Future fish distributions constrained by depth in warming seas

Rutterford *et al.* (in press) Nature Climate Change

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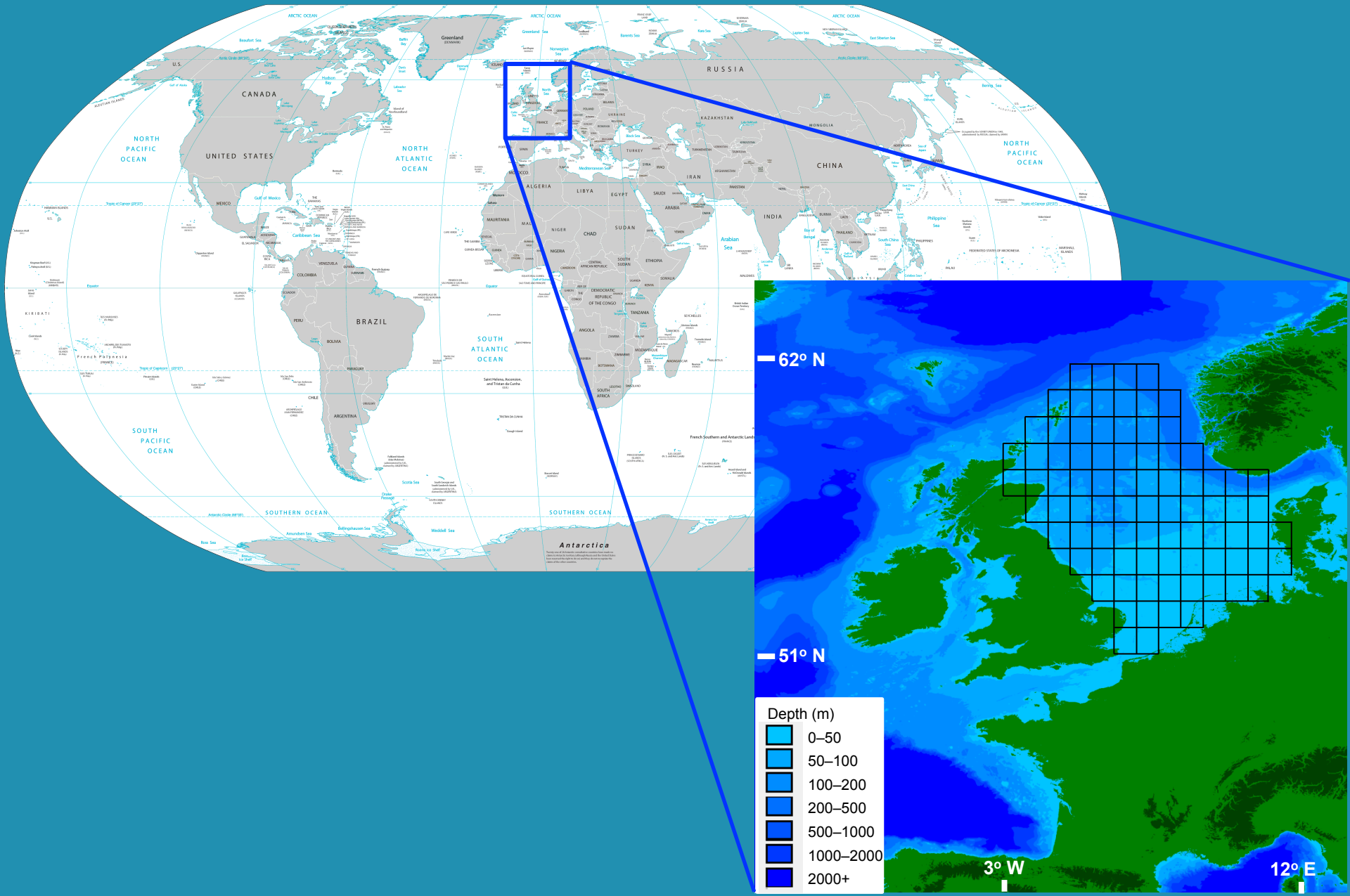
Project aim

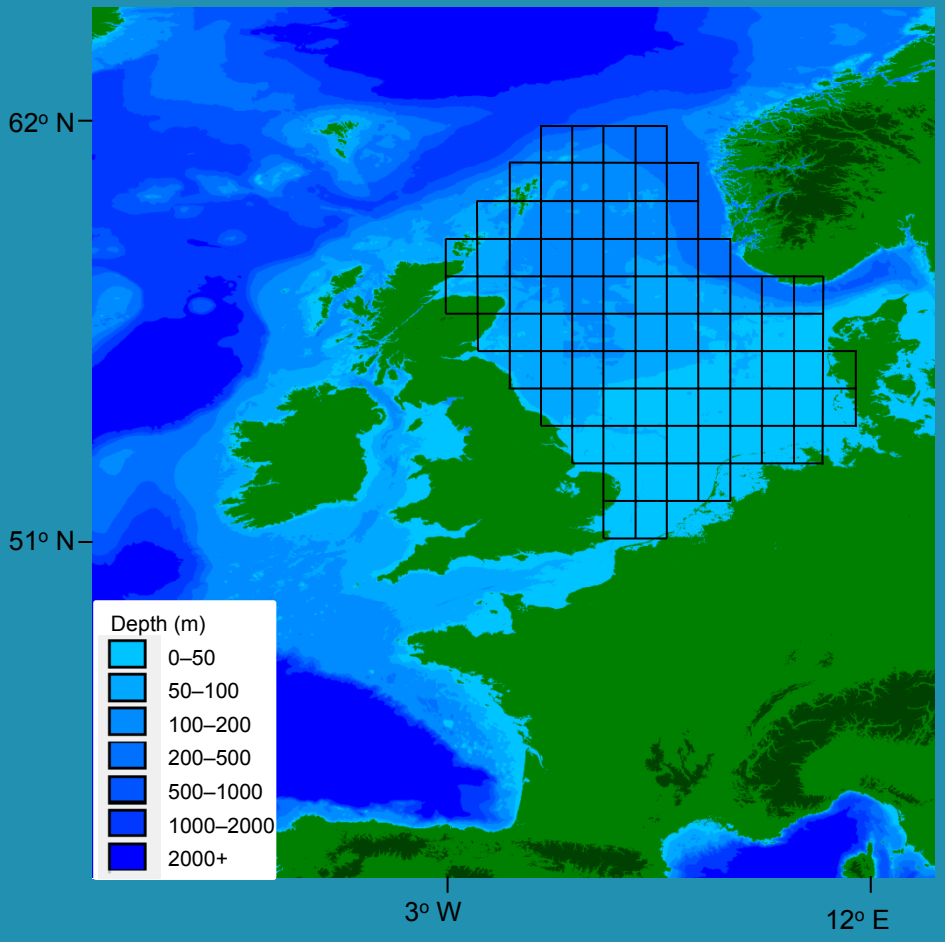
To use fisheries survey and climate model data to reliably predict North Sea trends in fish distribution and abundance in the future

