Update on work for EBS pollock assessment

Jim Ianelli AFSC



SSC Recommendations

- Ongoing genetic studies to determine the relationship between pollock in the NBS and EBS, and nearby GOA and AI regions.
- The 2019 BSAI GPT recommendation to revisit and evaluate the treatment of variance parameters within the assessment, with particular attention to those that are fixed.
- Efforts to quantify pollock movement and abundance along the US-Russia EEZ boundary.
- Geostatistical analyses of combined trawl and acoustic data to provide a single time-series, statistically accounting for the overlap between these data, for informing stock trends.

The SSC provides the following additional recommendations:

- Exploration of young-of-year pollock density and quality estimates from NMFS BASIS surveys to inform pollock recruitment.
- Consideration of whether the observed sensitivity in the SRR to prior specification should constitute an increased risk level specification within the assessment or population dynamicsrelated considerations. This could provide a clearer justification for the use of the Tier 3 calculation as the basis for harvest specification.
- Given the time-varying specification of fishery selectivity within the assessment model and the large change in the estimated 2021 FOFL between the 2019 and 2020 assessments, the authors should provide a retrospective comparison of the selectivity assumed in projections to that estimated with the addition of new data.
- Consideration of whether risk table specifications should account for the importance of pollock as a key forage species in the EBS ecosystem to better justify the use of a Tier 3 ABC determination as a precautionary measure for this Tier 1 stock.
- Given the apparent disappearance of the second and large mode in fishery length compositions as the 2020 B-season progressed, exploration of within-season spatial variation in fishery length composition would be useful in evaluating whether these larger pollock simply moved out of the area of fishing effort, or died as a result of natural or fishing mortality.

Ongoing genetic studies to determine the relationship between pollock in the NBS and EBS, and nearby GOA and Al regions.

- Results by the assessment deadline (sometime in October)
- IcWGS was conducted on 600 walleye pollock from throughout their range in Alaska
- Analyses are underway



The 2019 BSAI GPT recommendation to revisit and evaluate the treatment of variance parameters ...

Alternative weightings of indices will be evalued in the coming assessment including variance specification



Efforts to quantify pollock movement and abundance along the US-Russia EEZ boundary.

- Upward looking sonar/ecosounder data evaluation continues, no new information to report on yet!
- Two papers in 2020...studying ways to incorporate factors

EBS pollock SSC/Plan Team recommendations

Contents lists available at ScienceDirect Deep-Sea Research Part II journal homepage: http://www.elsevier.com/locate/dsr2

Deep-Sea Research II 181-182 (2020) 104881

Environmental impacts on walleye pollock (*Gadus chalcogrammus*) distribution across the Bering Sea shelf



Lisa B. Eisner ^{a,*}, Yury I. Zuenko^b, Eugene O. Basyuk^b, Lyle L. Britt^a, Janet T. Duffy-Anderson^a, Stan Kotwicki^a, Carol Ladd^c, Wei Cheng^{c,d}

^a NOAA Alaska Fisheries Science Center, Seattle, WA, USA
^b Russian Research Institute of Fisheries and Oceanography, Pacific Branch (TINRO), Vladivostok, Russia
^c NOAA Pacific Marine Environmental Lab, Seattle, WA, USA
^d Iniversity of Washington, Cooperative Institute for Climate, Ocean and Ecosystem Studies, Seattle, WA, USA

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RESEARCH ARTICLE

Journal of Applied Ecology 📑 BRITISH ECOLOGIC

Estimating spatiotemporal availability of transboundary fishes to fishery-independent surveys

Cecilia A. O'Leary^{1,5} | Stan Kotwicki¹ | Gerald R. Hoff¹ | James T. Thorson² | Vladimir V. Kulik³ | James N. Ianelli⁴ | Robert R. Lauth¹ | Daniel G. Nichol¹ | Jason Conner¹ | André E. Punt⁵



Geostatistical analyses of combined trawl and acoustic data to provide a single time-series...

Paper was published but no new combined data will be available until after the 2022 survey (summer) season for EBS trawl and acoustic data

EBS pollock SSC/Plan Team recommendations

ICES Journal of Marine Science



ICES Journal of Marine Science (2021), doi:10.1093/icesjms/fsab085

Incorporating vertical distribution in index standardization accounts for spatiotemporal availability to acoustic and bottom trawl gear for semi-pelagic species

Cole C. Monnahan (1)^{1,2*}, James T. Thorson (1)¹, Stan Kotwicki (1)¹, Nathan Lauffenburger¹, James N. Ianelli¹, and Andre E. Punt (1)²

¹Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Seattle, WA 98115, USA ²School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA 98195, USA

*Corresponding author: e-mail: cole.monnahan@noaa.gov.

Monnahan, C. C., Thorson, J. T., Kotwicki, S., Lauffenburger, N., Ianelli, J. N., and Punt, A. E. Incorporating vertical distribution in index standardization accounts for spatiotemporal availability to acoustic and bottom trawl gear for semi-pelagic species. – ICES Journal of Marine Science, doi:10.1093/icesjms/fsab085.

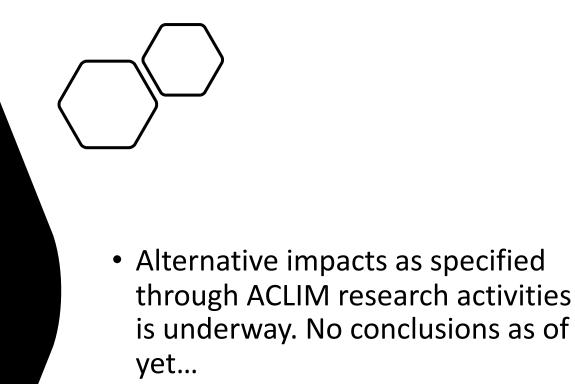
Received 12 August 2020; revised 7 April 2021; accepted 12 April 2021.



Exploration of young-of-year pollock density and quality estimates from NMFS BASIS surveys to inform pollock recruitment

- No further work on including these data has been developed
- Yasumiishi's copepod index examined





Consideration of whether the observed sensitivity in the SRR to prior specification should constitute an increased risk level specification within the assessment or population dynamics related considerations. This could provide a clearer justification for the use of the Tier 3 calculation as the basis for harvest specification.



Given the time-varying specification of fishery selectivity within the assessment model and the large change in the estimated 2021 FOFL between the 2019 and 2020 assessments, the authors should provide a retrospective comparison of the selectivity assumed in projections to that estimated with the addition of new data.

- Further study supports the inclination to make 2021 ABC recommendations (below max(ABC)) given the tendency towards smaller (younger) pollock in 2021
- Alternative diagnostics on how selectivity has changed retrospectively will be attempted



Consideration of whether risk table specifications should account for the importance of pollock as a key forage species in the EBS ecosystem to better justify the use of a Tier 3 ABC determination as a precautionary measure for this Tier 1 stock.

Work on this limited

CEATTLE notes importance as prey

Seeking further advice!



Given the apparent disappearance of the second and large mode in fishery length compositions as the 2020 B-season progressed, exploration of within-season spatial variation in fishery length composition would be useful in evaluating whether these larger pollock simply moved out of the area of fishing effort, or died as a result of natural or fishing mortality.

- Patterns of 2020 and 2021 size composition suggest that the larger (older) age-classes are less abundant in the catch
- Resolution on shifts in the relative year-class strengths are affected vs new recruitment is an important area of research/support given available data



Hypotheses being considered as part of ACLIM project

Some being considered for EBS pollock

- Recruitment is related to temperature
- Survival to age 3 related to large copepods
- Natural mortality can be drawn reasonably from CEATTLE
- Growth increment is related to temperature

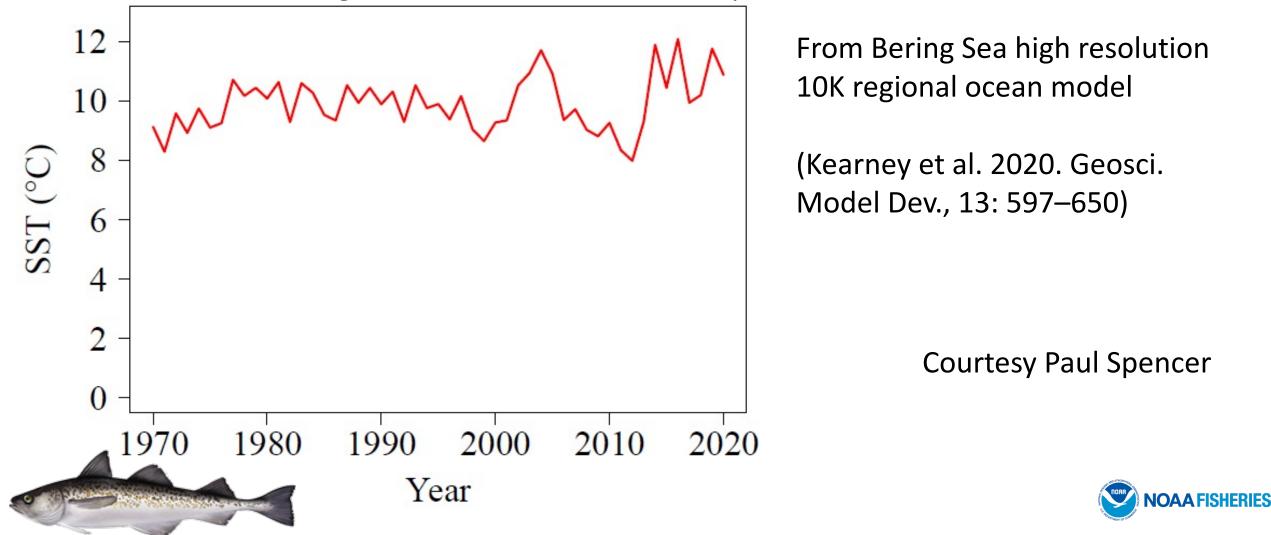


Recruitment is related to temperature



Temperature moderated recruitment

Hindcast eastern Bering Sea summer sea surface temperature



Temperature moderated recruitment

Hypothesis:

 Pollock recruitment declines at high temperatures

Support:

- Mueter et al. (2011)
- Spencer et al. (2016)

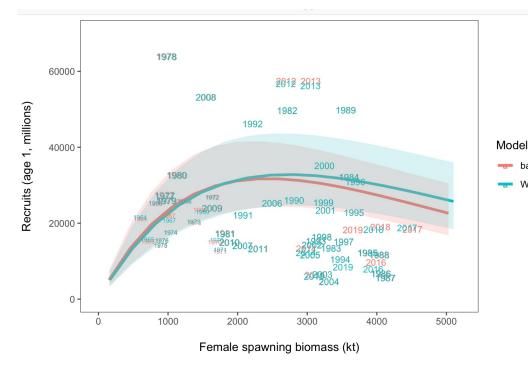
Implementation within pollock assessment model:

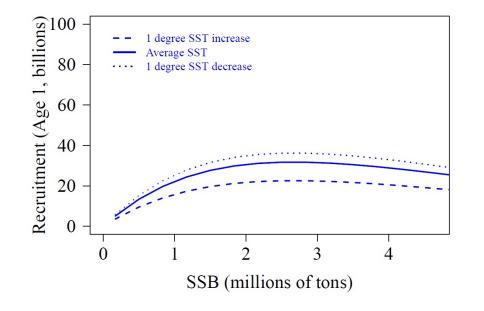
$$R_t = f(SSB_{t-a})e^{\alpha + x_1SST_{t-a} + x_2SST_{t-a}^2}e^{\varepsilon_t}$$

Courtesy Paul Spencer









Stock-recruit relationship

Climate-enhanced model

base With CE

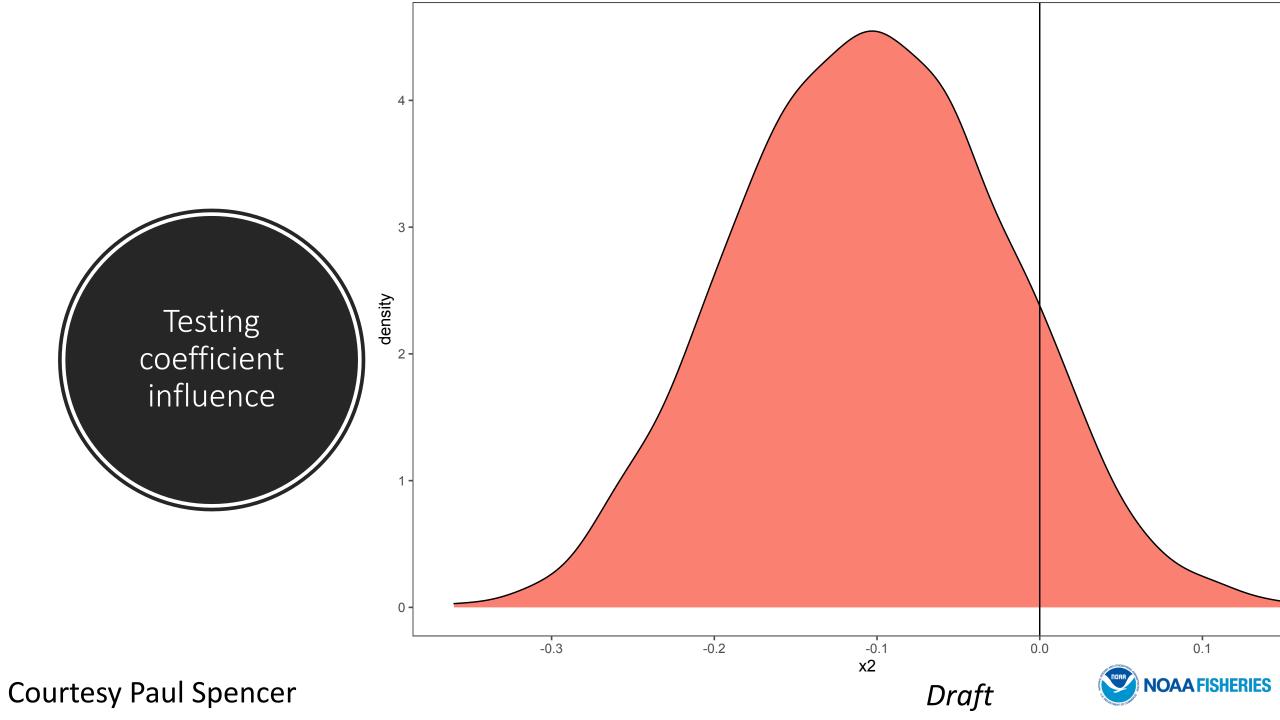
- Minor impact on recruits and spawning biomass
- Due to extensive age composition data
- Curves similar (at average temperature)

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- However, as temperature increases, the expected recruitment substantially decreases
- This would affect estimated reference points and harvest recommendations.







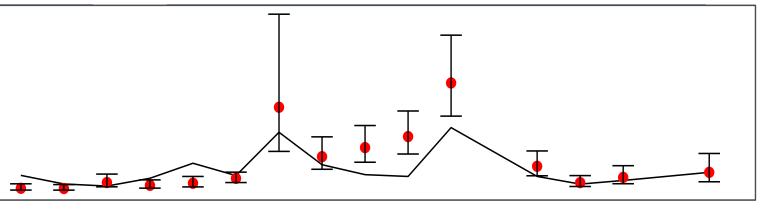
Survival to age 3 related to large copepods



Copepod index affects survival to age 3

Hypothesis:

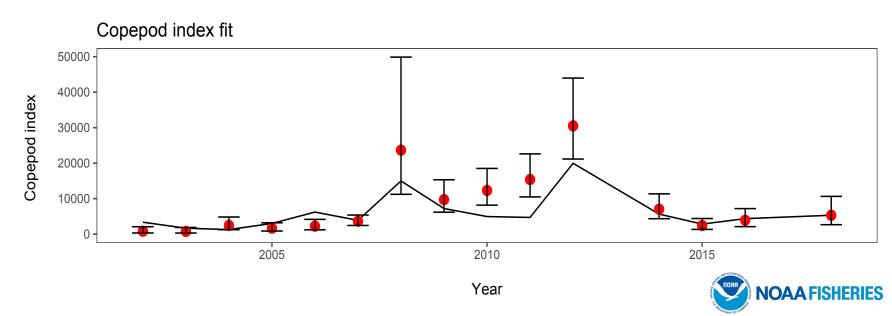
 Pollock age 0 survival affected large zooplankton abundance



Implementation within pollock assessment model:

As a form of "data" related to age 3 model abundance

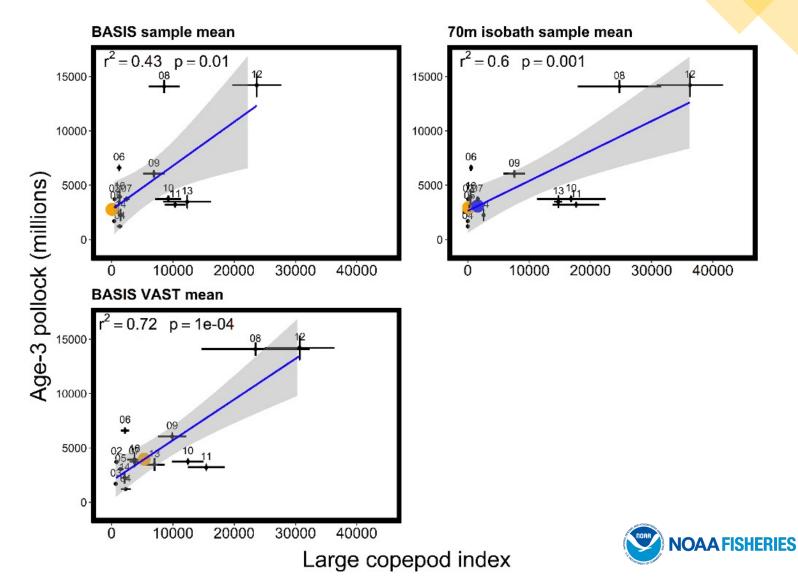
As yet, lacks linkage within assessment to mortality

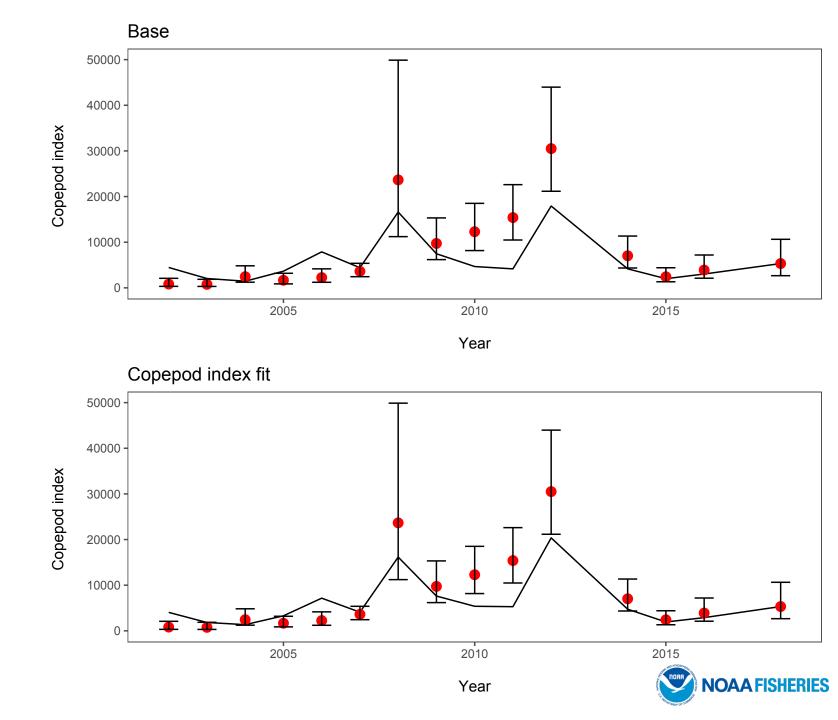


Large copepod for age-0 pollock

From Yasumiishi, Eisner, and Kimmel

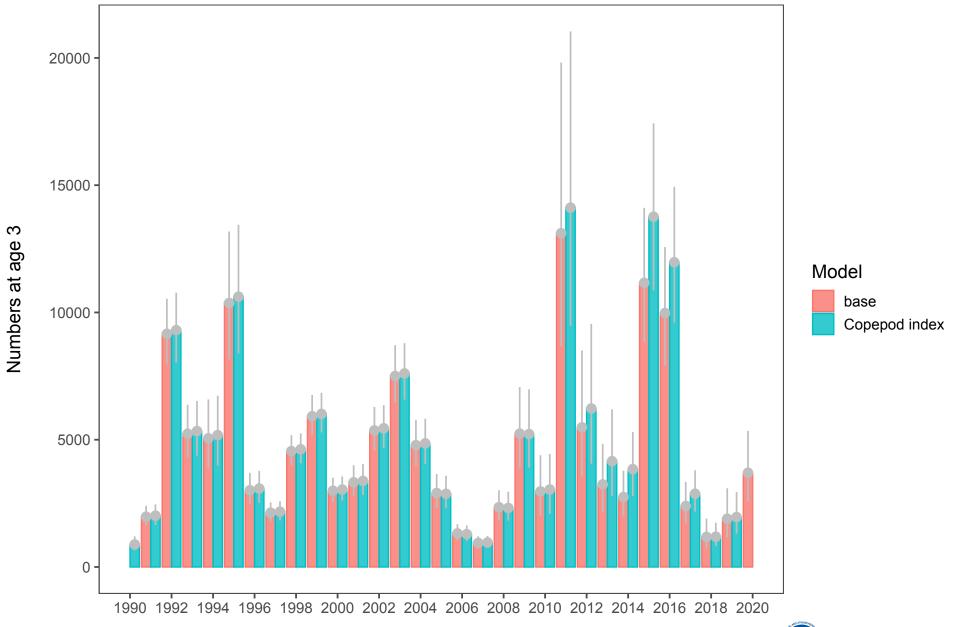
 Index sums Calanus marshallae/glacialis (copepodite stage 3 (C3)-adult), Neocalanus spp. (C3-adult), and Metridia pacifica (C4-adult),





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Copepod index on age 3 abundance





Natural mortality can be drawn reasonably from CEATTLE



Apply CEATTLE results for natural mortality

Hypothesis:

• Pollock mortality varies over time and age due to predator diets

Support:

• Holsman et al. (various)

Implementation within pollock assessment model:

Matrix of natural mortality (years and ages) pre-specified

Does it improve fits to the assessment data?



