JOURNAL ARTICLE

Incorporating distribution shifts and spatio-temporal variation when estimating weight-at-age for stock assessments: a case study involving the Bering Sea pollock (*Gadus chalcogrammus*)

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ICES Journal of Marine Science, Volume 80, Issue 2, March 2023, Pages 258–271,
https://doi.org/10.1093/icesjms/fsac236

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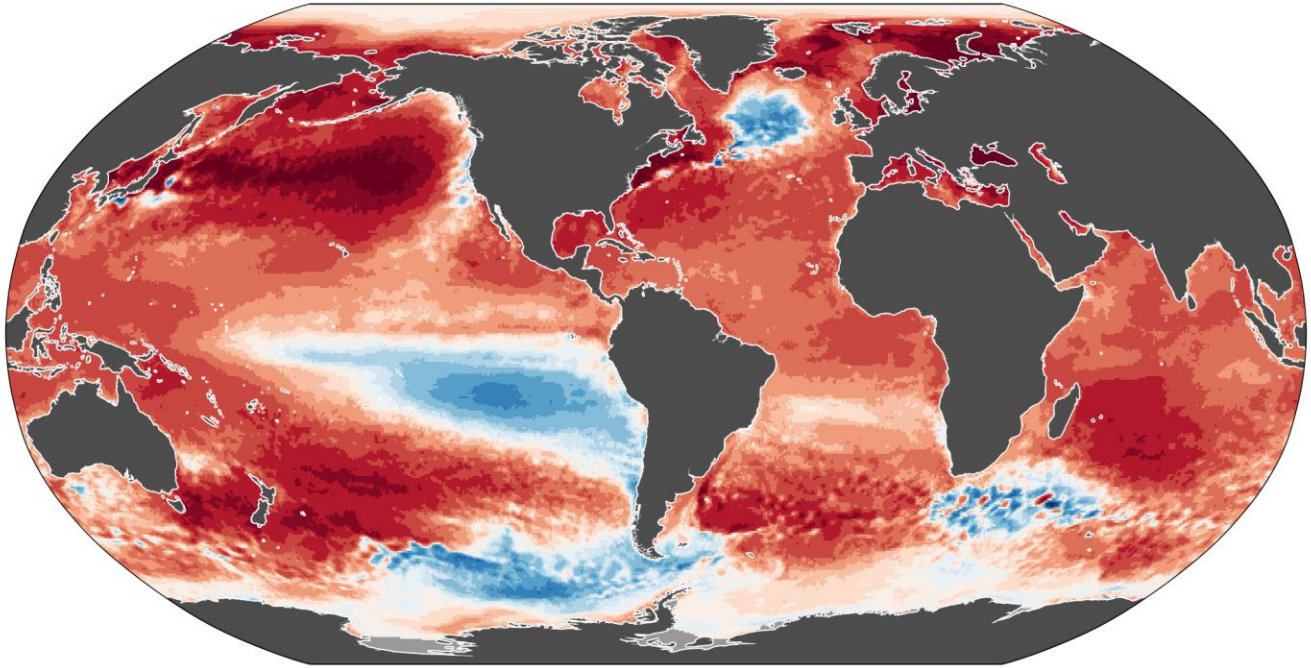
Trend in sea surface temperature for 1993–2023

Data: ESA CCI SST v3.0 • Reference period: 1991–2020 • Credit: C3S/ECMWF



Trend (°C per decade)