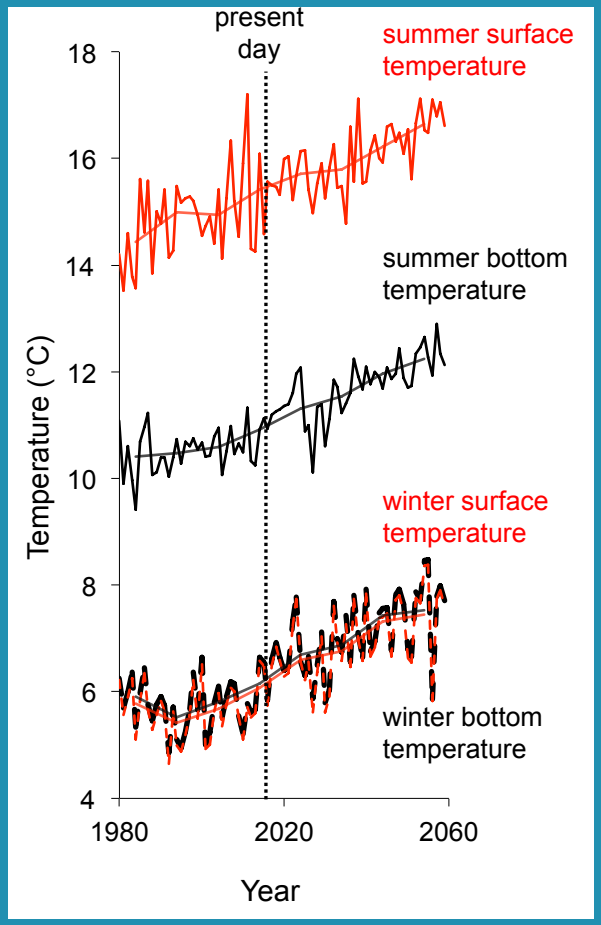
This data driven approach resulted in very different findings to process based models

Study area


62° N
51° N
3° W
12° E
Depth (m)
0–50
50–100
100–200
200–500
500–1000
1000–2000
2000+

Impacts of warming on commercial fish in the North Sea





Hadley Centre *QUMP_ens_00* model

‘cauldron of climate change’

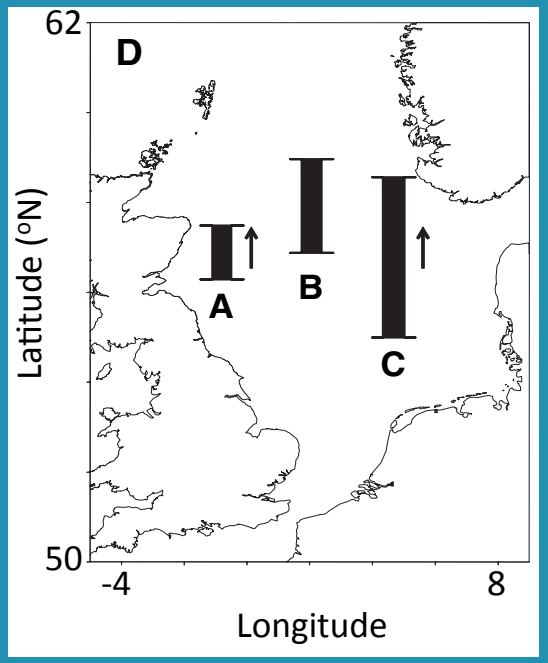
Very well surveyed area with a long time series from two independent fisheries surveys

