Incorporating climate change into Management strategy evaluations

Nis Sand Jacobsen
DTU Aqua
@nissandjac
nsja@aqua.dtu.dk

How can we manage resources that have large variability? Management strategy evaluation (MSE)

- Investigate uncertainty, management rules, and potential biological changes
- A collaborative effort between stakeholders, scientists, and managers
- Closed loop simulation which includes an operating model, estimation model and a management model

Climate effects in management strategy evaluations

- Often tests recruitment hypothesis in combination with climate indices
- The inherent uncertainty modeled in MSEs often makes the noise to signal ratio high for climate indices
- Climate change can become important in terms of spatial redistribution of stocks
- Can be modeled in operating models and/or estimation models to improve management or knowledge of a stock

Pacific hake

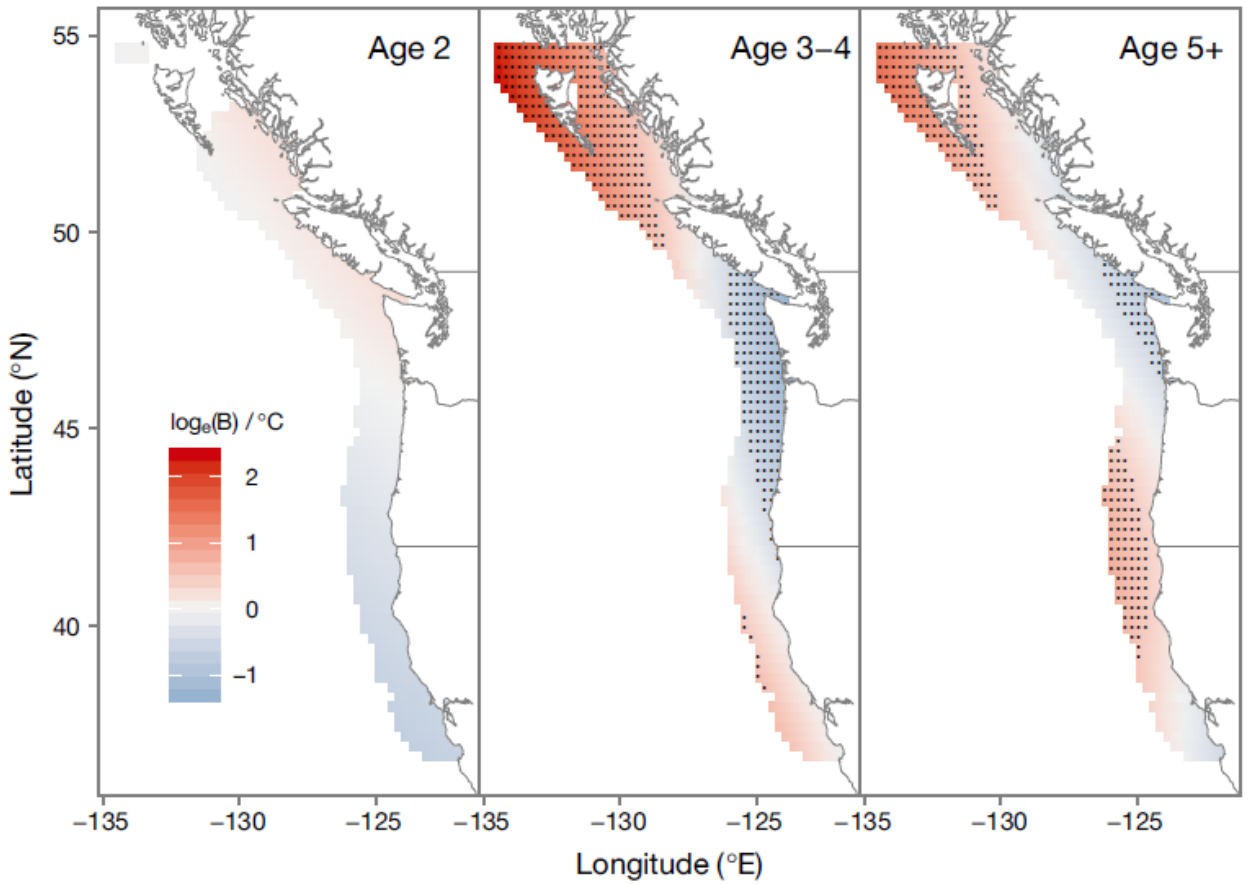
- Annual catch approx. 400 thousand tonnes
- Total allowable catch shared between USA (76%) and Canada (24%) based on a treaty agreement
- Currently, most fish spawn in the Southern California current, and then move to Canada during the year
- Recently, warmer years have pushed fish further north towards Canada
- Characterized by large recruitment variability
- Stock assessment is an age based single species model with acoustic survey, age compositional, and catch-data. No spatial patterns assumed

