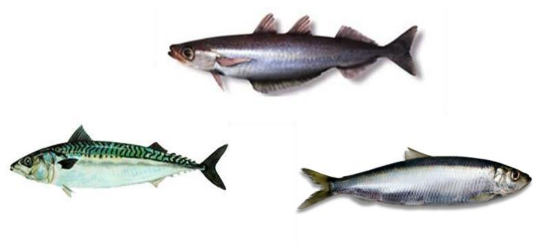
Simulation case: North East Atlantic Pelagic Fisheries

Assessing future climate effects on the pelagic complex in the Norwegian Sea



2020 International Forum on the Effects of Climate Change on Fisheries & Aquaculture

25-26 February 2020, Rome

Solfrid Sætre Hjøllo, E.A Mousing, K.R. Utne, S. Agnarsson, J. Arias-Hansen, R. Friðriksdóttir, U. Laksá, M.D. Skogen, J. R. Viðarsson, S.Ö. Ragnarsson

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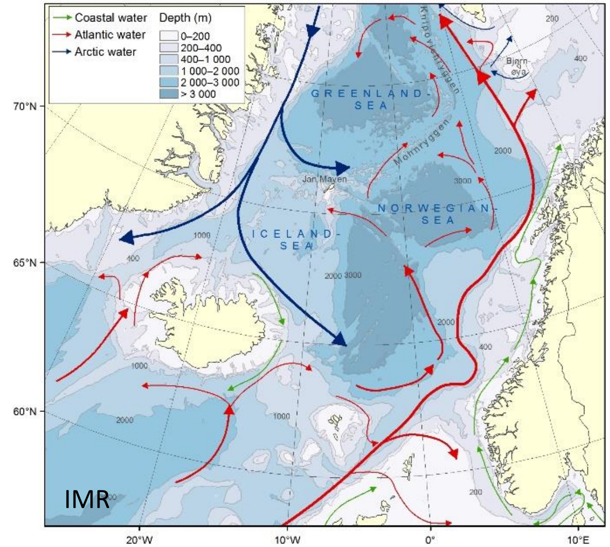
North East Atlantic Pelagic Fisheries

- A multinational fishery of pelagic stocks that cross multiple EEZs and high seas
  - Norway
  - Iceland
  - Faroe Island
  - Greenland
  - EU
  - Russia



- Species considered and modelled:
  - Mackerel
  - Blue whiting
  - Norwegian spring spawning herring

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Challenges

- Complex negotiations on quota allocations and lack of overarching quota sharing agreements
- Current unilaterally set quotas exceed scientific advice
- Root cause of disagreements: <u>distributional changes of stocks</u>