CEATTLE

• M matrix

Year x age

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1978	2.24	0.42	0.35	0.32	0.31	0.31	0.30	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
1979	2.45	0.41	0.34	0.32	0.30	0.31	0.30	0.30	0.31	0.30	0.30	0.30	0.30	0.30	0.30
1980	2.66	0.43	0.35	0.32	0.31	0.31	0.31	0.30	0.31	0.30	0.30	0.30	0.30	0.30	0.30
1981	2.87	0.46	0.36	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
1982	2.83	0.46	0.36	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.31	0.31	0.31	0.31
1983	3.19	0.49	0.38	0.34	0.31	0.31	0.31	0.31	0.32	0.30	0.30	0.31	0.31	0.31	0.31
1984	3.18	0.48	0.37	0.33	0.31	0.31	0.31	0.31	0.32	0.30	0.30	0.31	0.31	0.31	0.31
1985	3.27	0.49	0.37	0.34	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
1986	3.47	0.52	0.39	0.34	0.31	0.31	0.31	0.31	0.31	0.30	0.31	0.31	0.31	0.31	0.31
1987	3.35	0.53	0.39	0.34	0.31	0.31	0.31	0.31	0.31	0.30	0.31	0.31	0.31	0.31	0.31
1988	3.31	0.56	0.41	0.35	0.31	0.31	0.31	0.31	0.32	0.30	0.31	0.31	0.31	0.31	0.31
1989	2.83	0.49	0.38	0.34	0.31	0.31	0.31	0.31	0.32	0.30	0.30	0.31	0.31	0.31	0.31
1990	2.86	0.46	0.37	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.31	0.31	0.31	0.31
1991	2.90	0.44	0.35	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
1992	2.88	0.43	0.35	0.32	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
1993	3.13	0.45	0.35	0.32	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
1994	3.20	0.47	0.36	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.31	0.31	0.31	0.31
1995	3.01	0.47	0.36	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.31	0.31	0.31	0.31
1996	2.84	0.46	0.36	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
1997	3.12	0.48	0.37	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.31	0.31	0.31	0.31
1998	2.85	0.45	0.36	0.32	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
1999	2.93	0.46	0.36	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
2000	2.79	0.45	0.36	0.32	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
2001	2.91	0.45	0.36	0.32	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
2002	3.04	0.46	0.36	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
2003	3.05	0.48	0.37	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
2004	3.08	0.51	0.38	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.31	0.31	0.31	0.31
2005	3.01	0.50	0.38	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.31	0.31	0.31	0.31
2006	2.76	0.47	0.37	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
2007 2008	2.81 2.61	0.47	0.36	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
2008	2.83	0.45	0.36	0.32	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30 0.30	0.30	0.30	0.30
2009	2.96	0.46	0.36	0.32	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
2011	2.92	0.40	0.36	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
2012	2.74	0.45	0.36	0.32	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
2013	3.01	0.46	0.36	0.32	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
2013	3.42	0.40	0.36	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
2015	3.72	0.52	0.38	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.31	0.31	0.31	0.31
2016	3.21	0.51	0.38	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.31	0.31	0.31	0.31
2017	3.19	0.51	0.39	0.34	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0,21	0.31	0.31	0.31
2018	2.98	0.48	0.37	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	I DORA		AGISH	
2019	2.98	0.48	0.37	0.33	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.31	0.31	0.31	0.31
	2.00	0.10	0.57	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.02	0.01	0.01	0.01



A suite of pollock models with some climate enhancements



Models crossed w/ some indicators

	SST Climate	M-matrix from	Copepod
Name	enhanced recruit	CEATTLE	index
base			
With CE			
CEATTLE M			
CEATTLE M CE			
Copepod index			
Copepod index+ CE			
Copepod index + CE + M			



Fits to indices, root mean squared errors

					Copepod	Cope+	Cope+CE
Component	base	With CE	CEATTLE_M	CEATTLE_M_CE	index	CE	+CE_M
RMSE BTS	0.16	0.16	0.16	0.16	0.16	0.16	<mark>0.16</mark>
RMSE ATS	0.22	0.22	0.22	0.22	0.23	0.23	0.24
RMSE AVO	0.2	0.2	0.27	0.2	0.25	0.25	0.32
RMSE CPUE	0.09	0.08	0.08	0.08	0.09	0.08	0.08



Negative log-posterior (NLL) by model (columns)

Component	base	With CE	CEATTLE_M	CEATTLE_M_CE	Copepod index	Cope+ CE	Cope+CE +CE_M
BTS NLL	25.7	25.8	26.8	25.8	25.5	25.5	26.6
ATS NLL	8.7	8.5	8.2	8.5	11.6	11.4	11.5
AVO NLL	10.1	9.7	9.5	9.7	10.3	9.9	9.6
Copepod NLL	0.0	0.0	0.0	0.0	48.0	48.0	46.5
Fish Age NLL	148.8	148.9	150.3	148.9	147.5	147.8	149.0
BTS Age NLL	146.4	147.1	145.8	147.1	147.5	148.0	147.4
ATS Age NLL	25.0	24.7	25.4	24.7	24.5	24.4	24.6
Data NLL	380.1	379.8	389.3	379.8	433.9	433.8	440.2
Total NLL	593.3	588.0	626.4	588.0	649.2	644.0	679.6
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Negative log-posterior (NLL) by model (columns)

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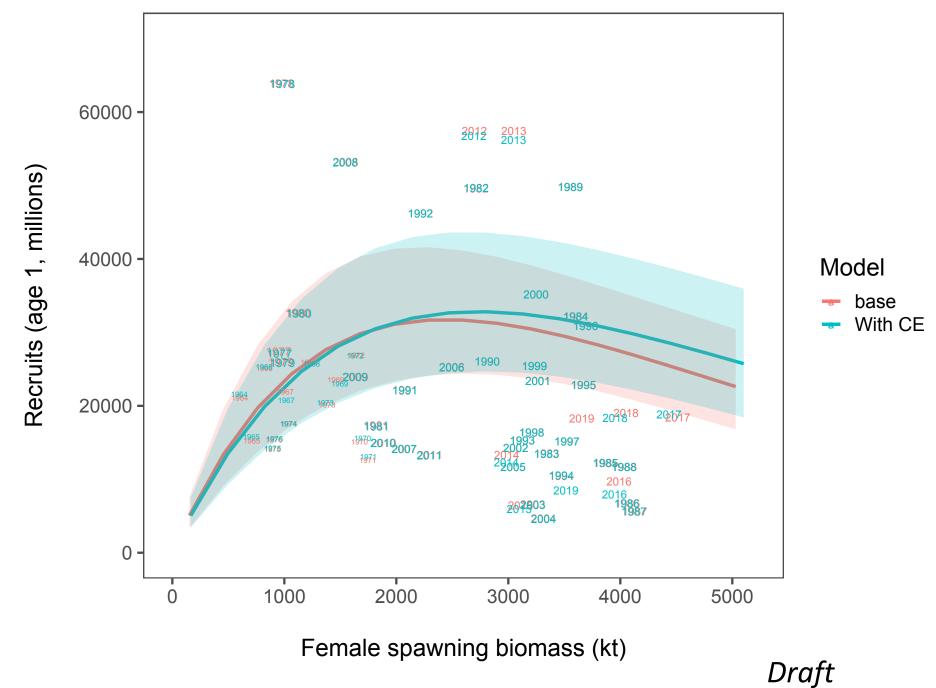
Relative to "Base" (but w/o copepod in totals)

Component	base	With CE	CEATTLE_M	CEATTLE_M_CE	Copepod index	Cope+ CE	Cope+CE +CE_M
BTS NLL	0.0	0.1	1.1	0.1	-0.2	-0.2	0.9
ATS NLL	0.0	-0.2	-0.4	-0.2	3.0	2.8	2.8
AVO NLL	0.0	-0.4	-0.6	-0.4	0.2	-0.2	-0.5
Copepod NLL	0.0	0.0	0.0	0.0	48.0	48.0	46.5
Fish Age NLL	0.0	0.1	1.4	0.1	-1.3	-1.0	0.1
BTS Age NLL	0.0	0.6	-0.6	0.6	1.1	1.6	1.0
ATS Age NLL	0.0	-0.3	0.4	-0.3	-0.5	-0.6	-0.4
Data NLL	0.0	-0.3	9.2	-0.3	5.8	5.7	13.6
Total NLL	0.0	-5.3	33.2	-5.3	7.9	2.8	<u>39.9</u>
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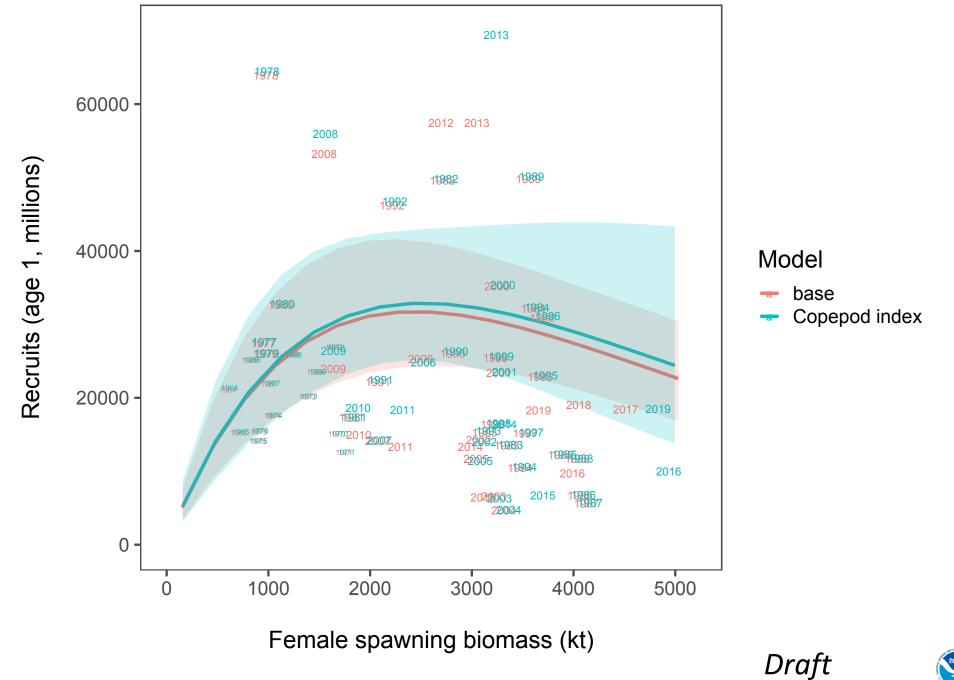
Comparing these model configurations