-0.5 -0.25 -0.125 -0.05 0 0.05 0.125 0.25 0.5

Copernicus Climate Change Service
European State of the Climate | 2023

PROGRAMME OF THE EUROPEAN UNION

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Europe's eyes on Earth

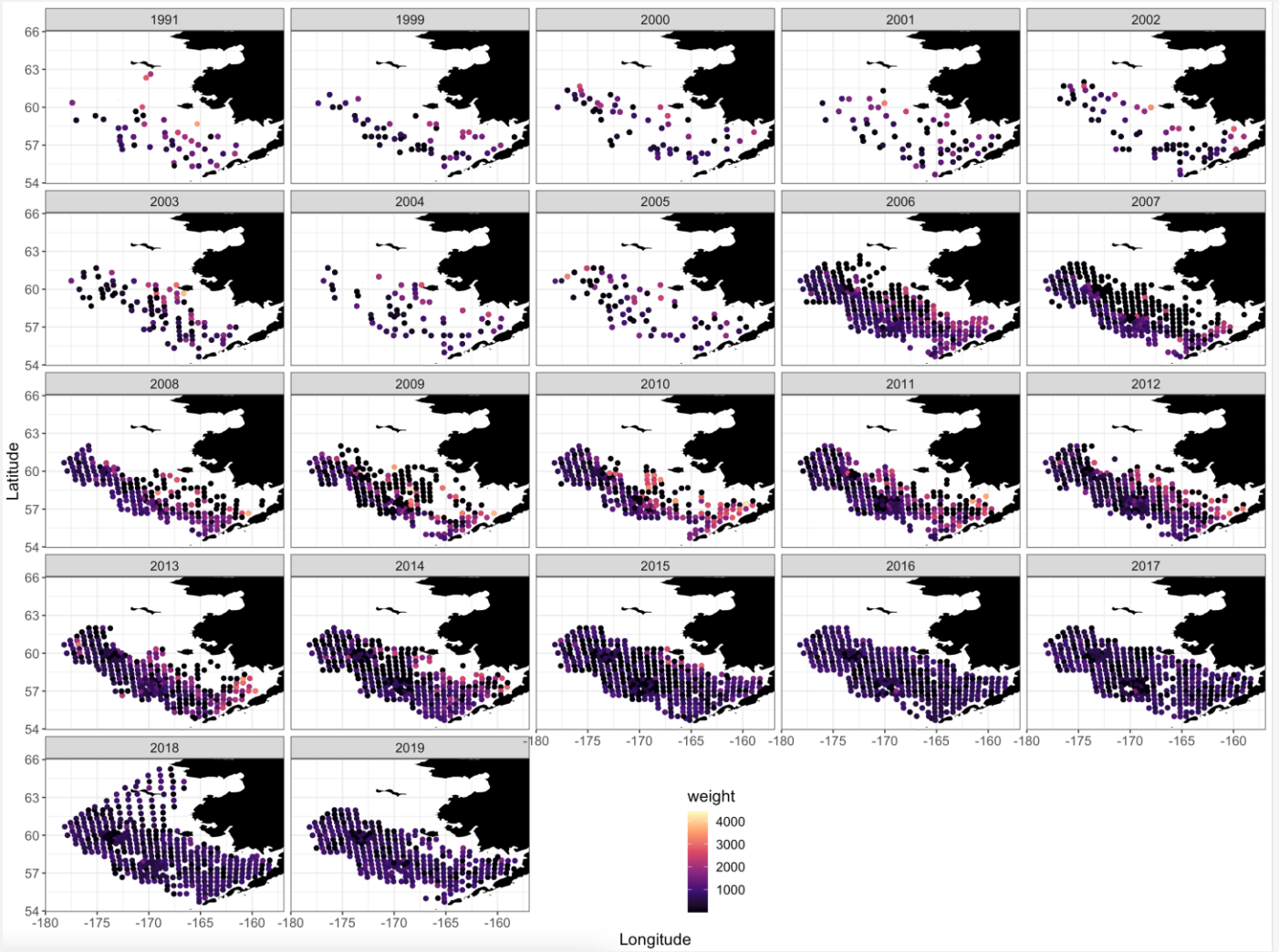
IMPLEMENTED BY ECMWF


Age


Length


Abundance


Weight


1991
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Latitude
66
63
60
57
54
-180
-175
-170
-165
-160
Longitude
weight
4000
3000
2000
1000


BEAUFORT SEA
CHUKCHI SEA
RUSSIA
Bering Strait
ALASKA (UNITED STATES)
CANADA
BERING SEA
Gulf of Alaska


BEAUFORT SEA
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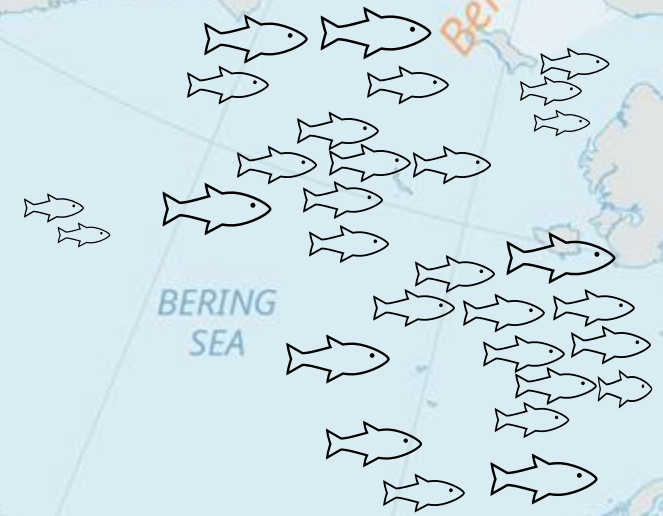
Gulf of Alaska


BEAUFORT SEA
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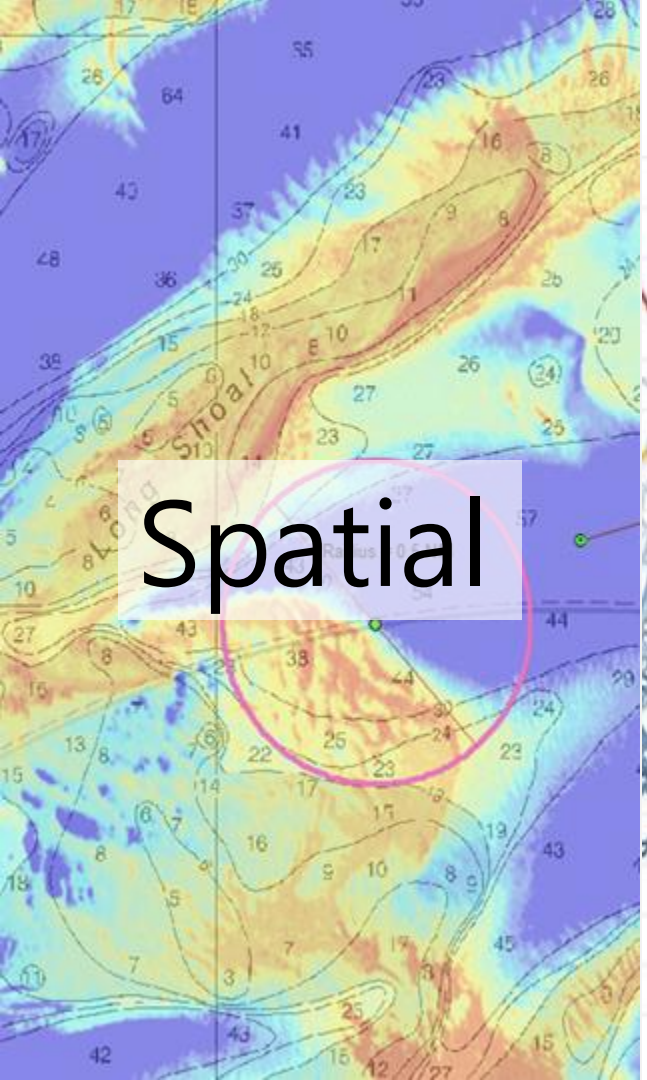
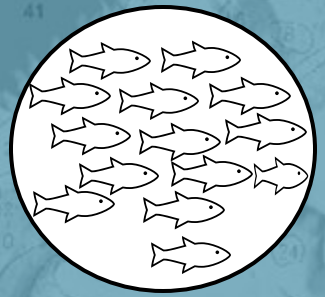


