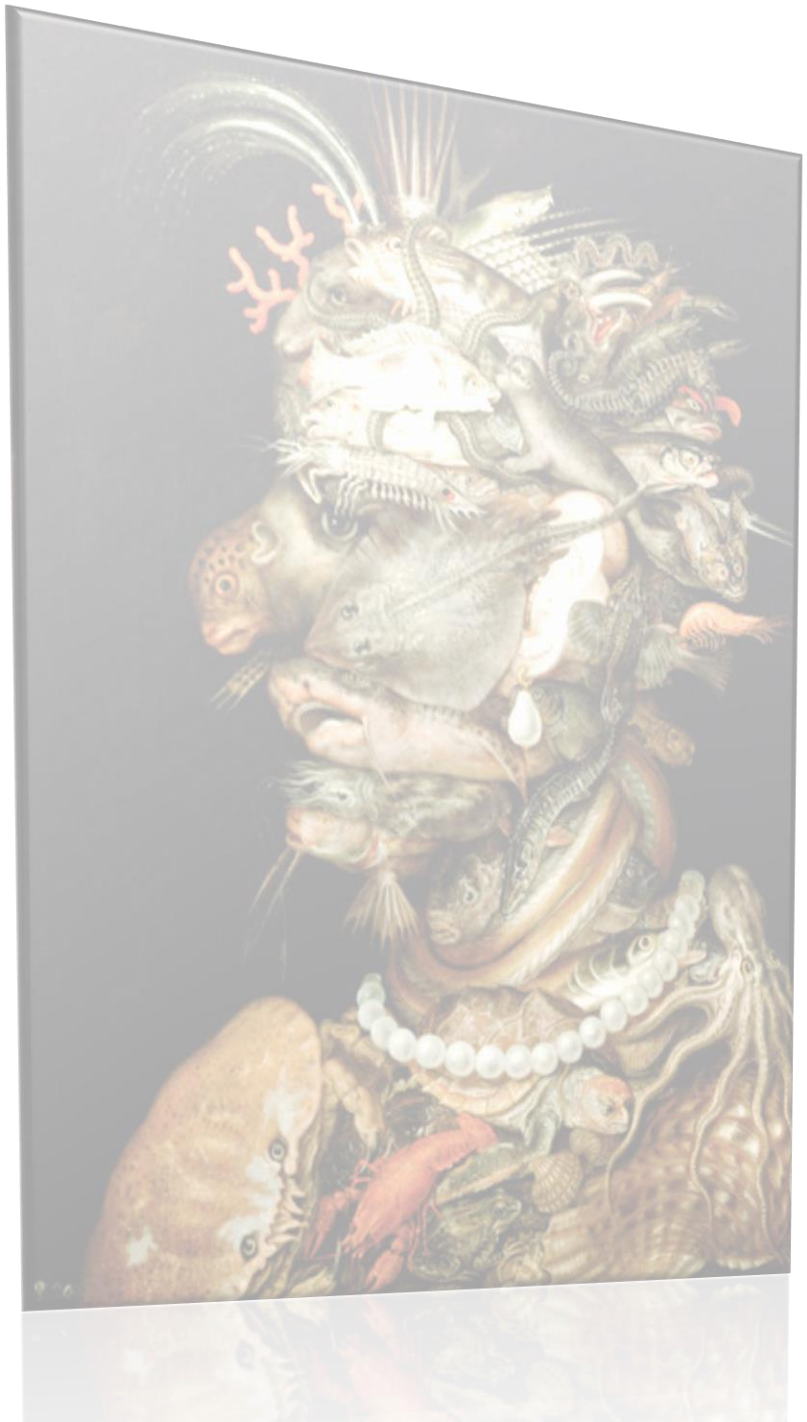


Assessment developments including climate enhanced multi-species models from the North Pacific.

James Ianelli
Kirstin Holsman and
James T. Thorson

Alaska Fisheries Science Center
NMFS/NOAA/Dept of Commerce
UW, Oct 30th 2019

I get to think about fish…

"Water" by Giuseppe Arcimboldo (1527–1593)
. Kunsthistorisches Museum, Vienna.

Key points

- Single species developments
  - State of space
    - Spatio-temporal modeling of catch rate data
    - Process errors and scientific surveys
  - Random effect models in stock assessment applications
    - Do we use information appropriately?
    - Shortcuts?
      - external, to estimate variances, fixed-effects within big model
      - Process errors on wt-age
- Multi-species extensions
  - Adding dimensionality—increased data demands scales poorly with increased model complexity

1979

- 1st job in fisheries

Punch card to magnetic

APL, Unix

1989

- UW

Mentor: Fournier

NOAA SS

1999

- NRC

ADMB Excel

2009

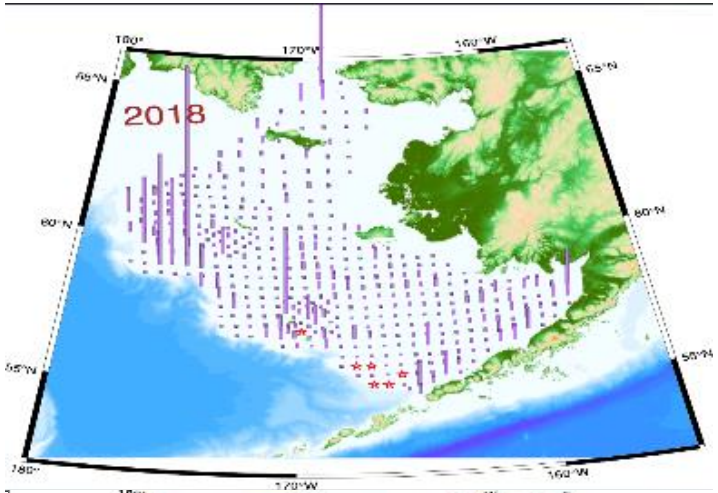
- Pollock…

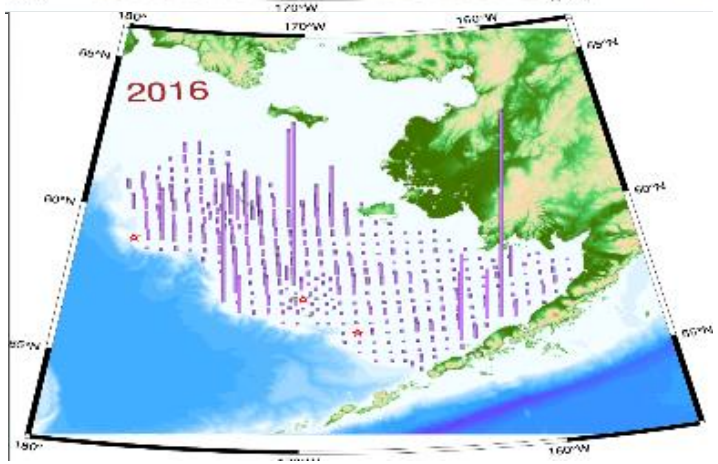
2019

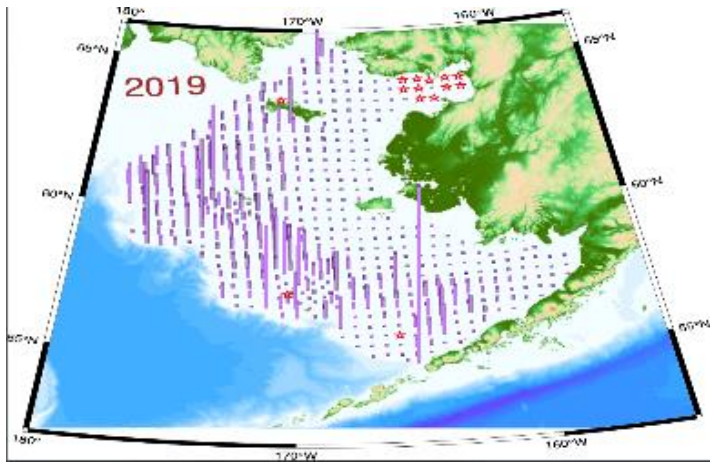
- HERE!

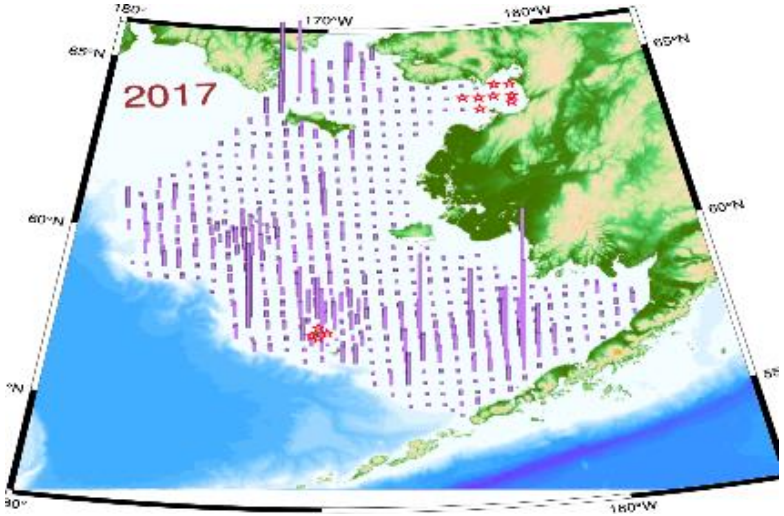
Are stock assessment models hard?

```
PROCEDURE_SECTION
  if (active(yr_eff)||active(coh_eff))
    Est_Fixed_Effects_wts();
  Get_Selectivity();
  Get_Mortality_Rates();
  GetNumbersAtAge();
  Get_Catch_at_Age();
  GetDependentVar();  // Includes MSY, F40% computations
  Evaluate_Objective_Function();
  if (do_fmort)
    Profile_F();
  if (mceval_phase())
    write_eval();
```

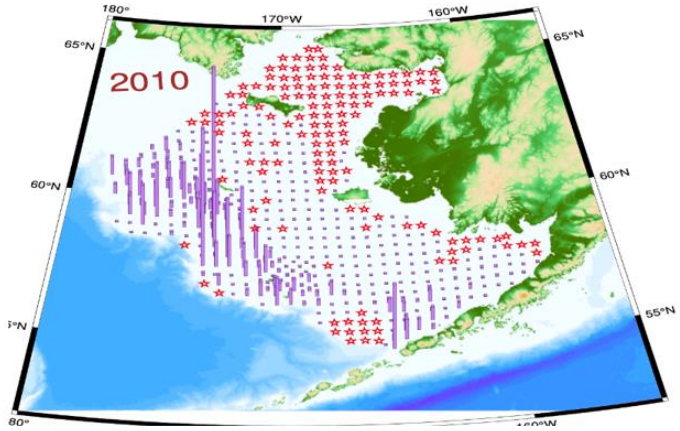








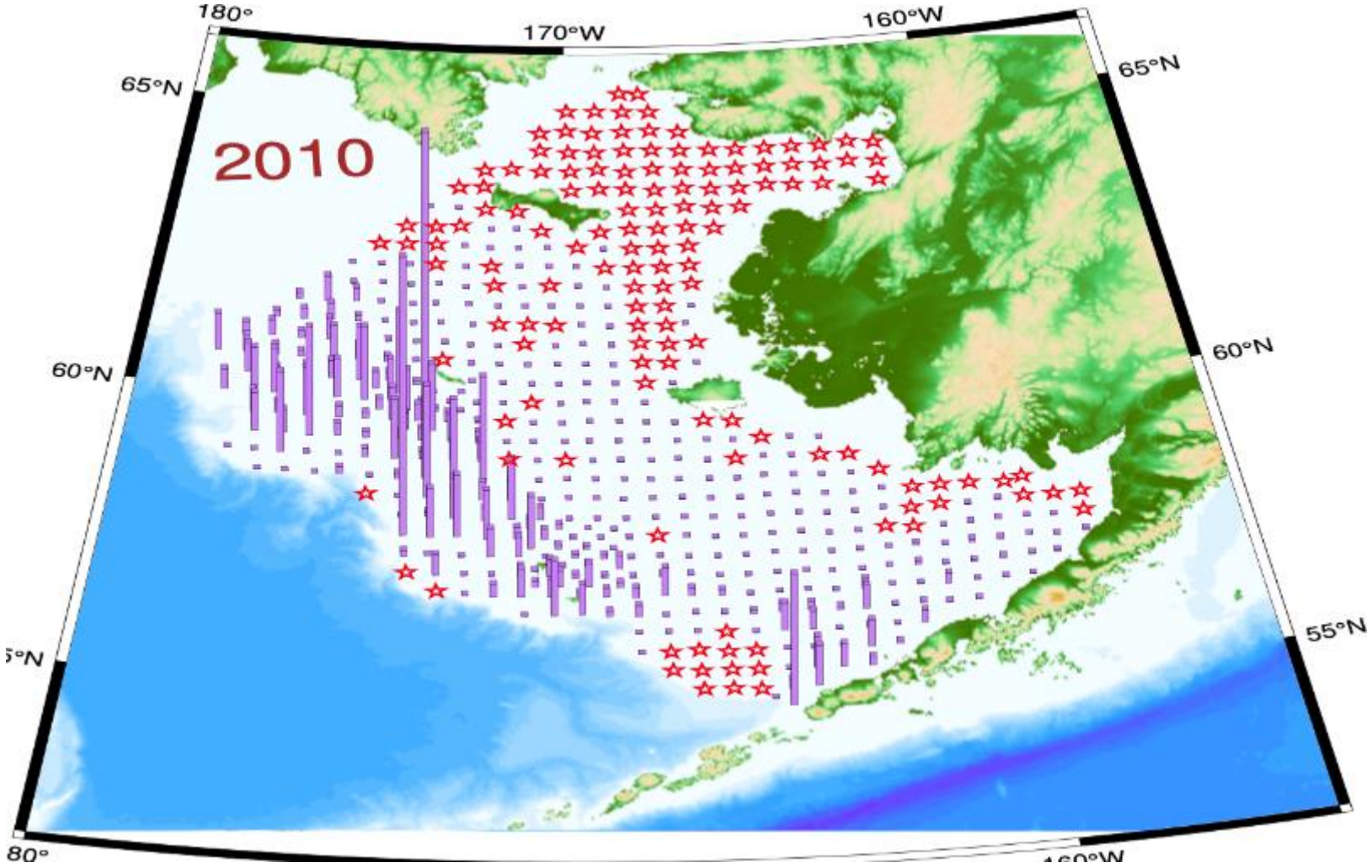
2010 standard survey
(3.74 million t pollock estimated)



Northern area: trace amounts

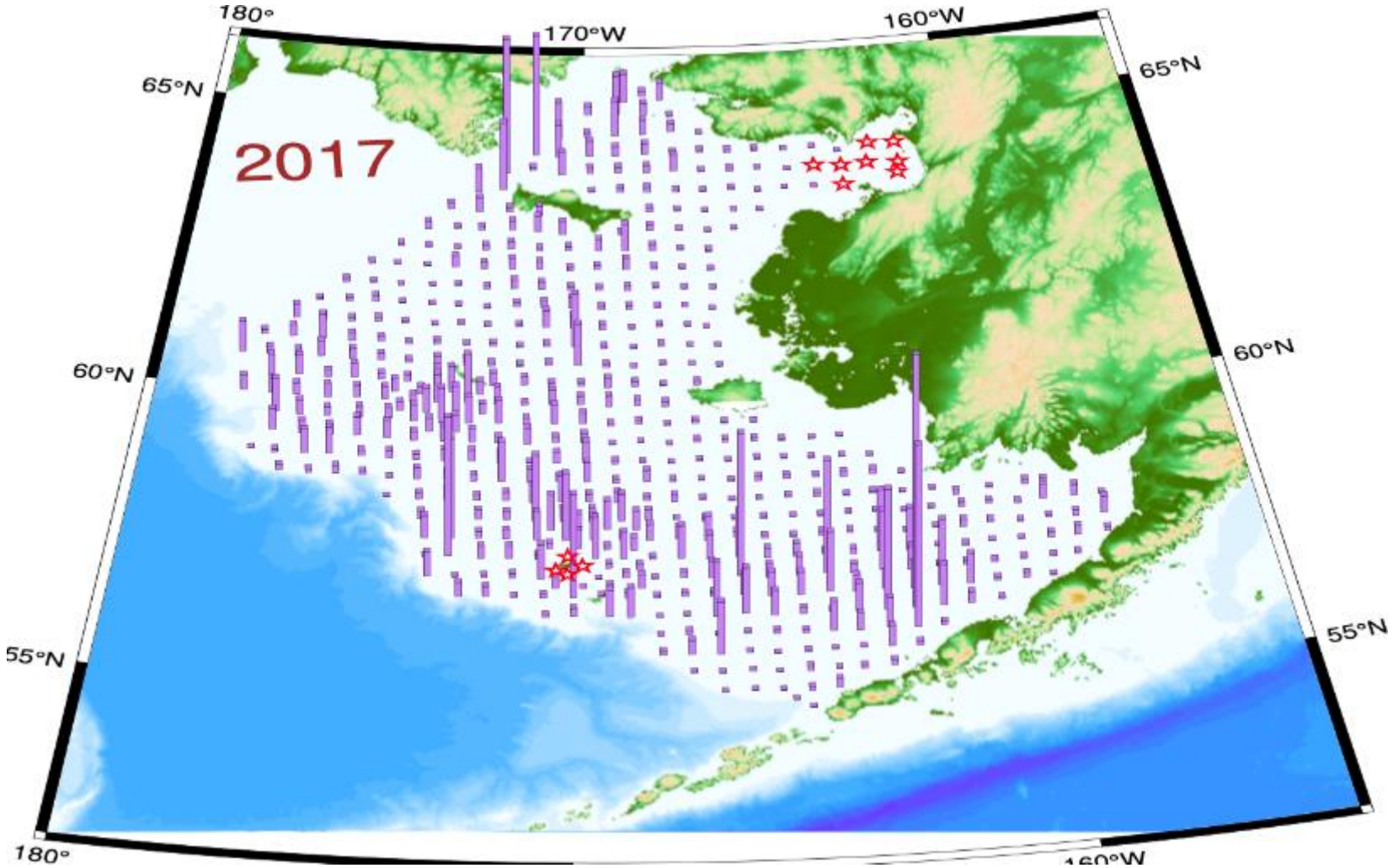
Bottom trawl survey spatial patterns

2010 standard survey
(3.74 million t pollock estimated)



