How climate is affecting fish stocks and what we do about it

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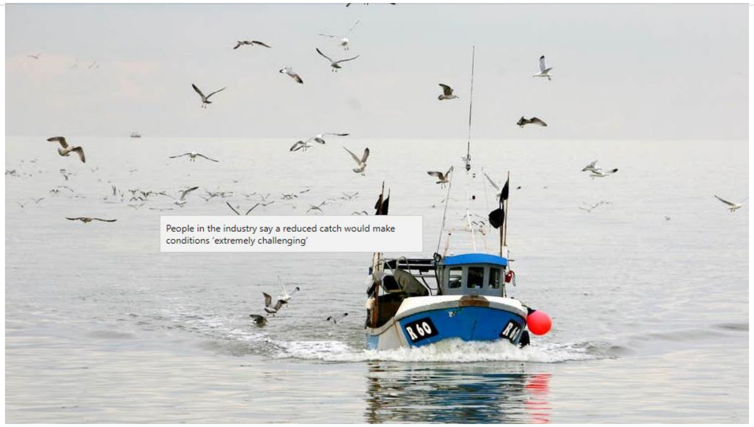
North Sea cod to lose sustainability 'blue tick' as fish population falls

MSC certificate to be suspended in October just two years after it was awarded

Rebecca Smithers
Consumer affairs correspondent
Wed 25 Sep 2019 06.00 BST

▲ Fishermen will be able to catch North Sea cod within lim
Photograph: Bloomberg via Getty Images



People in the industry say a reduced catch would make conditions 'extremely challenging'

North Sea cod quota halved in response to climate change and dwindling stocks

'This year there has been some very challenging science for cod stocks,' says fisheries minister

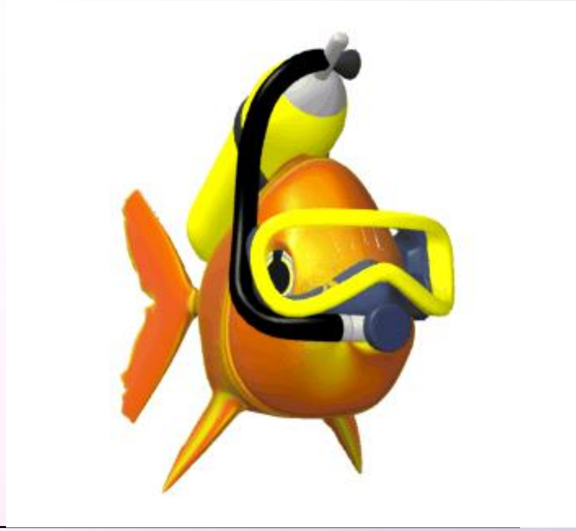
Outline

- Establishing salience of CC to UK fisheries
  - impact on individual growth of North Sea fish
  - impact on North Sea cod spawning times
  - impact on North Sea cod recruitment

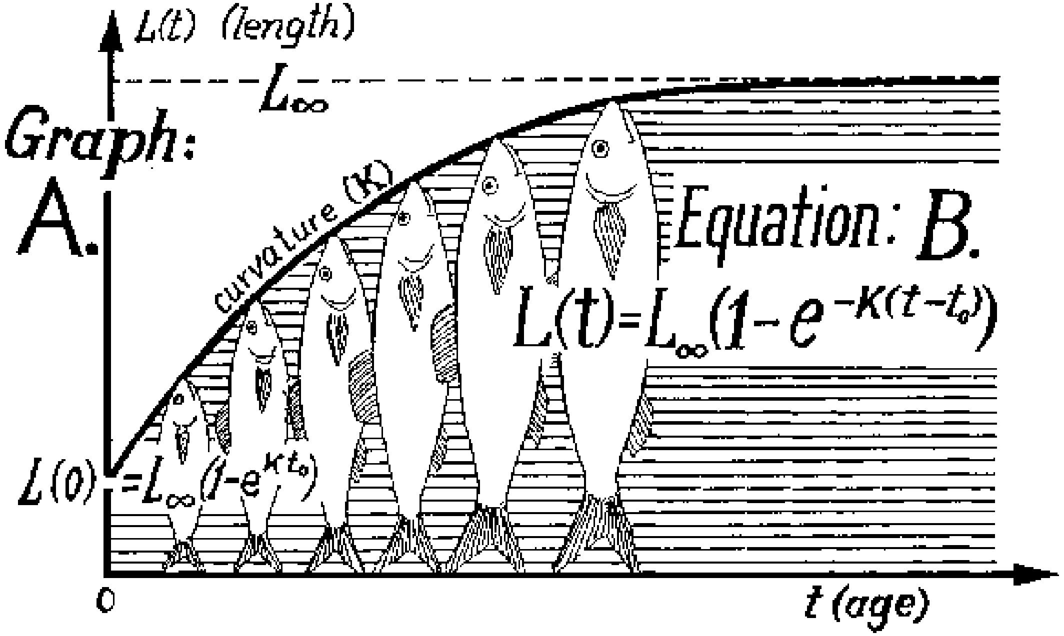
  → ***Yield***
- Mitigation measures
- Adaptation to CC
- Research needs

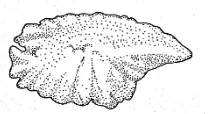
Temperature & marine fish – some fundamentals