Cefas – summer survey

IBTS – winter survey

Species movement and abundance responses to warming in the North East Atlantic

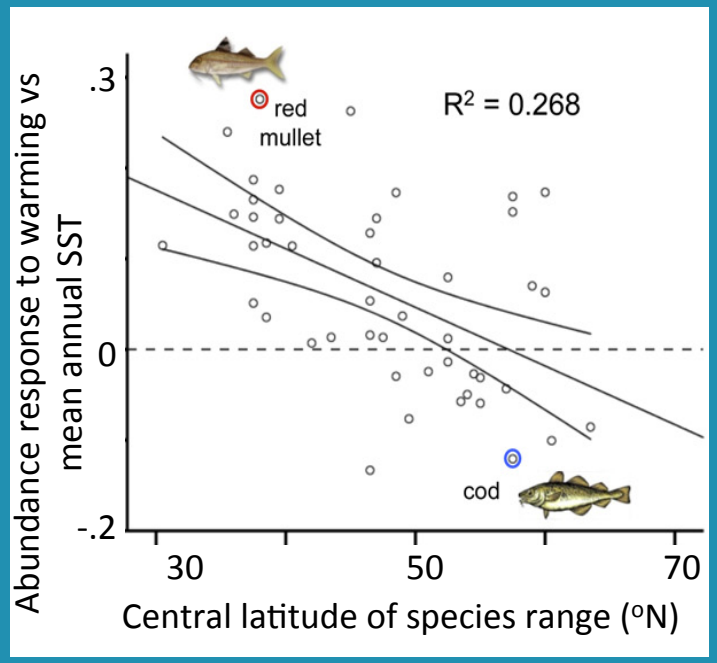
Species moving polewards



Perry *et al.* (2005) *Science*

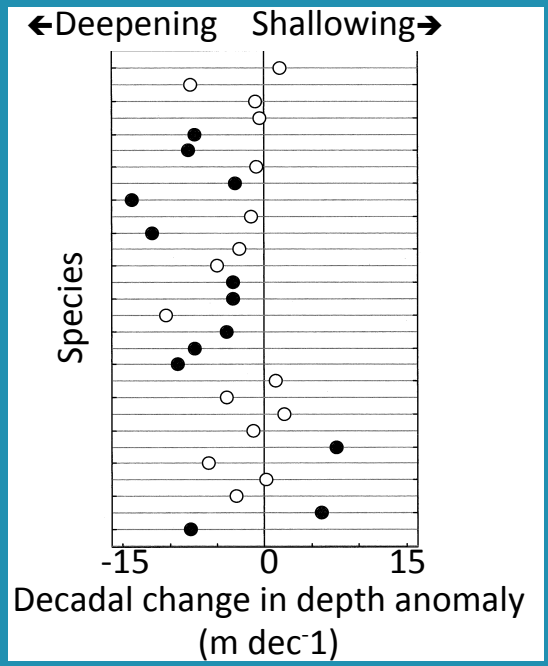
A – cod
B – anglerfish
C – snake blenny

Lusitanian species respond positively to warming



Simpson *et al.* (2011) *Curr. Biol.*

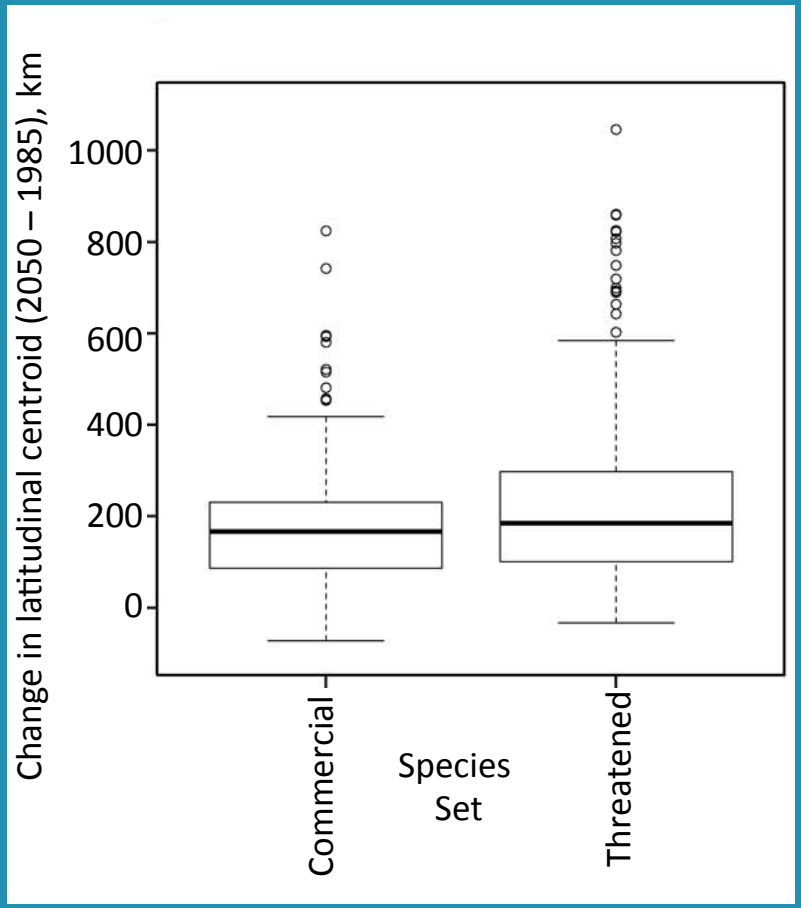
Species moving deeper



Dulvy *et al.* (2008) *J. Appl. Ecol.*

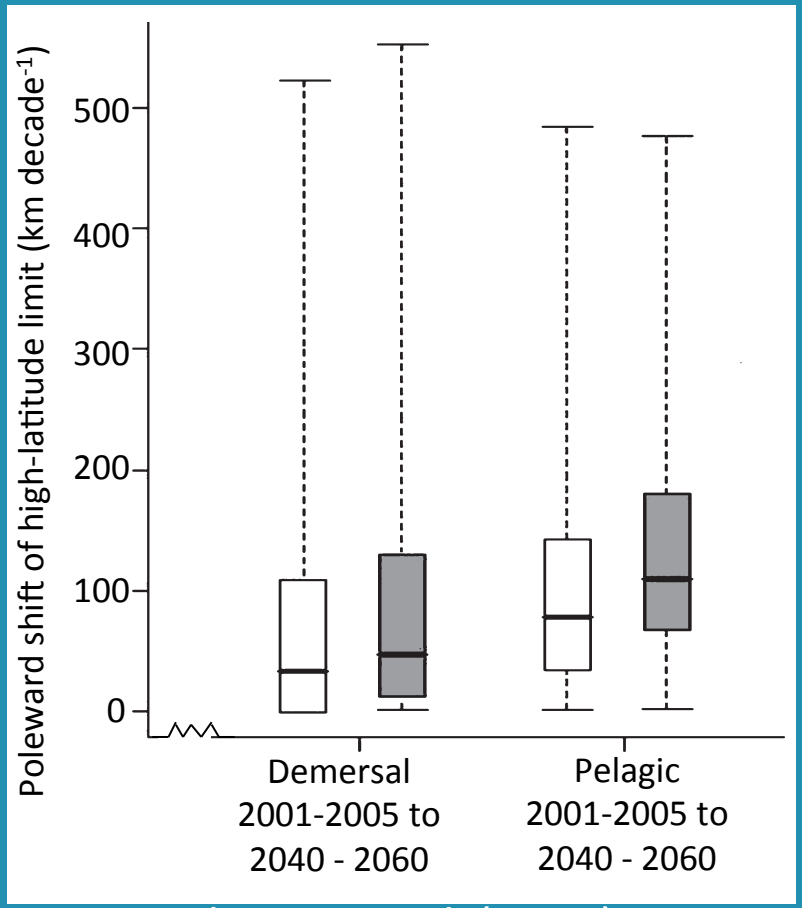
Predictions of poleward shifts in species movements