Hake change their distribution based on ambient temperature

We created a spatial and seasonal model of Pacific hake

Movement rates between areas (going North) was either allowed to remain constant, a medium, or high increase

Recruitment was assumed to occur south, so most spawning biomass was present there in the beginning of the year



Malick et al 2020, MEPS

Conceptual Pacific hake MSE simulation framework

Operating model

- Movement
- Recruitment (stochastic)
- Mortality

Data generation

- Catch
- Survey (reported w. error)
- Age compositions

x years

Into the future

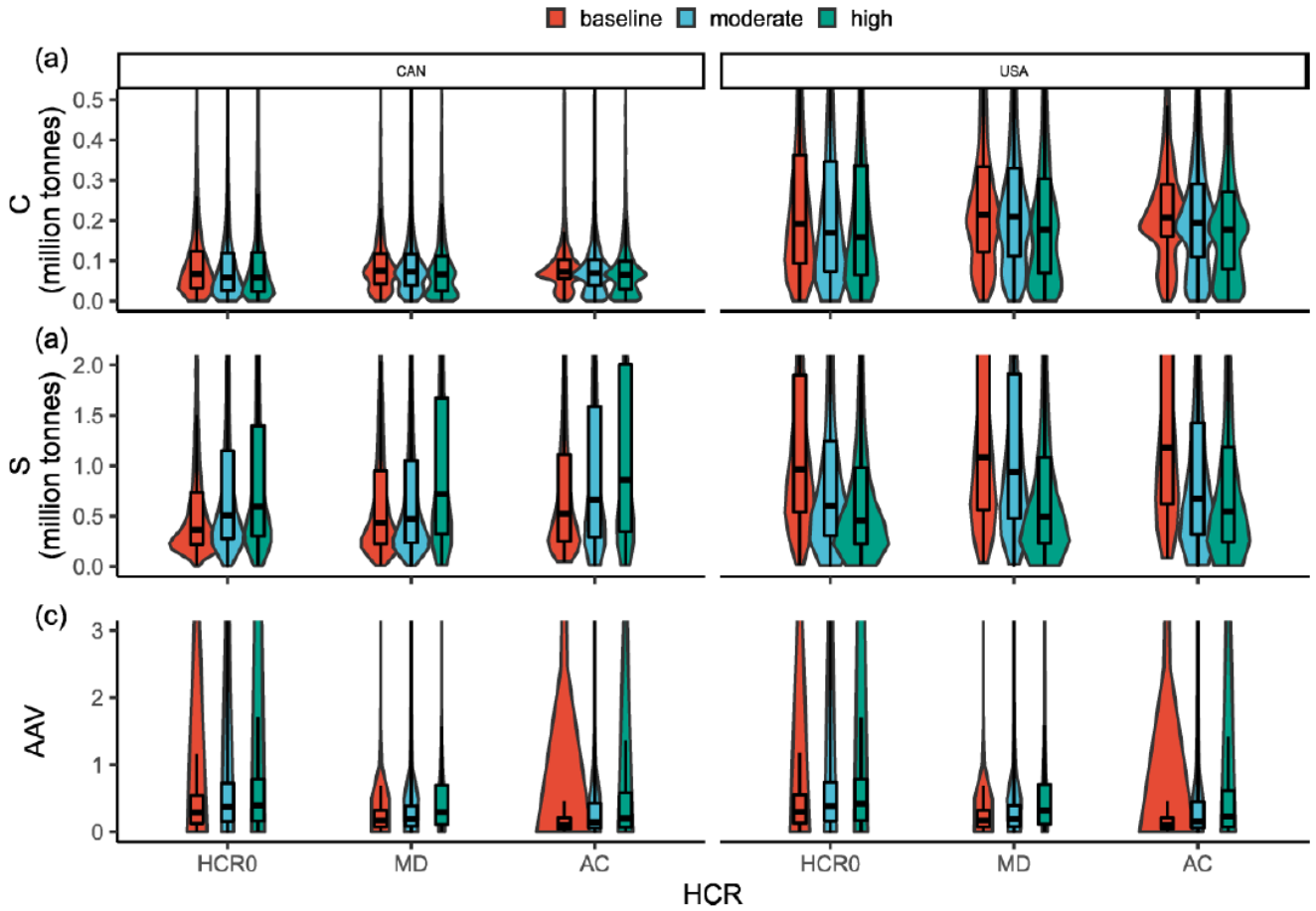
Estimation model

- Fishing mortality
- Stock status
- Reference points

Harvest control rule

- Total allowable catch

Meeting objectives when movement changes in the future

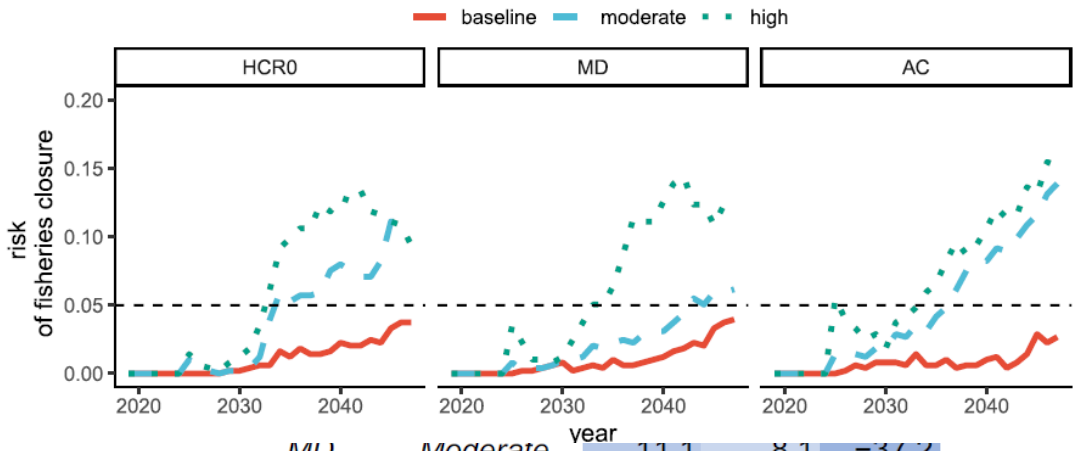


Jacobsen et al 2022, ICES JMS

With no action, the impact of movement is almost exclusively negative

Good Bad

% change in performance metrics



MD	*Moderate*	11.1	8.1	−37.2
AC	*Moderate*	2.3	4.3	−42.3
HCR_0	*High*	−17.8	−18.9	32.5
MD	*High*	−7.9	−5.8	4.4
AC	*High*	−9.2	9	−27.7