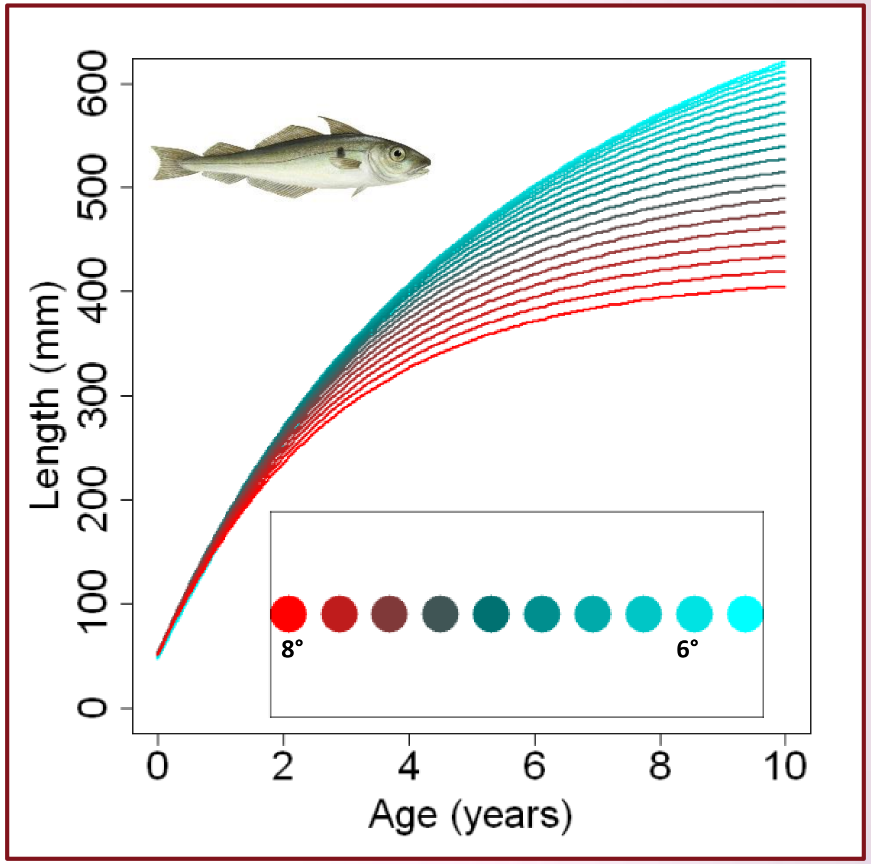
- fish are ectotherms
  - metabolic processes double for every 10˚C increase
- fish are water breathing
  - respire via gills (surface area); metabolism scales with volume
  - oxygen solubility in water decreases as temperature increases



Commercial fish have long time series of age & length data







Baudron et al. 2011

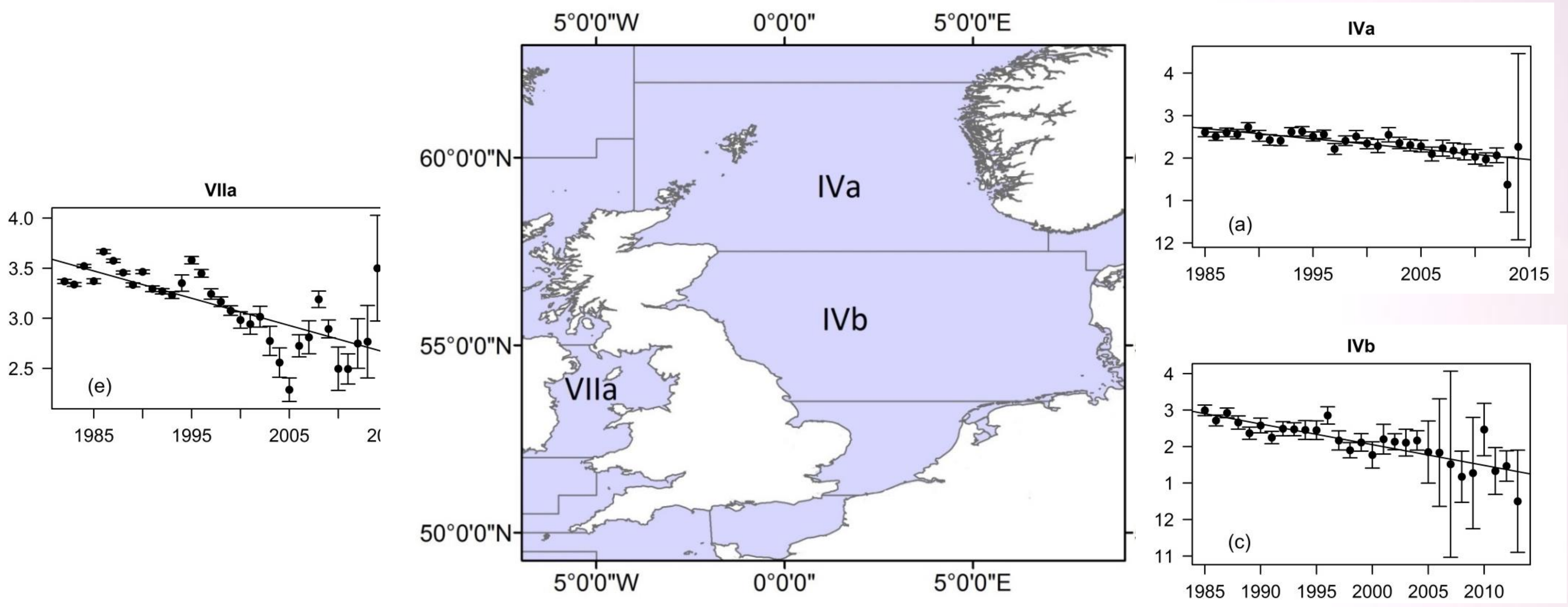
When fish shrink yields ↓ because ***more*** fish are required to make up 1 tonne