UK waters



Jones *et al*. (2013)
PLOS One

Global fish and invertebrates



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

Focus on top 10 commercially important species by landings

Pleuronectes platessa
plaice

Limanda limanda
dab

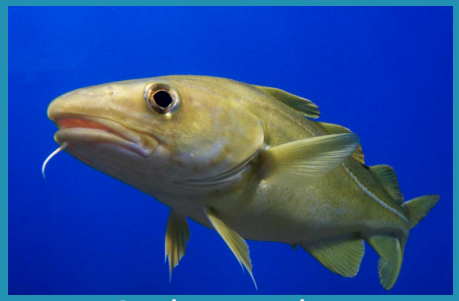
Microstomus kitt
Lemon sole

Melanogrammus aeglefinus
haddock

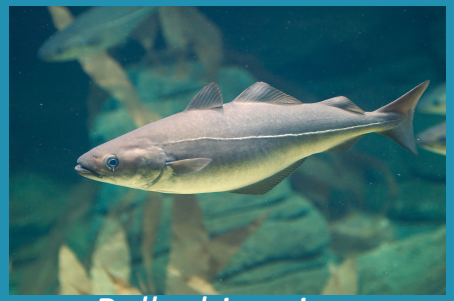
Hippoglossoides platessoides
long rough dab

Merlangius merlangus
whiting

Merluccius merluccius
hake



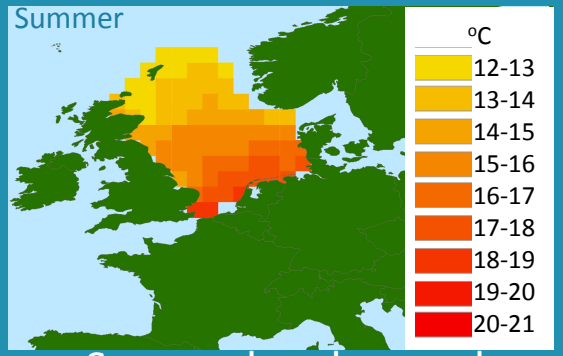
Gadus morhua
cod



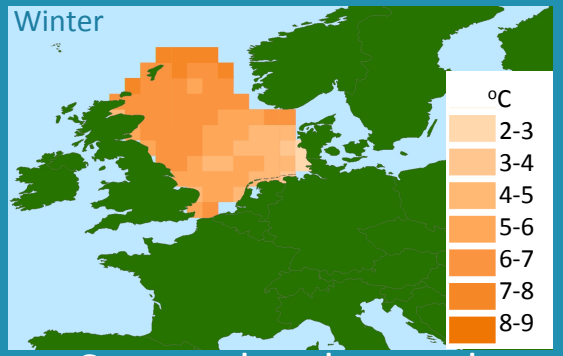
Pollachius virens
saithe

Molva molva
ling

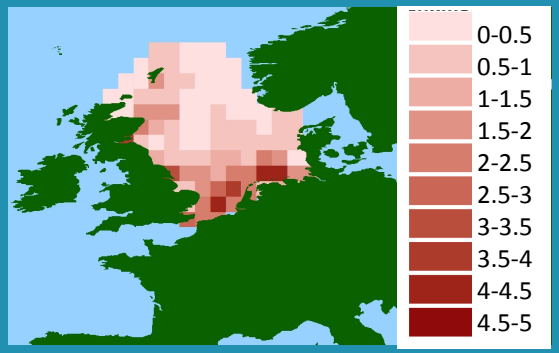
Generalised additive model (GAM) variables