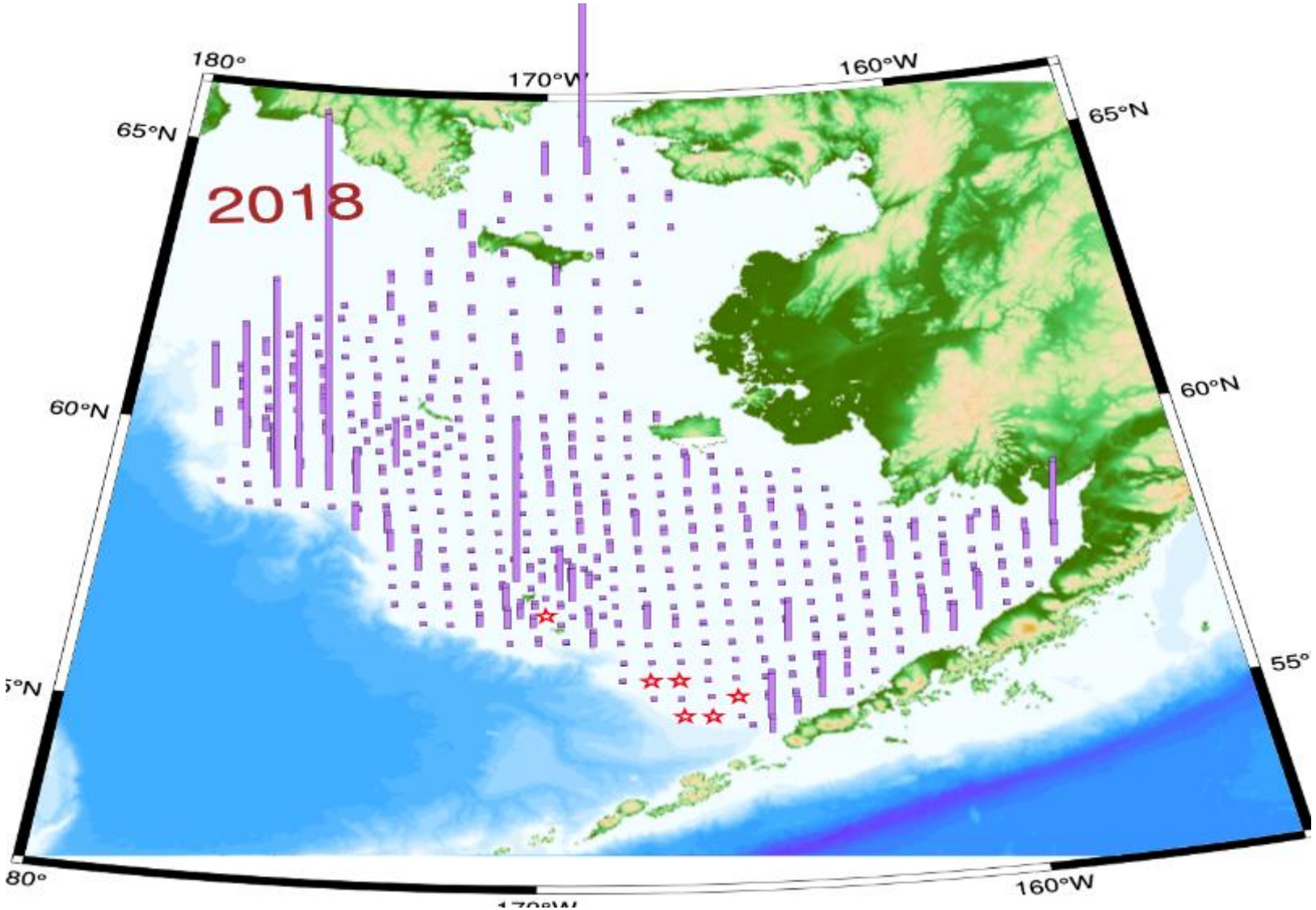
Northern area: trace amounts

2017 standard survey
(4.81 million t pollock estimated)



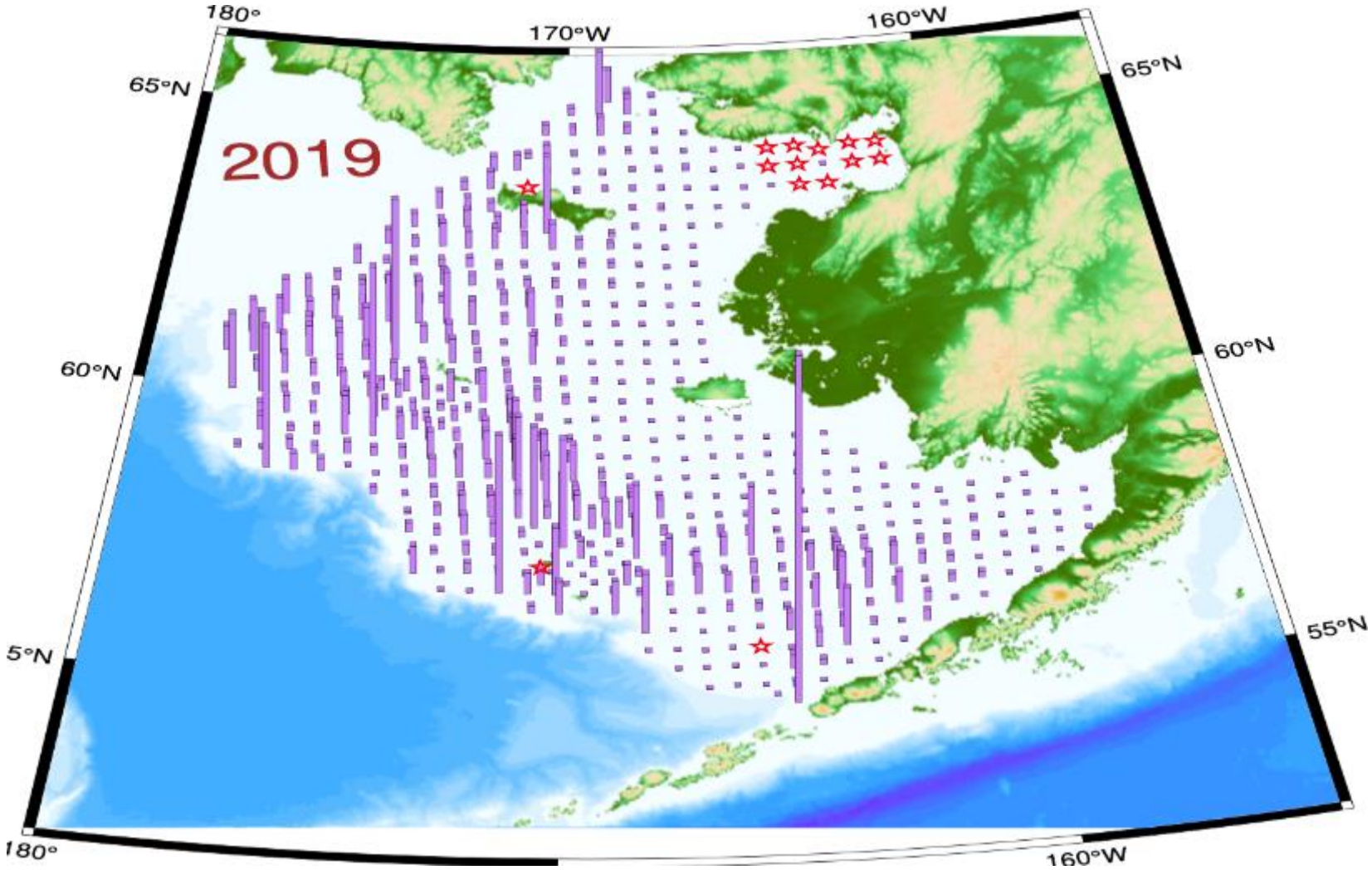
Northern area: 1.34 million t

2018 standard survey
(3.1 million t pollock estimated)



Northern area: 1.15 million t

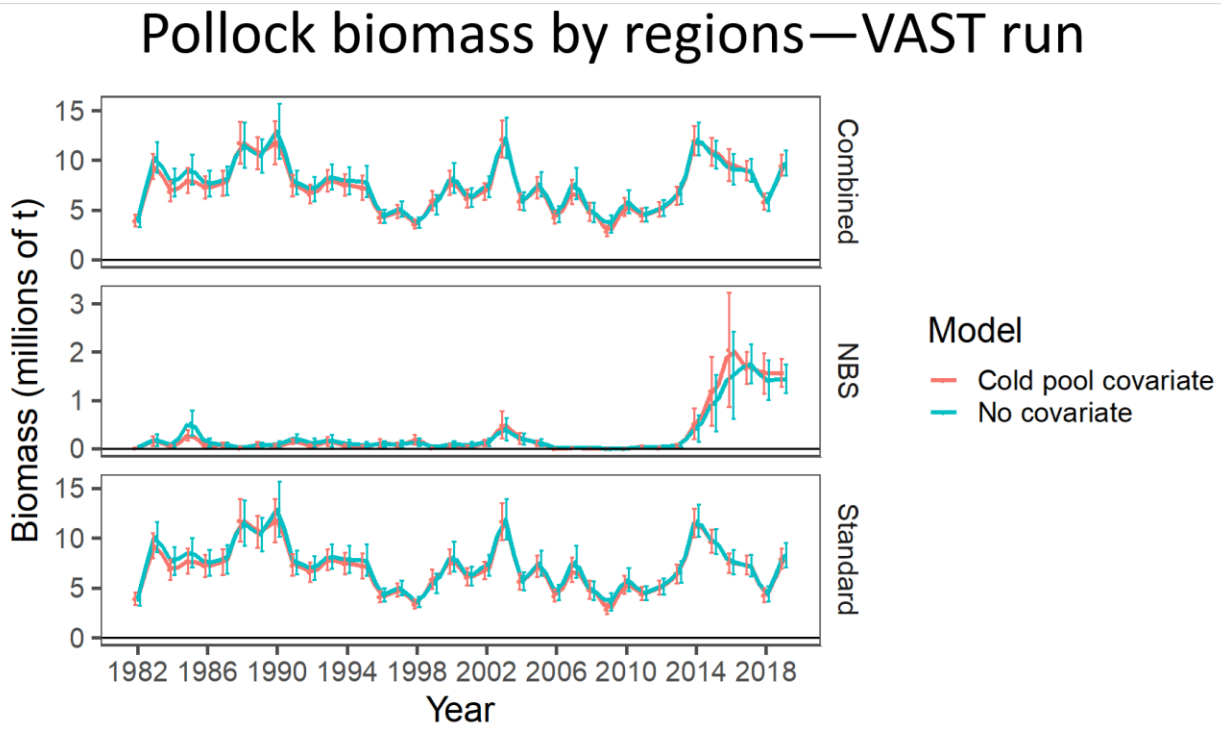
2019 standard survey
(5.4 million t pollock estimated)

