Evaluating drivers of spatiotemporal changes in the condition of Eastern Baltic cod

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Acknowledgements

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- People involved in data collection

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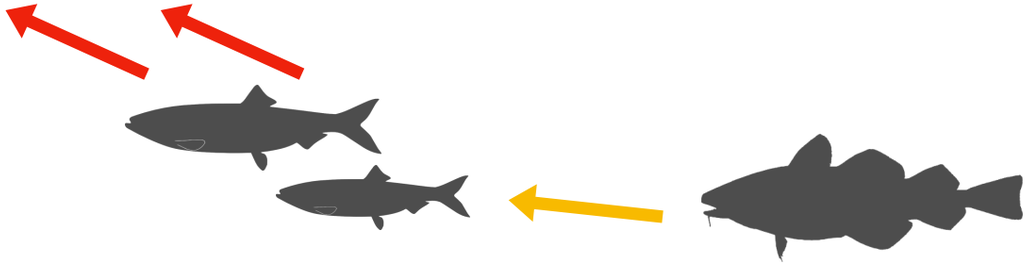
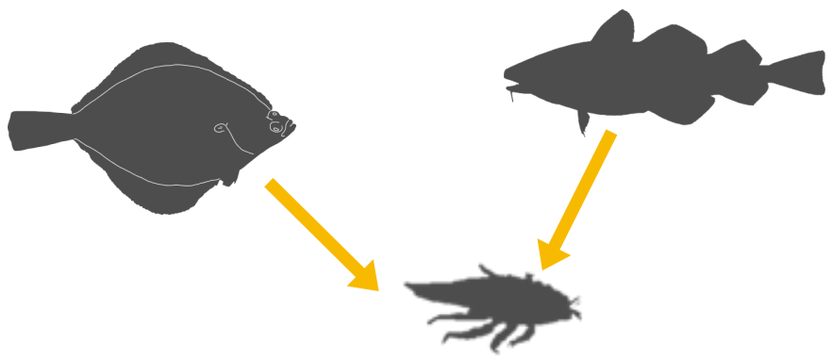
phylopic.org

Proposed causes



- Competition for benthic resources
- Spatial mismatch with pelagic prey
- Lack of right-sized pelagic prey



- Direct effects of oxygen

Casini et al. (2016b); Gårdmark et al. (2015); Orio et al. (2019, 2020); Neuenfeldt et al. (2020); Svedäng & Hornborg (2014); Limburg and Casini (2019); Svedäng et al. 2020)

Working questions

- Which variables are related to condition and how strongly?
- How has diets of cod changed over time?

Condition & density data

- Condition of individual i at spatial location s at time t
- Density of cod in haul i at spatial location s at time t
- Prey weight in individual i at spatial location s at time t

Approach

- Spatiotemporal data rich in ecological information, but come with particular features:

- Data closer in space are more similar

- Covariates can account for some of this dependence, but not all

Condition & density models

- Spatial and spatiotemporal Gaussian random fields
- Student-t distribution for condition | Tweedie for CPUE and stomach