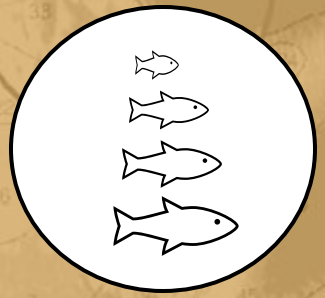
Spatial

Temporal

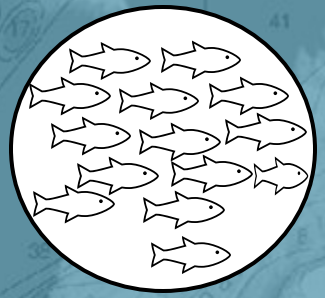
Spatio-temporal



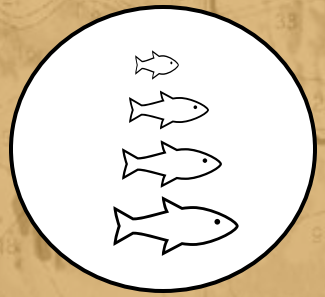
Local Abundance



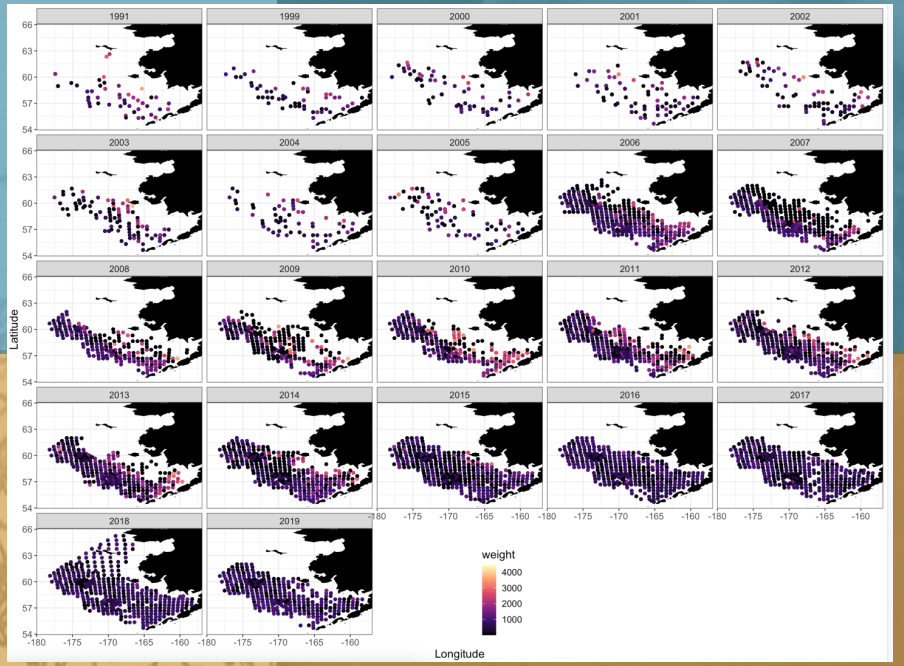
Local Growth



Local Abundance



Local Growth



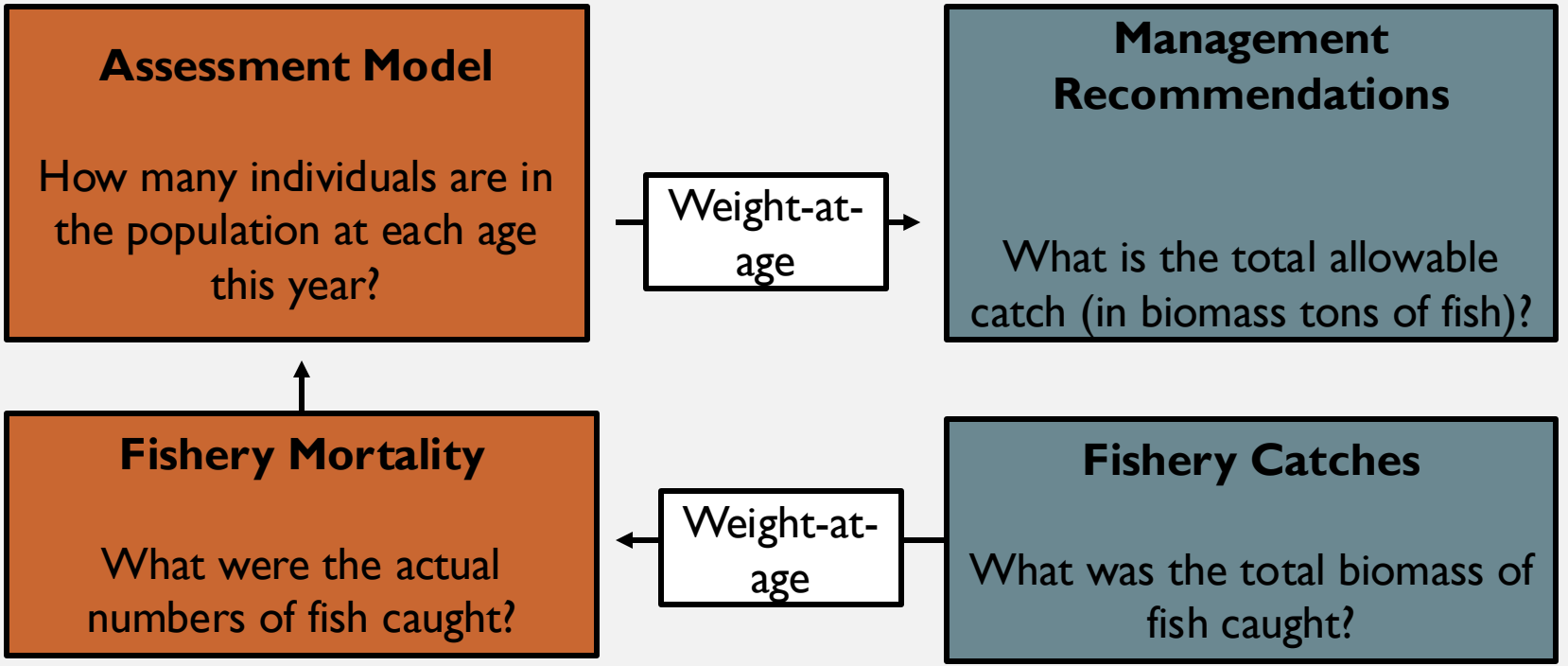
Ecology

Spatial management/Essential Fish Habitat

Stock assessments

Climate Change

Why does weight-at-age matter in the stock assessment?



