

Implications of climate change on harvestable, marine resources

Olav Sigurd Kjesbu

Institute of Marine Research, Bergen

NASF 2022



Climate vulnerability (impact) assessment

ORIGINAL ARTICLE

FISH and FISHERIES WILEY

Highly mixed impacts of near-future climate change on stock productivity proxies in the North East Atlantic

Olav Sigurd Kjesbu¹ | Svein Sundby¹ | Anne Britt Sandø¹ | Maud Alix¹ | Solfrid Sætre Hjøllo¹ | Maik Tiedemann¹ | Mette Skern-Mauritzen¹ | Claudia Junge² | Maria Fossheim² | Cecilie Thorsen Broms¹ | Guldborg Søvik¹ | Fabian Zimmermann¹ | Kjell Nedreaas¹ | Elena Eriksen¹ | Hannes Höffle² | Ann Merete Hjelset² | Cecilie Kvamme¹ | Yves Reecht¹ | Halvor Knutsen³ | Asgeir Aglen¹ | Ole Thomas Albert² | Erik Berg² | Bjarte Bogstad¹ | Caroline Durif⁴ | Kim Tallaksen Halvorsen³ | Åge Høines¹ | Carsten Hvingel² | Edda Johannesen¹ | Espen Johnsen¹ | Even Moland³ | Mari Skuggedal Myksvoll¹ | Leif Nøttestad¹ | Erik Olsen¹ | Georg Skaret¹ | Jon Egil Skjæraasen⁵ | Aril Slotte¹ | Arved Staby¹ | Erling Kåre Stenevik¹ | Jan Erik Stiansen¹ | Martina Stiasny¹ | Jan H. Sundet² | Frode Vikebø¹ | Geir Huse¹

- **A joint effort by 43 IMR research scientists** within stock assessment, ocean climate, ecology and physiology
- Both **data-poor and data-rich stocks**
- **Hybrid solution:** expert scorings + mechanistic studies
- **Done in a coherent fashion**
- Reviewed **799 publications**
- **39 stocks**; 84% of landings in the **NE Atlantic (2018)**
- **Supporting Information file (208 pp.)**

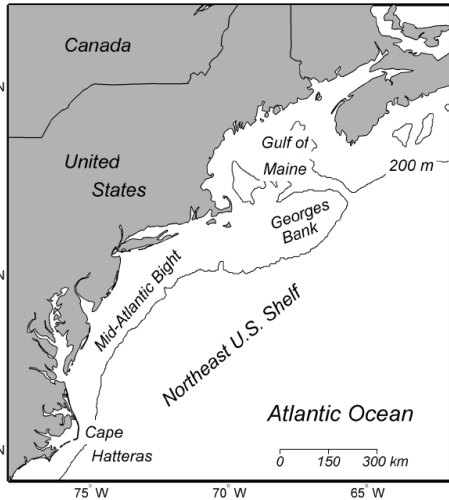


Fish and Fisheries
2022

“the resulting synopsis (**50-82°N**) contributes substantially to global assessment of major fisheries”

Earlier approaches of special interest

PLOS ONE

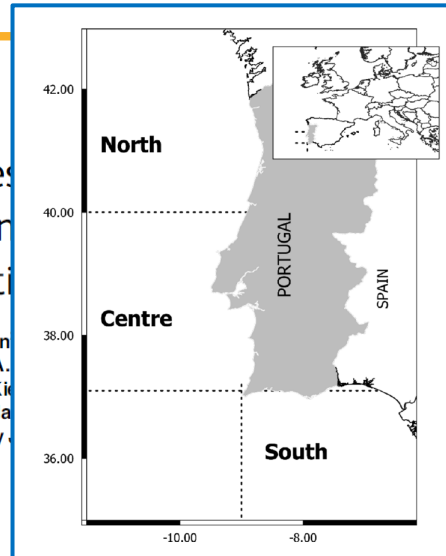


RESEARCH ARTICLE

A Vulnerability Assessment of Invertebrates to Climate Change on the Northeast U.S. Continental Shelf

Jonathan A. Hare^{1*}, Wendy E. Morrison¹, J. Teeters², Roger B. Griffis⁴, Michael A. Richard J. Bell^{1,ab}, Antonie S. Chute⁵, Kim John F. Kocik⁸, Sean M. Lucey⁶, Camilla E. Richardson¹, Eric Robillard⁶, Harvey E. Marancik¹⁰, Carolyn A. Griswold¹

