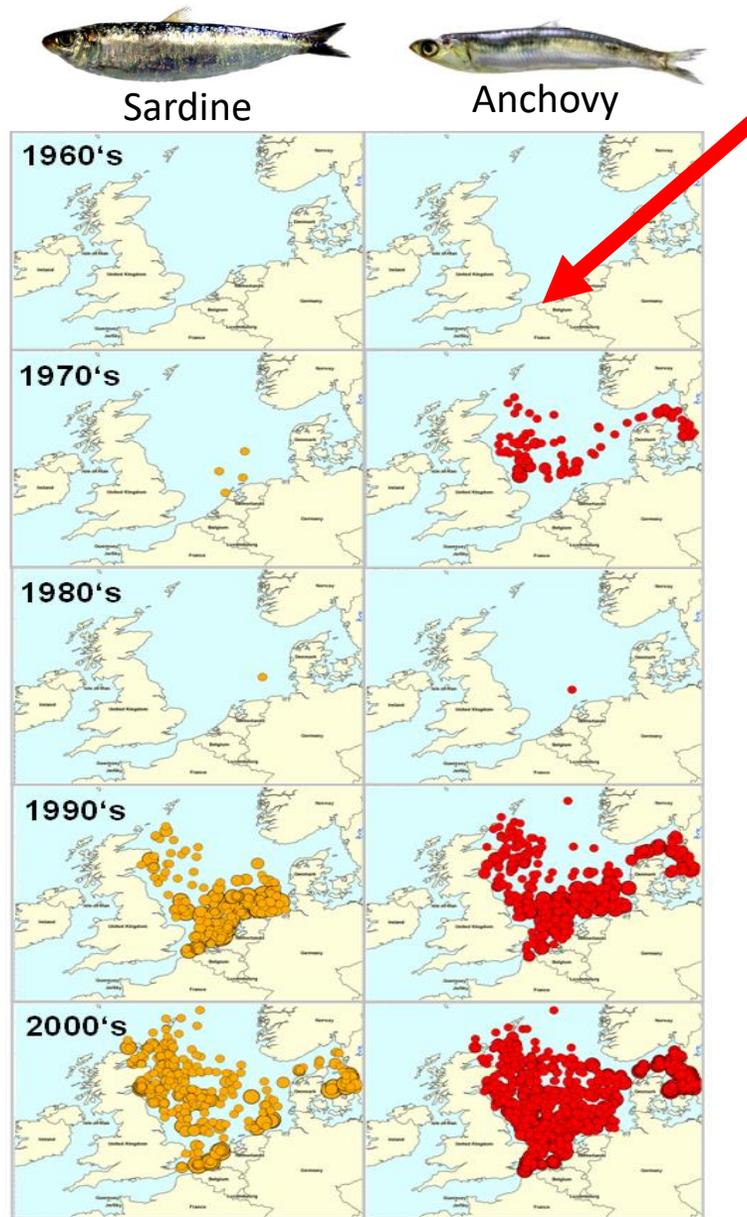


Astthorsson et al. 2012



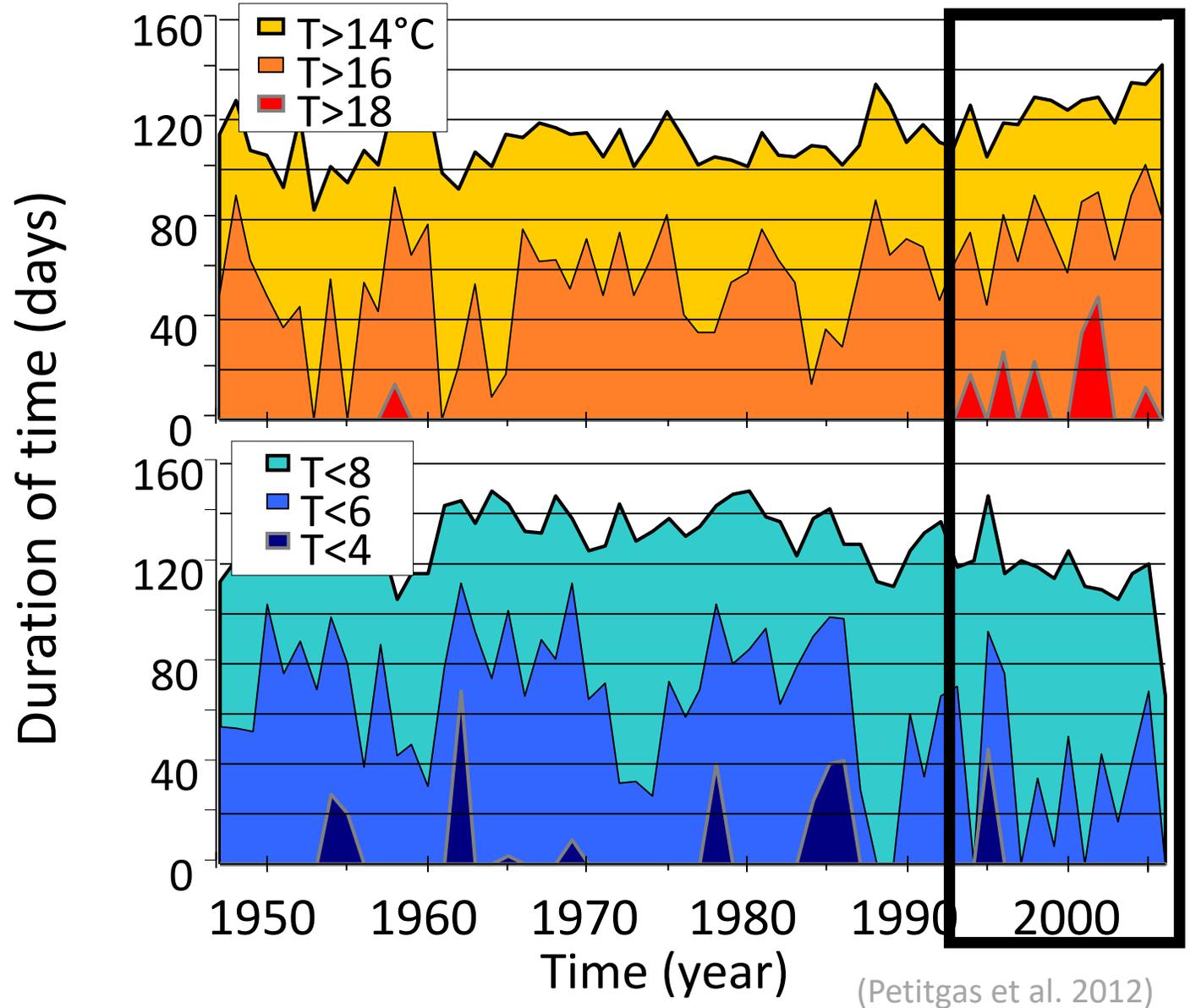
Bruge et al. 2016

# Poleward Shifts?



Peck et al. 2013

## Modelled Water Temperatures - Southern North Sea



(Petitgas et al. 2012)

# Changes in Future Policy?

EU introduced **discard ban** in 2014 - required to land all fish caught

Once the least plentiful quota - the “choke species”—is exhausted, the whole fishery must stop.

Hake, a warm-water species, has dramatically increased between 2004 and 2011 in the North Sea where it was largely absent for > 50 years.

Low quota for North Sea hake will become a limiting factor, that may result in premature closure of the entire demersal mixed fishery





The “Fourth International Symposium on the Effects of climate change on the world’s oceans” was held in June 2018, in Washington D.C. (USA) with the support of IOC, PICES and ICES,

Conveners: Jason Link, USA (ICES), Shin-Ichi Ito, Japan (PICES), and Manuel Barange, Italy (FAO), Véronique Garçon, France (IOC).

There were 669 registrations from 51 Countries. The conference had 14 plenary speakers representing 12 nations, 350 oral presentations and 158 poster presentations. This included 102 presentations by early career researchers.