• Stock-recruit relationship plots

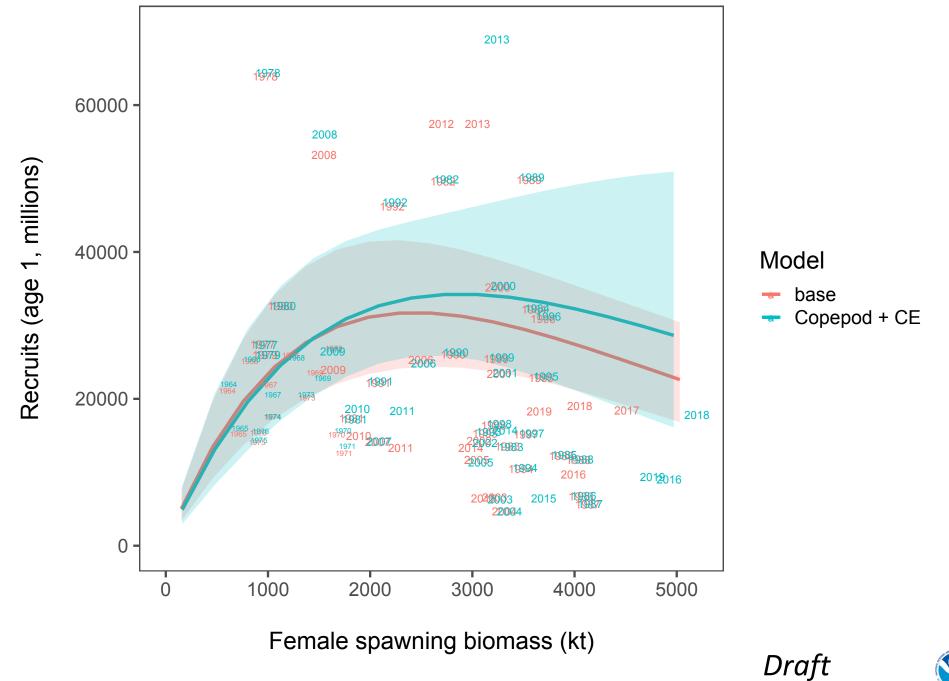




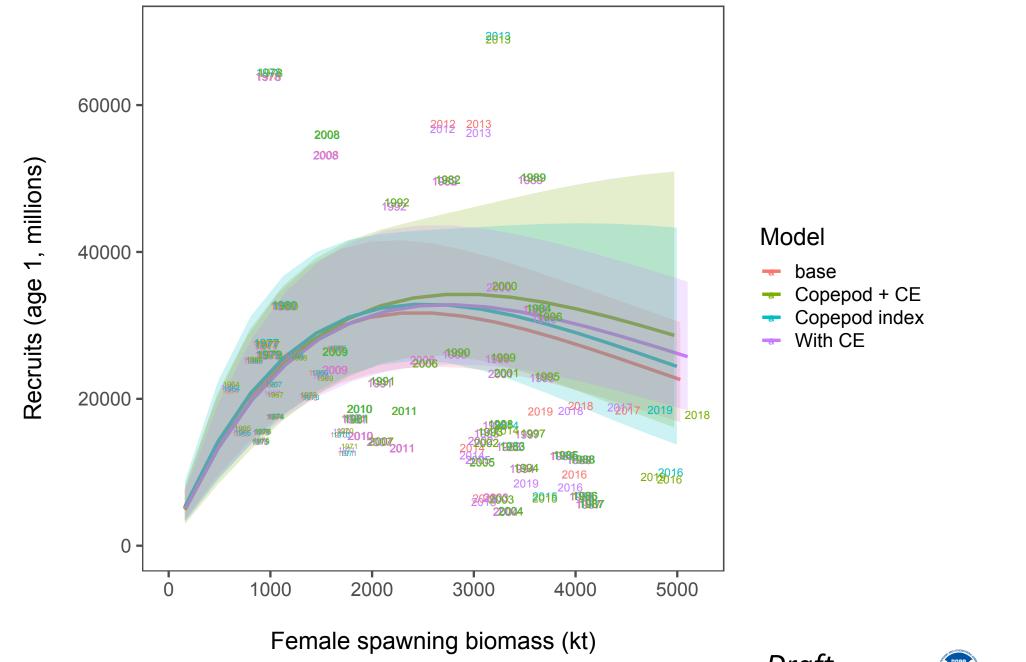












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Preliminary conclusion

Climate enhanced recruitment model improves fit

- This was also shown to be the case for the posterior predictive loss approach (next slide from Paul)
- Current M-matrix from CEATTLE degraded fit
 - Needs revisiting/cross checking
 - Reference point calculations affected
 - Projection mode?



Model selection and prediction of new data?

Posterior Predictive Loss (PPL; Gelfand and Gnosh 1998)

Based on decision theory, and a loss function

 $PPL = \mathcal{L}(\tilde{y}_i, \hat{y}_i) + w\mathcal{L}(y_i, \hat{y}_i) \blacktriangleleft$

 $\widetilde{\mathcal{Y}}_i$ = Replicate data drawn from posterior predictive distribution of the data

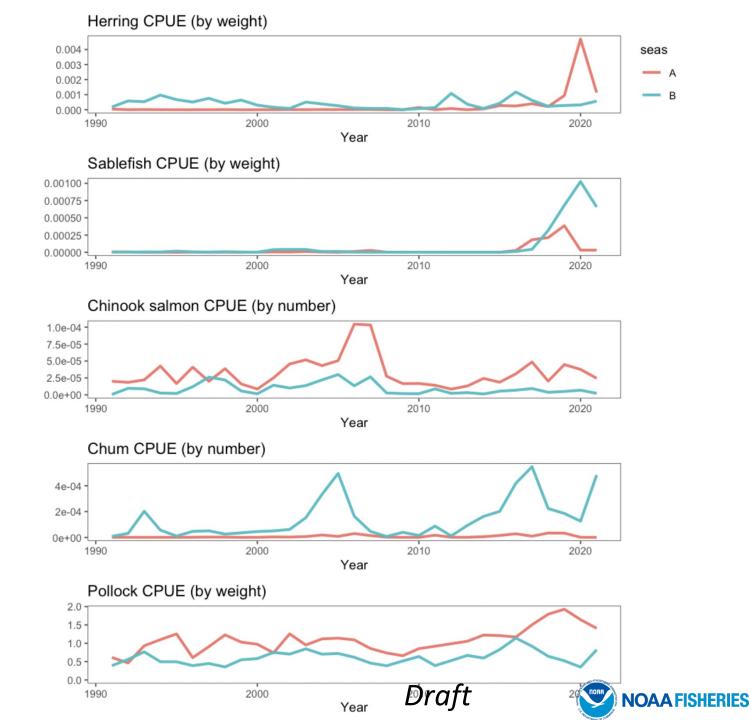
Squared error loss function $\mathcal{L}(x, y) = (x - y)^2$ Goodness of fit to observed data

Precision of estimation (i.e., how well the model fits new data not used in model fitting)

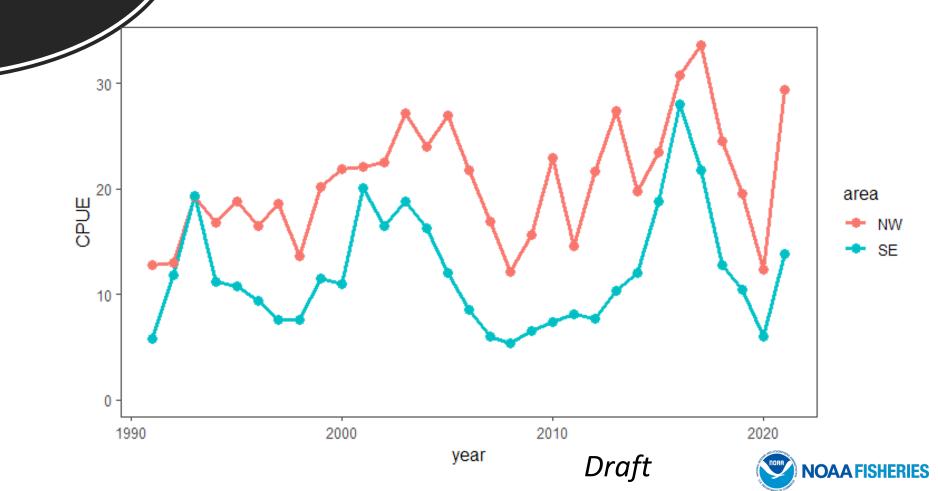
Courtesy Paul Spencer

Fishery conditions

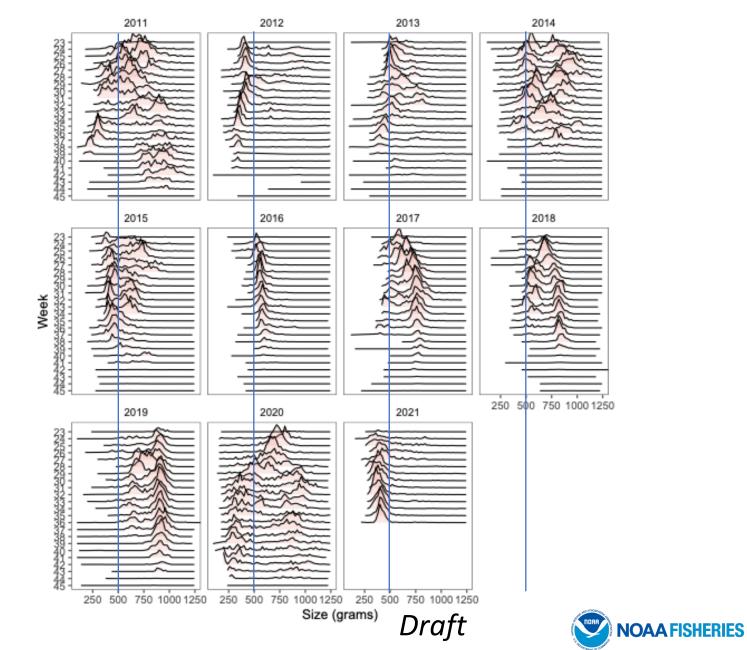
- Catch rates of pollock and selected bycatch species
- B-season through August

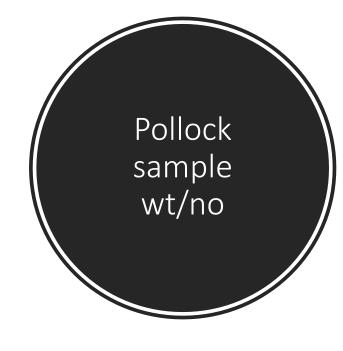


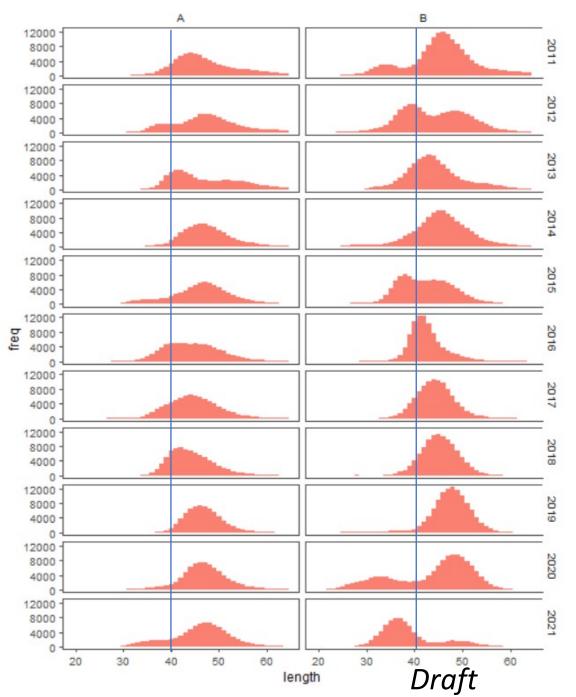
June-August Pollock fishery CPUE by area (E and W of 170)

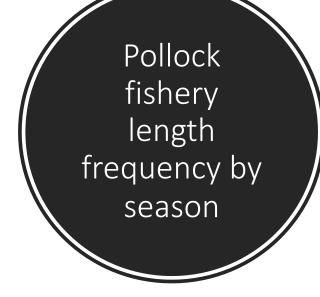


Weight frequency (by haul)

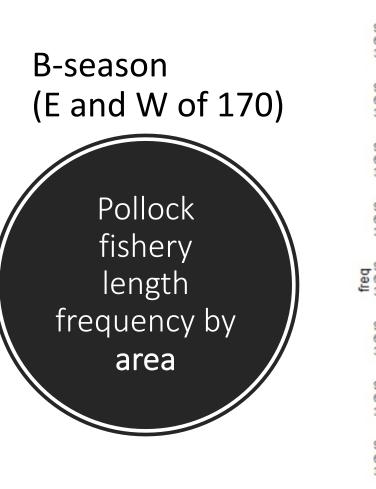


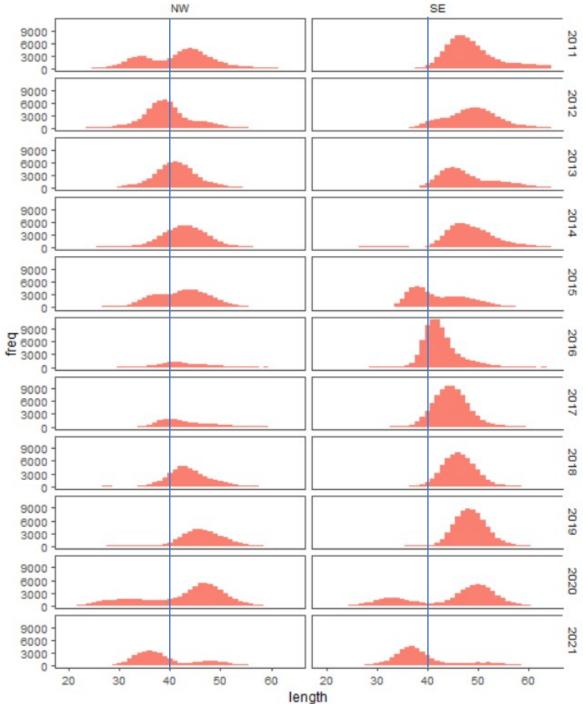




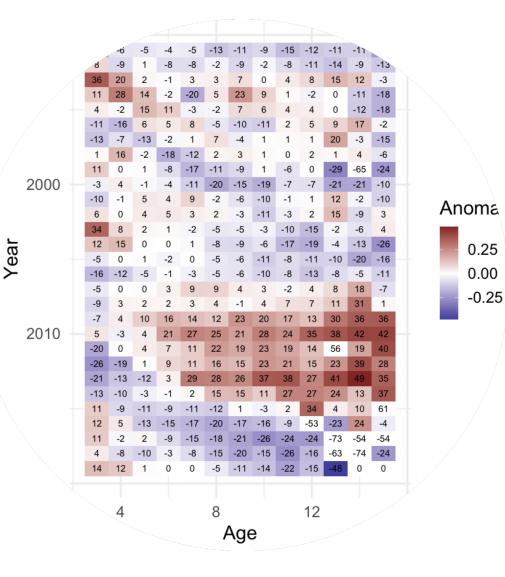


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• Can it be considered w/ an environmental index?

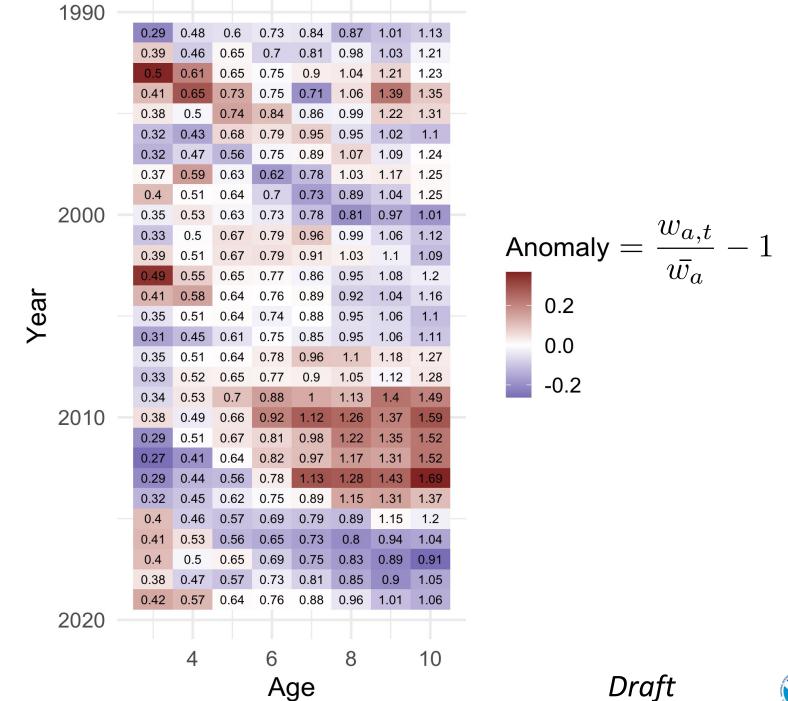




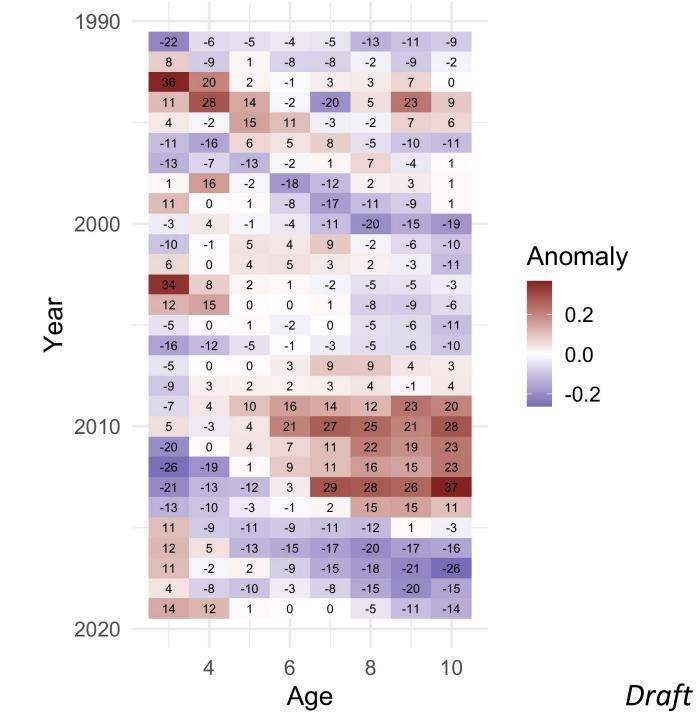
Start with
body mass
at age

1990 —									
	0.29	0.48	0.6	0.73	0.84	0.87	1.01	1.13	
	0.39	0.46	0.65	0.7	0.81	0.98	1.03	1.21	
	0.5	0.61	0.65	0.75	0.9	1.04	1.21	1.23	
	0.41	0.65	0.73	0.75	0.71	1.06	1.39	1.35	
	0.38	0.5	0.74	0.84	0.86	0.99	1.22	1.31	
	0.32	0.43	0.68	0.79	0.95	0.95	1.02	1.1	
	0.32	0.47	0.56	0.75	0.89	1.07	1.09	1.24	
	0.37	0.59	0.63	0.62	0.78	1.03	1.17	1.25	
	0.4	0.51	0.64	0.7	0.73	0.89	1.04	1.25	
2000 —	0.35	0.53	0.63	0.73	0.78	0.81	0.97	1.01	
	0.33	0.5	0.67	0.79	0.96	0.99	1.06	1.12	
	0.39	0.51	0.67	0.79	0.91	1.03	1.1	1.09	
	0.49	0.55	0.65	0.77	0.86	0.95	1.08	1.2	
Year	0.41	0.58	0.64	0.76	0.89	0.92	1.04	1.16	
. – e	0.35	0.51	0.64	0.74	0.88	0.95	1.06	1.1	
×	0.31	0.45	0.61	0.75	0.85	0.95	1.06	1.11	
	0.35	0.51	0.64	0.78	0.96	1.1	1.18	1.27	
	0.33	0.52	0.65	0.77	0.9	1.05	1.12	1.28	
	0.34	0.53	0.7	0.88	1	1.13	1.4	1.49	
2010 —	0.38	0.49	0.66	0.92	1.12	1.26	1.37	1.59	
	0.29	0.51	0.67	0.81	0.98	1.22	1.35	1.52	
	0.27	0.41	0.64	0.82	0.97	1.17	1.31	1.52	
	0.29	0.44	0.56	0.78	1.13	1.28	1.43	1.69	
	0.32	0.45	0.62	0.75	0.89	1.15	1.31	1.37	
	0.4	0.46	0.57	0.69	0.79	0.89	1.15	1.2	
	0.41	0.53	0.56	0.65	0.73	0.8	0.94	1.04	
	0.4	0.5	0.65	0.69	0.75	0.83	0.89	0.91	
	0.38	0.47	0.57	0.73	0.81	0.85	0.9	1.05	
	0.42	0.57	0.64	0.76	0.88	0.96	1.01	1.06	
2020 —									
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NOAA FISHERIES

	1990 —			_				_	_		
		0.29 0.48	0.6	0.73	0.84	0.87	1.01	1.13			
Fichom	(0.39 0.46	0.65	0.7	0.81	0.98	1.03	1.21			
Fishery		0.5 0.61	0.65	0.75	0.9	1.04	1.21	1.23			
	(0.41 0.65	0.73	0.75	0.71	1.06	1.39	1.35			
data	— (0.38 0.5	0.74	0.84	0.86	0.99	1.22	1.31			
Qala	(0.32 0.43	0.68	0.79	0.95	0.95	1.02	1.1			
	(0.32 0.47	0.56	0.75	0.89	1.07	1.09	1.24			
	(0.37 0.59	0.63	0.62	0.78	1.03	1.17	1.25			
Started with		0.4 0.51	0.64	0.7	0.73	0.89	1.04	1.25			
Started with	2000 —	0.35 0.53	0.63	0.73	0.78	0.81	0.97	1.01			
domestic	(0.33 0.5	0.67	0.79	0.96	0.99	1.06	1.12		Anomaly	
uomestic	(0.39 0.51	0.67	0.79	0.91	1.03	1.1	1.09		Anomaly	
fishery		0.49 0.55	0.65	0.77	0.86	0.95	1.08	1.2			
пзпегу	ar	0.41 0.58	0.64	0.76	0.89	0.92	1.04	1.16		0.2	
	, w	0.35 0.51	0.64	0.74	0.88	0.95	1.06	1.1		0.2	
	\succ	0.31 0.45		0.75	0.85	0.95	1.06	1.11		0.0	
		0.35 0.51	0.64	0.78	0.96	1.1	1.18	1.27		0.0	
		0.33 0.52		0.77	0.9	1.05	1.12	1.28		-0.2	
		0.34 0.53		0.88	1	1.13	1.4	1.49		•	
	2010	0.38 0.49		0.92	1.12	1.26	1.37	1.59			
(for pollock)		0.29 0.51		0.81	0.98	1.22	1.35	1.52			
		0.27 0.41		0.82	0.97	1.17	1.31	1.52			
		0.29 0.44		0.78	1.13	1.28	1.43	1.69			
		0.32 0.45		0.75	0.89	1.15	1.31	1.37			
		0.4 0.46		0.69	0.79	0.89	1.15	1.2			
		0.41 0.53		0.65	0.73	0.8	0.94	1.04			
		0.4 0.5	0.65	0.69	0.75	0.83	0.89	0.91			
		0.38 0.47		0.73	0.81	0.85	0.9	1.05			
		0.42 0.57	0.64	0.76	0.88	0.96	1.01	1.06			
	2020 —										
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Eastern Bering Sea

Draft



1980

Survey data

1980									
	0.17	0.35	0.43	0.67	1.02	1.12	1.2	1.38	1
	0.24	0.36	0.49	0.58	0.73	1.07	1.13	1.02	
	0.26	0.36	0.48	0.62	0.76	1.02	1.22	1.41	
	0.26	0.41	0.51	0.65	0.78	0.93	1.43	1.13	-
	0.18	0.36	0.46	0.64	0.72	0.85	1.01	1.29	
	0.26	0.35	0.43	0.53	0.71	0.8	0.9	1	
	0.3	0.36	0.46	0.52	0.6	0.75	0.85	1	
	0.17	0.38	0.45	0.53	0.63	0.67	0.93	0.92	
1990	 0.15	0.38	0.5	0.57	0.61	0.72	0.79	1.05	
	0.16	0.35	0.49	0.58	0.69	0.74	0.87	0.91	
	0.29	0.37	0.51	0.63	0.78	0.84	0.9	0.99	
	0.31	0.46	0.5	0.55	0.66	0.8	0.98	1.03	
	0.22	0.47	0.57	0.64	0.72	0.98	1.17	1.13	
	0.15	0.38	0.49	0.63	0.65	0.8	0.94	1.17	-
	0.14	0.34	0.51	0.6	0.73	0.81	0.97	1.06	
	0.18	0.36	0.44	0.59	0.71	0.81	0.97	1.02	
	0.17	0.33	0.47	0.52	0.7	0.84	0.92	1	
<u>ب</u>	0.21	0.36	0.42	0.56	0.63	0.78	0.98	1.01	
2000 X 63	0.23	0.38	0.46	0.53	0.65	0.71	0.78	0.96	-
Ð	0.17	0.37	0.51	0.6	0.67	0.77	0.86	0.91	
	0.25	0.39	0.54	0.65	0.68	0.81	0.89	0.93	
	0.33	0.44	0.57	0.67	0.73	0.83	0.89	0.96	
	0.3	0.48	0.56	0.68	0.76	0.79	0.94	0.95	
	0.22	0.4	0.53	0.6	0.7	0.8	0.87	0.91	
	0.16	0.39	0.52	0.61	0.72	0.81	0.91	1.05	
	0.28	0.43	0.55	0.67	0.78	0.85	0.93	1.08	
	0.23	0.41	0.52	0.64	0.76	0.87	0.93	1.07	
	0.22	0.41	0.55	0.67	0.84	0.91	0.96	1.17	
2010	0.24	0.4	0.55	0.68	0.9	0.98	1.02	1.12	
	0.23	0.43	0.55	0.65	0.8	1	1.1	1.15	
	0.21	0.36	0.54	0.67	0.8	0.95	1.21	1.24	
	0.22	0.42	0.5	0.62	0.83	0.98	1.09	1.23	
	0.21	0.37	0.49	0.61	0.67	0.9	1	1.13	
	0.29	0.39	0.52	0.6	0.73	0.81	1.05	1.08	-
	0.23	0.44	0.51	0.61	0.69	0.78	0.84	0.92	
	0.2	0.4	0.53	0.6	0.69	0.74	0.82	0.83	
	0.2	0.37	0.5	0.61	0.71	0.75	0.84	0.88	
0000	0.23	0.43	0.55	0.64	0.71	0.79	0.84	0.93	
2020									
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Eastern Bering Sea

Anomaly 0.4 0.2

> 0.0 -0.2

> > Draft



	1000	fishery										survey								
	1980																			
												0.17	0.35	0.43	0.67	1.02	1.12	1.2	1.38	
												0.24	0.36	0.49	0.58	0.73	1.07	1.13	1.02	
												0.26	0.36	0.48	0.62	0.76	1.02	1.22	1.41	
												0.26	0.41	0.51	0.65	0.78	0.93	1.43	1.13	
												0.18	0.36	0.46	0.64	0.72	0.85	1.01	1.29	
												0.26	0.35	0.43	0.53	0.71	0.8	0.9	1	
												0.3	0.36	0.46	0.52	0.6	0.75	0.85	1	
	4000											0.17	0.38	0.45	0.53	0.63	0.67	0.93	0.92	
	1990		0.00	0.40	0.0	0.70	0.04	0.07	1.04	1 10		0.15	0.38	0.5	0.57	0.61	0.72	0.79	1.05	
			0.29	0.48	0.6	0.73	0.84	0.87	1.01	1.13		0.16	0.35	0.49	0.58	0.69	0.74	0.87	0.91	
			0.39	0.46	0.65	0.7	0.81	0.98	1.03	1.21		0.29	0.37	0.51	0.63	0.78	0.84	0.9	0.99	
			0.5 0.41	0.61 0.65	0.65 0.73	0.75 0.75	0.9 0.71	1.04 1.06	1.21 1.39	1.23 1.35		0.31	0.46 0.47	0.5 0.57	0.55 0.64	0.66 0.72	0.8 0.98	0.98	1.03 1.13	
			0.41	0.05	0.73	0.75	0.71	0.99	1.22	1.35		0.22	0.47	0.37	0.64	0.72	0.90	0.94	1.13	
			0.30	0.43	0.68	0.79	0.95	0.95	1.02	1.1		0.13	0.34	0.49	0.6	0.03	0.81	0.94	1.06	
			0.32	0.43	0.56	0.75	0.89	1.07	1.02	1.24		0.14	0.34	0.44	0.59	0.73	0.81	0.97	1.00	
			0.37	0.59	0.63	0.62	0.78	1.03	1.17	1.25		0.17	0.33	0.47	0.52	0.7	0.84	0.92	1	
L			0.4	0.51	0.64	0.7	0.73	0.89	1.04	1.25		0.21	0.36	0.42	0.56	0.63	0.78	0.98	1.01	
ສ	2000		0.35	0.53	0.63	0.73	0.78	0.81	0.97	1.01		0.23	0.38	0.46	0.53	0.65	0.71	0.78	0.96	
٦) (D)	2000		0.33	0.5	0.67	0.79	0.96	0.99	1.06	1.12		0.17	0.37	0.51	0.6	0.67	0.77	0.86	0.91	
\succ			0.39	0.51	0.67	0.79	0.91	1.03	1.1	1.09		0.25	0.39	0.54	0.65	0.68	0.81	0.89	0.93	
			0.49	0.55	0.65	0.77	0.86	0.95	1.08	1.2		0.33	0.44	0.57	0.67	0.73	0.83	0.89	0.96	
			0.41	0.58	0.64	0.76	0.89	0.92	1.04	1.16		0.3	0.48	0.56	0.68	0.76	0.79	0.94	0.95	
			0.35	0.51	0.64	0.74	0.88	0.95	1.06	1.1		0.22	0.4	0.53	0.6	0.7	0.8	0.87	0.91	
			0.31	0.45	0.61	0.75	0.85	0.95	1.06	1.11		0.16	0.39	0.52	0.61	0.72	0.81	0.91	1.05	
			0.35	0.51	0.64	0.78	0.96	1.1	1.18	1.27		0.28	0.43	0.55	0.67	0.78	0.85	0.93	1.08	
			0.33	0.52	0.65	0.77	0.9	1.05	1.12	1.28		0.23	0.41	0.52	0.64	0.76	0.87	0.93	1.07	
	0040		0.34	0.53	0.7	0.88	1	1.13	1.4	1.49		0.22	0.41	0.55	0.67	0.84	0.91	0.96	1.17	
	2010		0.38	0.49	0.66	0.92	1.12	1.26	1.37	1.59		0.24	0.4	0.55	0.68	0.9	0.98	1.02	1.12	
			0.29 0.27	0.51	0.67 0.64	0.81	0.98	1.22	1.35	1.52 1.52		0.23	0.43	0.55	0.65	0.8 0.8	1	1.1	1.15	
			0.27	0.41 0.44	0.64	0.82	0.97 1.13	1.17 1.28	1.31 1.43	1.69		0.21 0.22	0.36	0.54 0.5	0.67 0.62	0.83	0.95 0.98	1.21 1.09	1.24 1.23	
			0.23	0.44	0.62	0.75	0.89	1.15	1.31	1.37		0.22	0.42	0.49	0.61	0.67	0.90	1.03	1.13	
			0.4	0.46	0.57	0.69	0.79	0.89	1.15	1.2		0.29	0.39	0.52	0.6	0.73	0.81	1.05	1.08	
			0.41	0.53	0.56	0.65	0.73	0.8	0.94	1.04		0.23	0.44	0.51	0.61	0.69	0.78	0.84	0.92	
			0.4	0.5	0.65	0.69	0.75	0.83	0.89	0.91		0.2	0.4	0.53	0.6	0.69	0.74	0.82	0.83	
			0.38	0.47	0.57	0.73	0.81	0.85	0.9	1.05		0.2	0.37	0.5	0.61	0.71	0.75	0.84	0.88	
			0.42	0.57	0.64	0.76	0.88	0.96	1.01	1.06		0.23	0.43	0.55	0.64	0.71	0.79	0.84	0.93	
	2020																			
				4		6		8		10			4		6		8		10	
											Age	•						Ľ)ra	ft



Fishery weight-at-age

Hypothesis:

 Pollock weight-at-age in fishery has year and cohort effects

Support:

 SAFE reports for EBS and GOA pollock

Implementation within pollock assessment model:

Modeled as random effects outside of model to get year and cohort effect variances

Those variances then used within model to estimate year and cohort effects as fixed

Future consideration: can cohort and year effects be effectively modeled as driven by the environment and/or density dependence?