Hare et al. 2016



scientific reports

OPEN

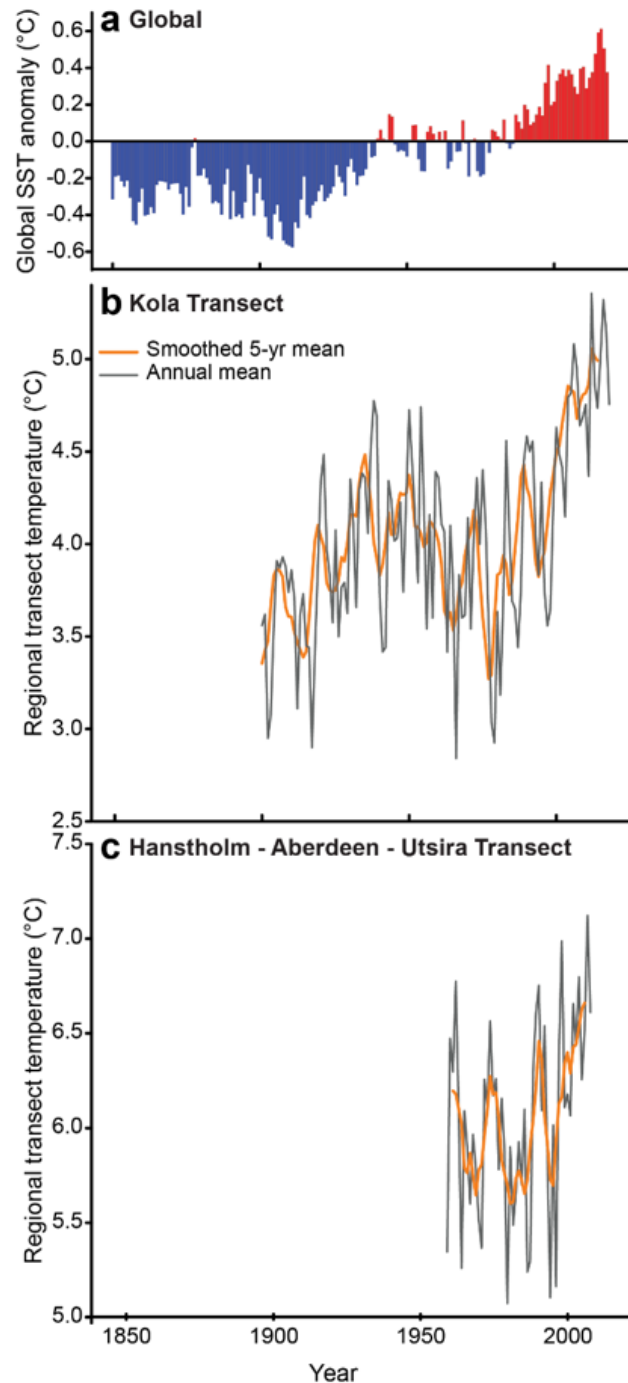
Climate change vulnerability assessment of the main marine commercial fish and invertebrates of Portugal

Juan Bueno-Pardo^{1,2,3}, Daniela Nobre¹, João N. Monteiro¹, Pedro M. Sousa¹, Eudriano F. S. Costa¹, Vânia Baptista¹, Andreia Ovelheiro¹, Vasco M. N. C. S. Vieira², Luís Chicharro³, Miguel Gaspar⁴, Karim Erzini¹, Susan Kay⁵, Henrique Queiroga⁶, Maria A. Teodósio¹ & Francisco Leitão¹

Bueno-Pardo et al. 2021



Observed long-term trends in ocean temperature



Global trend
(SST anomaly, 1850-2018)

Regional trend – Barents Sea
(0-200 m, 1900-2018)

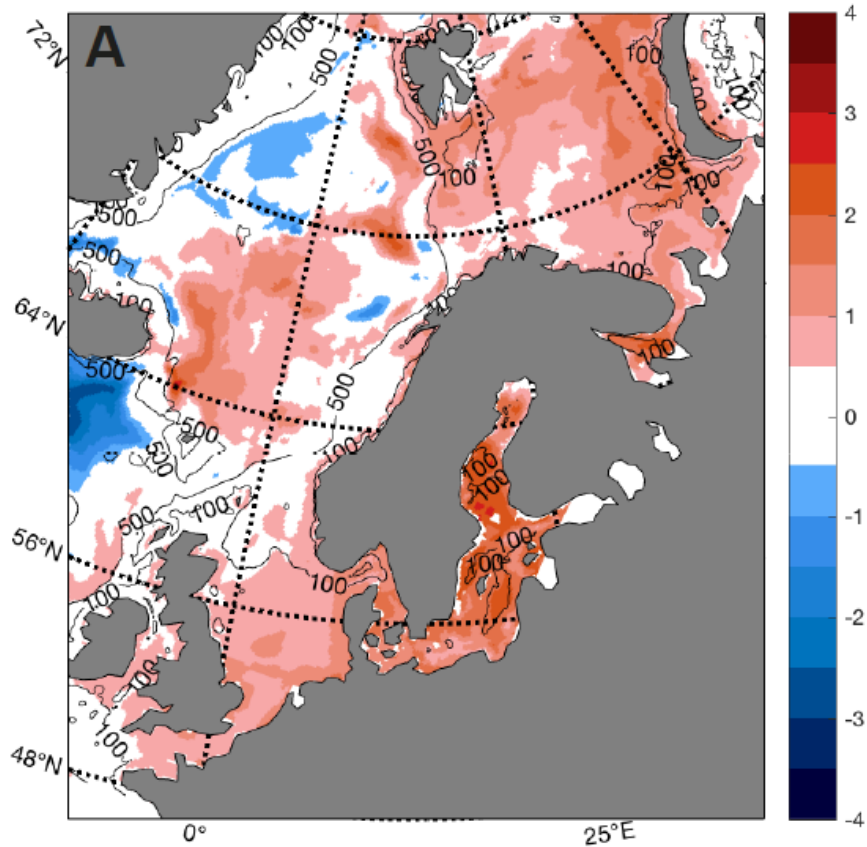
Regional trend – North Sea
(0-100 m, 1958-2008)