Species	Sub-stock	Decrease in L_∞ (%)	Decrease in Yield-Per-Recruit
Haddock	North	**29%**	38.7%
Whiting	North	13%	**3.1%**
Whiting	South	**29%**	**48.1%**
Herring	North	10%	12.3%
Norway pout	North	19%	22.2%
Sprat	South	16%	4.0%
Plaice	Male South	12%	46.2%
Sole	Male South	13%	17.8%
Sole	Female South	**1%**	15.9%
AVERAGE		**16%**	**23.1%**

*reductions in YPR have **already** occurred 1970-2006*

Baudron et al. 2014

North Sea and Irish Sea cod are spawning earlier due to warming

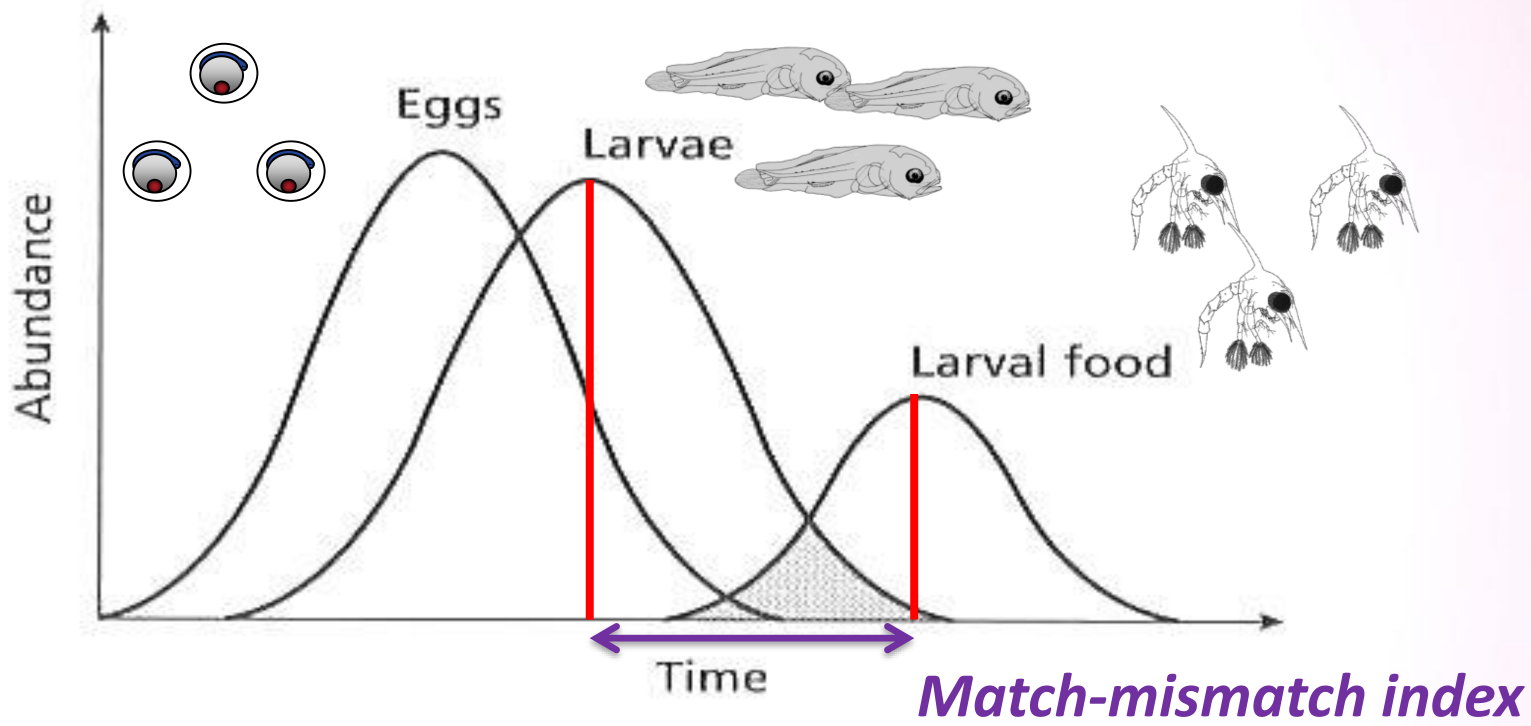


Cod have shifted their spawning time:

- **1** week per decade in the northern North Sea
- **2.3** weeks per decade in the central North Sea
- **0.7** weeks per decade in the Irish Sea