Basic model for body mass-at-age

$$\begin{aligned} \hat{w}_{ta} &= \bar{w}_{a} e_{t}^{\upsilon} & a = 1, t \ge 1964 \\ \hat{w}_{ta} &= \hat{w}_{t-1,a-1} + \Delta_{a} e_{t}^{\psi} & a > 1, t > 1964 \\ \Delta_{a} &= \bar{w}_{a+1} - \bar{w}_{a} & a < A \\ \bar{w}_{a} &= \alpha \left\{ L_{1} + (L_{2} - L_{1}) \left(\frac{1 - K^{a-1}}{1 - K^{A-1}} \right) \right\}^{3} \end{aligned}$$

where the fixed effects parameters are L_1, L_2, K , and α while the random effects parameters are v_t and ψ_t .

$$nll_i = 0.5 \sum_{at} \frac{\ln(w_{at}/\hat{w}_{at})^2}{2\sigma_{w_{at}}^2} \qquad \text{Draft}$$

NOAA FISHERIES

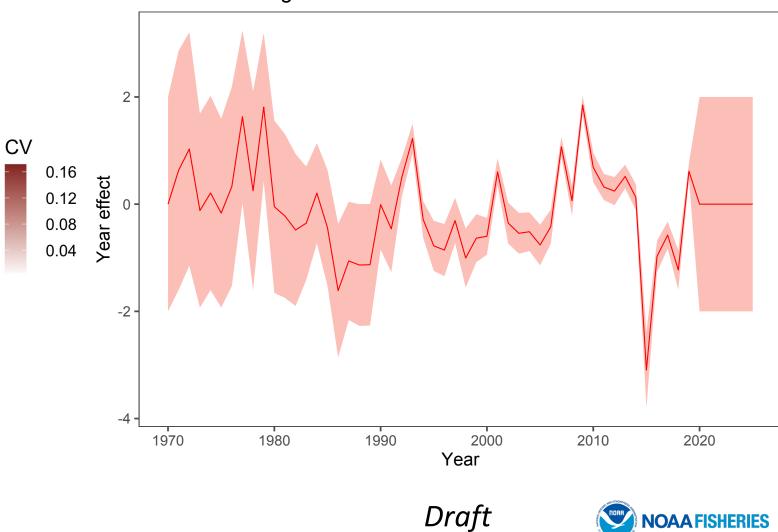
1980 -				fish	ery							inc	lex							mo	del				
									0.17 0.24 0.26 0.26	0.35 0.36 0.36 0.41	0.43 0.49 0.48 0.51	0.67 0.58 0.62 0.65	1.02 0.73 0.76 0.78	1.12 1.07 1.02 0.93	1.2 1.13 1.22 1.43	1.38 1.02 1.41 1.13	0.35 0.39 0.44 0.46	0.45 0.47 0.53 0.55	0.59 0.57 0.61 0.64	0.67 0.71 0.72 0.73	1.07 0.79 0.85 0.83	1.11 1.18 0.93 0.96	1.45 1.22 1.32 1.03	1.57 1.55 1.34 1.42	
									0.18 0.26 0.3 0.17	0.36 0.35 0.36 0.38	0.46 0.43 0.46 0.45	0.64 0.53 0.52 0.53	0.72 0.71 0.6 0.63	0.85 0.8 0.75 0.67	1.01 0.9 0.85 0.93	1.29 1 1 0.92	0.38 0.42 0.39 0.33	0.53 0.47 0.51 0.47	0.63 0.62 0.55 0.59	0.72 0.71 0.7 0.64	0.8 0.8 0.8 0.79	0.9 0.88 0.89 0.88	1.03 0.98 0.96 0.97	1.1 1.1 1.05 1.04	
1990 -	0.29 0.39 0.5	0.48 0.46 0.61	0.6 0.65 0.65	0.73 0.7 0.75	0.84 0.81 0.9	0.87 0.98 1.04	1.01 1.03 1.21	1.13 1.21 1.23	0.15 0.16 0.29 0.31	0.38 0.35 0.37 0.46	0.5 0.49 0.51 0.5	0.57 0.58 0.63 0.55	0.61 0.69 0.78 0.66	0.72 0.74 0.84 0.8	0.79 0.87 0.9 0.98	1.05 0.91 0.99 1.03	0.29 0.28 0.41 0.48	0.46 0.4 0.44 0.61	0.61 0.58 0.57 0.65	0.73 0.72 0.74 0.79	0.77 0.84 0.89 0.96	0.92 0.88 1 1.1	1.01 1.02 1.03 1.2	1.08 1.1 1.16 1.22	
	0.41 0.38 0.32 0.32	0.65 0.5 0.43 0.47	0.73 0.74 0.68 0.56	0.75 0.84 0.79 0.75	0.71 0.86 0.95 0.89	1.06 0.99 0.95 1.07	1.39 1.22 1.02 1.09	1.35 1.31 1.1 1.24	0.22 0.15 0.14 0.18	0.47 0.38 0.34 0.36	0.57 0.49 0.51 0.44	0.63 0.6 0.59	0.72 0.65 0.73 0.71	0.98 0.8 0.81 0.81	1.17 0.94 0.97 0.97	1.13 1.17 1.06 1.02	0.4 0.32 0.37 0.44	0.6 0.5 0.41 0.48	0.74 0.7 0.59 0.53	0.78 0.84 0.8 0.71	0.91 0.88 0.93 0.92	1.08 1 0.97 1.05	1.21 1.17 1.09 1.08	1.3 1.29 1.25 1.2	
2000 -	0.37 0.4 0.35 0.33 0.39	0.59 0.51 0.53 0.5 0.51	0.63 0.64 0.63 0.67 0.67	0.62 0.7 0.73 0.79 0.79	0.78 0.73 0.78 0.96 0.91	1.03 0.89 0.81 0.99 1.03	1.17 1.04 0.97 1.06 1.1	1.25 1.25 1.01 1.12 1.09	0.17 0.21 0.23 0.17 0.25	0.33 0.36 0.38 0.37 0.39	0.47 0.42 0.46 0.51 0.54	0.52 0.56 0.53 0.6 0.65	0.7 0.63 0.65 0.67 0.68	0.84 0.78 0.71 0.77 0.81	0.92 0.98 0.78 0.86 0.89	1 1.01 0.96 0.91 0.93	0.4 0.4 0.38 0.43 0.43	0.53 0.51 0.5 0.54 0.54	0.58 0.64 0.61 0.67 0.66	0.63 0.68 0.74 0.79 0.79	0.8 0.73 0.79 0.92 0.9	1.01 0.91 0.83 0.95 1.03	1.13 1.1 0.99 1.06	1.16 1.22 1.19 1.15 1.09	
>	0.49 0.41 0.35 0.31 0.35	0.55 0.58 0.51 0.45 0.51	0.65 0.64 0.64 0.61 0.64	0.77 0.76 0.74 0.75 0.78	0.86 0.89 0.88 0.85 0.96	0.95 0.92 0.95 0.95 1.1	1.08 1.04 1.06 1.06 1.18	1.2 1.16 1.1 1.11 1.27	0.33 0.3 0.22 0.16 0.28	0.44 0.48 0.4 0.39 0.43	0.57 0.56 0.53 0.52 0.55	0.67 0.68 0.6 0.61 0.67	0.73 0.76 0.7 0.72 0.78	0.83 0.79 0.8 0.81 0.85	0.89 0.94 0.87 0.91 0.93	0.96 0.95 0.91 1.05 1.08	0.45 0.38 0.32 0.3 0.33	0.53 0.56 0.47 0.43 0.5	0.65 0.65 0.66 0.59 0.64	0.77 0.76 0.75 0.77 0.8	0.9 0.88 0.86 0.86 0.98	1.01 1 0.98 0.97 1.06	1.13 1.11 1.1 1.08 1.16	1.15 1.22 1.19 1.19 1.26	
2010 -	0.33 0.34 0.38 0.29	0.52 0.53 0.49 0.51	0.65 0.7 0.66 0.67	0.77 0.88 0.92 0.81	0.9 1 1.12 0.98	1.05 1.13 1.26 1.22	1.12 1.4 1.37 1.35	1.28 1.49 1.59 1.52	0.23 0.22 0.24 0.23	0.41 0.41 0.4 0.43	0.52 0.55 0.55 0.55	0.64 0.67 0.68 0.65	0.76 0.84 0.9 0.8	0.87 0.91 0.98 1	0.93 0.96 1.02 1.1	1.07 1.17 1.12 1.15	0.24 0.34 0.3 0.27	0.46 0.51 0.51 0.45	0.64 0.74 0.69 0.66	0.78 0.92 0.92 0.84	0.93 1.06 1.1 1.07	1.11 1.2 1.23 1.24	1.19 1.36 1.36 1.37	1.28 1.42 1.52 1.5	
	0.27 0.29 0.32 0.4 0.41	0.41 0.44 0.45 0.46 0.53	0.64 0.56 0.62 0.57 0.56	0.82 0.78 0.75 0.69 0.65	0.97 1.13 0.89 0.79 0.73	1.17 1.28 1.15 0.89 0.8	1.31 1.43 1.31 1.15 0.94	1.52 1.69 1.37 1.2 1.04	0.21 0.22 0.21 0.29 0.23	0.36 0.42 0.37 0.39 0.44	0.54 0.5 0.49 0.52 0.51	0.67 0.62 0.61 0.6 0.61	0.8 0.83 0.67 0.73 0.69	0.95 0.98 0.9 0.81 0.78	1.21 1.09 1 1.05 0.84	1.24 1.23 1.13 1.08 0.92	0.31 0.37 0.44 0.44 0.38	0.42 0.47 0.51 0.48 0.53	0.6 0.58 0.62 0.55 0.57	0.81 0.77 0.73 0.66 0.64	0.99 0.98 0.91 0.77 0.75	1.22 1.15 1.12 0.95 0.86	1.38 1.37 1.28 1.16 1.04	1.49 1.52 1.49 1.32 1.24	
2020 -	0.4 0.38 0.42	0.5 0.47 0.57	0.65 0.57 0.64	0.69 0.73 0.76	0.75 0.81 0.88	0.83 0.85 0.96	0.89 0.9 1.01	0.91 1.05 1.06	0.2 0.2 0.23	0.4 0.37 0.43	0.53 0.5 0.55	0.6 0.61 0.64	0.69 0.71 0.71	0.74 0.75 0.79	0.82 0.84 0.84	0.83 0.88 0.93	0.38 0.37 0.36 0.36 0.36	0.49 0.46 0.5 0.49	0.64 0.58 0.6 0.64	0.69 0.73 0.71 0.74	0.75 0.77 0.86 0.85	0.86 0.84 0.91 0.99	0.96 0.94 0.96 1.03 1.12	1.13 1.04 1.06 1.08	
		4		6		8		10		4		6		8		10		0.49	0.63	0.77	0.91	1	1.1	1.24 10	
		ſ		0		0				т			ge	0				Ďı	raft			- MATTORNE	TORR		AFISHERIES