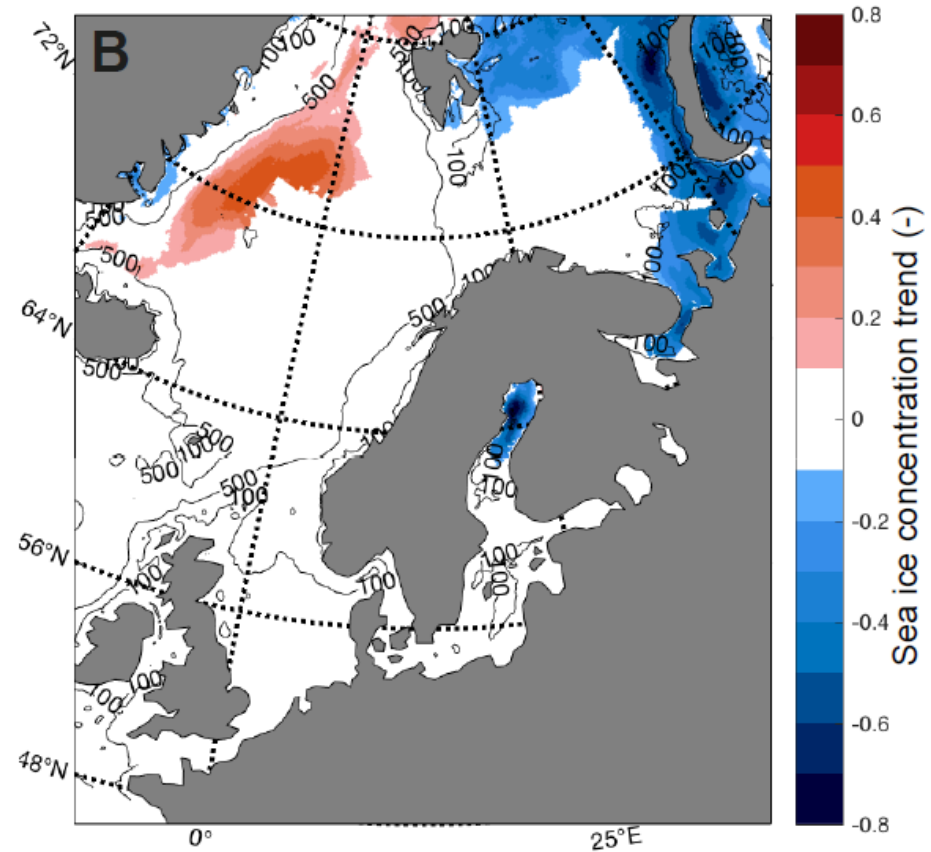
Climate exposure

Projected change (RCP 4.5) in *sea surface temperature** and *ice concentration* from **2010 to 2041**

Sea temperature



Ice concentration

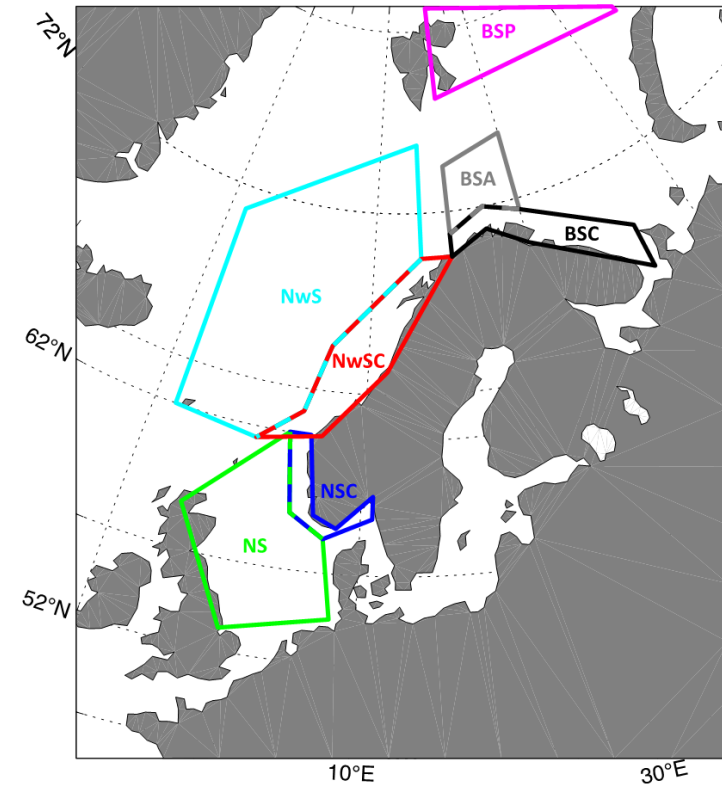


*studying also trends in temperature at 100 and 500 m, as well as bottom temperature