$$E(y_{s,t}) = \mu_{s,t}$$

$$\mu_{s,t} = f^{-1}(X\beta + \omega_s + \epsilon_{s,t})$$

$$\boldsymbol{\omega} \sim \text{MVNormal}(0, \Sigma_\omega)$$

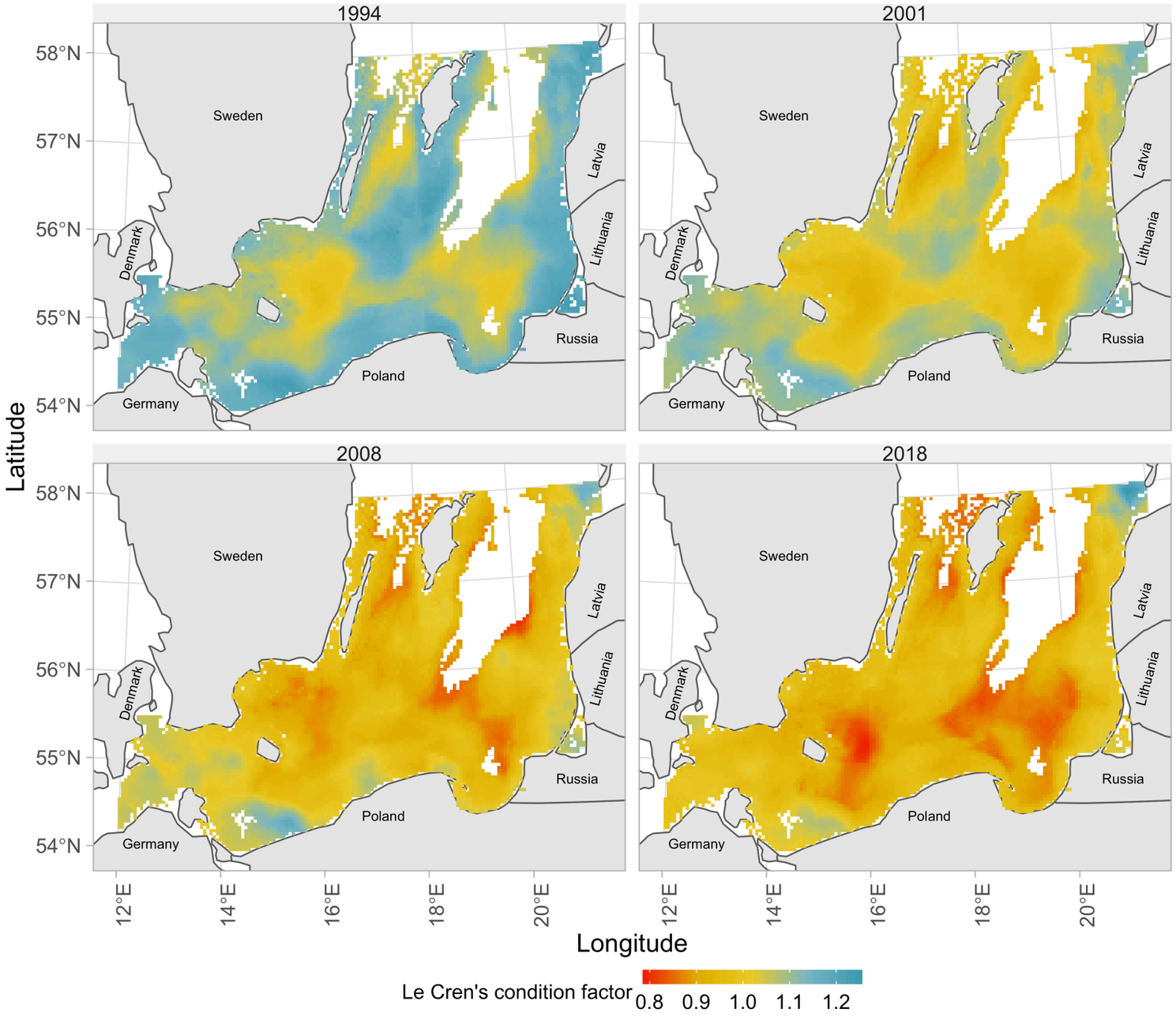
$$\boldsymbol{\epsilon_t} \sim \text{MVNormal}(0, \Sigma_\epsilon)$$

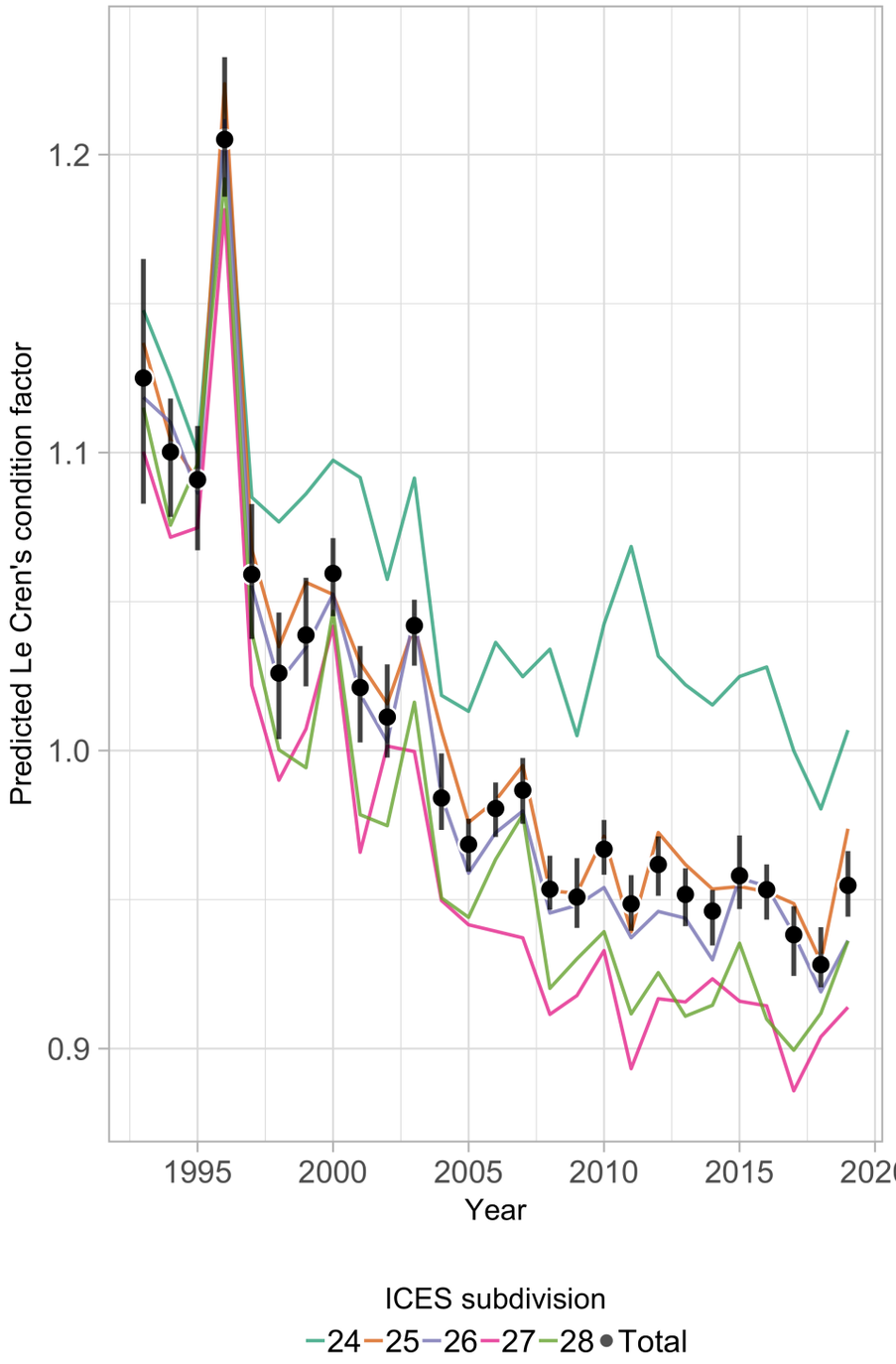
'sdmTMB' (Anderson and Ward, 2019; Anderson et al., 2021; Barnett et al., 2021) ; 'R-INLA' (Rue et al., 2009) ; 'TMB' (Kristensen et al., 2016)