Weight-at-age CV

	1970										
	1970		0.17	0.14	0.12	0.1	0.08	0.07	0.06	0.05	
			0.15	0.17	0.12	0.14	0.12	0.11	0.09	0.08	
			0.15	0.14	0.14	0.14	0.12	0.11	0.1	0.09	
			0.15	0.14	0.16 0.14 0.12	0.12	0.12	0.11 0.11	0.1	0.09	
			0.15	0.13	0.12	0.11	0.11	0.11	0.1	0.09	
			0.15	0.14	0.12	0.11	0.1	0.1	0.1	0.09	
			0.14	0.12 0.13	0.1	0.09	0.08	0.08	0.08 0.07	0.09	
			0.14 0.13	0.13	0.1	0.09	0.08	0.08	0.07	0.08	
	1000		0.13	0.09	0.09	0.07	0.06	0.06	0.05	0.05	
	1980	_	0.11 0.09	0.1 0.08	0.07 0.07	0.07	0.06 0.06	0.05	0.05	0.05	
			0.09	0.08	0.07	0.06 0.05	0.06	0.05	0.05 0.04 0.04	0.04 0.04	
			0.06	0.05	0.05	0.05	0.05 0.04	0.04 0.04	0.04	0.04	
			0.00	0.05	0.04	0.04	0.04	0.04	0.04	0.04	
			0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	
			0.05	0.04	0.03	0.03	0.03	0.02	0.03	0.03	
			0.04	0.04	0.03	0.03	0.03	0.03	0.02	0.02	
			0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	
			0.05	0.04	0.03	0.03	0.02	0.02	0.02	0.02	
	1990	-	0.05 0.06 0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	
			0.04	0.04	0.02	0.02	0.01	0.02	0.01	0.01	
			0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.01	
			0.03 0.02 0.03 0.03 0.03 0.03 0.03 0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	
L			0.03	0.02	0.01	0.01	0.02	0.01	0.01	0.01	
Year			0.03	0.02 0.02	0.01 0.02	0.01 0.01	0.01 0.01	0.01 0.01	0.01 0.01	0.01 0.01	
Ũ			0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	
Ň			0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	
			0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	
	2000		0.02 0.03 0.02 0.02 0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
	2000		0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	
			0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	
			0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	
			0.01 0.02 0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
			0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
			0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01	
			0.04	0.02 0.03	0.01	0.01	0.01 0.01	0.01 0.01	0.01 0.01	0.01 0.01	
			0.04 0.03	0.03	0.01 0.02	0.01 0.01	0.01	0.01	0.01	0.01	
	2010		0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	
	2010		0.04 0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
			0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	
			0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
			0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	
			0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	
			0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
			0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
			0.08	0.04	0.01	0.01	0.01	0.01	0.01	0.01	
	2020		0.17	0.12	0.09	0.08	0.06	0.06	0.05	0.04	
	2020		0.17	0.16 0.16	0.12	0.11 0.12	0.09 0.11	0.07	0.07 0.08	0.06 0.07	
			0.17 0.17	0.16	0.15 0.15	0.12	0.11	0.09 0.11	0.08	0.07	
			0.17	0.10	0.10	0.14	0.12	0.11	0.00	0.00	
						0		6		4.0	
				4		6		8		10	

certainty propogation

Year-effect on growth increment



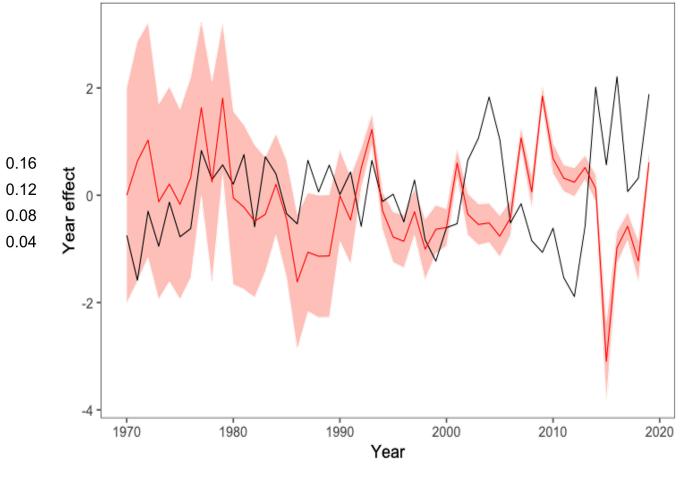
Weight-at-age CV

	1070									
	1970 —	0.17	0.14	0.12	0.1	0.08	0.07	0.06	0.05	
		0.15	0.17	0.16	0.1 0.14	0.12	0.11	0.09	0.08	
		0.15	0.14	0.14 0.12	0.14	0.12	0.11	0.1	0.09	
		0.15	0.14	0.12	0.14 0.12	0.12	0.11	0.1	0.09	
		0.15	0.13	0.12 0.12	0.11	0.11	0.11	0.1	0.09	
		0.15	0.14	0.12	0.11	0.1	0.1	0.1	0.09	
		0.14	0.12	0.1	0.09	0.08	0.08	0.08	0.09	
		0.14	0.13 0.09	0.1	0.09	0.08 0.06	0.08	0.07 0.05	0.08	
	1980 —	0.13 0.11	0.09	0.09 0.07	0.07 0.07	0.06	0.06 0.05	0.05	0.05 0.05	
	1900	0.09	0.08	0.07	0.06	0.06	0.05	0.05	0.03	
		0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	
		0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.04	
		0.05	0.05	0.04	0.04	0.03	0.03	0.04	0.04	
		0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	
		0.05	0.04	0.03	0.03	0.03	0.02	0.03	0.03	
		0.04	0.04	0.03	0.03	0.03	0.03	0.02	0.02	
		0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	
	1000	0.05	0.04	0.03	0.03	0.02	0.02	0.02	0.02	
	1990 —	0.06 0.04	0.04 0.04	0.03 0.02	0.03 0.02	0.03 0.01	0.02 0.02	0.02 0.01	0.02 0.01	
		0.04	0.04	0.02	0.02	0.01	0.02	0.01	0.01	
		0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.01	
		0.03	0.02	0.01	0.01	0.02	0.01	0.01	0.01	
<u> </u>		0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01	
Year		0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	
ŪΦ,		0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	
\succ		0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	
		0.02 0.03 0.02 0.02 0.02	0.01	0.02	0.01	0.01	0.01	0.01 0.01	0.01	
	2000 —	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
		0.02	0.02 0.02	0.01 0.01	0.01	0.01	0.01	0.01 0.01	0.01	
		0.02	0.02	0.01	0.01 0.01	0.01	0.01 0.01	0.01	0.01 0.01	
		0.01	0.02	0.01 0.01	0.01	0.01 0.01	0.01	0.01 0.01	0.01	
		0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
		0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01	
		0.04	0.02	0.01	0.01	0.01	0.01	0.01	0.01	
		0.04 0.04	0.03	0.01	0.01	0.01	0.01	0.01	0.01	
		0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	
	2010 —	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
		0.04 0.03 0.02 0.02 0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	
		0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	
		0.02	0.01 0.02	0.01 0.01	0.01 0.01	0.01 0.01	0.01 0.01	0.01 0.01	0.01 0.01	
		0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	
		0.01 0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	
		0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
		0.08	0.04	0.01	0.01	0.01	0.01	0.01	0.01	
		0.17	0.12	0.09	0.08	0.06	0.06	0.05	0.04	
	2020 —	0.17	0.16	0.12	0.11	0.09	0.07	0.07	0.06	<u> </u>
		0.17	0.16	0.15 0.15	0.12	0.11	0.09	0.08	0.07	
		0.17	0.16	0.15	0.14	0.12	0.11	0.09	0.08	
			Λ		6		8		10	
			<u></u>				()			

CV

certainty propogation

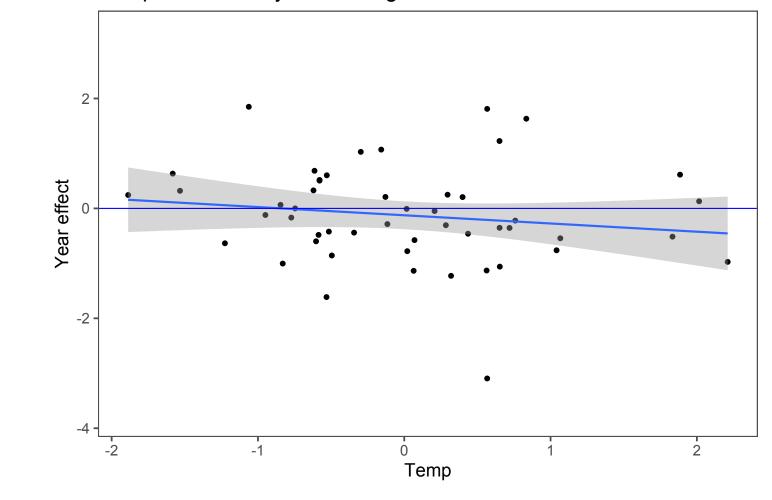
Year-effect on growth increment



Draft



Temperature and year-effect growth increment





Draft



Summary

• New data for 2021:

Bottom trawl survey Combined NBS+EBS Age compositions (EBS only) Acoustic vessels of opportunity (AVO) Fishery 2020 age composition Fishery updated weight-at-age

• Model

Standard from 2020

Some alternatives for reference point sensitivities