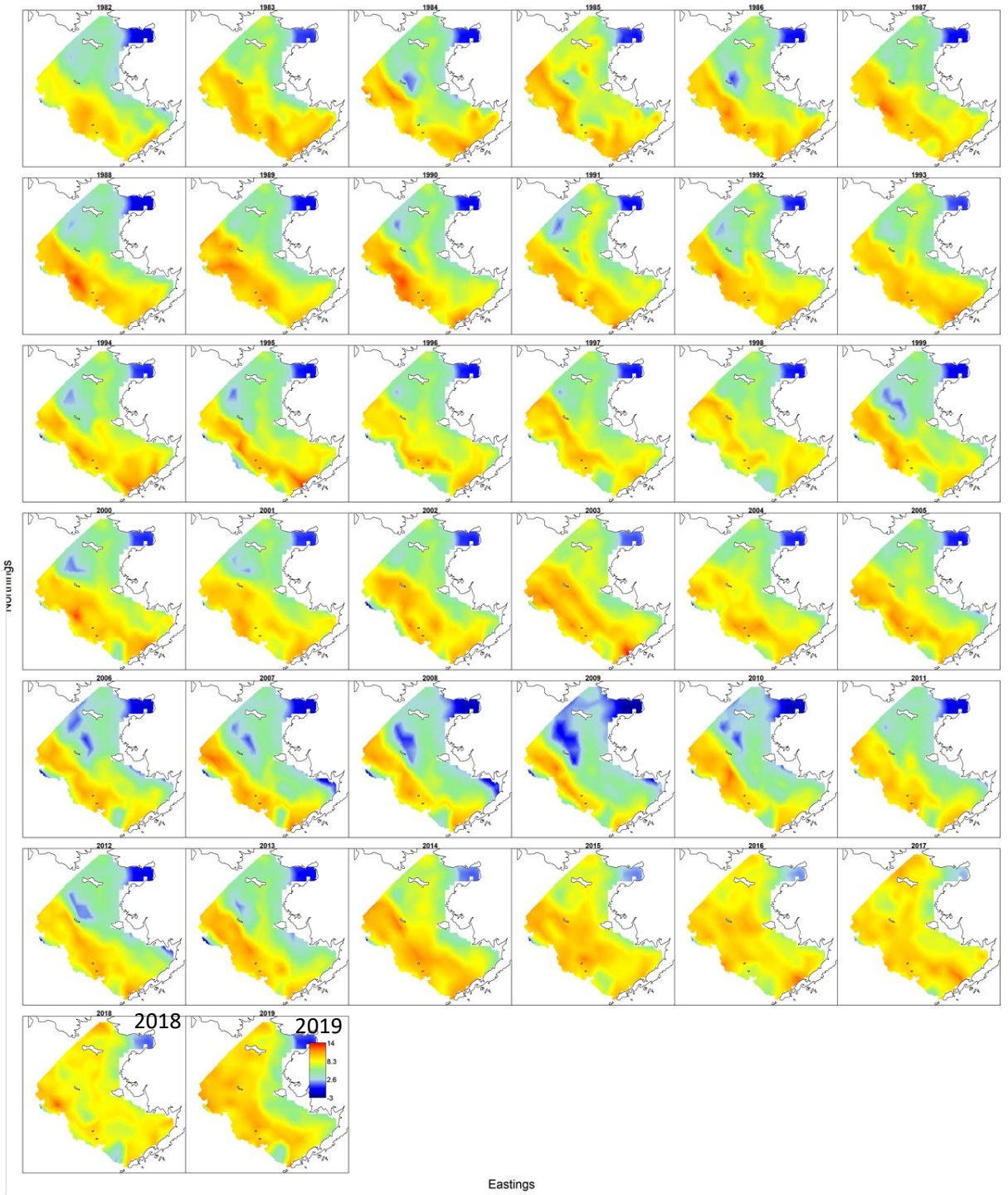


Northern area: 1.2xx million t

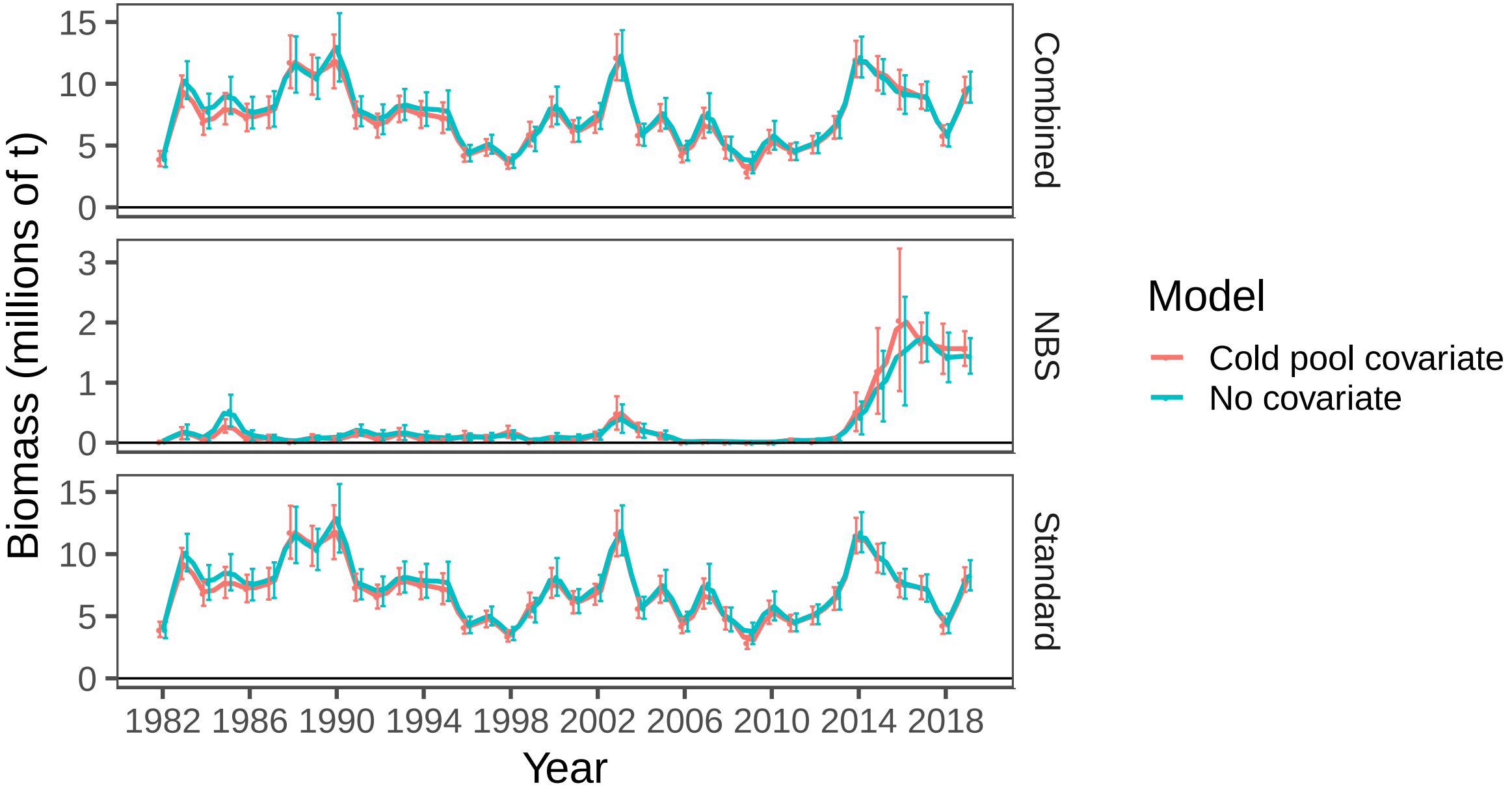
Modeling surveys

- To account for missed areas/years…
- VAST model of Thorson

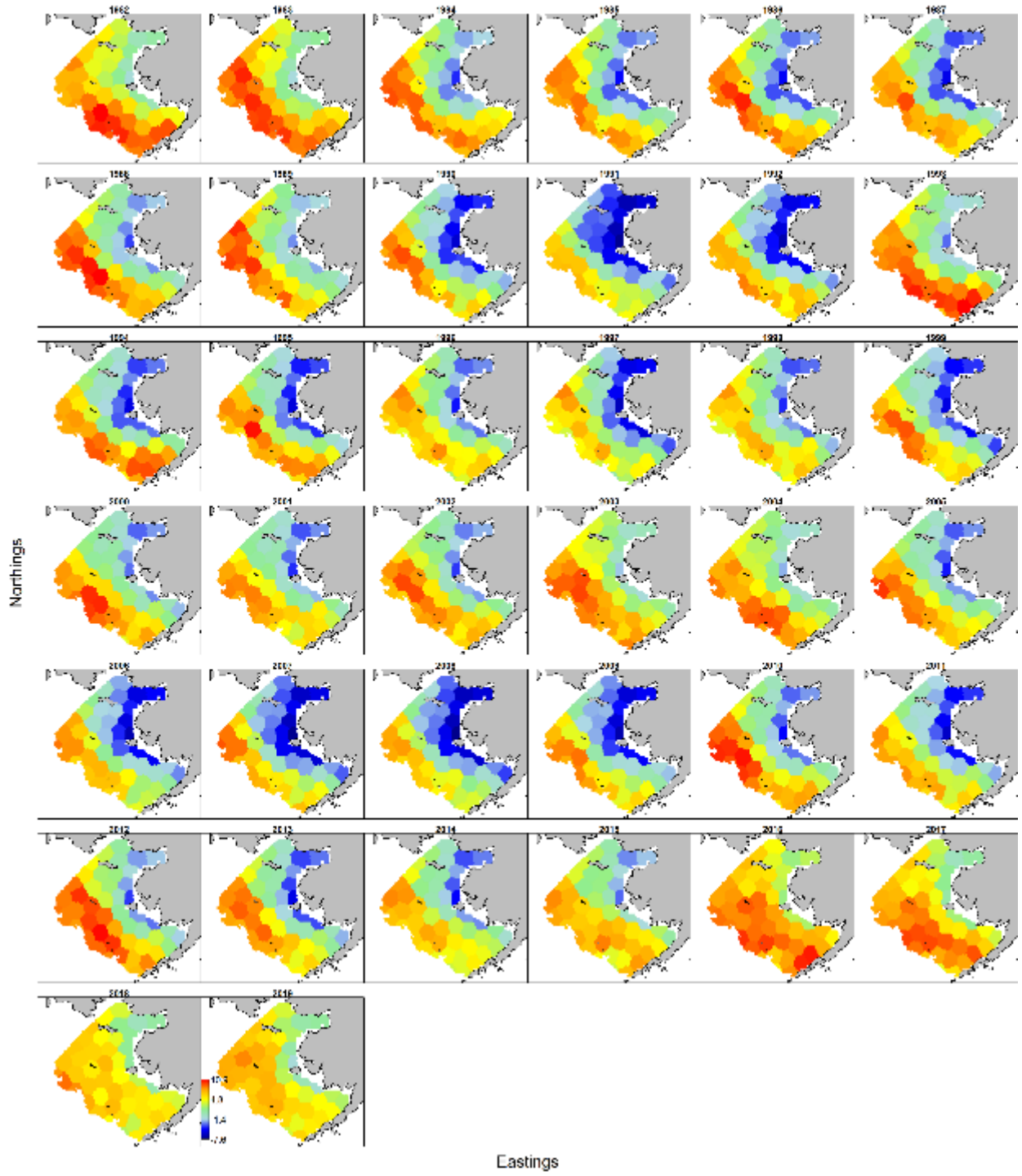




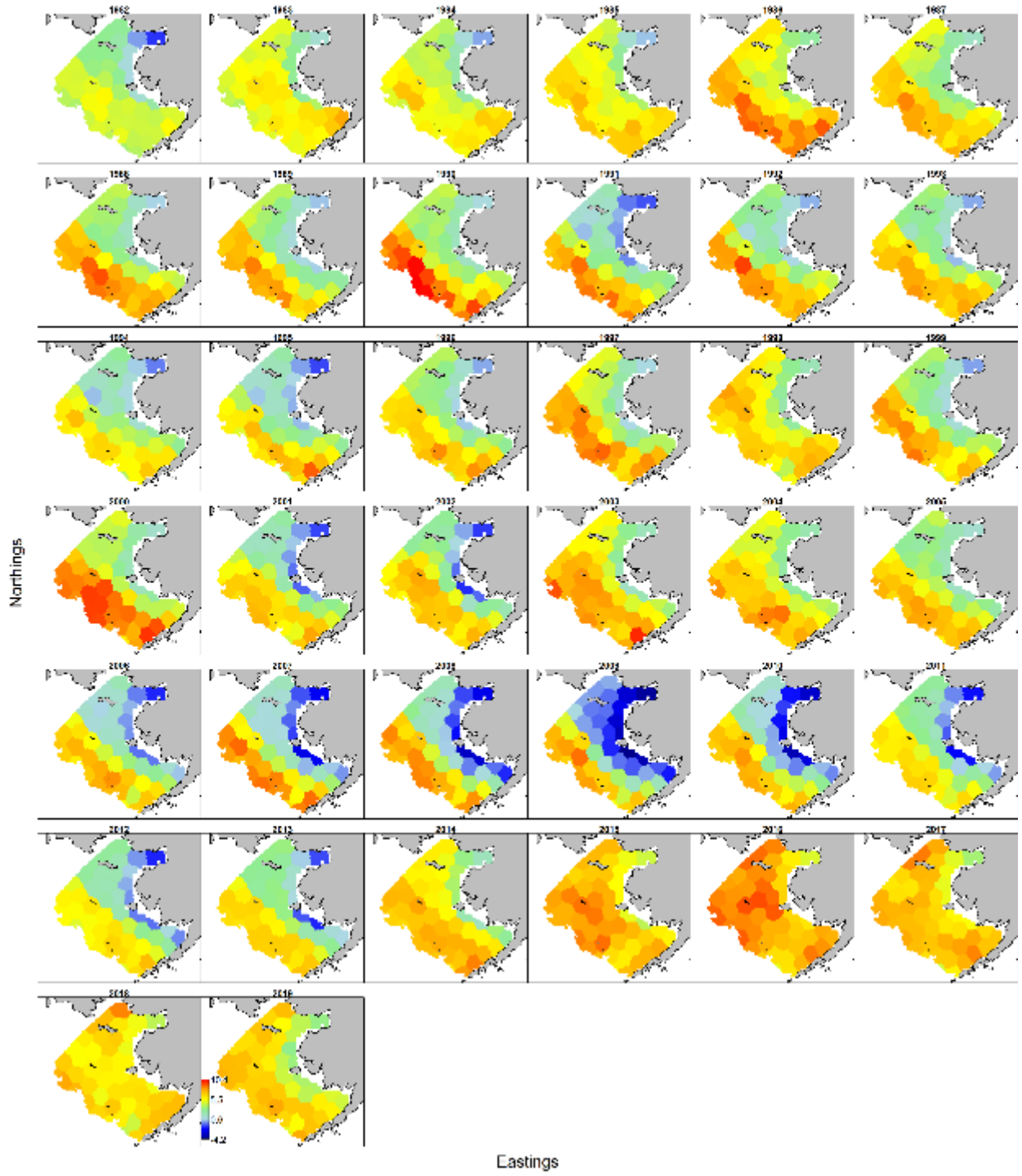
Pollock biomass by regions—VAST run

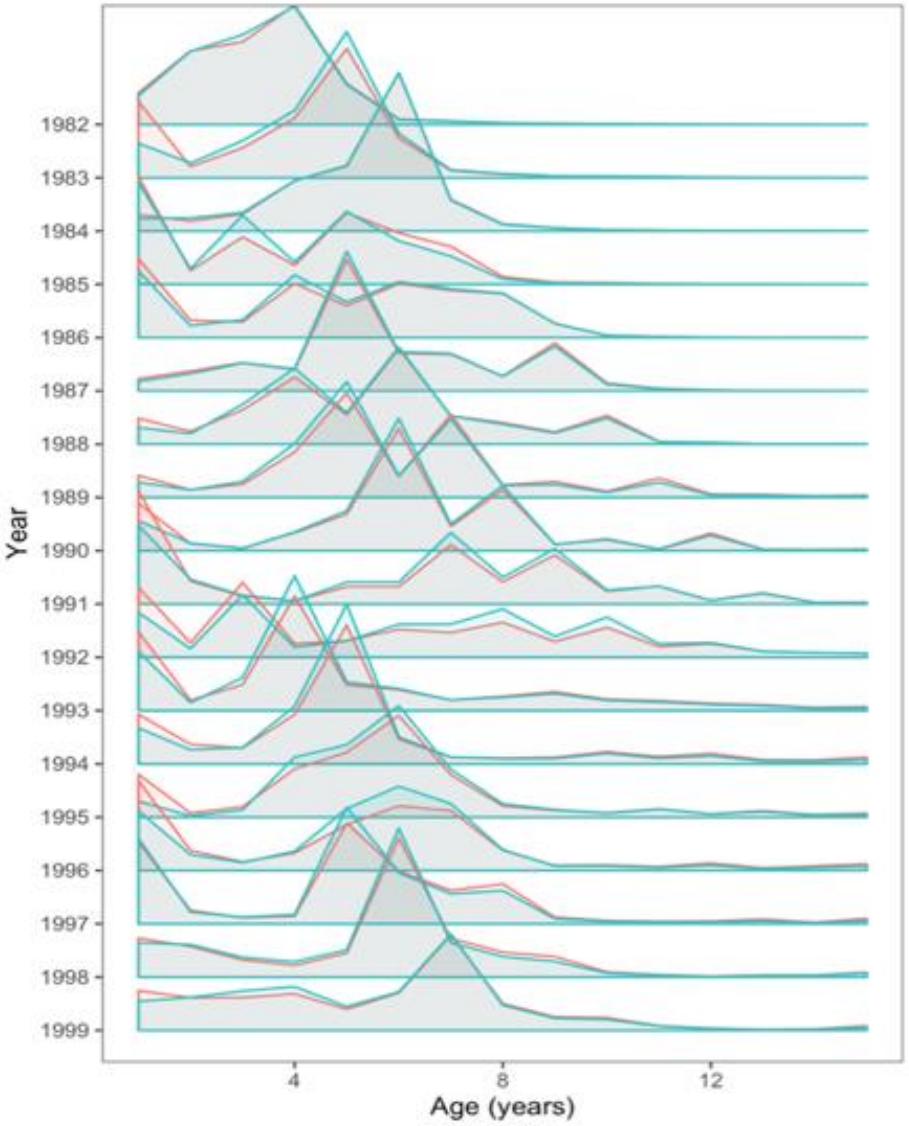


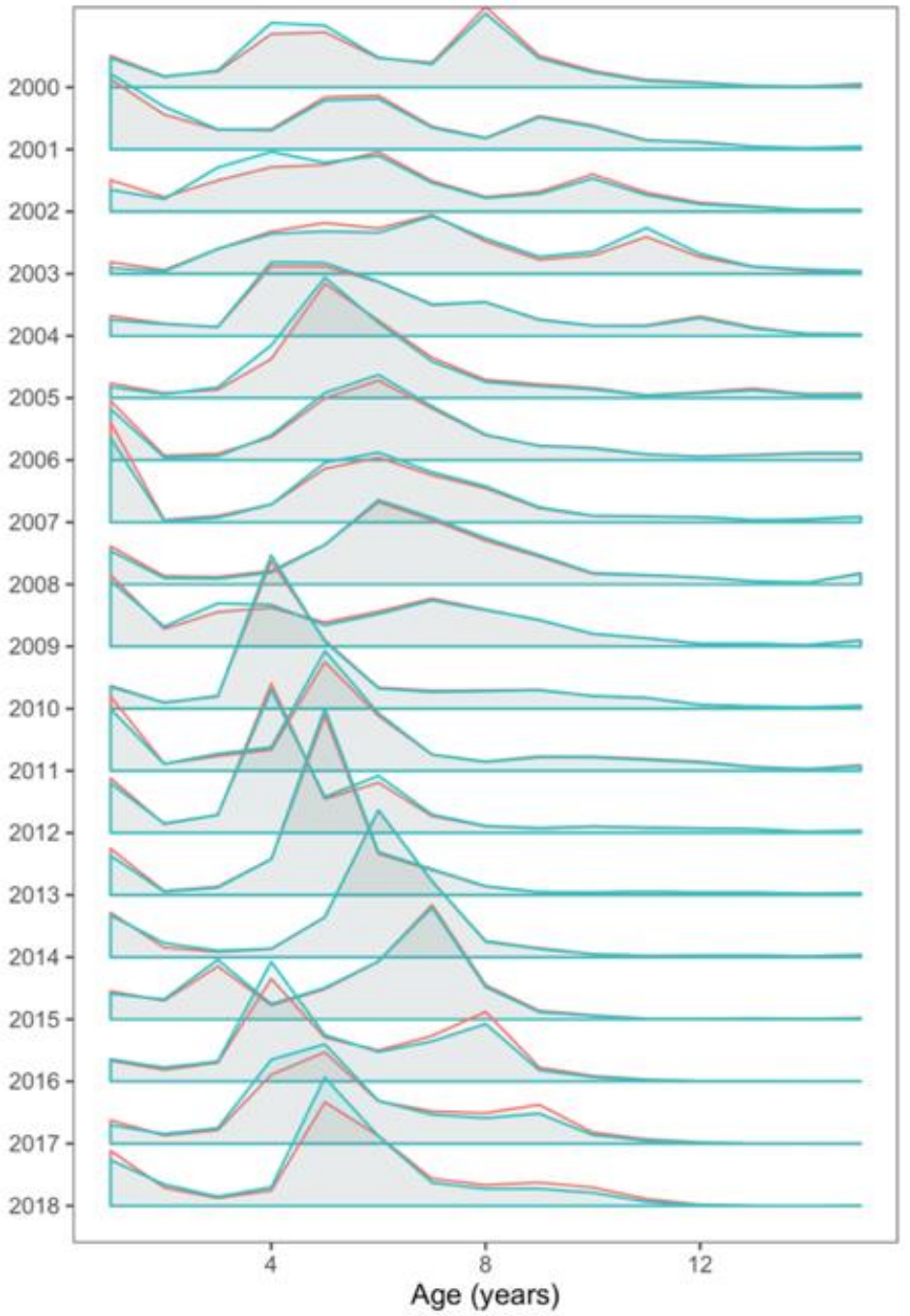
4 Year olds

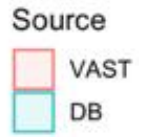


8 Year olds









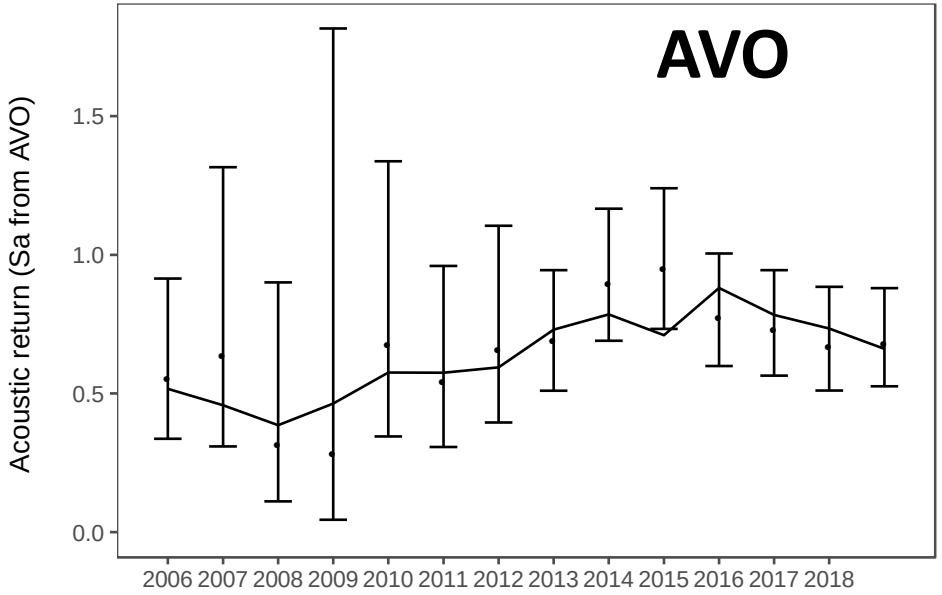
VAST Age compositions

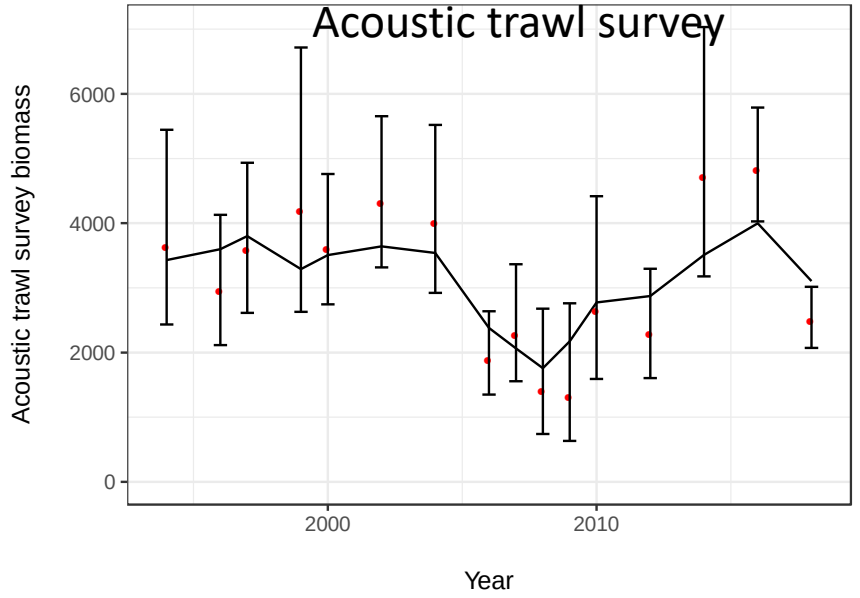
compared to design-based

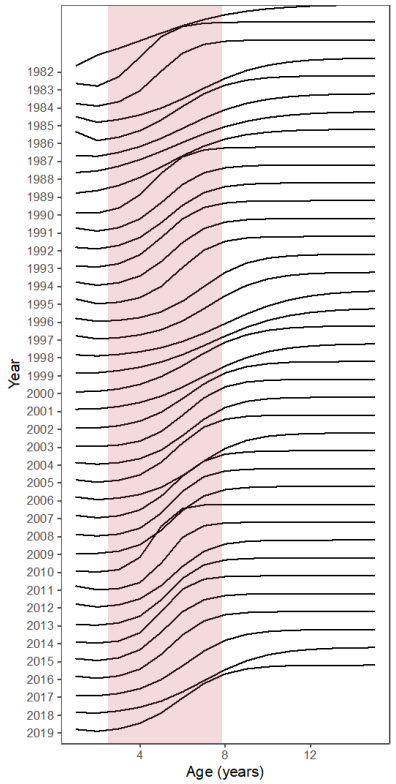
Assessment model coding challenge?

- Index time series correlated by definition
  - ~ 3 line code change to add facility to use an input covariance
  - – It did result in adding an “if” statement…no noticeable performance knock…

Example Assessment Results

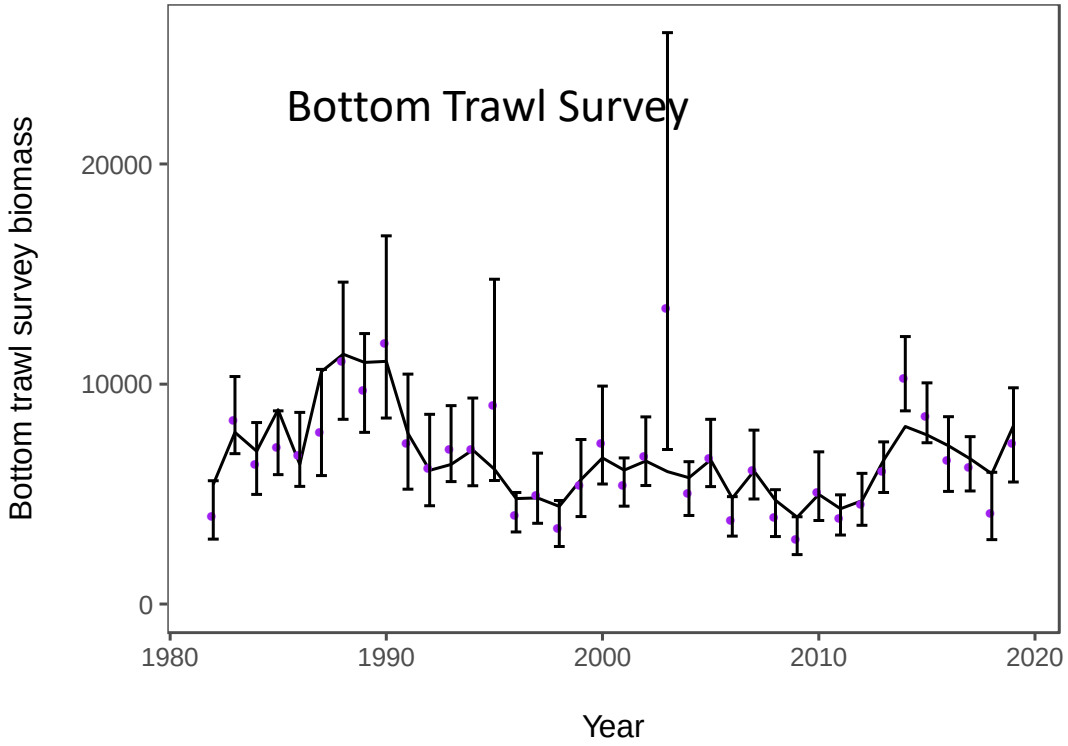


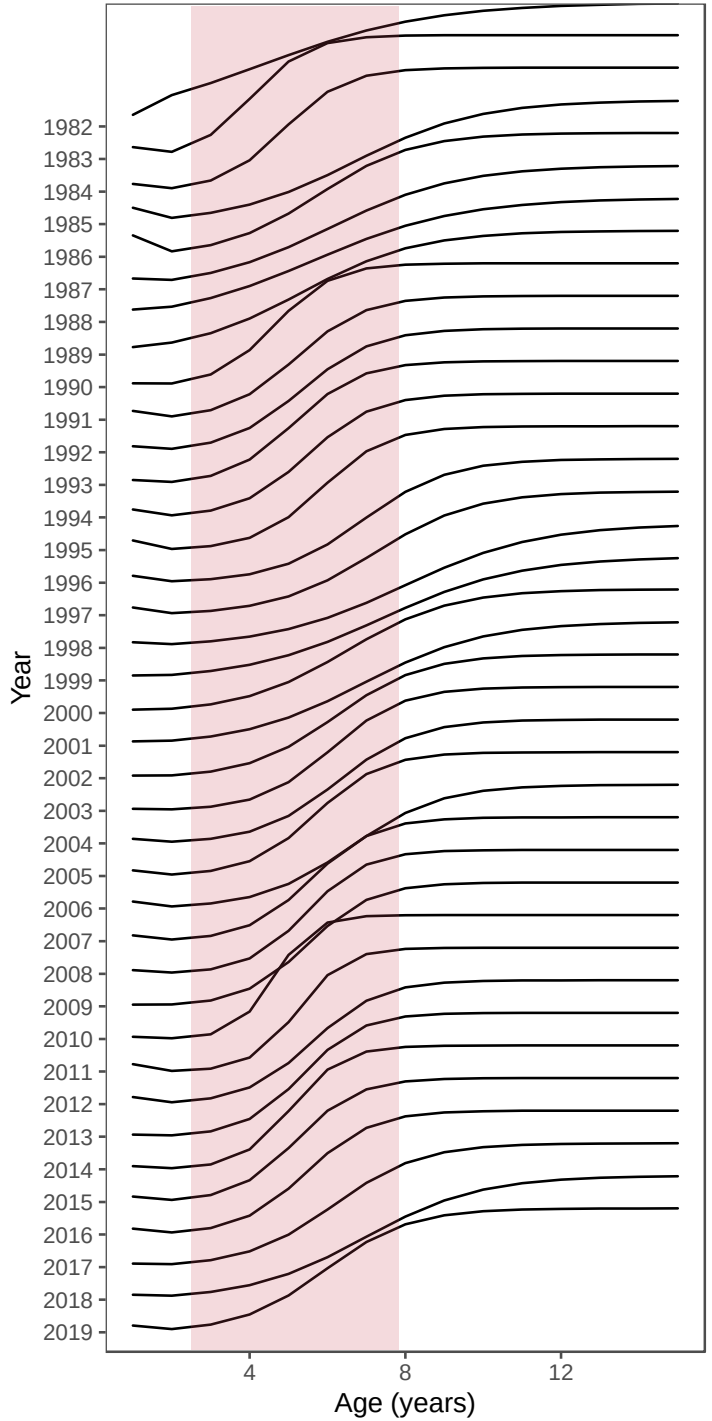




Bottom trawl survey Selectivity …

Model fits to indices





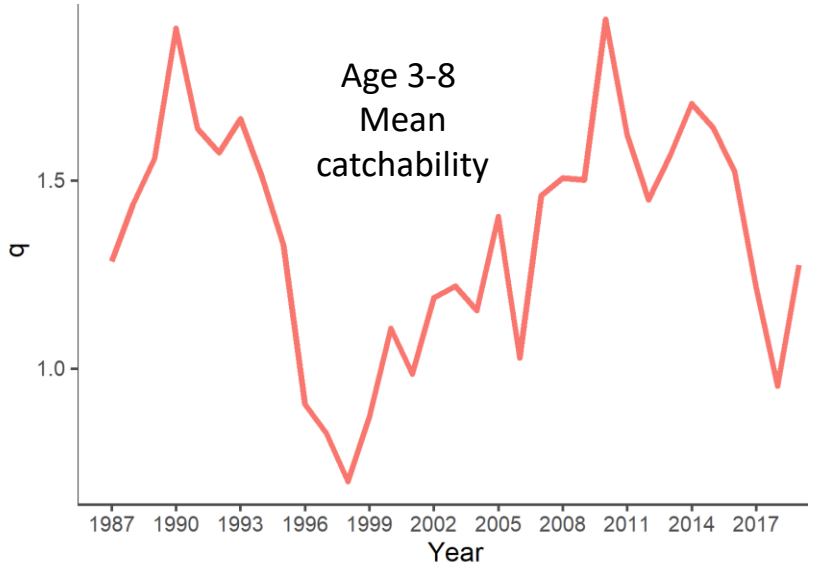
Bottom trawl survey Selectivity

…

Process errors in survey catchability/availability

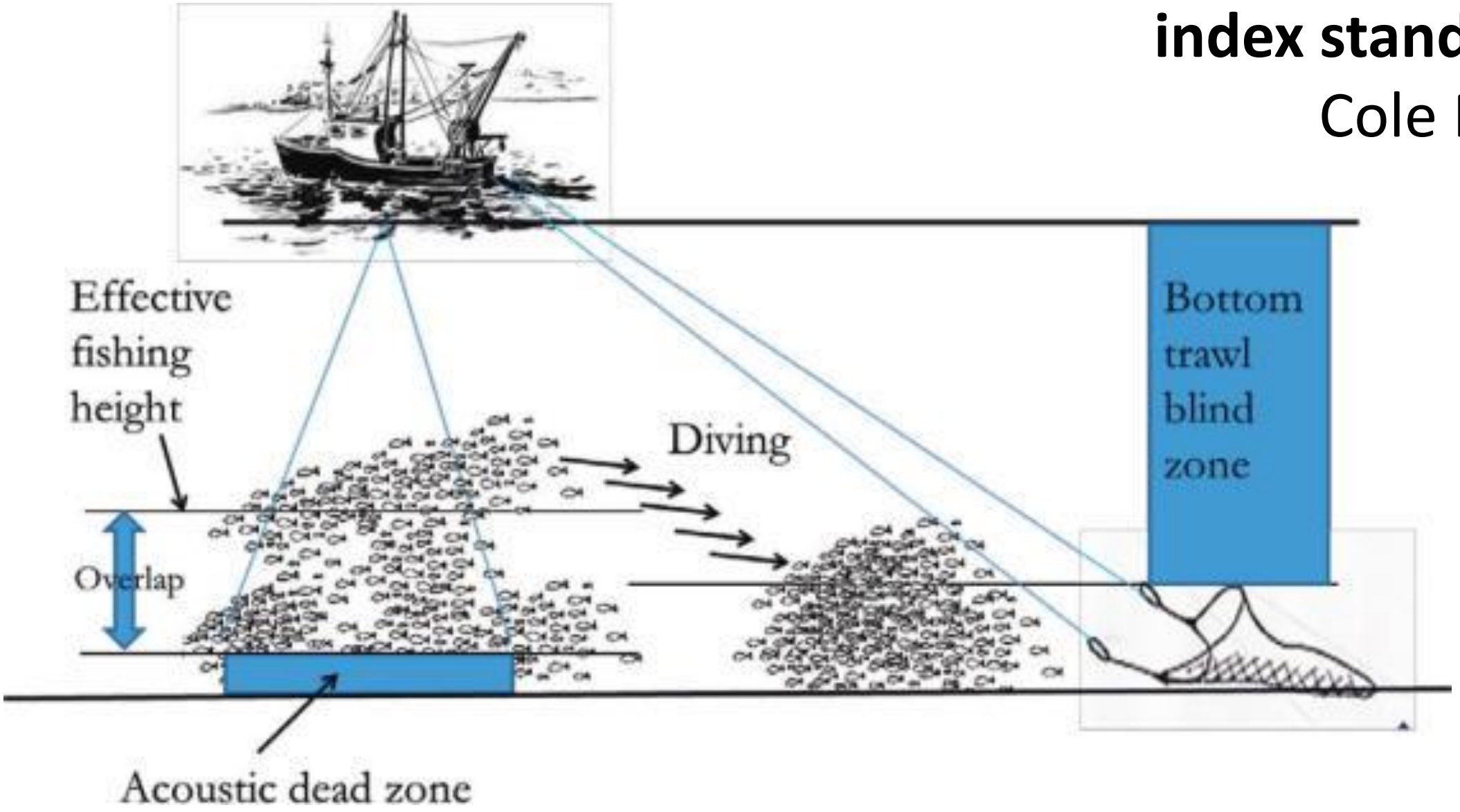
…time varying "catchability" for rigorously conducted scientific fishery-independent survey…

- Incorrect assumption if:
  - Fish don't move
  - They stay in the same place in the water column
- Problem: **how to estimate?**
- Solution
  - "Layers" project combining information

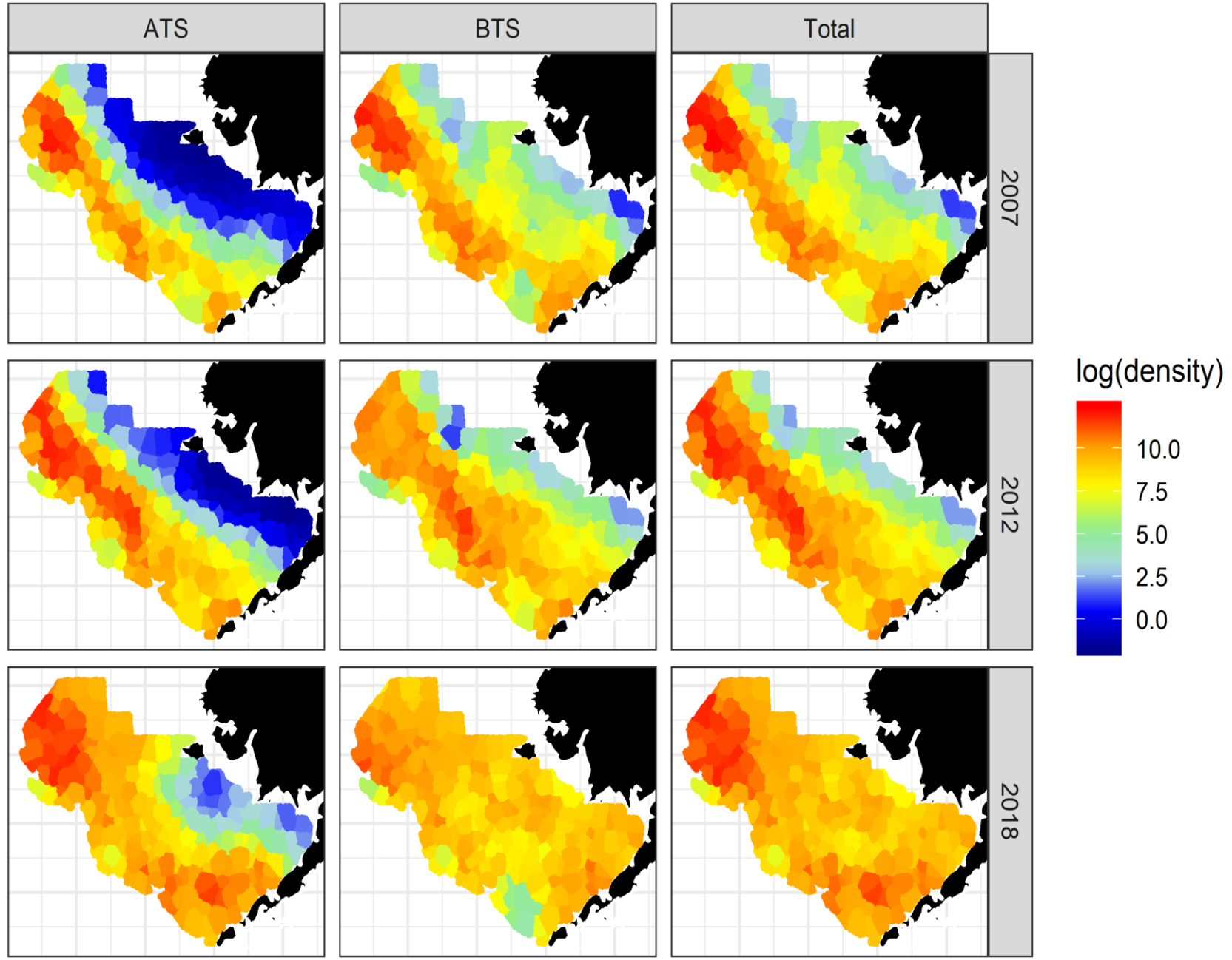


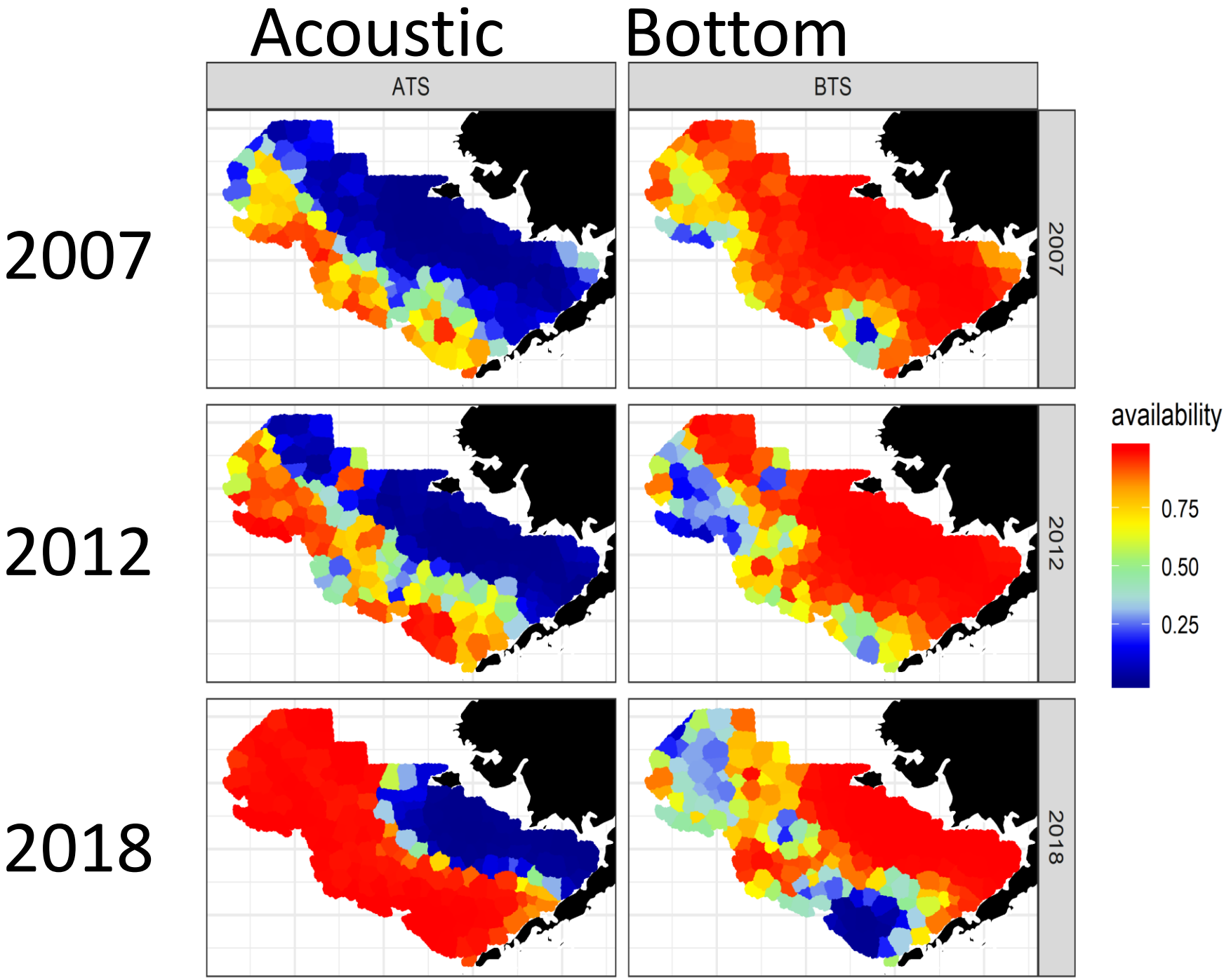
Acoustic and bottom trawl survey spatio-temporal modeling—Incorporating vertical distribution in index standardization

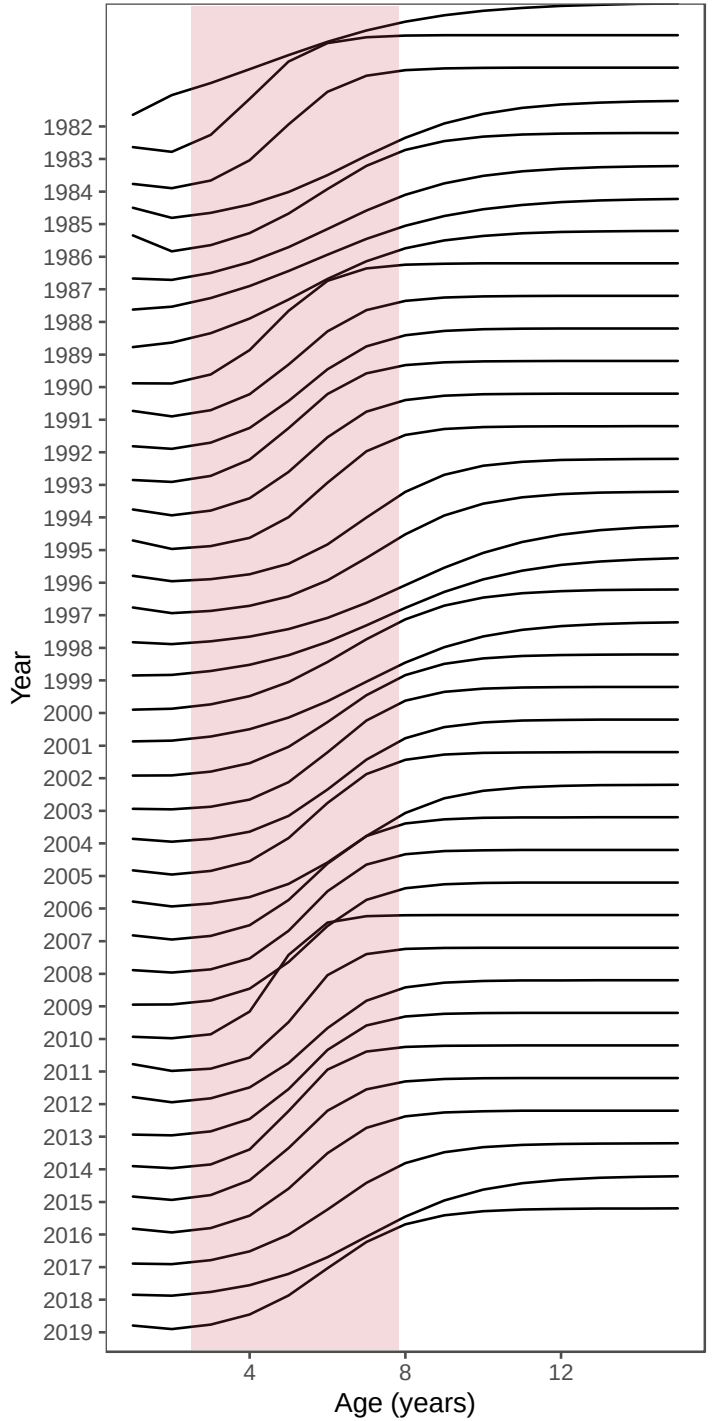
Cole Monnahan



Acoustic Bottom ***Combined***




Acoustic
Bottom
ATS
BTS
2007
2012
2018
availability
0.75
0.50
0.25



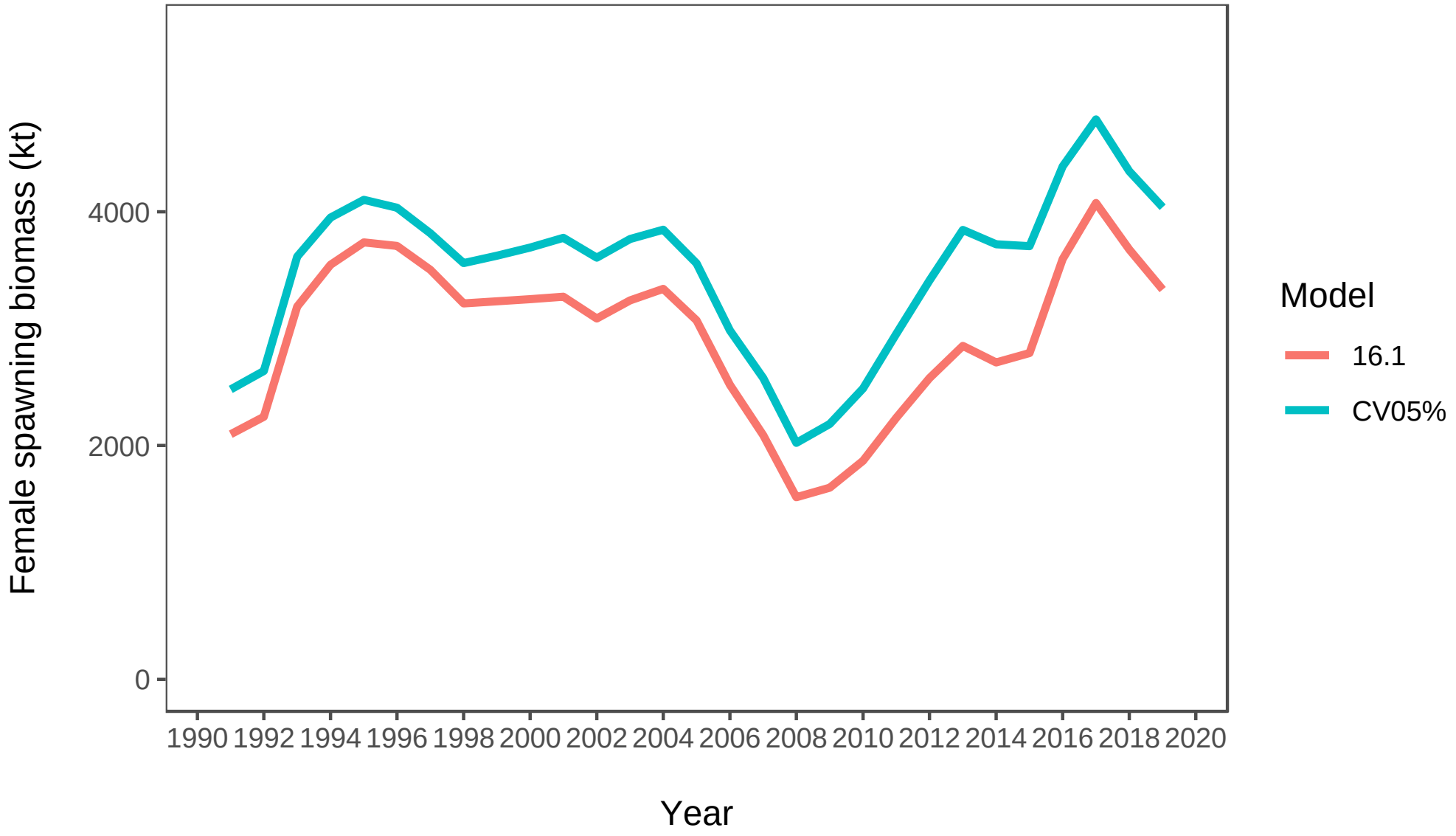
Bottom trawl survey Selectivity

…

Table 27: Goodness of fit to primary data used for assessment model parameter estimation profiling over different constraints on the extent bottom-trawl survey selectivity/availability is allowed to change; EBS pollock.

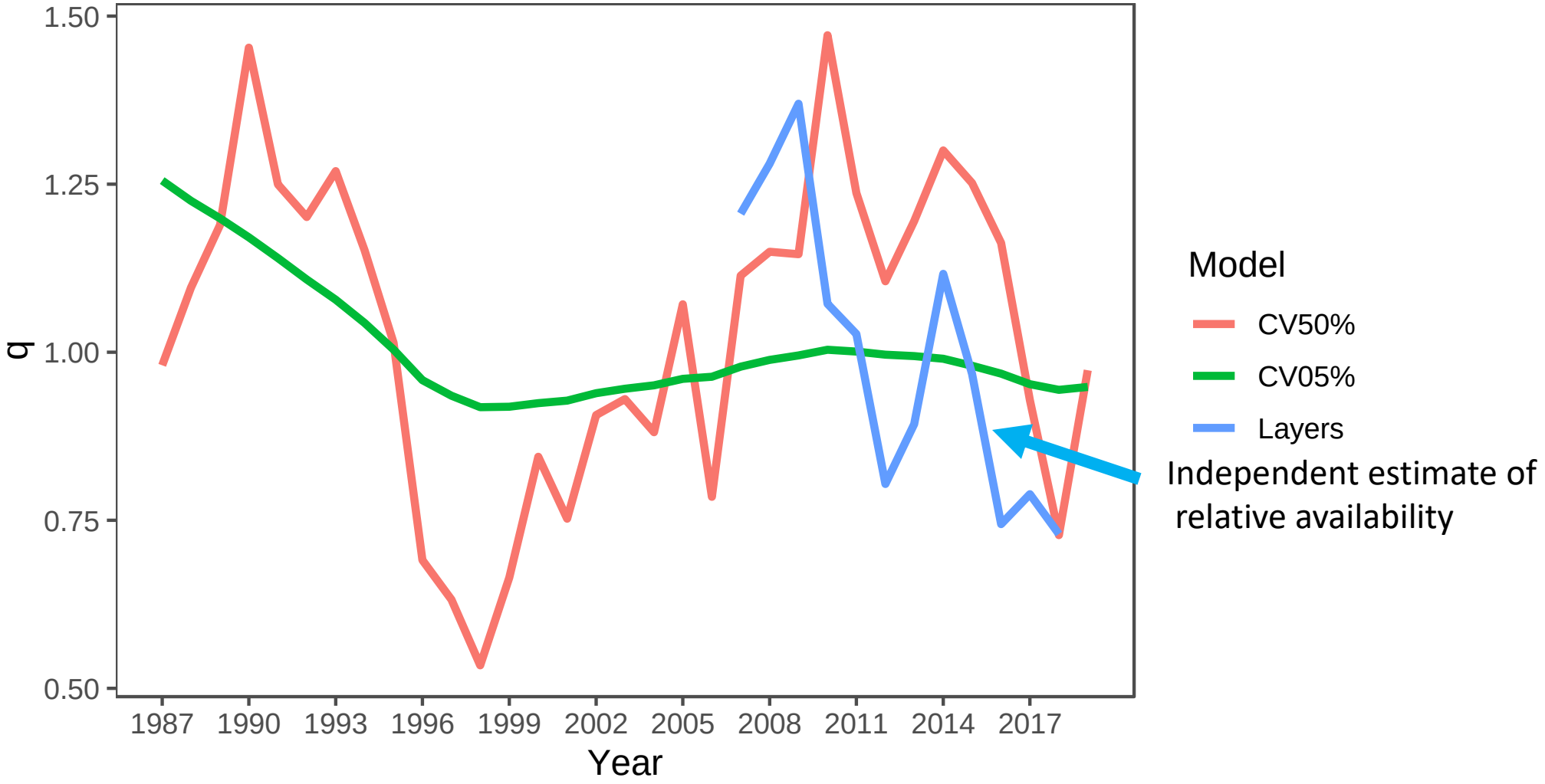
Less flexibility in survey "catchability"

Component	CV70%	CV50%	CV20%	CV10%	CV05%
RMSE BTS	0.19	0.20	0.25	0.29	0.31
RMSE ATS	0.22	0.22	0.22	0.23	0.25
RMSE AVO	0.20	0.20	0.20	0.20	0.20
RMSE CPUE	0.09	0.09	0.09	0.09	0.09
SDNR BTS	1.02	1.19	1.79	2.23	2.47
SDNR ATS	1.10	1.10	1.11	1.14	1.22
SDNR AVO	0.76	0.75	0.74	0.72	0.71
Eff. N Fishery	1365.51	1372.40	1392.26	1372.23	1278.89
Eff. N BTS	208.52	203.80	178.75	159.65	141.48
Eff. N ATS	215.18	215.53	214.51	209.21	200.07
BTS NLL	20.81	28.35	64.62	99.66	122.72
ATS NLL	8.84	8.85	8.97	9.33	10.33
AVO NLL	9.55	9.54	9.53	9.60	9.71
Fish Age NLL	137.34	138.83	143.86	149.91	159.59
BTS Age NLL	146.41	149.94	168.84	190.99	239.72
ATS Age NLL	26.81	26.89	27.61	28.90	30.68

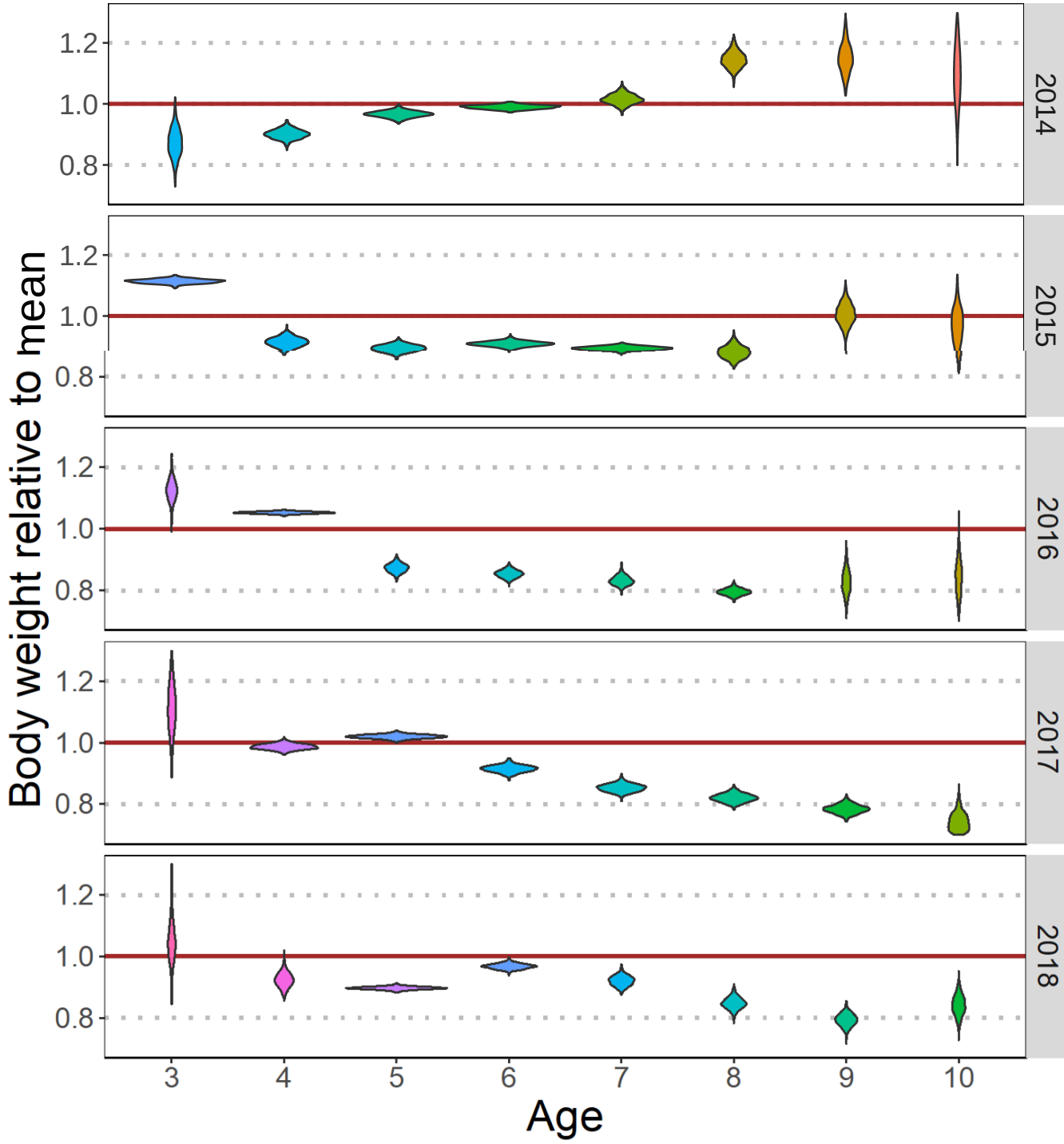

Female spawning biomass (kt)
4000
2000
0
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020
Year
Model
16.1
CV05%

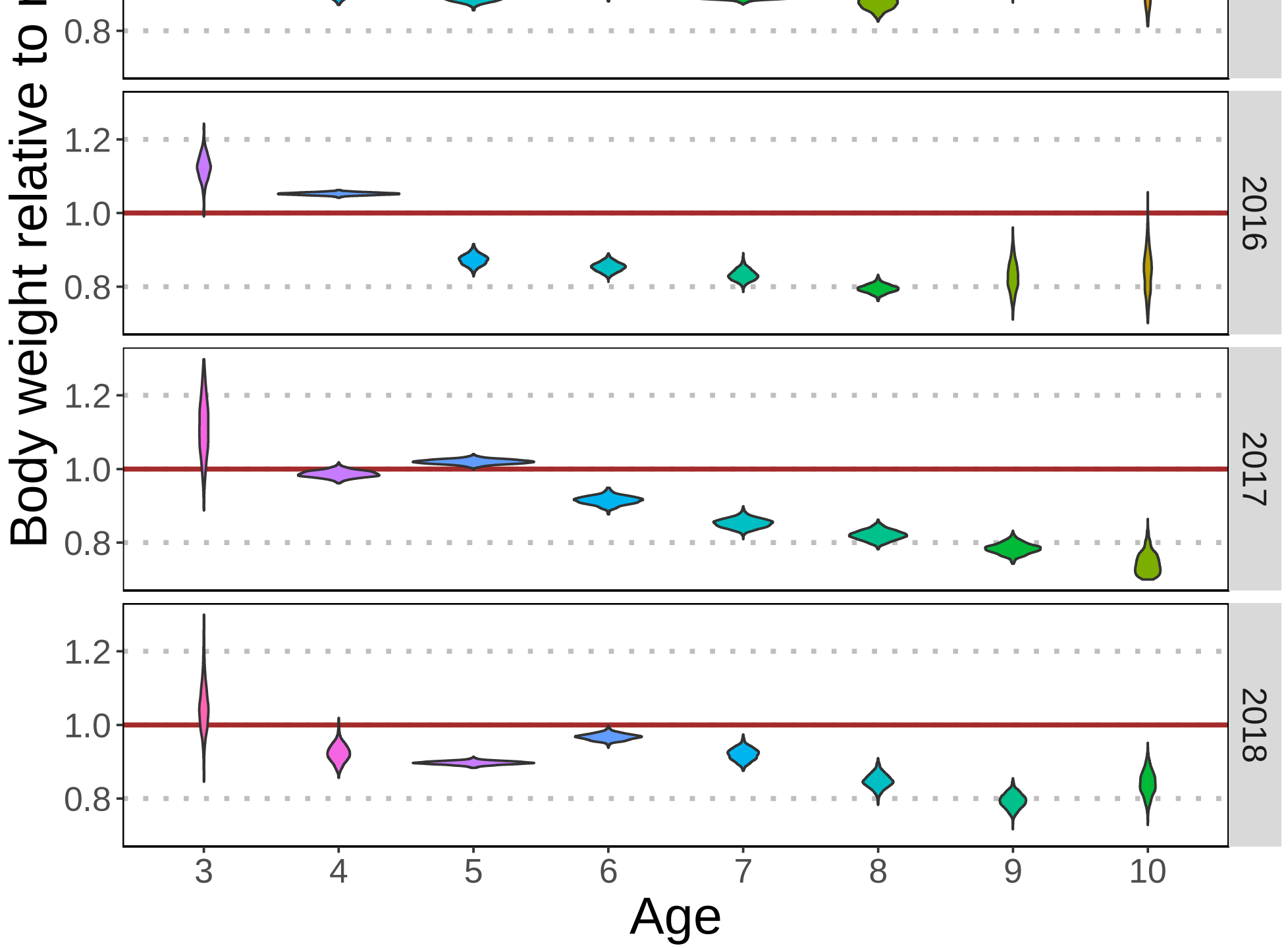
Age 3-8 relative “availability” to bottom trawl survey

Conclusion: tentative support for status quo model specification…



- Random effects model for body mass-at-age
  - Critically important
  - Year and cohort effects
- Under-appreciated impact in near-term forecasts




Body weight relative to
0.8
1.2
1.0
0.8
2016
1.2
1.0
0.8
2017
1.2
1.0
0.8
2018
3
4
5
6
7
8
9
10
Age

- Some utility to fitting simple RE models outside
  - Provide justification and specification for fixed-effects in big models
- Another case for fixed-effects modeling…
  - Invert the problem of process error variability
    - Assume input variance (and/or priors)
    - Find the fixed-effect variability that is consistent with that.

2019 Climate-enhanced multi-species Stock Assessment for walleye pollock, Pacific cod, and arrowtooth flounder in the Eastern Bering Sea

Kirstin K. Holsman, James N. Ianelli, Kerim Aydin, Ingrid Spies

kirstin.holsman@noaa.gov

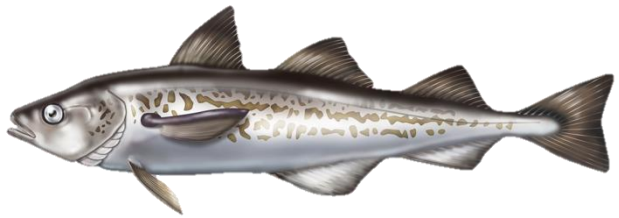
November 2019

Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA,
7600 Sand Point Way N.E., Seattle, Washington 98115

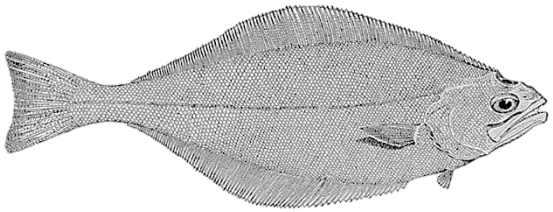
Model-based estimates: CEATTLE

K. Holsman

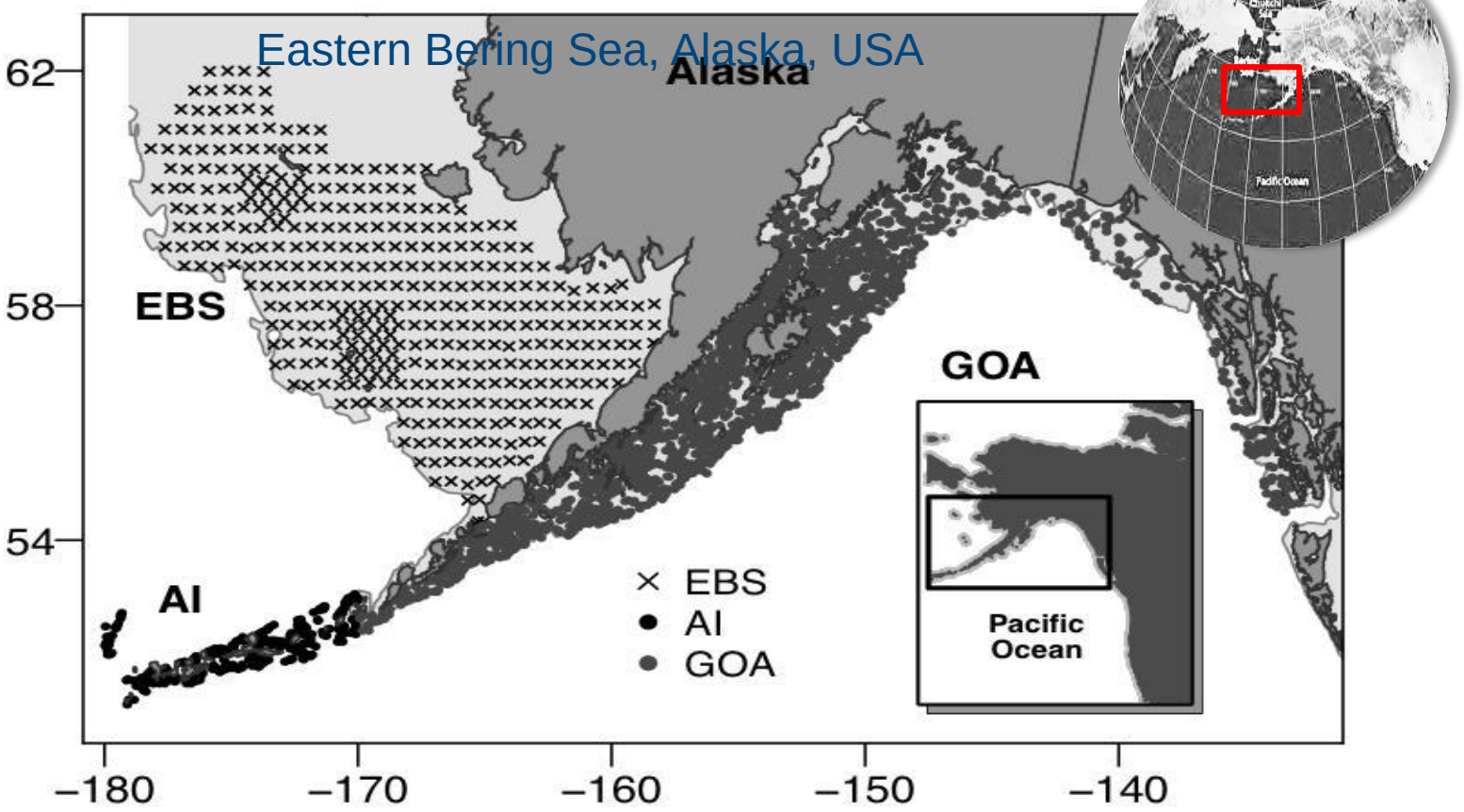
Climate-Enhanced, Age-based model with Temperature-specific Trophic Linkages and Energetics



Walleye pollock
(*Gadus chalcogrammus*)



Arrowtooth flounder
(*Atheresthes stomias)*



Pacific cod
(*Gadus macrocephalus*)

W@Age~*f*(Temperature)
Pred/prey~*f*(Temperature)

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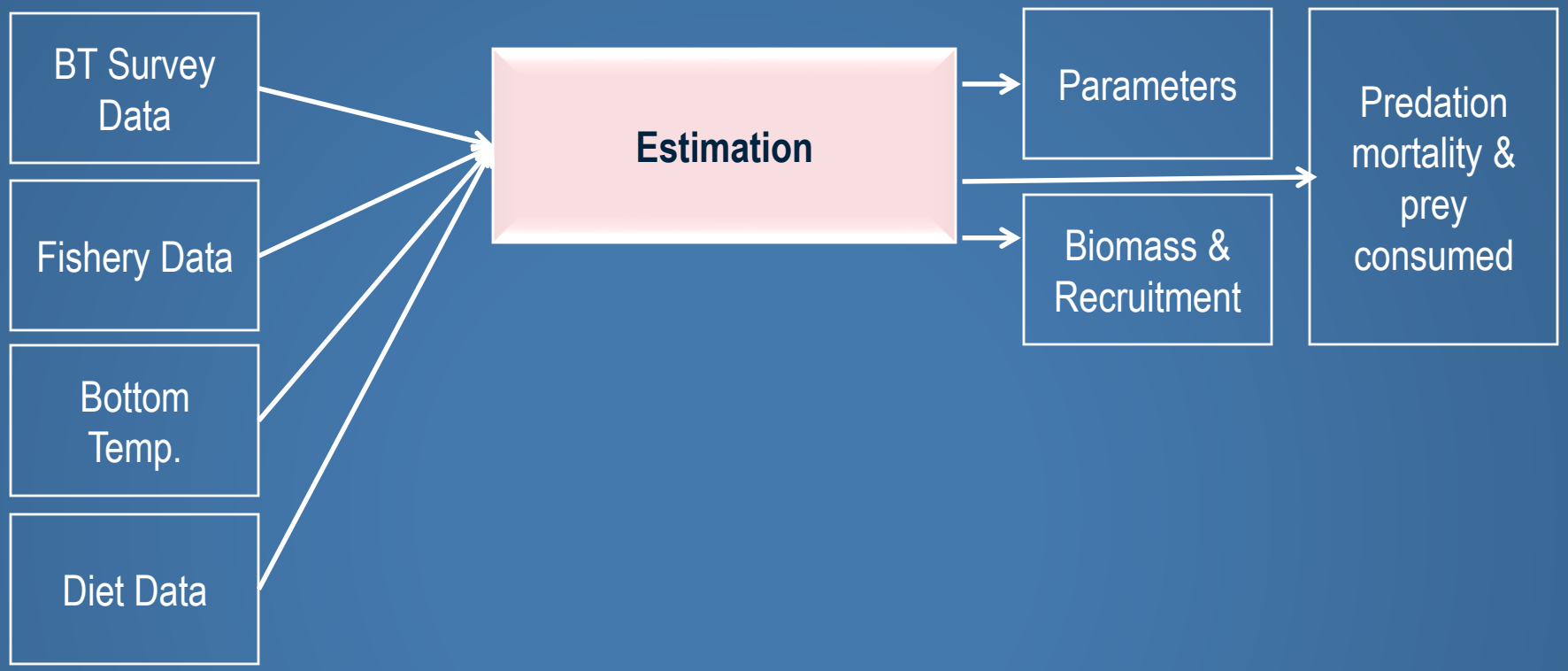
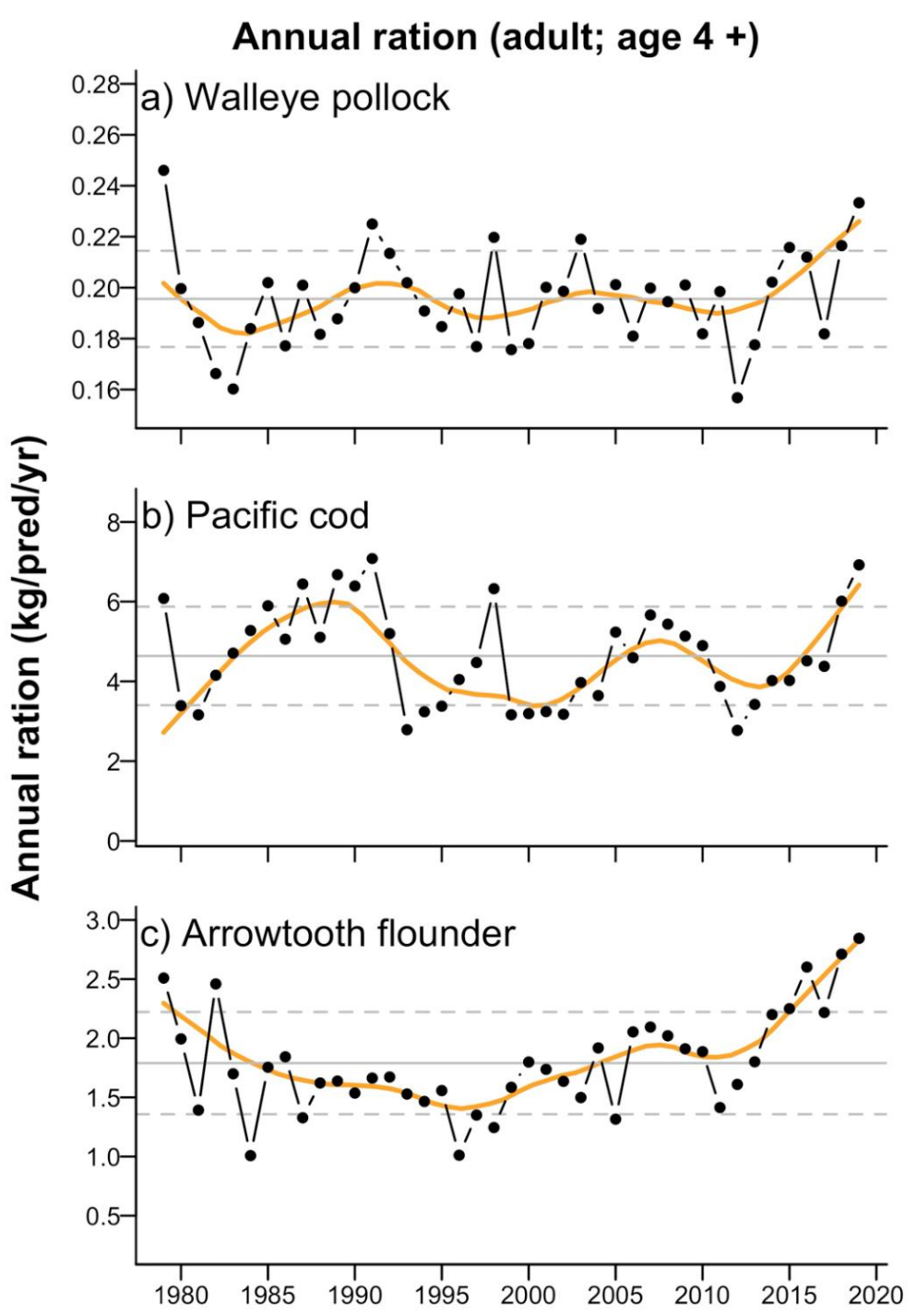
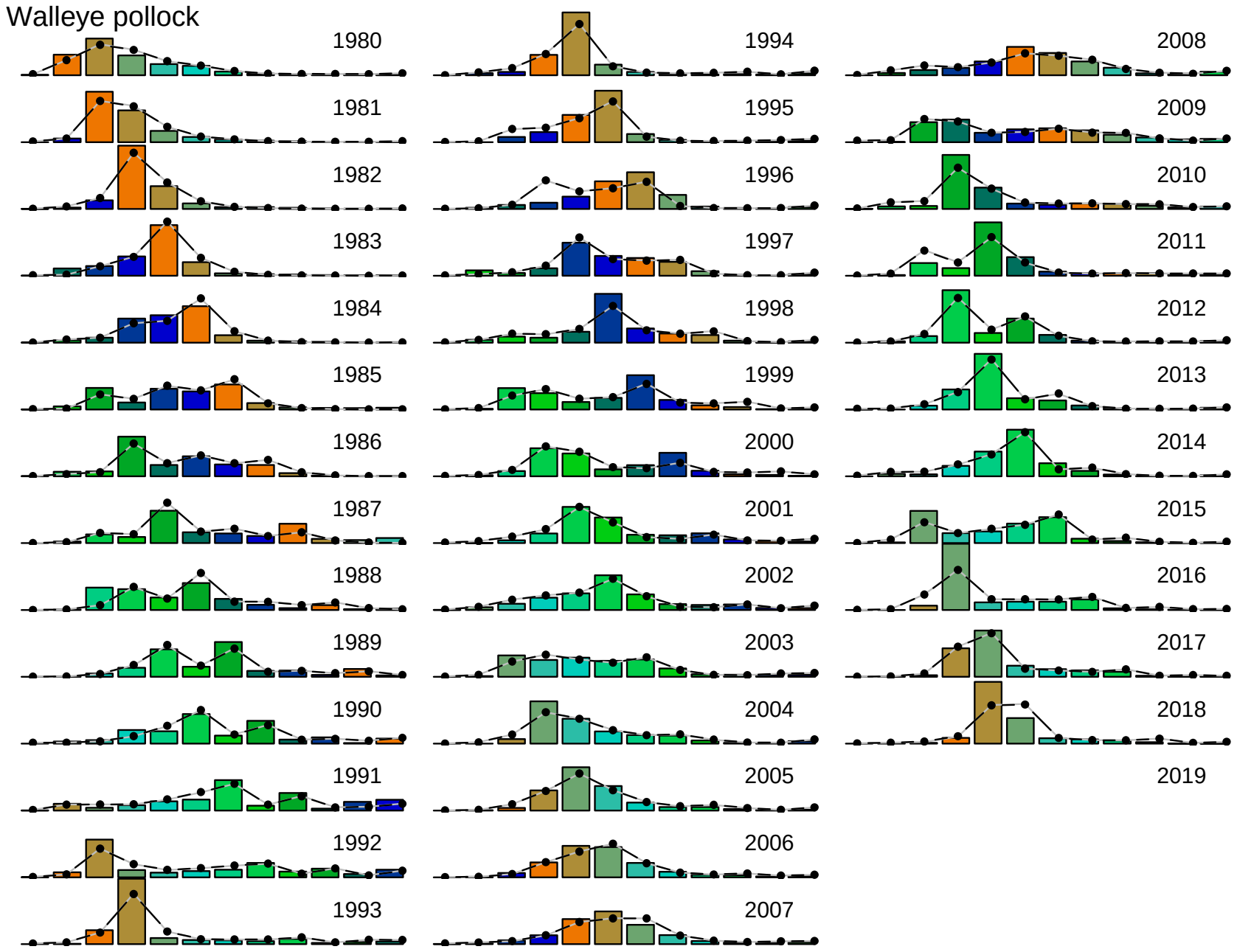

BT Survey Data
Fishery Data
Bottom Temp.
Diet Data
Estimation
Parameters
Biomass & Recruitment
Predation mortality & prey consumed

Multi-species model




Walleye pollock
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019

Result: natural mortality rates

EBS: 2016-now

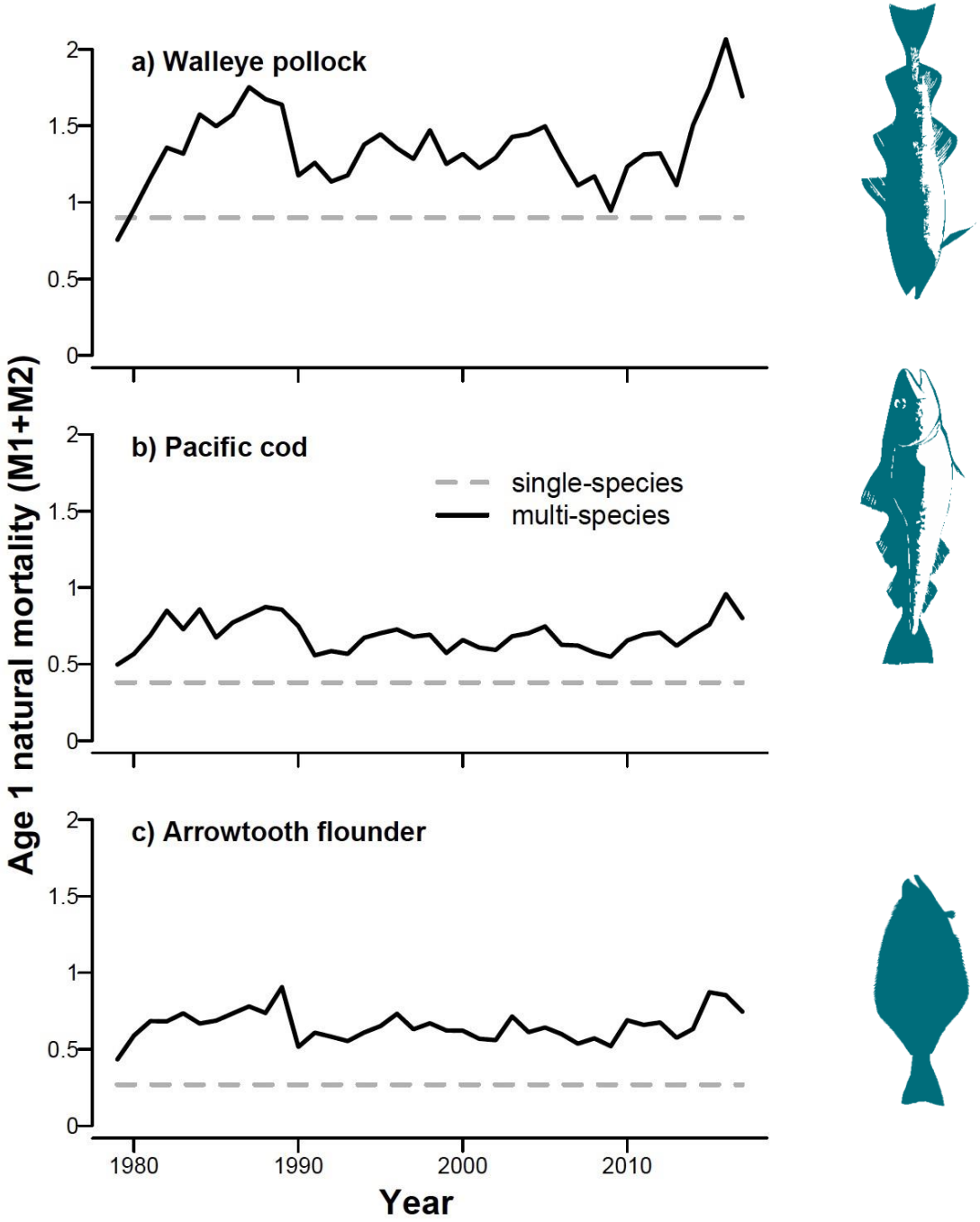
- Pollock, Cod, ATF
- 2019/2020 + NFS

Holsman, Ianelli, Spies, Thompson, Aydin, Adams, Kearney

GOA: *2019*

- Pollock, cod, ATF
- Halibut

Adams, Holsman, Dorn, Spies, Barbeaux, Punt



Result: Predation Index

EBS: 2016-now

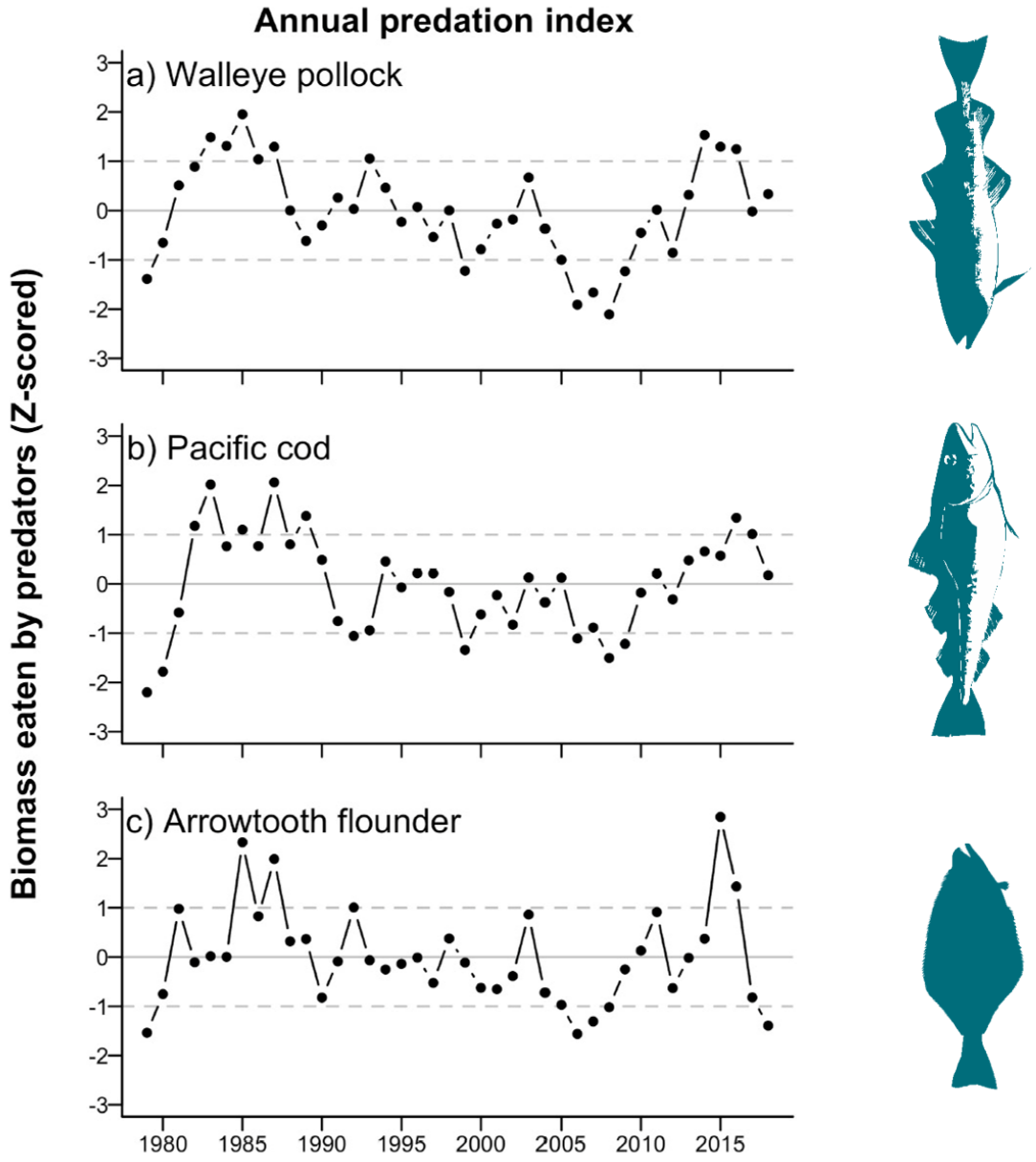
- Pollock, Cod, ATF
- 2019/2020 +NFS

Holsman, Ianelli, Spies, Thompson, Aydin, Adams, Kearney

GOA: *2019*

- Pollock, cod, ATF
- Halibut

Adams, Holsman, Dorn, Spies, Barbeaux, Punt



POC: K. Holsman

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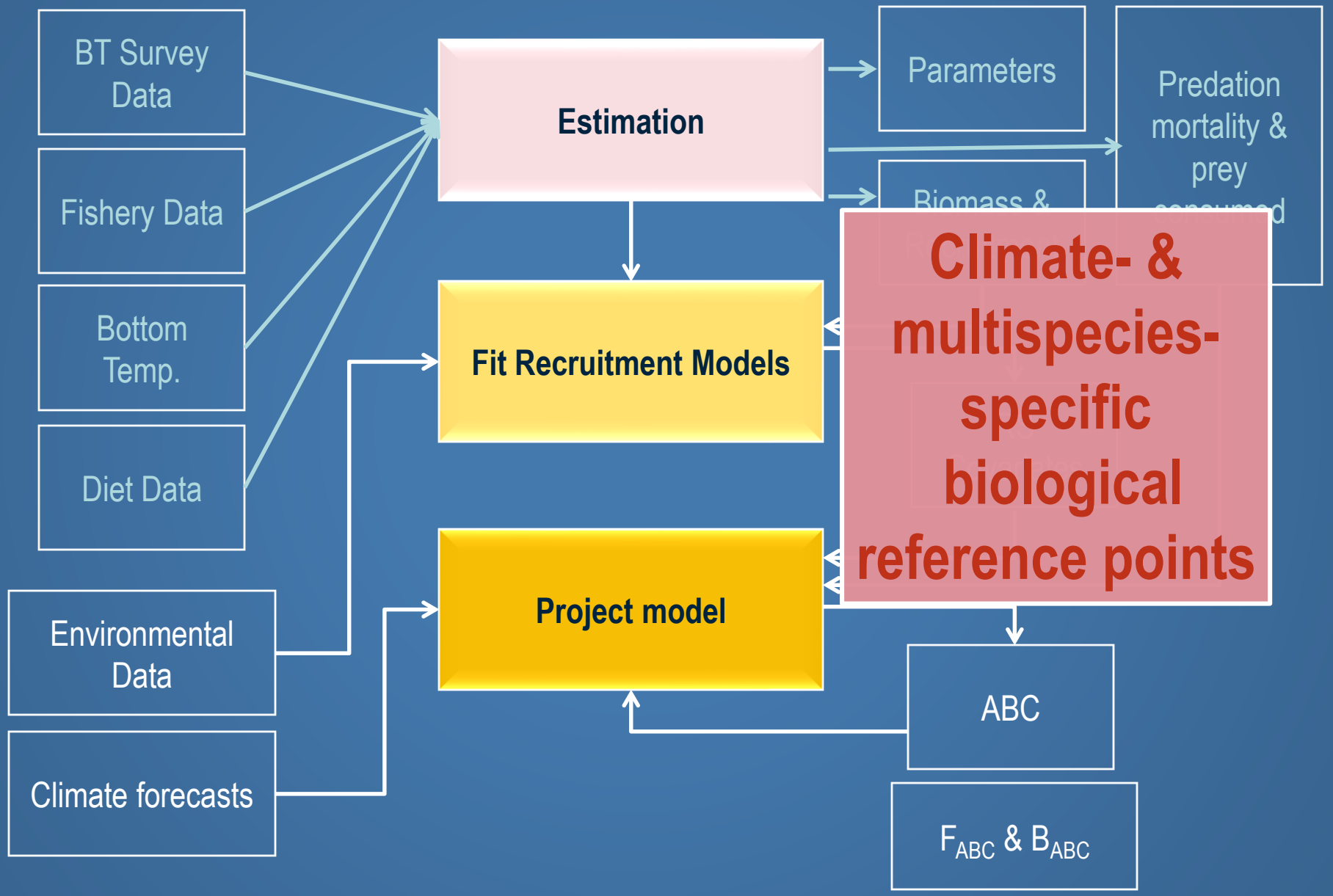
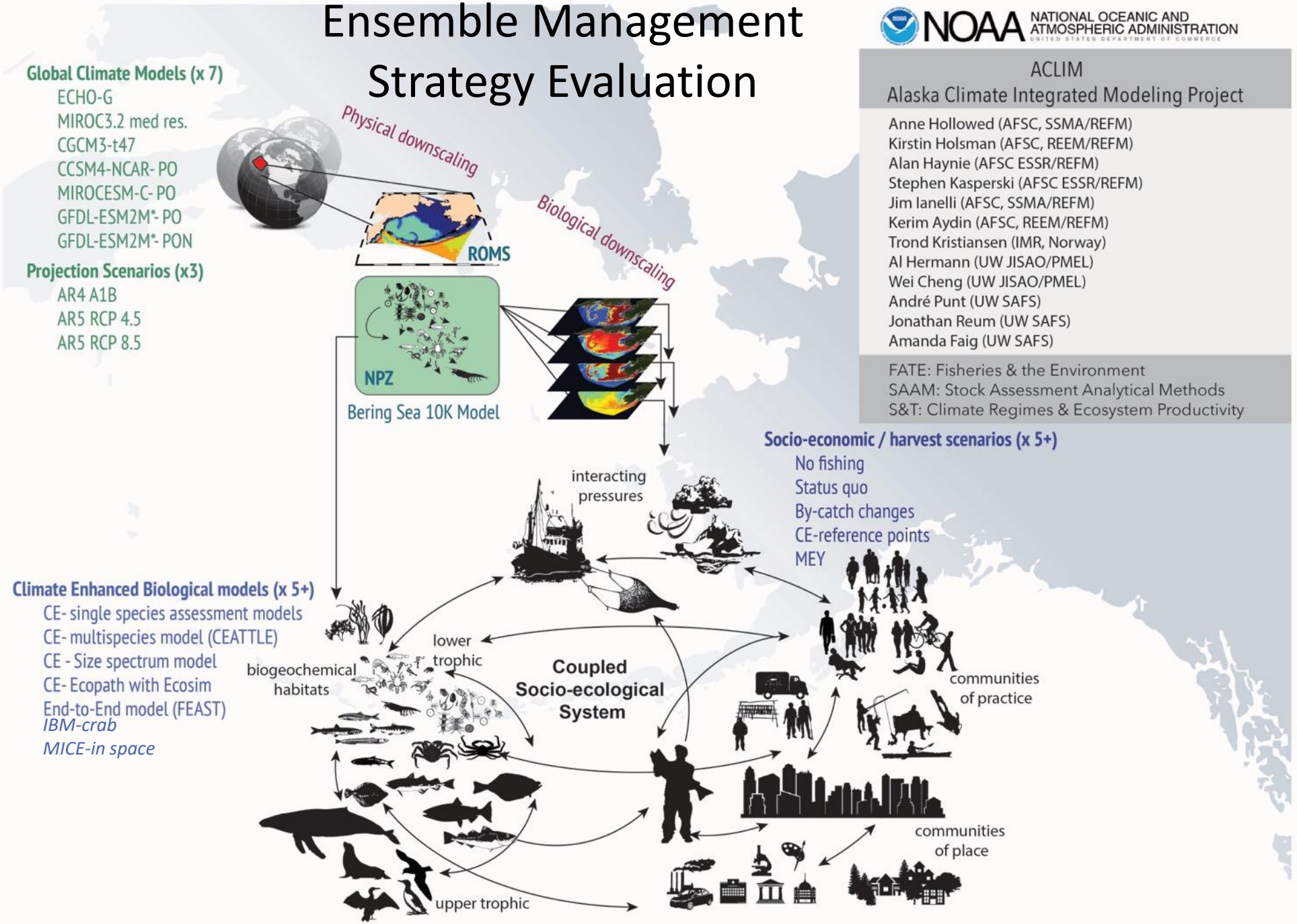