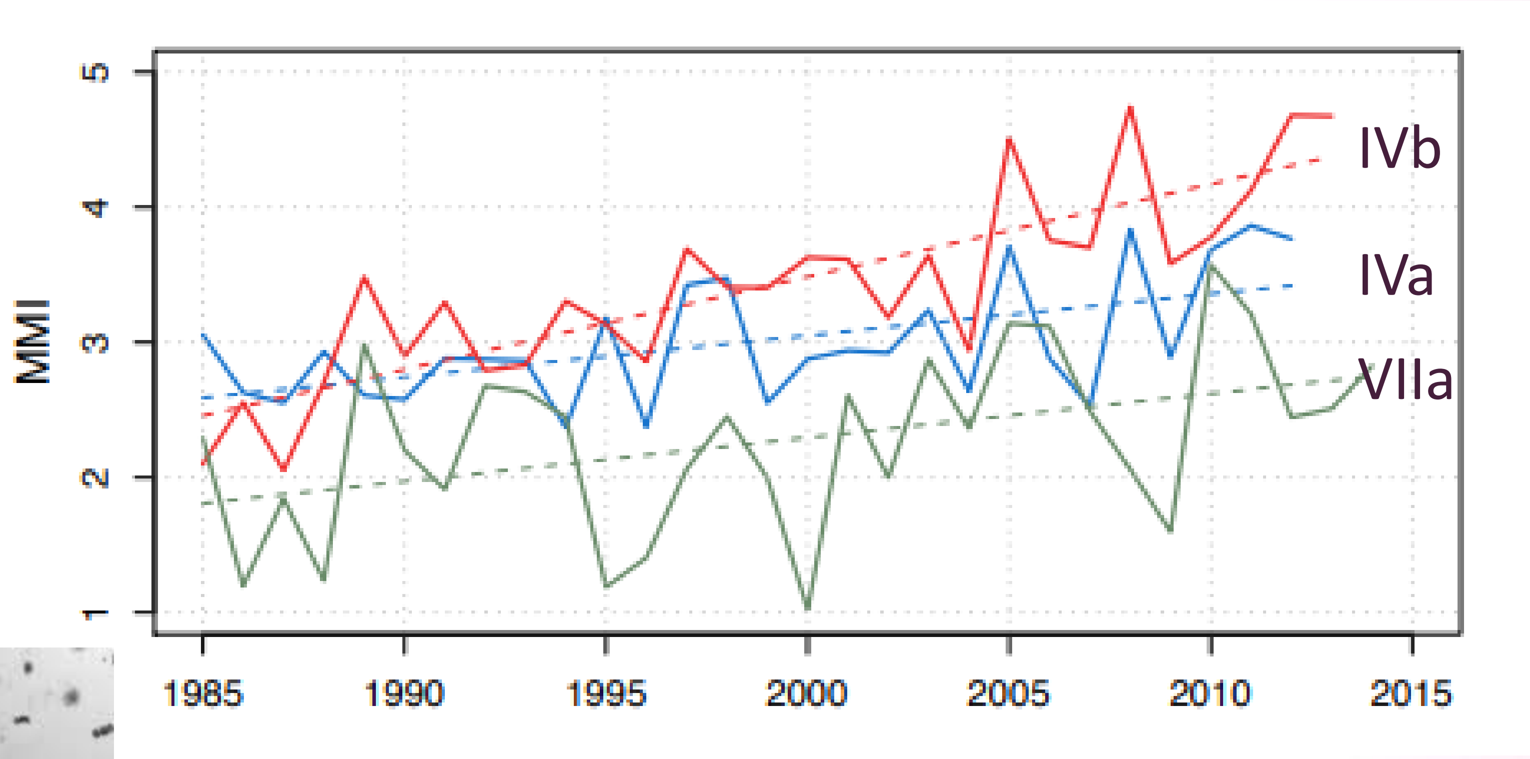
McQueen and Marshall 2017

Earlier spawning of cod has implications for larval survival



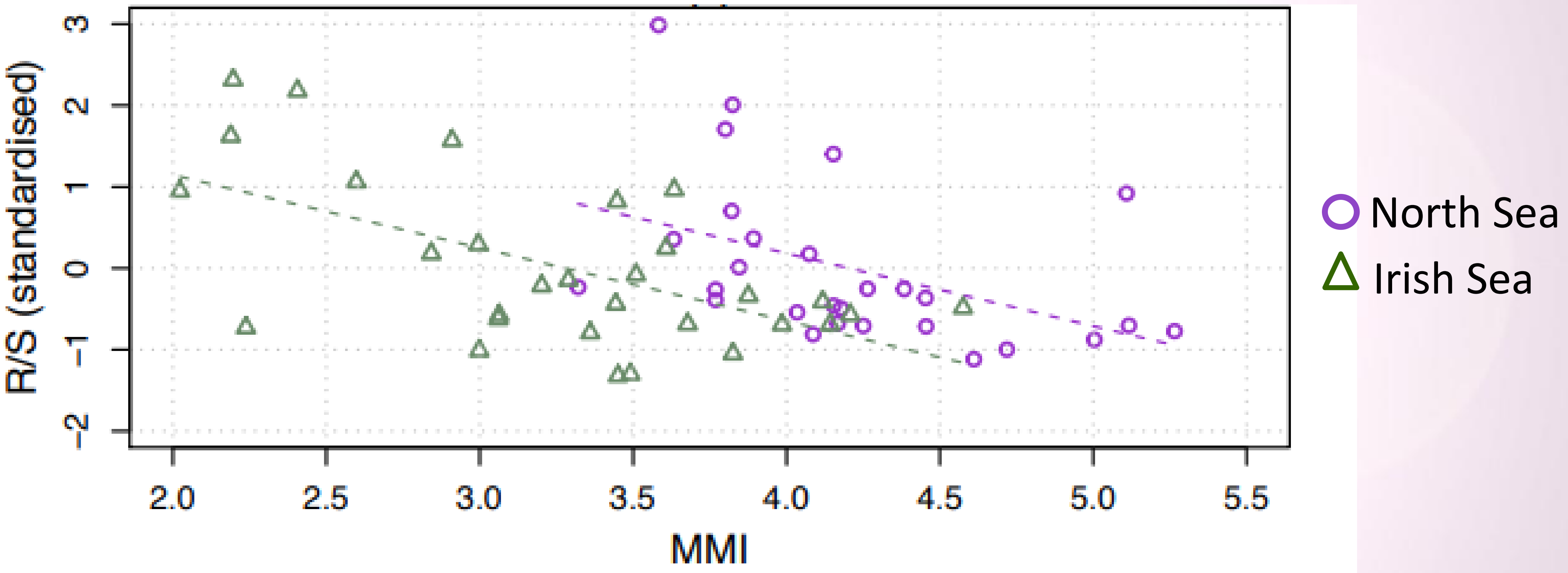
Match-mismatch hypothesis: survival (and recruitment) is high when there is a close overlap between production curves of fish larvae and their zooplankton prey (and vice versa)

Cod are spawning earlier in the North Sea and Irish Sea → match-mismatch index is increasing over time in three areas



Marshall et al *in prep.*

As mismatch has increased due to earlier spawning → recruitment rates of both cod stocks has decreased



Marshall et al *in prep.*

Yield/SSB = f (**Distribution** X **Temperature**)

$$\frac{Yield}{SSB} = \frac{Recruitment}{SSB} \times \frac{Yield}{Recruit}$$

Ectotherm physiology

Recruitment = f (**Temperature**)

Recruitment = f (Phenology)

Phenology = f (**Temperature**)

Yield per Recruit = f (**Temperature**)

Growth = f (**Temperature**)

Outline

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→ ***Yield***

- Mitigation measures
  - integration in fisheries management
  - decarbonisation & climate smart food production
  - role of certification schemes
- Adaptation to CC
  - *See presentation to CLG on 19/11/2019*
  - climate vulnerability assessment
- Research needs

UK Fisheries Bill designates CC as a fisheries objective

B I L L

TO

Make provision in relation to fisheries, fishing, aquaculture and marine conservation; to make provision about the functions of the Marine Management Organisation; and for connected purposes.

BE IT ENACTED by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows: —

Fisheries objectives, fisheries statements and fisheries management plans

1 Fisheries objectives

(1) The fisheries objectives are —
- (a) the sustainability objective,
- (b) the precautionary objective,
- (c) the ecosystem objective,
- (d) the scientific evidence objective,
- (e) the bycatch objective,
- (f) the equal access objective,
- (g) the national benefit objective, and
- (h) the climate change objective.

(9) The "climate change objective" is that —
- (a) the adverse effect of fish and aquaculture activities on climate change is minimised, and
- (b) fish and aquaculture activities adapt to climate change.

Integrating climate change in fisheries management

If yields ↓ with warming temperatures then the MSY reference points conditioned on historical productivity will not be appropriate

ICES Journal of Marine Science

ICES CIEM

ICES Journal of Marine Science (2019), 76(6), 1424–1435. doi:10.1093/icesjms/fsz038

Original Article

Responsive harvest control rules provide inherent resilience to adverse effects of climate change and scientific uncertainty

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Kritzer, J. P., Costello, C., Mangin, T., and Smith, S. L. Responsive harvest control rules provide inherent resilience to adverse effects of climate change and scientific uncertainty. – ICES Journal of Marine Science, 76: 1424–1435.

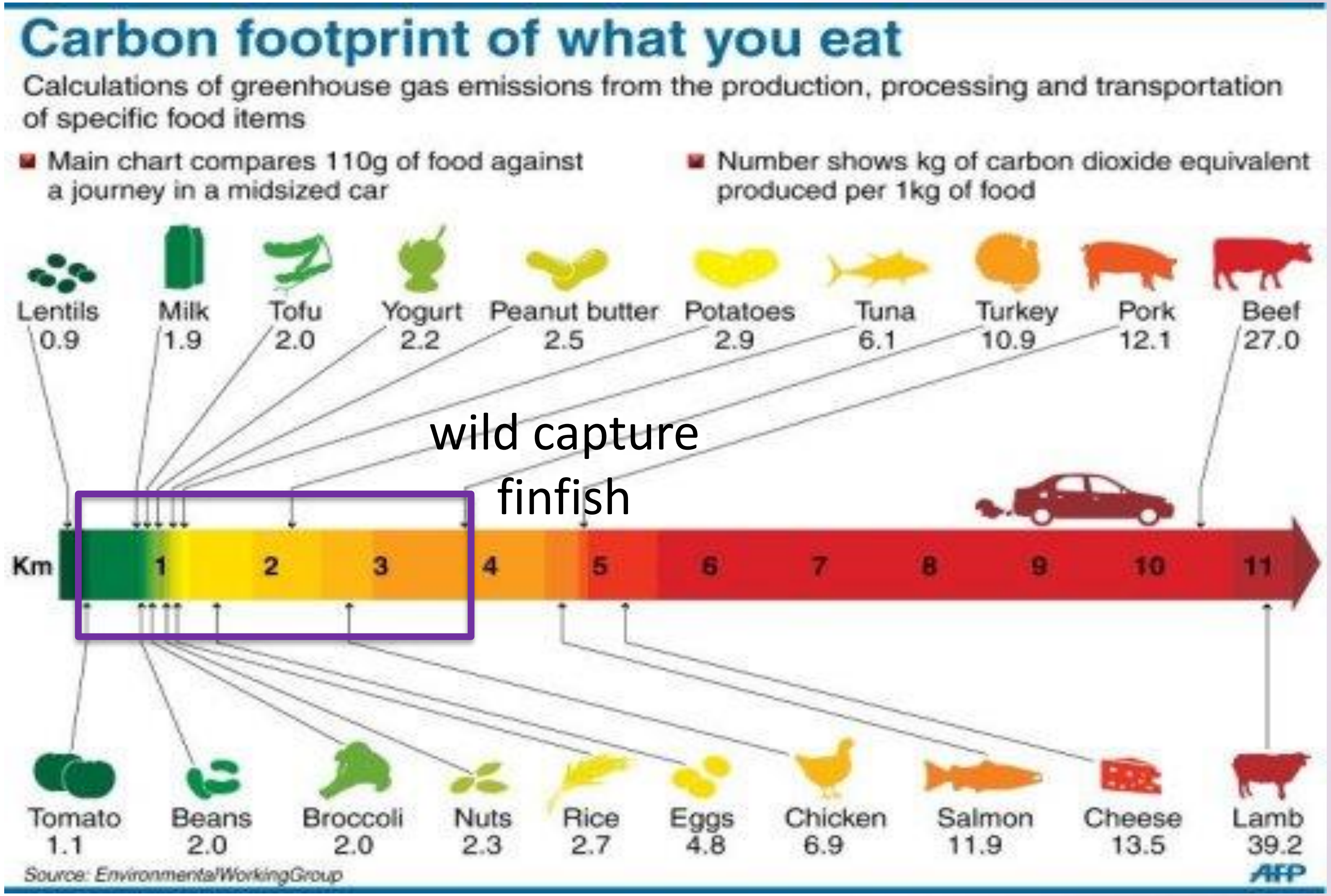
Received 27 May 2018; revised 20 February 2019; accepted 21 February 2019; advance access publication 1 April 2019.