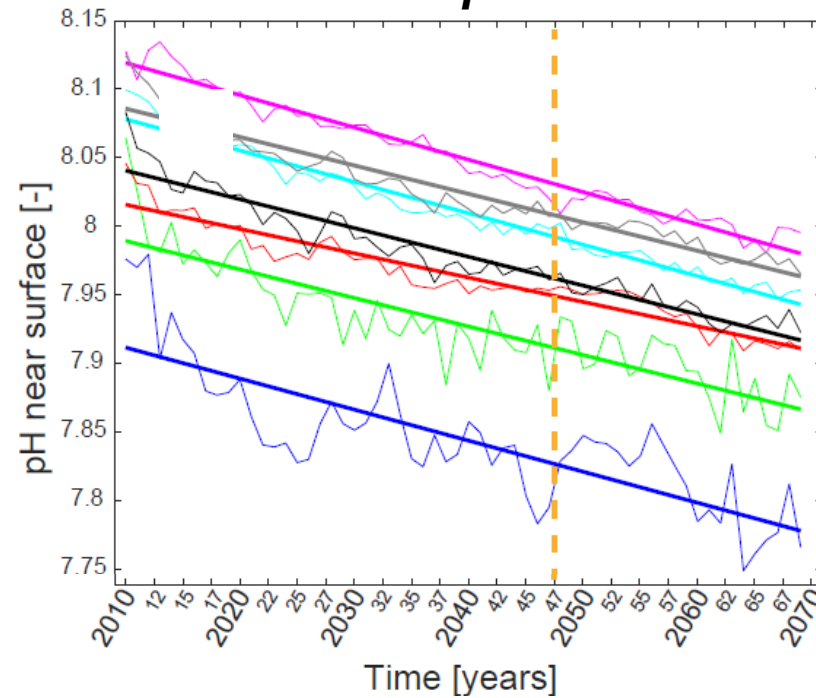
Climate exposure, cont'd

Projected change (RCP 4.5) in *pH* and *gross secondary plankton production** from 2010 to 2070 in different polygons in the Northeast Atlantic