Seasonal and annual
sea surface temperature

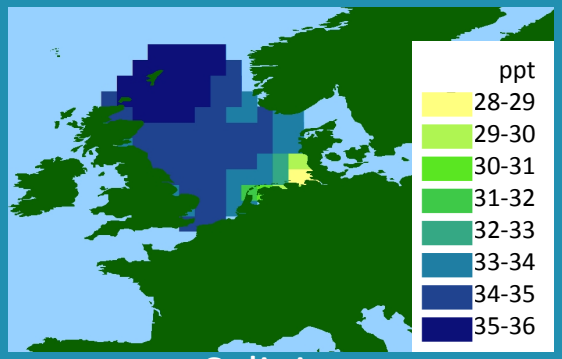


Seasonal and annual
near bottom temperature

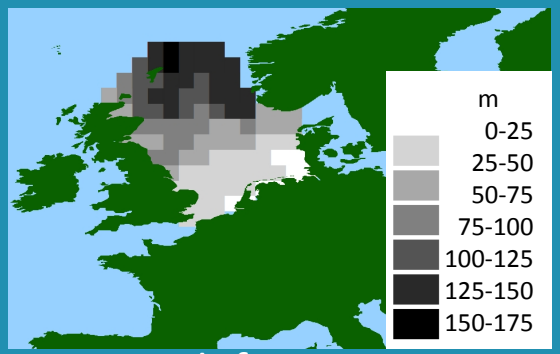


Relative fishing pressure

Mean values for each cell per decade 1980-2012



Salinity

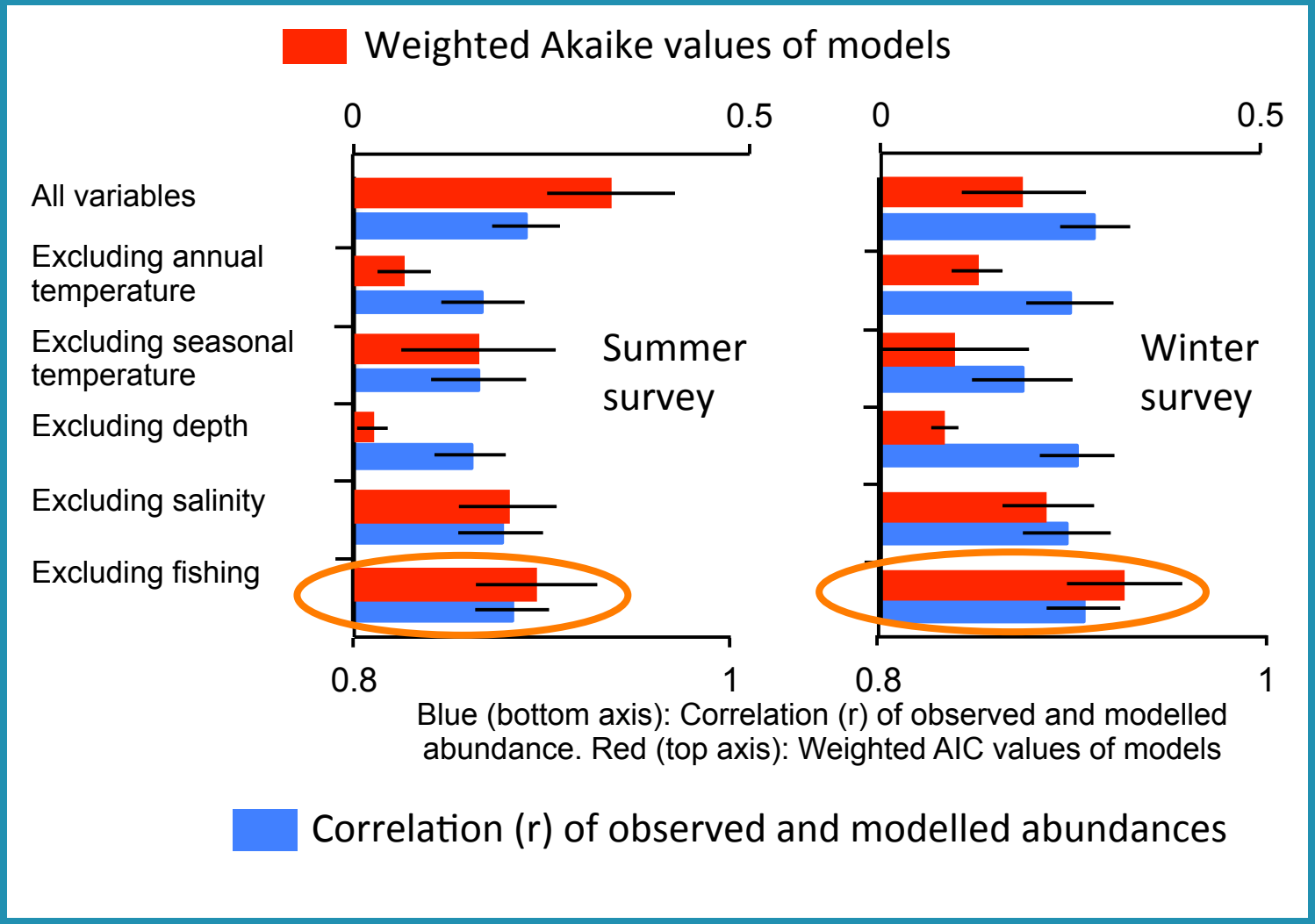


Depth from survey

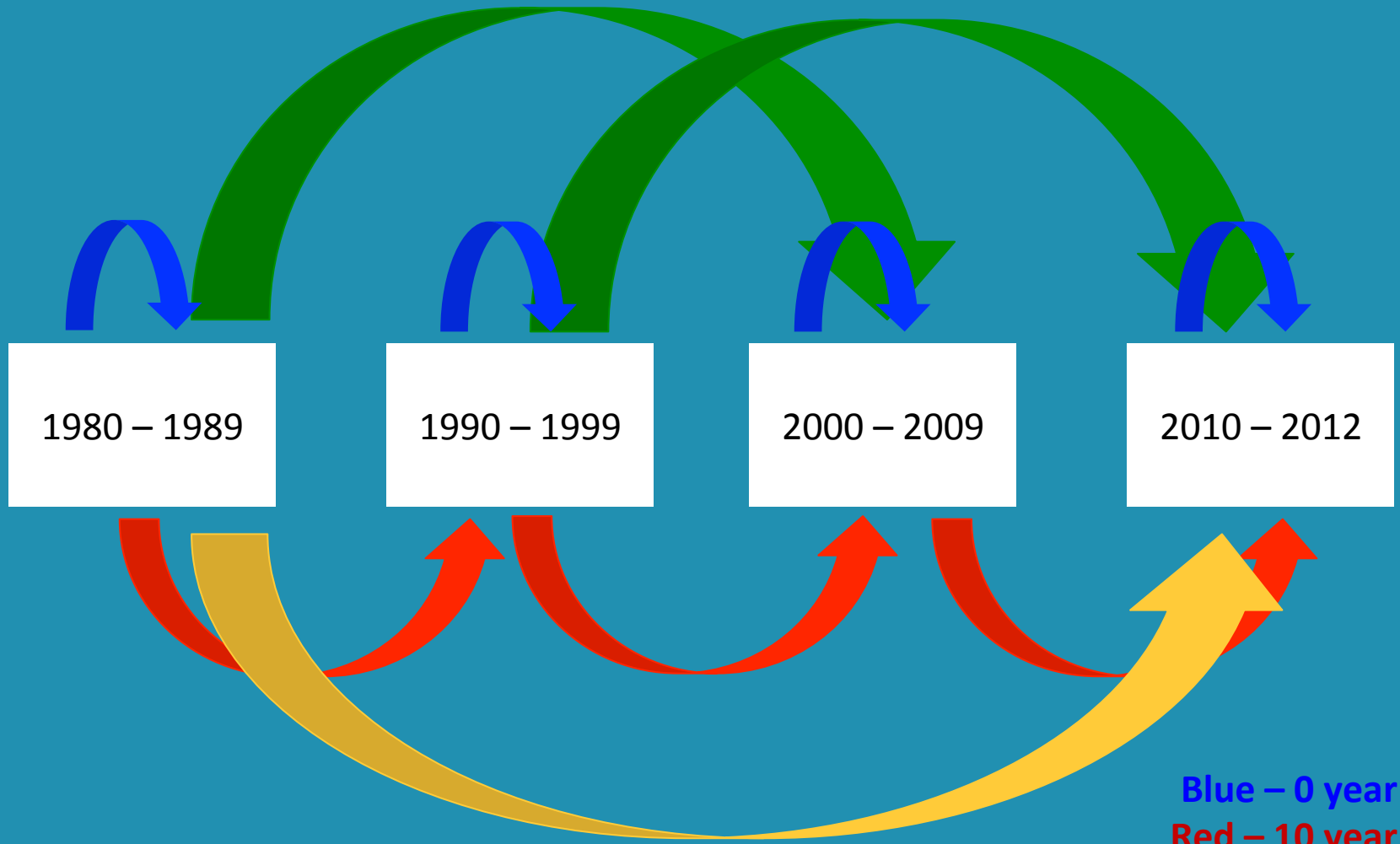
Hadley Centre *QUMP_ens_00* model

GAM variable selection

Mean for all 10 species with model trained on 2000-2009 and predicting the same period (mean ± SE)