Climate change is altering marine ecosystem and fish stock dynamics worldwide. These effects add to scientific uncertainties that compromise fisheries management. Among the strategies that can respond to climate change and scientific uncertainty, modifications to harvest control rules (HCRs) might be among the most direct and impactful. We used a bioeconomic model to compare alternative HCRs in terms of biomass, yield, and profits in response to potential effects of climate change and scientific uncertainty, specifically simulated retrospective patterns, for 14 stocks on the Northeast Shelf of the United States. Our results suggest that a responsive HCR in which fishing mortality changes with measured changes in biomass builds inherent resilience to adverse effects of both climate change and scientific uncertainty relative to an HCR in which fishing mortality is precautionary but fixed. This was despite that fact that the HCR algorithm did not account for the climate effects modelled. A fixed fishing mortality HCR was effective when climate effects were negligible or beneficial. Scientific uncertainty further reduced biomass, yield, and profits by about the same magnitude as climate change. Our results suggest that simple changes to HCRs can be a readily implementable strategy for responding to climate change and scientific uncertainty.

Keywords: climate change, harvest control rules, New England, retrospective pattern, scientific uncertainty

Kritzer et al. 2019

wild capture finfish a climate smart food source, albeit one that is inherently limited by stock productivity



Carbon footprint of seafood

Fish species	Region	Fishing method	Carbon Footprint (kg CO_2eq/ kg)	Source
Small pelagic	**Shetland**	**Pelagic trawl**	**0.452**	**Sandison et al. *in review***
Atlantic Mackerel	Galicia	Pelagic trawl	0.880	Iribarren et al. (2011)
Atlantic Mackerel	Galicia	Purse seine	0.610	Iribarren et al. (2011)
Horse Mackerel	Galicia	Purse seine	0.797	Vázquez-Rowe et al. (2010)
Horse Mackerel	Galicia	Bottom trawl	2.28	Vázquez-Rowe et al. (2010)
Salmon	UK	Farmed	3.27	Pelletier et al. (2009)
Cod	Norway	Mixed	1.60	Winther et al. (2009)
Haddock	Norway	Mixed	1.75	Winther et al. (2009)
Shrimp	Senegal	Trawl	~ 29	Ziegler et al. (2011)

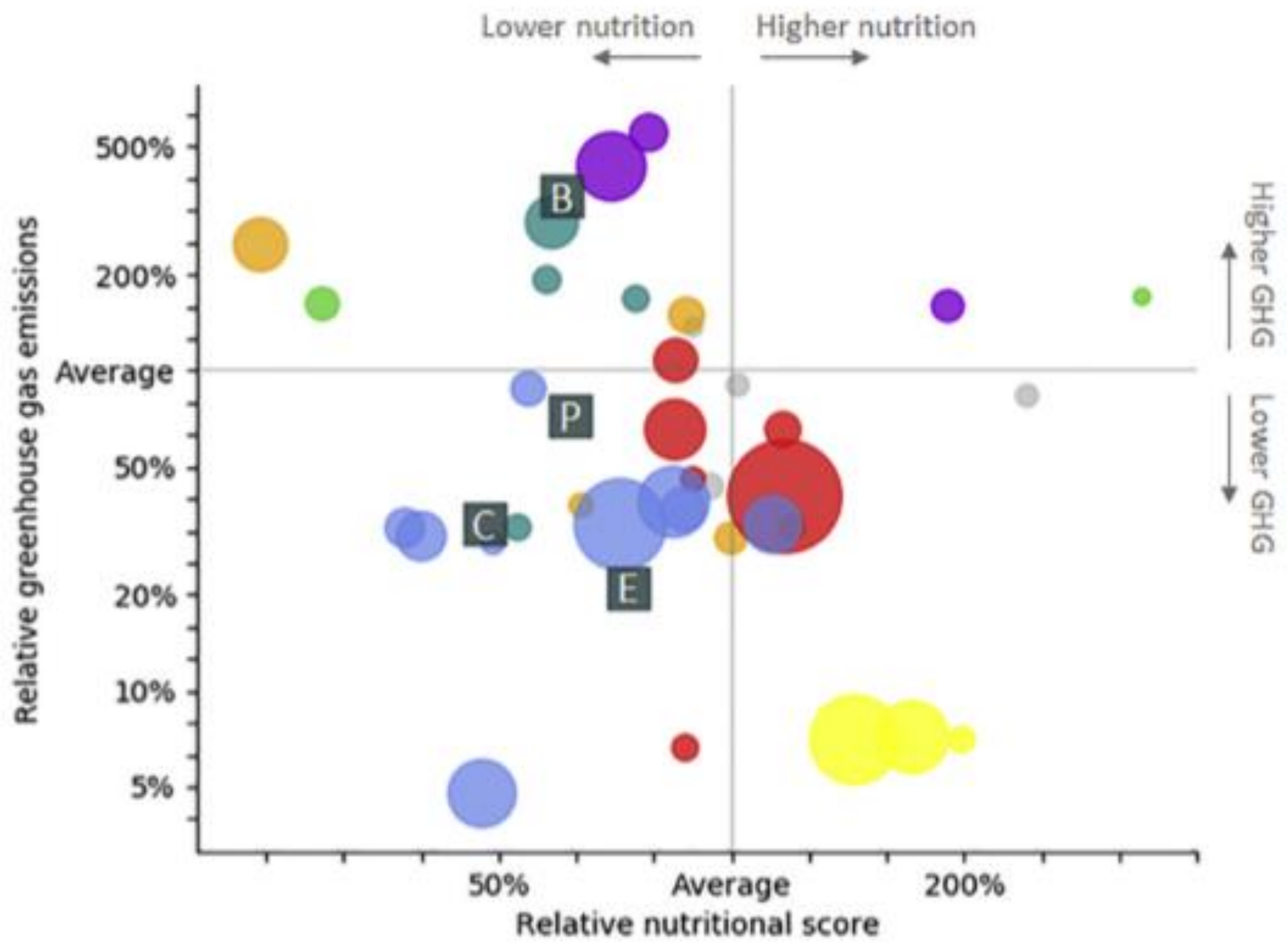
Are carbon footprints **currently** included in seafood ecolabels?

Gradient of inclusion of carbon footprint criteria in seafood ecolabels

Included as Essential	Partially Included	Non-Essential Inclusion	Related criteria included	Not Included
0%	**4%**	**4%**	**24%**	**72%**

Sandison et al. *in prep*

Joined up, smart targets for seafood policy objectives



Combined nutrient density and climate impact of seafoods analyzed. Log transformed data scaled around average. Bubble size reflects Swedish consumption rates on a continuous scale. **B** beef, **P** pork, **C** chicken, **E** egg.

Hallström et al. 2019

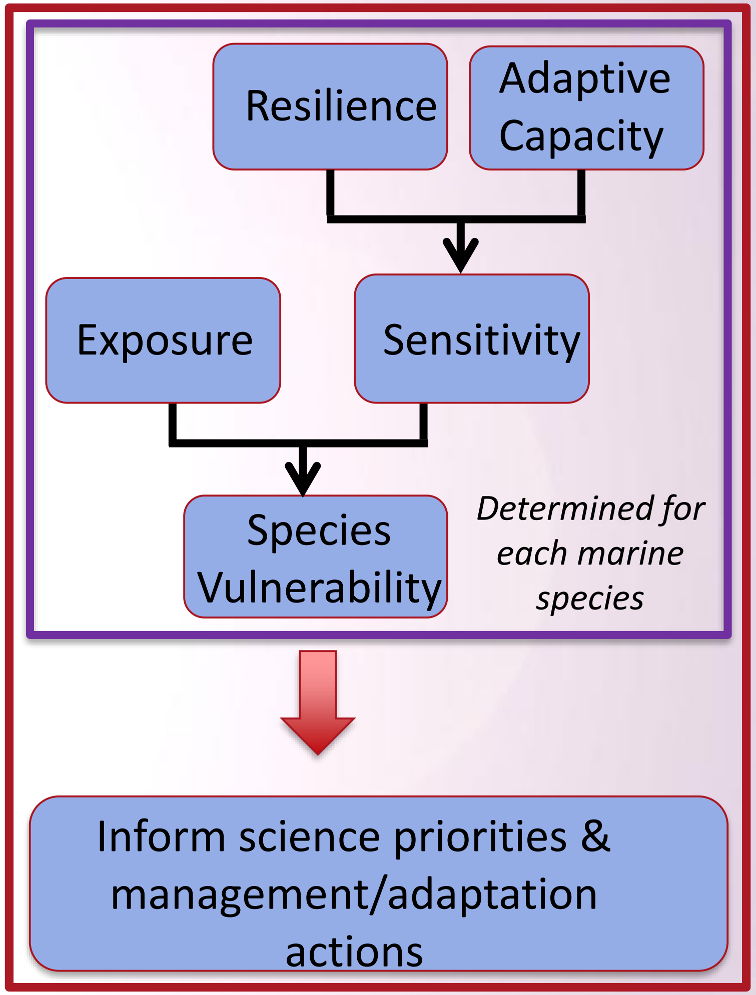
Climate Vulnerability Assessment (CVA) of fish and invertebrate species is becoming an established tool for adaptation planning