BT Survey Data
Fishery Data
Bottom Temp.
Diet Data
Environmental Data
Climate forecasts
Estimation
Fit Recruitment Models
Project model
Parameters
Predation mortality & prey
Climate- & multispecies-specific biological reference points
ABC
F_{ABC} & B_{ABC}

Ensemble Management Strategy Evaluation



NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ACLIM
Alaska Climate Integrated Modeling Project

Anne Hollowed (AFSC, SSMA/REFM)
Kirstin Holsman (AFSC, REEM/REFM)
Alan Haynie (AFSC ESSR/REFM)
Stephen Kasperski (AFSC ESSR/REFM)
Jim Ianelli (AFSC, SSMA/REFM)
Kerim Aydin (AFSC, REEM/REFM)
Trond Kristiansen (IMR, Norway)
Al Hermann (UW JISAO/PMEL)
Wei Cheng (UW JISAO/PMEL)
André Punt (UW SAFS)
Jonathan Reum (UW SAFS)
Amanda Faig (UW SAFS)

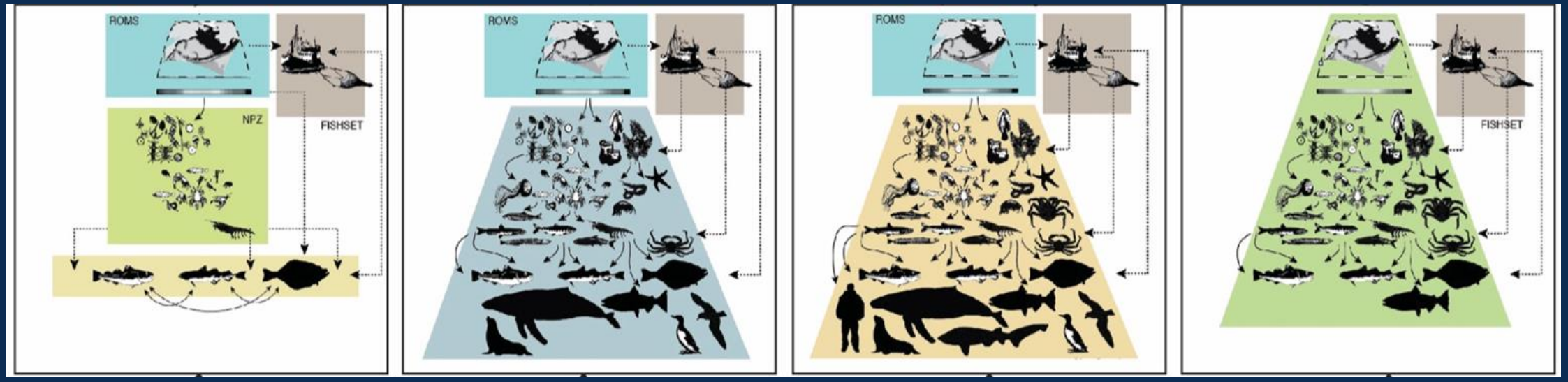
FATE: Fisheries & the Environment
SAAM: Stock Assessment Analytical Methods
S&T: Climate Regimes & Ecosystem Productivity

CEATTLE

CE-EwE

CE-MIZER

FEAST

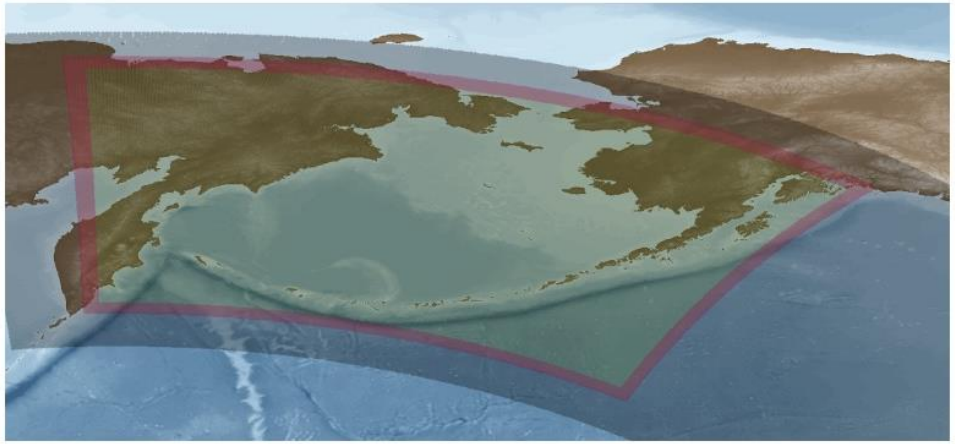


Fast
Statistical
Implicit ecosystem noise

Slow
High resolution
Explicit ecosystem interactions

ROMS NPZ model

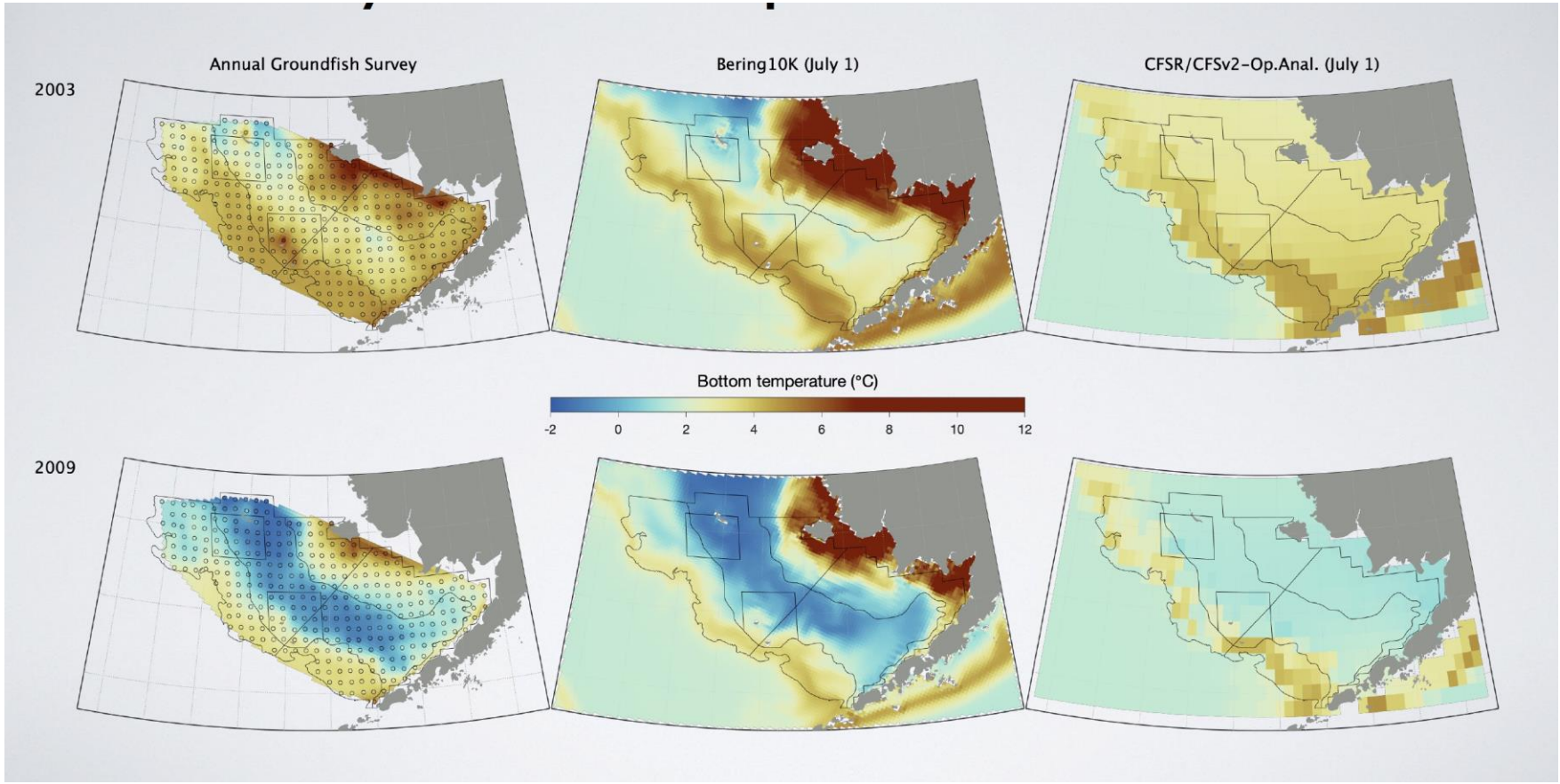
- Developed with NSF/NPRB (Bering Project)
- Ongoing IEA partnership (AFSC/PMEL)
- Significant advances in ice modeling, ice plankton



- Products
  - 40-year hindcast (1971-2012)
  - Nowcasts (annual)
  - 9-month forecast (annual)
  - Forecasts to 2100 with IPCC outputs

ROMSNPZ model

OBSERVATIONS ROMSNPZ (downscaled) GLOBAL MODEL



Global Model Reanalysis products:

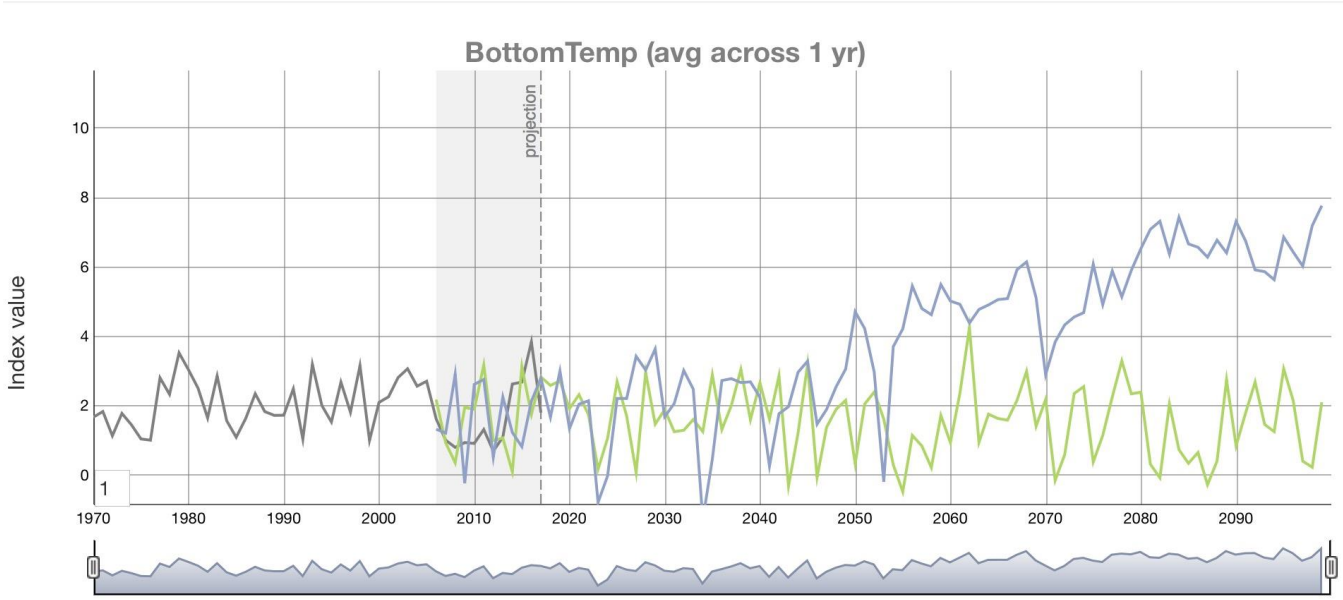
Image: Kelly Kearney

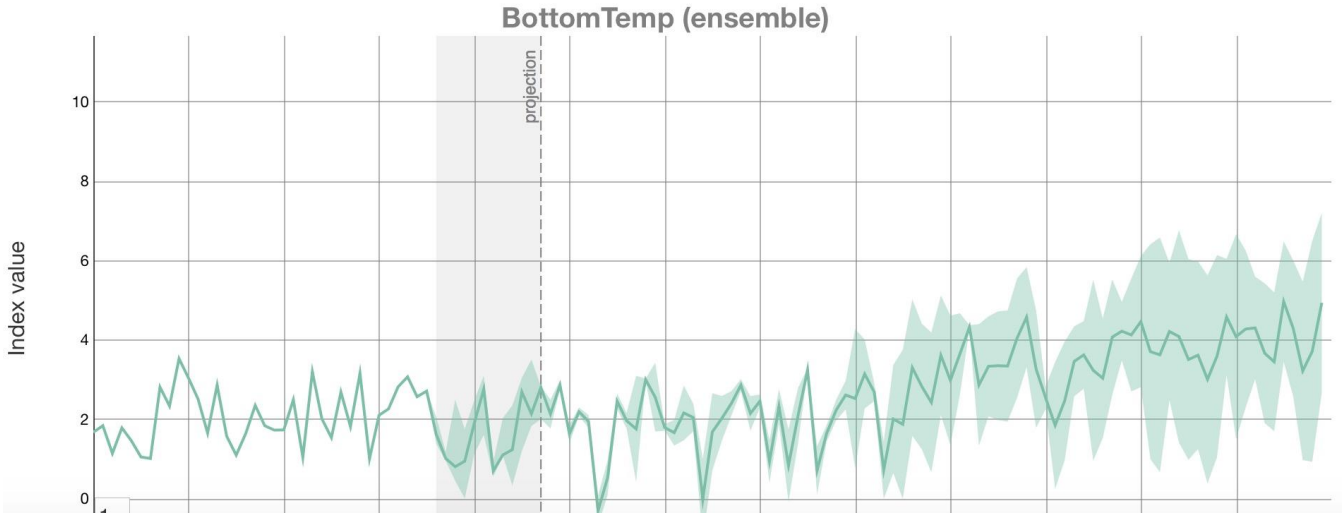
https://cfs.ncep.noaa.gov/cfsr/
https://polar.ncep.noaa.gov/sst/rtg_high_res/

CMIP5

https://kholsman.shinyapps.io/aclim/

ACLIM ROMS-NPZ indices





Coming soon!

Download Data

smoothing # of years

1

Raw or corrected values

2= bias corrected & recentered

Z-score the values

Hindcast

13= 1976-2017, ACLIM updated

projection model

aclim_hindcast GFDL_rcp45 CESM_rcp85

Variables

Bottom temperature

Reference period

1970 2006 2017

1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2017

Plot options

Set Y axis range

lower Y limit

0

upper Y limit

7

line width

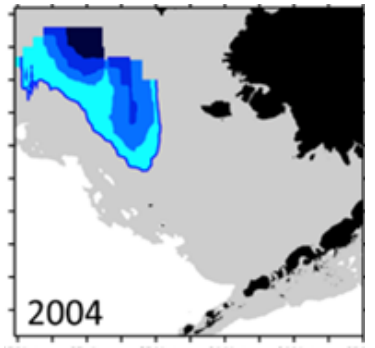
2

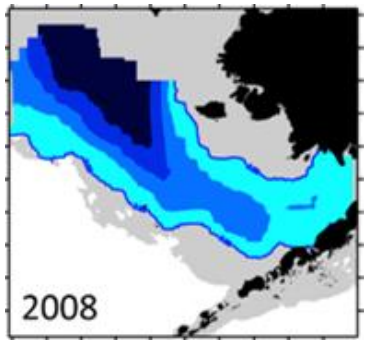
lower quantile

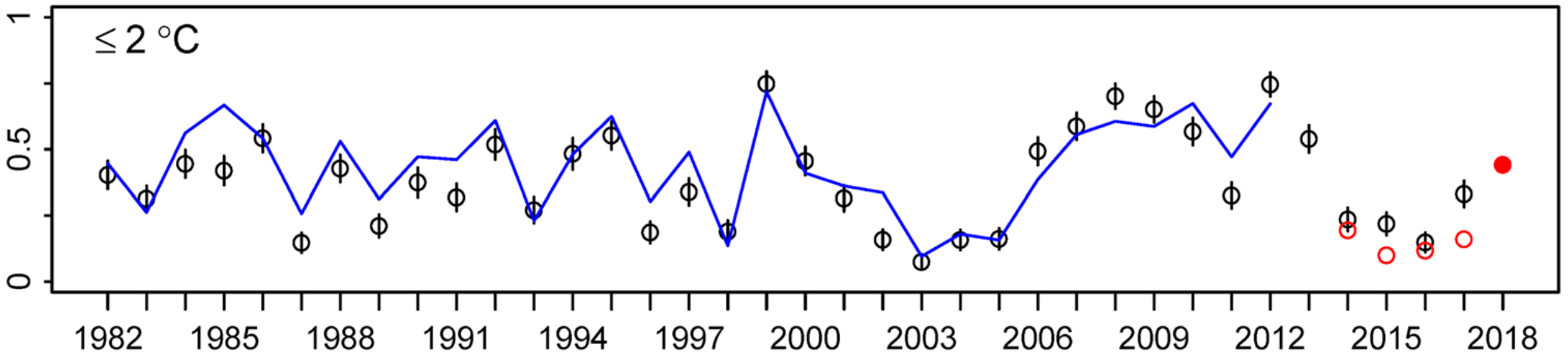
K. Holsman, K. Aydin

9-month (seasonal) forecast - cold pool

K. Aydin







- Skill testing of ROMS…

Take home

Topics missing?

- Robustness
- Model parameterizations

Computer programmers & Mathematicians?

Pragmatism for management

- Engage environmental and biological expertise
- OPERATING MODEL SPECIFICATIONS!