Prediction of decades beyond GAM training period



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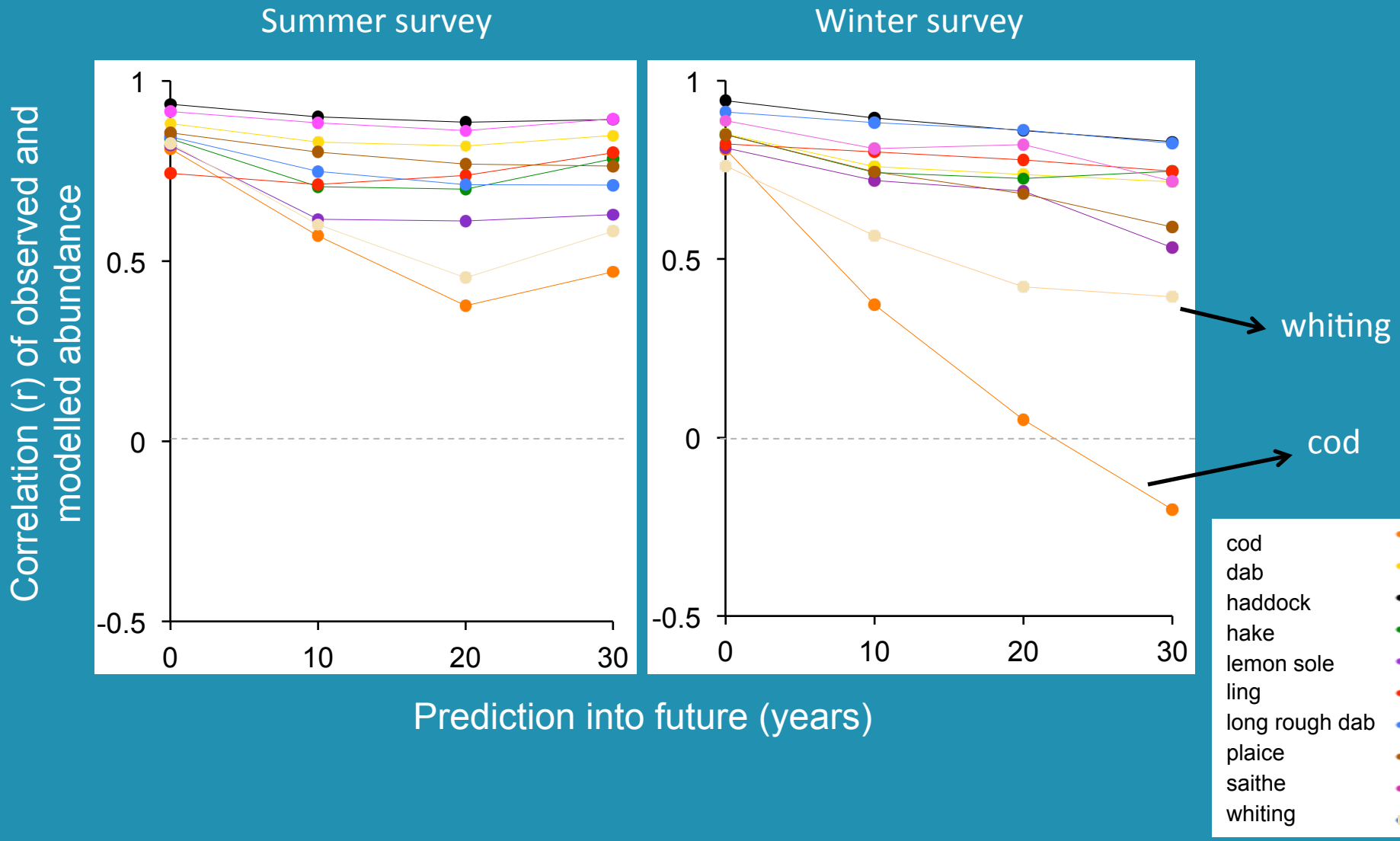
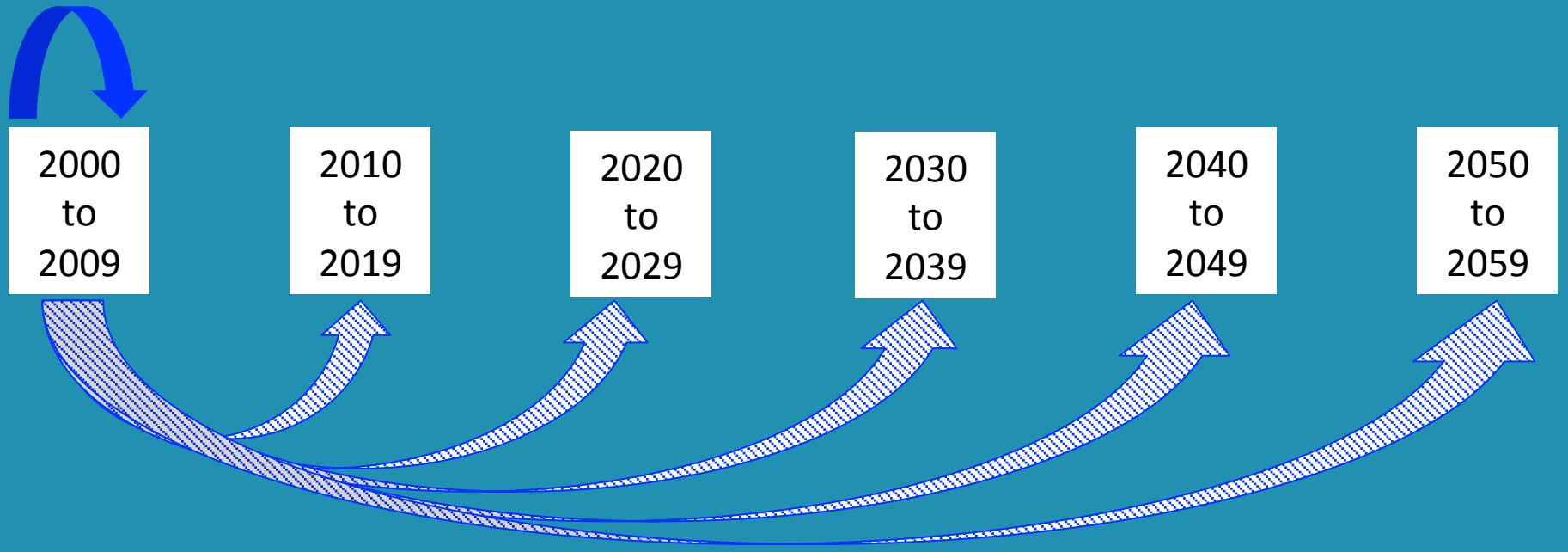
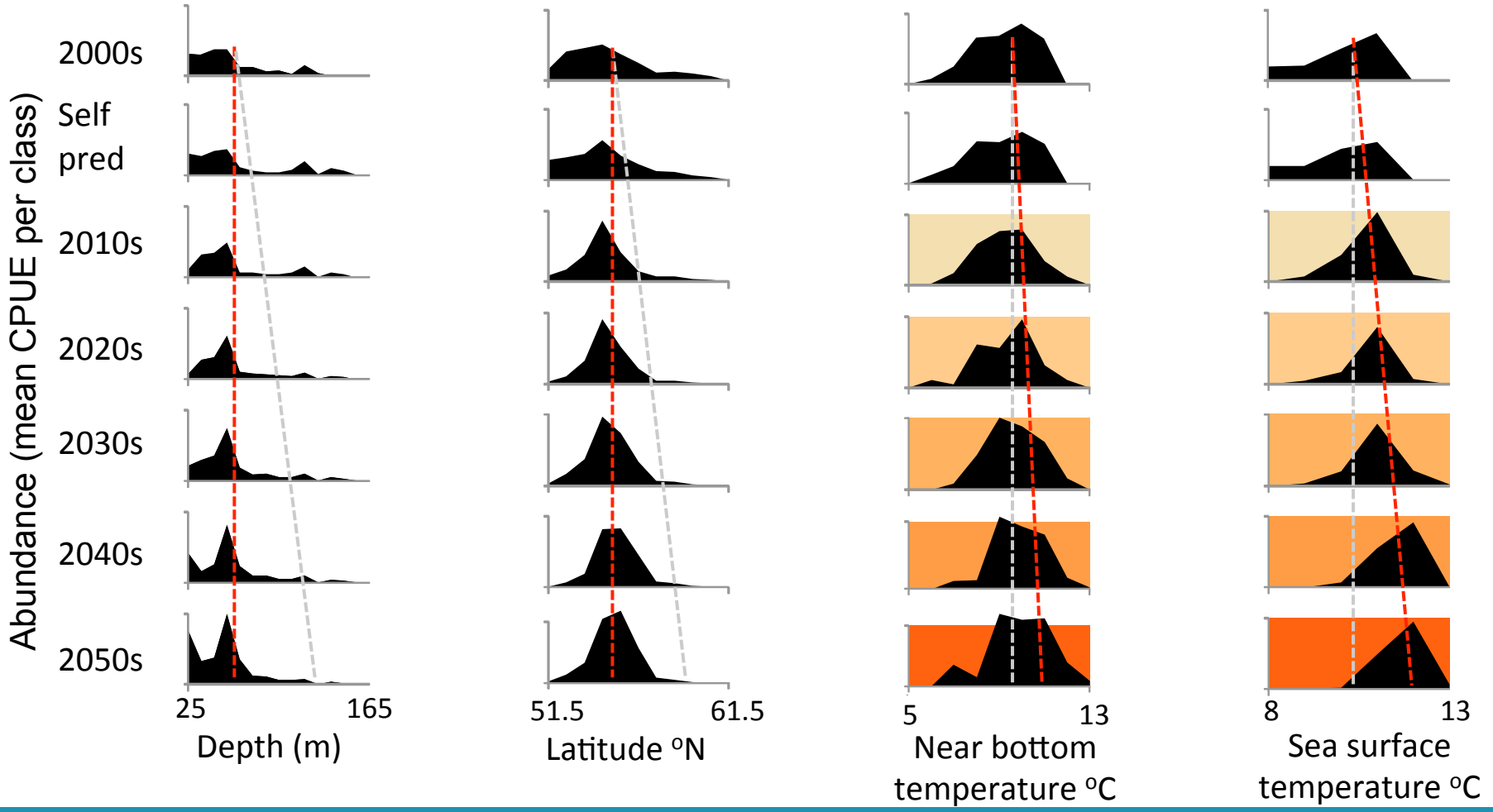