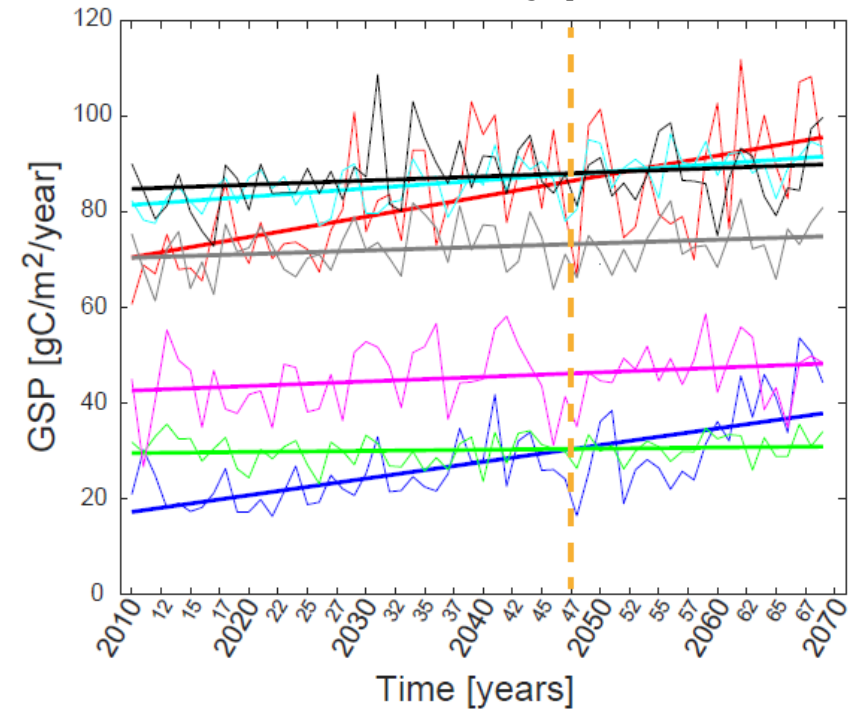
Polygons



pH

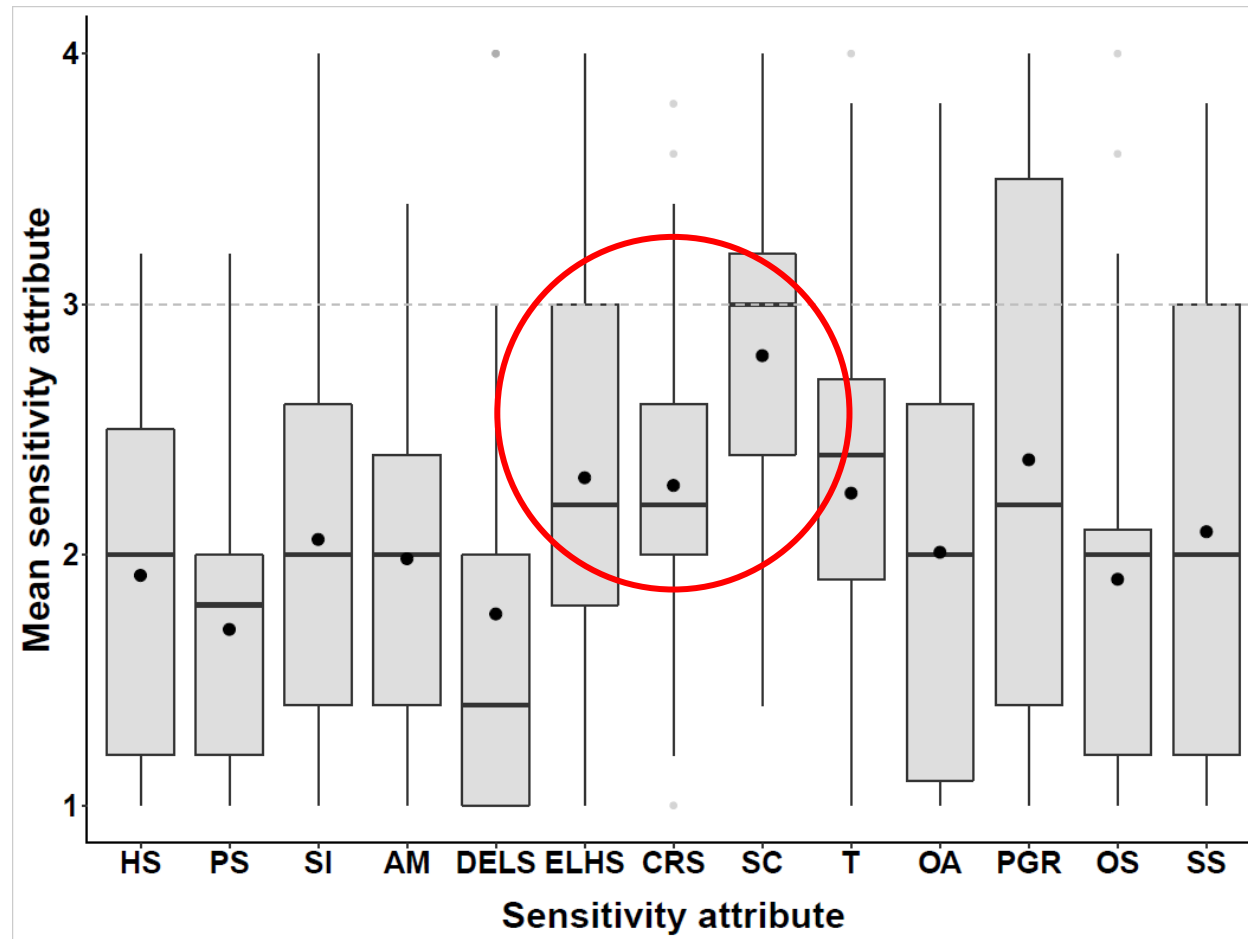


Gross secondary production



*studying also trends in O₂ and gross primary production

Sensitivity attributes (life-history-based adaptive capacity) of the 39 studied stocks: Scoring: 1 = low; 2 = moderate; 3 = high; 4 = very



Particularly sensitive:

ELHS = Early-life history survival and settlement requirement

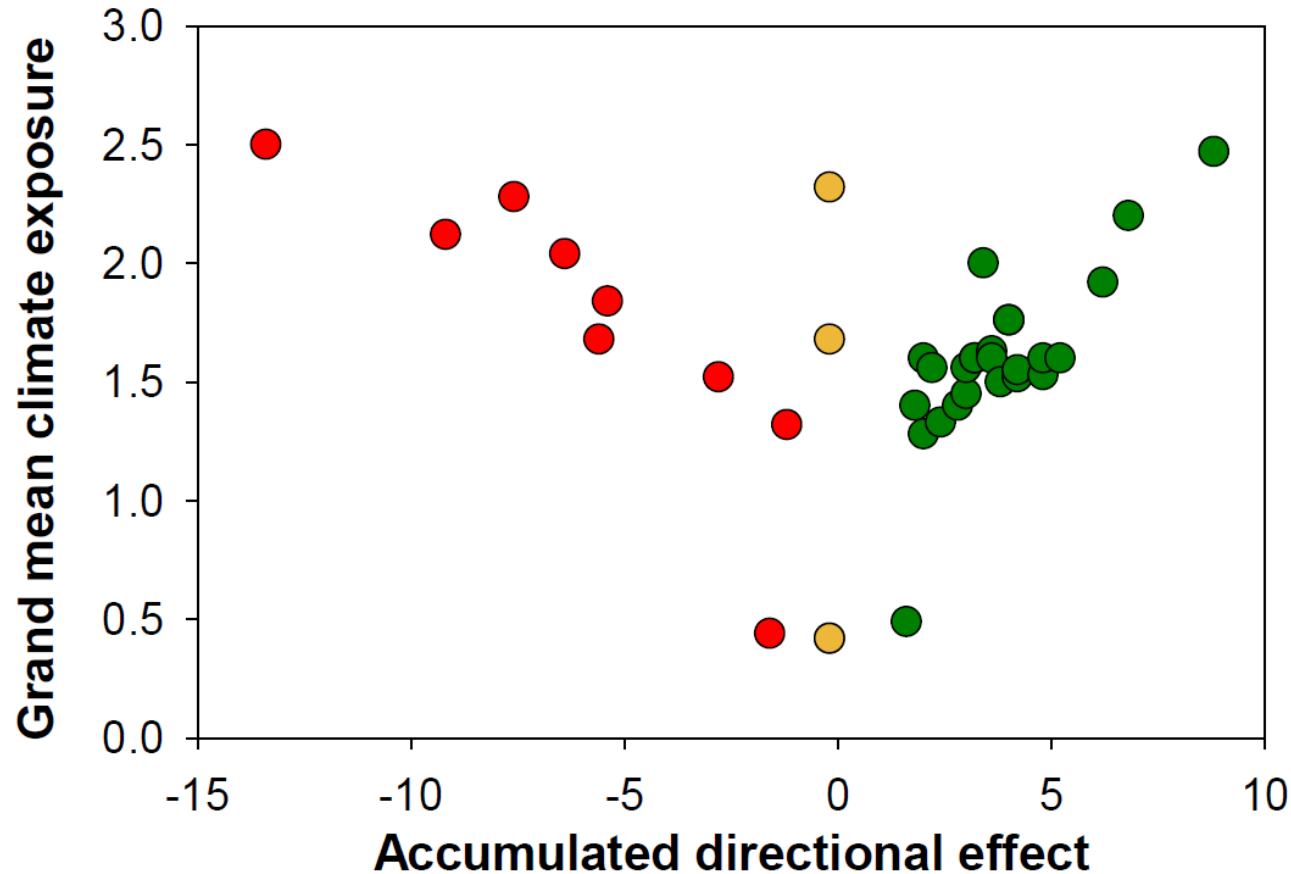
CRS = Complexity in reproductive strategy

SC = Spawning cycle

(adopting criteria in Hare et al., 2016)



Directional effect (sensitivity attributes + climate exposure) for the 39 studied stocks



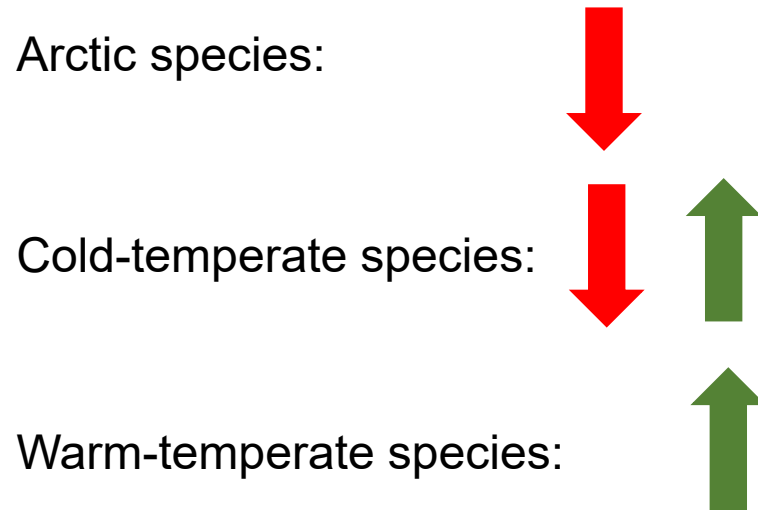
Relative scale for directional effect
negative: below -1
neutral: between -1 and 1
positive: above 1

Seeing four patterns related to productivity:

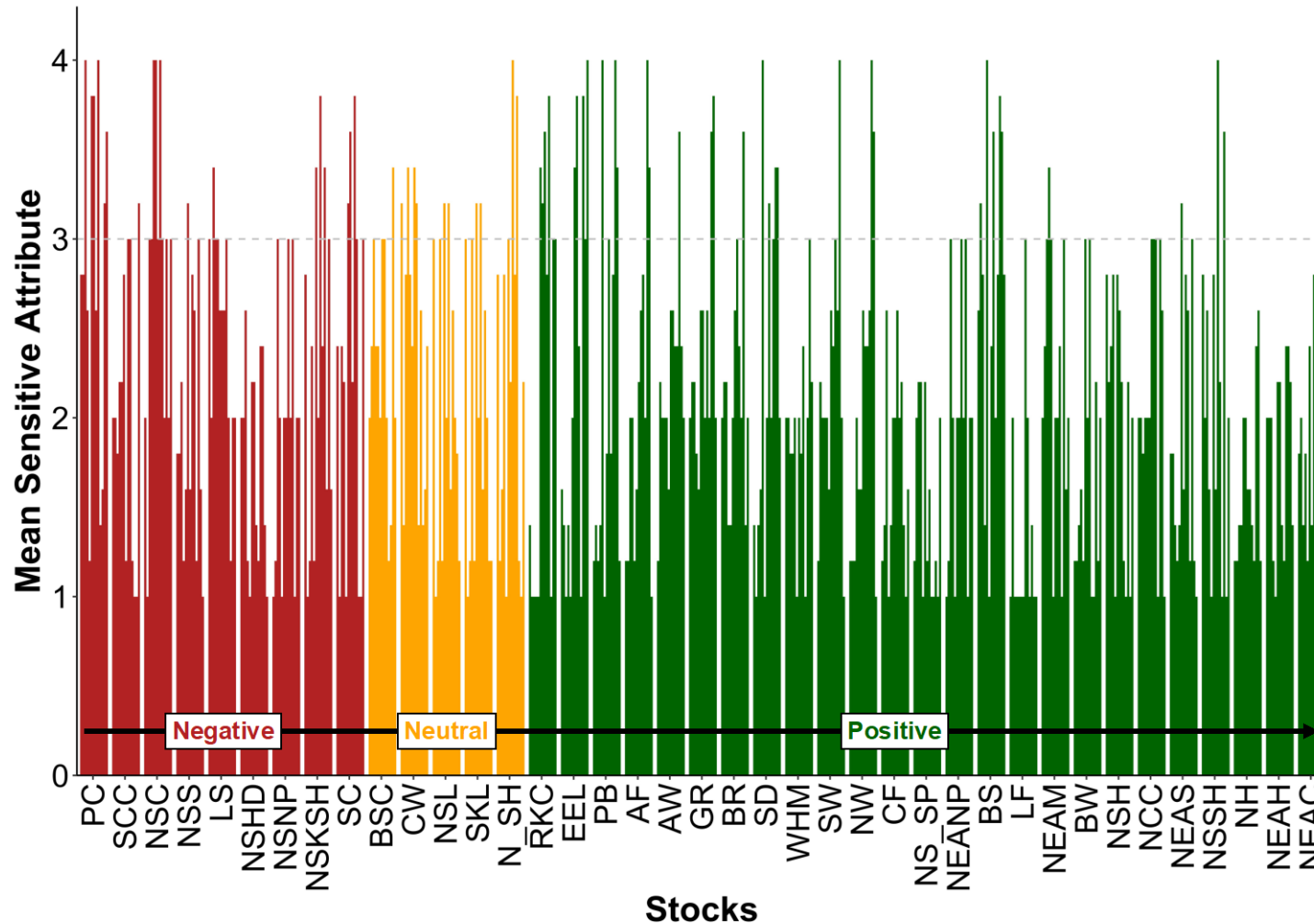
- ❖ Species that suffer
- ❖ No clear response
- ❖ Species that thrive
- ❖ Mixed responses within the same species



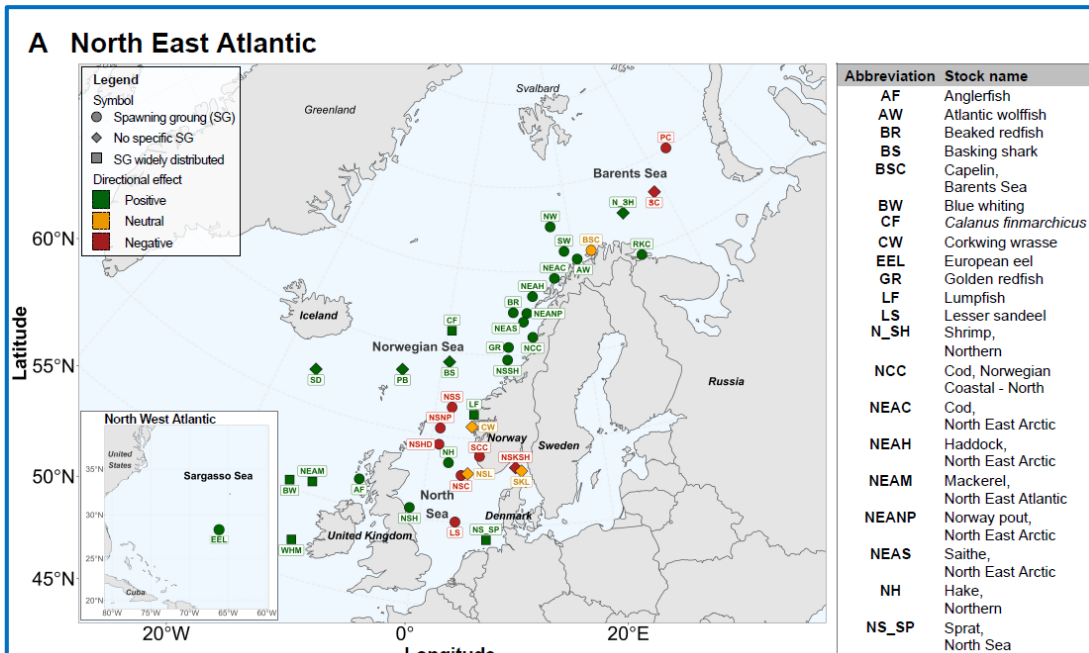
*“The currently outlined directional effect patterns characterizing the 39 assessed North East Atlantic stocks with either declining, neutral or increasing productivity appeared **closely linked to their thermal window of tolerance**”*