1. Spatiotemporal condition & distribution model

2. Historical feeding

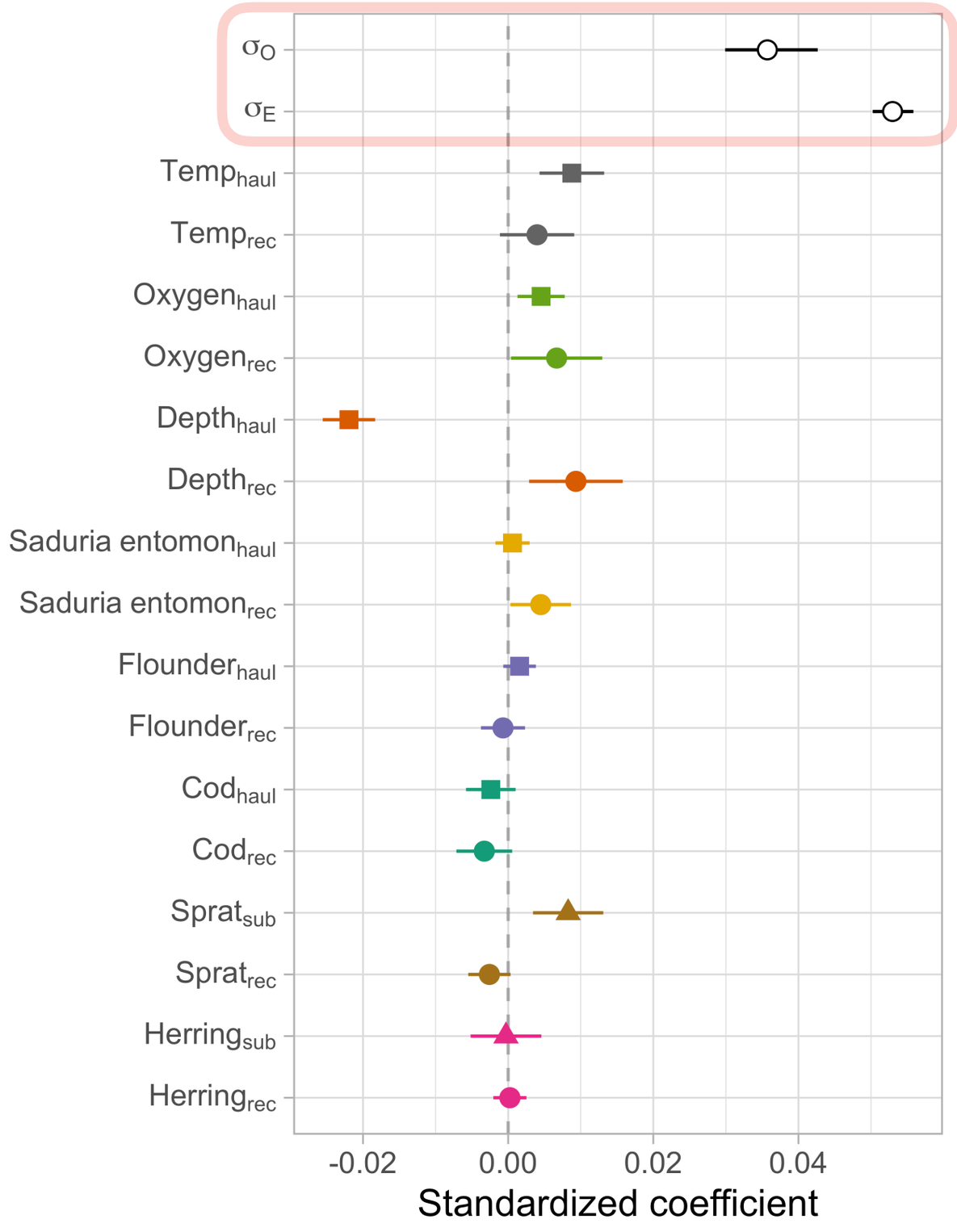
Condition declines in the