Goals:

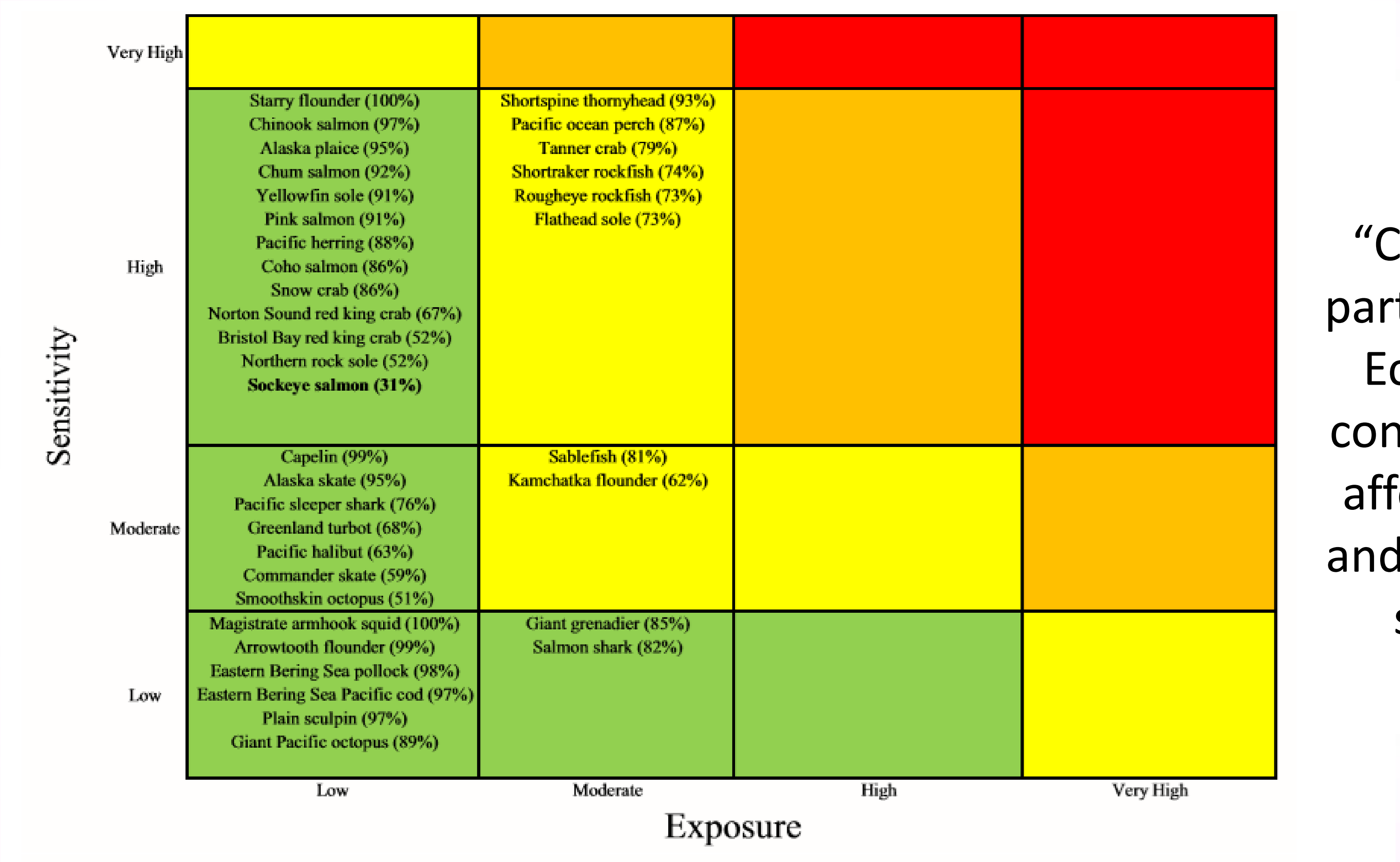
- determine which stocks are vulnerable to CC and why
- identify data gaps and research priorities

Implementations of CVA methodology:

- Southeast Australia (Pecl et al. 2014)
- Northeast U.S. Large Marine Ecosystem (Hare et al. 2016)
- Eastern Bering Sea (Spencer et al. 2019)



CVA for Eastern Bering Sea (Spencer et al. 2019)



"CVA … is anticipated to be part of the Bering Sea Fishery Ecosystem Plan which will consider how climate change affects human communities and what types of adaptation strategies are suitable"

Research priorities

- continue to grow the evidence base for climate impacts on UK fish
- examine whether current reference points are sufficiently resilient to CC
- develop tools for quantifying carbon footprint to meet policy objectives and decarbonisation commitments
- explore joined up, smart targets policy objectives for achieving sustainability, CC, and nutrition targets
- undertake trait-based climate vulnerability assessment of fish and invertebrate communities in UK waters
- promote knowledge exchange to increase salience and support adaptation & mitigation planning

Acknowledgements

- Alan Baudron (former PhD, now Marine Scotland)
- Frances Sandison (PhD)
- Kate McQueen (former MSc, now Thünen Institute)
- Nikolai Nawri (former MSc, now Cefas)
- Paul Spencer (NOAA, Alaskan Fisheries Science Centre)
- Scottish Pelagic Fisheries Association
- Fisheries Innovation Scotland

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