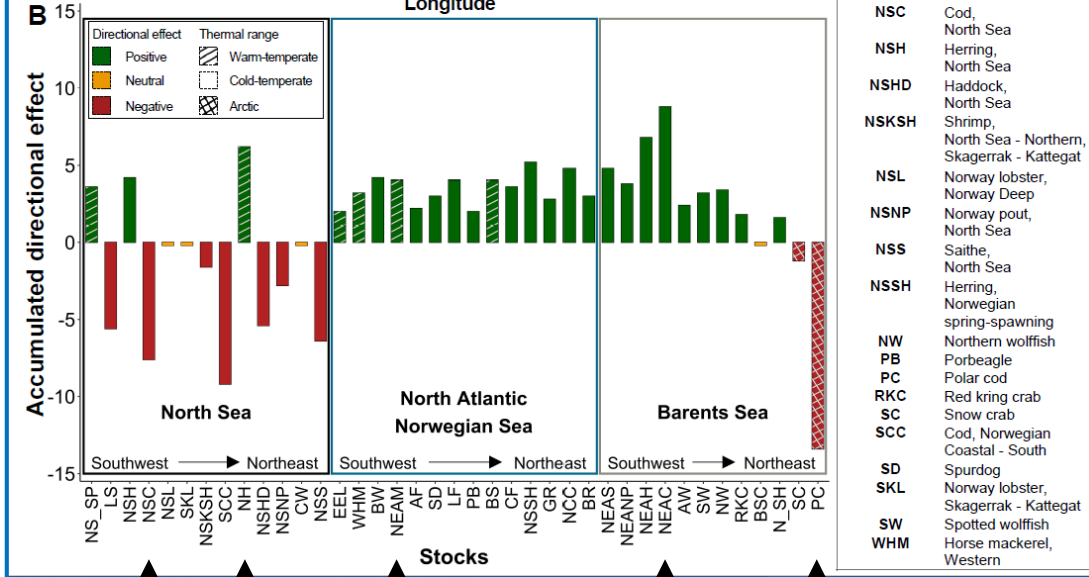
“However, further in-depth examinations revealed that 32 out of 39 stocks showed presence of individual sensitivity attributes with high or very high scores, that is with mean values between 3 and 4 —factors that might become critical or even more critical if greenhouse gas emissions are not reduced in the future”



Spawning grounds



Directional effect



cod hake mackerel cod polar cod

Summing-up

Based on

- RCP 4.5
- Until 2050 (“drivers” to 2070)
- 13 sensitivity attributes, e.g., reproduction, species interactions
- 9 climate exposure factors, e.g. temperature at relevant depth, secondary production

A complex, mixed picture

- Arctic species, as polar cod
- Cold-temperate species in south, as North Sea cod
- Warm-temperate, widely-distributed species, as Atlantic mackerel
- Warm-temperate species from south, as European hake
- Cold-temperate species in north, as NE Atlantic cod



References

- Bueno-Pardo, J. *et al.* Climate change vulnerability assessment of the main marine commercial fish and invertebrates of Portugal. *Sci Rep* **11**, 2958, doi:10.1038/s41598-021-82595-5 (2021).
- Gullestad, P., Sundby, S. & Kjesbu, O. S. Management of transboundary and straddling fish stocks in the Northeast Atlantic in view of climate-induced shifts in spatial distribution. *Fish. Fish.* **21**, 1008-1026, doi:10.1111/faf.12485 (2020)
- Hare, J. A. *et al.* A vulnerability assessment of fish and invertebrates to climate change on the northeast US continental shelf. *PLoS One* **11**, 30, doi:10.1371/journal.pone.0146756 (2016).
- Kjesbu, O. S. *et al.* Highly mixed impacts of near-future climate change on stock productivity proxies in the North East Atlantic. *Fish Fish.* **23**, 601-615, doi:10.1111/faf.12635 (2022).
- Huse, G. & Kjesbu, O. S. <https://www.dn.no/forskningviser-at-/klima/fisk/fiskeri/innlegg-hvordan-pavirkes-fiskeriene-av-klimaendringene/2-1-1194269>. Dagens Næringsliv 02.04.2022
- Species. <https://www.hi.no/en/hi/temasider/species>



Final remark:

We foresee that this work should be repeated at some later stage when the knowledge about climate projections and effects has further increased.



Thank you for your attention

Røst, Lofoten. 7 April 2018. Photo: osk