whole southern Baltic





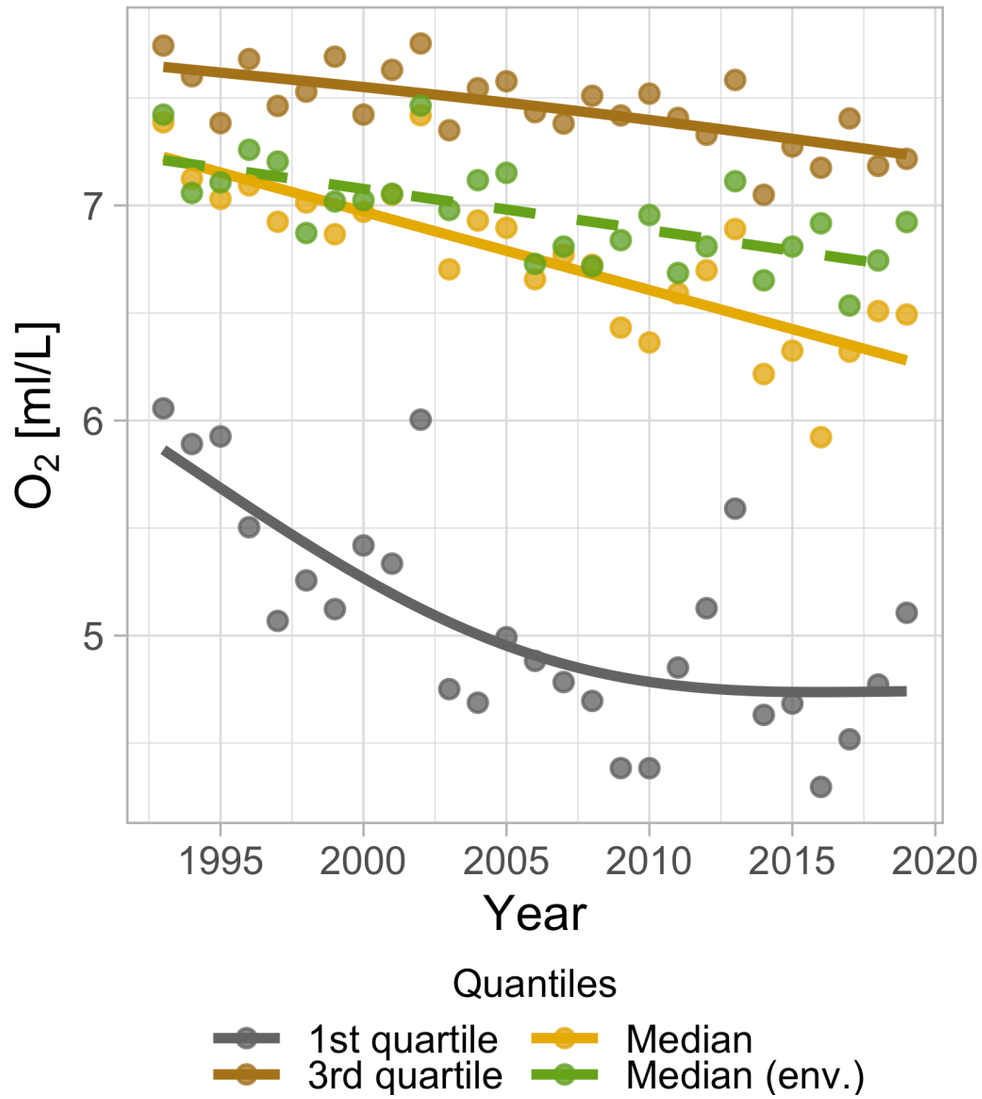
Lindmark et al (2022) bioRxiv https://doi.org/10.1101/2022.04.19.488709