Ianelli et al. 2019. Assessment of the Walleye Polliock Stock in the Eastern Bering Sea.


Age


Length


Abundance


Weight

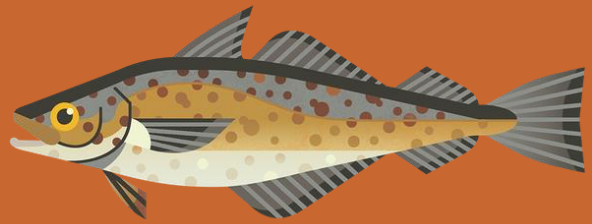
Why do we need to consider variation in size and abundance in the survey data?

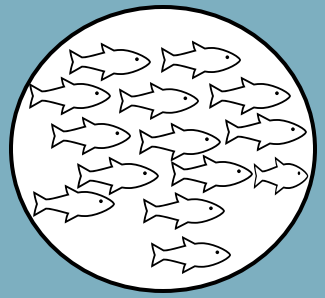
- Spatial gaps in data
- Shifts in fish distribution due to climate change
- Inherent unobserved variation

How does incorporating fine-scale variation over space and time and shifts in abundance into population-level weight-at-age impact the stock assessment?

Case Study:

Weight-at-age of walleye pollock in the Bering Sea and implications for the stock assessment

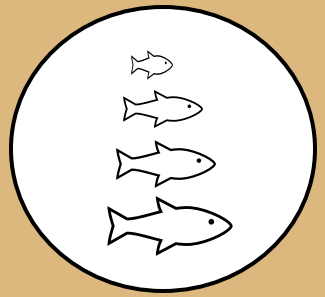




Local Abundance

VAST

$$log(N_{g_i,a_i,y_i}) = \underbrace{\beta_{a_i,y_i}}_{Temporal\ variation} + \underbrace{\omega_{a_i,g_i}}_{Spatial\ variation} + \underbrace{\varepsilon_{g_i,a_i,y_i}}_{Spatio-temporal\ variatio}$$

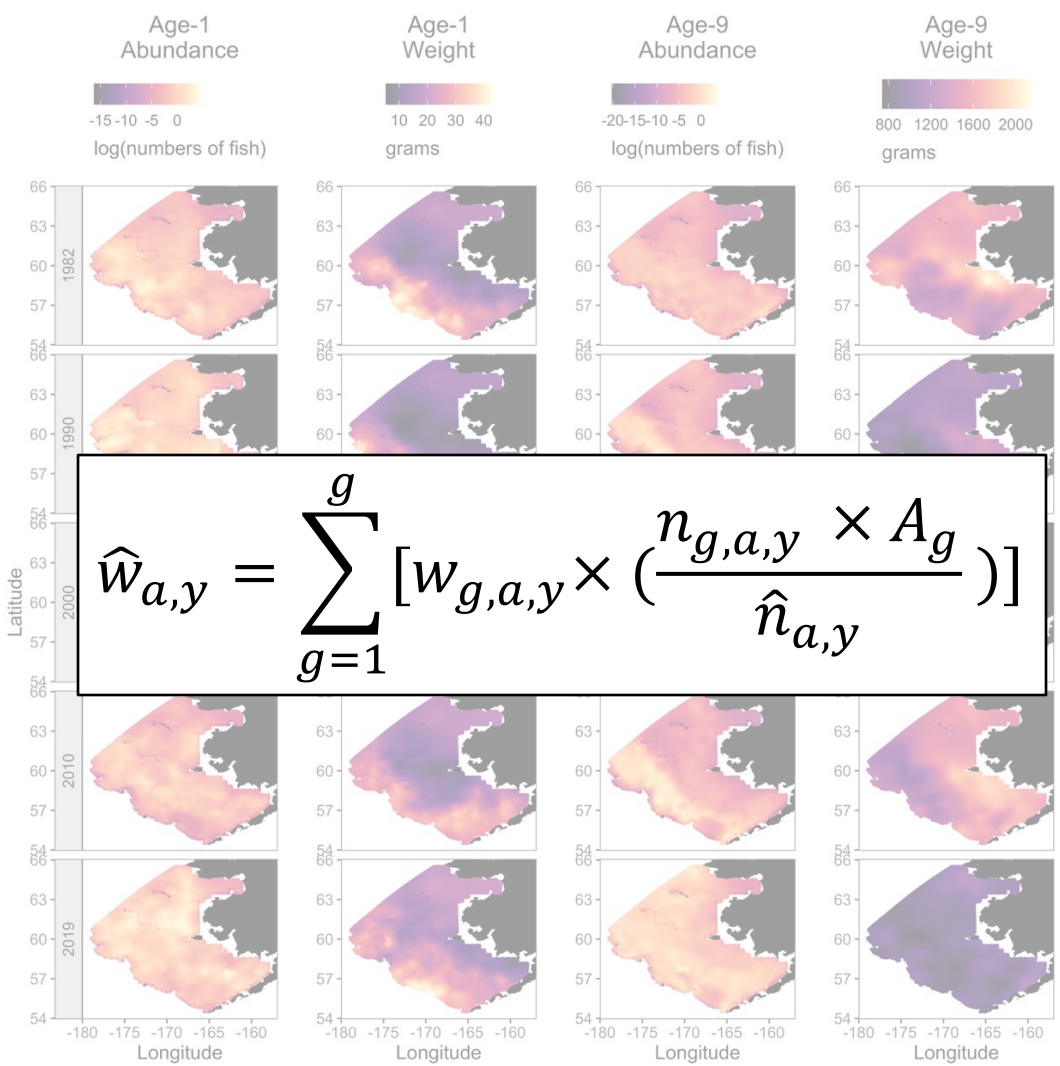


Local Weight

$$log(w_{g_i,a_i,y_i}) = \underbrace{\beta_{a_i,y_i}}_{Temporal\ variation} + \underbrace{\omega_{a_i,g_i}}_{Spatial\ variation} + \underbrace{\varepsilon_{g_i,a_i,y_i}}_{Spatio-temporal\ variatio}$$