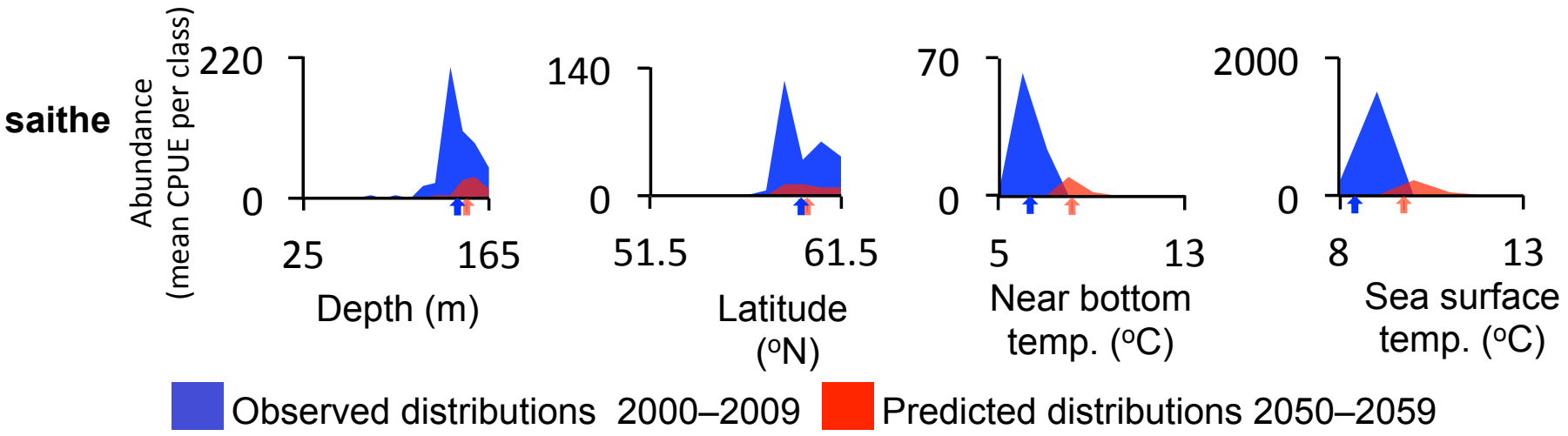
Predictions into future



Decade by decade predictions
Plaice - winter survey

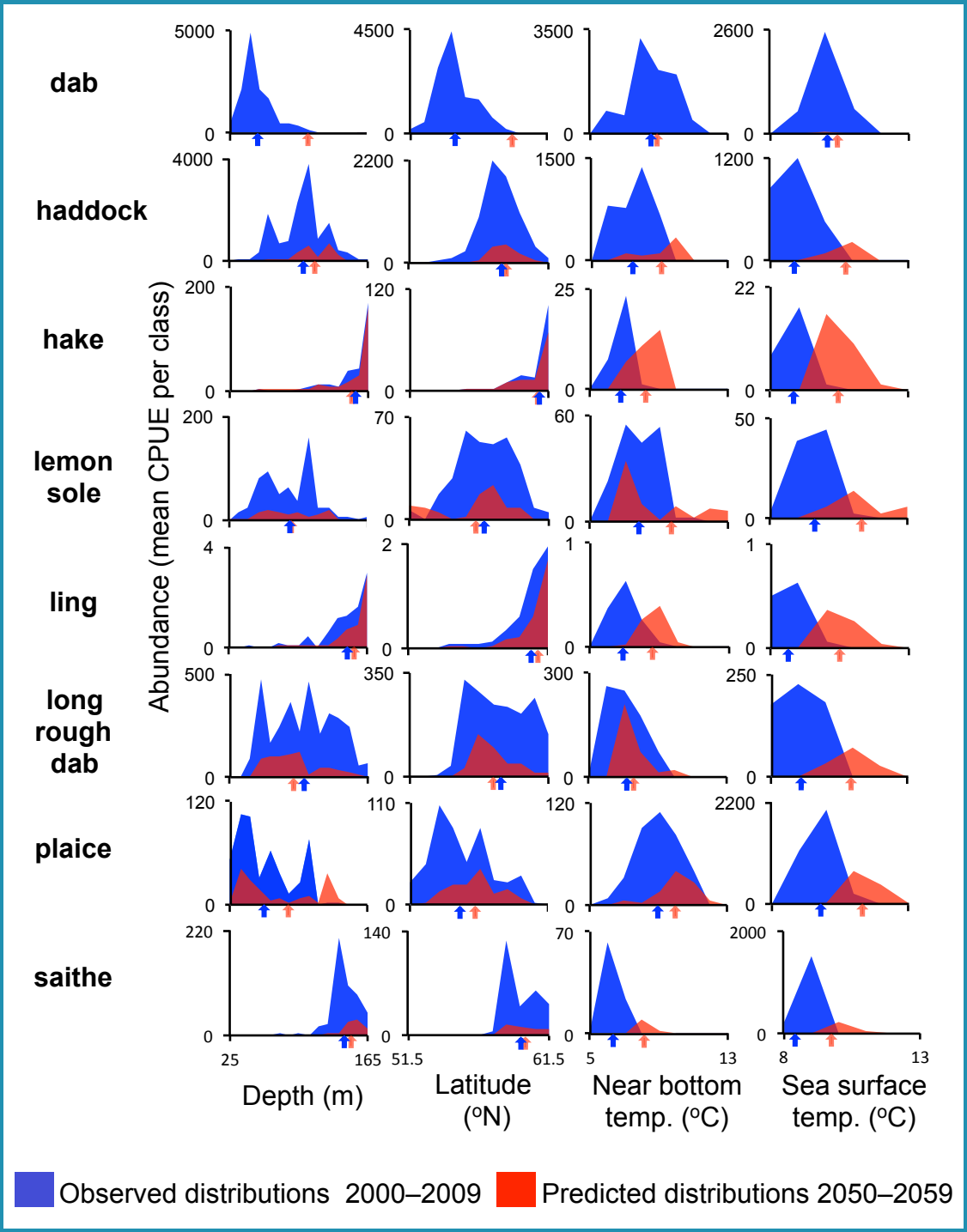


Current and 2050 experience



Summer survey

Summer survey



Main finding

All 8 species studied show a dramatic decline in abundance. None have the capacity to shift pole-wards or to move deeper. As a consequence they will be exposed to higher temperatures

Acclimate
Move and adapt
Decline

Thanks to…

- NERC CASE Studentship with Cefas
- David Maxwell, Cefas
- Steve Simpson, Martin Genner and Simon Jennings for detailed support
- And thanks to the reviewers for their generous support in shaping this study