Larger magnitude of residual spatiotemporal variation than covariates



Lindmark et al (2022) bioRxiv

Oxygen positively related to condition, but cod experience high oxygen on average…

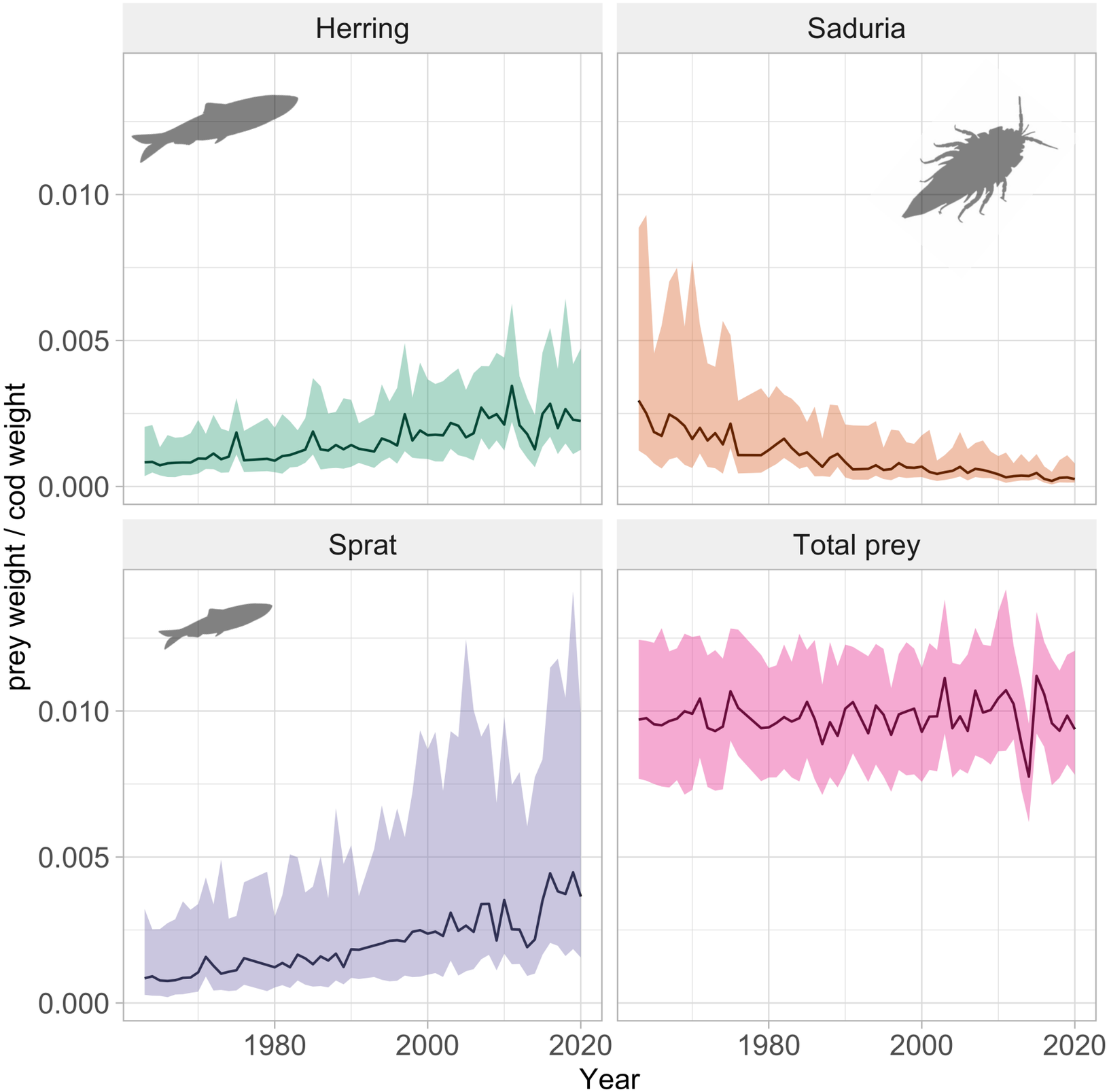


Lindmark et al (2022) bioRxiv

1. Spatiotemporal condition & distribution model

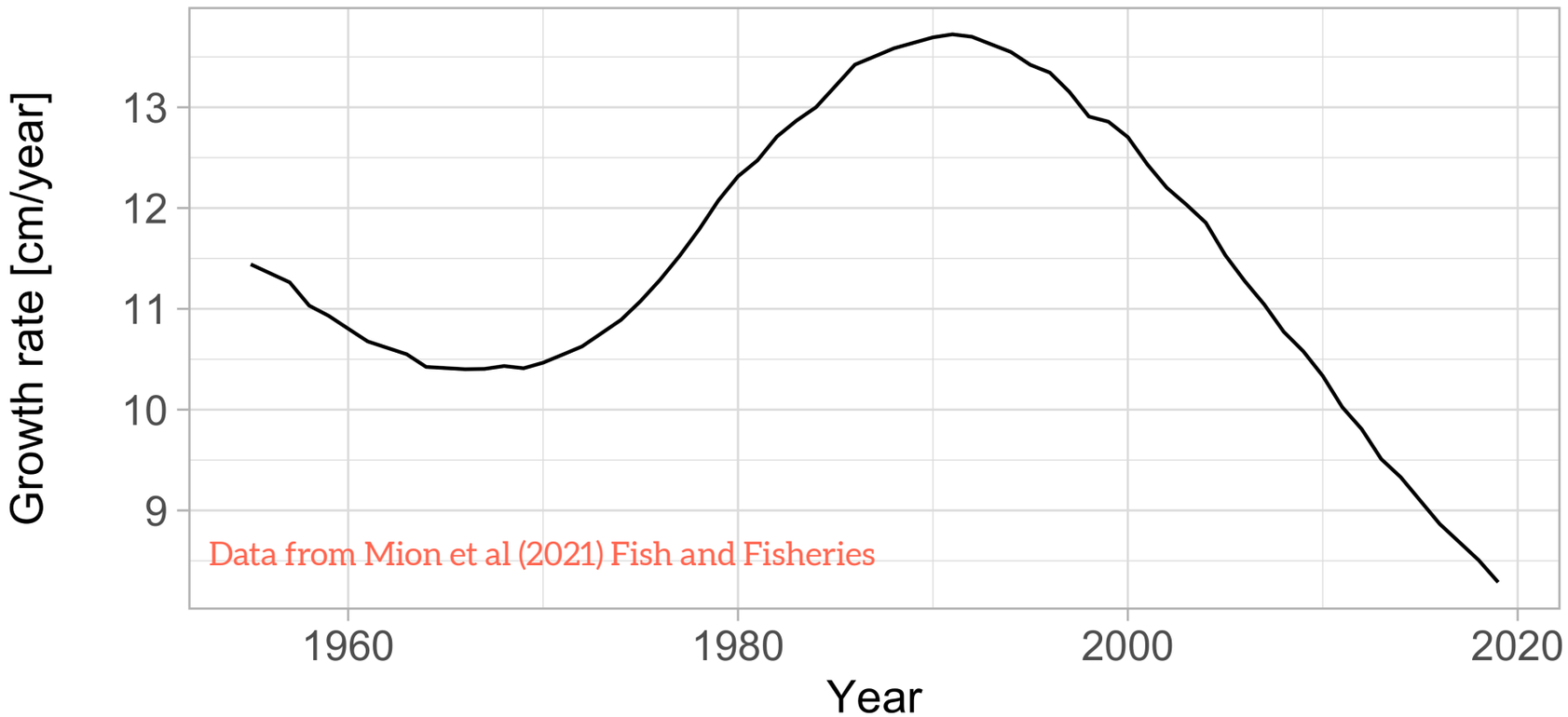
2. Historical feeding

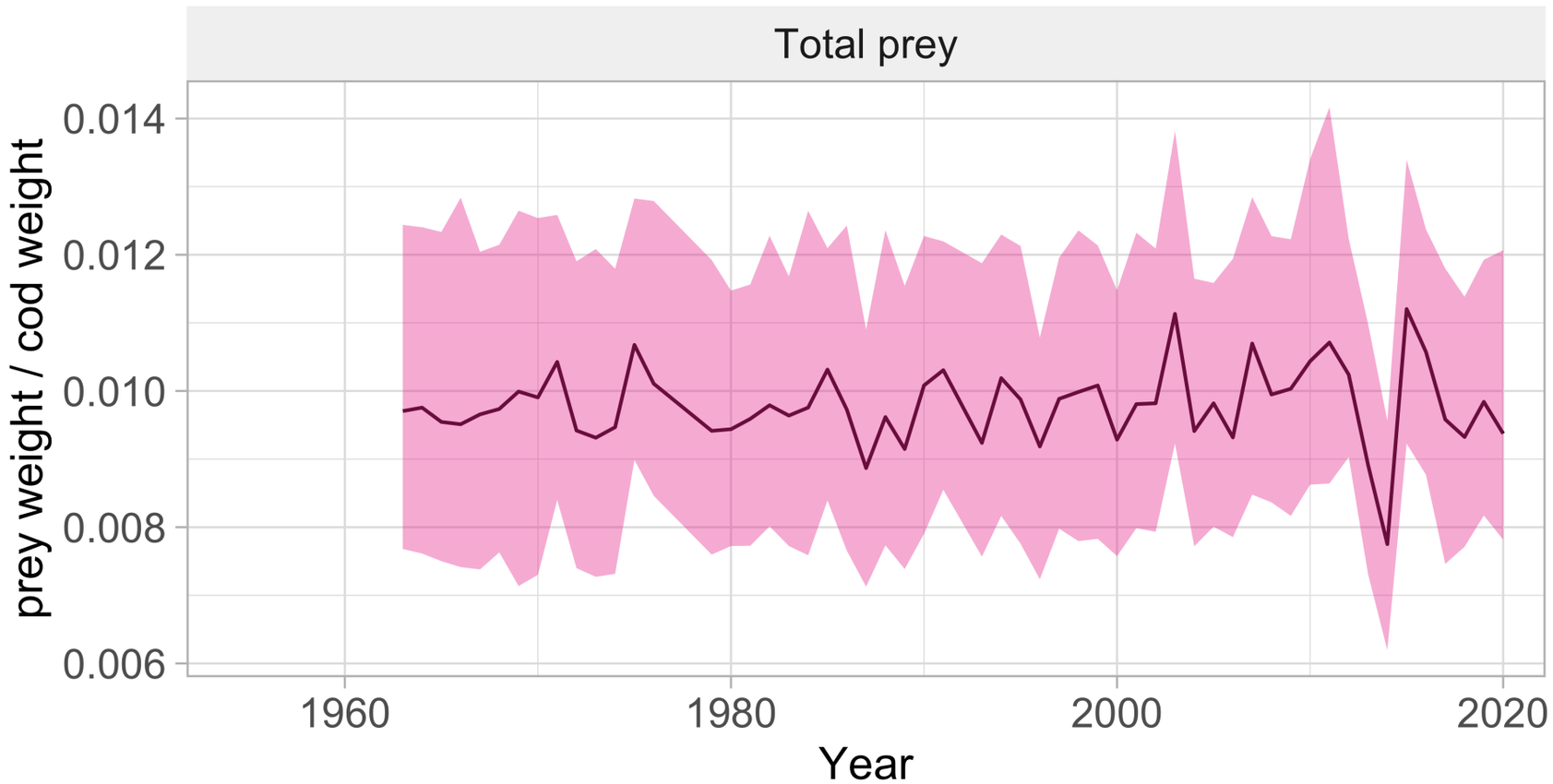
Pelagic species ↑, benthic ↓, but total prey remains stable…



Lindmark et al (2022) in prep

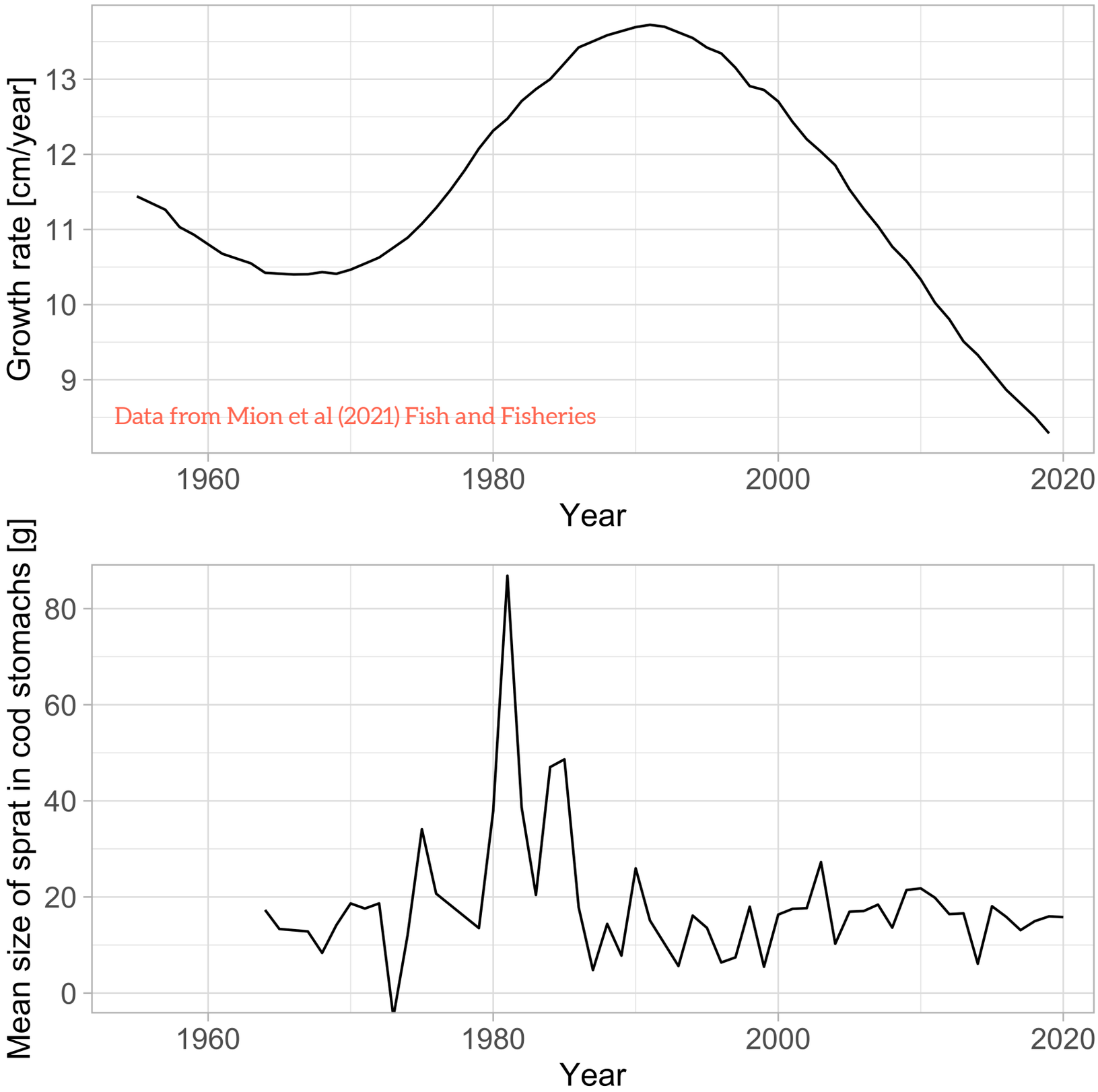
But growth trends are unimodal...





Lindmark et al (2022) in prep

Sprat size in stomachs peaks in 80's before growth outburst



Lindmark et al (2022) in prep

Summary & outlook

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- Small effects of covariates, latent spatial processes important!

- Weight of food in stomach unchanged over time despite drastic changes in growth

- Important to evaluate broader changes in diet over long time scales & think about reference state

Thank you for listening!

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Extra slides