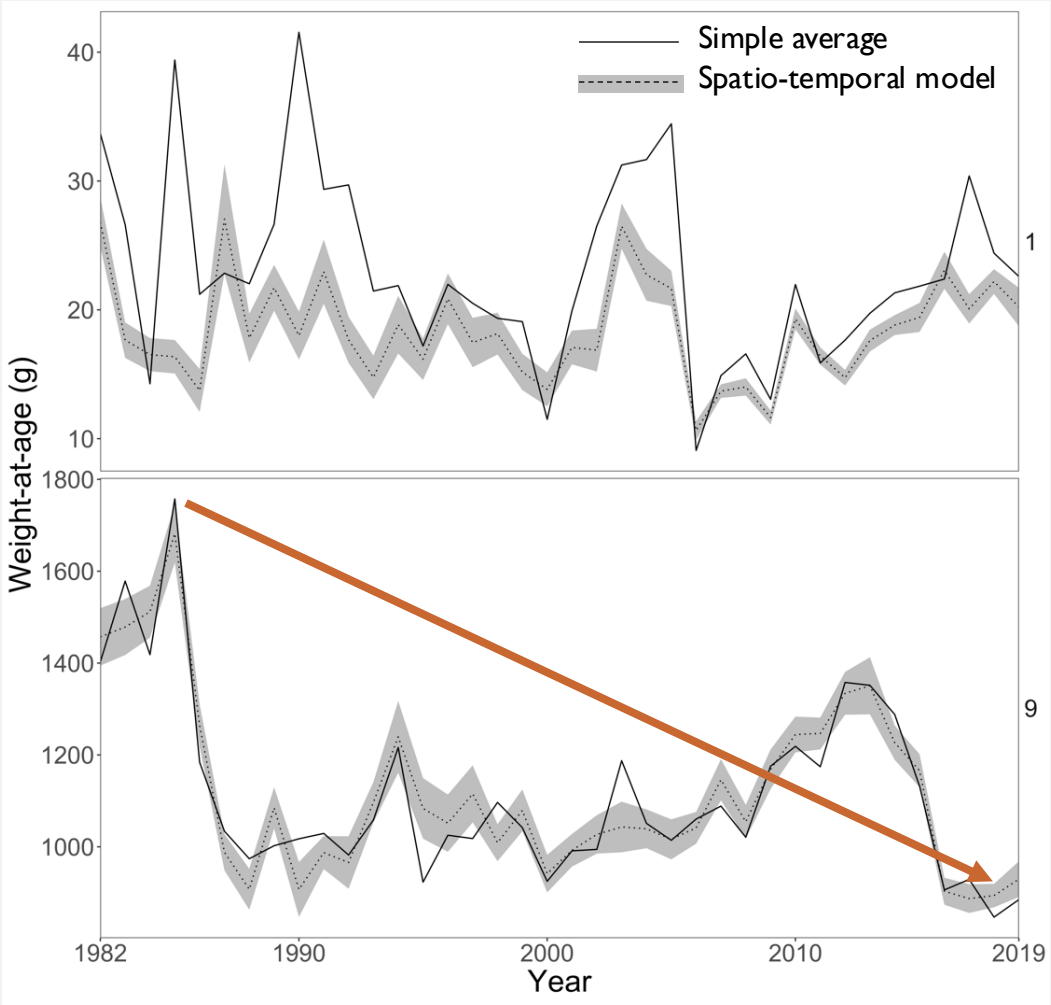
Thorson 2019. Guidance for decisions using Vector Autoregressive Spatio-Temporal (VAST) package in stock, ecosystem, habitat and climate assessments. Fish. Res. 210, 143-161.

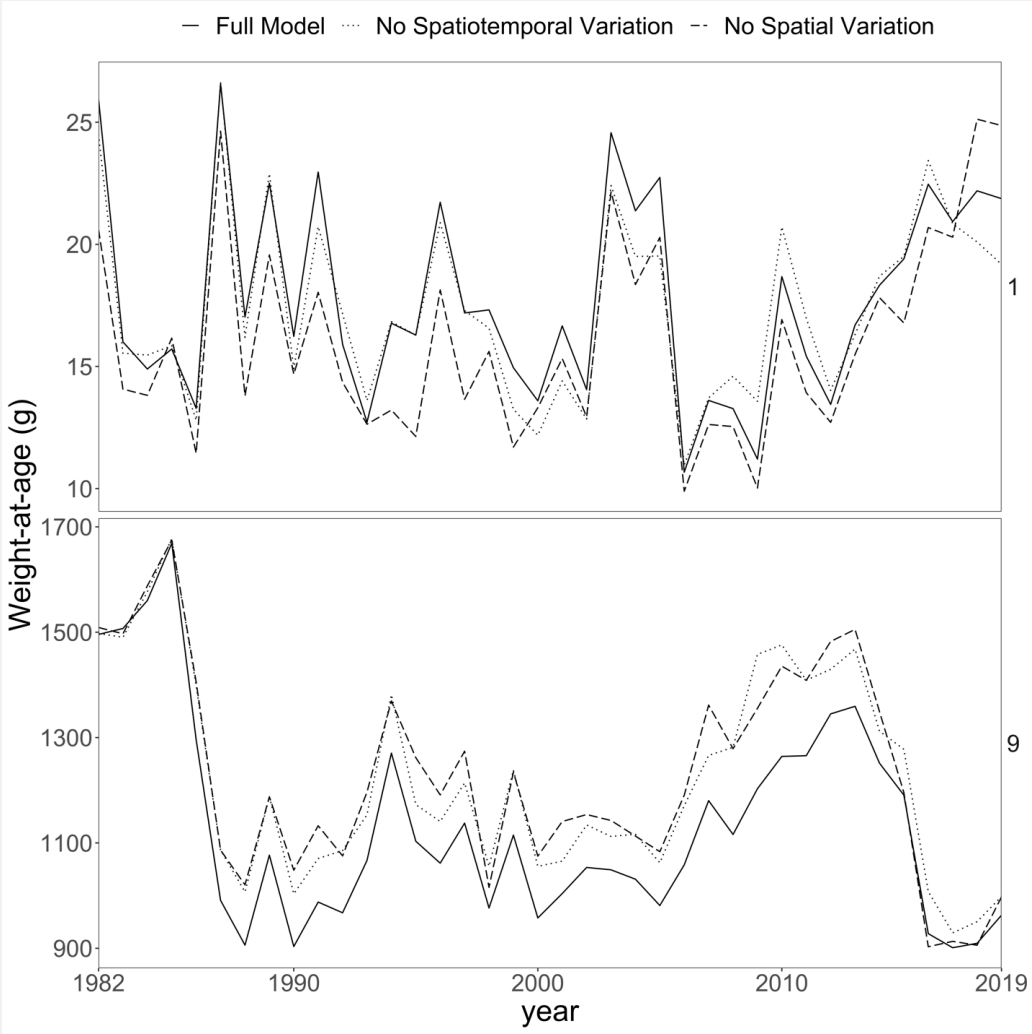
https://github.com/James-Thorson-NOAA/VAST