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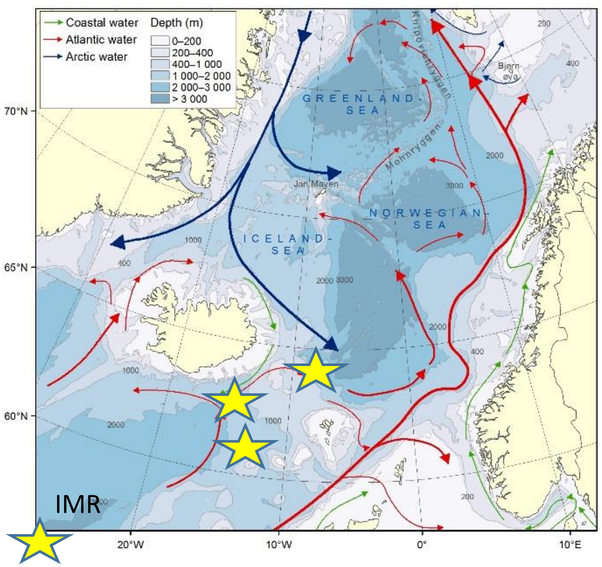
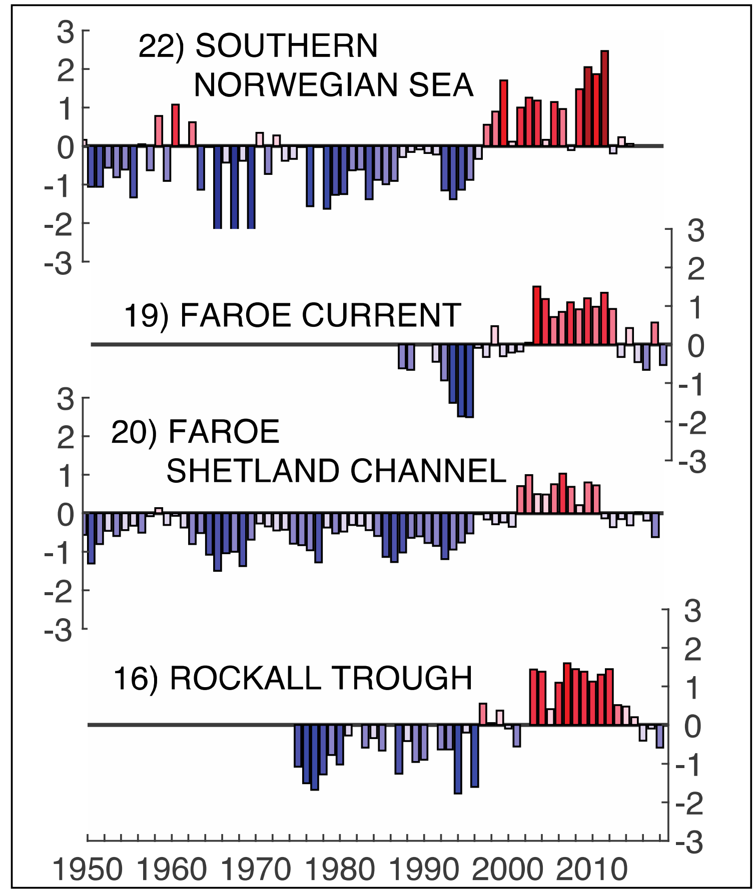
The Norwegian Sea are warming





Temperature anomalies (°C). IROC 2018

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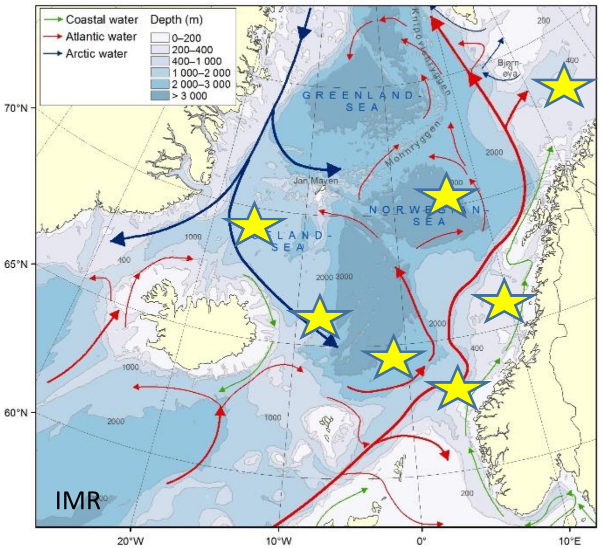
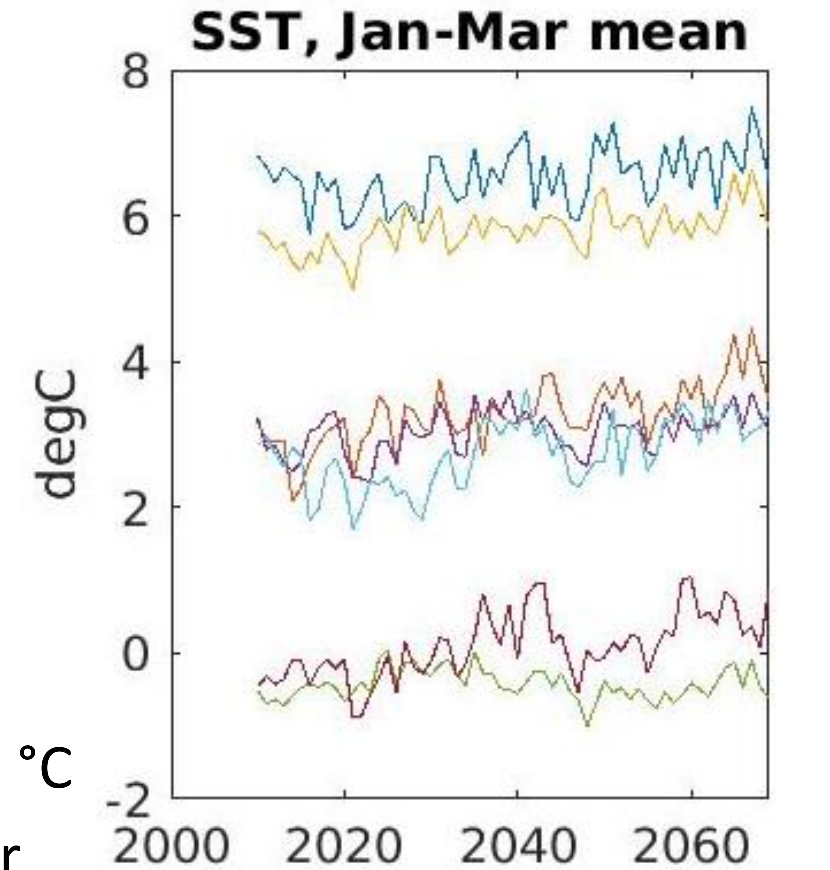
Warming are projected to continue





- Temperature changes ~ 0.3-0.7 °C
- Northward extension of warmer water

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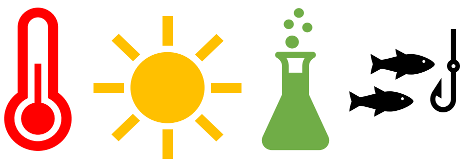
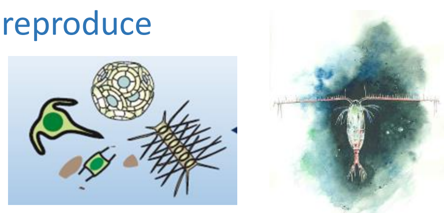
Forecasting future ecosystem state

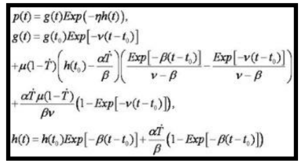
1. Create 3D environment

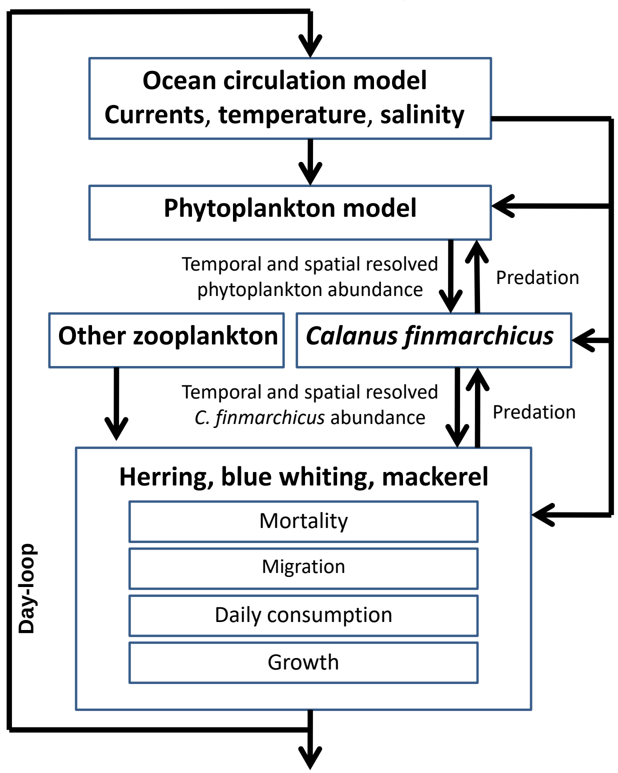


2. Let plankton grow, drift and reproduce

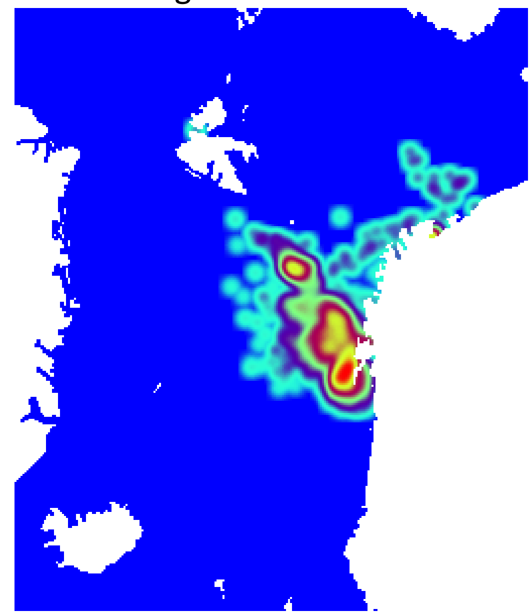


3. Let fish grow, swim and reproduce





NSS Herring Jan-Dec 2012



Full 3D representation of **present** and **future** fish biomass and distribution

ClimeFish

Utne et al (2012), Hjøllo et al (2012), Huse et al (2018), Skogen et al (2018), Mousing et al 2020

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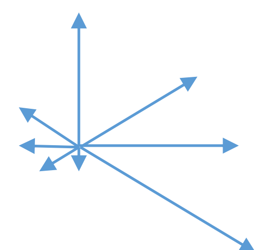
Biological forecasting with NORWECOM.E2E ecosystem model

- Including full lifecyles modules for fish and it´s prey
- Starting with realistic fish stocks from analytic assessments
- Harvest control rules included: F reduced if SSB < trigger level
- Daily resolution in time and 10km in space, allows for movement
  - Generic fish movement routine:temperature, food, stock density.

STAY

MOVE to best suitable habitat nearby



Based only on 1 single possible future climate evolution and 1 ecosystem model

Mousing et el 2020, ClimeFish D3.3

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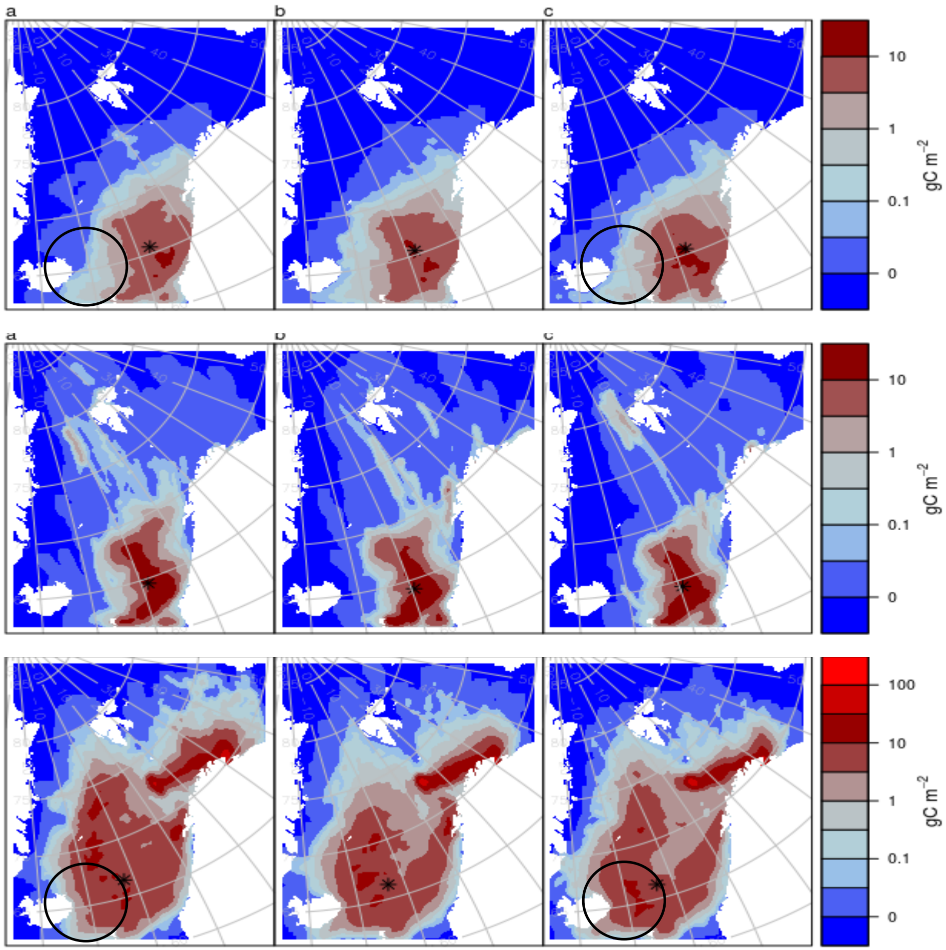
Changes in fish distribution

Mackerel

Blue Whiting

Herring



Present day 2045-2054 2060-2069

ClimeFish

ClimeFish D3.3

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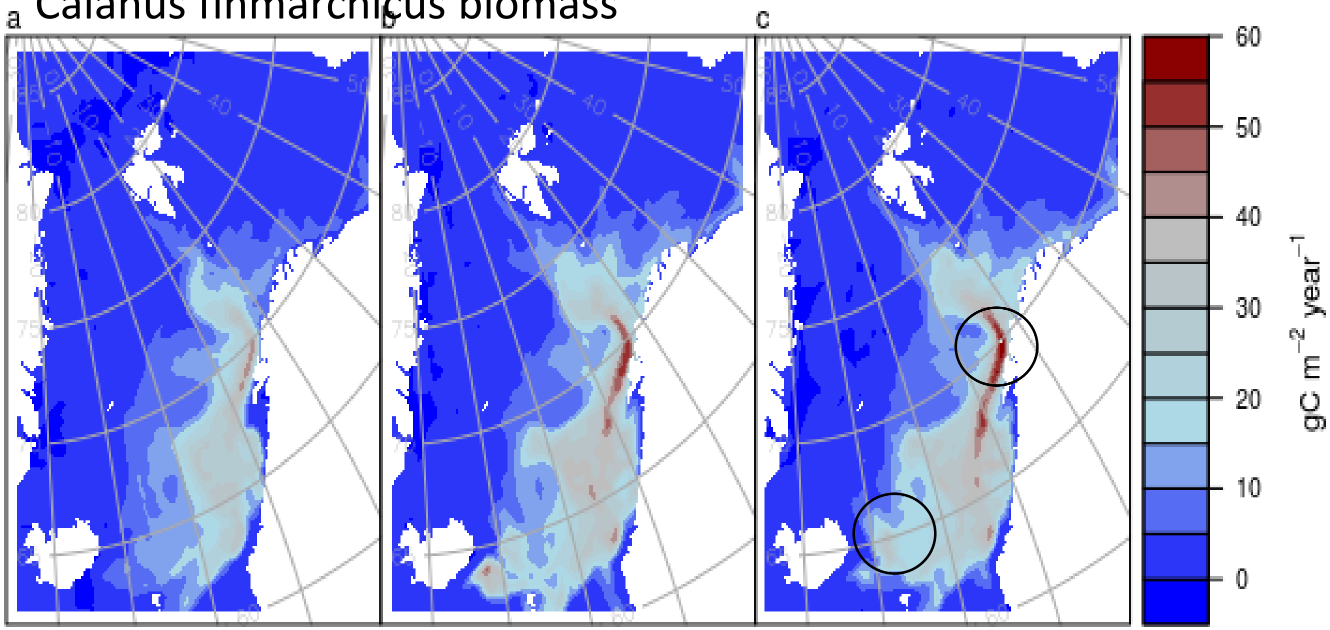
Increased food availability

Calanus finmarchicus biomass



Present day 2045-2054 2060-2069

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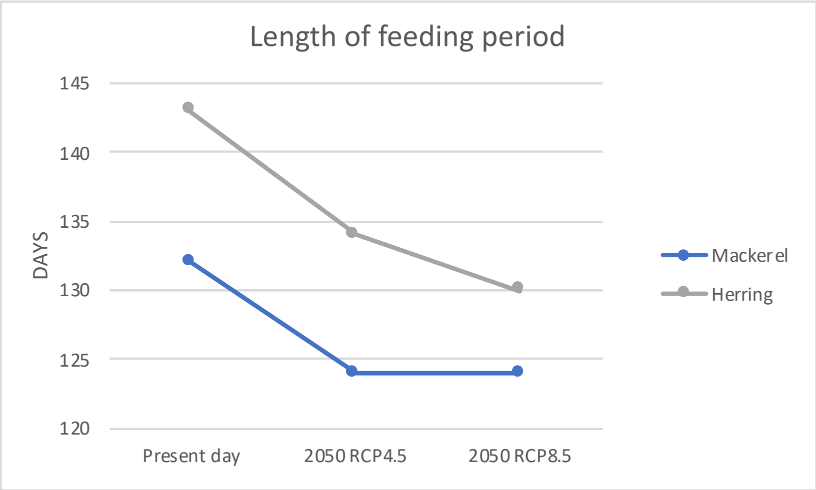
Individual growth

- Better feeding conditions will in general give faster growth and a shorter feeding period



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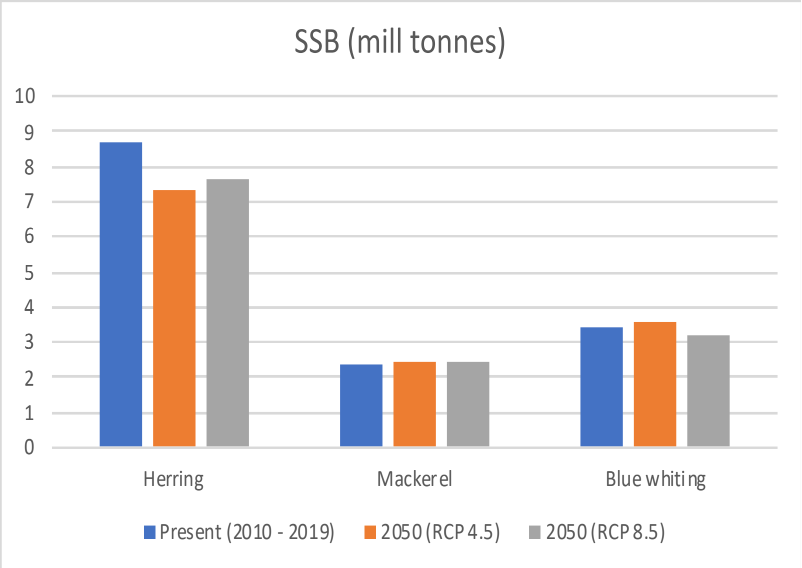
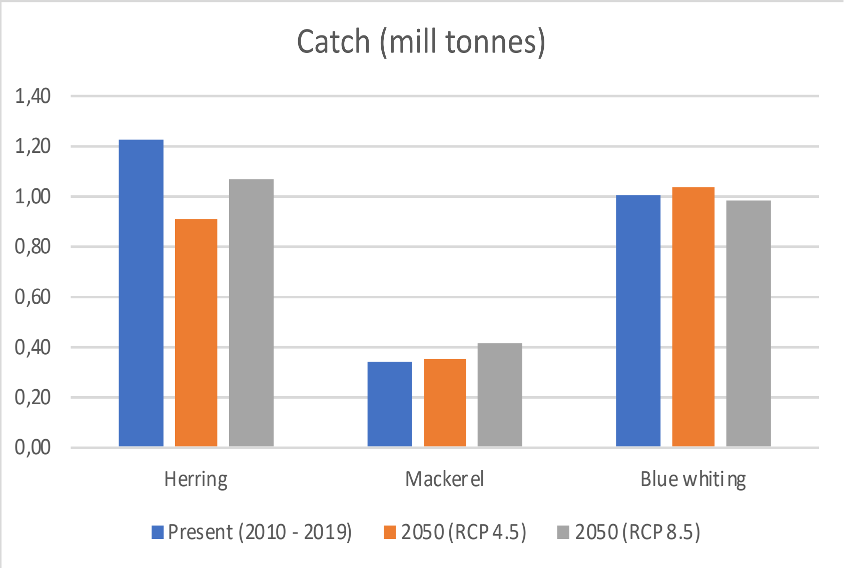
Changes in biomass and catch: all-area





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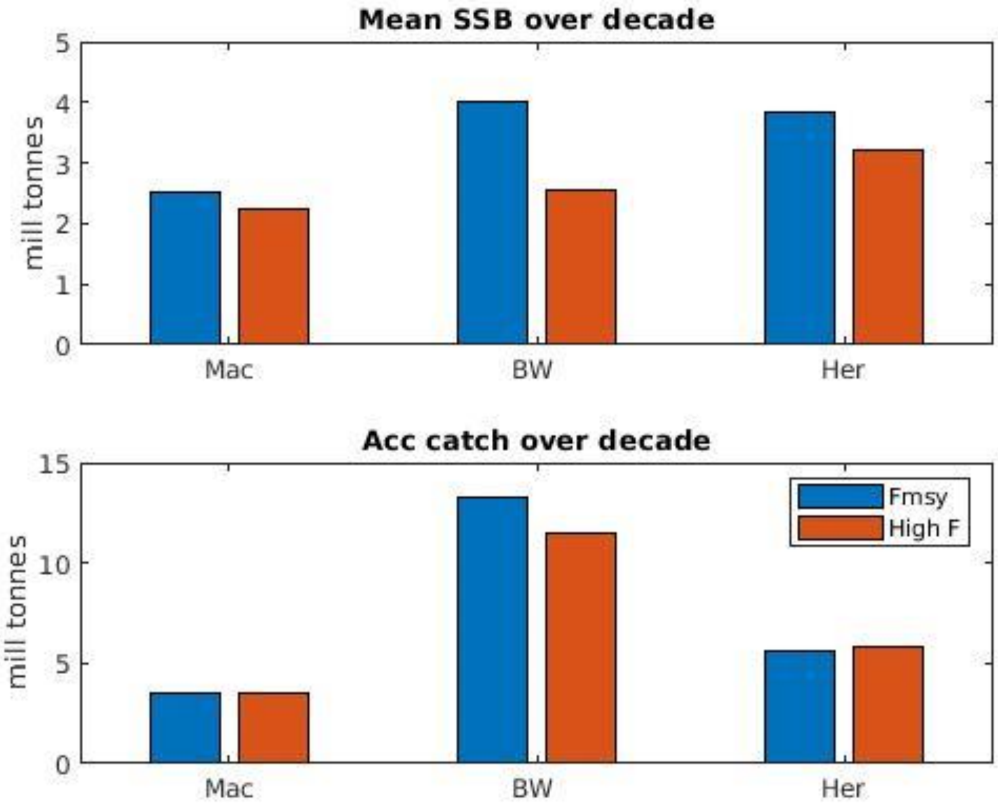
Human pressures: overfishing

- ✓Fishing at F_{msy} or with high F
- ✓Management influence accumulated catch:
  - ✓F was lowered if SSB dropped below trigger level



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Impact × Likelihood = Risk/Opportunity Level

Major risks and opportunities

Ecosystem

- Increase in total stock biomass of mackerel
- Expansion of feeding grounds of pelagic species to northeast of Iceland
- Increased growth rates of mackerel resulting in larger individuals
- Change in the spatial distribution of target species

Fishery

- Increased fishery for *Calanus finmarchicus* due to vast increase in abundance
- Increased fishery for *Calanus finmarchicus* due to vast increase in abundance
- Increased bycatch of fish larvae, such as herring, with *Calanus finmarchicus* fishery

Governance/ Socio-economic

- Increased complexity in negotiations on allocations of shared stocks
- Overfishing of shared pelagic stocks due to unilaterally set quotas
- Reduced safety at sea due to storminess

Transformative opportunity | Major opportunity | Severe Risk | Major Risk

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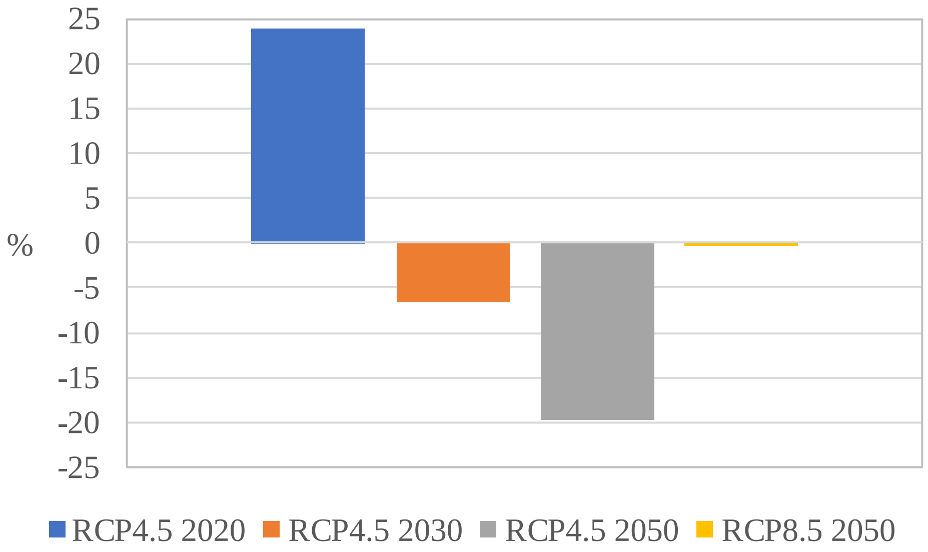
Socio-economic analysis

Impact of changes in catches:

- Industry level - income, operating costs and profits
- National level – value added and multiplier effects
- Simple linear relationships assumed

Projected profits – all catches
% changes from baseperiod (2010-2019)



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Adaptation measures

Industry	Research needs

• Participation in - and gear development for - *Calanus* fishery
  • Including exclusion devices
• Increased marketing effort for new emerging species
• Robust vessels and gear development
	• Research migration of target species
	  • Spatial changes and timing
	• Research on possible fishery for *Calanus*
	  • Ecosystem effects, bycatch, gear development, etc.

ClimeFish D5.9

ClimeFish

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Adaptation measures

Need for overarching sharing agreements to prevent overfishing due to unilaterally set quotas

Policy recommendations include:

- Revision and settlement of allocation keys and criteria
- Regular revision of allocation keys
- Explore feasibility of including more than one pelagic stock in the agreements
- Area closures for *Calanus* fishery

ClimeFish D5.9 and D5.1

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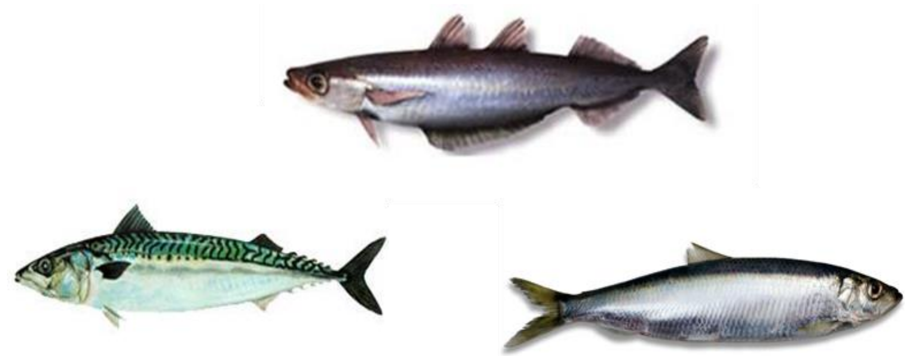
Summary



- Changing biomass, catches and spatial distribution of target species, negative effect of overfishing on SSB
- Transformative opportunities and severe risks
- Projected reduced profits

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Thank you for your attention

References

ClimeFish deliverables

- D1.5 Updated case study characterization for all cases
- D3.3 Production-biomass and distribution scenarios for simulation and implementation case studies
- D4.2 Socio-economic assessment for case studies for a range of IPCC scenarios
- D4.3 Climate-related risks and opportunities of climate change for fisheries and aquaculture in Europe
- D5.1 Good regulatory practice recommendations on how to address legal challenges associated with developing strategies for fisheries, aquaculture and lake and pond production
- D5.9 Report on strategies developed for each case study based on general guidelines

Publications:

- Hjøllo SS, Huse G, Skogen MD, Melle W. (2012). Modeling secondary production in the Norwegian Sea with a fully coupled physical/primary production/individual-based Calanus finmarchicus model system. Marine Biology Research 8:508_26.
- Huse Geir, Melle Webjørn, Skogen Morten D., Hjøllo Solfrid S., Svendsen Einar, Budgell W. Paul (2018): Modeling Emergent Life Histories of Copepods. Frontiers in Ecology and Evolution.
- Mousing et al (2020): Pelagic fish migration patterns (In prep)
- Skogen, SS Hjøllo, AB Sandø, J Tjiputra (2018). Future ecosystem changes in the Northeast Atlantic: a comparison between a global and a regional model system ICES Journal of Marine Science, https://doi.org/10.1093/icesjms/fsy088
- Utne KR, Hjøllo SS, Huse G, Skogen M. (2012). Estimating consumption of Calanus finmarchicus by planktivorous fish in the Norwegian Sea using a fully coupled 3D model system. Marine Biology Research 8:527_47.

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