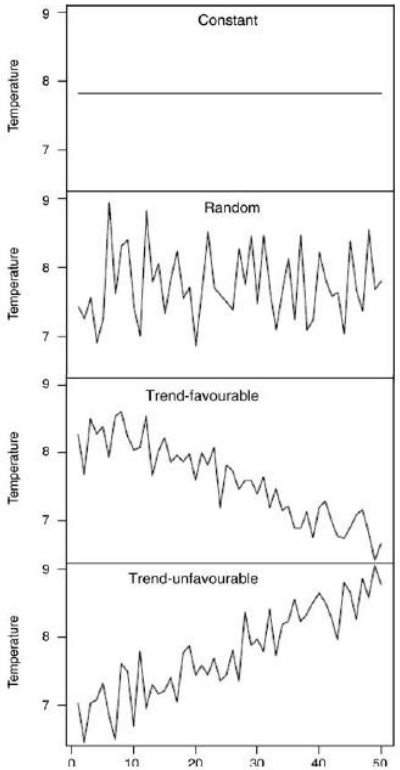
Jacobsen et al 2022, ICES JMS

Conclusion

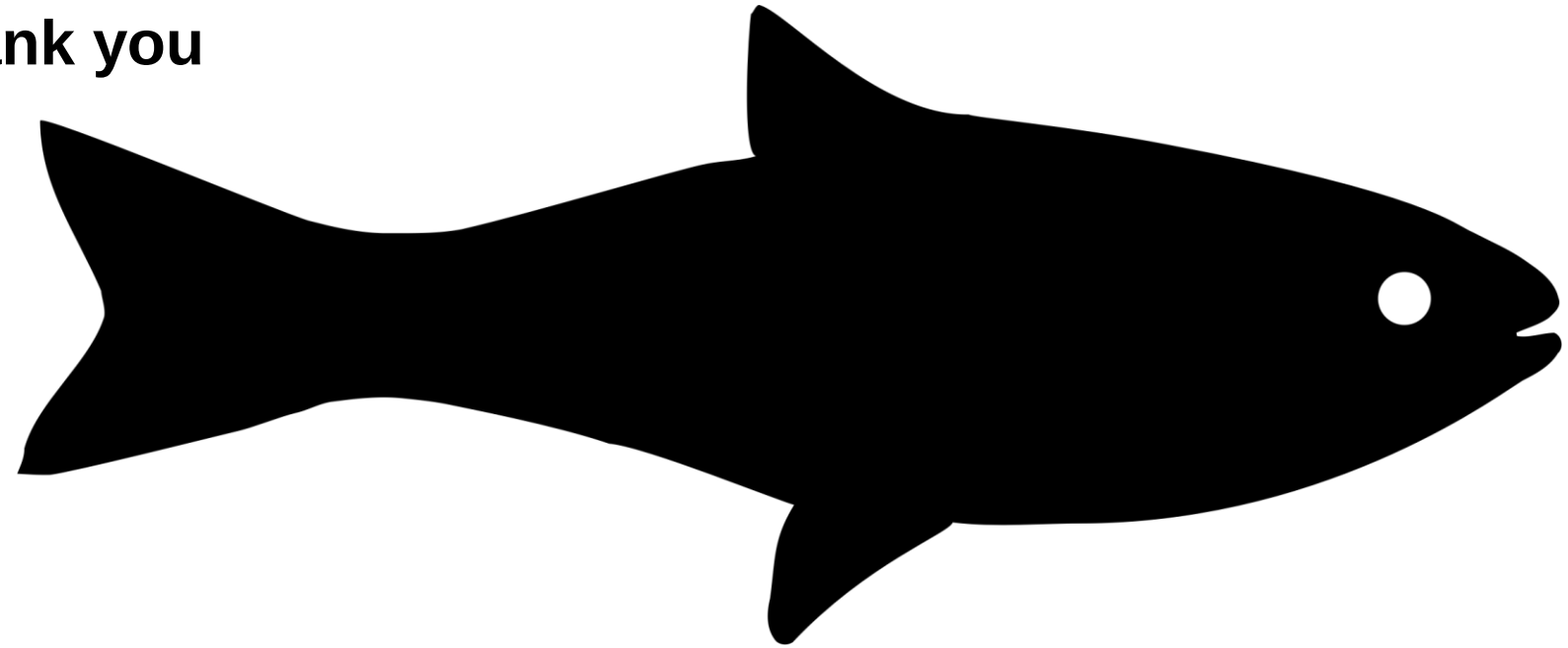
- Future changes in distribution can lead to issues with allocating quota
- Can lead to detrimental effects, such as lowered total catch, higher variation and less spawning biomass
- Risk of fisheries closure increased in all scenarios where northward movement increased

Climate change in MSEs

- Currently, effects of climate have only been included in few MSEs, almost all as recruitment indices
- It can be included as either misspecified operating models, or as a part of estimation models
- Climate change can affect vital rates, density dependence and spatial distribution
- The ecosystem approach to fisheries should be considered when designing MSEs



Thank you



Github : https://github.com/nissandjac

Email : nsja@aqua.dtu.dk

Twitter: @nissandjac

Climate-mediated stock redistribution causes increased risk and challenges for fisheries management

Nis S. Jacobsen[1,2], Kristin N. Marshall[1], Aaron M. Berger[3], Chris Grandin[4] and Ian G. Taylor[1]

[1]Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 2725 Montlake Blvd. East, Seattle, WA 98112-2097, USA
[2]Technical University of Denmark, National Institute of Aquatic Resources, Kemitorvet 1, Lyngby 2800, Denmark
[3]Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 2032 SE OSU Dr Bldg. 955, Newport, OR 97365-5275, USA
[4]Pacific Biological Station, Fisheries and Oceans Canada, 3190 Hammond Bay Road, Nanaimo, BC V9T 6N7, Canada

* *Corresponding author: tel: +4535883390;* e-mail: nissandjac@gmail.com.