$$\hat{w}_{a,y} = \sum_{g=1}^{g} [w_{g,a,y} \times (\frac{n_{g,a,y} \times A_g}{\hat{n}_{a,y}})]$$

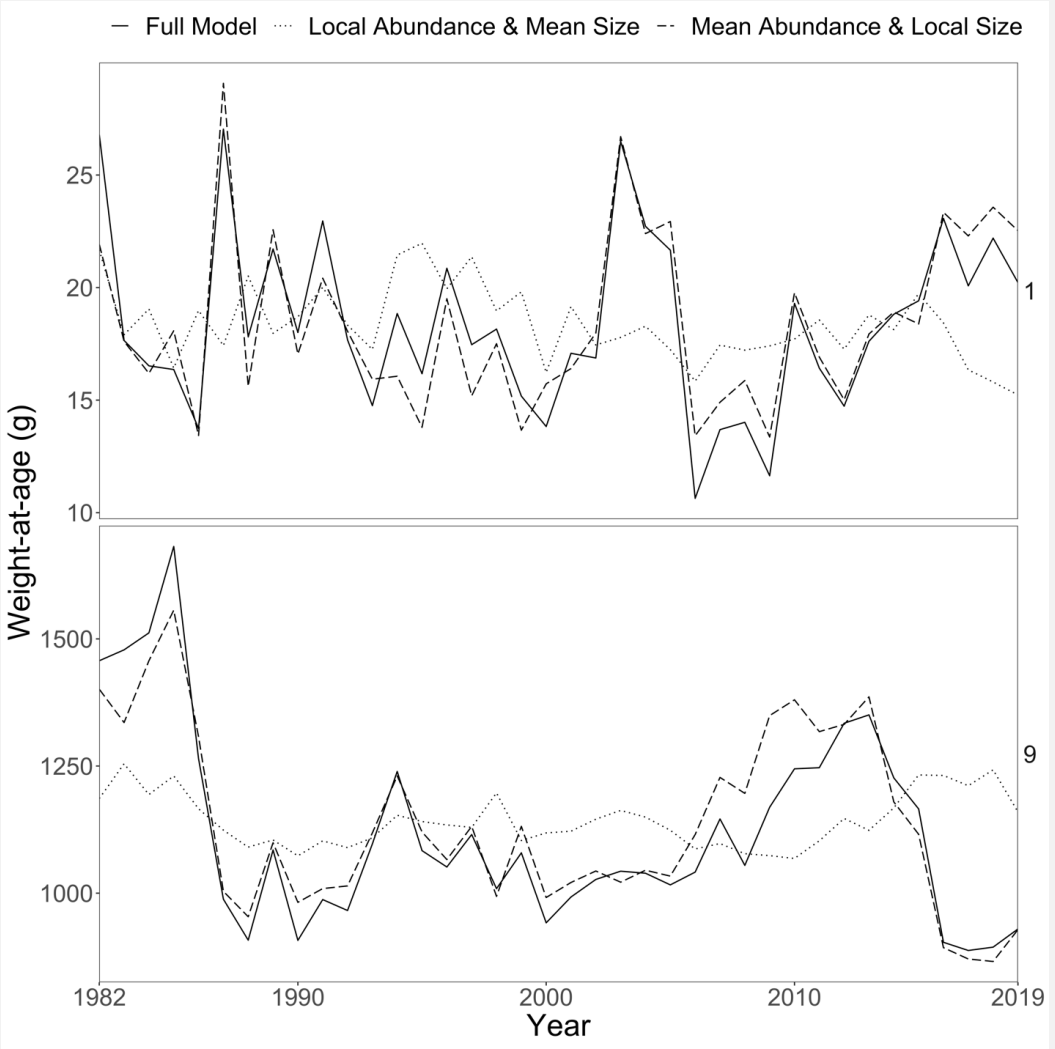
Change over time



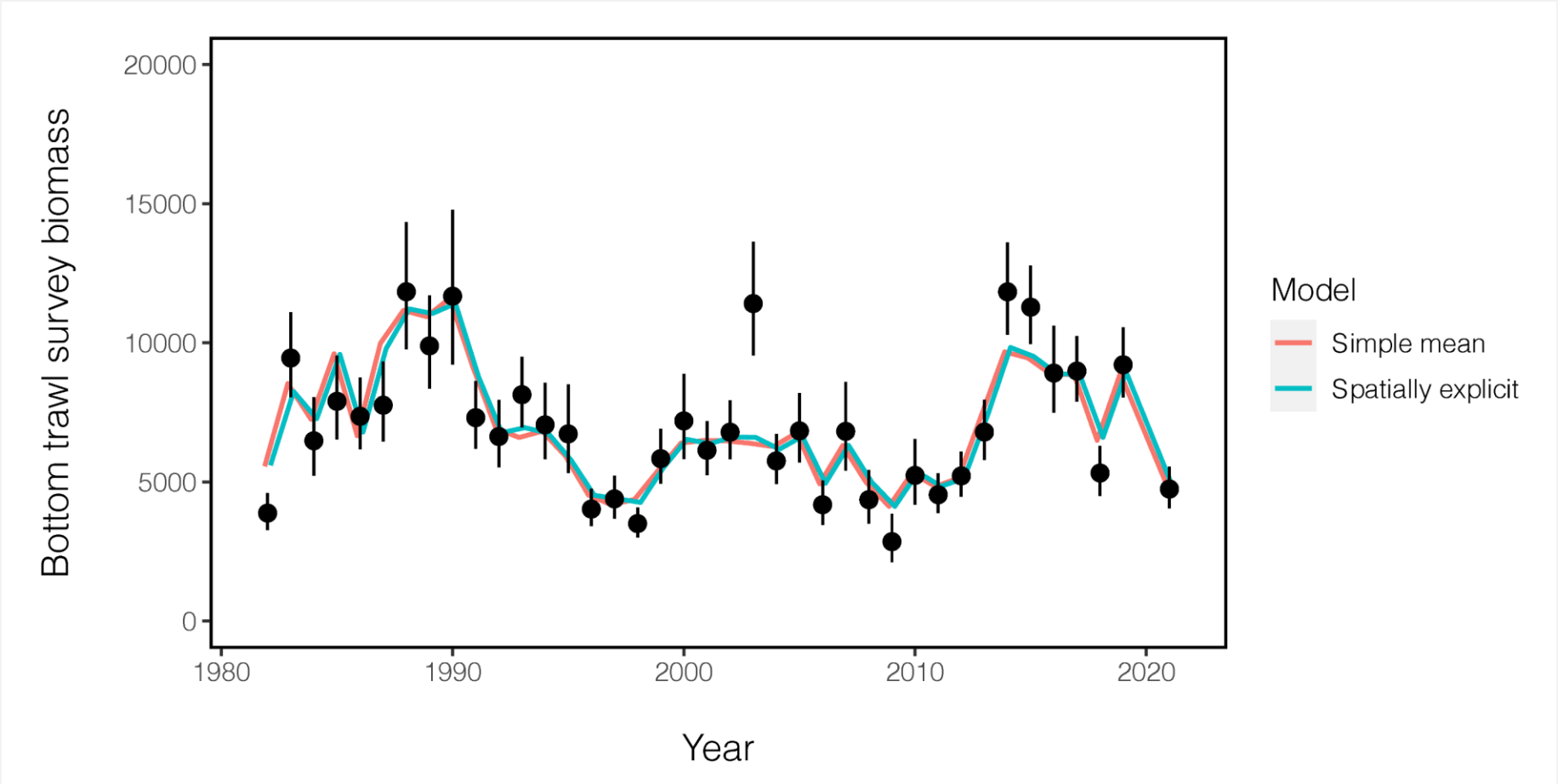


Spatial vs. spatio-temporal varaiation

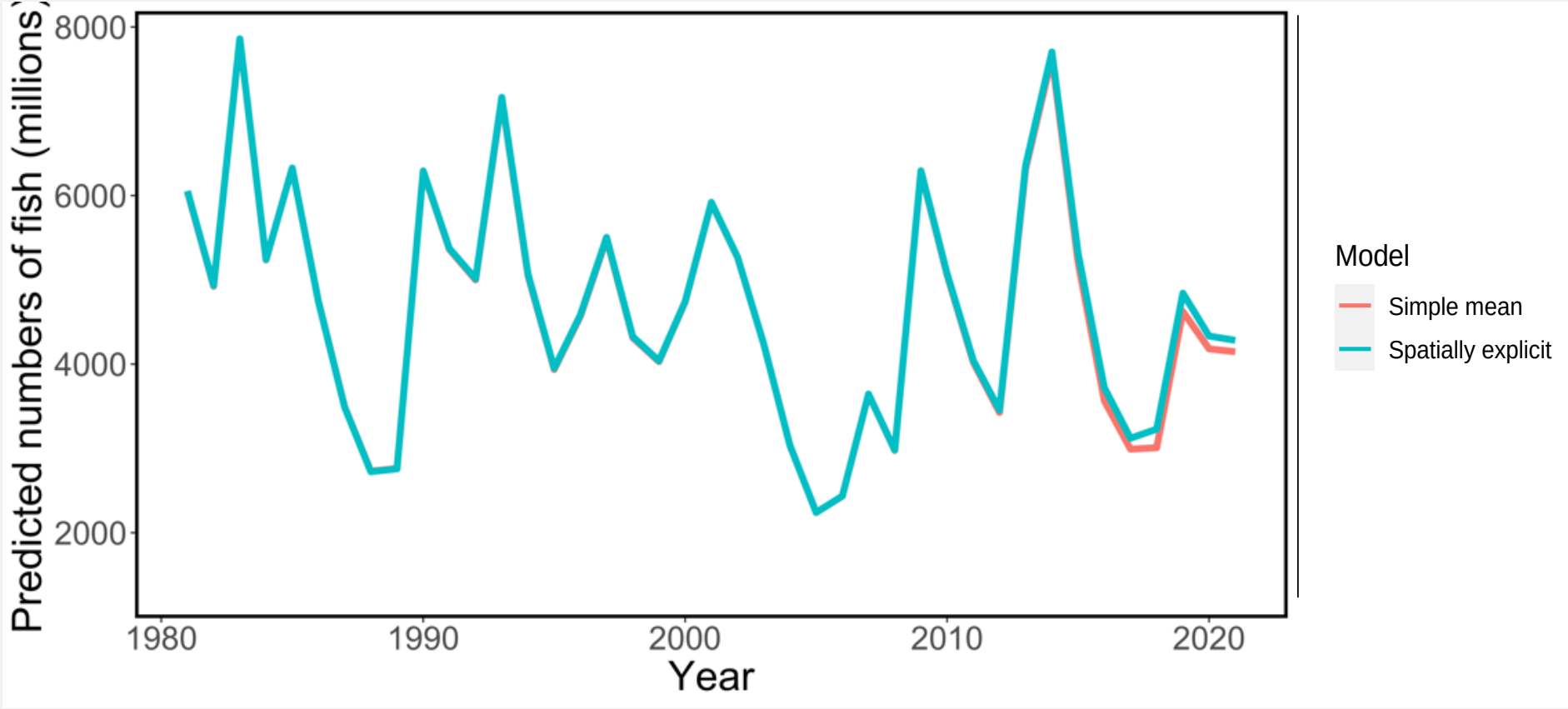
Local abundance versus local size



Impact on stock assessment



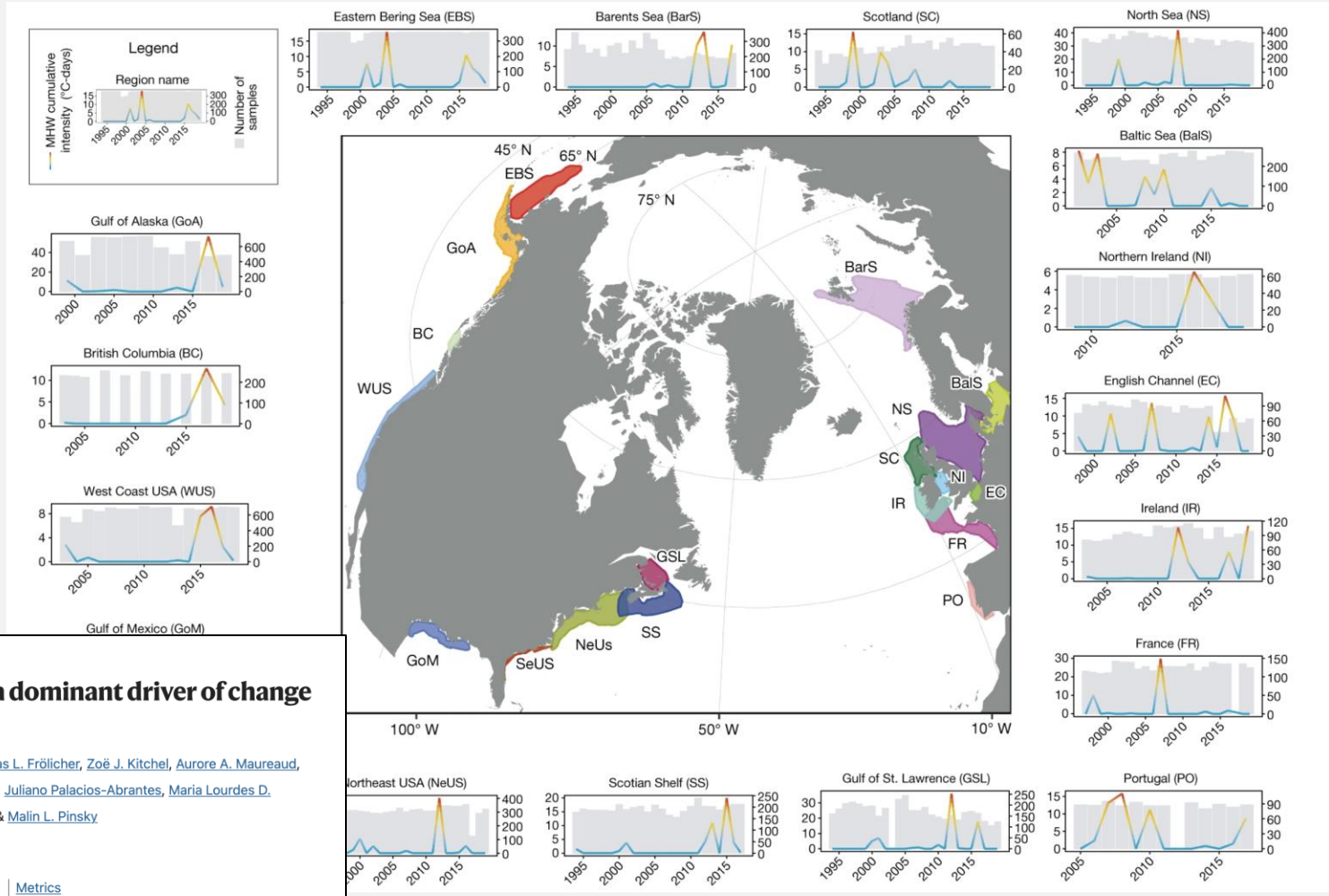
Impact on stock assessment



Ecology	*Fine-scale and decadal changes in different age classes*
Spatial management	*Identify hotspots*
Stock assessments	*Spatio-temporal weighted size-at-age matrix*
Climate Change	*Extrapolate to unsampled areas*

Future Directions & Applications

Ecology	*Environmental covariates, other characteristics, mechanisms*
Spatial management	*Growth*
Stock assessments	*Fishery size-at-age, cohort effects*
Climate Change	*Include environmental covariates*



Article | Published: 30 August 2023

Marine heatwaves are not a dominant driver of change in demersal fishes

Alexa L. Fredston, William W. L. Cheung, Thomas L. Frölicher, Zoë J. Kitchel, Aurore A. Maureaud, James T. Thorson, Arnaud Auber, Bastien Mérigot, Juliano Palacios-Abrantes, Maria Lourdes D. Palomares, Laurène Pecuchet, Nancy L. Shackell & Malin L. Pinsky

Nature **621**, 324–329 (2023) | Cite this article

Acknowledgements

Funding support from National Pacific Research Board (NPRB) and Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES)

Special thanks to Caitlin Allen-Akselrud, the trawl survey crews and the AFSC age-and-growth department

VAST

sdmTMB

tiny VAST

https://github.com/James-Thorson-NOAA/VAST
https://vast-lib.github.io/tinyVAST/
https://pbs-assess.github.io/sdmTMB/

Code to implement in VAST on GitHub: